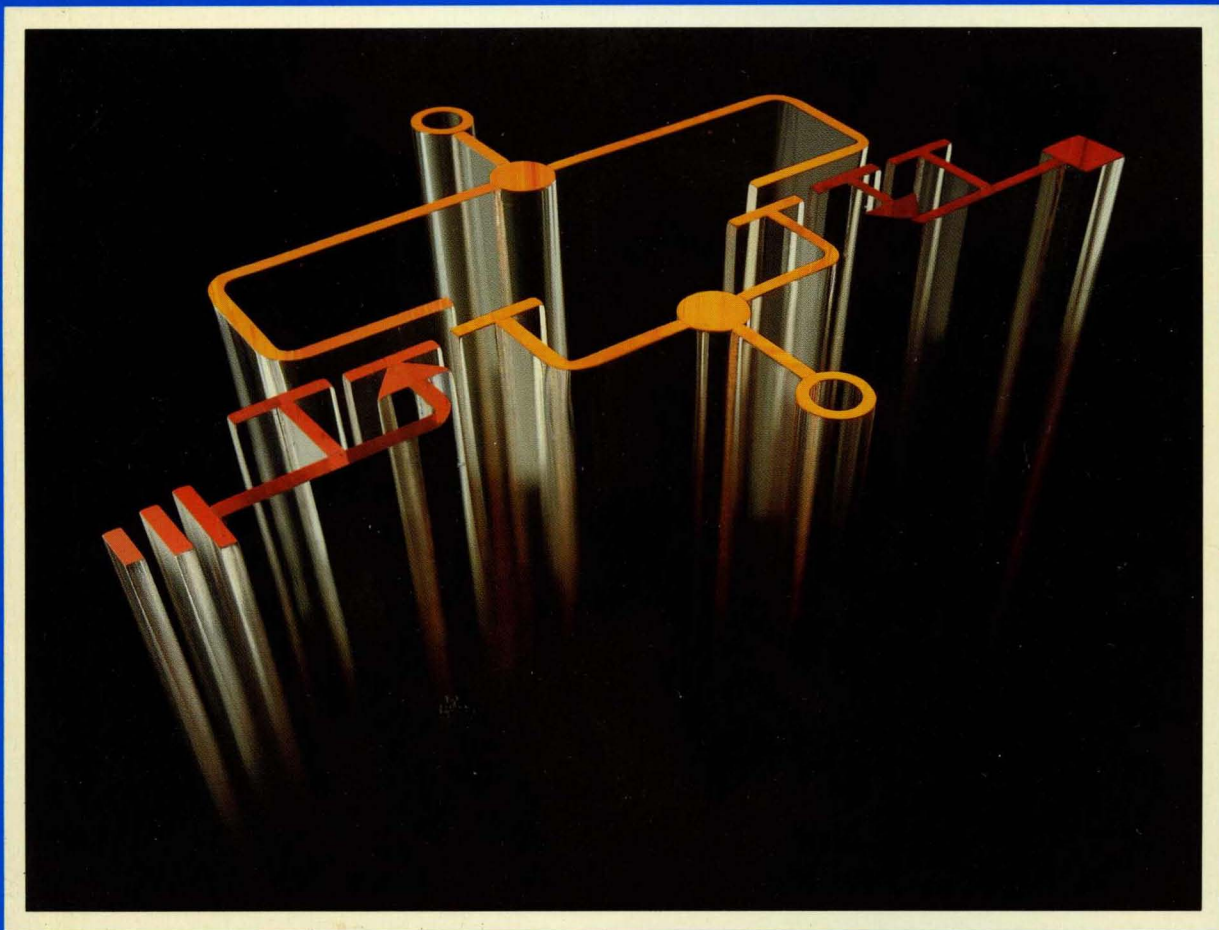


DL131  
REV 1



**MOTOROLA**



# CMOS LOGIC DATA

**MOTOROLA CMOS LOGIC DATA**

Q2/88  
DL131  
REV 1

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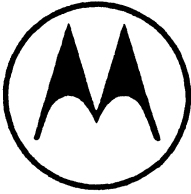
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# **MOTOROLA**

## CMOS LOGIC DATA

Prepared by  
Technical Information Center

This book presents technical data for the broad line of CMOS logic integrated circuits and demonstrates Motorola's continued commitment to Metal-Gate CMOS. Complete specifications are provided in the form of data sheets. In addition, a Product Selector Guide and a Handling and Design Guidelines chapter have been included to familiarize the user with these circuits.

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This index includes Motorola's entire MC14000 series CMOS products, although this book contains data sheets for Logic Devices only. Data sheets for devices in the CMOS/NMOS Special Functions Data book (DL130) are designated in the page number column as SF.

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MC14163B	Synchronous Presetable 4-Bit Binary Counter . . . . .	6-180
MC14510B	Presetable BCD Up/Down Counter . . . . .	6-244
MC14516B	Presetable Binary Up/Down Counter . . . . .	6-276
MC14518B	Dual BCD Up Counter . . . . .	6-288
MC14520B	Dual Binary Up Counter . . . . .	6-288
MC14522B	Presetable BCD Down Counter . . . . .	6-303
MC14526B	Presetable 4-Bit Binary Down Counter . . . . .	6-303
MC14534B	5 Cascaded BCD Counters . . . . .	6-343
MC14553B	3-Digit BCD Counter . . . . .	6-408
MC14566B	Industrial Time Base Generator . . . . .	6-451
MC14569B	Programmable Dual 4-Bit Binary/BCD Counter . . . . .	6-467
<b>Oscillators/Timers</b>		
MC14521B	24-Stage Frequency Divider . . . . .	6-297
MC14536B	Programmable Timer . . . . .	6-350
MC14541B	Programmable Oscillator/Timer . . . . .	6-373
<b>Multivibrators</b>		
MC14528B	Dual Monostable Multivibrator (Not Recommended for New Designs) . . . . .	6-317
MC14538B	Dual Precision Monostable Multivibrator . . . . .	6-361

Device	Function	Page
<b>Adders/Comparators</b>		
MC14008B	4-Bit Full Adder . . . . .	6-27
MC14032B	Triple Serial Adder (Positive Logic) . . . . .	6-92
MC14038B	Triple Serial Adder (Negative Logic) . . . . .	6-92
MC14560B	NBCD Adder . . . . .	6-430
MC14561B	9's Complementer . . . . .	6-441
MC14582B	Look-Ahead Carry Block . . . . .	6-490
MC14585B	4-Bit Magnitude Comparator . . . . .	6-503
<b>ALU/Rate Multipliers</b>		
MC14527B	BCD Rate Multiplier . . . . .	6-311
MC14554B	2 x 2-Bit Parallel Binary Multiplier . . . . .	6-414
MC14581B	4-Bit Arithmetic Logic Unit . . . . .	6-485
<b>Parity Checker</b>		
MC14531B	12-Bit Parity Tree . . . . .	6-334
<b>Memory</b>		
MC14580B	4 x 4 Multiport Register . . . . .	6-480
<b>Microprocessor/Industrial Control</b>		
MC14500B	Industrial Control Unit . . . . .	6-213
<b>Other Complex Functions</b>		
MC14046B	Phase-Locked Loop . . . . .	6-120
MC14415	Quad Precision Timer/Driver . . . . .	6-201
MC14490	Hex Contact Bounce Eliminator . . . . .	6-206
MC14568B	Phase Comparator and Programmable Counters . . . . .	6-457





# The “Better” Program

3

# The "BETTER" Program

The "BETTER" program is offered on Metal-Gate CMOS in dual-in-line ceramic and plastic packages.

Motorola standard commercial integrated circuits are manufactured under stringent in-process controls and quality

inspections combined with the industry's finest outgoing quality inspections. The "BETTER" program offers two levels of extra processing each tailored to meet different user needs at nominal costs.

## BETTER PROCESSING — STANDARD PRODUCT PLUS:

100% Screen	Level II "D"	Level III "DS"
Temp Cycle 10 Cycles — 25°C to +150°C		X
25°C Functional and Parametric Test	X	X
High Temperature Test*		X
Burn-In	X	X
25°C Post Burn-In Functional and Parametric Test	X	X

\*T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

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## PART MARKING

The Standard Motorola part number with the corresponding "BETTER" suffix can be ordered from your local authorized Motorola distributor or Motorola sales offices. "BETTER" pricing will be quoted as an adder to standard commercial product price.

MC14001B  
|  
Part  
Identification

## HOW TO ORDER

CP  
|  
Standard  
Package  
Suffix

D  
|  
"BETTER"  
PROCESSING  
LEVEL II = SUFFIX D  
LEVEL III = SUFFIX DS

## **B and UB Series Family Data**

**4**

# B AND UB SERIES CMOS FAMILY DATA

The CMOS Devices in this volume which have a B or UB suffix meet the minimum values for the industry-standardized# family specification. These standardized values are shown in the Maximum Ratings and Electrical Characteristics Tables. In addition to a standard minimum specification for characteristics the B/UB devices feature:

- 3-18 volt operational limits
- Capable of driving two low-power TTL loads or one low-power Schottky TTL load over the rated temperature range
- Direct Interface to High-Speed CMOS
- Maximum input current of  $\pm 1 \mu\text{A}$  at 15 volt power supply over the temperature range
- Parameters specified at 5.0, 10, and 15 volt supply
- Noise margins: B Series
  - 1.0 V min @ 5.0 V supply
  - 2.0 V min @ 10 V supply
  - 2.5 V min @ 15 V supply
- UB Series
  - 0.5 V min @ 5.0 V supply
  - 1.0 V min @ 10 V supply
  - 1.0 V min @ 15 V supply

The industry-standardized maximum ratings are shown at the bottom of this page. Limits for the static characteristics are shown in two formats: Table 1 is in the industry format and Table 2 is in the equivalent Motorola format. The Motorola format is used throughout this data book. Additional specification values are shown on the individual data sheets.

Switching characteristics for the B and UB series devices are specified under the following conditions:

- Load Capacitance,  $C_L$ , of 50 pF
- Input Voltage equal to  $V_{SS} - V_{DD}$  (Rail-to-Rail swing)
- Input pulse rise and fall times of 20 ns
- Propagation Delay times measured from 50% point of input voltage to 50% point of output voltage
- Three different supply voltages: 5, 10, and 15 V

## Exceptions to the B and UB Series Family Specification

There are a number of devices which have a B or UB suffix whose inputs and/or outputs vary somewhat from the family specification because of functional requirements. Some categories of notable exceptions are:

Devices with specialized outputs on the chip, such as NPN emitter-follower drivers or transmission gates, do not meet output specifications.

#Specifications coordinated by EIA/JEDEC Solid-State Products Council.

Devices with specialized inputs, such as oscillator inputs, have unique input specifications.

## Input Voltage

The input voltage specification is interpreted as the worst-case input voltage to produce an output level of "1" or "0". This "1" or "0" output level is defined as a deviation from the supply ( $V_{DD}$ ) and ground ( $V_{SS}$ ) levels. For a 5.0 V supply, this deviation is 0.5 V; for a 10 V supply, 1.0 V; and for 15 V, 1.5 V. As an example, in a device operating at a 5.0 V supply, the device with the input starting at ground is guaranteed to switch on or before 3.5 V and not to switch up to 1.5 V. Switching and not switching are defined as within 0.5 V of the ideal output level for the example with a 5.0 V supply. The actual switching level referred to the input is between 1.5 V and 3.5 V.

## Noise Margin

The values for input voltages and the defined output deviations lead to the calculated noise margins. Noise margin is defined as the difference between  $V_{IL}$  or  $V_{IH}$  and  $V_{out}$  (output deviation). As an example, for a noninverting buffer at  $V_{DD} = 5.0$  volts:  $V_{IL} = 1.5$  volts and  $V_{out} = 0.5$  volts. Therefore, Noise Margin equals  $V_{IL} - V_{out} = 1.0$  volt. This figure is useful while cascading stages (See Figure 1). With the input to the first stage at a worst-case voltage level ( $V_{IL} = 1.5$  V), the output is guaranteed to be no greater than 0.5 volts with a 5.0 volt supply. Since the maximum allowable logic 0 for the second stage is 1.5 volts, this 0.5 volt output provides a 1.0 volt margin for noise to the next stage.

## Output Drive Current

Devices in the B Series are capable of sinking a minimum of 0.36 mA over the temperature range with a 5.0 V supply. This value guarantees that these CMOS devices will drive one low-power Schottky TTL input.

## B Series vs UB CMOS

The primary difference between B series and UB series devices is that UB series gates and inverters are constructed with a single inverting stage between input and output. The decreased gain caused by using a single stage results in less noise immunity and a transfer characteristic that is less ideal.

The decreased gain is quite useful when CMOS Gates and inverters are used in a "Linear" mode to form oscillators, monostables, or amplifiers. The decreased gain results in increased stability and a "cleaner" output waveform. In addition to linear operation, the UB gates and inverters offer an increase in speed, since only a single stage is involved.

The B and UB series, and devices with no suffix can be used interchangeably in digital circuits that interface to other CMOS devices, such as High-Speed CMOS Logic.

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## MAXIMUM RATINGS\* (Voltages Referenced to $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

FIGURE 1

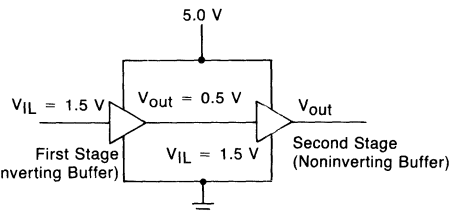


TABLE 1 – EIA/JEDEC FORMAT FOR CMOS INDUSTRY B AND UB SERIES SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

PARAMETER		TEMP RANGE	VDD (Vdc)	CONDITIONS	LIMITS						UNITS
					T <sub>LOW</sub> *		+ 25°C		T <sub>HIGH</sub> *		
					Min	Max	Min	Max	Min	Max	
I <sub>DD</sub>	Quiescent Device Current	Mil	5	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>DD</sub>		0.25		0.25		7.5	μAdc
			10			0.5		0.5		15	
			15			1.0		1.0		30	
	GATES	Comm	5	All valid input combinations		1.0		1.0		7.5	μAdc
			10			2.0		2.0		15	
			15			4.0		4.0		30	
	BUFFERS, FLIP-FLOPS	Mil	5	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>DD</sub>		1.0		1.0		30	μAdc
			10			2.0		2.0		60	
			15			4.0		4.0		120	
	MSI	Comm	5	All valid input combinations		4		4.0		30	μAdc
			10			8		8.0		60	
			15			16		16.0		120	
	Mil	5	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>DD</sub>		5		5		150	μAdc	
		10			10		10		300		
		15			20		20		600		
	Comm	5	All valid input combinations		20		20		150	μAdc	
		10			40		40		300		
		15			80		80		600		
V <sub>OL</sub>	Low-Level Output Voltage	All	5 10 15	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>DD</sub>  I <sub>O</sub>   < 1μA		0.05 0.05 0.05		0.05 0.05 0.05		Vdc	
V <sub>OH</sub>	High-Level Output Voltage	All	5 10 15	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>DD</sub>  I <sub>O</sub>   < 1μA	4.95 9.95 14.95		4.95 9.95 14.95		4.95 9.95 14.95		Vdc
V <sub>IL</sub>	Input Low Voltage # B Types	All	5 10 15	V <sub>O</sub> = 0.5V or 4.5V V <sub>O</sub> = 1.0V or 9.0V V <sub>O</sub> = 1.5V or 13.5V  I <sub>O</sub>   < 1μA		1.5 3.0 4.0		1.5 3.0 4.0		1.5 3.0 4.0	Vdc
V <sub>IL</sub>	Input Low Voltage # UB Types	All	5 10 15	V <sub>O</sub> = 0.5V or 4.5V V <sub>O</sub> = 1.0V or 9.0V V <sub>O</sub> = 1.5V or 13.5V  I <sub>O</sub>   < 1μA		1.0 2.0 2.5		1.0 2.0 2.5		1.0 2.0 2.5	Vdc
V <sub>IH</sub>	Input High Voltage # B Types	All	5 10 15	V <sub>O</sub> = 0.5V or 4.5V V <sub>O</sub> = 1.0V or 9.0V V <sub>O</sub> = 1.5V or 13.5V  I <sub>O</sub>   < 1μA	3.5 7.0 11.0		3.5 7.0 11.0		3.5 7.0 11.0		Vdc
V <sub>IH</sub>	Input High Voltage # UB Types	All	5 10 15	V <sub>O</sub> = 0.5V or 4.5V V <sub>O</sub> = 1.0V or 9.0V V <sub>O</sub> = 1.5V or 13.5V  I <sub>O</sub>   < 1μA	4.0 8.0 12.5		4.0 8.0 12.5		4.0 8.0 12.5		Vdc
I <sub>OL</sub>	Output Low (Sink) Current	Mil	5	V <sub>O</sub> = 0.4V, V <sub>IN</sub> = 0 or 5V	0.64		0.51		0.36		mAdc
			10	V <sub>O</sub> = 0.5V, V <sub>IN</sub> = 0 or 10V	1.6		1.3		0.9		
			15	V <sub>O</sub> = 1.5V, V <sub>IN</sub> = 0 or 15V	4.2		3.4		2.4		
		Com	5	V <sub>O</sub> = 0.4V, V <sub>IN</sub> = 0 or 5V	0.52		0.44		0.36		mAdc
			10	V <sub>O</sub> = 0.5V, V <sub>IN</sub> = 0 or 10V	1.3		1.1		0.9		
			15	V <sub>O</sub> = 1.5V, V <sub>IN</sub> = 0 or 15V	3.6		3.0		2.4		

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TABLE 1 – Continued

ELECTRICAL CHARACTERISTICS

PARAMETER	TEMP RANGE	V <sub>DD</sub> (Vdc)	CONDITIONS	LIMITS						UNITS	
				T <sub>LOW</sub> *		+ 25°C		T <sub>HIGH</sub> *			
				Min	Max	Min	Max	Min	Max		
I <sub>OH</sub> Output High (Source) Current	Mil	5	V <sub>O</sub> = 4.6V, V <sub>IN</sub> = 0 or 5V	-0.25		-0.2		-0.14		mAdc	
				10	V <sub>O</sub> = 9.5V, V <sub>IN</sub> = 0 or 10V	-0.62		-0.5			-0.35
						15	V <sub>O</sub> = 13.5V, V <sub>IN</sub> = 0 or 15V	-1.8			-1.5
	Com	5	V <sub>O</sub> = 4.6V, V <sub>IN</sub> = 0 or 5V	-0.2				-0.16			-0.12
				10	V <sub>O</sub> = 9.5V, V <sub>IN</sub> = 0 or 10V	-0.5		-0.4			-0.3
						15	V <sub>O</sub> = 13.5V, V <sub>IN</sub> = 0 or 15V	-1.4			-1.2
I <sub>IN</sub> Input Current	Mil	15	V <sub>IN</sub> = 0 or 15V		±0.1				±0.1	±1.0	μAdc
	Comm	15		V <sub>IN</sub> = 0 or 15V		±0.3		±0.3	±1.0	μAdc	
I <sub>oz</sub> 3-State Output Leakage Current	Mil	15	V <sub>IN</sub> = 0 or 15V		±0.4		±0.4		±12	μAdc	
	Comm	15	V <sub>IN</sub> = 0 or 15V		±1.6		±1.6		±12	μAdc	
C <sub>IN</sub> Input Capacitance per unit load	All	-	Any Input				7.5			pF	

\*T<sub>LOW</sub> = -55°C for Military temperature range device, -40°C for Commercial temperature range device.

T<sub>HIGH</sub> = +125°C for Military temperature range device, +85°C for Commercial temperature range device.

#Applies for Worst Case input combinations.

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TABLE 2 – MOTOROLA FORMAT FOR CMOS INDUSTRY B AND UB SERIES SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C		T <sub>high</sub> *		Unit	
			Min	Max	Min	Max	Min	Max		
			Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	-	0.05		-
10	-	0.05				-	0.05	-	0.05	
15	-	0.05				-	0.05	-	0.05	
"1" Level	V <sub>OH</sub>	5.0		4.95	-	4.95	-	4.95	-	
		10		9.95	-	9.95	-	9.95	-	
		15		14.95	-	14.95	-	14.95	-	
Input Voltage B Types (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	-	1.5	-	1.5	-	1.5	Vdc
			10	-	3.0	-	3.0	-	3.0	
			15	-	4.0	-	4.0	-	4.0	
	"1" Level	V <sub>IH</sub>	5.0	3.5	-	3.5	-	3.5	-	
			10	7.0	-	7.0	-	7.0	-	
			15	11.0	-	11.0	-	11.0	-	
Input Voltage UB Types (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	-	1.0	-	1.0	-	1.0	Vdc
			10	-	2.0	-	2.0	-	2.0	
			15	-	2.5	-	2.5	-	2.5	
	"1" Level	V <sub>IH</sub>	5.0	4.0	-	4.0	-	4.0	-	
			10	8.0	-	8.0	-	8.0	-	
			15	12.5	-	12.5	-	12.5	-	

TABLE 2 – Continued

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> <sup>*</sup>		25 <sup>o</sup> C		T <sub>high</sub> <sup>*</sup>		Unit
			Min	Max	Min	Max	Min	Max	
Output Drive Current (AL) B Gates (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	-	-2.4	-	-1.7	-	mAdc
		5.0	-0.64	-	-0.51	-	-0.36	-	
		10	-1.6	-	-1.3	-	-0.9	-	
		15	-4.2	-	-3.4	-	-2.4	-	
	I <sub>OL</sub>	5.0	0.64	-	0.51	-	0.36	-	
		10	1.6	-	1.3	-	0.9	-	
		15	4.2	-	3.4	-	2.4	-	
Output Drive Current (CL/CP) B Gates (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	-	-2.1	-	-1.7	-	mAdc
		5.0	-0.52	-	-0.44	-	-0.36	-	
		10	-1.3	-	-1.1	-	-0.9	-	
		15	-3.6	-	-3.0	-	-2.4	-	
	I <sub>OL</sub>	5.0	0.52	-	0.44	-	0.36	-	
		10	1.3	-	1.1	-	0.9	-	
		15	3.6	-	3.0	-	2.4	-	
Output Drive Current (AL) UB Gates (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.2	-	-1.0	-	-0.7	-	mAdc
		5.0	-0.25	-	-0.2	-	-0.14	-	
		10	-0.62	-	-0.5	-	-0.35	-	
		15	-1.8	-	-1.5	-	-1.1	-	
	I <sub>OL</sub>	5.0	0.64	-	0.51	-	0.36	-	
		10	1.6	-	1.3	-	0.9	-	
		15	4.2	-	3.4	-	2.4	-	
Output Drive Current (CL/CP) UB Gates (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	-	-0.8	-	-0.6	-	mAdc
		5.0	-0.2	-	-0.16	-	-0.12	-	
		10	-0.5	-	-0.4	-	-0.3	-	
		15	-1.4	-	-1.2	-	-1.0	-	
	I <sub>OL</sub>	5.0	0.52	-	0.44	-	0.36	-	
		10	1.3	-	1.1	-	0.9	-	
		15	3.6	-	3.0	-	2.4	-	
Output Drive Current (AL) Other Devices (V <sub>OH</sub> = 4.6 Vdc!) Source (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-0.64	-	-0.51	-	-0.36	-	mAdc
		10	-1.6	-	-1.3	-	-0.9	-	
		15	-4.2	-	-3.4	-	-2.4	-	
	I <sub>OL</sub>	5.0	0.64	-	0.51	-	0.36	-	
		10	1.6	-	1.3	-	0.9	-	
		15	4.2	-	3.4	-	2.4	-	
Output Drive Current (CL/CP) Other Devices (V <sub>OH</sub> = 4.6 Vdc) Source (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-0.52	-	-0.44	-	-0.36	-	mAdc
		10	-1.3	-	-1.1	-	-0.9	-	
		15	-3.6	-	-3.0	-	-2.4	-	
	I <sub>OL</sub>	5.0	0.52	-	0.44	-	0.36	-	
		10	1.3	-	1.1	-	0.9	-	
		15	3.6	-	3.0	-	2.4	-	
Input Current (AL Device)	I <sub>in</sub>	15	-	±0.1	-	±0.1	-	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	-	±0.3	-	±0.3	-	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	-	-	-	-	7.5	-	-	pF
Gate Quiescent Current (AL Device) (Per Package)  (CL/CP Device)	I <sub>DD</sub>	5.0	-	0.25	-	0.25	-	7.5	μAdc
		10	-	0.5	-	0.5	-	15	
		15	-	1.0	-	1.0	-	30	
	I <sub>DD</sub>	5.0	-	1.0	-	1.0	-	7.5	
		10	-	2.0	-	2.0	-	15	
		15	-	4.0	-	4.0	-	30	





TABLE 2 – Continued

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	VDD Vdc	T <sub>low</sub> <sup>*</sup>		25°C		T <sub>high</sub> <sup>*</sup>		Unit	
			Min	Max	Min	Max	Min	Max		
Flip-Flop and Buffer Quiescent Current (Per Package)	(AL Device)	5.0	–	1.0	–	1.0	–	30	μA <sub>dc</sub>	
		10	–	2.0	–	2.0	–	60		
		15	–	4.0	–	4.0	–	120		
	(CL/CP Device)	I <sub>DD</sub>	5.0	–	4.0	–	4.0	–	30	μA <sub>dc</sub>
			10	–	8.0	–	8.0	–	60	
			15	–	16	–	16	–	120	
MSI Quiescent Current (Per Package)	(AL Device)	5.0	–	5.0	–	5.0	–	150	μA <sub>dc</sub>	
		10	–	10	–	10	–	300		
		15	–	20	–	20	–	600		
	(CL/CP Device)	I <sub>DD</sub>	5.0	–	20	–	20	–	150	μA <sub>dc</sub>
			10	–	40	–	40	–	300	
			15	–	80	–	80	–	600	
LSI Quiescent Current	I <sub>DD</sub>		See Individual Data Sheets.							

\* T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

# **CMOS Handling and Design Guidelines**

**5**

## HANDLING AND DESIGN GUIDELINES

### HANDLING PRECAUTIONS

All MOS devices have insulated gates that are subject to voltage breakdown. The gate oxide for Motorola CMOS devices is about 800 Å thick and breaks down at a gate-source potential of about 100 volts. To guard against such a breakdown from static discharge or other voltage transients, the protection network shown in Figure 1 is used on each input to the CMOS device.

Static damaged devices behave in various ways, depending on the severity of the damage. The most severely damaged inputs are the easiest to detect because the input has been completely destroyed and is either shorted to  $V_{DD}$ , shorted to  $V_{SS}$ , or open-circuited. The effect is that the device no longer responds to signals present at the damaged input. Less severe cases are more difficult to detect because they show up as intermittent failures or as degraded performance. Another effect of static damage is that the inputs generally have increased leakage currents.

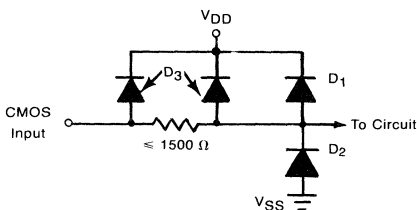
Although the input protection network does provide a great deal of protection, CMOS devices are not immune to large static voltage discharges that can be generated during handling. For example, static voltages generated by a person walking across a waxed floor have been measured in the 4-15 kV range (depending on humidity, surface conditions, etc.). Therefore, the following precautions should be observed:

1. Do not exceed the Maximum Ratings specified by the data sheet.
2. All unused device inputs should be connected to  $V_{DD}$  or  $V_{SS}$ .
3. All low-impedance equipment (pulse generators, etc.) should be connected to CMOS inputs only after the device is powered up. Similarly, this type of equipment should be disconnected before power is turned off.
4. Circuit boards containing CMOS devices are merely extensions of the devices, and the same handling precautions apply. Contacting edge connectors wired directly to device inputs can cause damage. Plastic wrapping should be avoided. When external connections to a PC board are connected to an input of a CMOS device, a resistor should be used in series with the input. This resistor helps limit accidental damage if the PC board is removed and brought into contact with static generating materials. The limiting factor for the series resistor is the added delay. This is caused by the time constant formed by the series resistor and

input capacitance. Note that the maximum input rise and fall times should not be exceeded. In Figure 2, two possible networks are shown using a series resistor to reduce ESD (Electrostatic Discharge) damage. For convenience, an equation for added propagation delay and rise time effects due to series resistance size is given.

5. All CMOS devices should be stored or transported in materials that are antistatic. CMOS devices must not be inserted into conventional plastic "snow", styrofoam, or plastic trays, but should be left in their original container until ready for use.
6. All CMOS devices should be placed on a grounded bench surface and operators should ground themselves prior to handling devices, since a worker can be statically charged with respect to the bench surface. Wrist straps in contact with skin are strongly recommended. See Figure 3 for an example of a typical work station.
7. Nylon or other static generating materials should not come in contact with CMOS devices.
8. If automatic handlers are being used, high levels of static electricity may be generated by the movement of the device, the belts, or the boards. Reduce static build-up by using ionized air blowers or room humidifiers. All parts of machines which come into contact with the top, bottom, or sides of IC packages must be grounded to metal or other conductive material.
9. Cold chambers using  $CO_2$  for cooling should be equipped with baffles, and the CMOS devices must be contained on or in conductive material.
10. When lead-straightening or hand-soldering is necessary, provide ground straps for the apparatus used and be sure that soldering ties are grounded.
11. The following steps should be observed during wave solder operations:
  - a. The solder pot and conductive conveyor system of the wave soldering machine must be grounded to an earth ground.
  - b. The loading and unloading work benches should have conductive tops which are grounded to an earth ground.
  - c. Operators must comply with precautions previously explained.
  - d. Completed assemblies should be placed in antistatic containers prior to being moved to subsequent stations.

FIGURE 1 — INPUT PROTECTION NETWORK



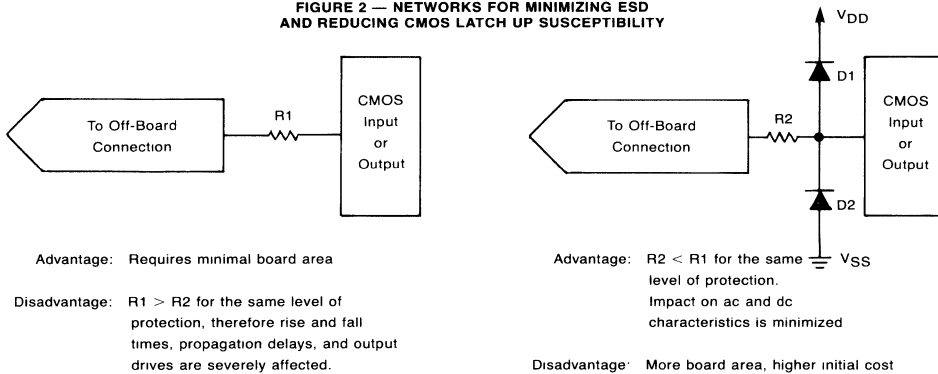
12. The following steps should be observed during board-cleaning operations:
  - a. Vapor degreasers and baskets must be grounded to an earth ground.
  - b. Brush or spray cleaning should not be used.
  - c. Assemblies should be placed into the vapor degreaser immediately upon removal from the antistatic container.
  - d. Cleaned assemblies should be placed in antistatic containers immediately after removal from the cleaning basket.
  - e. High velocity air movement or application of solvents and coatings should be employed only when assembled printed circuit boards are grounded and a static eliminator is directed at the board.
13. The use of static detection meters for production line surveillance is highly recommended.
14. Equipment specifications should alert users to the presence of CMOS devices and require familiarization with this specification prior to performing any kind of maintenance or replacement of devices or modules.
15. Do not insert or remove CMOS devices from test sockets with power applied. Check all power supplies to be used for testing devices to be certain there are no voltage transients present.
16. Double check test equipment setup for proper polarity of  $V_{DD}$  and  $V_{SS}$  before conducting parametric or functional testing.
17. Do not recycle shipping rails or trays. Repeated use causes deterioration of their antistatic coating.

**RECOMMENDED FOR READING:**

“Total Control of the Static in Your Business”

Available by writing to:  
 3M Company  
 Static Control Systems  
 P.O. Box 2963  
 Austin, Texas 78769-2963  
 Or by Calling:  
 1-800-328-1368

**FIGURE 2 — NETWORKS FOR MINIMIZING ESD AND REDUCING CMOS LATCH UP SUSCEPTIBILITY**



Note: These networks are useful for protecting the following

A digital inputs and outputs	C 3-state outputs
B analog inputs and outputs	D bidirectional (I/O) ports

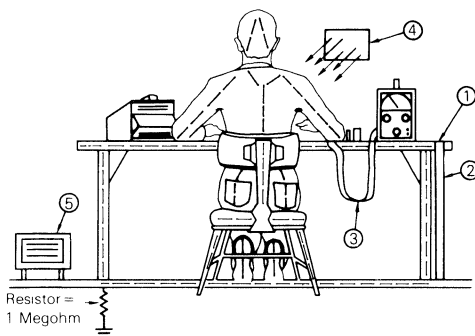
**PROPAGATION DELAY AND RISE TIME vs. SERIES RESISTANCE**

$$R = \frac{t}{C \cdot k}$$

where:

- R = the maximum allowable series resistance in ohms
- t = the maximum tolerable propagation delay or rise time in seconds
- C = the board capacitance plus the driven device's input capacitance in farads
- k = 0.7 for propagation delay calculations
- k = 2.3 for rise time calculations

**FIGURE 3 — TYPICAL MANUFACTURING WORK STATION**



- NOTES
- 1 1/16 inch conductive sheet stock covering bench top work area
  - 2 Ground strap
  - 3 Wrist strap in contact with skin
  - 4 Static neutralizer (ionized air blower directed at work) Primarily for use in areas where direct grounding is impractical.
  - 5 Room humidifier Primarily for use in areas where the relative humidity is less than 45% Caution. building heating and cooling systems usually dry the air causing the relative humidity inside of buildings to be less than outside humidity

## POWER SUPPLIES

CMOS devices have low power requirements and the ability to operate over a wide range of supply voltages. These two characteristics allow CMOS designs to be implemented using inexpensive, conventional power supplies, instead of switching power supplies and power supplies with cooling fans. In addition, batteries may be used as either a primary power source or for emergency backup.

The *absolute* maximum power supply voltage for 14000 Series Metal-gate CMOS is 18.0 Vdc. Figure 4 offers some insight as to how this specification was derived. In the figure,  $V_S$  is the maximum power supply voltage and  $I_S$  is the sustaining current of the latch-up mode. The value of  $V_S$  was chosen so that the secondary breakdown effect may be avoided.

In an ideal system design, a power supply should be designed to deliver only enough current to insure proper operation of all devices. The obvious benefit of this type design is cost savings; an added benefit is protection

against the possibility of latch-up related failures. This system protection can be provided by the power supply filter and/or voltage regulator.

CMOS devices can be used with battery or battery backup systems. A few precautions should be taken when designing battery-operated systems:

1. The recommended power supply voltage should be observed. For battery backup systems such as the one in Figure 5, the battery voltage must be at least 3.7 Volts (3 Volts from the minimum power supply voltage and 0.7 Volts to account for the voltage drop across the series diode).
2. Inputs that might go above the battery backup voltage should either use a series resistor to limit the input current to less than 10 mA or use the MC14049UB or MC14050B high-to-low voltage translators.
3. Outputs that are subject to voltage levels above  $V_{DD}$  or below  $V_{SS}$  should be protected with a series resistor to limit the current to less than 10 mA or with clamping diodes.

FIGURE 4 — SECONDARY BREAKDOWN CHARACTERISTICS

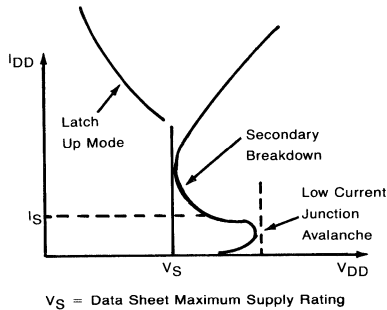
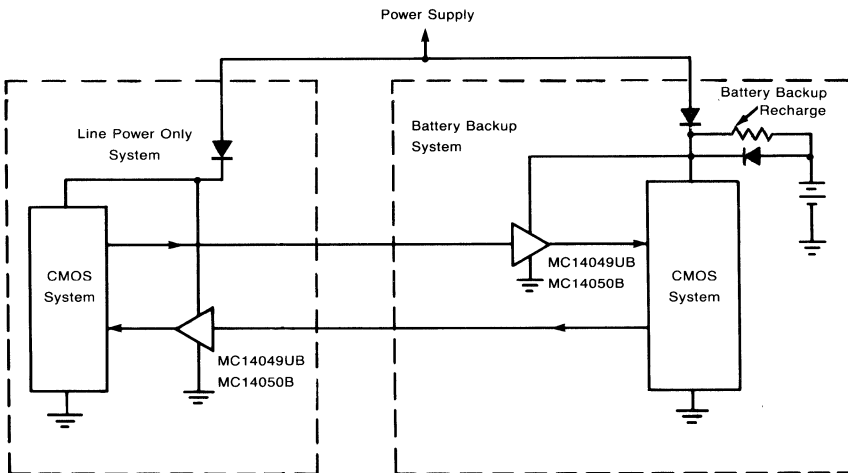


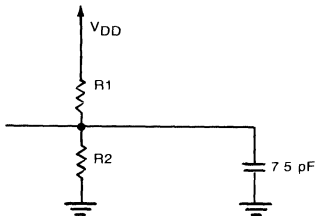
FIGURE 5 — BATTERY BACKUP INTERFACE



## INPUTS

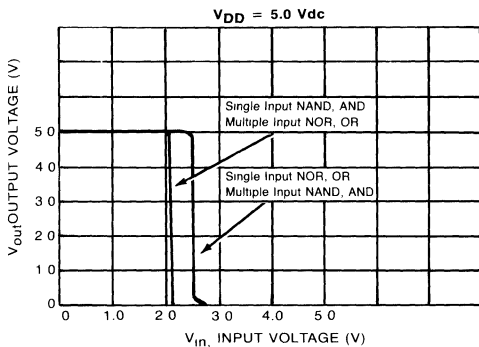
All inputs, while in the recommended operating range ( $V_{SS} < V_{in} < V_{DD}$ ) can be modeled as shown in Figure 6. For input voltages in this range, diodes D1 and D2 are modeled as resistors, representing the reverse bias impedance of the diodes. The maximum input current is worst case,  $1\mu\text{A}$ , when the inputs are at  $V_{DD}$  or  $V_{SS}$ , and  $V_{DD} = 15.0\text{ V}$ . This model does not apply to inputs with pull-up or pull-down resistors.

FIGURE 6 — INPUT MODEL FOR  $V_{SS} \leq V_{in} \leq V_{DD}$



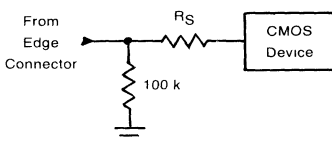
When left open-circuited, the inputs may self-bias at or near the typical switchpoint, where both the P-channel and N-channel transistors are conducting, causing excessive current drain. Due to the high gain of the inverters (see Figure 7), the device may also go into oscillation from any noise in the system. Since CMOS devices dissipate the most power during switching, this oscillation can cause very large current drain and undesired switching.

FIGURE 7 — TYPICAL TRANSFER CHARACTERISTICS FOR BUFFERED DEVICES



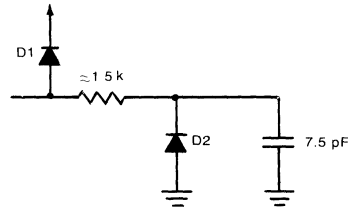
For these reasons, all unused inputs should be connected either to  $V_{DD}$  or  $V_{SS}$ . For applications with inputs going to edge connectors, a 100 kilohm resistor to  $V_{SS}$  should be used, as well as a series resistor for static protection and current limiting (Figure 8). The 100 kilohm resistor will help eliminate any static charges that might develop on the printed circuit board. See Figure 2 for other possible protection arrangements.

FIGURE 8 — EXTERNAL PROTECTION



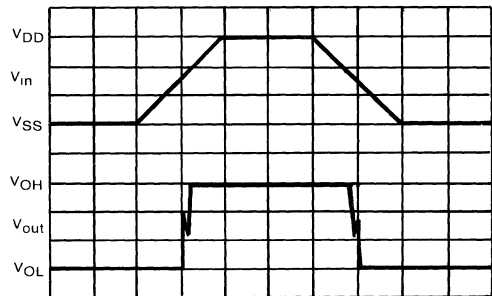
For input voltages outside of the recommended operating range, the CMOS input is modeled as in Figure 9. The resistor-diode protection network allows the user greater freedom when designing a worst case system. The device inputs are guaranteed to withstand voltages from  $V_{SS} - 0.5\text{ V}$  to  $V_{DD} + 0.5\text{ V}$  and a maximum current of  $10\text{ mA}$ . With the above input ratings, most designs will require no special terminations or design considerations.

FIGURE 9 — INPUT MODEL FOR  $V_{in} > V_{DD}$  or  $V_{in} < V_{SS}$



Other specifications that should be noted are the maximum input rise and fall times. Figure 10 shows the oscillations that may result from exceeding the  $15\mu\text{s}$  maximum rise and fall time at  $V_{DD} = 5.0\text{ V}$ ,  $5\mu\text{s}$  at  $10\text{ V}$ , or  $4\mu\text{s}$  at  $15\text{ V}$ . As the voltage passes through the switching threshold region with a slow rise time, any noise that is on the input is amplified, and passed through to the output, causing oscillations. The oscillation may have a low enough frequency to cause succeeding stages to switch, giving unexpected results. If input rise or fall times are expected to exceed  $15\mu\text{s}$  at  $5.0\text{ V}$ ,  $5\mu\text{s}$  at  $10\text{ V}$ , or  $4\mu\text{s}$  at  $15\text{ V}$ , Schmitt-trigger devices such as the MC14093B, MC14583B, MC14584B, MC14106B, HC14, or HC132 are recommended for squaring-up these slow transitions.

FIGURE 10 — MAXIMUM RISE AND FALL TIME VIOLATIONS



## OUTPUTS

All CMOS B-Series outputs are buffered to insure consistent output voltage and current performance. All buffered outputs have guaranteed output voltages of  $V_{OL} = 0.05 V$  and  $V_{OH} = V_{DD} - 0.05 V$  for  $V_{in} = V_{DD}$  or  $V_{SS}$  and  $I_{out} = 0 \mu A$ . The output drives for all buffered CMOS devices are such that 1 LSTTL load can be driven across the full temperature range.

CMOS outputs are limited to externally forced output voltages of  $V_{SS} - 0.5 V \leq V_{out} \leq V_{DD} + 0.5 V$ . When voltages are forced outside of this range, a silicon controlled rectifier (SCR) formed by parasitic transistors can be triggered, causing the device to latch up. For more information on this, see the explanation of CMOS Latch Up in this section.

The maximum rated output current for most outputs is 10 mA. The output short-circuit currents of these devices typically exceed these limits. Care must be taken not to exceed the maximum ratings found on every data sheet.

For applications that require driving high capacitive loads where fast propagation delays are needed (e.g., driving power MOSFETs), two or more outputs on the same chip may be externally paralleled.

## CMOS LATCH UP

Latch up will not be a problem for most designs, but the designer should be aware of it, what causes it, and how to prevent it.

Figure 11 shows the cross-section of a typical CMOS inverter and Figure 12 shows the parasitic bipolar devices. The circuit formed by the parasitic transistors and resistors is the basic configuration of a silicon controlled rectifier, or SCR. In the latch up condition, transistors Q1 and Q2 are turned ON, each providing the base current necessary for the other to remain in saturation, thereby latching

the devices in the ON state. Unlike a conventional SCR, where the device is turned ON by applying a voltage to the base of the NPN transistor, the parasitic SCR is turned ON by applying a voltage to the emitter of either transistor. The two emitters that trigger the SCR are the same point, the CMOS output. Therefore, to latch up the CMOS device, the output voltage must be greater than  $V_{DD} + 0.5 V$  or less than  $V_{SS} - 0.5 V$  and have sufficient current to trigger the SCR. The latch-up mechanism is similar for the inputs.

Once a CMOS device is latched up, if the supply current is not limited, the device will be destroyed. Ways to prevent such occurrences are listed below:

1. Insure that inputs and outputs are limited to the maximum rated values, as follows:  
 $-0.5 V \leq V_{in}$  or  $V_{out} \leq V_{DD} + 0.5 V$  (referenced to  $V_{SS}$ )  
 $|I_{in}$  or  $I_{out}| \leq 10$  mA (unless otherwise indicated on the data sheet)
2. If voltage transients of sufficient energy to latch up the device are expected on the inputs or outputs, external protection diodes can be used to clamp the voltage. Another method of protection is to use a series resistor to limit the expected worst case current to the maximum rating of 10 mA. (See Figure 2).
3. Sequence power supplies so that the inputs or outputs of CMOS devices are not active before the supply pins are powered up (e.g., recessed edge connectors and/or series resistors may be used in plug-in board applications).
4. Voltage regulating or filtering should be used in board design and layout to insure that power-supply lines are free of excessive noise.
5. Limit the available power supply current to the devices that are subject to latch-up conditions. This can be accomplished with the power supply filtering network or with a current-limiting regulator.

FIGURE 11 — CMOS WAFER CROSS SECTION

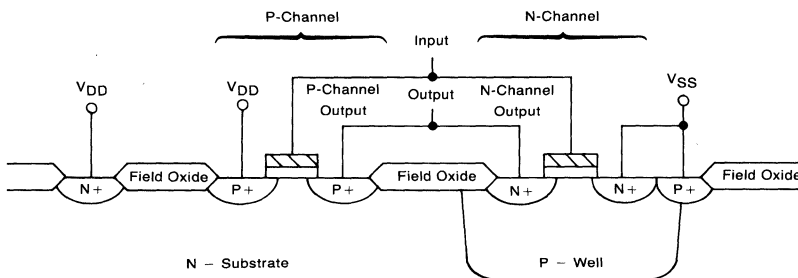
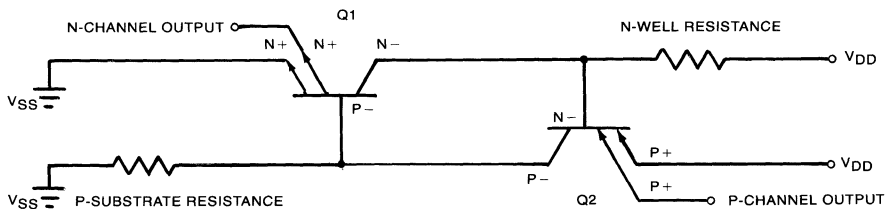


FIGURE 12 — LATCH UP CIRCUIT SCHEMATIC



# Data Sheets

6





**MOTOROLA**

**MC14000UB**

**CMOS SSI**

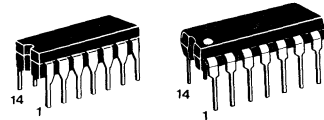
(LOW-POWER COMPLEMENTARY MOS)

**DUAL 3-INPUT "NOR" GATE PLUS INVERTER**

**DUAL 3-INPUT "NOR" GATE PLUS INVERTER**

The MC14000UB dual 3-input NOR gate plus inverter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Swing Independent of Fanout
- Pin-for-Pin Replacement for CD4000UB



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

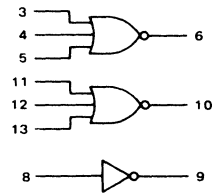
C Series: -40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>In</sub> , V <sub>Out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>In</sub> , I <sub>Out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

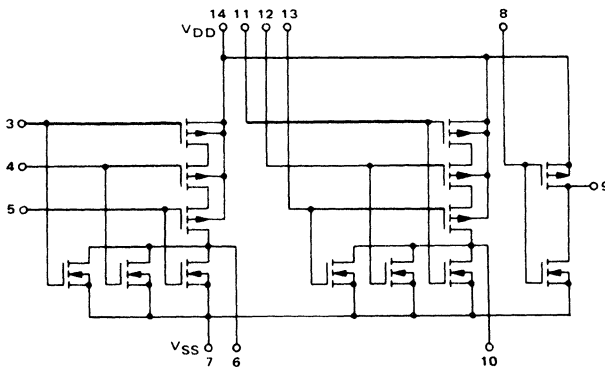
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**LOGIC DIAGRAM**

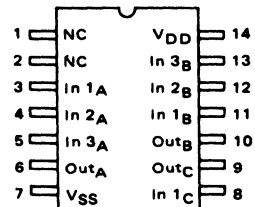


V<sub>DD</sub> = Pin 14  
V<sub>SS</sub> = Pin 7

**CIRCUIT SCHEMATIC**



**PIN ASSIGNMENT**



NC = NO CONNECTION

# MC1400UB

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
Input Voltage (V <sub>O</sub> = 4.5 Vdc) (V <sub>O</sub> = 9.0 Vdc) (V <sub>O</sub> = 13.5 Vdc)	V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc
		10	—	2.0	—	4.50	2.0	—	2.0	
(V <sub>O</sub> = 0.5 Vdc) (V <sub>O</sub> = 1.0 Vdc) (V <sub>O</sub> = 1.5 Vdc)	V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
		10	8.0	—	8.0	5.50	—	8.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc
		10	-0.25	—	-0.2	-0.36	—	-0.14	—	
(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mAdc
		10	-0.2	—	-0.16	-0.36	—	-0.12	—	
(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc
		10	—	0.5	—	0.0010	0.5	—	15	
		15	—	1.0	—	0.0015	1.0	—	30	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc
		10	—	2.0	—	0.0010	2.0	—	15	
		15	—	4.0	—	0.0015	4.0	—	30	
Total Supply Current**† (Dynamic plus Quiescent, Per Gate, C <sub>L</sub> = 50 pF)	I <sub>T</sub>	5.0					I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub> /N			μAdc
10					I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub> /N					
15					I <sub>T</sub> = (0.8 μA/kHz) f + I <sub>DD</sub> /N					

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V/k}$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001 × the number of exercised gates per package.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14000UB

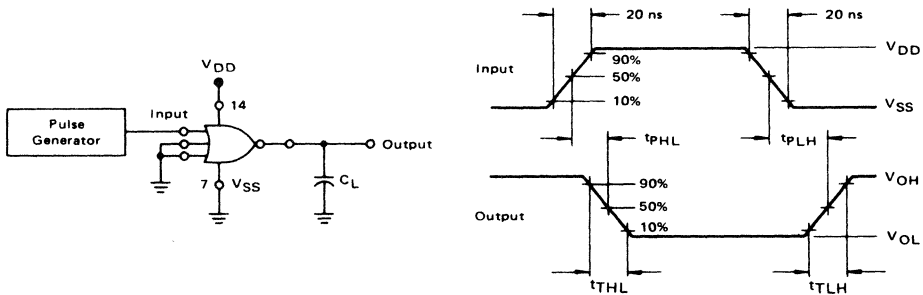
**SWITCHING CHARACTERISTICS\*** ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	Min	Typ #	Max	Unit
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 22 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.50 \text{ ns/pF}) C_L + 15 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	115 55 40	230 110 80	ns

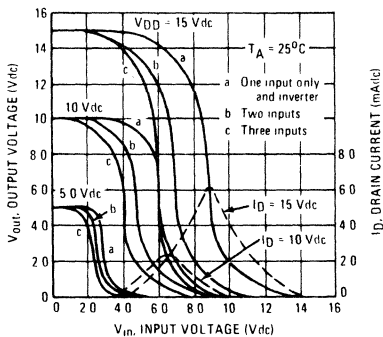
\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

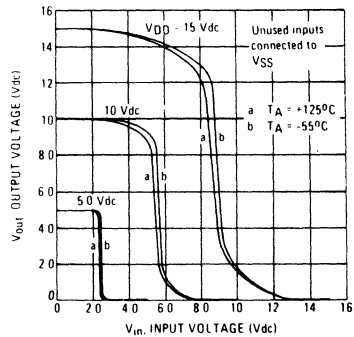
**FIGURE 1 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS**



**FIGURE 2 – TYPICAL VOLTAGE AND CURRENT TRANSFER CHARACTERISTICS**



**FIGURE 3 – TYPICAL VOLTAGE TRANSFER CHARACTERISTICS versus TEMPERATURE**



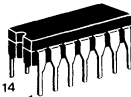


**MOTOROLA**

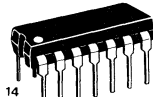
**B-SUFFIX SERIES CMOS GATES**

The B Series logic gates are constructed with P and N channel enhancement mode devices in a single monolithic structure (Complementary MOS). Their primary use is where low power dissipation and/or high noise immunity is desired.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- All Outputs Buffered
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.
- Double Diode Protection on All Inputs
- Pin-for-Pin Replacements for Corresponding CD4000 Series B Suffix Devices



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package: - 12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**MC14001B**  
Quad 2-Input NOR Gate

**MC14002B**  
Dual 4-Input Nor Gate

**MC14011B**  
Quad 2-Input NAND Gate

**MC14012B**  
Dual 4-Input NAND Gate

**MC14023B**  
Triple 3-Input NAND Gate

**MC14025B**  
Triple 3-Input NOR Gate

**MC14068B**  
8-Input NAND Gate

**MC14071B**  
Quad 2-Input OR Gate

**MC14072B**  
Dual 4-Input OR Gate

**MC14073B**  
Triple 3-Input AND Gate

**MC14075B**  
Triple 3-Input OR Gate

**MC14078B**  
8-Input NOR Gate

**MC14081B**  
Quad 2-Input AND Gate

**MC14082B**  
Dual 4-Input AND Gate

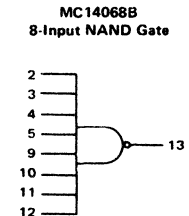
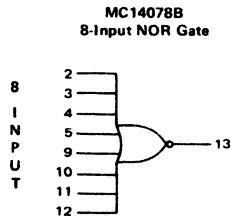
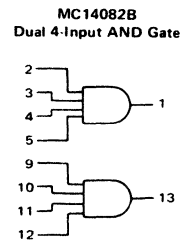
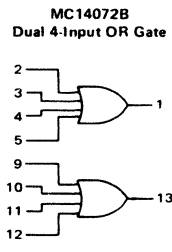
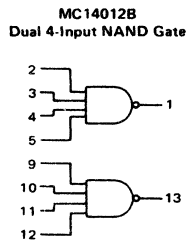
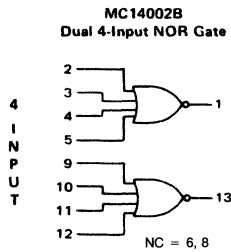
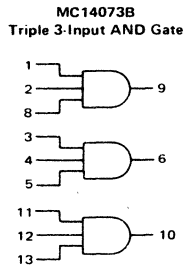
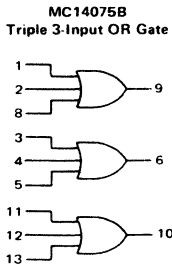
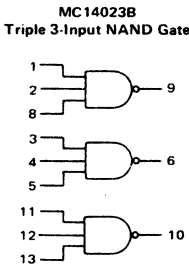
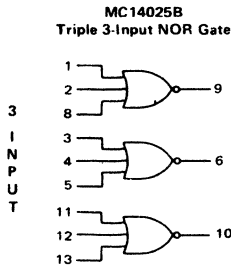
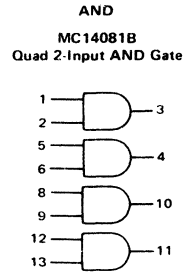
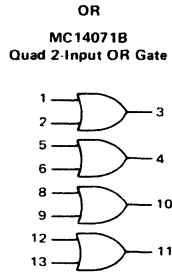
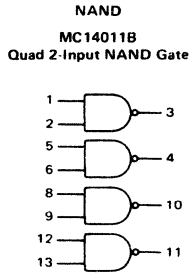
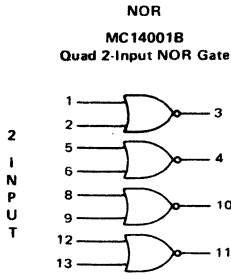
**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**B-SERIES GATES**

# CMOS B-SERIES GATES

## LOGIC DIAGRAMS



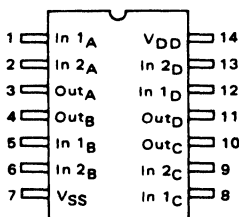
V<sub>DD</sub> = Pin 14  
V<sub>SS</sub> = Pin 7  
for All Devices

6

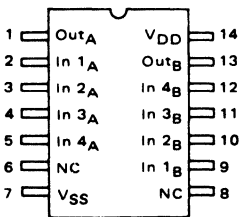
# CMOS B-SERIES GATES

## PIN ASSIGNMENTS

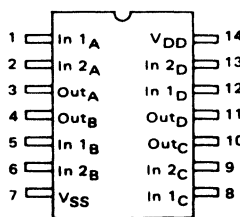
**MC14001B**  
Quad 2-Input NOR Gate



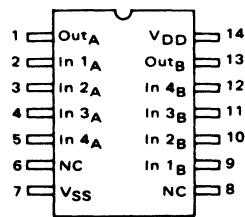
**MC14002B**  
Dual 4-Input NOR Gate



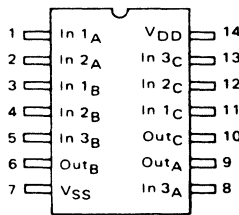
**MC14011B**  
Quad 2-Input NAND Gate



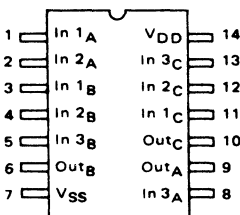
**MC14012B**  
Dual 4-Input NAND Gate



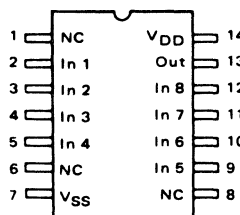
**MC14023B**  
Triple 3-Input NAND Gate



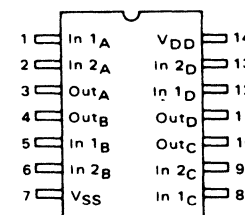
**MC14025B**  
Triple 3-Input NOR Gate



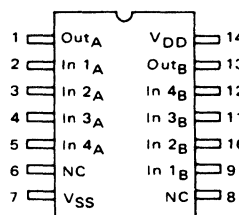
**MC14068B**  
8-Input NAND Gate



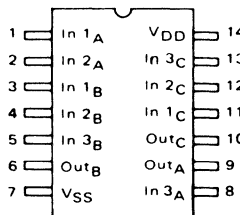
**MC14071B**  
Quad 2-Input OR Gate



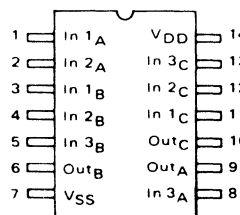
**MC14072B**  
Dual 4-Input OR Gate



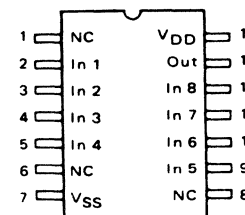
**MC14073B**  
Triple 3-Input AND Gate



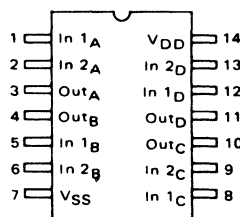
**MC14075B**  
Triple 3-Input OR Gate



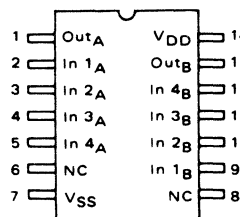
**MC14078B**  
8-Input NOR Gate



**MC14081B**  
Quad 2-Input AND Gate



**MC14082B**  
Dual 4-Input AND Gate



NC = No Connection

# CMOS B-SERIES GATES

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc		
		10	—	0.05	—	0	0.05	—	0.05			
		15	—	0.05	—	0	0.05	—	0.05			
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc		
		10	9.95	—	9.95	10	—	9.95	—			
		15	14.95	—	14.95	15	—	14.95	—			
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc		
		10	—	3.0	—	4.50	3.0	—	3.0			
		15	—	4.0	—	6.75	4.0	—	4.0			
	V <sub>in</sub> Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device)	I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc) Source	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	(V <sub>OH</sub> = 13.5 Vdc)	I <sub>OL</sub>	(V <sub>OL</sub> = 0.4 Vdc) Sink	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			(V <sub>OL</sub> = 0.5 Vdc)	10	1.6	—	1.3	2.25	—	0.9	—	
			(V <sub>OL</sub> = 1.5 Vdc)	15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)	I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc) Source	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	(V <sub>OH</sub> = 13.5 Vdc)	I <sub>OL</sub>	(V <sub>OL</sub> = 0.4 Vdc) Sink	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			(V <sub>OL</sub> = 0.5 Vdc)	10	1.3	—	1.1	2.25	—	0.9	—	
			(V <sub>OL</sub> = 1.5 Vdc)	15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc		
		10	—	0.50	—	0.0010	0.50	—	15.0			
		15	—	1.00	—	0.0015	1.00	—	30.0			
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc		
		10	—	2.0	—	0.0010	2.0	—	15.0			
		15	—	4.0	—	0.0015	4.0	—	30.0			
Total Supply Current**† (Dynamic plus Quiescent, Per Gate, C <sub>L</sub> = 50 pF)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub> /N							μAdc		
10	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub> /N											
15	I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub> /N											

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001 × the number of exercised gates per package

\*\*The formulas given are for the typical characteristics only at 25°C.

# CMOS B-SERIES GATES

## B-SERIES GATE SWITCHING TIMES

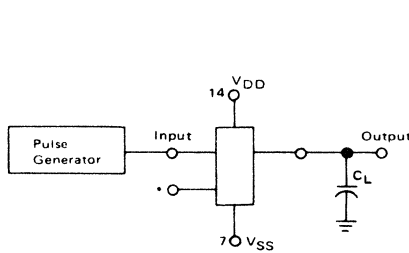
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ $V_{dc}$	Min	Typ #	Max	Unit
Output Rise Time, All B-Series Gates $t_{TLH} = (1.35 \text{ ns/pF}) C_L + 33 \text{ ns}$ $t_{TLH} = (0.60 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH} = (0.40 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Output Fall Time, All B-Series Gates $t_{THL} = (1.35 \text{ ns/pF}) C_L + 33 \text{ ns}$ $t_{THL} = (0.60 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{THL} = (0.40 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time MC14001B, MC14011B only $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 80 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 32 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 27 \text{ ns}$ All Other 2, 3, and 4 Input Gates $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 115 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 47 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 37 \text{ ns}$ 8-Input Gates (MC14068B, MC14078B) $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 155 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 62 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 47 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15  5.0 10 15  5.0 10 15	— — —  — — —  — — —	125 50 40  160 65 50  200 80 60	250 100 80  300 130 100  350 150 110	ns

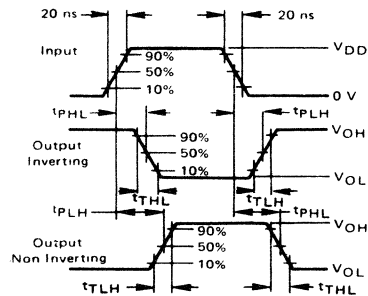
\*The formulas given are for the typical characteristics only at 25°C.

#Data labeled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



\*All unused inputs of AND, NAND gates must be connected to  $V_{DD}$   
All unused inputs of OR, NOR gates must be connected to  $V_{SS}$ .

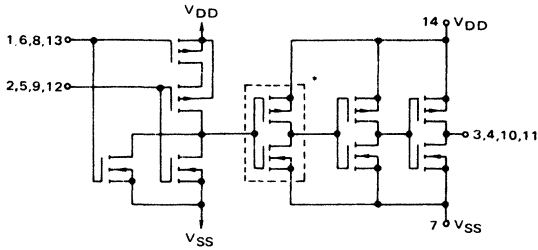




# CMOS B-SERIES GATES

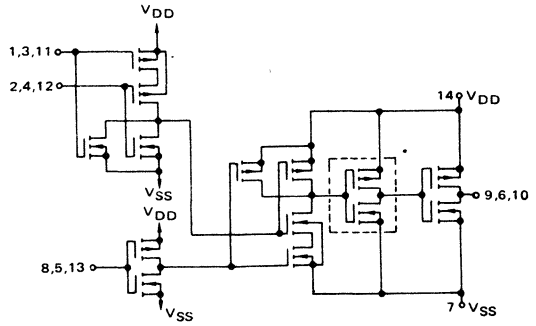
## CIRCUIT SCHEMATIC NOR, OR Gates

MC14001B  
MC14071B  
One of Four  
Gates Shown



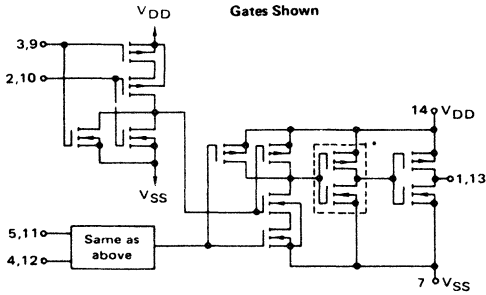
\*Inverter Omitted in MC14001B

MC14025B  
MC14075B  
One of Three  
Gates Shown



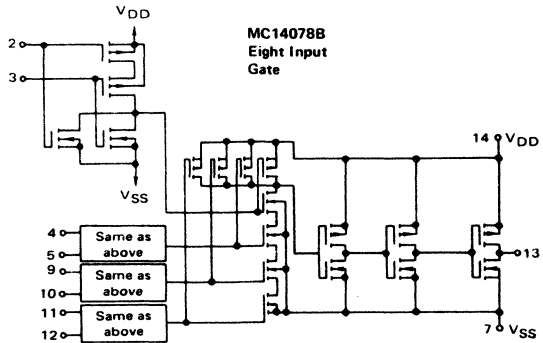
\*Inverter Omitted in MC14025B

MC14002B  
MC14072B  
One of Two  
Gates Shown



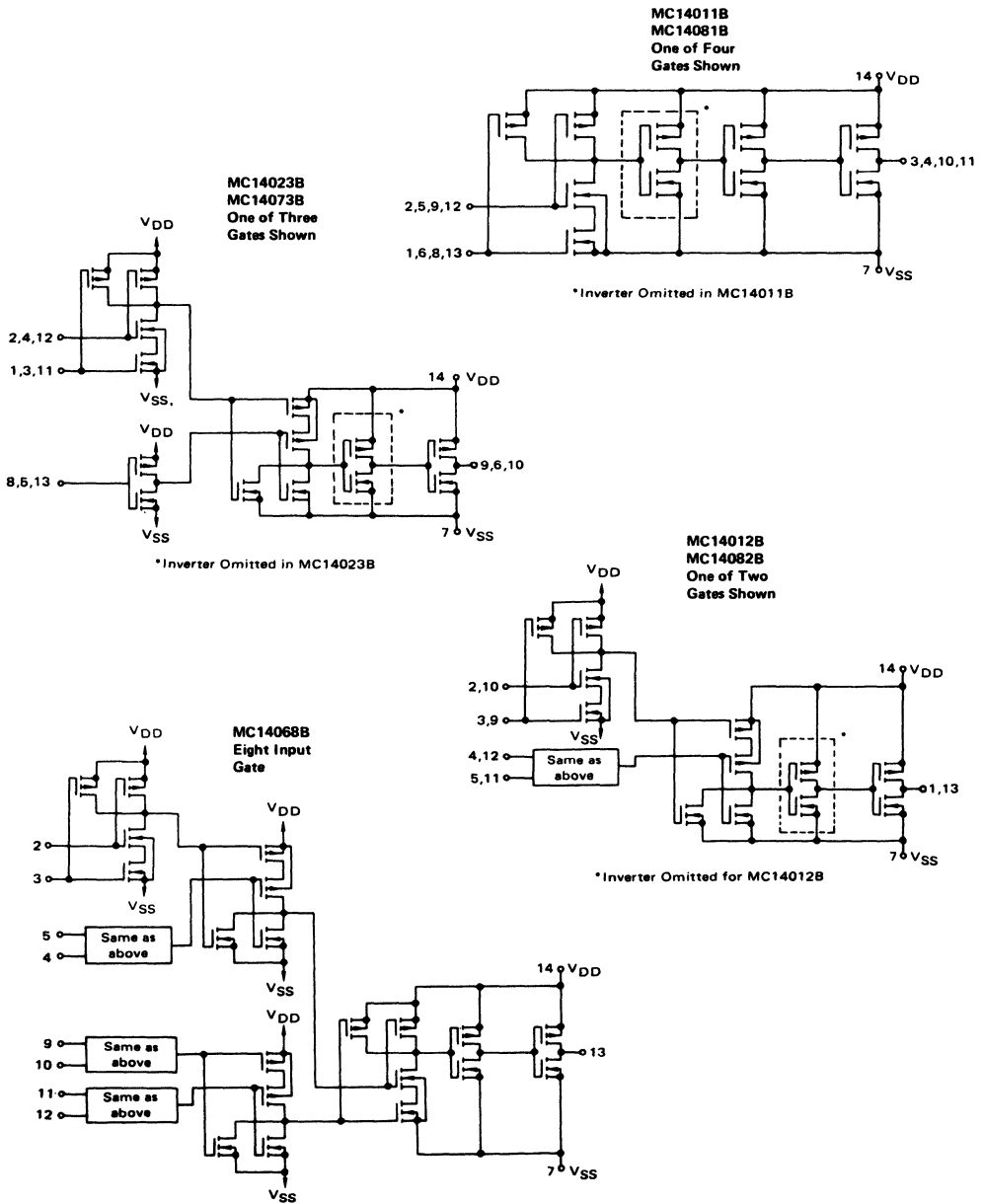
\*Inverter Omitted in MC14002B

MC14078B  
Eight Input  
Gate



# CMOS B-SERIES GATES

## CIRCUIT SCHEMATICS NAND, AND Gates

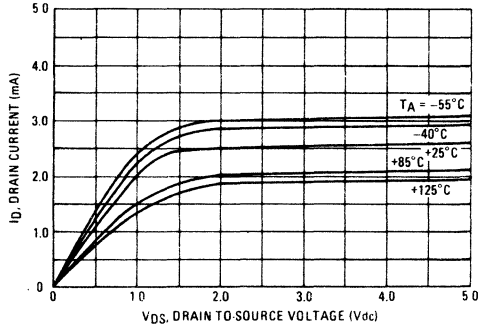


# CMOS B-SERIES GATES

## TYPICAL B-SERIES GATE CHARACTERISTICS

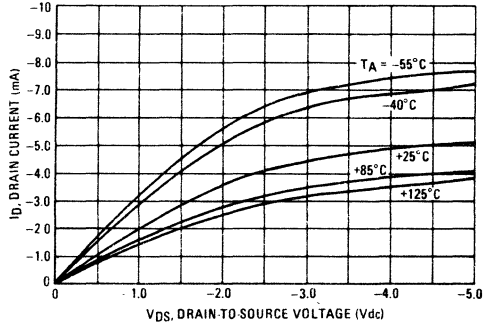
**N-CHANNEL DRAIN CURRENT (SINK)**

**FIGURE 2 –  $V_{GS} = 5.0$  Vdc**

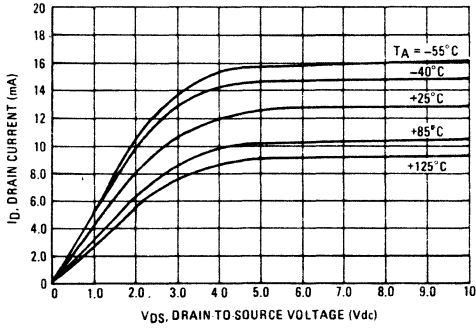


**P-CHANNEL DRAIN CURRENT (SOURCE)**

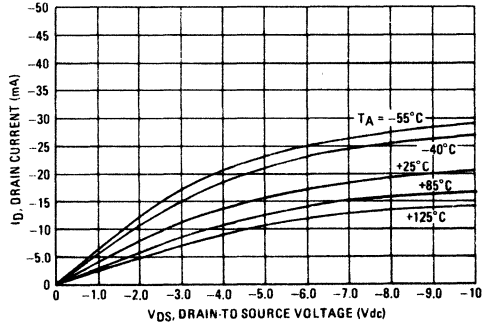
**FIGURE 3 –  $V_{GS} = -5.0$  Vdc**



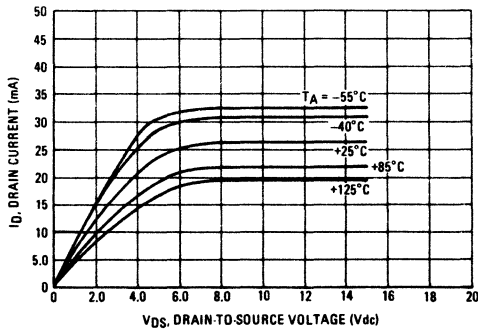
**FIGURE 4 –  $V_{GS} = 10$  Vdc**



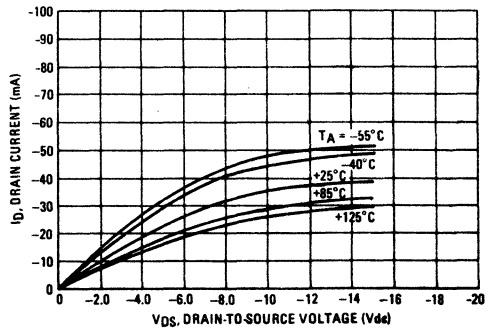
**FIGURE 5 –  $V_{GS} = -10$  Vdc**



**FIGURE 6 –  $V_{GS} = 15$  Vdc**



**FIGURE 7 –  $V_{GS} = -15$  Vdc**



These typical curves are not guarantees, but are design aids.  
 Caution: The maximum rating for output current is 10 mA per pin.

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# CMOS B-SERIES GATES

## TYPICAL B-SERIES GATE CHARACTERISTICS (cont'd)

### VOLTAGE TRANSFER CHARACTERISTICS

FIGURE 8 –  $V_{DD} = 5.0 \text{ Vdc}$

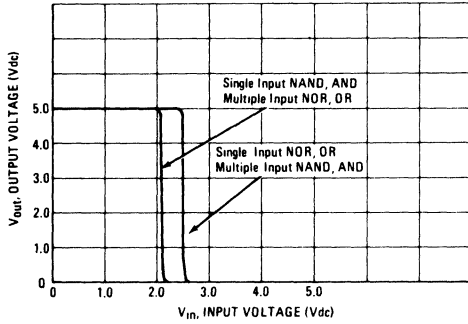


FIGURE 9 –  $V_{DD} = 10 \text{ Vdc}$

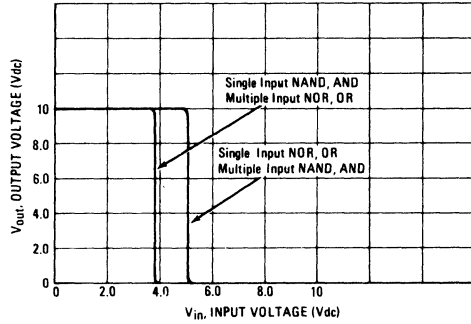
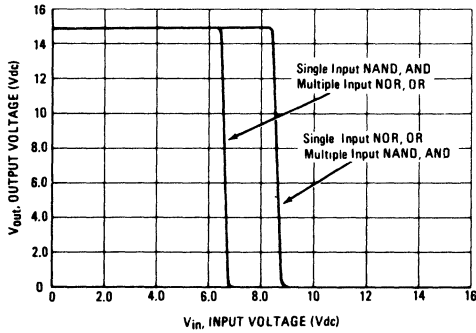


FIGURE 10 –  $V_{DD} = 15 \text{ Vdc}$



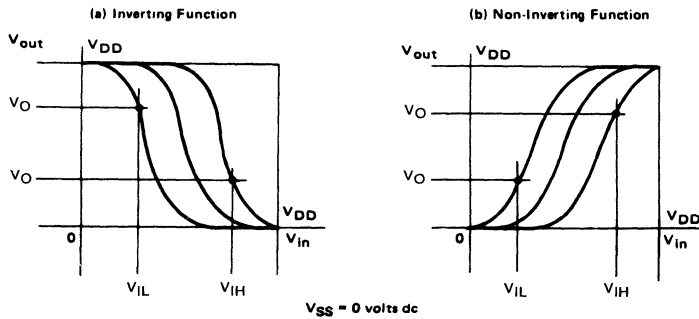
### DC NOISE MARGIN

The DC noise margin is defined as the input voltage range from an ideal "1" or "0" input level which does not produce output state change(s). The typical and guaranteed limit values of the input values  $V_{IL}$  and  $V_{IH}$  for the output(s) to be at a fixed voltage  $V_O$  are given in the Electrical Characteristics table.  $V_{IL}$  and  $V_{IH}$  are presented graphically in Figure 11.

Guaranteed minimum noise margins for both the "1" and "0" levels =

- 1.0 V with a 5.0 V supply
- 2.0 V with a 10.0 V supply
- 2.5 V with a 15.0 V supply

FIGURE 11 – DC NOISE IMMUNITY





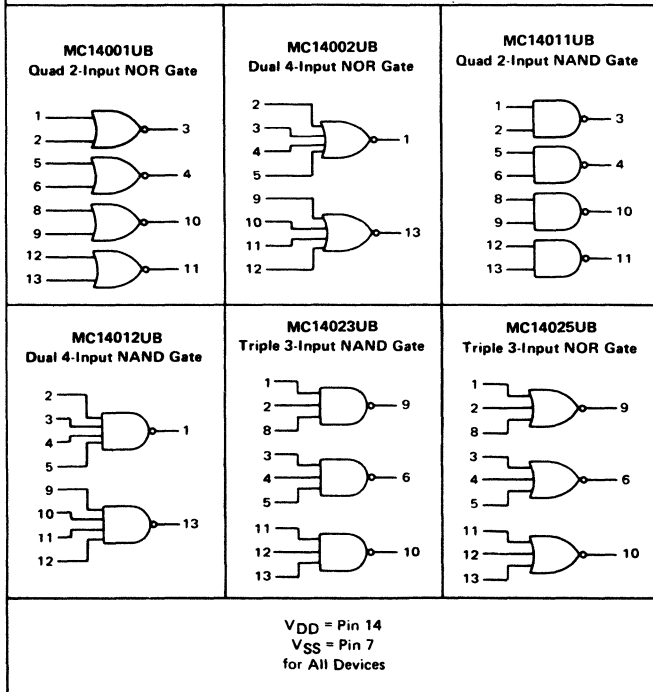
**MOTOROLA**

### UB-SUFFIX SERIES CMOS GATES

The UB Series logic gates are constructed with P and N channel enhancement mode devices in a single monolithic structure (Complementary MOS). Their primary use is where low power dissipation and/or high noise immunity is desired. The UB set of CMOS gates are inverting non-buffered functions.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Linear and Oscillator Applications
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.
- Double Diode Protection on All Inputs
- Pin-for-Pin Replacements for Corresponding CD4000 Series UB Suffix Devices

### LOGIC DIAGRAMS



**MC14001UB**  
Quad 2-Input NOR Gate

**MC14002UB**  
Dual 4-Input NOR Gate

**MC14011UB**  
Quad 2-Input NAND Gate

**MC14012UB**  
Dual 4-Input NAND Gate

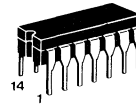
**MC14023UB**  
Triple 3-Input NAND Gate

**MC14025UB**  
Triple 3-Input NOR Gate

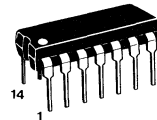
### CMOS SSI

(LOW-POWER COMPLEMENTARY MOS)

### UB-SERIES GATES



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

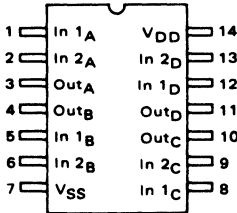
C Series: -40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

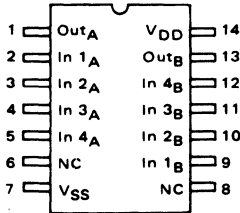
# CMOS UB-SERIES GATES

## PIN ASSIGNMENTS

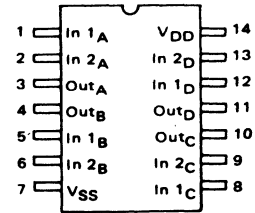
**MC14001UB**  
Quad 2-Input NOR Gate



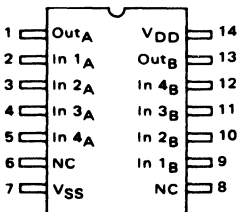
**MC14002UB**  
Dual 4-Input NOR Gate



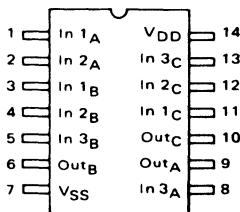
**MC14011UB**  
Quad 2-Input NAND Gate



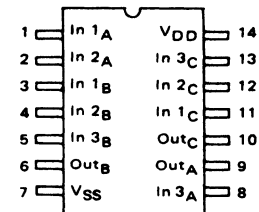
**MC14012UB**  
Dual 4-Input NAND Gate



**MC14023UB**  
Triple 3-Input NAND Gate



**MC14025UB**  
Triple 3-Input NOR Gate



**NC = No Connection**

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### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating. Plastic "P" Package - 12mW/°C from 65°C to 85°C

Ceramic "L" Package - 12mW/°C from 100°C to 125°C

# CMOS UB-SERIES GATES

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 Vdc) (V <sub>O</sub> = 9.0 Vdc) (V <sub>O</sub> = 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc	
		10	—	2.0	—	4.50	2.0	—	2.0		
		15	—	2.5	—	6.75	2.5	—	2.5		
	(V <sub>O</sub> = 0.5 Vdc) (V <sub>O</sub> = 1.0 Vdc) (V <sub>O</sub> = 1.5 Vdc)	"1" Level V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
			10	8.0	—	8.0	5.50	—	8.0	—	
			15	12.5	—	12.5	8.25	—	12.5	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source IOH	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc	
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—		
		10	-0.62	—	-0.5	-0.9	—	-0.35	—		
	(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source IOH	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mAdc	
		5.0	-0.2	—	-0.16	-0.36	—	-0.12	—		
		10	-0.5	—	-0.4	-0.9	—	-0.3	—		
	(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc	
		10	—	0.5	—	0.0010	0.5	—	15		
		15	—	1.0	—	0.0015	1.0	—	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc	
		10	—	2.0	—	0.0010	2.0	—	15		
		15	—	4.0	—	0.0015	4.0	—	30		
Total Supply Current**† (Dynamic plus Quiescent, Per Gate, C <sub>L</sub> = 50 pF)	I <sub>T</sub>	5.0				I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub> /N					μAdc
		10				I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub> /N					
		15				I <sub>T</sub> = (0.8 μA/kHz) f + I <sub>DD</sub> /N					

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V}k$$

where: I<sub>T</sub> is in μH (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001 × the number of exercised gates per package.

# CMOS UB-SERIES GATES

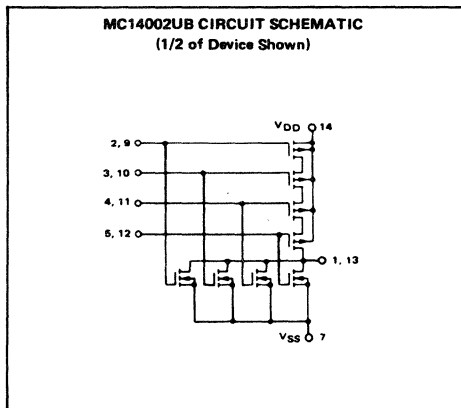
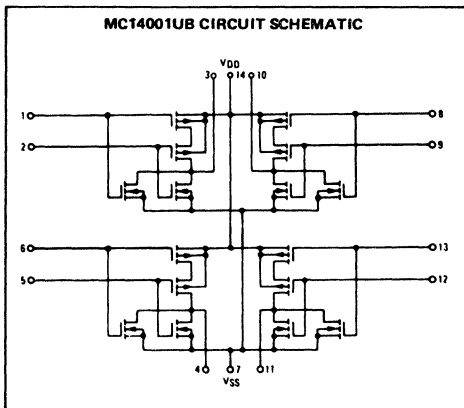
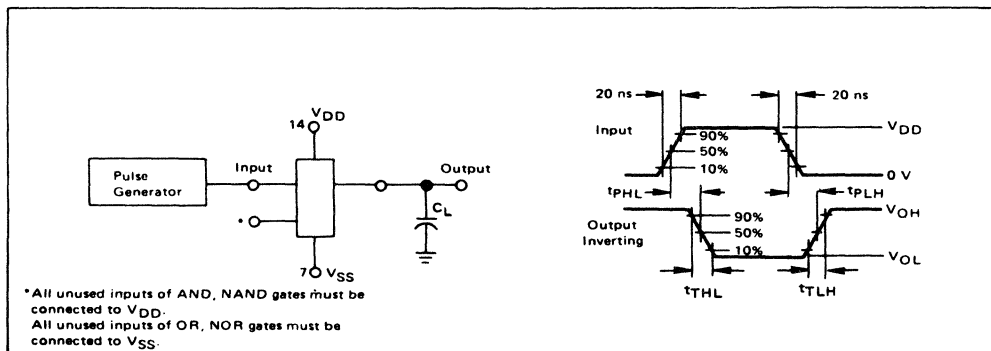
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 22 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.50 \text{ ns/pF}) C_L + 15 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	90 50 40	180 100 80	ns

\*The formulas given are for the typical characteristics only at 25°C.

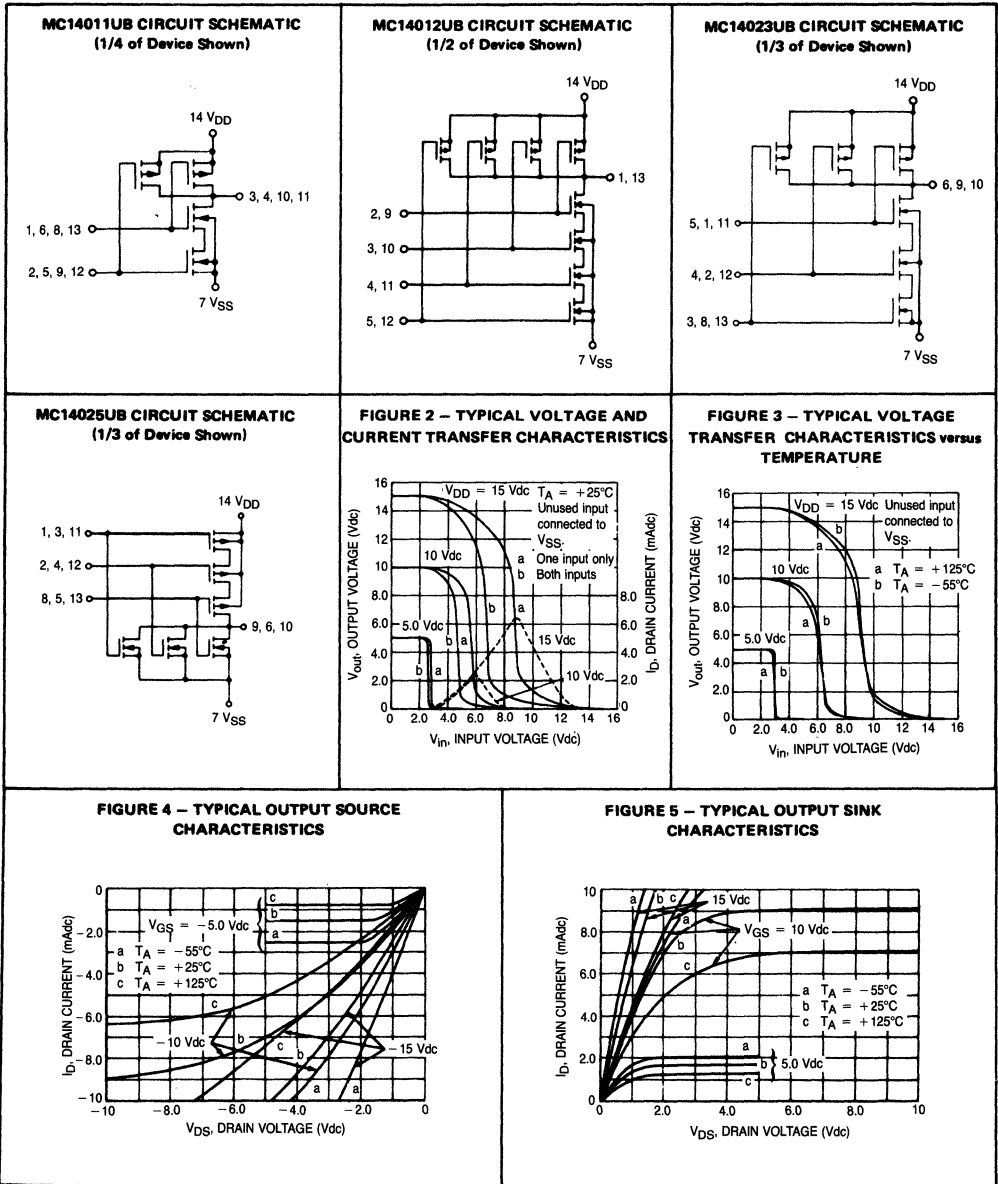
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





# CMOS UB-SERIES GATES



6



**MOTOROLA**

**MC14002B**  
See Page 6-5

**MC14002UB**  
See Page 6-14

**MC14006B**

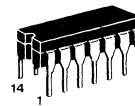
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)  
**18-BIT STATIC SHIFT REGISTER**

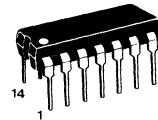
**18-BIT STATIC SHIFT REGISTER**

The MC14006B shift register is comprised of four separate shift register sections sharing a common clock: two sections have four stages, and two sections have five stages with an output tap on both the fourth and fifth stages. This makes it possible to obtain a shift register of 4, 5, 8, 9, 10, 12, 13, 14, 16, 17, or 18 bits by appropriate selection of inputs and outputs. This part is particularly useful in serial shift registers and time delay circuits.

- Output Transitions Occur on the Falling Edge of the Clock Pulse
- Fully Static Operation
- Can be Cascaded to Provide Longer Shift Register Lengths
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4006B



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)  
C Series -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

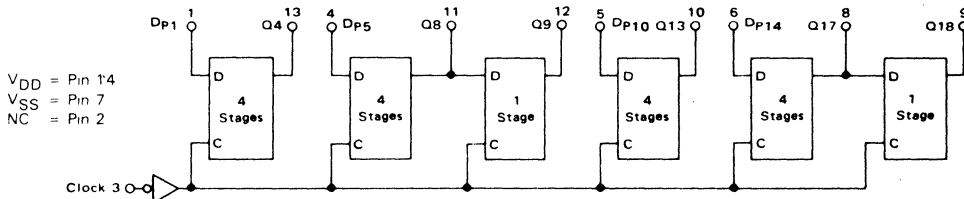
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating Plastic "P" Package -12mW/°C from 65°C to 85°C  
Ceramic "L" Package -12mW/°C from 100°C to 125°C

**TRUTH TABLE**  
(Single Stage)

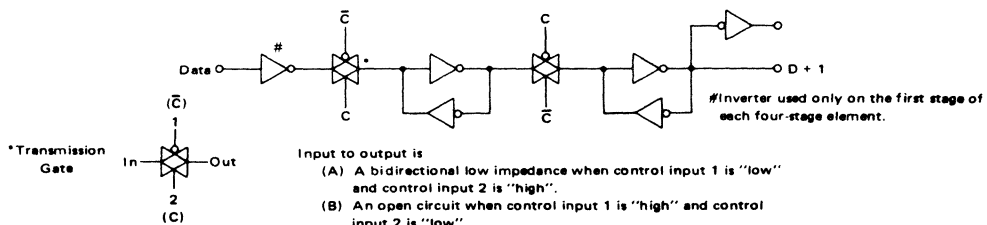
D <sub>n</sub>	C	Q <sub>n+1</sub>
0	—	0
1	—	1
X	—	Q <sub>n</sub>

X = Don't Care

**BLOCK DIAGRAM**



**LOGIC DIAGRAM**  
(ONE REGISTER STAGE)



**6**

# MC14006B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.3 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>
		10	I <sub>T</sub> = (2.6 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (3.9 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

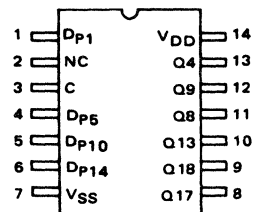
$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001

\*\*The formulas given are for the typical characteristics only at 25°C.

### PIN ASSIGNMENT



NC = No Connection

# MC14006B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	Min	Typ #	Max	Unit
Output Rise and Fall Time						ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
Propagation Delay Time						ns
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 220 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	300	600	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 77 \text{ ns}$		10	—	110	220	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 55 \text{ ns}$		15	—	80	160	
Clock Pulse Width	$t_{WH}$	5.0	200	100	—	ns
		10	120	60	—	
		15	80	40	—	
Clock Pulse Frequency	$f_{cl}$	5.0	—	5.0	2.5	MHz
		10	—	8.3	4.2	
		15	—	12	6.0	
Clock Pulse Rise and Fall Time**						$\mu\text{s}$
	$t_{TLH}$ , $t_{THL}$	5.0	—	—	15	
		10	—	—	5	
		15	—	—	4	
Setup Time	$t_{su}$	5.0	0	-50	—	ns
		10	0	-15	—	
		15	0	-8.0	—	
Hold Time	$t_h$	5.0	180	75	—	ns
		10	90	25	—	
		15	75	20	—	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*When shift register sections are cascaded, the maximum rise and fall times of the clock input should be equal to or less than the rise and fall times of the data outputs driving data inputs, plus the propagation delay of the output driving stage for the output capacitance load.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

6

FIGURE 1 — TYPICAL OUTPUT SOURCE CURRENT CHARACTERISTICS TEST CIRCUIT

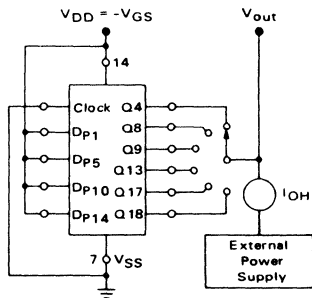
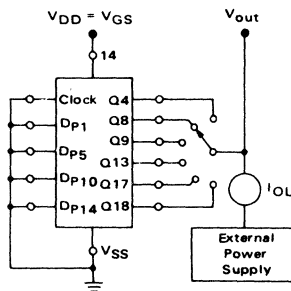


FIGURE 2 — TYPICAL OUTPUT SINK CURRENT CHARACTERISTICS TEST CIRCUIT



# MC14006B

FIGURE 3 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

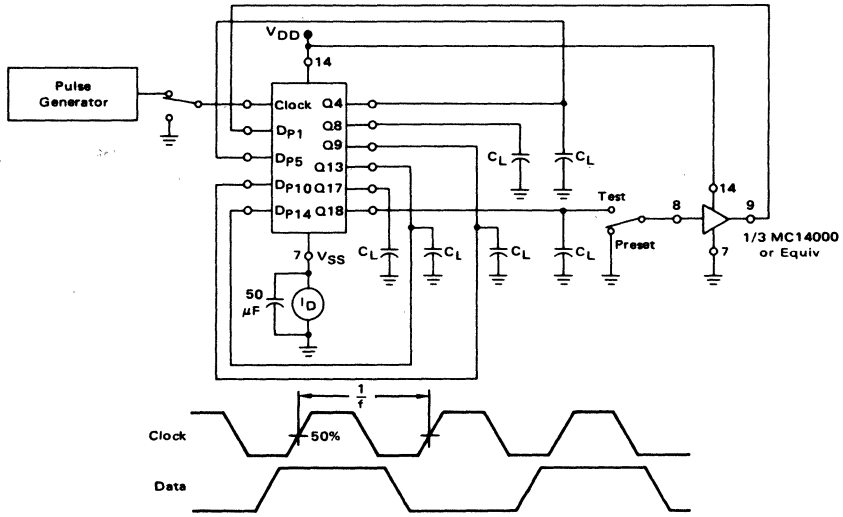
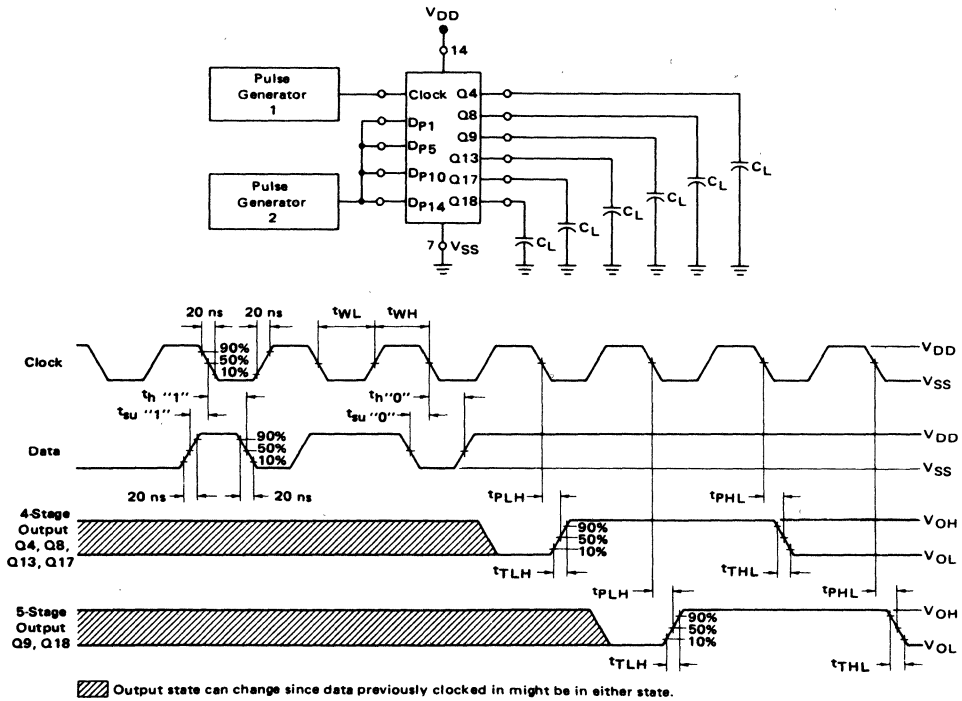


FIGURE 4 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



6



**MOTOROLA**

**MC14007UB**

**DUAL COMPLEMENTARY PAIR PLUS INVERTER**

The MC14007UB multi-purpose device consists of three N-channel and three P-channel enhancement mode devices packaged to provide access to each device. These versatile parts are useful in inverter circuits, pulse-shapers, linear amplifiers, high input impedance amplifiers, threshold detectors, transmission gating, and functional gating.

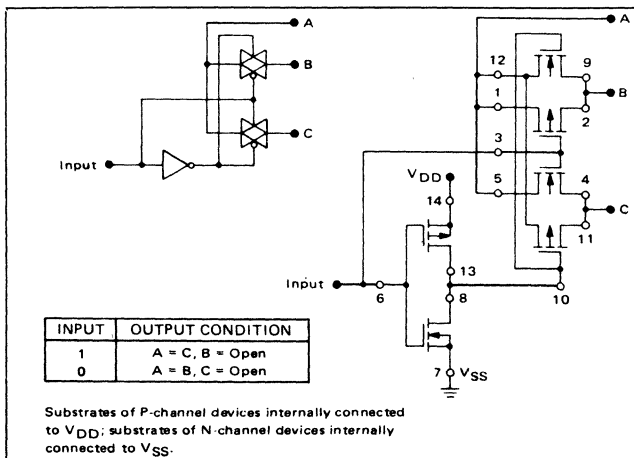
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4007A or CD4007UB
- This device has 2 outputs without ESD Protection. Anti-static precautions must be taken.

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

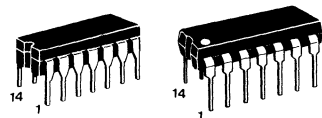
**FIGURE 1 — TYPICAL APPLICATION: 2-INPUT ANALOG MULTIPLEXER**



**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL COMPLEMENTARY PAIR PLUS INVERTER**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 632

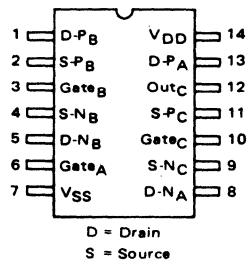
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 646

**ORDERING INFORMATION**

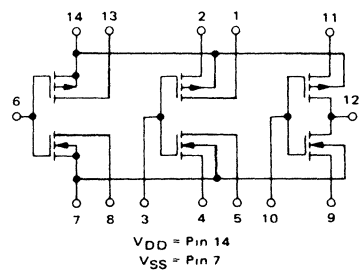
A Series: -55°C to +125°C  
 MC14XXXUBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXUBCP (Plastic Package)  
 MC14XXXUBCL (Ceramic Package)

**PIN ASSIGNMENT**



**SCHEMATIC**



# MC14007UB

## ELECTRICAL CHARACTERISTICS (Connected as Inverters) (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	Vdc
		10	–	0.05	–	0	0.05	–	0.05	
		15	–	0.05	–	0	0.05	–	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	Vdc
		10	9.95	–	9.95	10	–	9.95	–	
		15	14.95	–	14.95	15	–	14.95	–	
Input Voltage (V <sub>O</sub> = 4.5) (V <sub>O</sub> = 9.0) (V <sub>O</sub> = 13.5)  (V <sub>O</sub> = 0.5) (V <sub>O</sub> = 1.0) (V <sub>O</sub> = 1.5)	"0" Level V <sub>IL</sub>	5.0	–	1.0	–	2.25	1.0	–	1.0	Vdc
		10	–	2.0	–	4.50	2.0	–	2.0	
		15	–	2.5	–	6.75	2.5	–	2.5	
	"1" Level V <sub>IH</sub>	5.0	4.0	–	4.0	2.75	–	4.0	–	Vdc
		10	8.0	–	8.0	5.50	–	8.0	–	
		15	12.5	–	12.5	8.25	–	12.5	–	
Output Drive Current (AL Device)  Source        Sink	I <sub>OH</sub>	5.0	–3.0	–	–2.4	–5.0	–	–1.7	–	mAdc
		5.0	–0.64	–	–0.51	–1.0	–	–0.36	–	
		10	–1.6	–	–1.3	–2.5	–	–0.9	–	
		10	–1.6	–	–1.3	–2.5	–	–0.9	–	
		15	–4.2	–	–3.4	–10	–	–2.4	–	
		15	–4.2	–	–3.4	–10	–	–2.4	–	
	I <sub>OL</sub>	5.0	0.64	–	0.51	1.0	–	0.36	–	mAdc
		10	1.6	–	1.3	2.5	–	0.9	–	
		10	1.6	–	1.3	2.5	–	0.9	–	
		15	4.2	–	3.4	10	–	2.4	–	
		15	4.2	–	3.4	10	–	2.4	–	
		15	4.2	–	3.4	10	–	2.4	–	
Output Drive Current (CL/CP Device)  Source        Sink	I <sub>OH</sub>	5.0	–2.5	–	–2.1	–5.0	–	–1.7	–	mAdc
		5.0	–0.52	–	–0.44	–1.0	–	–0.36	–	
		10	–1.3	–	–1.1	–2.5	–	–0.9	–	
		10	–1.3	–	–1.1	–2.5	–	–0.9	–	
		15	–3.6	–	–3.0	–10	–	–2.4	–	
		15	–3.6	–	–3.0	–10	–	–2.4	–	
	I <sub>OL</sub>	5.0	0.52	–	0.44	1.0	–	0.36	–	mAdc
		10	1.3	–	1.1	2.5	–	0.9	–	
		10	1.3	–	1.1	2.5	–	0.9	–	
		15	3.6	–	3.0	10	–	2.4	–	
		15	3.6	–	3.0	10	–	2.4	–	
		15	3.6	–	3.0	10	–	2.4	–	
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	–	0.25	–	0.0005	0.25	–	7.5	μAdc
		10	–	0.50	–	0.0010	0.50	–	15	
		15	–	1.00	–	0.0015	1.00	–	30	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	–	1.0	–	0.0005	1.0	–	7.5	μAdc
		10	–	2.0	–	0.0010	2.0	–	15	
		15	–	4.0	–	0.0015	4.0	–	30	
Total Supply Current**† (Dynamic plus Quiescent, Per Gate) (C <sub>L</sub> = 50 pF)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.7 μA/kHz) f + I <sub>DD</sub> /6							μAdc
		10	I <sub>T</sub> = (1.4 μA/kHz) f + I <sub>DD</sub> /6							
		15	I <sub>T</sub> = (2.2 μA/kHz) f + I <sub>DD</sub> /6							

\*T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device.  
 T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> – V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.003

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14007UB

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ #	Max	Unit
Output Rise Time $t_{TLH} = (1.2 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (0.5 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH} = (0.4 \text{ ns/pF}) C_L + 15 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	90 45 35	180 90 70	ns
Output Fall Time $t_{THL} = (1.2 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{THL} = (0.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{THL} = (0.4 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	75 40 30	150 80 60	ns
Turn-Off Delay Time $t_{PLH} = (1.5 \text{ ns/pF}) C_L + 35 \text{ ns}$ $t_{PLH} = (0.2 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{PLH} = (0.15 \text{ ns/pF}) C_L + 17.5 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	60 30 25	125 75 55	ns
Turn-On Delay Time $t_{PHL} = (1.0 \text{ ns/pF}) C_L + 10 \text{ ns}$ $t_{PHL} = (0.3 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{PHL} = (0.2 \text{ ns/pF}) C_L + 15 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	60 30 25	125 75 55	ns

\* The formulas given are for the typical characteristics only.

Switching specifications are for device connected as an inverter.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 2 – TYPICAL OUTPUT SOURCE CHARACTERISTICS

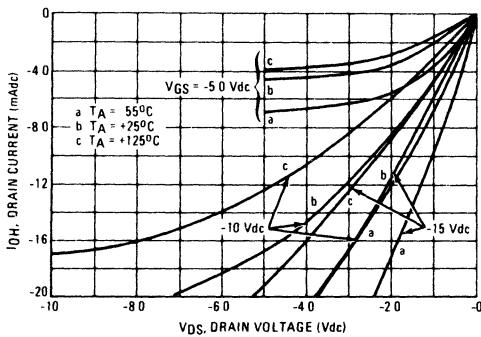
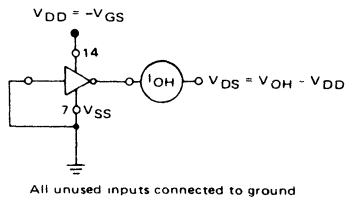
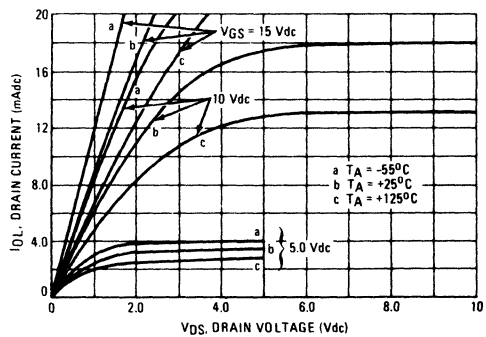
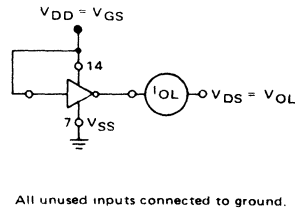


FIGURE 3 – TYPICAL OUTPUT SINK CHARACTERISTICS

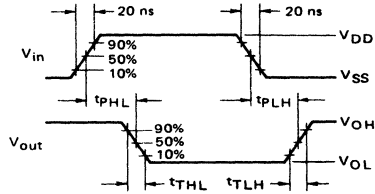
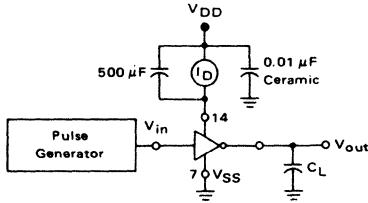


These typical curves are not guarantees, but are design aids  
Caution: The maximum current rating is 10 mA per pin.



# MC14007UB

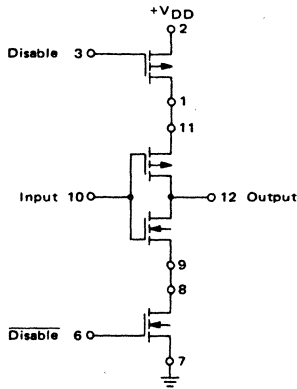
FIGURE 4 – SWITCHING TIME AND POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS



## APPLICATIONS

The MC14007UB dual pair plus inverter, which has access to all its elements offers a number of unique circuit applications. Figures 1, 5, and 6 are a few examples of the device flexibility.

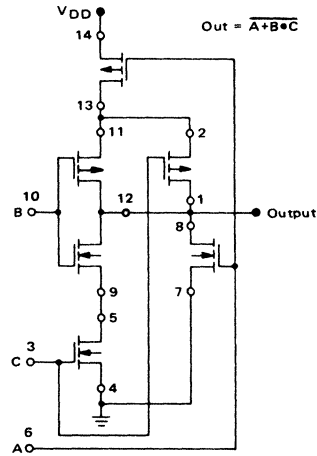
FIGURE 5 – 3-STATE BUFFER



INPUT	DISABLE	OUTPUT
1	0	0
0	0	1
X	1	Open

X = Don't Care

FIGURE 6 – AOI FUNCTIONS USING TREE LOGIC



Substrates of P-channel devices internally connected to  $V_{DD}$ .  
Substrates of N-channel devices internally connected to  $V_{SS}$ .



**MOTOROLA**

**MC14008B**

**4-BIT FULL ADDER**

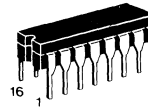
The MC14008B 4-bit full adder is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. This device consists of four full adders with fast internal look-ahead carry output. It is useful in binary addition and other arithmetic applications. The fast parallel carry output bit allows high-speed operation when used with other adders in a system.

- Look-Ahead Carry Output
- Diode Protection on All Inputs
- All Outputs Buffered
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4008B

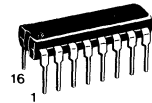
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT FULL ADDER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

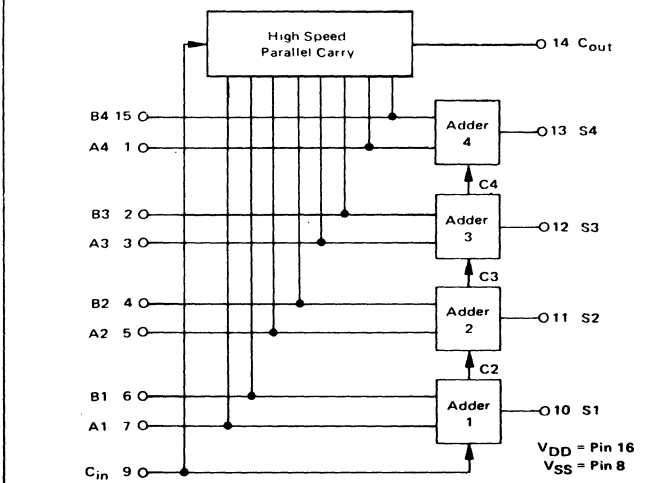
Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Packaget	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package -12mW/°C from 65°C to 85°C  
Ceramic "L" Package -12mW/°C from 100°C to 125°C

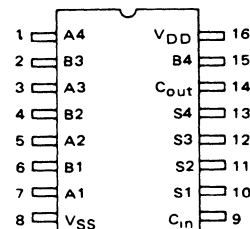
**TRUTH TABLE**  
(One Stage)

$C_{in}$	B	A	$C_{out}$	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

**BLOCK DIAGRAM**



**PIN ASSIGNMENT**



**6**

# MC14008B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (3.4 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (5.0 μA/kHz) f + I <sub>DD</sub>						μAdc		

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.005.

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14008B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	15	—	40	80	
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$					ns
Sum In to Sum Out						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	400	800	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 127 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	10	—	160	320	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 90 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	15	—	115	230	
Sum In to Carry Out						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 220 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	305	610	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 112 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	10	—	145	290	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 85 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	15	—	110	220	
Carry In to Sum Out						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 290 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	375	750	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 122 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	10	—	155	310	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 90 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	15	—	115	230	
Carry In to Carry Out						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 85 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	170	340	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	10	—	75	150	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 30 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	15	—	55	110	

\*The formulas given are for the typical characteristics only at 25°C

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

FIGURE 1 – TYPICAL SOURCE CURRENT CHARACTERISTICS TEST CIRCUIT

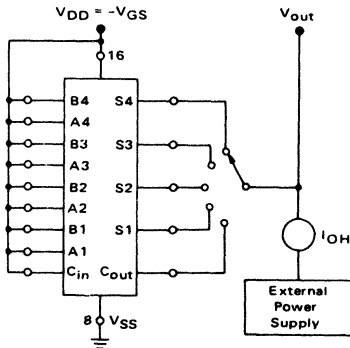
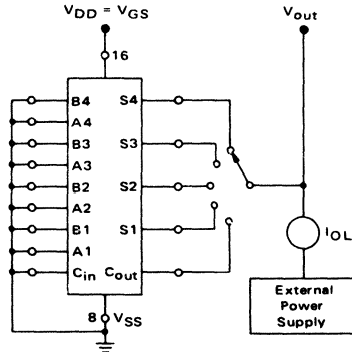


FIGURE 2 – TYPICAL SINK CURRENT CHARACTERISTICS TEST CIRCUIT



# MC14008B

FIGURE 3 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

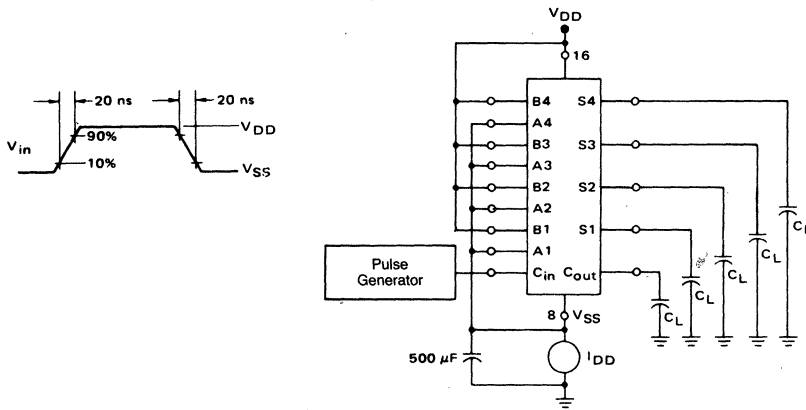
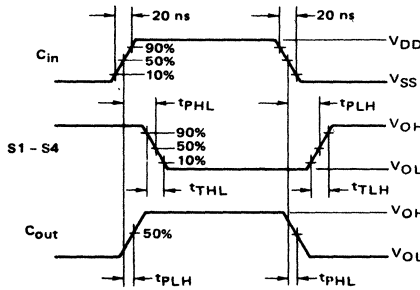
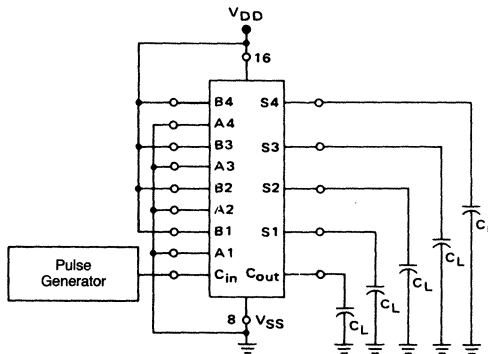


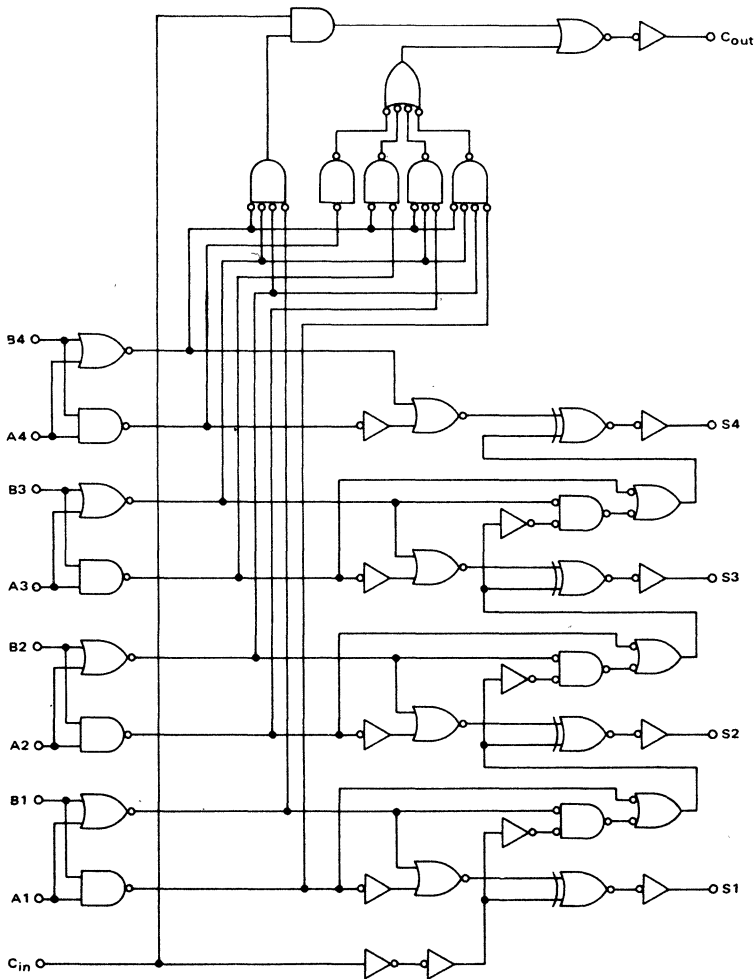
FIGURE 4 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



6

# MC14008B

FIGURE 5 – LOGIC DIAGRAM

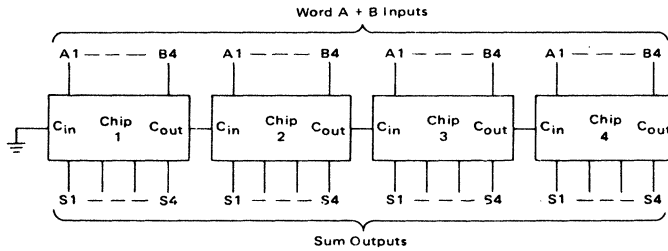


6

# MC14008B

## TYPICAL APPLICATION

FIGURE 6 – USING THE MC14008B IN A 16-BIT ADDER CONFIGURATION



Calculation of 16-bit adder speed:

$$t_p \text{ total} = t_p (\text{Sum to Carry}) + t_p (\text{Carry to Sum}) + 2 t_p (\text{Carry to Carry})$$

The guaranteed 16-bit adder speed at 10 V, 25°C,  $C_L = 50 \text{ pF}$  is:

$$t_p \text{ total} = 290 + 310 + 300 = 900 \text{ ns}$$



**MOTOROLA**

**MC14011B, MC14012B**  
See Page 6-5

**MC14011UB, MC14012UB**  
See Page 6-14

**MC14013B**

**DUAL TYPE D FLIP-FLOP**

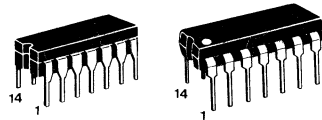
The MC14013B dual type D flip-flop is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each flip-flop has independent Data, (D), Direct Set, (S), Direct Reset, (R), and Clock (C) inputs and complementary outputs (Q and  $\bar{Q}$ ). These devices may be used as shift register elements or as type T flip-flops for counter and toggle applications.

- Static Operation
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Edge-Clocked Flip-Flop Design --  
Logic state is retained indefinitely with clock level either high or low; information is transferred to the output only on the positive-going edge of the clock pulse
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4013B

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL TYPE D FLIP-FLOP**



**L SUFFIX** CERAMIC PACKAGE CASE 632  
**P SUFFIX** PLASTIC PACKAGE CASE 646

**ORDERING INFORMATION**

A Series -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

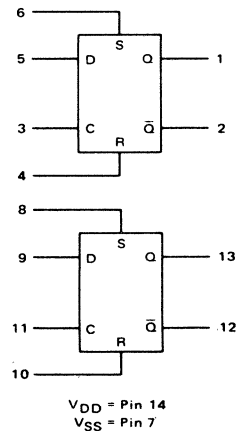
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating Plastic "P" Package -12mW/°C from 65°C to 85°C  
Ceramic "L" Package -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

CLOCK†	INPUTS			OUTPUTS		No Change
	DATA	RESET	SET	Q	$\bar{Q}$	
	0	0	0	0	1	
	1	0	0	1	0	
	X	0	0	Q	$\bar{Q}$	
X	X	1	0	0	1	
X	X	0	1	1	0	
X	X	1	1	1	1	

X = Don't Care  
† = Level Change

**BLOCK DIAGRAM**



**6**



# MC14013B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.0001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc	
		10	—	2.0	—	0.004	2.0	—	60		
		15	—	4.0	—	0.006	4.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc	
		10	—	8.0	—	0.004	8.0	—	60		
		15	—	16	—	0.006	16	—	120		
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.75 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (1.5 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (2.3 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

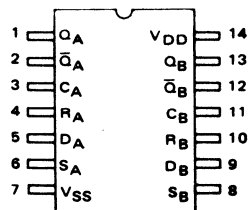
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14013B

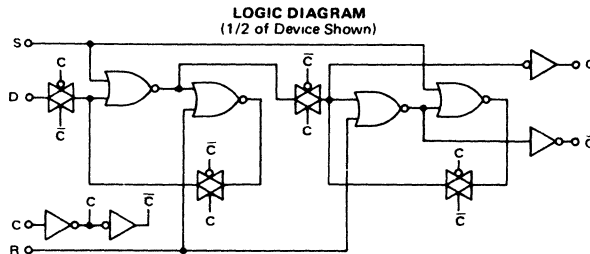
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	Min	Typ #	Max	Unit
<b>Output Rise and Fall Time</b>	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
<b>Propagation Delay Time</b>	$t_{PLH}$ , $t_{PHL}$					ns
<b>Clock to Q, <math>\bar{Q}</math></b>						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 90 \text{ ns}$		5.0	—	175	350	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$		10	—	75	150	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		15	—	50	100	
<b>Set to Q, <math>\bar{Q}</math></b>						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 90 \text{ ns}$		5.0	—	175	350	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$		10	—	75	150	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		15	—	50	100	
<b>Reset to Q, <math>\bar{Q}</math></b>						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 265 \text{ ns}$		5.0	—	350	450	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 67 \text{ ns}$		10	—	100	200	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 50 \text{ ns}$		15	—	75	150	
<b>Setup Times**</b>	$t_{su}$	5.0	40	20	—	ns
		10	20	10	—	
		15	15	7.5	—	
<b>Hold Times**</b>	$t_h$	5.0	40	20	—	ns
		10	20	10	—	
		15	15	7.5	—	
<b>Clock Pulse Width</b>	$t_{WL}$ , $t_{WH}$	5.0	250	125	—	ns
		10	100	50	—	
		15	70	35	—	
<b>Clock Pulse Frequency</b>	$f_{cl}$	5.0	—	4.0	2.0	MHz
		10	—	10	5.0	
		15	—	14	7.0	
<b>Clock Pulse Rise and Fall Time</b>	$t_{TLH}$ , $t_{THL}$	5.0	—	—	15	$\mu\text{s}$
		10	—	—	5.0	
		15	—	—	4.0	
<b>Set and Reset Pulse Width</b>	$t_{WL}$ , $t_{WH}$	5.0	250	125	—	ns
		10	100	50	—	
		15	70	35	—	
<b>Removal Times</b>	$t_{rem}$					ns
Set		5	80	0	—	
		10	45	5	—	
		15	35	5	—	
Reset		5	50	-35	—	
		10	30	-10	—	
		15	25	-5	—	

\*The formulas given are for the typical characteristics only at 25°C.

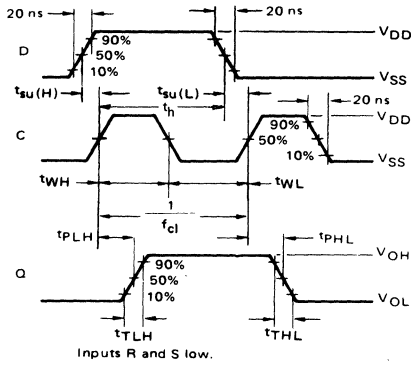
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*Data must be valid for 250 ns with a 5 V supply, 100 ns with 10 V, and 70 ns with 15 V.

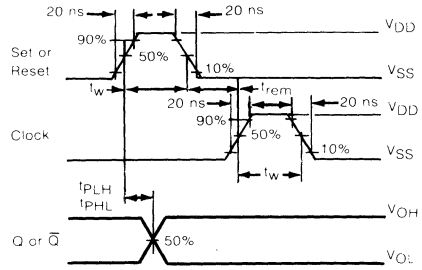


# MC14013B

**FIGURE 1 — DYNAMIC SIGNAL WAVEFORMS (Data, Clock, and Output)**

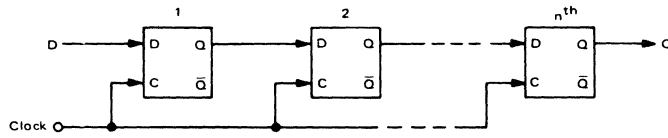


**FIGURE 2 — DYNAMIC SIGNAL WAVEFORMS (Set, Reset, Clock, and Output)**

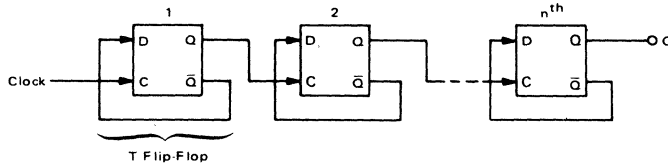


## TYPICAL APPLICATIONS

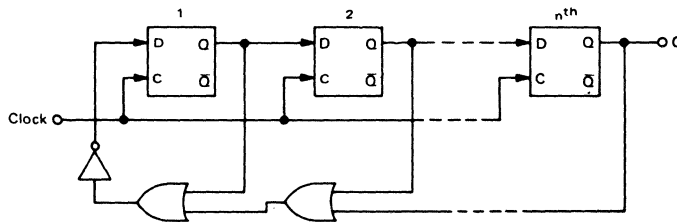
### n-STAGE SHIFT REGISTER



### BINARY RIPPLE UP-COUNTER (Divide-by-2<sup>n</sup>)



### MODIFIED RING COUNTER (Divide-by-(n + 1))





**MOTOROLA**

**MC14014B  
MC14021B**

**8-BIT STATIC SHIFT REGISTER**

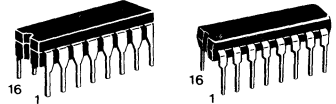
The MC14014B and MC14021B 8-bit static shift registers are constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These shift registers find primary use in parallel-to-serial data conversion, synchronous and asynchronous parallel input, serial output data queuing; and other general purpose register applications requiring low power and/or high noise immunity.

- Synchronous Parallel Input/Serial Output (MC14014B)
- Asynchronous Parallel Input/Serial Output (MC14021B)
- Synchronous Serial Input/Serial Output
- Full Static Operation
- "Q" Outputs from Sixth, Seventh, and Eighth Stages
- Double Diode Input Protection
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- MC14014B Pin-for-Pin Replacement for CD4014B
- MC14021B Pin-for-Pin Replacement for CD4021B

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**8-BIT STATIC SHIFT REGISTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**  
**SERIAL OPERATION:**

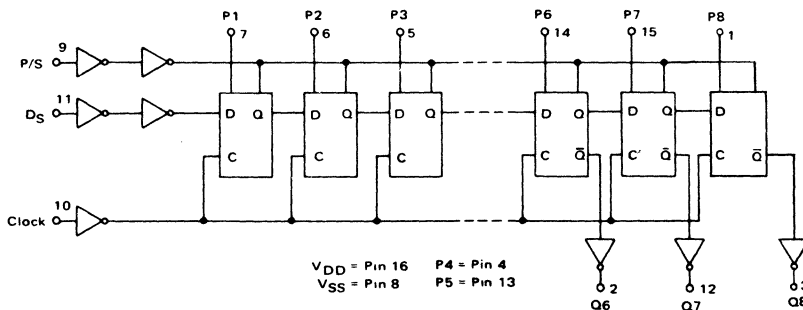
t	CLOCK	D <sub>S</sub>	P/S	Q6 t = n+6	Q7 t = n+7	Q8 t = n+8
n		0	0	0	?	?
n+1		1	0	1	0	?
n+2		0	0	0	1	0
n+3		1	0	1	0	1
		X	0	Q6	Q7	Q8

**PARALLEL OPERATION:**

CLOCK		D <sub>S</sub>	P/S	P <sub>n</sub>	*Q <sub>n</sub>
MC14014B	MC14021B				
		X	X	1	0
		X	X	1	1

\*Q6, Q7, & Q8 are available externally  
X = Don't Care

**LOGIC DIAGRAM**



# MC14014B•MC14021B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.75 μA/kHz) f + I <sub>DD</sub>								μA <sub>dc</sub>
10	I <sub>T</sub> = (1.50 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (2.25 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

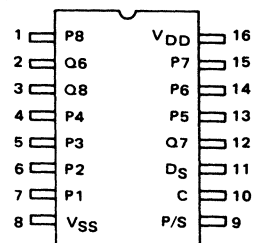
$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.0015.

\*\*The formulas given are for the typical characteristics only at 25°C.

### PIN ASSIGNMENT



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14014B•MC14021B

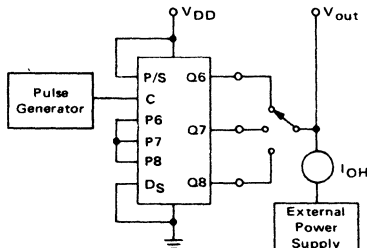
## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time (Clock to Q, P/S to Q) t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 315 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 137 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 90 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	400 170 115	800 340 230	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	400 175 135	150 75 40	— — —	ns
Clock Frequency	f <sub>cl</sub>	5.0 10 15	— — —	3.0 6.0 8.0	1.5 3.0 4.0	MHz
Parallel/Serial Control Pulse Width	t <sub>WH</sub>	5.0 10 15	400 175 135	150 75 40	— — —	ns
Setup Time P/S to Clock	t <sub>su</sub>	5.0 10 15	200 100 80	100 50 40	— — —	ns
Hold Time Clock to P/S	t <sub>h</sub>	5.0 10 15	20 20 25	-2.5 -10 0	— — —	ns
Setup Time Data (Parallel or Serial) to Clock or P/S	t <sub>su</sub>	5.0 10 15	350 80 60	150 50 30	— — —	ns
Hold Time Clock to D <sub>S</sub>	t <sub>h</sub>	5.0 10 15	45 35 35	0 0 5	— — —	ns
Hold Time Clock to P <sub>n</sub>	t <sub>h</sub>	5.0 10 15	50 45 45	25 20 20	— — —	ns
Input Clock Rise Time	t <sub>r(c)</sub>	5.0 10 15	— — —	— — —	15 5 4	μs

\*The formulas given are for the typical characteristics only at 25°C.

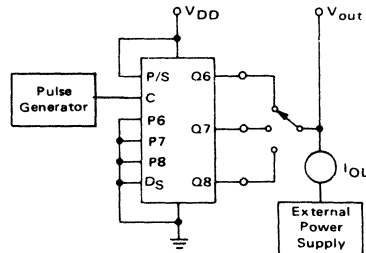
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – OUTPUT SOURCE CURRENT TEST CIRCUIT



Preset output under test to a logic "1" level.

FIGURE 2 – OUTPUT SINK CURRENT TEST CIRCUIT



# MC14014B • MC14021B

FIGURE 3 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

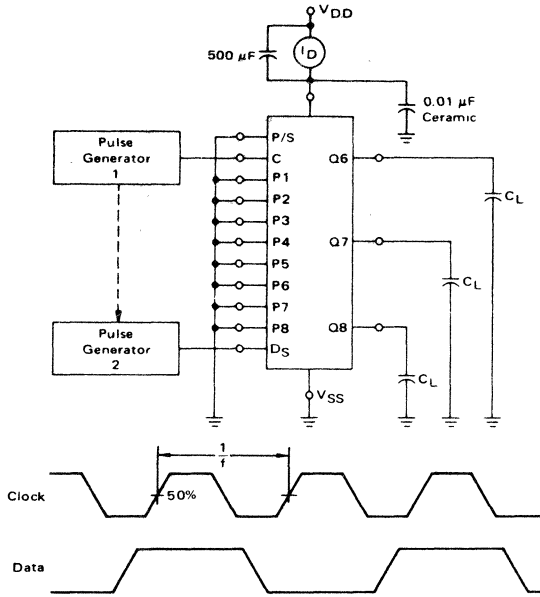
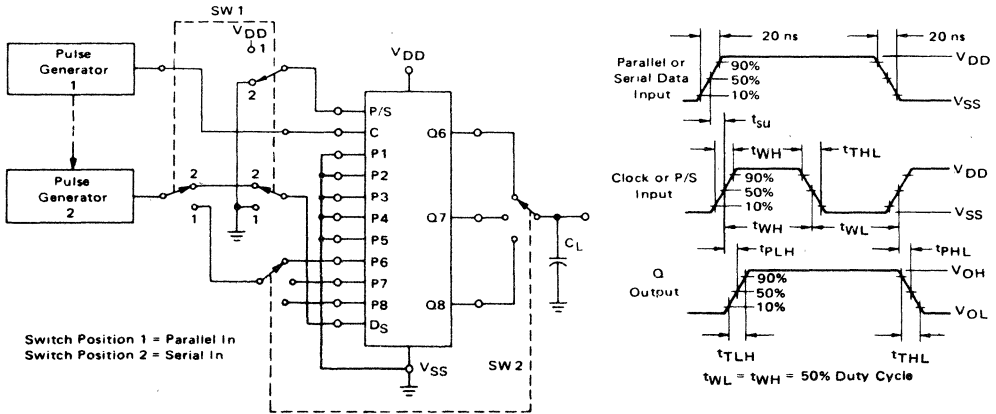


FIGURE 4 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



6



**MOTOROLA**

**MC14015B**

**DUAL 4-BIT STATIC SHIFT REGISTER**

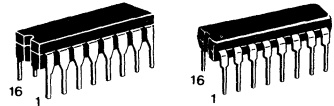
The MC14015B dual 4-bit static shift register is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. It consists of two identical, independent 4-state serial-input/parallel-output registers. Each register has independent Clock and Reset inputs with a single serial Data input. The register states are type D master-slave flip-flops. Data is shifted from one stage to the next during the positive-going clock transition. Each register can be cleared when a high level is applied on the Reset line. These complementary MOS shift registers find primary use in buffer storage and serial-to-parallel conversion where low power dissipation and/or noise immunity is desired.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Edge-Clocked Flip-Flop Design –  
Logic state is retained indefinitely with clock level either high or low; information is transferred to the output only on the positive going edge of the clock pulse.
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL 4-BIT STATIC SHIFT REGISTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

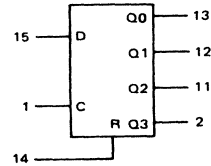
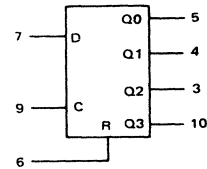
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

C	D	R	Q <sub>0</sub>	Q <sub>n</sub>
	0	0	0	Q <sub>n-1</sub>
	1	0	1	Q <sub>n-1</sub>
	X	0	No Change	No Change
X	X	1	0	0

X = Don't Care  
Q<sub>n</sub> = Q<sub>0</sub>, Q<sub>1</sub>, Q<sub>2</sub>, or Q<sub>3</sub>, as applicable.  
Q<sub>n-1</sub> = Output of prior stage.

**BLOCK DIAGRAM**



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8



# MC14015B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.5J	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
10	1.6	—	1.3	2.25	—	0.9	—				
15	4.2	—	3.4	8.8	—	2.4	—				
Output Drive Current (CL/CP Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
10	1.3	—	1.1	2.25	—	0.9	—				
15	3.6	—	3.0	8.8	—	2.4	—				
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	
10	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{fk}$$

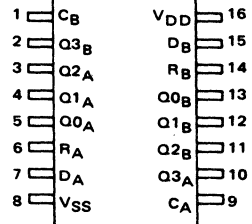
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14015B

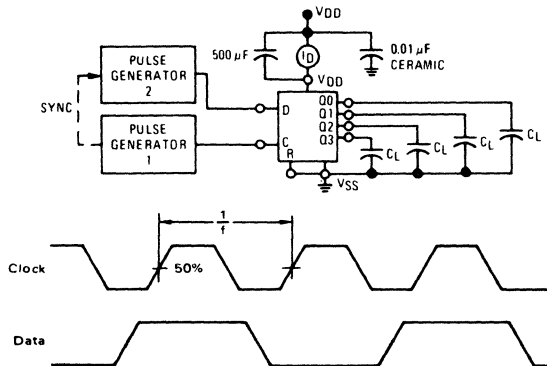
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pf}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock, Data to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 225 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 92 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$ Reset to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 375 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 147 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 95 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	310 125 90	750 250 170	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	400 175 135	185 85 55	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	2.0 6.0 7.5	1.5 3.0 3.75	MHz
Clock Pulse Rise and Fall Times	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$
Reset Pulse Width	$t_{WH}$	5.0 10 15	400 160 120	200 80 60	— — —	ns
Setup Time	$t_{su}$	5.0 10 15	350 100 75	100 50 40	— — —	ns

\*The formulas given are for typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



# MC14015B

FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

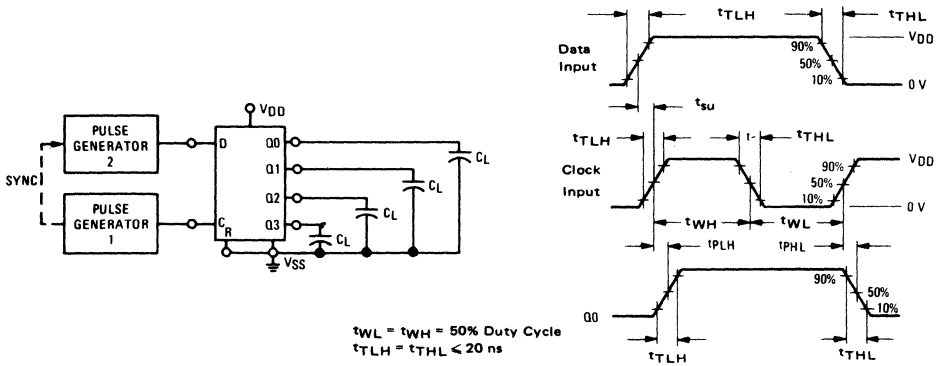
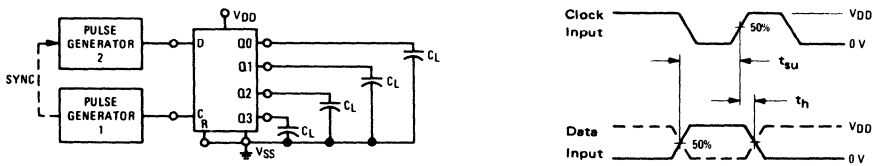
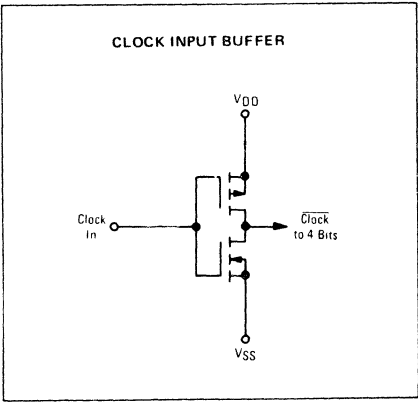
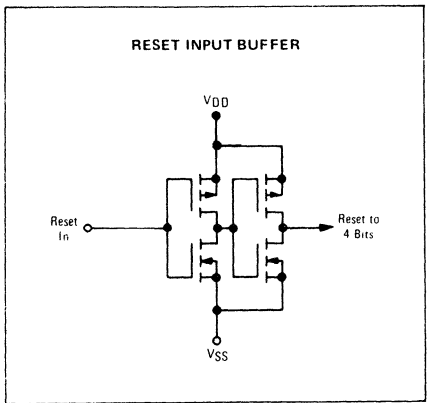
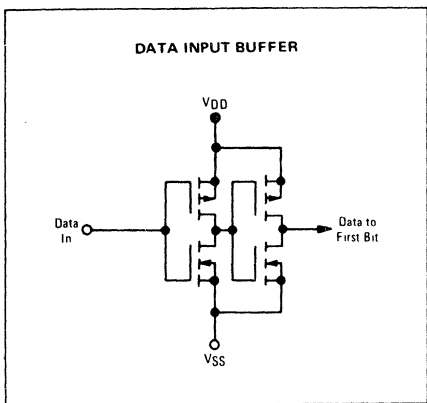
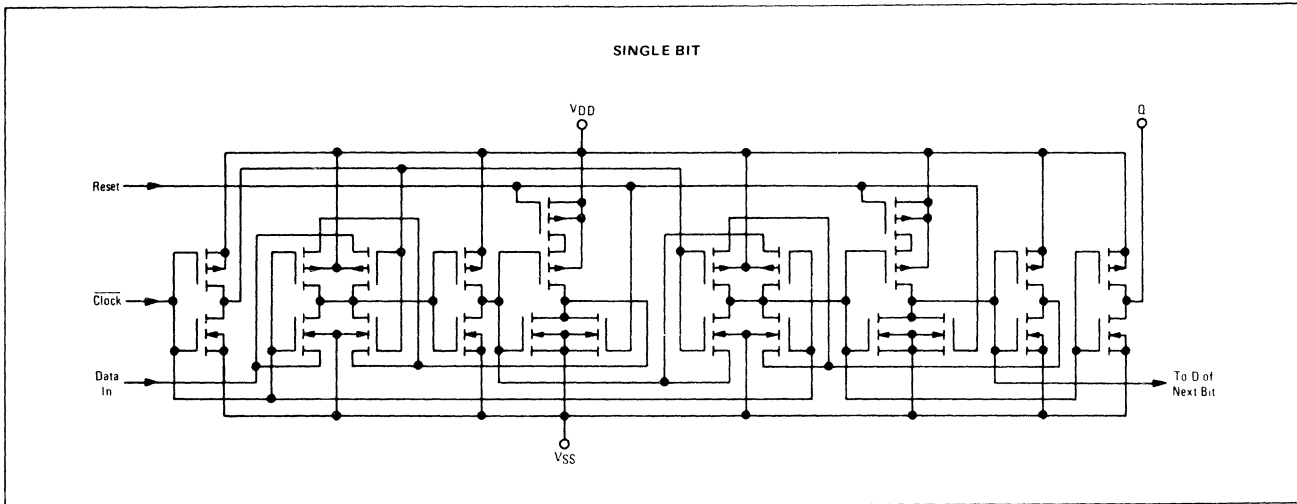


FIGURE 3 – SETUP AND HOLD TIME TEST CIRCUIT AND WAVEFORMS

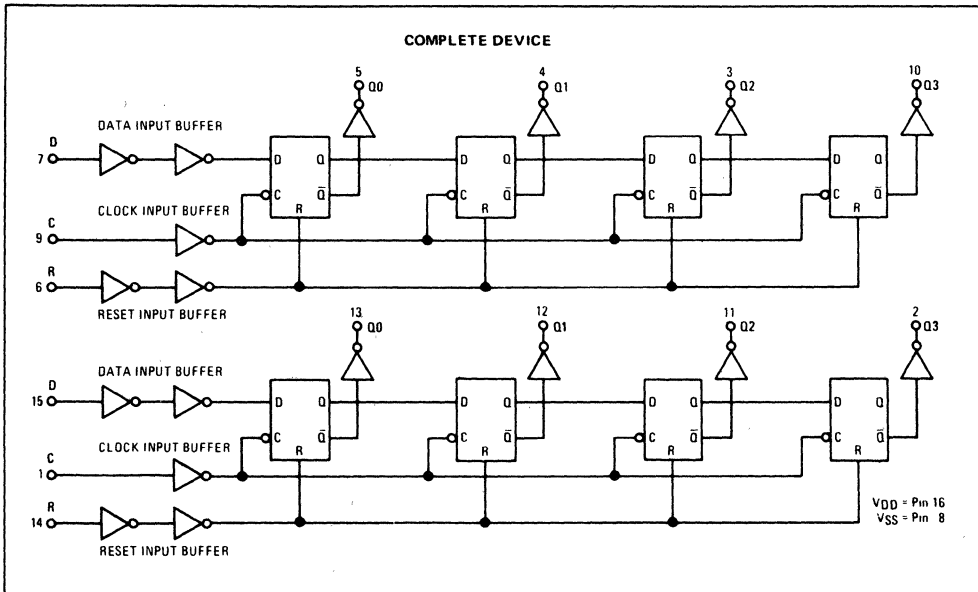
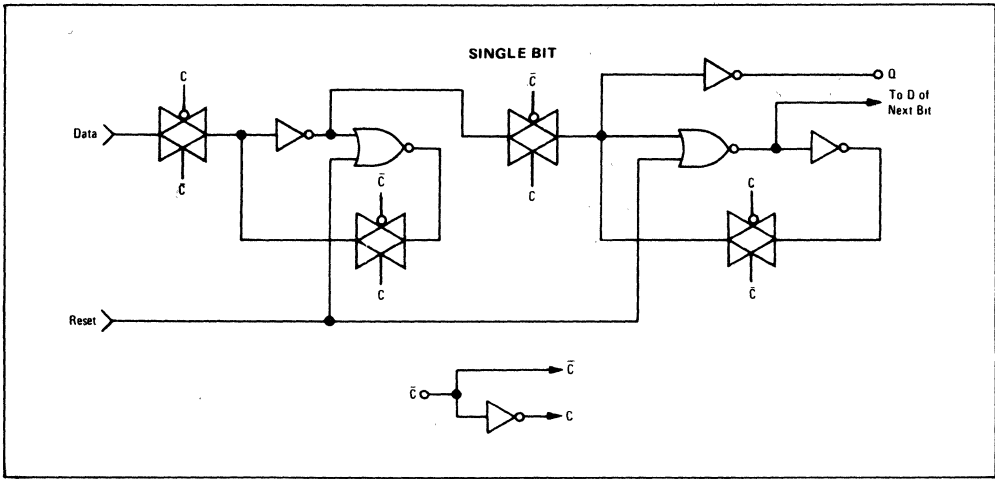


CIRCUIT SCHEMATICS



# MC14015B

## LOGIC DIAGRAMS





# MC14016B

## QUAD ANALOG SWITCH/QUAD MULTIPLEXER

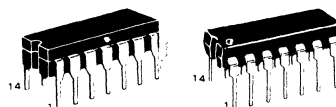
The MC14016B quad bilateral switch is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each MC14016B consists of four independent switches capable of controlling either digital or analog signals. The quad bilateral switch is used in signal gating, chopper, modulator, demodulator and CMOS logic implementation.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Linearized Transfer Characteristics
- Low Noise -  $12nV/\sqrt{\text{Cycle}}$ ,  $f \geq 1$  kHz typical
- Pin-for-Pin Replacement for CD4016B, CD4066B
- For Lower  $R_{ON}$ , Use The HC4016 High-Speed CMOS Device or The MC14066B
- This Device Has Inputs and Outputs Which Do Not Have ESD Protection. Antistatic Precautions Must Be Taken.

## CMOS SSI

(LOW POWER COMPLEMENTARY MOS)

## QUAD ANALOG SWITCH QUAD MULTIPLEXER



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### MAXIMUM RATINGS\* (Voltages Referenced to $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Control Pin	$\pm 10$	mA
$I_{sw}$	Switch Through Current	$\pm 25$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

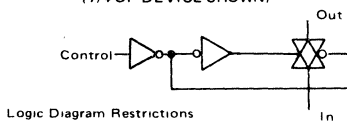
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

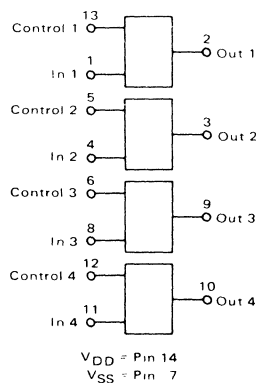
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**LOGIC DIAGRAM**  
(1/4 OF DEVICE SHOWN)



Logic Diagram Restrictions  
 $V_{SS} \leq V_{in} \leq V_{DD}$   
 $V_{SS} < V_{out} \leq V_{DD}$

### BLOCK DIAGRAM



CONTROL	SWITCH
0 = $V_{SS}$	OFF
1 = $V_{DD}$	ON

# MC14016B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristics	Figure	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit					
				Min	Max	Min	Typ #	Max	Min	Max						
Input Voltage Control Input	1	V <sub>IL</sub>	5.0	—	—	—	1.5	0.9	—	—	Vdc					
			10	—	—	—	1.5	0.9	—	—						
			15	—	—	—	1.5	0.9	—	—						
		V <sub>IH</sub>	5.0	—	—	3.0	2.0	—	—	—	Vdc					
			10	—	—	8.0	6.0	—	—	—						
			15	—	—	13	11	—	—	—						
Input Current (AL Device) Control	—	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc					
Input Current (CL/CP Device) Control	—	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc					
Input Capacitance Control Switch Input Switch Output Feed Through	—	C <sub>in</sub>	—	—	—	—	5.0	—	—	—	pF					
			—	—	—	—	5.0	—	—	—						
			—	—	—	—	5.0	—	—	—						
			—	—	—	—	0.2	—	—	—						
			—	—	—	—	—	—	—	—		—				
Quiescent Current (AL Device)** (Per Package)	2,3	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc					
			10	—	0.50	—	0.0010	0.50	—	15						
			15	—	1.00	—	0.0015	1.00	—	30						
Quiescent Current (CL/CP Device)** (Per Package)	2,3	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc					
			10	—	2.0	—	0.0010	2.0	—	15						
			15	—	4.0	—	0.0015	4.0	—	30						
"ON" Resistance (AL Device)** (V <sub>C</sub> = V <sub>DD</sub> , R <sub>L</sub> = 10 kΩ) (V <sub>in</sub> = +5.0 Vdc) (V <sub>in</sub> = -5.0 Vdc) V <sub>SS</sub> = -5 Vdc (V <sub>in</sub> = ±0.25 Vdc) (V <sub>in</sub> = +7.5 Vdc) (V <sub>in</sub> = -7.5 Vdc) V <sub>SS</sub> = -7.5 Vdc (V <sub>in</sub> = ±0.25 Vdc) (V <sub>in</sub> = +10 Vdc) (V <sub>in</sub> = +0.25 Vdc) V <sub>SS</sub> = 0 Vdc (V <sub>in</sub> = +5.6 Vdc) (V <sub>in</sub> = +15 Vdc) (V <sub>in</sub> = +0.25 Vdc) V <sub>SS</sub> = 0 Vdc (V <sub>in</sub> = +9.3 Vdc)	4,5,6	R <sub>ON</sub>	5.0	—	600	—	300	660	—	960	Ohms					
				—	600	—	300	660	—	960						
				—	600	—	280	660	—	960						
			7.5	—	360	—	240	400	—	600						
				—	360	—	240	400	—	600						
				—	360	—	180	400	—	600						
			10	—	600	—	260	660	—	960						
				—	600	—	310	660	—	960						
				—	600	—	310	660	—	960						
			15	—	360	—	260	400	—	600						
				—	360	—	260	400	—	600						
				—	360	—	300	400	—	600						
			"ON" Resistance (CL/CP Device)** (V <sub>C</sub> = V <sub>DD</sub> , R <sub>L</sub> = 10 kΩ) (V <sub>in</sub> = +5.0 Vdc) (V <sub>in</sub> = -5.0 Vdc) V <sub>SS</sub> = -5 Vdc (V <sub>in</sub> = ±0.25 Vdc) (V <sub>in</sub> = +7.5 Vdc) (V <sub>in</sub> = -7.5 Vdc) V <sub>SS</sub> = -7.5 Vdc (V <sub>in</sub> = ±0.25 Vdc) (V <sub>in</sub> = +10 Vdc) (V <sub>in</sub> = +0.25 Vdc) V <sub>SS</sub> = 0 Vdc (V <sub>in</sub> = +5.6 Vdc) (V <sub>in</sub> = +15 Vdc) (V <sub>in</sub> = +0.25 Vdc) V <sub>SS</sub> = 0 Vdc (V <sub>in</sub> = +9.3 Vdc)	4,5,6	R <sub>ON</sub>	5.0	—	610	—	300		660	—	840	Ohms	
							—	610	—	300		660	—	840		
							—	610	—	280		660	—	840		
7.5	—	370				—	240	400	—	520						
	—	370				—	240	400	—	520						
	—	370				—	180	400	—	520						
10	—	610				—	260	660	—	840						
	—	610				—	260	660	—	840						
	—	610				—	310	660	—	840						
15	—	370				—	260	400	—	520						
	—	370				—	260	400	—	520						
	—	370				—	300	400	—	520						
Δ"ON" Resistance Between any 2 circuits in a common package (V <sub>C</sub> = V <sub>DD</sub> ) (V <sub>in</sub> = ±5.0 Vdc) V <sub>SS</sub> = -5 Vdc (V <sub>in</sub> = ±7.5 Vdc) V <sub>SS</sub> = -7.5 Vdc	—	ΔR <sub>ON</sub>				5.0	—	—	—	15	—	—	—	Ohms		
							7.5	—	—	—	10	—	—			—
								—	—	—	—	—	—			—
Input/Output Leakage Current (V <sub>C</sub> = V <sub>SS</sub> ) (V <sub>in</sub> = +7.5, V <sub>out</sub> = -7.5 Vdc) (V <sub>in</sub> = -7.5, V <sub>out</sub> = +7.5 Vdc)	—	—	7.5	—	±0.100	—	±0.0015	±0.100	—	±1.0	μAdc					
			7.5	—	±0.100	—	±0.0015	±0.100	—	±1.0						

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

NOTE: All unused inputs must be returned to V<sub>DD</sub> or V<sub>SS</sub> as appropriate for the circuit application

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*For voltage drops across the switch (ΔV<sub>switch</sub>) > 600 mV (> 300 mV at high temperature), excessive V<sub>DD</sub> current may be drawn; i.e., the current out of the switch may contain both V<sub>DD</sub> and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded. (See first page of this data sheet.) Reference Figure 14

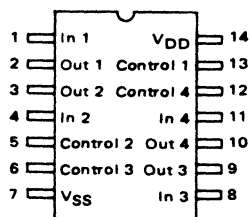
# MC14016B

## ELECTRICAL CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Figure	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit				
Propagation Delay Time ( $V_{SS} = 0 \text{ Vdc}$ ) $V_{in}$ to $V_{out}$ ( $V_C = V_{DD}$ , $R_L = 10 \text{ k}\Omega$ )	7	$t_{PLH}$ ,	5.0	—	15	45	ns				
		$t_{PHL}$	10	—	7.0	15					
			15	—	6.0	12					
Control to Output ( $V_{in} < 10 \text{ Vdc}$ , $R_L = 1.0 \text{ k}\Omega$ )	8	$t_{PHZ}$ ,	5.0	—	34	90	ns				
		$t_{PLZ}$ ,	10	—	20	45					
		$t_{PZH}$ ,	15	—	15	35					
		$t_{PZL}$									
Crosstalk, Control to Output ( $V_{SS} = 0 \text{ Vdc}$ ) ( $V_C = V_{DD}$ , $R_{in} = 1.0 \text{ k}\Omega$ , $R_{out} = 10 \text{ k}\Omega$ , $f = 1 \text{ kHz}$ )	9	—	5.0	—	30	—	mV				
			10	—	50	—					
			15	—	100	—					
Crosstalk between any two switches ( $V_{SS} = 0 \text{ Vdc}$ ) ( $R_L = 1.0 \text{ k}\Omega$ , $f = 1.0 \text{ MHz}$ , crosstalk = $20 \log_{10} \frac{V_{out1}}{V_{out2}}$ )	—	—	5.0	—	-80	—	dB				
Noise Voltage ( $V_{SS} = 0 \text{ Vdc}$ ) ( $V_C = V_{DD}$ , $f = 100 \text{ Hz}$ )  ( $V_C = V_{DD}$ , $f = 100 \text{ kHz}$ )	10,11	—	5.0	—	24	—	nV/ $\sqrt{\text{Cycle}}$				
			10	—	25	—					
			15	—	30	—					
			5.0	—	12	—					
			10	—	12	—					
			15	—	15	—					
Second Harmonic Distortion ( $V_{SS} = -5 \text{ Vdc}$ ) ( $V_{in} = 1.77 \text{ Vdc RMS Centered @ } 0.0 \text{ Vdc}$ , $R_L = 10 \text{ k}\Omega$ , $f = 1.0 \text{ kHz}$ )	—	—	5.0	—	0.16	—	%				
Insertion Loss ( $V_C = V_{DD}$ , $V_{in} = 1.77 \text{ Vdc}$ , $V_{SS} = -5 \text{ Vdc}$ , RMS centered = $0.0 \text{ Vdc}$ , $f = 1.0 \text{ MHz}$ ) $I_{loss} = 20 \log_{10} \frac{V_{out}}{V_{in}}$ ( $R_L = 1.0 \text{ k}\Omega$ ) ( $R_L = 10 \text{ k}\Omega$ ) ( $R_L = 100 \text{ k}\Omega$ ) ( $R_L = 1.0 \text{ M}\Omega$ )	12	—	5.0	—			dB				
Bandwidth (-3 dB) ( $V_C = V_{DD}$ , $V_{in} = 1.77 \text{ Vdc}$ , $V_{SS} = -5 \text{ Vdc}$ , RMS centered @ $0.0 \text{ Vdc}$ ) ( $R_L = 1.0 \text{ k}\Omega$ ) ( $R_L = 10 \text{ k}\Omega$ ) ( $R_L = 100 \text{ k}\Omega$ ) ( $R_L = 1.0 \text{ M}\Omega$ )	12,13	BW	5.0	—			MHz				
OFF Channel Feedthrough Attenuation ( $V_{SS} = -5 \text{ Vdc}$ ) $(V_C = V_{SS}, 20 \log_{10} \frac{V_{out}}{V_{in}} = -50 \text{ dB})$ ( $R_L = 1.0 \text{ k}\Omega$ ) ( $R_L = 10 \text{ k}\Omega$ ) ( $R_L = 100 \text{ k}\Omega$ ) ( $R_L = 1.0 \text{ M}\Omega$ )	—	—	5.0	—			kHz				

\*Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

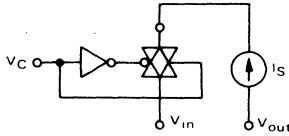
### PIN ASSIGNMENT





# MC14016B

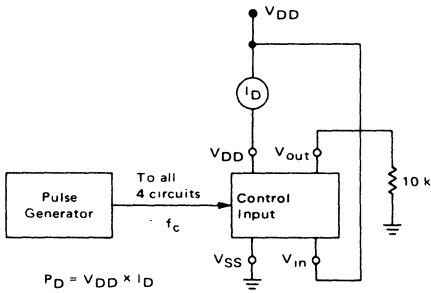
**FIGURE 1 – INPUT VOLTAGE TEST CIRCUIT**



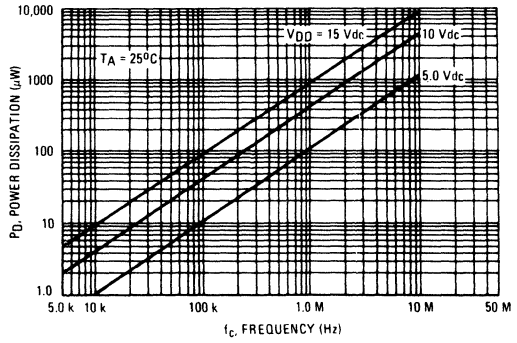
$V_{IL}$ :  $V_C$  is raised from  $V_{SS}$  until  $V_C = V_{IL}$ .  
at  $V_C = V_{IL}$ :  $I_S = \pm 10 \mu A$  with  $V_{in} = V_{SS}$ ,  $V_{out} = V_{DD}$  or  $V_{in} = V_{DD}$ ,  $V_{out} = V_{SS}$

$V_{IH}$ : When  $V_C = V_{IH}$  to  $V_{DD}$ , the switch is ON and the  $R_{ON}$  specifications are met.

**FIGURE 2 – QUIESCENT POWER DISSIPATION TEST CIRCUIT**

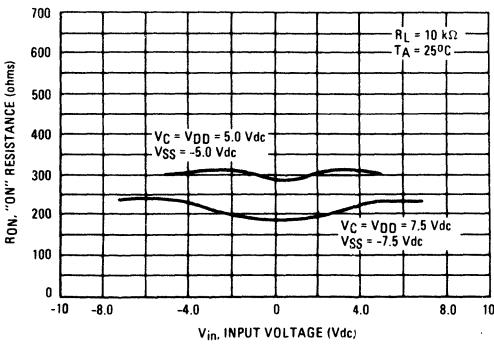


**FIGURE 3 – TYPICAL POWER DISSIPATION PER CIRCUIT (1/4 OF DEVICE SHOWN)**

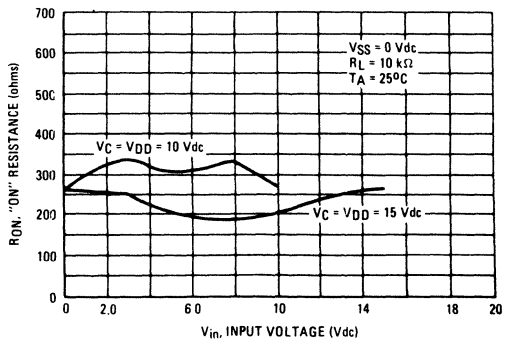


## TYPICAL $R_{ON}$ versus INPUT VOLTAGE

**FIGURE 4 –  $V_{SS} = -5.0 V$  AND  $-7.5 V$**

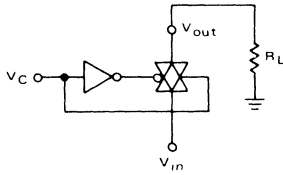


**FIGURE 5 –  $V_{SS} = 0 V$**

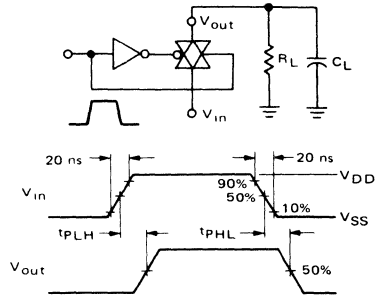


# MC14016B

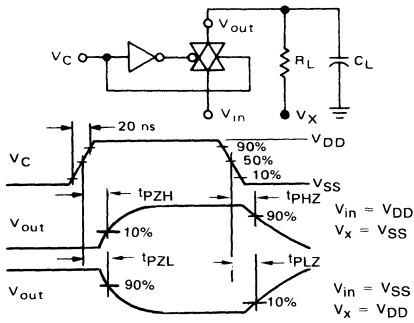
**FIGURE 6 –  $R_{ON}$  CHARACTERISTICS TEST CIRCUIT**



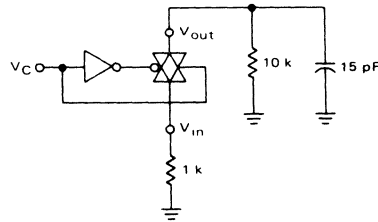
**FIGURE 7 – PROPAGATION DELAY TEST CIRCUIT AND WAVEFORMS**



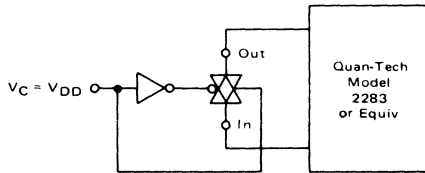
**FIGURE 8 – TURN-ON DELAY TIME TEST CIRCUIT AND WAVEFORMS**



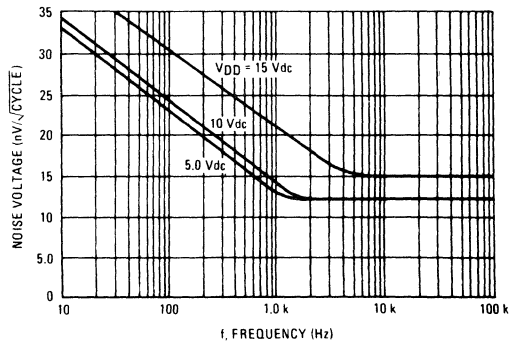
**FIGURE 9 – CROSSTALK TEST CIRCUIT**



**FIGURE 10 – NOISE VOLTAGE TEST CIRCUIT**

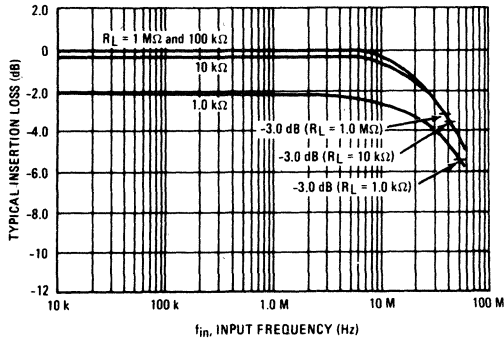


**FIGURE 11 – TYPICAL NOISE CHARACTERISTICS**

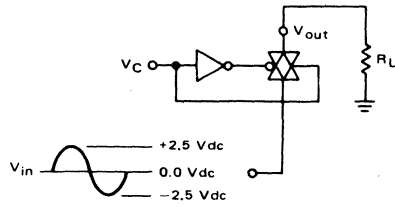


# MC14016B

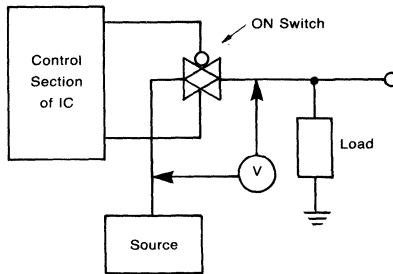
**FIGURE 12 – TYPICAL INSERTION LOSS/BANDWIDTH CHARACTERISTICS**



**FIGURE 13 – FREQUENCY RESPONSE TEST CIRCUIT**



**FIGURE 14 –  $\Delta V$  ACROSS SWITCH**



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# MC14016B

## APPLICATIONS INFORMATION

Figure A illustrates use of the Analog Switch. The 0-to-5 V Digital Control signal is used to directly control a 5 V<sub>p-p</sub> analog signal.

The digital control logic levels are determined by V<sub>DD</sub> and V<sub>SS</sub>. The V<sub>DD</sub> voltage is the logic high voltage; the V<sub>SS</sub> voltage is logic low. For the example, V<sub>DD</sub> = +5V = logic high at the control inputs; V<sub>SS</sub> = GND = 0V = logic low.

The maximum analog signal level is determined by V<sub>DD</sub> and V<sub>SS</sub>. The analog voltage must not swing higher than V<sub>DD</sub> or lower than V<sub>SS</sub>.

The example shows a 5 V<sub>p-p</sub> signal which allows no margin at either peak. If voltage transients above V<sub>DD</sub> and/or below V<sub>SS</sub> are anticipated on the analog channels, external diodes (D<sub>x</sub>) are recommended as shown in Figure B. These diodes should be small signal types able to absorb the maximum anticipated current surges during clipping.

The *absolute* maximum potential difference between V<sub>DD</sub> and V<sub>SS</sub> is 18.0V. Most parameters are specified up to 15V which is the *recommended* maximum difference between V<sub>DD</sub> and V<sub>SS</sub>.

FIGURE A — APPLICATION EXAMPLE

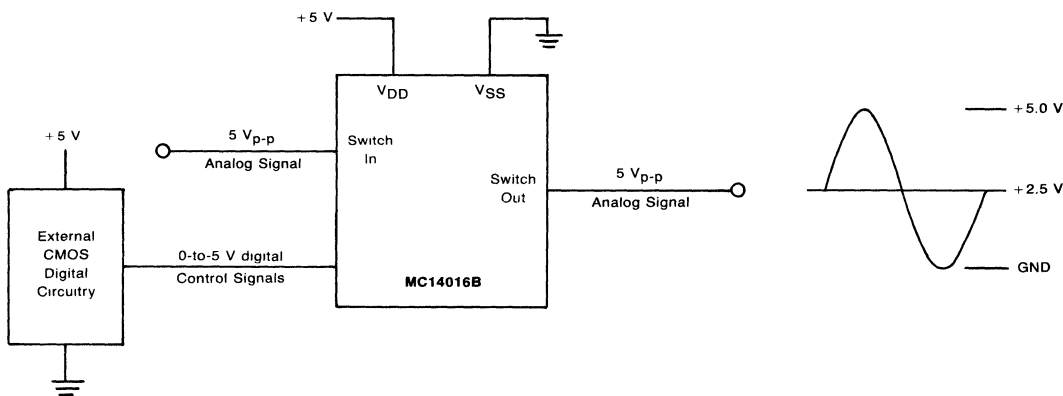
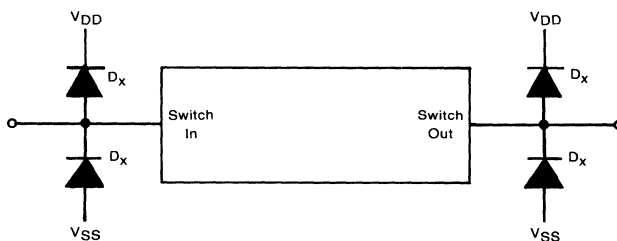


FIGURE B — EXTERNAL GERMANIUM OR SCHOTTKY CLIPPING DIODES





# MC14017B

## DECADE COUNTER

The MC14017B is a five-stage Johnson decade counter with built-in code converter. High speed operation and spike-free outputs are obtained by use of a Johnson decade counter design. The ten decoded outputs are normally low, and go high only at their appropriate decimal time period. The output changes occur on the positive-going edge of the clock pulse. This part can be used in frequency division applications as well as decade counter or decimal decode display applications.

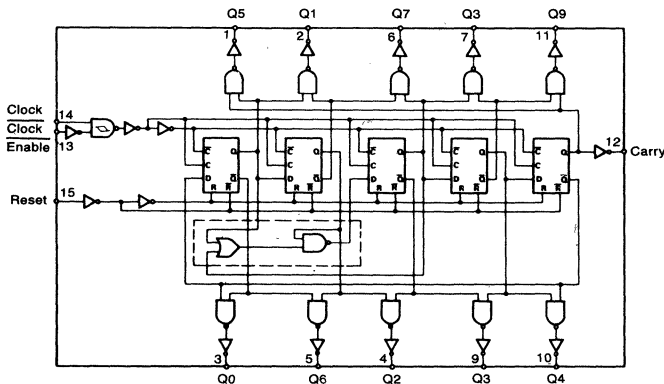
- Fully Static Operation
- DC Clock Input Circuit Allows Slow Rise Times
- Carry Out Output for Cascading
- Divide-by-N Counting
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4017B

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

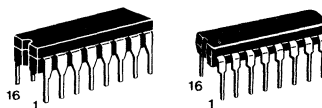
\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating. Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

### LOGIC DIAGRAM



## CMOS MSI

(LOW POWER COMPLEMENTARY MOS)  
 DECADE COUNTER



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620

**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

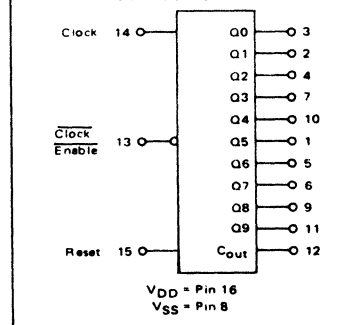
C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

### FUNCTIONAL TRUTH TABLE (Positive Logic)

CLOCK	CLOCK ENABLE	RESET	DECODE OUTPUT = n
0	X	0	n
X	1	0	n
X	X	1	Q0
	0	0	n+1
X	X	0	n
1	X	0	n
1	0	0	n+1

X = Don't Care; if n < 5 Carry = "1", Otherwise = "0"

### BLOCK DIAGRAM



# MC14017B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	V <sub>in</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.27 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (0.55 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (0.83 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) Vfk$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

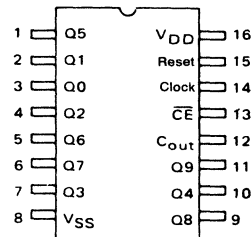
where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.0011

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper op-

eration, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14017B

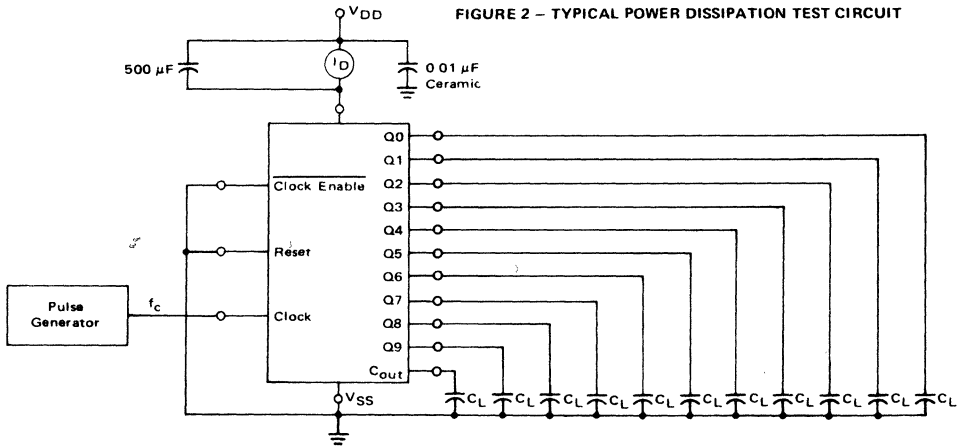
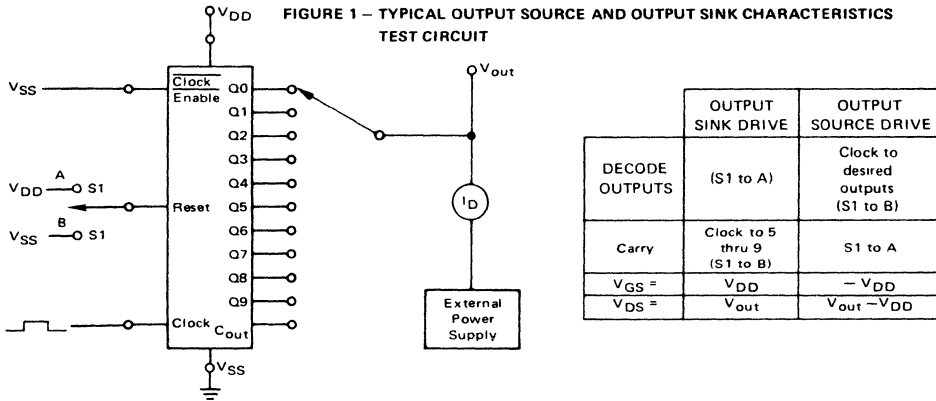
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Reset to Decode Output $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	500 230 175	1000 460 350	ns
Propagation Delay Time Clock to Cout $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	400 175 125	800 350 250	ns
Propagation Delay Time Clock to Decode Output $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	500 230 175	1000 460 350	ns
Turn-Off Delay Time Reset to Cout $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	400 175 125	800 350 250	ns
Clock Pulse Width	$t_{w(H)}$	5.0 10 15	250 100 75	125 50 35	— — —	ns
Clock Frequency	$f_{cl}$	5.0 10 15	— — —	5.0 12 16	2.0 5.0 6.7	MHz
Reset Pulse Width	$t_{w(H)}$	5.0 10 15	500 250 190	250 125 95	— — —	ns
Reset Removal Time	$t_{rem}$	5.0 10 15	750 275 210	375 135 105	— — —	ns
Clock Input Rise and Fall Time	$t_{TLH}$ , $t_{THL}$	5.0 10 15	No Limit			—
Clock Enable Setup Time	$t_{su}$	5.0 10 15	350 150 115	175 75 52	— — —	ns
Clock Enable Removal Time	$t_{rem}$	5.0 10 15	420 200 140	260 100 70	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

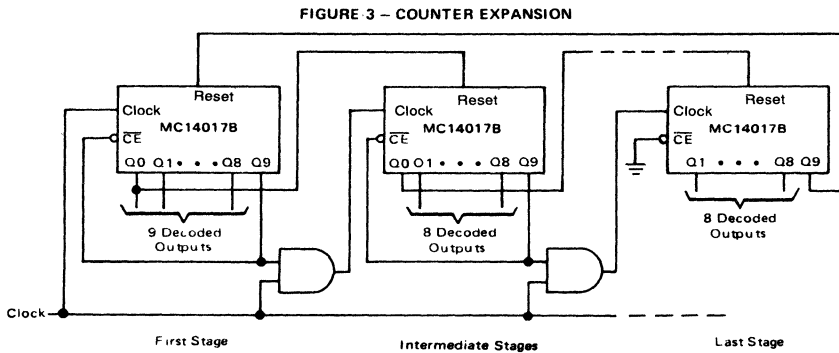
# MC14017B



6

## APPLICATIONS INFORMATION

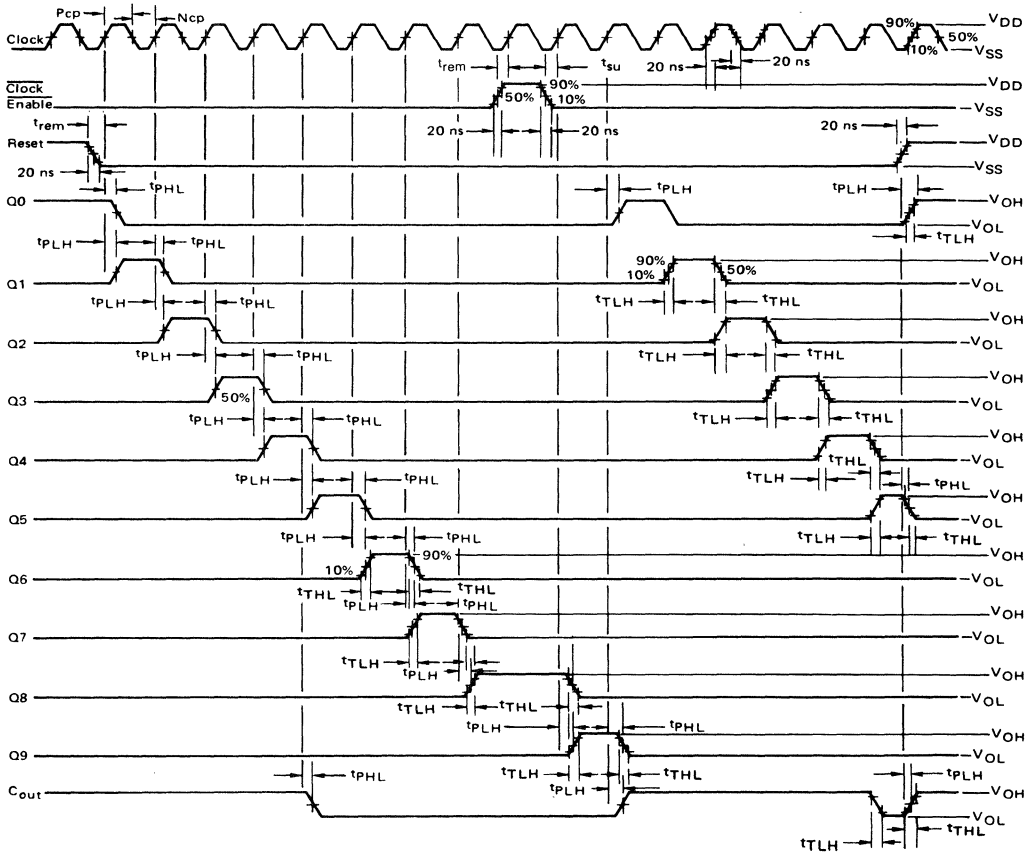
Figure 3 shows a technique for extending the number of decoded output states for the MC14017B. Decoded outputs are sequential within each stage and from stage to stage, with no dead time (except propagation delay).





# MC14017B

FIGURE 4 – AC MEASUREMENT DEFINITION AND FUNCTIONAL WAVEFORMS



6



**MOTOROLA**

**PRESETTABLE DIVIDE-BY-N COUNTER**

The MC14018B contains five Johnson counter stages which are asynchronously presettable and resettable. The counters are synchronous, and increment on the positive going edge of the clock.

Presetting is accomplished by a logic 1 on the preset enable input. Data on the Jam inputs will then be transferred to their respective  $\bar{Q}$  outputs (inverted). A logic 1 on the reset input will cause all  $\bar{Q}$  outputs to go to a logic 1 state.

Division by any number from 2 to 10 can be accomplished by connecting appropriate  $\bar{Q}$  outputs to the data input, as shown in the Function Selection table. Anti-lock gating is included in the MC14018B to assure proper counting sequence.

- Fully Static Operation
- Schmitt Trigger on Clock Input
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4018B

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur

†Temperature Derating. Plastic "P" Package -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

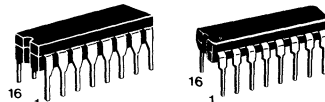
This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**MC14018B**

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**PRESETTABLE DIVIDE-BY-N COUNTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

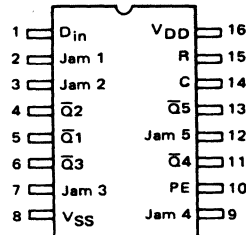
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**FUNCTIONAL TRUTH TABLE**

Clock	Reset	Preset Enable	Jam Input	$\bar{Q}_n$
	0	0	X	$\bar{Q}_n$
	0	0	X	$\bar{D}_n$
X	0	1	0	1
X	0	1	1	0
X	1	X	X	1

\* $\bar{D}_n$  is the Data input for that stage. Stage 1 has Data brought out to Pin 1.

**PIN ASSIGNMENT**



# MC14018B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		10	-0.64	—	-0.51	-0.88	—	-0.36	—	
Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		10	-0.52	—	-0.44	-0.88	—	-0.36	—	
Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>
10	I <sub>T</sub> = (0.7 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (1.0 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001

# MC14018B

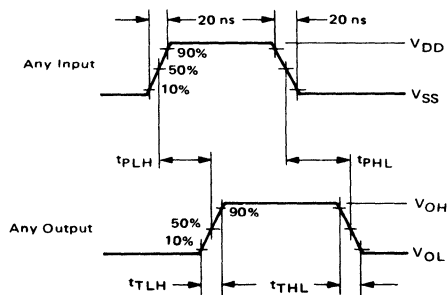
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.35 \text{ ns/pF}) C_L + 32 \text{ ns}$ $t_{TLH}, t_{THL} = (0.6 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH}, t_{THL} = (0.4 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to $\bar{Q}$ $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 265 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 102 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 72 \text{ ns}$ Reset to $\bar{Q}$ $t_{PLH} = (0.90 \text{ ns/pF}) C_L + 325 \text{ ns}$ $t_{PLH} = (0.36 \text{ ns/pF}) C_L + 132 \text{ ns}$ $t_{PLH} = (0.26 \text{ ns/pF}) C_L + 81 \text{ ns}$ Preset Enable to $\bar{Q}$ $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 325 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 132 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 81 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	310 120 85	620 240 170	ns
Setup Time Data (Pin 1) to Clock	$t_{su}$	5.0 10 15	200 100 80	0 0 0	— — —	ns
Jam Inputs to Preset Enable		5.0 10 15	200 100 80	0 0 0	— — —	ns
Data (Jam Inputs)-to-Preset Enable Hold Time	$t_h$	5.0 10 15	540 500 480	270 250 240	— — —	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	400 200 160	200 100 80	— — —	ns
Reset or Preset Enable Pulse Width	$t_{WH}$	5.0 10 15	290 130 110	145 65 55	— — —	ns
Clock Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	No Limit			ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	2.5 6.5 8.0	1.25 3.25 4.0	MHz

\*The formulas given are for typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME WAVEFORMS







**MOTOROLA**

**MC14020B**

**14-BIT BINARY COUNTER**

The MC14020B 14-stage binary counter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. This part is designed with an input wave shaping circuit and 14 stages of ripple-carry binary counter. The device advances the count on the negative-going edge of the clock pulse. Applications include time delay circuits, counter controls, and frequency-dividing circuits.

- Fully Static Operation
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Buffered Outputs Available from stages 1 and 4 thru 14
- Common Reset Line
- Pin-for-Pin Replacement for CD4020B

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

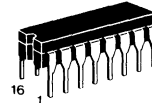
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

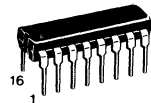
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**14-BIT BINARY COUNTER**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620



**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

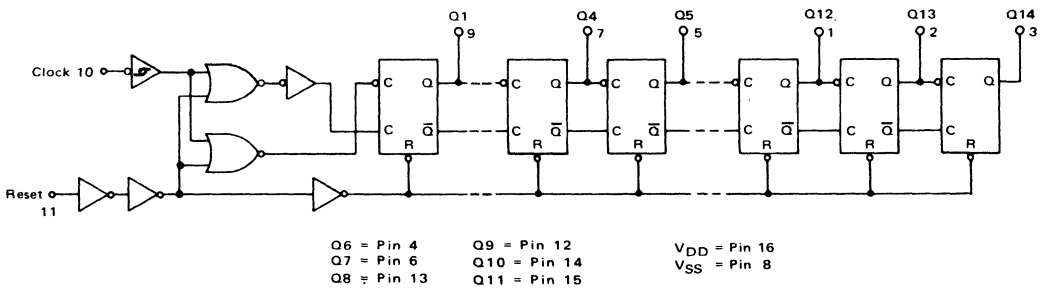
**TRUTH TABLE**

CLOCK	RESET	OUTPUT STATE
	0	No Change
	0	Advance to next state
X	1	All Outputs are low

X = Don't Care

**6**

**LOGIC DIAGRAM**



# MC14020B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.42 μA/kHz) f + I <sub>DD</sub>						μAdc		
10	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (1.43 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{fk}$$

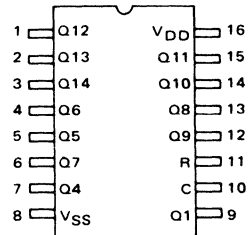
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14020B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time T <sub>TLH</sub> , T <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns T <sub>TLH</sub> , T <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns T <sub>TLH</sub> , T <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q1 t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 175 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 82 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 55 ns  Clock to Q14 t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 1735 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 772 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 535 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	260 115 80	520 230 160	ns
Propagation Delay Time Reset to Q <sub>n</sub> t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 285 ns t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 122 ns t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 90 ns	t <sub>PHL</sub>	5.0 10 15	— — —	370 155 115	740 310 230	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	500 165 125	140 55 38	— — —	ns
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	2.0 6.0 8.0	1.0 3.0 4.0	MHz
Clock Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	No Limit			—
Reset Pulse Width	t <sub>WL</sub>	5.0 10 15	3000 550 420	320 120 80	— — —	ns
Reset Removal Time	t <sub>rem</sub>	5.0 10 15	130 50 30	65 25 15	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labeled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

6

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

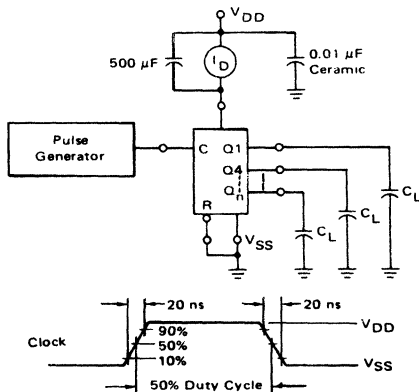
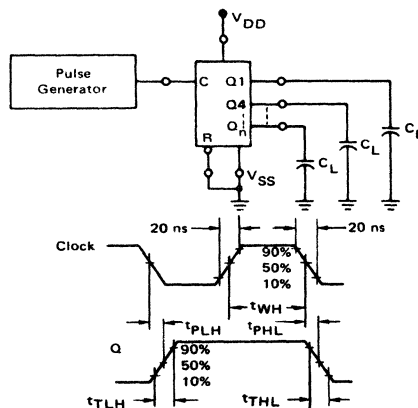


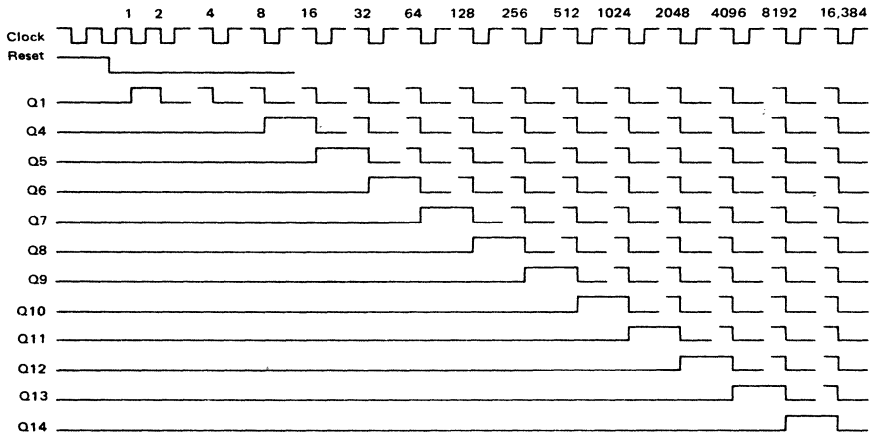
FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





# MC14020B

FIGURE 3 – TIMING DIAGRAM





**MOTOROLA**

**MC14021B**  
See Page 6-37

**MC14022B**

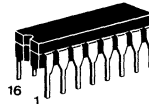
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)  
**OCTAL COUNTER**

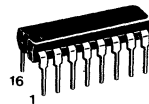
**OCTAL COUNTER**

The MC14022B is a four-stage Johnson octal counter with built-in code converter. High-speed operation and spike-free outputs are obtained by use of a Johnson octal counter design. The eight decoded outputs are normally low, and go high only at their appropriate octal time period. The output changes occur on the positive-going edge of the clock pulse. This part can be used in frequency division applications as well as octal counter or octal decode display applications.

- Fully Static Operation
- DC Clock Input Circuit Allows Slow Rise Times
- Carry Out Output for Cascading
- Divide-by-N Counting
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4022B



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

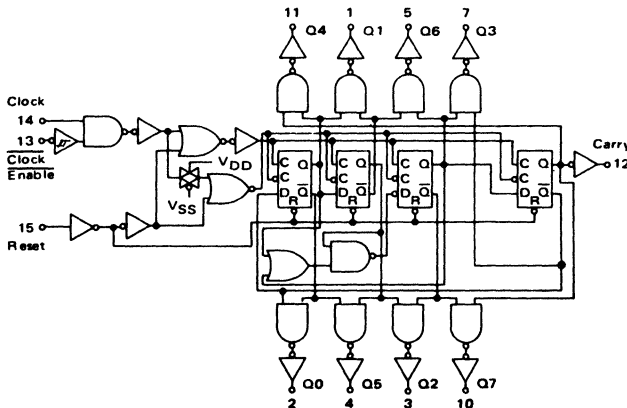
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**FUNCTIONAL TRUTH TABLE**  
(Positive Logic)

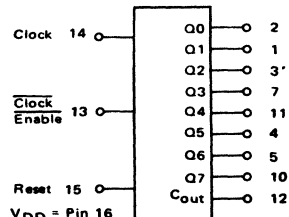
CLOCK	CLOCK ENABLE	RESET	OUTPUT = n
0	X	0	n
X	1	0	n
	0	0	n+1
	X	0	n
1		0	n+1
X		0	n
X	X	1	00

X Don't Care If n < 4 Carry = 1, Otherwise = 0

**LOGIC DIAGRAM**



**BLOCK DIAGRAM**



NC = Pin 6,9

6

# MC14022B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
Output Voltage "1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	Input Voltage "1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
Output Drive Current (AL Device) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
Output Drive Current (CL/CP Device) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current** f (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0				I <sub>T</sub> = (0.28 μA/kHz) f + I <sub>DD</sub>			μAdc		
10				I <sub>T</sub> = (0.56 μA/kHz) f + I <sub>DD</sub>							
15				I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

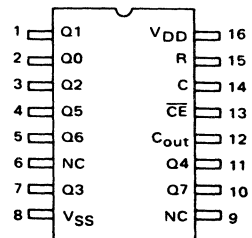
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.00125.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>IH</sub> and V<sub>OH</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



NC = No Connection

# MC14022B

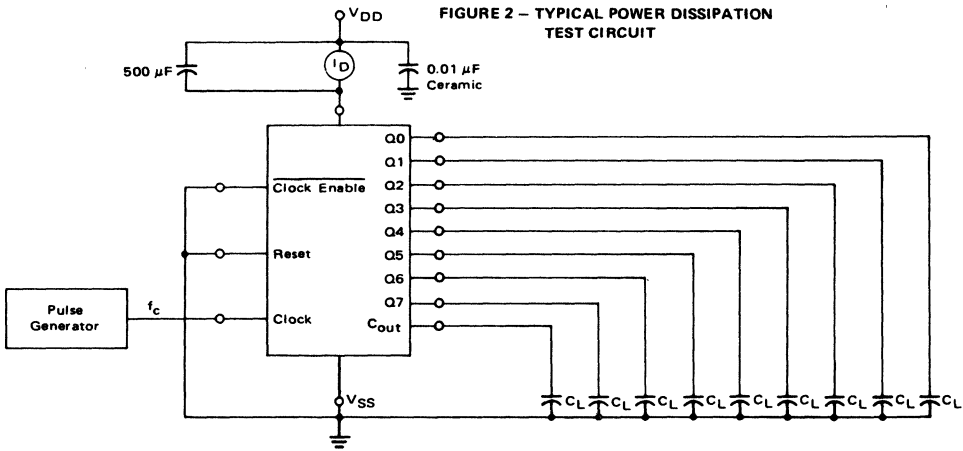
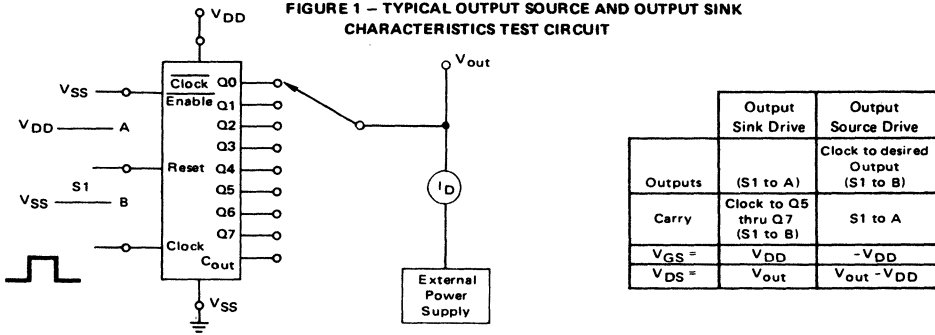
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Reset to Decode Output $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	500 230 175	1000 460 350	ns
Propagation Delay Time Clock to C <sub>out</sub> $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	400 175 125	800 350 250	ns
Propagation Delay Time Clock to Decode Output $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 150 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	275 125 95	1000 460 350	ns
Turn-Off Delay Time Reset to C <sub>out</sub> $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 100 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	400 175 125	800 350 250	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	250 100 75	125 50 35	— — —	ns
Clock Frequency	$f_{cl}$	5.0 10 15	— — —	5.0 12 16	2.0 5.0 6.7	MHz
Reset Pulse Width	$t_{WH}$	5.0 10 15	500 250 190	250 125 95	— — —	ns
Reset Removal Time	$t_{rem}$	5.0 10 15	750 275 210	375 135 105	— — —	ns
Clock Input Rise and Fall Time	$t_{TLH}$ , $t_{THL}$	5.0 10 15	No Limit			—
Clock Enable Setup Time	$t_{su}$	5.0 10 15	350 150 115	175 75 52	— — —	ns
Clock Enable Removal Time	$t_{rem}$	5.0 10 15	420 200 140	260 100 70	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14022B



## APPLICATIONS INFORMATION

Figure 3 shows a technique for extending the number of decoded output states for the MC14022B. Decoded outputs are sequential within each stage and from stage to stage, with no dead time (except propagation delay).

**FIGURE 3 – COUNTER EXPANSION**

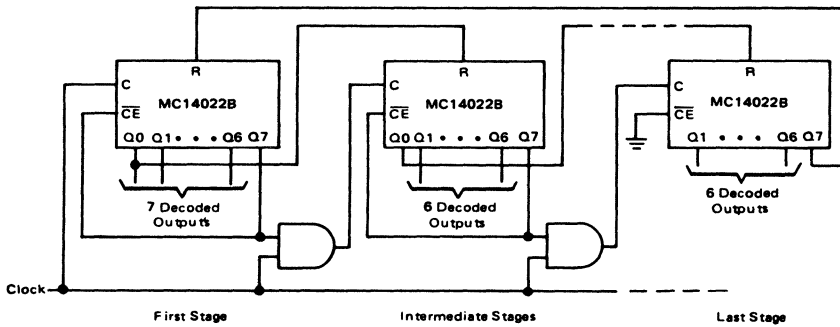
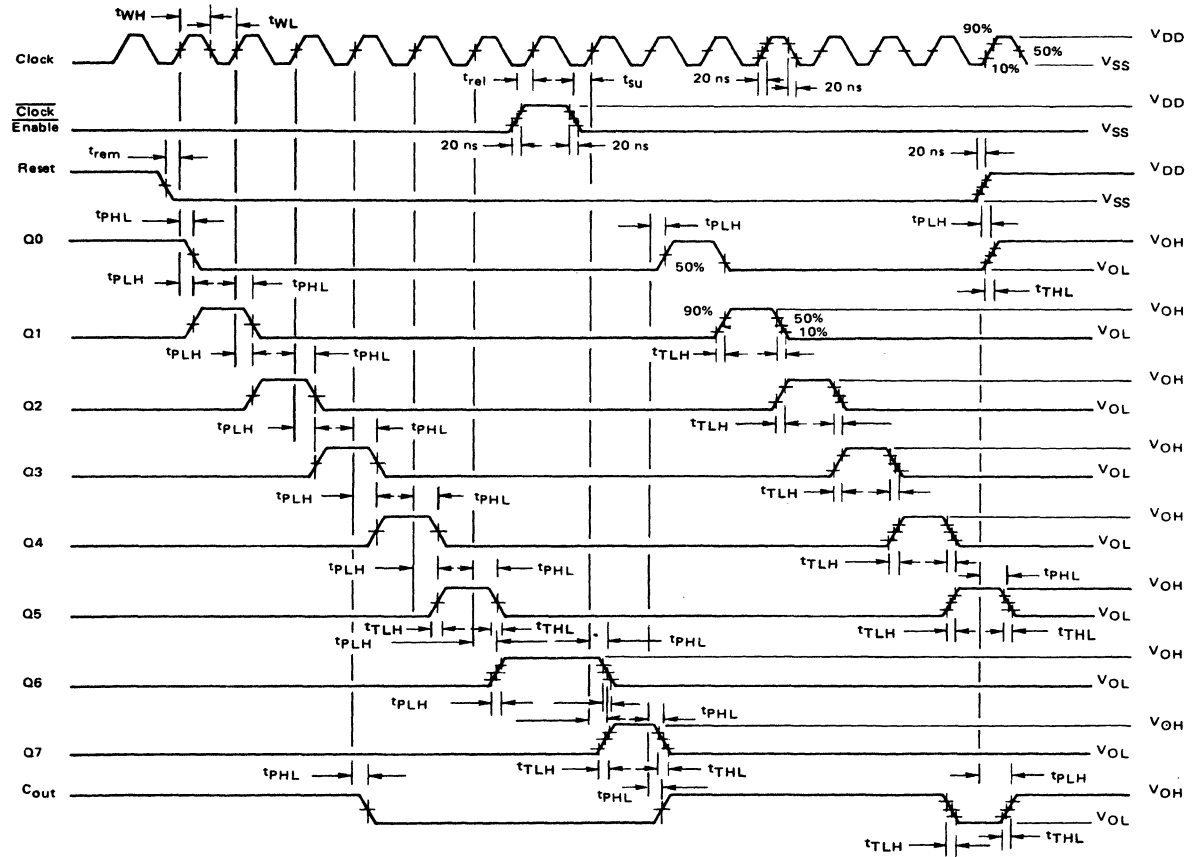


FIGURE 4 – AC MEASUREMENT DEFINITION AND FUNCTIONAL WAVEFORMS





**MOTOROLA**

**MC14023B**  
See Page 6-5

**MC14023UB**  
See Page 6-14

**MC14024B**

**CMOS SSI**  
(LOW-POWER COMPLEMENTARY MOS)  
  
**7-STAGE**  
**RIPPLE COUNTER**

**7-STAGE RIPPLE COUNTER**

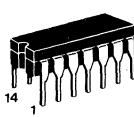
The MC14024B is a 7-stage ripple counter with short propagation delays and high maximum clock rates. The Reset input has standard noise immunity, however the Clock input has increased noise immunity due to Hysteresis. The output of each counter stage is buffered.

- Diode Protection on All Inputs
- Output Transitions Occur on the Falling Edge of the Clock Pulse
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4024B

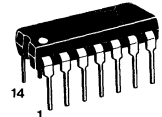
**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

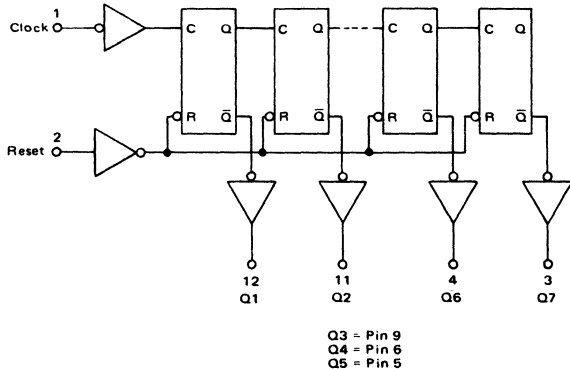


**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

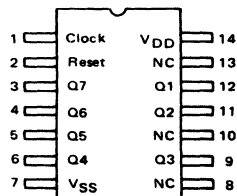
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)  
  
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**LOGIC DIAGRAM**



**PIN ASSIGNMENT**



V<sub>DD</sub> = Pin 14  
V<sub>SS</sub> = Pin 7  
NC = No Connection

# MC14024B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0  "1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  "0" Level  "1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)  Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)  Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current** †† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.31 μA/kHz) f + I <sub>DD</sub>						μA <sub>dc</sub>	
		10	I <sub>T</sub> = (0.60 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (0.89 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 ††T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

† To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{f_k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001

\*\*The formulas given are for the typical characteristics only at 25°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.







# MC14024B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
<b>Output Rise and Fall Time</b>						ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
<b>Propagation Delay Time</b>						ns
<b>Clock to Q1</b>	$t_{PLH}$ , $t_{PHL}$					
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 295 \text{ ns}$		5.0	—	380	600	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 117 \text{ ns}$		10	—	150	230	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 85 \text{ ns}$		15	—	110	175	
<b>Clock to Q7</b>						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 915 \text{ ns}$		5.0	—	1000	2000	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 367 \text{ ns}$		10	—	400	750	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 275 \text{ ns}$		15	—	300	565	
<b>Reset to Q<sub>n</sub></b>						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$		5.0	—	500	800	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 217 \text{ ns}$		10	—	250	400	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 155 \text{ ns}$		15	—	180	300	
<b>Clock Pulse Width</b>	$t_{WH}$	5.0	500	200	—	ns
		10	165	60	—	
		15	125	40	—	
<b>Reset Pulse Width</b>	$t_{WH}$	5.0	600	375	—	ns
		10	350	200	—	
		15	260	150	—	
<b>Reset Removal Time</b>	$t_{rem}$	5.0	625	250	—	ns
		10	190	75	—	
		15	145	50	—	
<b>Clock Input Rise and Fall Times</b>	$t_{TLH}$ , $t_{THL}$	5.0	—	—	1.0	s
		10	—	—	8.0	ms
		15	—	—	200	μs
<b>Input Pulse Frequency</b>	$f_{cl}$	5.0	—	2.5	1.0	MHz
		10	—	8.0	3.0	
		15	—	12	4.0	

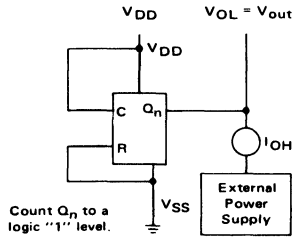
\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

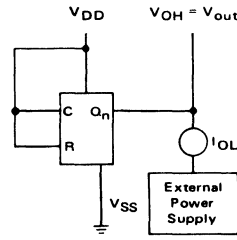
TRUTH TABLE		
CLOCK	RESET	STATE
0	0	No Change
0	1	All Outputs Low
1	0	No Change
1	1	All Outputs Low
	0	No Change
	1	All Outputs Low
	0	Advance One Count
	1	All Outputs Low

# MC14024B

**FIGURE 1 – TYPICAL OUTPUT SOURCE CHARACTERISTICS TEST CIRCUIT**



**FIGURE 2 – TYPICAL OUTPUT SINK CHARACTERISTICS TEST CIRCUIT**



**FIGURE 3 – POWER DISSIPATION TEST CIRCUIT**

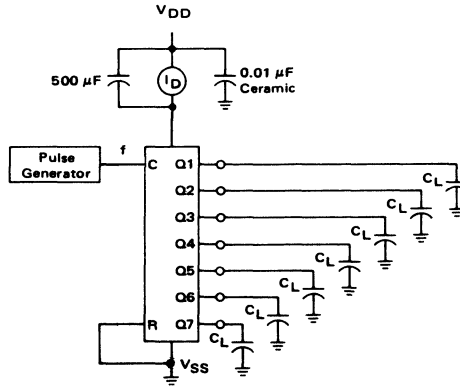
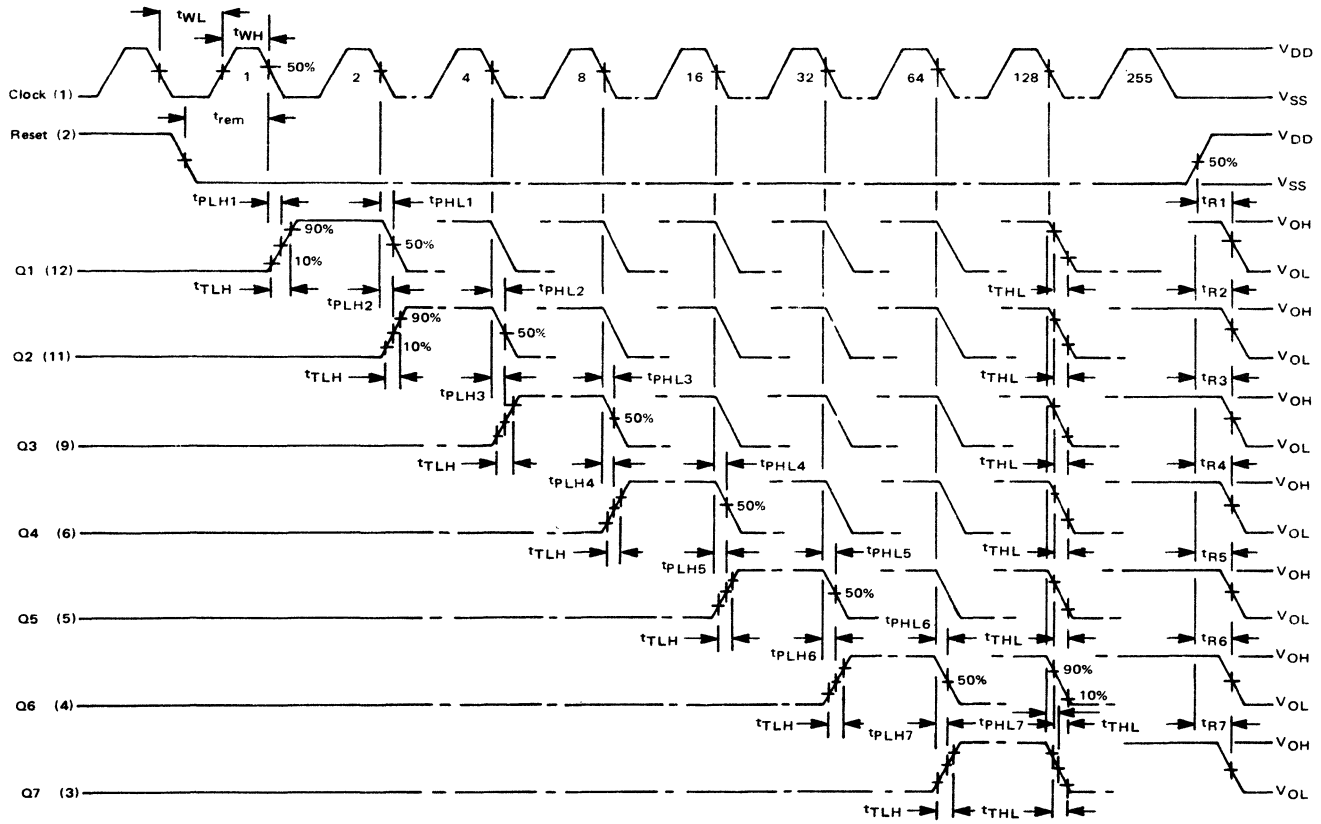




FIGURE 4 – FUNCTIONAL WAVEFORMS



Input  $t_{TLH}$  and  $t_{THL}$  = 20 ns



**MOTOROLA**

**DUAL J-K FLIP-FLOP**

The MC14027B dual J-K flip-flop has independent J, K, Clock (C), Set (S) and Reset (R) inputs for each flip-flop. These devices may be used in control, register, or toggle functions.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Swing Independent of Fanout
- Logic Edge-Clocked Flip-Flop Design – Logic state is retained indefinitely with clock level either high or low; information is transferred to the output only on the positive-going edge of the clock pulse
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4027B

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	- 0.5 to + 18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	- 0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	- 65 to + 150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
 †Temperature Derating. Plastic "P" Package - 12mW/°C from 65°C to 85°C  
 Ceramic "L" Package. - 12mW/°C from 100°C to 125°C

**TRUTH TABLE**

$C^\dagger$	INPUTS				OUTPUTS*		
	J	K	S	R	$Q_n^\ddagger$	$Q_{n+1}$	$\bar{Q}_{n+1}$
	1	X	0	0	0	1	0
	X	0	0	0	1	1	0
	0	X	0	0	0	0	1
	X	1	0	0	1	0	1
	1	1	0	0	$Q_0$	$\bar{Q}_0$	$Q_0$
	X	X	0	0	X	$Q_n$	$\bar{Q}_n$
	X	X	1	0	X	1	0
	X	X	X	0	1	X	0
	X	X	X	1	1	X	1

X = Don't Care       $\ddagger$  = Present State  
 † = Level Change      \* = Next State

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**MC14025B**

See Page 6-5

**MC14025UB**

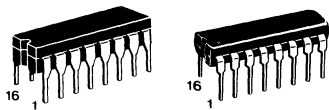
See Page 6-14

**MC14027B**

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL J-K FLIP-FLOP**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620

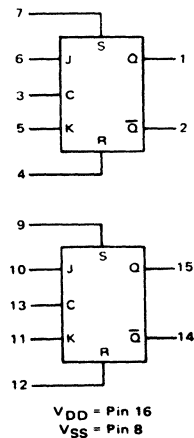
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



# MC14027B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0 "0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub> "1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc) "0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc) Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc) Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc	
		10	—	2.0	—	0.004	2.0	—	60		
		15	—	4.0	—	0.006	4.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc	
		10	—	8.0	—	0.004	8.0	—	60		
		15	—	16	—	0.006	16	—	120		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (0.80 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.60 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.40 μA/kHz) f + I <sub>DD</sub>							μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

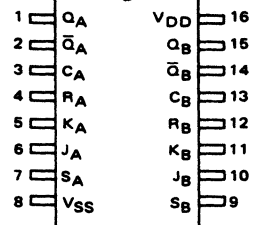
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

### PIN ASSIGNMENT



# MC14027B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

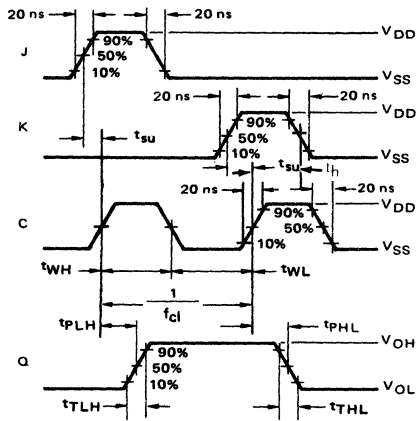
Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns						
t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns						
t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 12.5 ns						
Propagation Delay Times**	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	175 75 50	350 150 100	ns
Clock to Q, Q						
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 90 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 42 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 25 ns						
Set to Q, Q						
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 90 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 42 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 25 ns						
Reset to Q, Q						
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 265 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 67 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 50 ns						
Setup Times	t <sub>su</sub>	5.0 10 15	140 50 35	70 25 17	— — —	ns
Hold Times	t <sub>h</sub>	5.0 10 15	140 50 35	70 25 17	— — —	ns
Clock Pulse Width	t <sub>WH</sub> , t <sub>WL</sub>	5.0 10 15	330 110 75	165 55 38	— — —	ns
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	3.0 9.0 13	1.5 4.5 6.5	MHz
Clock Pulse Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	— — —	15 5.0 4.0	μs
Removal Times	t <sub>rem</sub>	5 10 15	90 45 35	10 5 3	— — —	ns
Set						
Reset						
Set and Reset Pulse Width	t <sub>WH</sub>	5.0 10 15	250 100 70	125 50 35	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

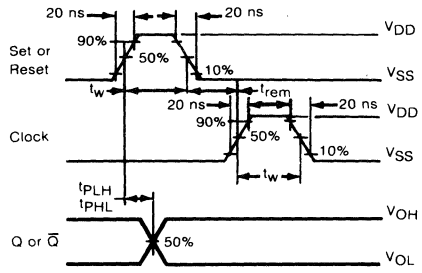
# MC14027B

**FIGURE 1 — DYNAMIC SIGNAL WAVEFORMS**  
(J, K, Clock, and Output)

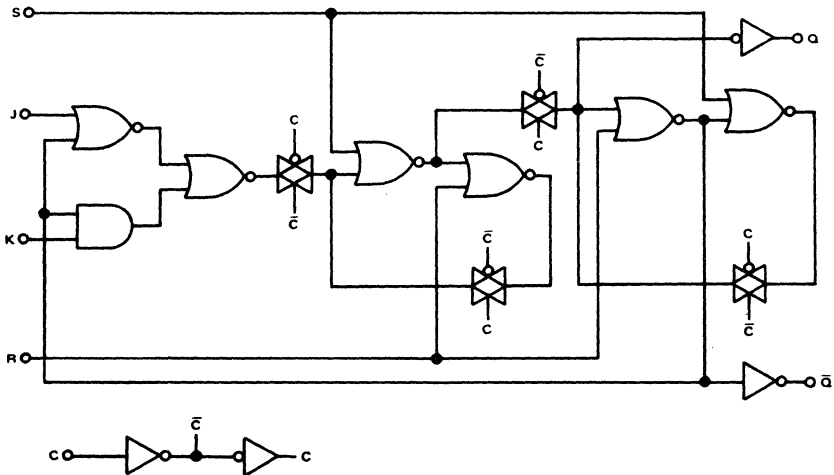


Inputs R and S low.  
For the measurement of  $t_{WH}$ ,  $1/f_{cl}$ , and  $P_D$   
the Inputs J and K are kept high.

**FIGURE 2 — DYNAMIC SIGNAL WAVEFORMS**  
(Set, Reset, Clock, and Output)



**LOGIC DIAGRAM**  
(1/2 of Device Shown)



6



**MOTOROLA**

**MC14028B**

**BCD-TO-DECIMAL DECODER  
BINARY-TO-OCTAL DECODER**

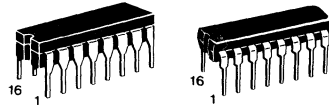
The MC14028B decoder is constructed so that an 8421 BCD code on the four inputs provides a decimal (one-of-ten) decoded output, while a 3-bit binary input provides a decoded octal (one-of-eight) code output with D forced to a logic "0". Expanded decoding such as binary-to-hexadecimal (one-of-16), etc., can be achieved by using other MC14028B devices. The part is useful for code conversion, address decoding, memory selection control, demultiplexing, or read-out decoding.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Positive Logic Design
- Low Outputs on All Illegal Input Combinations
- Similar to CD4028B.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BCD-TO-DECIMAL DECODER  
BINARY-TO-OCTAL DECODER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

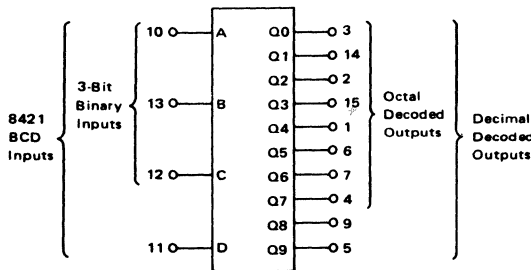
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package -12mW/°C from 100°C to 125°C

**BLOCK DIAGRAM**



**TRUTH TABLE**

INPUT				OUTPUT									
D	C	B	A	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	1	0
0	0	1	0	0	0	0	0	0	0	0	1	0	0
0	0	1	1	0	0	0	0	0	0	1	0	0	0
0	1	0	0	0	0	0	0	0	1	0	0	0	0
0	1	0	1	0	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	0	1	0	0	0	0	0	0
0	1	1	1	0	0	1	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0	0	0	0

6



# MC14028B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

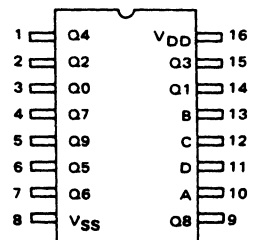
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14028B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

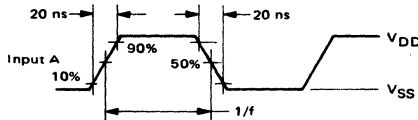
Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$	5.0	—	100	200	ns
	$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	10	—	50	100	
	$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	15	—	40	80	
Propagation Delay Time	$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 215 \text{ ns}$	5.0	—	300	600	ns
	$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$	10	—	130	260	
	$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$	15	—	90	180	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

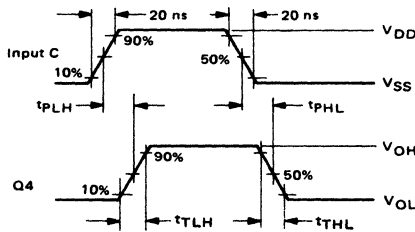
FIGURE 1 – DYNAMIC SIGNAL WAVEFORMS

Inputs B, C, and D  
switching in respect  
to a BCD code.



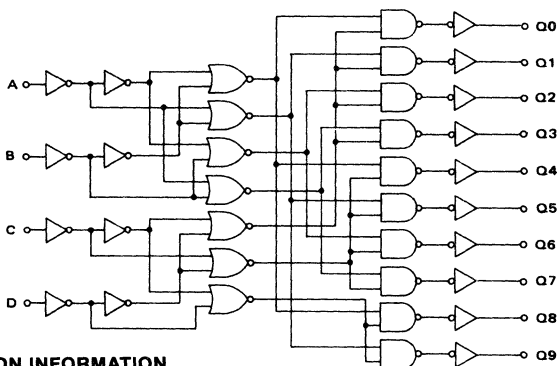
All outputs connected  
to respective  $C_L$  loads.  
f in respect to a system  
clock.

Inputs A, B, and D low.



# MC14028B

## LOGIC DIAGRAM

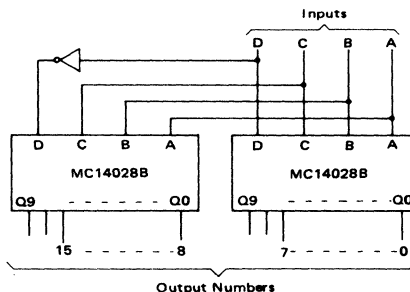


## APPLICATION INFORMATION

Expanded decoding can be performed by using the MC14028B and other CMOS Integrated Circuits. The circuit in Figure 2 converts any 4-bit code to a decimal or hexadecimal code. The accompanying table shows the input binary combinations, the associated "output numbers" that go "high" when selected, and the "redefined output numbers" needed for the proper code. For example: For the combination DCBA = 0111 the output number 7 is redefined for the 4-bit binary, 4-bit gray, excess-3, or excess-3 gray codes as 7, 5, 4, or 2, respectively. Figure 3 shows a 6-bit binary 1-of-64 decoder using nine MC14028B circuits and two MC14069UB inverters.

The MC14028B can be used in decimal digit displays, such as, neon readouts or incandescent projection indicators as shown in Figure 4.

FIGURE 2 - CODE CONVERSION CIRCUIT AND TRUTH TABLE



INPUTS				OUTPUT NUMBERS																CODE AND REDEFINED OUTPUT NUMBERS					
																				Hexadecimal		Decimal			
D	C	B	A	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	4-Bit Binary	4-Bit Gray	Excess-3	Excess-3 Gray	Aiken	4221
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0			0	0
0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1			1	1
0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3		0	2	2
0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	3		
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	7	1	4	4	
0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	6	2		3	
0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4	3	1		
0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	5	4	2		
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	15	5			
1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	14	6			5
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	12	7	9		6
1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	13	8			5
1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	8	9	5	6	
1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	9		6	7	
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	11		8	8	8
1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	10		7	9	9

# MC14028B

FIGURE 3 – SIX-BIT BINARY 1-OF-64 DECODER

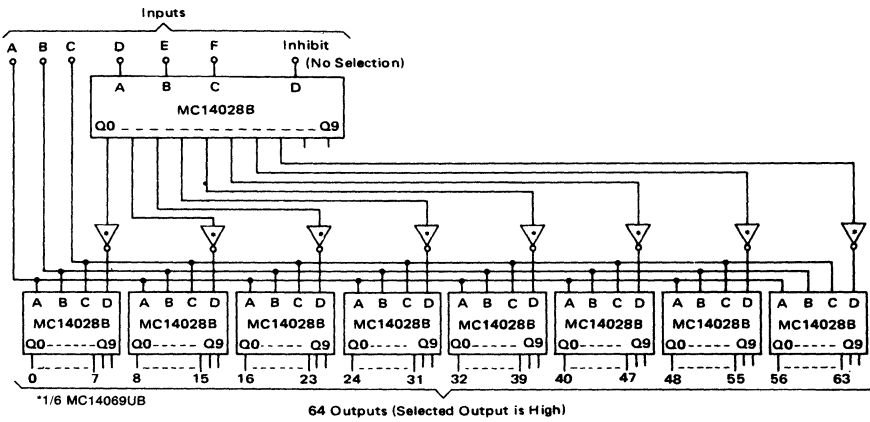
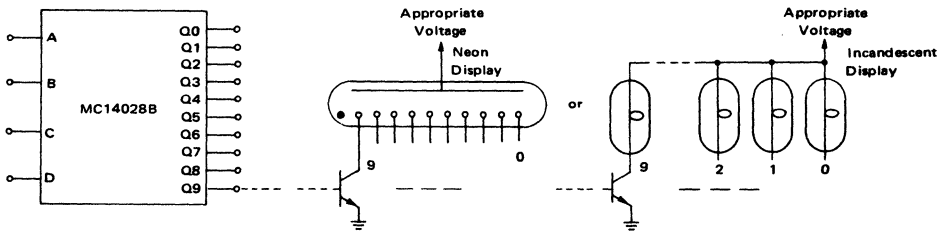


FIGURE 4 – DECIMAL DIGIT DISPLAY APPLICATION





**MOTOROLA**

**MC14029B**

**BINARY/DECADE UP/DOWN COUNTER**

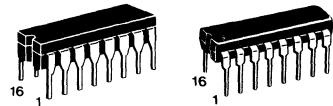
The MC14029B Binary/Decade up/down counter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. The counter consists of type D flip-flop stages with a gating structure to provide toggle flip-flop capability. The counter can be used in either Binary or BCD operation. This complementary MOS counter finds primary use in up/down and difference counting and frequency synthesizer applications where low power dissipation and/or high noise immunity is desired. It is also useful in A/D and D/A conversion and for magnitude and sign generation.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Internally Synchronous for High Speed
- Logic Edge-Clocked Design – Count Occurs on Positive Going Edge of Clock
- Asynchronous Preset Enable Operation
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin for Pin Replacement for CD4029B

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BINARY/DECADE UP/DOWN COUNTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: –55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: –40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	–0.5 to +18.0	V
$V_{In}, V_{out}$	Input or Output Voltage (DC or Transient)	–0.5 to $V_{DD} + 0.5$	V
$I_{In}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	–65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: –12mW/°C from 65°C to 85°C

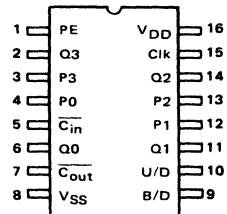
Ceramic "L" Package: –12mW/°C from 100°C to 125°C

**TRUTH TABLE**

Carry In	Up/Down	Preset Enable	Action
1	X	0	No Count
0	1	0	Count Up
0	0	0	Count Down
X	X	1	Preset

X = Don't Care

**PIN ASSIGNMENT**



# MC14029B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C		T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min		Max	
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		10	-0.64	—	-0.51	-0.88	—	-0.36	—		
		15	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		10	-0.52	—	-0.44	-0.88	—	-0.36	—		
		15	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub>						μAdc		
10	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14029B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50$ pF, $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH},$ $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clk to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ Clk to $C_{out}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ $C_{in}$ to $C_{out}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 95 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 47 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$ PE to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ PE to $C_{out}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 192 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 125 \text{ ns}$	$t_{PLH},$ $t_{PHL}$	5.0 10 15	— — —	200 100 90	400 200 180	ns
Clock Pulse Width	$t_W(\text{cl})$	5.0 10 15	180 80 60	90 40 30	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	4.0 8.0 10	2.0 4.0 5.0	MHz
Preset Removal Time The Preset Signal must be low prior to a positive-going transition of the clock.	$t_{rem}$	5.0 10 15	160 80 60	80 40 30	— — —	ns
Clock Rise and Fall Time	$t_r(\text{cl})$ $t_f(\text{cl})$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$
Carry In Setup Time	$t_{su}$	5.0 10 15	150 60 40	75 30 20	— — —	ns
Up/Down Setup Time		5.0 10 15	340 140 100	170 70 50	— — —	ns
Binary/Decade Setup Time		5.0 10 15	320 140 100	160 70 50	— — —	ns
Preset Enable Pulse Width	$t_W$	5.0 10 15	130 70 50	65 35 25	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14029B

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

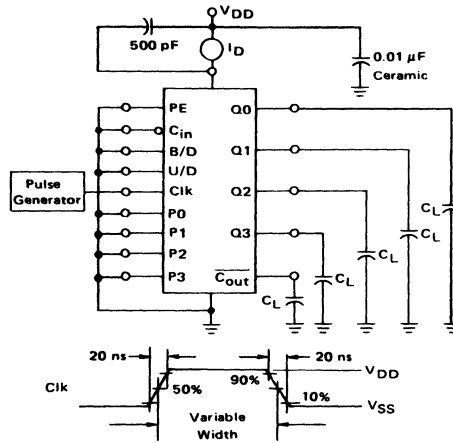
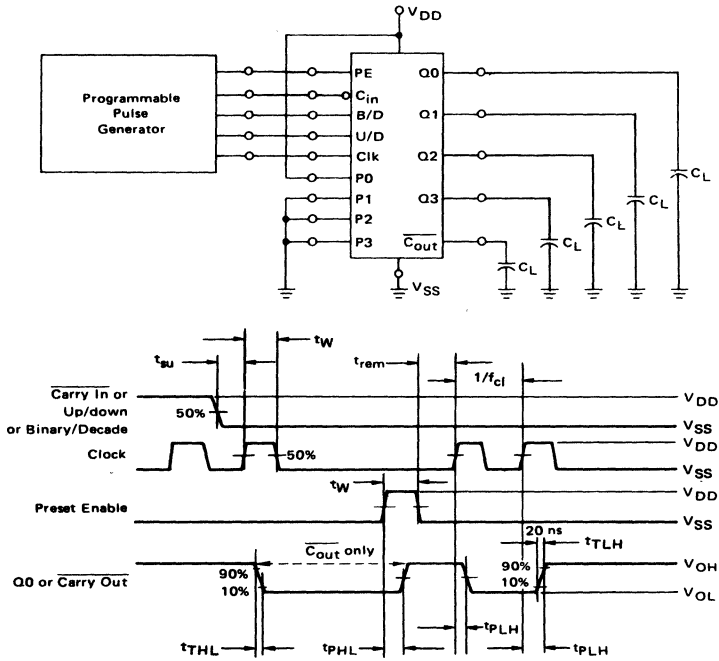


FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





# MC14029B

## TIMING DIAGRAM

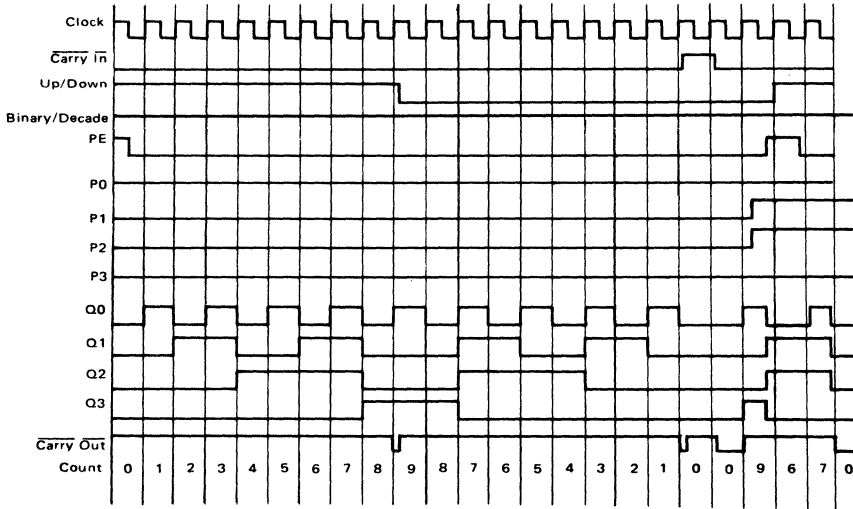
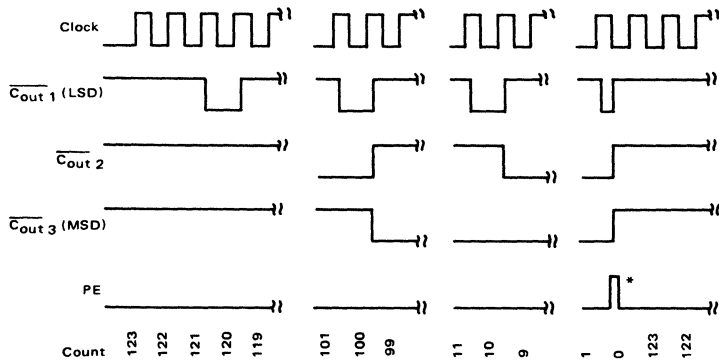
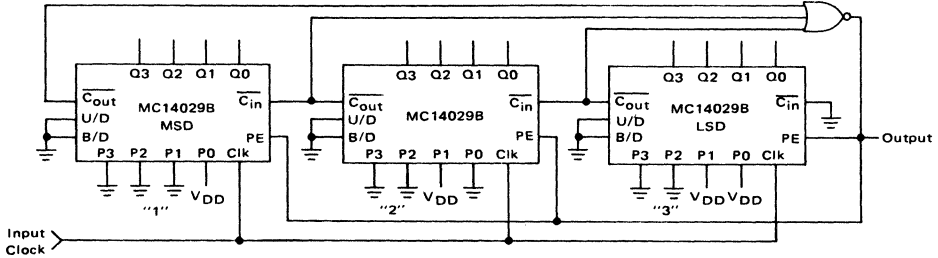


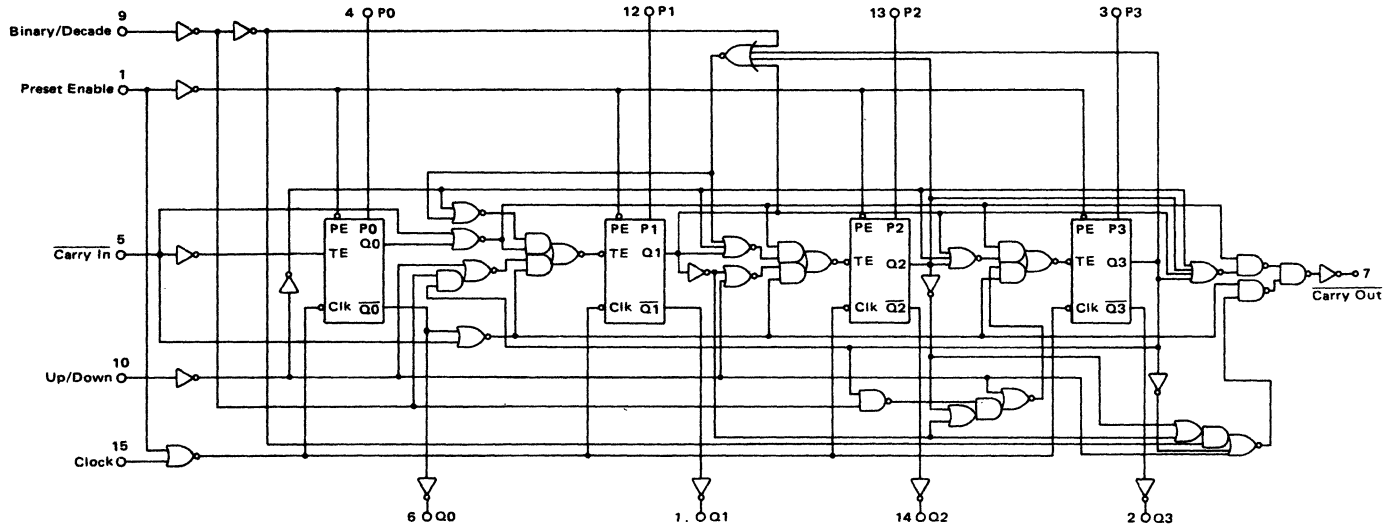
FIGURE 3 – DIVIDE BY N BCD DOWN COUNTER and TIMING DIAGRAM  
(Shown for N = 123)



\* $t_W \cong 900 \text{ ns} @ V_{DD} = 5 \text{ V}$

6

LOGIC DIAGRAM



MC14029B



**MOTOROLA**

**TRIPLE SERIAL ADDERS**

The MC14032B and MC14038B triple serial adders have the clock and carry reset inputs common to all three adders. The carry is added on the positive-going clock transition for the MC14032B, and on the negative-going clock transition for the MC14038B. Typical applications include serial arithmetic units, digital correlators, digital servo control systems, datalink computers, and flight control computers.

- Buffered Outputs
- Single-Phase Clocking
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.
- Pin-for-Pin Replacement for CD4032B and CD4038B.

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

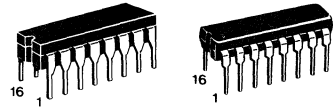
\*Maximum Ratings are those values beyond which damage to the device may occur  
 †Temperature Derating Plastic "P" Package - 12mW/°C from 65°C to 85°C  
 Ceramic "L" Package - 12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**MC14032B  
MC14038B**

**CMOS MSI**  
(LOW-POWER COMPLEMENTARY MOS)  
**TRIPLE SERIAL ADDERS**

Positive Logic - MC14032B  
Negative Logic - MC14038B



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

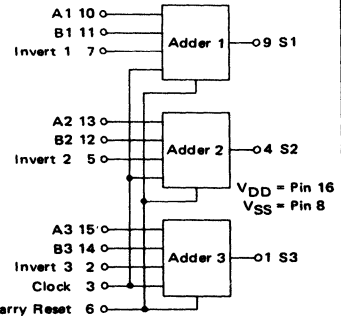
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

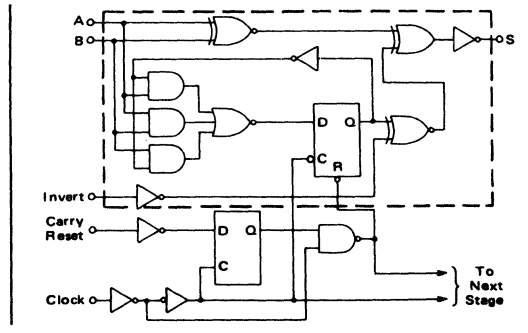
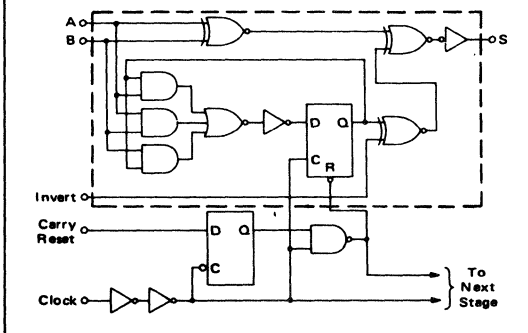
**BLOCK DIAGRAM**



**MC14032B**

**LOGIC DIAGRAMS**  
(ONE SECTION AND COMMON INPUTS SHOWN)

**MC14038B**



# MC14032B•MC14038B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage ·V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA
		10	-0.64	—	-0.51	-0.88	—	-0.36	—	
		15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA
		10	-0.52	—	-0.44	-0.88	—	-0.36	—	
		15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.96 μA/kHz) f + I <sub>DD</sub>						μA	
10	I <sub>T</sub> = (1.93 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (2.8 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

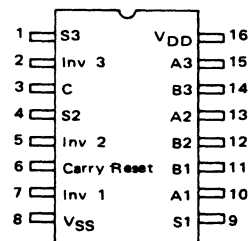
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.003.

### PIN ASSIGNMENT



# MC14032B•MC14038B

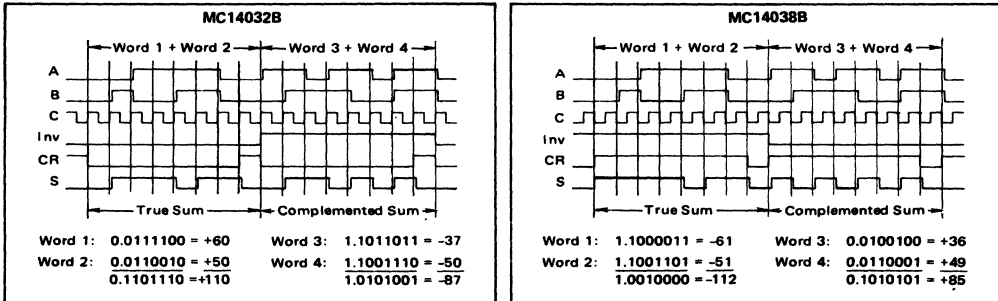
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	Min	Typ #	Max	Unit	
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	ns	
		10	—	50	100		
		15	—	40	80		
		—	—	—	—		
Propagation Delay Time A, B or Invert to Sum $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 195 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 87 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$ Clock to Sum $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 415 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 147 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 110 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	280	1400	ns	
		10	—	120	300		
		15	—	90	230		
	Clock to Sum		5.0	—	500	2400	ns
			10	—	180	600	
			15	—	135	450	
	Input Setup Time	$t_{su}$	5.0	10	-10	—	ns
			10	10	0	—	
			15	10	0	—	
	Clock Pulse Frequency	$f_{cl}$	5.0	—	4.0	1.0	MHz
10			—	10	2.5		
15			—	12	4.0		
Clock Rise and Fall Times	$t_{THL}$ , $t_{TLH}$	5.0	—	—	15	$\mu\text{s}$	
		10	—	—	5		
		15	—	—	4		

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

## TIMING DIAGRAMS



Note: Unused input pins must be connected to either  $V_{DD}$  or  $V_{SS}$ .

# MC14032B•MC14038B

FIGURE 1 – TYPICAL OUTPUT SOURCE TEST CIRCUIT

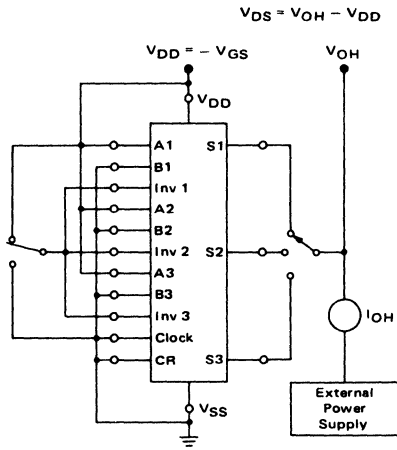


FIGURE 2 – TYPICAL OUTPUT SINK TEST CIRCUIT

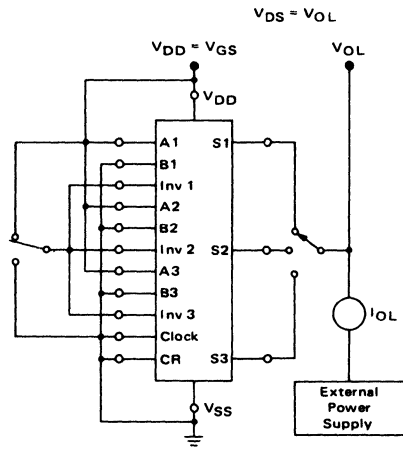
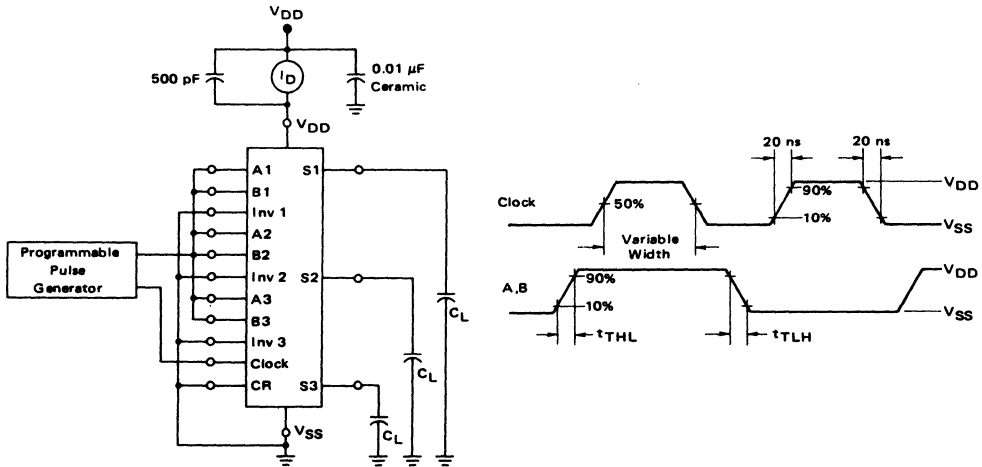
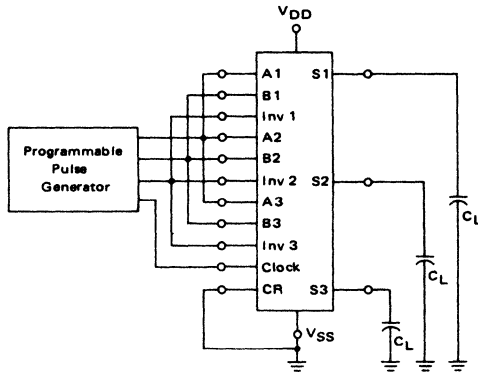


FIGURE 3 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS

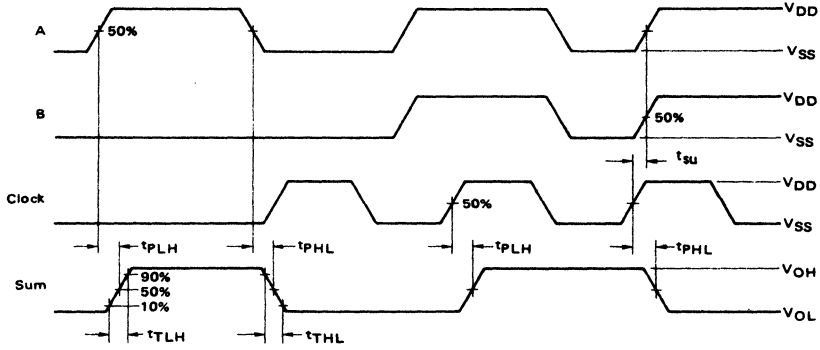


# MC14032B•MC14038B

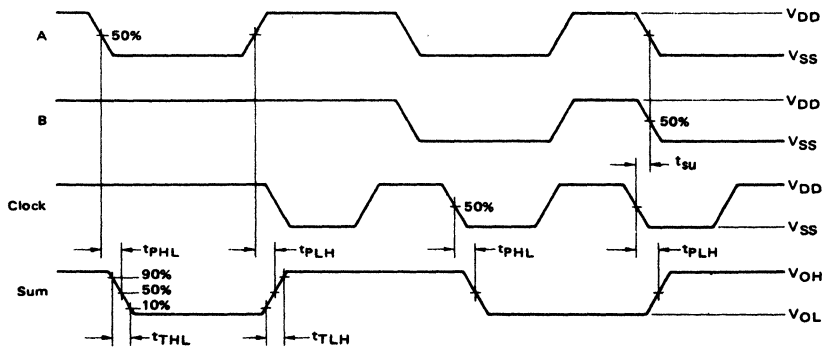
FIGURE 4 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



MC14032B



MC14038B





**MOTOROLA**

# MC14034B

## CMOS LSI

(LOW-POWER COMPLEMENTARY MOS)

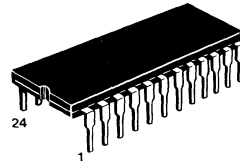
### 8-BIT UNIVERSAL BUS REGISTER

#### 8-BIT UNIVERSAL BUS REGISTER

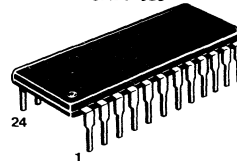
The MC14034B is a bidirectional 8-bit static parallel/serial, input/output bus register. The device contains two sets of input/output lines which allows the bidirectional transfer of data between two buses; the conversion of serial data to parallel form, or the conversion of parallel data to serial form. Additionally the serial data input allows data to be entered shift/right, while shift/left can be accomplished by hard-wiring each parallel output to the previous parallel bit input.

Other useful applications for this device include pseudo-random code generation, sample and hold register, frequency and phase-comparator, address or buffer register, and serial/parallel input/output conversions.

- Bidirectional Parallel Data Input
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.
- Pin-for-Pin Replacement for CD4034B.



L SUFFIX  
CERAMIC PACKAGE  
CASE 623



P SUFFIX  
PLASTIC PACKAGE  
CASE 709

#### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

#### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

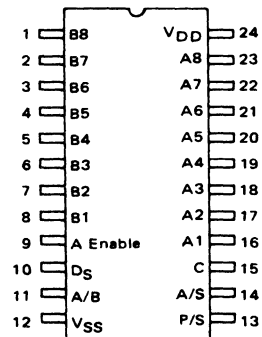
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

#### PIN ASSIGNMENT





# MC14034B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	Vdc
		10	–	0.05	–	0	0.05	–	0.05	
		15	–	0.05	–	0	0.05	–	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	Vdc
		10	9.95	–	9.95	10	–	9.95	–	
		15	14.95	–	14.95	15	–	14.95	–	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	–	1.5	–	2.25	1.5	–	1.5	Vdc
		10	–	3.0	–	4.50	3.0	–	3.0	
		15	–	4.0	–	6.75	4.0	–	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	–	3.5	2.75	–	3.5	–	Vdc
		10	7.0	–	7.0	5.50	–	7.0	–	
		15	11.0	–	11.0	8.25	–	11.0	–	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	–1.2	–	–1.0	–1.7	–	–0.7	–	mA <sub>dc</sub>
		5.0	–0.25	–	–0.2	–0.36	–	–0.14	–	
		10	–0.62	–	–0.5	–0.9	–	–0.35	–	
	Sink I <sub>OL</sub>	5.0	0.64	–	0.51	0.88	–	0.36	–	mA <sub>dc</sub>
		10	1.6	–	1.3	2.25	–	0.9	–	
		15	4.2	–	3.4	8.8	–	2.4	–	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	–1.0	–	–0.8	–1.7	–	–0.6	–	mA <sub>dc</sub>
		5.0	–0.2	–	–0.16	–0.36	–	–0.12	–	
		10	–0.5	–	–0.4	–0.9	–	–0.3	–	
	Sink I <sub>OL</sub>	5.0	0.52	–	0.44	0.88	–	0.36	–	mA <sub>dc</sub>
		10	1.3	–	1.1	2.25	–	0.9	–	
		15	3.6	–	3.0	8.8	–	2.4	–	
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	–	5.0	–	0.010	5.0	–	150	μA <sub>dc</sub>
		10	–	10	–	0.020	10	–	300	
		15	–	20	–	0.030	20	–	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	–	50	–	0.010	50	–	375	μA <sub>dc</sub>
		10	–	100	–	0.020	100	–	750	
		15	–	200	–	0.030	200	–	1500	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (2.2 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>
		10	I <sub>T</sub> = (4.4 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (6.6 μA/kHz) f + I <sub>DD</sub>							
3-State Output Leakage Current (AL Device)	I <sub>TL</sub>	15	–	±0.1	–	±0.0001	±0.1	–	±3.0	μA <sub>dc</sub>
3-State Output Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	–	±1.0	–	±0.0001	±1.0	–	±7.5	μA <sub>dc</sub>

\*T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{tk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> – V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14034B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>d</sub> c	Min	Typ #	Max	Unit
Output Rise Time A or B t <sub>TLH</sub> = (3.0 ns/pF) C <sub>L</sub> + 30 ns t <sub>TLH</sub> = (1.5 ns/pF) C <sub>L</sub> + 15 ns t <sub>TLH</sub> = (1.1 ns/pF) C <sub>L</sub> + 10 ns	t <sub>TLH</sub>	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time A or B t <sub>FHL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>FHL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>FHL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>FHL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time A (B) Synchronous Parallel Data Input, B (A) Parallel Data Output t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 440 ns t <sub>PHL</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 172 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 120 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	525 205 145	1050 410 290	ns
Propagation Delay Time A (B) Asynchronous Parallel Data Input B (A) Parallel Data Output t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 420 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 147 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 105 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	505 180 130	1010 360 260	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	340 140 110	170 70 55	— — —	ns
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	2.5 6.0 8.0	1.2 3.0 4.0	MHz
Clock Pulse Rise	t <sub>TLH</sub> , t <sub>FHL</sub>	5.0 10 15	— — —	— — —	15 5 4	μs
A, B Input Setup Time	t <sub>su</sub>	5.0 10 15	100 45 35	35 15 12	— — —	ns
High Level SE, P/S, A/S Pulse Width	t <sub>WH</sub>	5.0 10 15	600 270 200	200 90 80	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

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## TRUTH TABLE

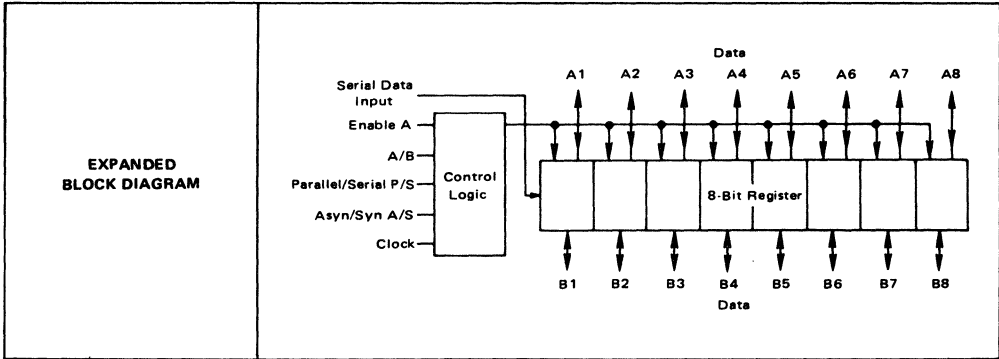
"A" Enable	P/S	A/B	A/S	MODE	OPERATION†
0	0	0	X	Serial	Synchronous Serial data input, A and B parallel data outputs disabled.
0	0	1	X	Serial	Synchronous Serial data input, B-Parallel data output.
0	1	0	0	Parallel	B Synchronous Parallel data inputs, A-Parallel data outputs disabled.
0	1	0	1	Parallel	B Asynchronous Parallel data inputs, A-Parallel data outputs disabled.
0	1	1	0	Parallel	A-Parallel data inputs disabled, B-Parallel data outputs.
0	1	1	1	Parallel	A-Parallel data inputs disabled, B-Parallel data outputs.
1	0	0	X	Serial	Synchronous serial data input, A-Parallel data output.
1	0	1	X	Serial	Synchronous serial data input, B-Parallel data output.
1	1	0	0	Parallel	B-Synchronous Parallel data input, A-Parallel data output.
1	1	0	1	Parallel	B-Asynchronous Parallel data input, A-Parallel data output.
1	1	1	0	Parallel	A-Synchronous Parallel data input, B-Parallel data output.
1	1	1	1	Parallel	A-Asynchronous Parallel data input, B-Parallel data output.

X = Don't Care

†Outputs change at positive transition of clock in the serial mode and when the A/S input is low in the parallel mode.

During transfer from parallel to serial operation, A/S should remain low in order to prevent D<sub>S</sub> transfer into flip-flops.

# MC14034B



## OPERATING CHARACTERISTICS

The MC14034B is composed of eight register cells connected in cascade with additional control logic. Each register cell is composed of one "D" master-slave flip-flop with separate internal clocks, and two data transfer gates allowing the data to be transferred bidirectionally from bus A to bus B and from bus B to bus A, and to be memorized. Besides the single phase clock and the serial data inputs, the control logic provides four other features:

**A Enable Input** – When high, this input enables the bus A data lines.

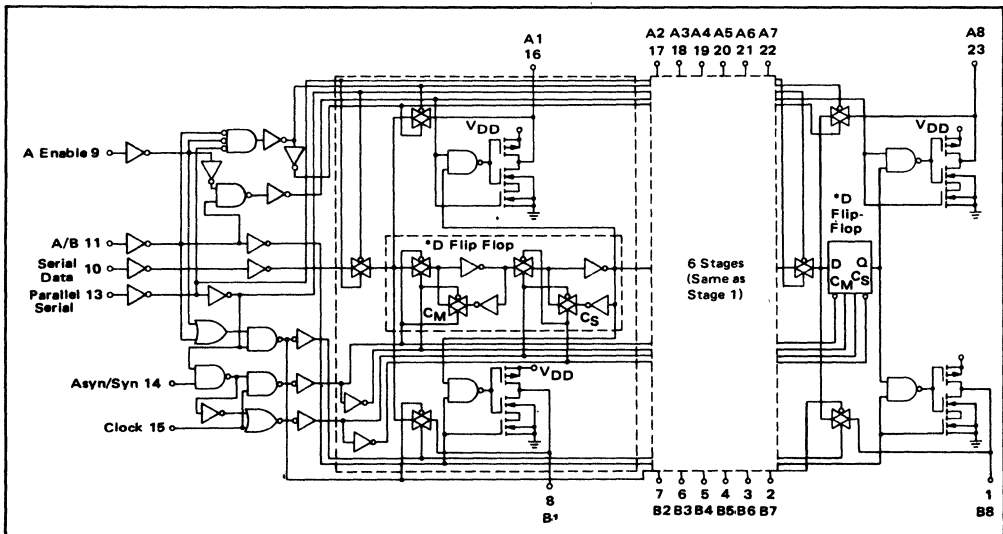
**A/B Input (Data A or B)** – This input controls the direction of data flow: when high, the data flows from

bus A to bus B; when low, the data flows from bus B to bus A.

**P/S Input (Parallel/Serial)** – This input controls the data input mode (parallel or serial). When high, the data is transferred to the register in a parallel asynchronous mode or a parallel synchronous mode (positive clock transition). When low, the data is entered into the register in a serial synchronous mode (positive clock transition).

**A/S Input (Asynchronous/Synchronous to the Clock)** – When this input is high, the data is transferred independently from the clock rate; when low, the clock is enabled and the data is transferred synchronously.

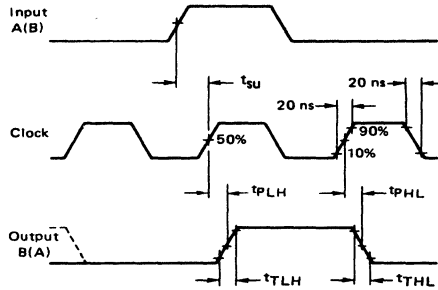
## LOGIC DIAGRAM



6

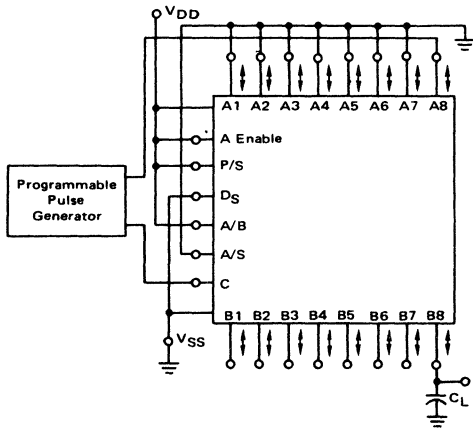
# MC14034B

**FIGURE 1 – PROPAGATION DELAY AND TRANSITION TIMES WAVEFORMS**

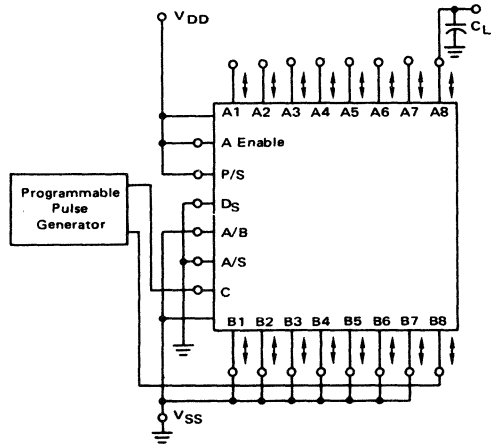


## PROPAGATION AND TRANSITION TIME TEST CIRCUITS

**FIGURE 2 – A SYNCHRONOUS DATA INPUT, B PARALLEL DATA OUTPUT AND SETUP TIME**



**FIGURE 3 – B SYNCHRONOUS DATA INPUT, A PARALLEL DATA OUTPUT AND SETUP TIME**



# MC14034B

FIGURE 4 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS

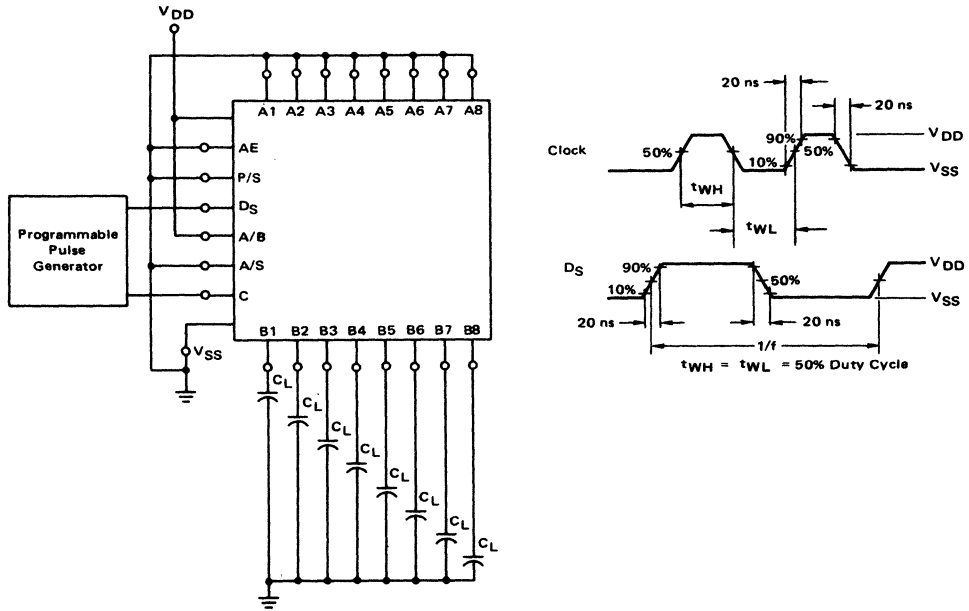
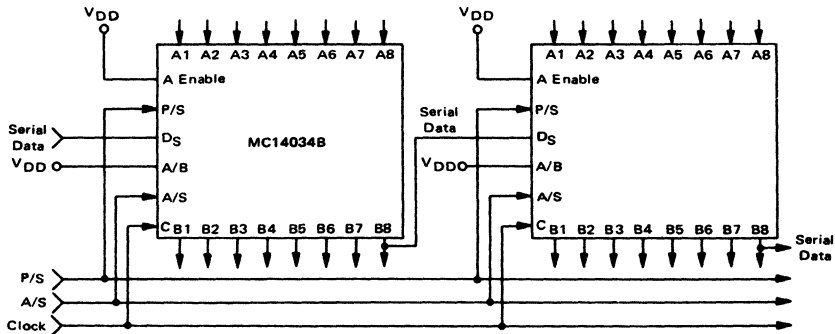


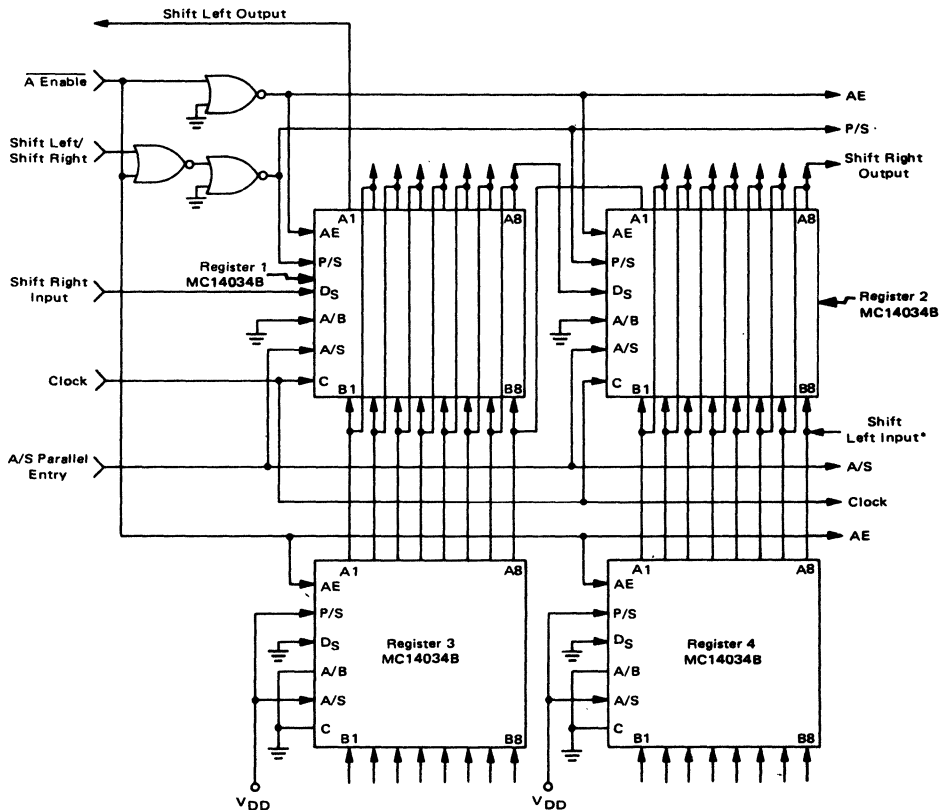
FIGURE 5 – 16-BIT PARALLEL IN/PARALLEL OUT, PARALLEL IN/SERIAL OUT, SERIAL IN/PARALLEL OUT, SERIAL IN/SERIAL OUT REGISTER



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# MC14034B

FIGURE 6 – SHIFT RIGHT/SHIFT LEFT WITH PARALLEL INPUTS



A "High" ("Low") on the Shift Left/Shift Right input allows serial data on the Shift Left Input (Shift Right Input) to enter the register on the positive transition of the clock signal. A "high" on the "A" Enable Input disables the "A" parallel data lines on Reg. 1 and 2 and enables the "A" data lines on registers 3 and 4 and allows parallel data into registers 1 and 2. Other logic schemes may be used in place of registers 3 and 4 for parallel loading.

When parallel inputs are not used Reg. 3 and 4 and associated logic are not required.

\*Shift left input must be disabled during parallel entry.



**MOTOROLA**

**MC14035B**

**4-BIT PARALLEL-IN/PARALLEL-OUT  
SHIFT REGISTER**

The MC14035B 4-bit shift register is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. It consists of a 4-stage clocked serial-shift register with synchronous parallel inputs and buffered parallel outputs. The Parallel/Serial (P/S) input allows serial-right shifting of data or synchronous parallel loading via inputs Dp0 thru Dp3. The True/Complement (T/C) input determines whether the outputs display the Q or  $\bar{Q}$  outputs of the flip-flop stages. J-K logic forms the serial input to the first stage. With the J and K inputs connected together they operate as a serial "D" input.

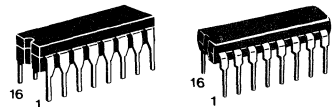
This device may be effectively used for shift-right/shift-left registers, parallel-to-serial/serial-to-parallel conversion, sequence generation, up/down Johnson or ring counters, pseudo-random code generation, frequency and phase comparators, sample and hold registers, etc. . .

- 4-Stage Clocked Serial-Shift Operation
- Synchronous Parallel Loading of all Four Stages
- J-K Serial Inputs on First Stage
- Asynchronous True/Complement Control of all Outputs
- Fully Static Operation
- Asynchronous Master Reset
- Data Transfer Occurs on the Positive-Going Clock Transition
- No Limit on Clock Rise and Fall Times
- All Inputs are Buffered
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT  
PARALLEL-IN/PARALLEL-OUT  
SHIFT REGISTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
i <sub>in</sub> , i <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

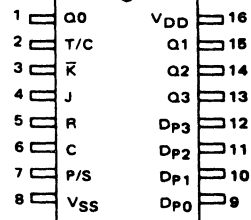
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

INPUTS				t <sub>n</sub> OUTPUT
C	J	K	R	Q0
0	0	0	0	0
0	1	0	0	Q0 (n - 1)
1	0	0	0	$\bar{Q}0$ (n - 1)
1	1	0	0	1
x	x	x	0	Q0 (n - 1)
x	x	x	1	0

x = Don't Care  
P/S = 0 = Serial Mode  
T/C = 1 = True Outputs

**PIN ASSIGNMENT**



# MC14035B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub> "1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.0001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.0 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (2.0 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (3.0 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V/k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



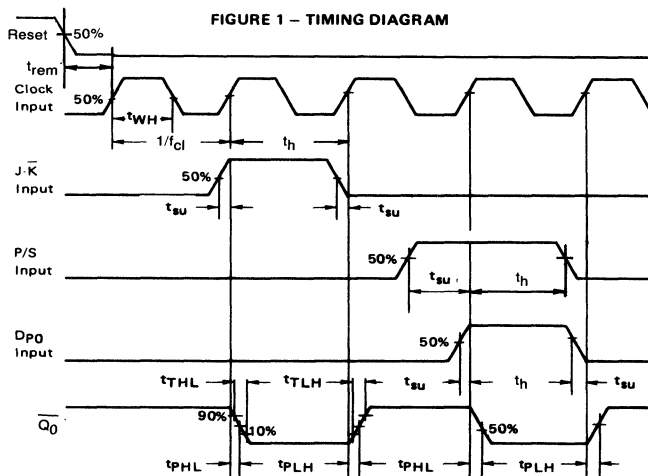
# MC14035B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C. See Figure 1)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time T <sub>TLH</sub> , T <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns T <sub>TLH</sub> , T <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns T <sub>TLH</sub> , T <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 12.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time, Clock or Reset to Q T <sub>PLH</sub> , T <sub>PHL</sub> = (1.75 ns/pF) C <sub>L</sub> + 223 ns T <sub>PLH</sub> , T <sub>PHL</sub> = (0.70 ns/pF) C <sub>L</sub> + 89 ns T <sub>PLH</sub> , T <sub>PHL</sub> = (0.53 ns/pF) C <sub>L</sub> + 67 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	300 130 95	600 260 190	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	335 165 125	135 45 40	— — —	ns
Reset Pulse Width	t <sub>WH</sub>	5.0 10 15	400 175 130	80 40 35	— — —	ns
Reset Removal Time	t <sub>rem</sub>	5.0 10 15	80 30 25	40 15 10	— — —	ns
Clock Pulse Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	No Limit			—
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	2.5 6.0 10	1.2 2.0 3.0	MHz
J-K̄ to Clock Setup Time	t <sub>su</sub>	5.0 10 15	500 200 150	120 50 30	— — —	ns
Clock to J-K̄ Hold Time	t <sub>h</sub>	5.0 10 15	40 30 25	-40 -5 0	— — —	ns
P/S to Clock Setup Time	t <sub>su</sub>	5.0 10 15	500 200 150	25 10 7.5	— — —	ns
Clock to P/S Hold Time	t <sub>h</sub>	5.0 10 15	30 20 20	-70 -20 -10	— — —	ns
D <sub>p</sub> to Clock Setup Time	t <sub>su</sub>	5.0 10 15	500 200 150	90 20 15	— — —	ns
Clock to D <sub>p</sub> Hold Time	t <sub>h</sub>	5.0 10 15	90 40 40	-25 0 5	— — —	ns

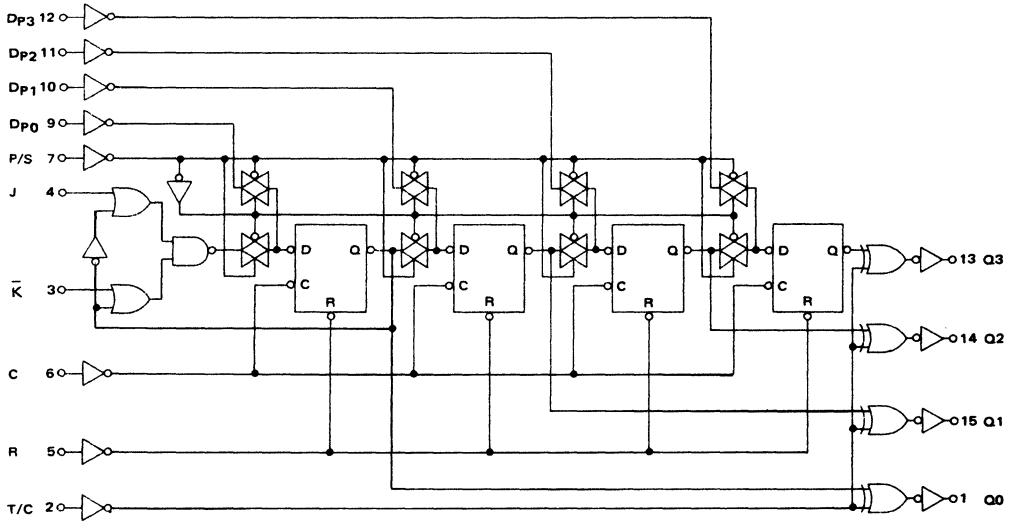
\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

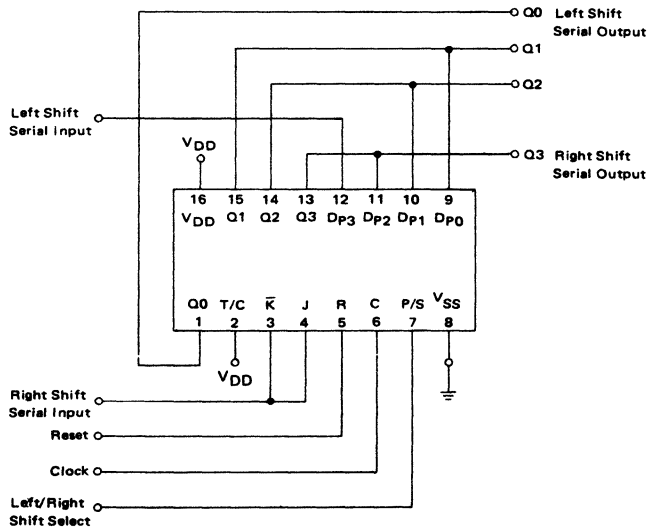


# MC14035B

## LOGIC DIAGRAM



## APPLICATION DIAGRAM Shift Left/Shift Right Register



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**MOTOROLA**

**MC14038B**  
See Page 6-92

**MC14040B**

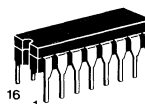
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)  
**12-BIT BINARY COUNTER**

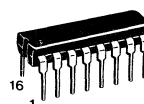
**12-BIT BINARY COUNTER**

The MC14040B 12-stage binary counter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. This part is designed with an input wave shaping circuit and 12 stages of ripple-carry binary counter. The device advances the count on the negative-going edge of the clock pulse. Applications include time delay circuits, counter controls, and frequency-driving circuits.

- Fully Static Operation
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Common Reset Line
- Pin-for-Pin Replacement for CD4040B



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	± 10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

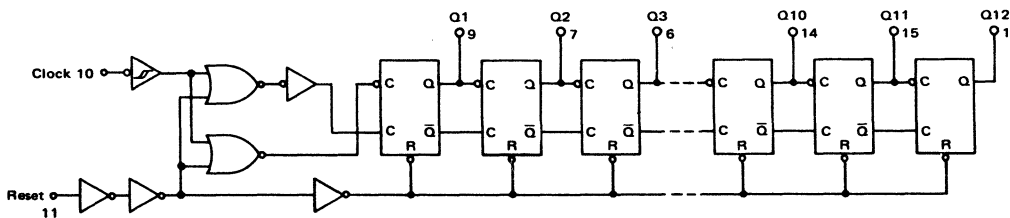
**TRUTH TABLE**

CLOCK	RESET	OUTPUT STATE
	0	No Change
	0	Advance to next state
X	1	All Outputs are low

X = Don't Care

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**LOGIC DIAGRAM**



Q4 = Pin 5    Q7 = Pin 4  
Q5 = Pin 3    Q8 = Pin 13  
Q6 = Pin 2    Q9 = Pin 12  
 $V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

# MC14040B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub> "1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc) "0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
		15	—	±0.3	—	±0.00001	±0.3	—	±1.0		
		15	—	—	—	5.0	7.5	—	—		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
		15	—	—	—	5.0	7.5	—	—		
		15	—	—	—	5.0	7.5	—	—		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
		—	—	—	—	5.0	7.5	—	—		
		—	—	—	—	5.0	7.5	—	—		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.42 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (1.43 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†To calculate total supply current at loads other than 50 pF-

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

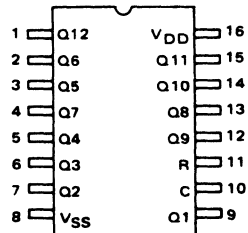
where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C

6

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14040B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dc</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time T <sub>TLH</sub> , T <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns T <sub>PLH</sub> , T <sub>PHL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns T <sub>TLH</sub> , T <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q1 t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 315 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 137 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 95 ns  Clock to Q12 t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 2415 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 867 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 475 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	260 115 80	520 230 160	ns
Propagation Delay Time Reset to Q <sub>n</sub> t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 485 ns t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 182 ns t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 145 ns	t <sub>PHL</sub>	5.0 10 15	— — —	370 155 115	740 310 230	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	385 150 115	140 55 38	— — —	ns
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	2.1 7.0 10.0	1.5 3.5 4.5	MHz
Clock Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	No Limit			ns
Reset Pulse Width	t <sub>WH</sub>	5.0 10 15	960 360 270	320 120 80	— — —	ns
Reset Removal Time	t <sub>rem</sub>	5.0 10 15	130 50 30	65 25 15	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.  
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – POWER DISSIPATION TEST  
CIRCUIT AND WAVEFORM

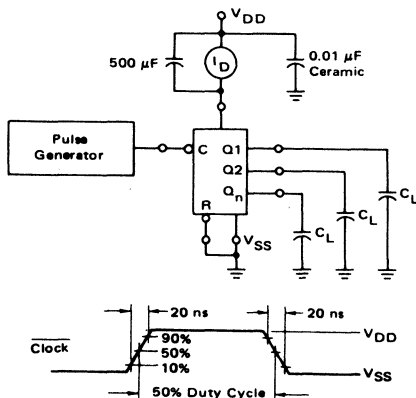
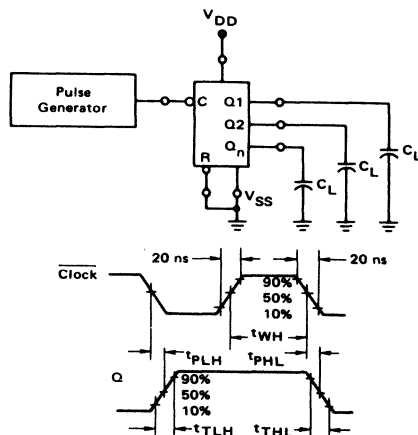
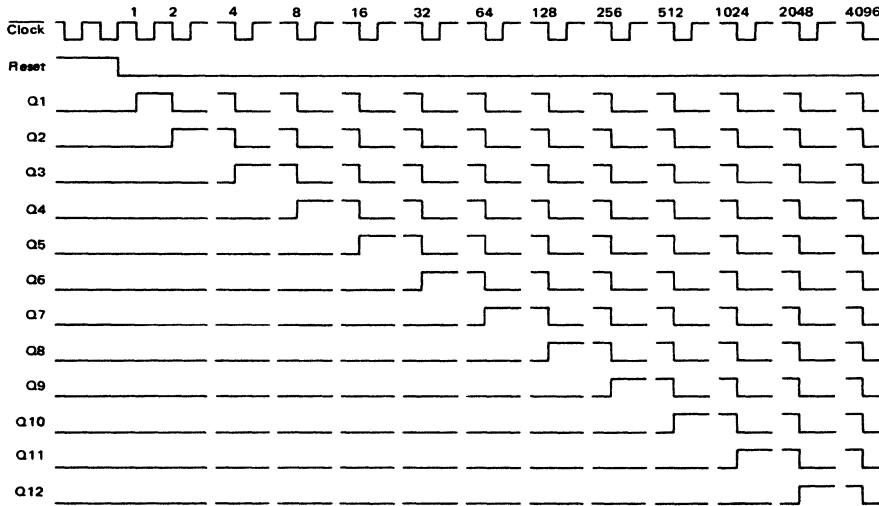


FIGURE 2 – SWITCHING TIME TEST  
CIRCUIT AND WAVEFORMS



# MC14040B

FIGURE 3 – TIMING DIAGRAM

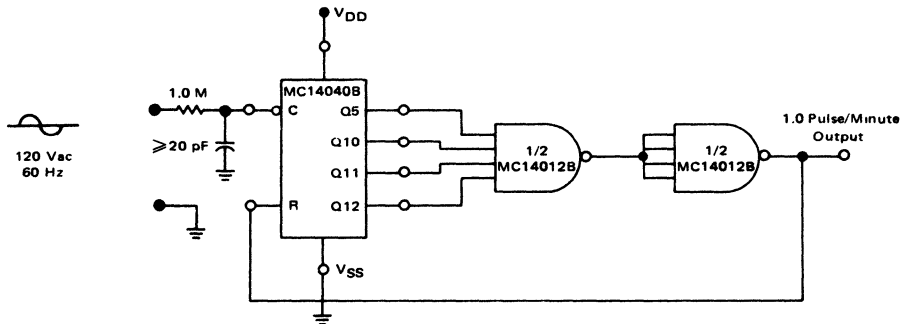


## APPLICATIONS INFORMATION

### TIME-BASE GENERATOR

A 60 Hz sinewave obtained through a 1.0 Megohm resistor connected directly to a standard 120 Vac power line is applied to the clock input of the MC14040B. By selecting outputs Q5, Q10, Q11, and Q12 division by

3600 is accomplished. The MC14012B decodes the counter outputs, produces a single output pulse, and resets the binary counter. The resulting output frequency is 1.0 pulse/minute.





**MOTOROLA**

**MC14042B**

**QUAD TRANSPARENT LATCH**

The MC14042B Quad Transparent Latch is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each latch has a separate data input, but all four latches share a common clock. The clock polarity (high or low) used to strobe data through the latches can be reversed using the polarity input. Information present at the data input is transferred to outputs Q and  $\bar{Q}$  during the clock level which is determined by the polarity input. When the polarity input is in the logic "0" state, data is transferred during the low clock level, and when the polarity input is in the logic "1" state the transfer occurs during the high clock level.

- Buffered Data Inputs
- Common Clock
- Clock Polarity Control
- Q and  $\bar{Q}$  Outputs
- Double Diode Input Protection
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

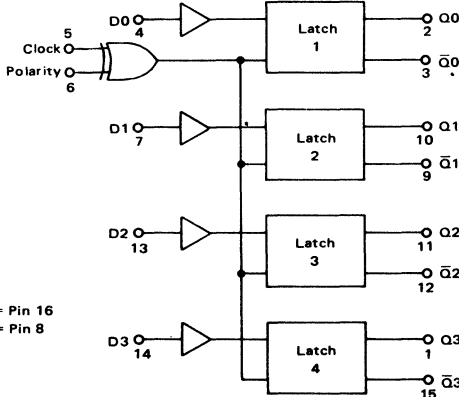
**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
 †Temperature Derating Plastic "P" Package - 12mW/°C from 65°C to 85°C  
 Ceramic "L" Package - 12mW/°C from 100°C to 125°C

6

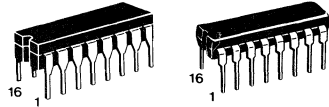
**LOGIC DIAGRAM**



**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**QUAD  
TRANSPARENT LATCH**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620

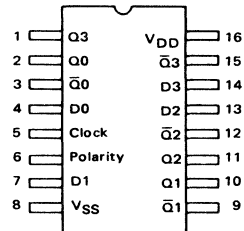
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**PIN ASSIGNMENT**



**TRUTH TABLE**

CLOCK	POLARITY	Q
0	0	Data
1	0	Latch
1	1	Data
0	1	Latch

# MC14042B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	Vdc
		10	–	0.05	–	0	0.05	–	0.05	
		15	–	0.05	–	0	0.05	–	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	Vdc
		10	9.95	–	9.95	10	–	9.95	–	
		15	14.95	–	14.95	15	–	14.95	–	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	–	1.5	–	2.25	1.5	–	1.5	Vdc
		10	–	3.0	–	4.50	3.0	–	3.0	
		15	–	4.0	–	6.75	4.0	–	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	–	3.5	2.75	–	3.5	–	Vdc
		10	7.0	–	7.0	5.50	–	7.0	–	
		15	11.0	–	11.0	8.25	–	11.0	–	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	–3.0	–	–2.4	–4.2	–	–1.7	–	mA <sub>dc</sub>
		10	–0.64	–	–0.51	–0.88	–	–0.36	–	
		15	–1.6	–	–1.3	–2.25	–	–0.9	–	
	Sink I <sub>OL</sub>	5.0	0.64	–	0.51	0.88	–	0.36	–	mA <sub>dc</sub>
		10	1.6	–	1.3	2.25	–	0.9	–	
		15	4.2	–	3.4	8.8	–	2.4	–	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	–2.5	–	–2.1	–4.2	–	–1.7	–	mA <sub>dc</sub>
		10	–0.52	–	–0.44	–0.88	–	–0.36	–	
		15	–1.3	–	–1.1	–2.25	–	–0.9	–	
	Sink I <sub>OL</sub>	5.0	0.52	–	0.44	0.88	–	0.36	–	mA <sub>dc</sub>
		10	1.3	–	1.1	2.25	–	0.9	–	
		15	3.6	–	3.0	8.8	–	2.4	–	
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	–	1.0	–	0.002	1.0	–	30	μA <sub>dc</sub>
		10	–	2.0	–	0.004	2.0	–	60	
		15	–	4.0	–	0.006	4.0	–	120	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	–	4.0	–	0.002	4.0	–	30	μA <sub>dc</sub>
		10	–	8.0	–	0.004	8.0	–	60	
		15	–	16	–	0.006	16	–	120	
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	$I_T = (1.0 \mu\text{A}/\text{kHz}) f + I_{DD}$ $I_T = (2.0 \mu\text{A}/\text{kHz}) f + I_{DD}$ $I_T = (3.0 \mu\text{A}/\text{kHz}) f + I_{DD}$							μA <sub>dc</sub>

\*T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> – V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



# MC14042B

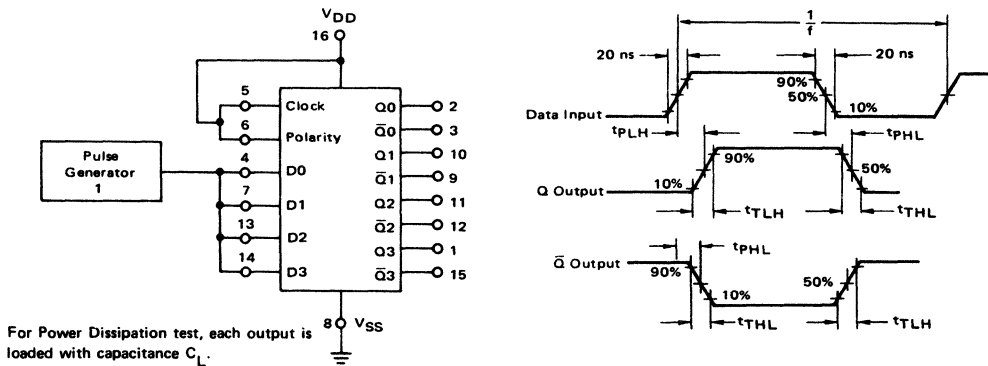
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time, D to Q, $\bar{Q}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 135 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	220 90 60	440 180 120	ns
Propagation Delay Time, Clock to Q, $\bar{Q}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 135 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 25	— — —	220 90 60	440 180 120	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	300 100 80	150 50 40	— — —	ns
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5.0 4.0	$\mu\text{s}$
Hold Time	$t_h$	5.0 10 15	100 50 40	50 25 20	— — —	ns
Setup Time	$t_{su}$	5.0 10 15	50 30 25	0 0 0	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

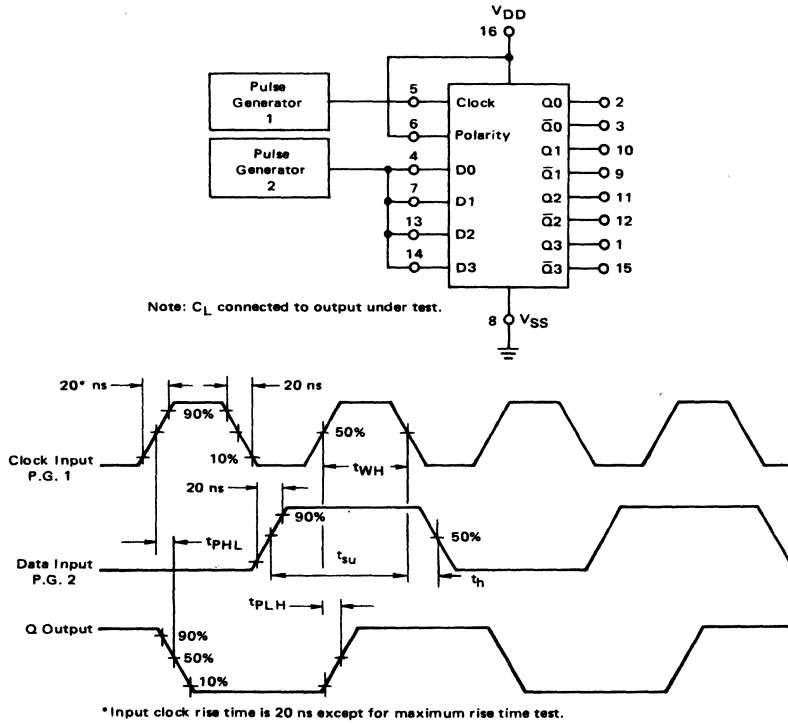
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – AC AND POWER DISSIPATION TEST CIRCUIT AND TIMING DIAGRAM  
(Data to Output)



# MC14042B

**FIGURE 2 – AC TEST CIRCUIT AND TIMING DIAGRAM  
(Clock to Output)**





**MOTOROLA**

**MC14043B**

QUAD "NOR" R-S LATCH

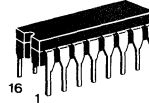
**MC14044B**

QUAD "NAND" R-S LATCH

**CMOS MSI**  
QUAD R-S LATCHES

The MC14043B and MC14044B quad R-S latches are constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each latch has an independent Q output and set and reset inputs. The Q outputs are gated through three-state buffers having a common enable input. The outputs are enabled with a logical "1" or high on the enable input; a logical "0" or low disconnects the latch from the Q outputs, resulting in an open circuit at the Q outputs.

- Double Diode Input Protection
- Three-State Outputs with Common Enable
- Outputs Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Supply Voltage Range = 3.0 Vdc to 18 Vdc



L SUFFIX  
CERAMIC PACKAGE  
CASE 620



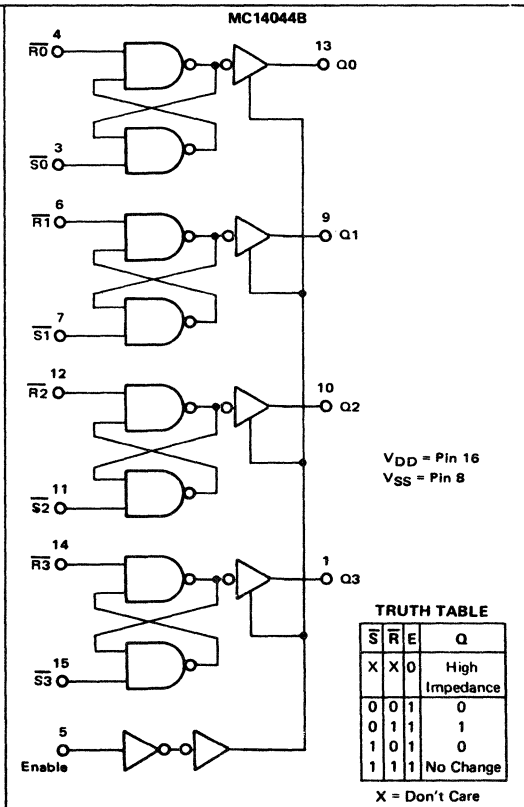
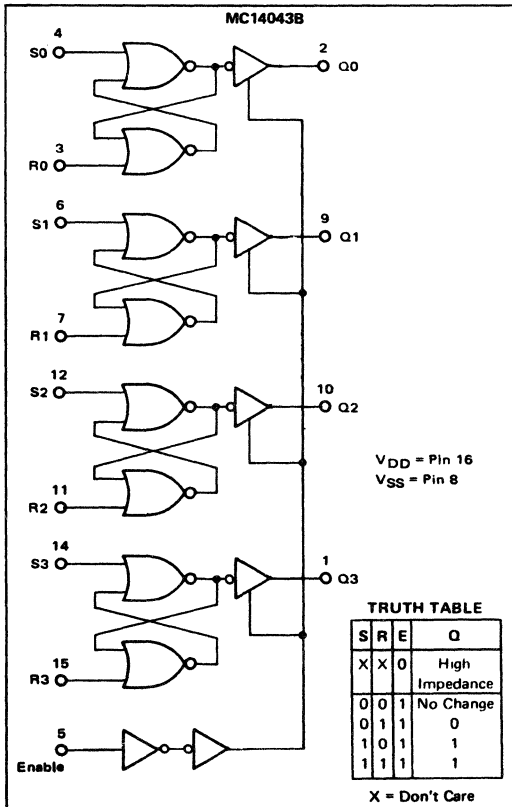
P SUFFIX  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

6



# MC14043B•MC14044B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
		15	-4.2	—	-3.4	-8.8	—	-2.4	—	
		15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	+0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	+0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc
		10	—	2.0	—	0.004	2.0	—	60	
		15	—	4.0	—	0.006	4.0	—	120	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc
		10	—	8.0	—	0.004	8.0	—	60	
		15	—	16	—	0.006	16	—	120	
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all outputs switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (1.15 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (1.73 μA/kHz) f + I <sub>DD</sub>							
Three-State Output Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±3.0	μAdc
Three-State Output Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.0001	±1.0	—	±7.5	μAdc

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14043B•MC14044B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

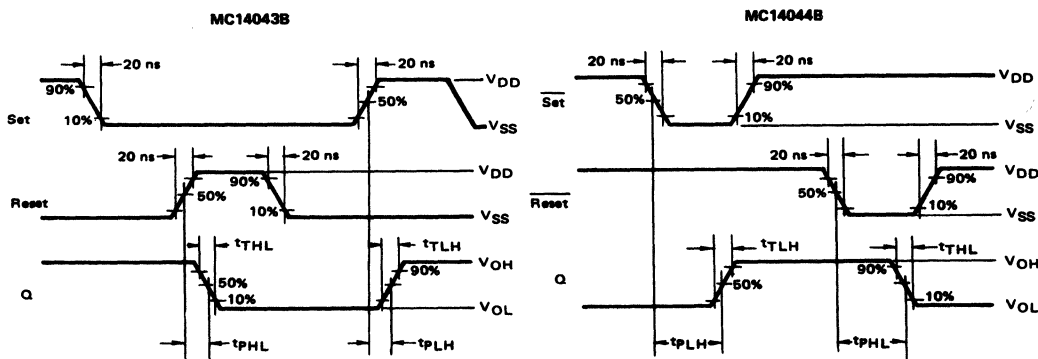
## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise Time t <sub>TLH</sub> = (1.35 ns/pF) C <sub>L</sub> + 32.5 ns t <sub>TLH</sub> = (0.60 ns/pF) C <sub>L</sub> + 20 ns t <sub>TLH</sub> = (0.40 ns/pF) C <sub>L</sub> + 20 ns	t <sub>TLH</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time t <sub>THL</sub> = (1.35 ns/pF) C <sub>L</sub> + 32.5 ns t <sub>THL</sub> = (0.60 ns/pF) C <sub>L</sub> + 20 ns t <sub>THL</sub> = (0.40 ns/pF) C <sub>L</sub> + 20 ns	t <sub>THL</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Propagation Delay Time t <sub>PLH</sub> = (0.90 ns/pF) C <sub>L</sub> + 130 ns t <sub>PLH</sub> = (0.36 ns/pF) C <sub>L</sub> + 57 ns t <sub>PLH</sub> = (0.26 ns/pF) C <sub>L</sub> + 47 ns t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 130 ns t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 57 ns t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 47 ns	t <sub>PLH</sub>	5.0	—	175	350	ns
		10	—	75	175	
		15	—	60	120	
	t <sub>PHL</sub>	5.0	—	175	350	ns
		10	—	75	175	
		15	—	60	120	
Set, Set Pulse Width	t <sub>w</sub>	5.0	200	80	—	ns
		10	100	40	—	
		15	70	30	—	
Reset, Reset Pulse Width	t <sub>w</sub>	5.0	200	80	—	ns
		10	100	40	—	
		15	70	30	—	
Three-State Enable/Disable Delay	t <sub>PLZ</sub>	5.0	—	150	300	ns
	t <sub>PHZ</sub>	10	—	80	160	
	t <sub>PZL</sub>	15	—	55	110	
	t <sub>PZH</sub>	15	—	55	110	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

## AC WAVEFORMS

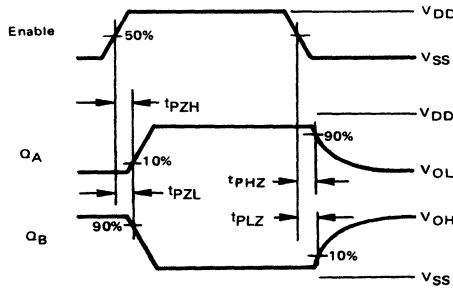
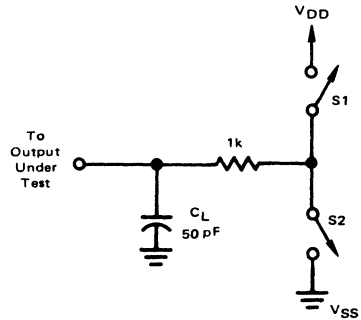


# MC14043B•MC14044B

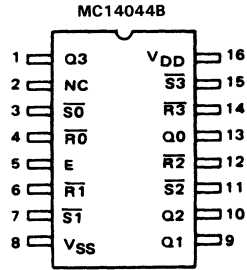
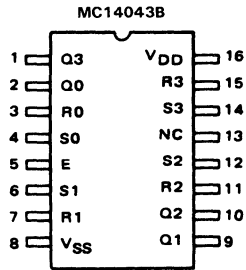
## THREE-STATE ENABLE/DISABLE DELAYS

Set, Reset, Enable, and Switch Conditions for 3-State Tests.

TEST	ENABLE	S1	S2	Q1	MC14043B		MC14044B	
					S	R	$\bar{S}$	$\bar{R}$
$t_{pZH}$		Open	Closed	A	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>
$t_{pZL}$		Closed	Open	B	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>SS</sub>
$t_{pHZ}$		Open	Closed	A	V <sub>DD</sub>	V <sub>SS</sub>	V <sub>SS</sub>	V <sub>DD</sub>
$t_{pLZ}$		Closed	Open	B	V <sub>SS</sub>	V <sub>DD</sub>	V <sub>DD</sub>	V <sub>SS</sub>



### PIN ASSIGNMENT



NC = No Connection

# MC14046B

## PHASE LOCKED LOOP

The MC14046B phase locked loop contains two phase comparators, a voltage-controlled oscillator (VCO), source follower, and zener diode. The comparators have two common signal inputs,  $PCA_{in}$  and  $PCB_{in}$ . Input  $PCA_{in}$  can be used directly coupled to large voltage signals, or indirectly coupled (with a series capacitor) to small voltage signals. The self-bias circuit adjusts small voltage signals in the linear region of the amplifier. Phase comparator 1 (an exclusive OR gate) provides a digital error signal  $PC1_{out}$ , and maintains  $90^\circ$  phase shift at the center frequency between  $PCA_{in}$  and  $PCB_{in}$  signals (both at 50% duty cycle). Phase comparator 2 (with leading edge sensing logic) provides digital error signals,  $PC2_{out}$  and LD, and maintains a  $0^\circ$  phase shift between  $PCA_{in}$  and  $PCB_{in}$  signals (duty cycle is immaterial). The linear VCO produces an output signal  $VCO_{out}$  whose frequency is determined by the voltage of input  $VCO_{in}$  and the capacitor and resistors connected to pins C1A, C1B, R1, and R2. The source-follower output  $SF_{out}$  with an external resistor is used where the  $VCO_{in}$  signal is needed but no loading can be tolerated. The inhibit input  $Inh$ , when high, disables the VCO and source follower to minimize standby power consumption. The zener diode can be used to assist in power supply regulation.

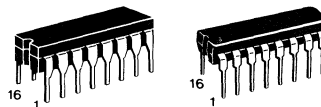
Applications include FM and FSK modulation and demodulation, frequency synthesis and multiplication, frequency discrimination, tone decoding, data synchronization and conditioning, voltage-to-frequency conversion and motor speed control.

- Buffered Outputs Compatible with MHTL and Low-Power TTL
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 to 18 V
- Pin-for-Pin Replacement for CD4046B
- Phase Comparator 1 is an Exclusive Or Gate and is Duty Cycle Limited
- Phase Comparator 2 switches on Rising Edges and is not Duty Cycle Limited

## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

## PHASE-LOCKED LOOP



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

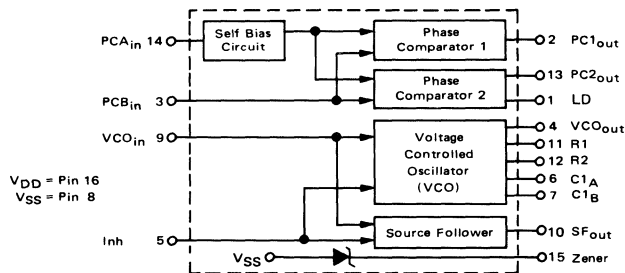
## ORDERING INFORMATION

A Series:  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$   
MC14XXXBAL (Ceramic Package Only)

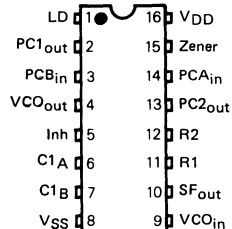
C Series:  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

6

## BLOCK DIAGRAM



## PIN ASSIGNMENT



# MC14046B

## MAXIMUM RATINGS (Voltages referenced to V<sub>SS</sub>)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +18	V <sub>dc</sub>
Input Voltage, All Inputs	V <sub>in</sub>	-0.5 to V <sub>DD</sub> + 0.5	V <sub>dc</sub>
DC Input Current, per Pin	I <sub>in</sub>	±10	mAdc
Operating Temperature Range – AL Device	T <sub>A</sub>	-55 to +125	°C
CL/CP Device		-40 to +85	
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dc</sub>	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	V	
		10	–	0.05	–	0	0.05	–	0.05		
		15	–	0.05	–	0	0.05	–	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	V
			10	9.95	–	9.95	10	–	9.95	–	
			15	14.95	–	14.95	15	–	14.95	–	
Input Voltage <sup>†</sup> (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	V <sub>IL</sub>	5.0	–	1.5	–	2.25	1.5	–	1.5	V	
		10	–	3.0	–	4.50	3.0	–	3.0		
		15	–	4.0	–	6.75	4.0	–	4.0		
	V <sub>O</sub> = 0.5 or 4.5 V) (V <sub>O</sub> = 1.0 or 9.0 V) (V <sub>O</sub> = 1.5 or 13.5 V)	V <sub>IH</sub>	5.0	3.5	–	3.5	2.75	–	3.5	–	V
			10	7.0	–	7.0	5.50	–	7.0	–	
			15	11.0	–	11.0	8.25	–	11.0	–	
Output Drive Current (AL Device)	Source	(V <sub>OH</sub> = 2.5 V)	5.0	-1.2	–	-1.0	-1.7	–	-0.7	–	mA
		(V <sub>OH</sub> = 4.6 V)	5.0	-0.25	–	-0.2	-0.36	–	-0.14	–	
		(V <sub>OH</sub> = 9.5 V)	10	-0.62	–	-0.5	-0.9	–	-0.35	–	
		(V <sub>OH</sub> = 13.5 V)	15	-1.8	–	-1.5	-3.5	–	-1.1	–	
	Sink	(V <sub>OL</sub> = 0.4 V)	5.0	0.64	–	0.51	0.88	–	0.36	–	mA
		(V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	10 15	1.6 4.2	–	1.3 3.4	2.25 8.8	–	0.9 2.4	–	
Output Drive Current (CL/CP Device)	Source	(V <sub>OH</sub> = 2.5 V)	5.0	-1.0	–	-0.8	-1.7	–	-0.6	–	mA
		(V <sub>OH</sub> = 4.6 V)	5.0	-0.2	–	-0.16	-0.36	–	-0.12	–	
		(V <sub>OH</sub> = 9.5 V)	10	-0.5	–	-0.4	-0.9	–	-0.3	–	
		(V <sub>OH</sub> = 13.5 V)	15	-1.4	–	-1.2	-3.5	–	-1.0	–	
	Sink	(V <sub>OL</sub> = 0.4 V)	5.0	0.52	–	0.44	0.88	–	0.36	–	mA
		(V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	10 15	1.3 3.6	–	1.1 3.0	2.25 8.8	–	0.9 2.4	–	
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA	
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA	
Input Capacitance	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF	
Quiescent Current (AL Device) (Per Package) I <sub>nh</sub> = PCA <sub>in</sub> = V <sub>DD</sub> , Zener = VCO <sub>in</sub> = 0 V, PCB <sub>in</sub> = V <sub>DD</sub> or 0 V, I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	5.0	–	0.005	5.0	–	150	μA	
		10	–	10	–	0.010	10	–	300		
		15	–	20	–	0.015	20	–	600		
Quiescent Current (CL/CP Device) (Per Package) I <sub>nh</sub> = PCA <sub>in</sub> = V <sub>DD</sub> , Zener = VCO <sub>in</sub> = 0 V, PCB <sub>in</sub> = V <sub>DD</sub> or 0 V, I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	20	–	0.010	20	–	150	μA	
		10	–	40	–	0.020	40	–	300		
		15	–	80	–	0.040	80	–	600		
Total Supply Current † (I <sub>nh</sub> = "0", f <sub>o</sub> = 10 kHz, C <sub>L</sub> = 50 pF, R <sub>1</sub> = 1 MΩ, R <sub>2</sub> = ∞, R <sub>SF</sub> = ∞, and 50% Duty Cycle)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (1.46 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.91 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (4.37 μA/kHz) f + I <sub>DD</sub>							μA	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†Noise immunity specified for worst-case input combination.

Noise Margin for both "1" and "0" level = 1.0 V<sub>dc</sub> min @ V<sub>DD</sub> = 5.0 V<sub>dc</sub>  
2.0 V<sub>dc</sub> min @ V<sub>DD</sub> = 10 V<sub>dc</sub>  
2.5 V<sub>dc</sub> min @ V<sub>DD</sub> = 15 V<sub>dc</sub>

†To Calculate Total Current in General:

$$I_T \approx 2.2 \times V_{DD} \left( \frac{V_{COin} - 1.65}{R_1} + \frac{V_{DD} - 1.35}{R_2} \right)^{3/4} + 1.6 \times \left( \frac{V_{COin} - 1.65}{R_{SF}} \right)^{3/4} + 1 \times 10^{-3} (C_L + 9) V_{DD} f + 1 \times 10^{-1} V_{DD}^2 \left( \frac{100 - \% \text{ Duty Cycle of PCA}_{in}}{100} \right) + I_Q$$

where: I<sub>T</sub> in μA, C<sub>L</sub> in pF, VCO<sub>in</sub>, V<sub>DD</sub> in V<sub>dc</sub>, f in KHz, and R<sub>1</sub>, R<sub>2</sub>, R<sub>SF</sub> in MΩ, C<sub>L</sub> on VCO<sub>out</sub>.



# MC14046B

## ELECTRICAL CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	Minimum		Typical All Types	Maximum		Units
			AL Device	CL/CP Device		AL Device	CL/CP Device	
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	— — —	180 90 65	350 150 110	400 200 160	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	— — —	100 50 37	175 75 55	200 100 80	ns

### PHASE COMPARATORS 1 and 2

Input Resistance – $PCA_{in}$	$R_{in}$	5.0	1.0	1.0	2.0	—	—	M $\Omega$
		10	0.2	0.2	0.4	—	—	
		15	0.1	0.1	0.2	—	—	
– $PCB_{in}$	$R_{in}$	15	150	15	1500	—	—	M $\Omega$
Minimum Input Sensitivity AC Coupled – $PCA_{in}$ C series = 1000 pF, f = 50 kHz	$V_{in}$	5.0	—	—	200	300	400	mV p-p
10		—	—	400	600	800		
15		—	—	700	1050	1400		
DC Coupled – $PCA_{in}, PCB_{in}$	—	5 to 15	See Noise Immunity					

### VOLTAGE CONTROLLED OSCILLATOR (VCO)

Maximum Frequency ( $VCO_{in} = V_{DD}$ , $C_1 = 50 \text{ pF}$ , $R_1 = 5 \text{ k}\Omega$ , and $R_2 = \infty$ )	$f_{max}$	5.0 10 15	0.50 1.0 1.4	0.35 0.7 1.0	0.70 1.4 1.9	— — —	— — —	MHz
Temperature – Frequency Stability ( $R_2 = \infty$ )	—	5.0 10 15	— — —	— — —	0.12 0.04 0.015	— — —	— — —	%/°C
Linearity ( $R_2 = \infty$ ) ( $VCO_{in} = 2.50 \text{ V} \pm 0.30 \text{ V}$ , $R_1 > 10 \text{ k}\Omega$ ) ( $VCO_{in} = 5.00 \text{ V} \pm 2.50 \text{ V}$ , $R_1 \geq 400 \text{ k}\Omega$ ) ( $VCO_{in} = 7.50 \text{ V} \pm 5.00 \text{ V}$ , $R_1 \geq 1000 \text{ k}\Omega$ )	—	5.0 10 15	— — —	— — —	1 1 1	— — —	— — —	%
Output Duty Cycle	—	5 to 15	—	—	50	—	—	%
Input Resistance – $VCO_{in}$	$R_{in}$	15	150	50	1500	—	—	M $\Omega$

### SOURCE-FOLLOWER

Offset Voltage ( $VCO_{in}$ minus $SF_{out}$ , $R_{SF} > 500 \text{ k}\Omega$ )	—	5.0 10 15	— — —	— — —	1.65 1.65 1.65	2.2 2.2 2.2	2.5 2.5 2.5	V
Linearity ( $VCO_{in} = 2.50 \text{ V} \pm 0.30 \text{ V}$ , $R_{SF} > 50 \text{ k}\Omega$ ) ( $VCO_{in} = 5.00 \text{ V} \pm 2.50 \text{ V}$ , $R_{SF} > 50 \text{ k}\Omega$ ) ( $VCO_{in} = 7.50 \text{ V} \pm 5.00 \text{ V}$ , $R_{SF} > 50 \text{ k}\Omega$ )	—	5.0 10 15	— — —	— — —	0.1 0.6 0.8	— — —	— — —	%

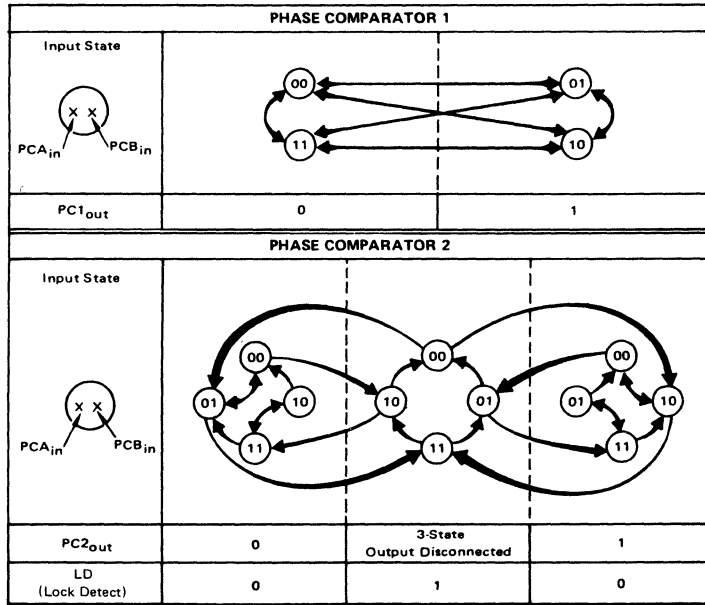
### ZENER DIODE

Zener Voltage ( $I_z = 50 \mu\text{A}$ )	$V_Z$	—	6.7	6.3	7.0	7.3	7.7	V
Dynamic Resistance ( $I_z = 1 \text{ mA}$ )	$R_Z$	—	—	—	100	—	—	$\Omega$

\*The formula given is for the typical characteristics only.

# MC14046B

FIGURE 1 – PHASE COMPARATORS STATE DIAGRAMS



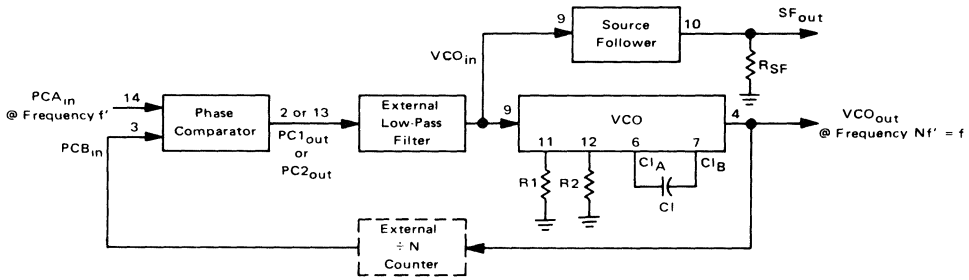
Refer to Waveforms in Figure 3.

FIGURE 2 – DESIGN INFORMATION

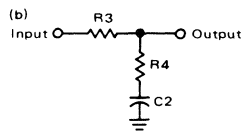
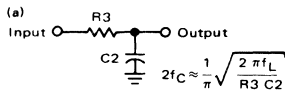
Characteristic	Using Phase Comparator 1	Using Phase Comparator 2
No signal on input PCA <sub>in</sub> .	VCO in PLL system adjusts to center frequency (f <sub>0</sub> ).	VCO in PLL system adjusts to minimum frequency (f <sub>min</sub> ).
Phase angle between PCA <sub>in</sub> and PCB <sub>in</sub> .	90° at center frequency (f <sub>0</sub> ), approaching 0° and 180° at ends of lock range (2f <sub>L</sub> ).	Always 0° in lock (positive rising edges).
Locks on harmonics of center frequency.	Yes	No
Signal input noise rejection.	High	Low
Lock frequency range (2f <sub>L</sub> ).	The frequency range of the input signal on which the loop will stay locked if it was initially in lock. 2f <sub>L</sub> = full VCO frequency range = f <sub>max</sub> - f <sub>min</sub> .	
Capture frequency range (2f <sub>C</sub> ).	The frequency range of the input signal on which the loop will lock if it was initially out of lock.	
	Depends on low-pass filter characteristics (see Figure 3). f <sub>C</sub> < f <sub>L</sub>	f <sub>C</sub> = f <sub>L</sub>
Center frequency (f <sub>0</sub> ).	The frequency of VCO <sub>out</sub> , when VCO <sub>in</sub> = 1/2 V <sub>DD</sub>	
VCO output frequency (f).	$f_{min} = \frac{1}{R_2(C_1 + 32 \text{ pF})} \quad (\text{VCO input} = V_{SS})$ $f_{max} = \frac{1}{R_1(C_1 + 32 \text{ pF})} + f_{min} \quad (\text{VCO input} = V_{DD})$ <p>Where: 10K &lt; R<sub>1</sub> &lt; 1M 10K &lt; R<sub>2</sub> &lt; 1M 100pF &lt; C<sub>1</sub> &lt; .01 μF</p>	
<p>Note: These equations are intended to be a design guide. Since calculated component values may be in error by as much as a factor of 4, laboratory experimentation may be required for fixed designs. Part to part frequency variation with identical passive components is less than ±20%.</p>		

# MC14046B

FIGURE 3 – GENERAL PHASE-LOCKED LOOP CONNECTIONS AND WAVEFORMS



### Typical Low-Pass Filters



Typically:

$$R_4 C_2 = \frac{6N}{f_{\max}} - \frac{N}{2\pi \Delta f}$$

$$(R_3 + 3,000\Omega) C_2 = \frac{100N\Delta f}{f_{\max}^2} - R_4 C_2$$

$$\Delta f = f_{\max} - f_{\min}$$

Note: Sometimes  $R_3$  is split into two series resistors each  $R_3 \div 2$ . A capacitor  $C_C$  is then placed from the midpoint to ground. The value for  $C_C$  should be such that the corner frequency of this network does not significantly affect  $\omega_n$ . In Figure B, the ratio of  $R_3$  to  $R_4$  sets the damping,  $R_4 \approx (0.1)(R_3)$  for optimum results.

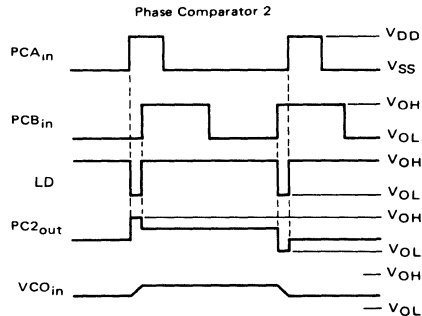
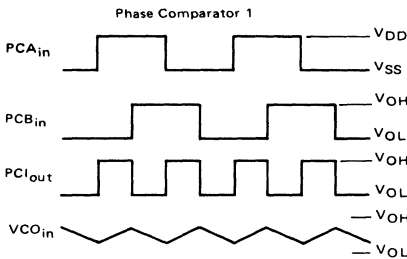
Definitions:  $N$  = Total division ratio in feedback loop  
 $K_\phi = V_{DD}/\pi$  for Phase Comparator 1  
 $K_\phi = V_{DD}/4\pi$  for Phase Comparator 2  
 $K_{VCO} = \frac{2\pi \Delta f_{VCO}}{V_{DD} - 2V}$   
 for a typical design  $\omega_n \approx \frac{2\pi f_r}{10}$  (at phase detector input)  
 $\zeta \approx 0.707$

### LOW-PASS FILTER

Filter A	Filter B
$\omega_n = \sqrt{\frac{K_\phi K_{VCO}}{NR_3 C_2}}$	$\omega_n = \sqrt{\frac{K_\phi K_{VCO}}{NC_2(R_3 + R_4)}}$
$\zeta = \frac{N\omega_n}{2K_\phi K_{VCO}}$	$\zeta = 0.5 \omega_n (R_3 C_2 + \frac{N}{K_\phi K_{VCO}})$
$F(s) = \frac{1}{R_3 C_2 s + 1}$	$F(s) = \frac{R_3 C_2 s + 1}{S(R_3 C_2 + R_4 C_2) + 1}$

6

### Waveforms



Note: for further information, see:

- (1) F. Gardner, "Phase-Lock Techniques", John Wiley and Son, New York, 1966.
- (2) G. S. Moschytz, "Miniature RC Filters Using Phase-Locked Loop", BSTJ, May, 1965.
- (3) Garth Nash, "Phase-Lock Loop Design Fundamentals", AN-535, Motorola Inc.
- (4) A. B. Przedpelski, "Phase-Locked Loop Design Articles", AR254, reprinted by Motorola Inc.



**MOTOROLA**

**MC14049UB  
MC14050B**

**HEX BUFFERS**

The MC14049UB hex inverter/buffer and MC14050B non-inverting hex buffer are constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS devices find primary use where low power dissipation and/or high noise immunity is desired. These devices provide logic-level conversion using only one supply voltage,  $V_{DD}$ . The input-signal high level ( $V_{IH}$ ) can exceed the  $V_{DD}$  supply voltage for logic-level conversions. Two TTL/DTL Loads can be driven when the devices are used as CMOS-to-TTL/DTL converters ( $V_{DD} = 5.0\text{ V}$ ,  $V_{OL} \leq 0.4\text{ V}$ ,  $I_{OL} \geq 3.2\text{ mA}$ ). Note that pins 13 and 16 are not connected internally on these devices; consequently connections to these terminals will not affect circuit operation.

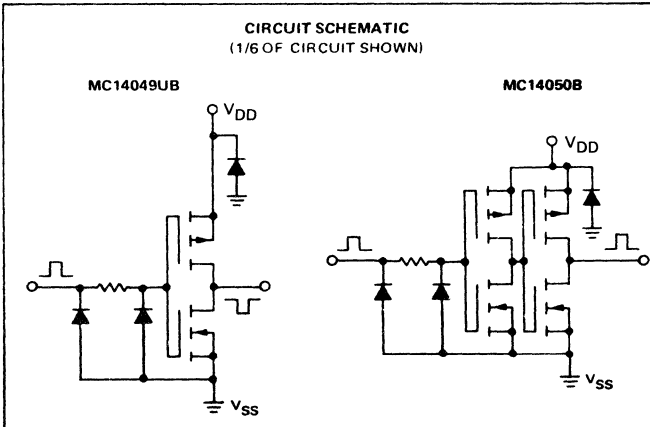
- High Source and Sink Currents
- High-to-Low Level Converter
- Supply Voltage Range = 3.0 V to 18 V
- Meets JEDEC UB Specifications—MC14049UB
- Meets JEDEC B Specification—MC14050B
- $V_{IN}$  can exceed  $V_{DD}$

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}$	Input Voltage (DC or Transient)	-0.5 to +18.0	V
$V_{out}$	Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Pin	$\pm 10$	mA
$I_{out}$	Output Current (DC or Transient), per Pin	+45	mA
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

**CIRCUIT SCHEMATIC**  
(1/6 OF CIRCUIT SHOWN)

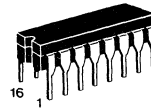


**CMOS SSI**

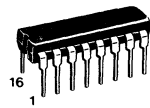
(LOW-POWER COMPLEMENTARY MOS)

**HEX BUFFERS**

Inverting — MC14049UB  
Noninverting — MC14050B



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



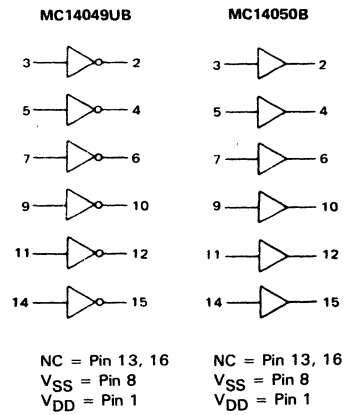
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL or UBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP or UBPCP (Plastic Package)  
MC14XXXBCL or UBCL (Ceramic Package)

**LOGIC DIAGRAMS**



# MC14049UB•MC14050B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage MC14049UB (V <sub>O</sub> = 4.5 Vdc) (V <sub>O</sub> = 9.0 Vdc) (V <sub>O</sub> = 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc
		10	—	2.0	—	4.50	2.0	—	2.0	
		15	—	2.5	—	6.75	2.5	—	2.5	
	"1" Level V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
		10	8.0	—	8.0	5.50	—	8.0	—	
		15	12.5	—	12.5	8.25	—	12.5	—	
Input Voltage MC14050B (V <sub>O</sub> = 0.5 Vdc) (V <sub>O</sub> = 1.0 Vdc) (V <sub>O</sub> = 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11	—	11	8.25	—	11	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.6	—	-1.25	-2.5	—	-0.9	—	mAdc
		10	-1.6	—	-1.3	-2.6	—	-0.9	—	
		15	-4.7	—	-3.75	-1.0	—	-2.7	—	
	Sink I <sub>OL</sub>	5.0	3.75	—	3.2	6.0	—	2.2	—	mAdc
		10	10	—	8.0	16	—	5.6	—	
		15	30	—	24	40	—	17.0	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.5	—	-1.25	-2.5	—	-1.0	—	mAdc
		10	-1.5	—	-1.3	-2.6	—	-1.0	—	
		15	-4.5	—	-3.75	-1.0	—	-3.0	—	
	Sink I <sub>OL</sub>	5.0	3.6	—	3.2	6.0	—	2.6	—	mAdc
		10	9.6	—	8.0	16	—	6.6	—	
		15	28	—	24	40	—	19	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	10	20	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc
		10	—	2.0	—	0.004	2.0	—	60	
		15	—	4.0	—	0.006	4.0	—	120	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc
		10	—	8.0	—	0.004	8.0	—	60	
		15	—	16	—	0.006	16	—	120	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.8 μA/kHz)f + I <sub>DD</sub>							
		10	I <sub>T</sub> = (3.5 μA/kHz)f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (5.3 μA/kHz)f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14049UB•MC14050B

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

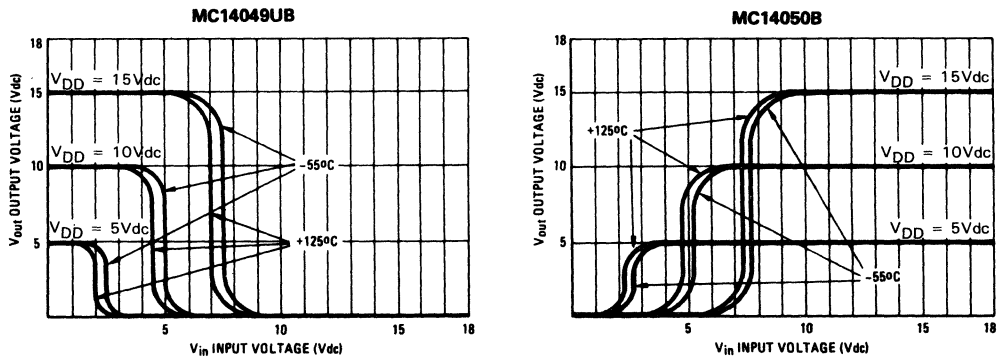
Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ #	Max	Unit
<b>MC14049UB</b>						
Output Rise Time $t_{TLH} = (0.8 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{TLH} = (0.3 \text{ ns/pF}) C_L + 35 \text{ ns}$ $t_{TLH} = (0.27 \text{ ns/pF}) C_L + 26.5 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	100 50 40	160 100 60	ns
Output Fall Time $t_{THL} = (0.3 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.12 \text{ ns/pF}) C_L + 14 \text{ ns}$ $t_{THL} = (0.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	40 20 15	60 40 30	ns
Propagation Delay Time $t_{PLH} = (0.38 \text{ ns/pF}) C_L + 61 \text{ ns}$ $t_{PLH} = (0.20 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{PLH} = (0.11 \text{ ns/pF}) C_L + 24.5 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	80 40 30	120 65 50	ns
Propagation Delay Time $t_{PHL} = (0.38 \text{ ns/pF}) C_L + 11 \text{ ns}$ $t_{PHL} = (0.12 \text{ ns/pF}) C_L + 9 \text{ ns}$ $t_{PHL} = (0.11 \text{ ns/pF}) C_L + 4.5 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	30 15 10	60 30 20	ns
<b>MC14050B</b>						
Output Rise Time $t_{TLH} = (0.7 \text{ ns/pF}) C_L + 65 \text{ ns}$ $t_{TLH} = (0.25 \text{ ns/pF}) C_L + 37.5 \text{ ns}$ $t_{TLH} = (0.2 \text{ ns/pF}) C_L + 30 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	100 50 40	160 80 60	ns
Output Fall Time $t_{THL} = (0.2 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{THL} = (0.06 \text{ ns/pF}) C_L + 17 \text{ ns}$ $t_{THL} = (0.04 \text{ ns/pF}) C_L + 13 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	40 20 15	60 40 30	ns
Propagation Delay Time $t_{PLH} = (0.33 \text{ ns/pF}) C_L + 63.5 \text{ ns}$ $t_{PLH} = (0.19 \text{ ns/pF}) C_L + 30.5 \text{ ns}$ $t_{PLH} = (0.06 \text{ ns/pF}) C_L + 27 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	80 40 30	140 80 60	ns
Propagation Delay Time $t_{PHL} = (0.2 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{PHL} = (0.1 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{PHL} = (0.05 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	40 20 15	80 40 30	ns

\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

6

FIGURE 1 — TYPICAL VOLTAGE TRANSFER CHARACTERISTICS versus TEMPERATURE



# MC14049UB•MC14050B

FIGURE 2 – TYPICAL OUTPUT SOURCE CHARACTERISTICS

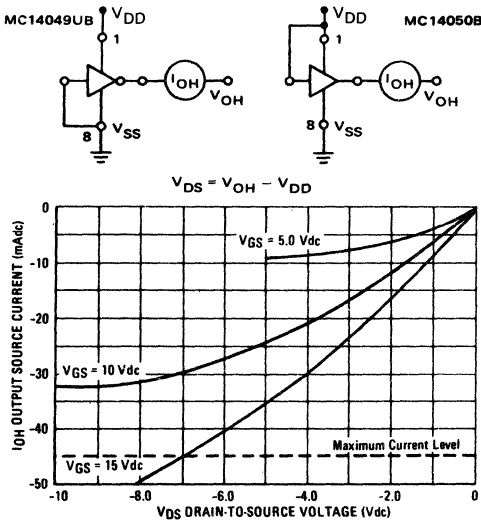


FIGURE 3 – TYPICAL OUTPUT SINK CHARACTERISTICS

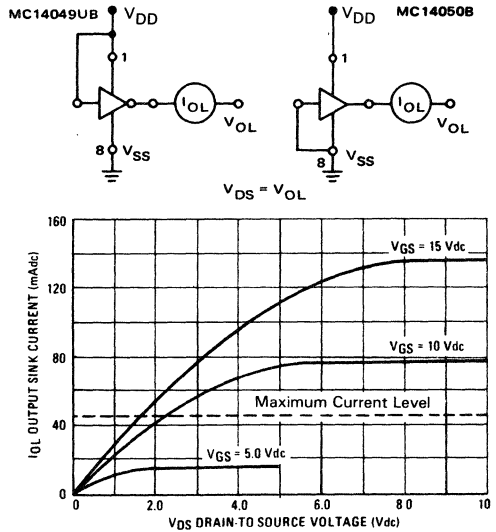
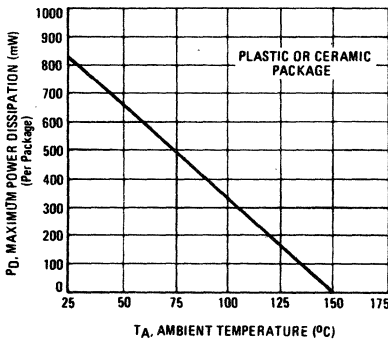


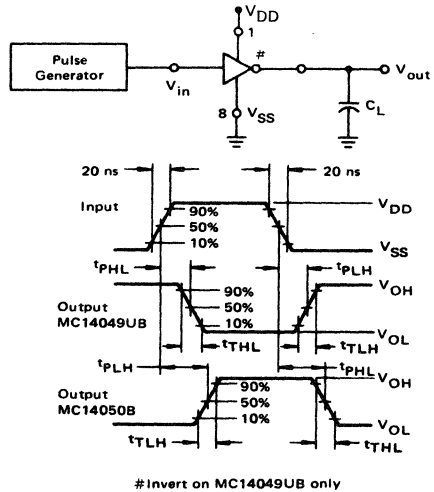
FIGURE 4 – AMBIENT TEMPERATURE POWER DERATING



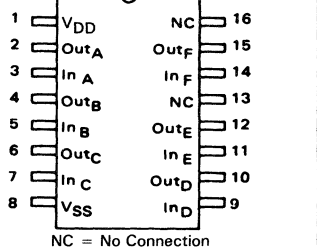
This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields **referenced to the VSS pin, only**. Extra precautions must be taken to avoid applications of any voltage higher than the maximum rated voltages to this high-impedance circuit. For proper operation, the ranges  $V_{SS} \leq V_{in} \leq 18\text{ V}$  and  $V_{SS} \leq V_{out} \leq V_{DD}$  are recommended.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either VSS or VDD). Unused outputs must be left open.

FIGURE 5 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



PIN ASSIGNMENT



NC = No Connection



**MC14051B  
MC14052B  
MC14053B**

**ANALOG MULTIPLEXERS/DEMULPLEXERS**

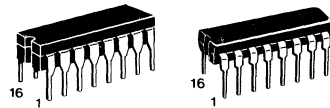
The MC14051B, MC14052B, and MC14053B analog multiplexers are digitally-controlled analog switches. The MC14051B effectively implements an SP8T solid state switch, the MC14052B a DP4T, and the MC14053B a Triple SPDT. All three devices feature low ON impedance and very low OFF leakage current. Control of analog signals up to the complete supply voltage range can be achieved.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Analog Voltage Range ( $V_{DD} - V_{EE}$ ) = 3 to 18 V  
Note:  $V_{EE}$  must be  $\leq V_{SS}$
- Linearized Transfer Characteristics
- Low-Noise  $-12 \text{ nV}/\sqrt{\text{Cycle}}$ ,  $f \geq 1 \text{ kHz}$  typical
- Pin-for-Pin Replacement for CD4051, CD4052, and CD4053
- For 4PDT Switch, See MC14551B
- For Lower  $R_{ON}$ , Use the HC4051, HC4052, or HC4053 High-Speed CMOS Devices

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**ANALOG MULTIPLEXERS/  
DEMULPLEXERS**



CASE 620 L SUFFIX CERAMIC PACKAGE      CASE 648 P SUFFIX PLASTIC PACKAGE

**ORDERING INFORMATION**

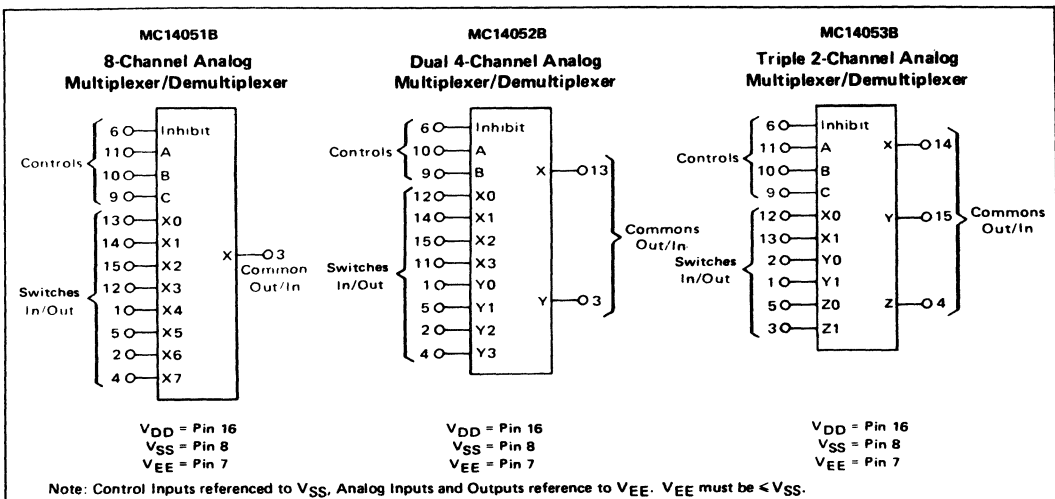
A Series:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$   
MC14XXXBAL (Ceramic Package Only)

C Series:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\***

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage (Referenced to $V_{EE}$ , $V_{SS} \geq V_{EE}$ )	$-0.5$ to $+18.0$	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient) (Referenced to $V_{SS}$ for Control Inputs and $V_{EE}$ for Switch I/O)	$-0.5$ to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Control Pin	$\pm 10$	mA
$I_{sw}$	Switch Through Current	$\pm 25$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	$-65$ to $+150$	$^{\circ}\text{C}$
$T_L$	Lead Temperature (8-Second Soldering)	260	$^{\circ}\text{C}$

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package:  $-12\text{mW}/^{\circ}\text{C}$  from  $65^{\circ}\text{C}$  to  $85^{\circ}\text{C}$   
Ceramic "L" Package:  $-12\text{mW}/^{\circ}\text{C}$  from  $100^{\circ}\text{C}$  to  $125^{\circ}\text{C}$





# MC14051B • MC14052B • MC14053B

## ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub>	Test Conditions	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
				Min	Max	Min	Typ#	Max	Min	Max		
<b>SUPPLY REQUIREMENTS</b> (Voltages Referenced to V <sub>EE</sub> )												
Power Supply Voltage Range	V <sub>DD</sub>	—	V <sub>DD</sub> - 3 ≥ V <sub>SS</sub> ≥ V <sub>EE</sub>	3	18	3	—	18	3	18	V	
Quiescent Current Per Package (AL Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>EE</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	5	—	0.005	5	—	150	μA	
		10		—	10	—	0.010	10	—	300		
		15		—	20	—	0.015	20	—	600		
Quiescent Current Per Package (CL/CP Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>EE</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	20	—	0.005	20	—	150	μA	
		10		—	40	—	0.010	40	—	300		
		15		—	80	—	0.015	80	—	600		
Total Supply Current (Dynamic Plus Quiescent, Per Package)	I <sub>D(AV)</sub>	5 10 15	T <sub>A</sub> = 25°C only (The channel component, (V <sub>in</sub> - V <sub>out</sub> )/R <sub>on</sub> , is not included.)	Typical						$(0.07 \mu\text{A}/\text{kHz})f + I_{DD}$ $(0.20 \mu\text{A}/\text{kHz})f + I_{DD}$ $(0.36 \mu\text{A}/\text{kHz})f + I_{DD}$		μA

## CONTROL INPUTS — INHIBIT, A, B, C (Voltages Referenced to V<sub>SS</sub>)

Low-Level Input Voltage	V <sub>IL</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	—	15	—	2.25	15	—	15	V
		10		—	3.0	—	4.50	3.0	—	3.0	
		15		—	4.0	—	6.75	4.0	—	4.0	
High-Level Input Voltage	V <sub>IH</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	3.5	—	3.5	2.75	—	3.5	—	V
		10		7.0	—	7.0	5.50	—	7.0	—	
		15		11.0	—	11.0	8.25	—	11.0	—	
Input Leakage Current (AL Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Leakage Current (CL/CP Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance	C <sub>in</sub>	—		—	—	—	5.0	7.5	—	—	pF

## SWITCHES IN/OUT AND COMMONS OUT/IN - X, Y, Z (Voltages Referenced to V<sub>EE</sub>)

Recommended Peak-to-Peak Voltage Into or Out of the Switch	V <sub>I/O</sub>	—	Channel On or Off	0	V <sub>DD</sub>	0	—	V <sub>DD</sub>	0	V <sub>DD</sub>	V <sub>PP</sub>
Recommended Static or Dynamic Voltage Across the Switch** (Figure 5)	ΔV <sub>switch</sub>	—	Channel On	0	600	0	—	600	0	300	mV
Output Offset Voltage	V <sub>OO</sub>	—	V <sub>in</sub> = 0 V, No load	—	—	—	10	—	—	—	μV
ON Resistance (AL Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	800	—	250	1050	—	1300	Ω
		10		—	400	—	120	500	—	550	
		15		—	220	—	80	280	—	320	
ON Resistance (CL/CP Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	880	—	250	1050	—	1200	Ω
		10		—	450	—	120	500	—	520	
		15		—	250	—	80	280	—	300	
Δ ON Resistance Between Any Two Channels in the Same Package	ΔR <sub>on</sub>	5		—	70	—	25	70	—	135	Ω
		10		—	50	—	10	50	—	95	
		15		—	45	—	10	45	—	65	
Off-Channel Leakage Current (AL Device) (Figure 10)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±100	—	±0.05	±100	—	±1000	nA
Off-Channel Leakage Current (CL/CP Device) (Figure 10)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±300	—	±0.05	±300	—	±1000	nA
Capacitance, Switch I/O	C <sub>I/O</sub>	—	Inhibit = V <sub>DD</sub>	—	—	—	10	—	—	—	pF
Capacitance, Common O/I	C <sub>O/I</sub>	—	Inhibit = V <sub>DD</sub> (MC14051B) (MC14052B) (MC14053B)	—	—	—	60	—	—	—	pF
		—		—	—	32	—	—	—		
		—		—	—	17	—	—	—		
Capacitance, Feedthrough (Channel Off)	C <sub>I/O</sub>	—	Pins Not Adjacent Pins Adjacent	—	—	—	0.15	—	—	—	pF
		—		—	—	0.47	—	—	—		

\* T<sub>low</sub> = -55°C for AL Device, -40° for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

# Data labeled "Typ" is not to be used for design purposes, but is intended as an indication of the IC's potential performance.

\*\*For voltage drops across the switch (ΔV<sub>switch</sub>) >600 mV (>300 mV at high temperature), excessive V<sub>DD</sub> current may be drawn; i.e. the current out of the switch may contain both V<sub>DD</sub> and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded. (See first page of this data sheet.)

# MC14051B•MC14052B•MC14053B

**ELECTRICAL CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C) (V<sub>EE</sub> ≤ V<sub>SS</sub> unless otherwise indicated)**

Characteristic	Symbol	V <sub>DD</sub> -V <sub>EE</sub> V <sub>dC</sub>	Typ # All Types	Max	Unit
<b>Propagation Delay Times (Figure 6)</b> Switch Input to Switch Output (R <sub>L</sub> = 10 kΩ) <b>MC14051</b> t <sub>PLH</sub> , t <sub>PHL</sub> = (0.17 ns/pF) C <sub>L</sub> + 26.5 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.08 ns/pF) C <sub>L</sub> + 11 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.06 ns/pF) C <sub>L</sub> + 9.0 ns <b>MC14052</b> t <sub>PLH</sub> , t <sub>PHL</sub> = (0.17 ns/pF) C <sub>L</sub> + 21.5 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.08 ns/pF) C <sub>L</sub> + 8.0 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.06 ns/pF) C <sub>L</sub> + 7.0 ns <b>MC14053</b> t <sub>PLH</sub> , t <sub>PHL</sub> = (0.17 ns/pF) C <sub>L</sub> + 16.5 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.08 ns/pF) C <sub>L</sub> + 4.0 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.06 ns/pF) C <sub>L</sub> + 3.0 ns Inhibit to Output (R <sub>L</sub> = 10 kΩ, V <sub>EE</sub> = V <sub>SS</sub> ) Output "1" or "0" to High Impedance, or High Impedance to "1" or "0" Level <b>MC14051B</b>  <b>MC14052B</b>  <b>MC14053B</b>  Control Input to Output (R <sub>L</sub> = 10 kΩ, V <sub>EE</sub> = V <sub>SS</sub> ) <b>MC14051B</b>  <b>MC14052B</b>  <b>MC14053B</b>	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	35	90	ns
		10	15	40	
		15	12	30	
		5.0	30	75	
		10	12	30	
		15	10	25	
	t <sub>PHZ</sub> , t <sub>PLZ</sub> , t <sub>PZH</sub> , t <sub>PZL</sub>	5.0	350	700	ns
		10	170	340	
		15	140	280	
		5.0	300	600	
		10	155	310	
		15	125	250	
t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	360	720	ns	
	10	160	320		
	15	120	240		
	5.0	325	650		
	10	130	260		
	15	90	180		
t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	300	600	ns	
	10	120	240		
	15	80	160		
Second Harmonic Distortion (R <sub>L</sub> = 10kΩ, f = 1kHz) V <sub>in</sub> = 5 V <sub>pp</sub>	—	10	0.07	—	%
Bandwidth (Figure 7) (R <sub>L</sub> = 1 kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> -V <sub>EE</sub> ) p-p, C <sub>L</sub> = 50pF 20 Log $\frac{V_{out}}{V_{in}} = -3$ dB)	BW	10	17	—	MHz
Off Channel Feedthrough Attenuation (Figure 7) R <sub>L</sub> = 1kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> - V <sub>EE</sub> ) p-p f <sub>in</sub> = 4.5 MHz — MC14051B f <sub>in</sub> = 30 MHz — MC14052B f <sub>in</sub> = 55 MHz — MC14053B	—	10	-50	—	dB
Channel Separation (Figure 8) (R <sub>L</sub> = 1 kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> -V <sub>EE</sub> ) p-p, f <sub>in</sub> = 3.0 MHz	—	10	-50	—	dB
Crosstalk, Control Input to Common O/I (Figure 9) (R <sub>1</sub> = 1 kΩ, R <sub>L</sub> = 10 kΩ Control t <sub>T<sub>LH</sub></sub> = t <sub>T<sub>HL</sub></sub> = 20 ns, Inhibit = V <sub>SS</sub> )	—	10	75	—	mV

\*The formulas given are for the typical characteristics only at 25°C.  
 #Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub>, V<sub>EE</sub>, or V<sub>DD</sub>). Unused outputs must be left open.



# MC14051B • MC14052B • MC14053B

FIGURE 1 – SWITCH CIRCUIT SCHEMATIC

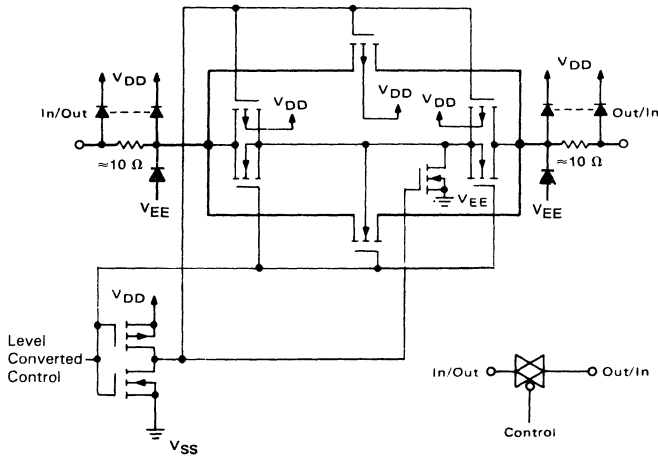
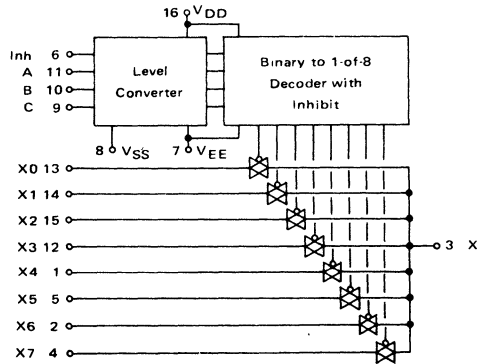


FIGURE 2 – MC14051B FUNCTIONAL DIAGRAM



TRUTH TABLE

Control Inputs		ON Switches				
Inhibit	Select			MC14051B	MC14052B	MC14053B
	C*	B	A			
0	0	0	0	X0	Y0 X0	Z0 Y0 X0
0	0	0	1	X1	Y1 X1	Z0 Y0 X1
0	0	1	0	X2	Y2 X2	Z0 Y1 X0
0	0	1	1	X3	Y3 X3	Z0 Y1 X1
0	1	0	0	X4		Z1 Y0 X0
0	1	0	1	X5		Z1 Y0 X1
0	1	1	0	X6		Z1 Y1 X0
0	1	1	1	X7		Z1 Y1 X1
1	x	x	x	None	None	None

\*Not applicable for MC14052  
x = Don't Care

FIGURE 3 – MC14052B FUNCTIONAL DIAGRAM

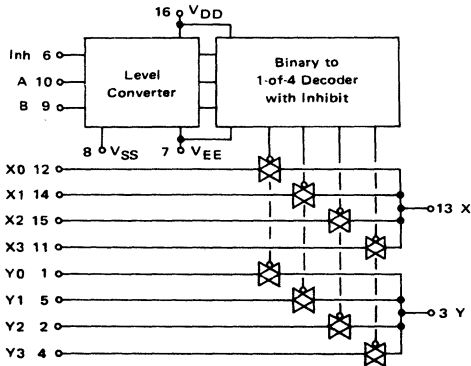
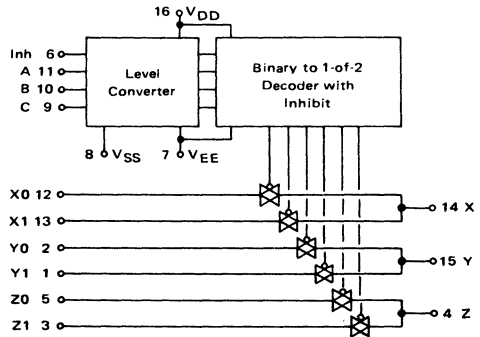


FIGURE 4 – MC14053B FUNCTIONAL DIAGRAM



# MC14051B•MC14052B•MC14053B

## TEST CIRCUITS

FIGURE 5 —  $\Delta V$  ACROSS SWITCH

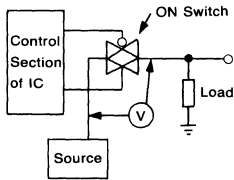


FIGURE 6 — PROPAGATION DELAY TIMES, CONTROL AND INHIBIT TO OUTPUT

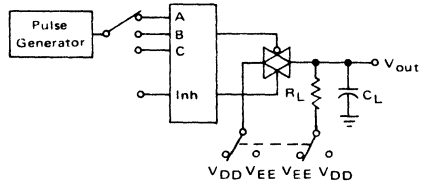


FIGURE 7 — BANDWIDTH AND OFF-CHANNEL FEEDTHROUGH ATTENUATION

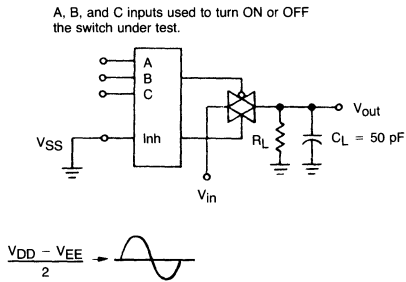


FIGURE 8 — CHANNEL SEPARATION (ADJACENT CHANNELS USED FOR SETUP)

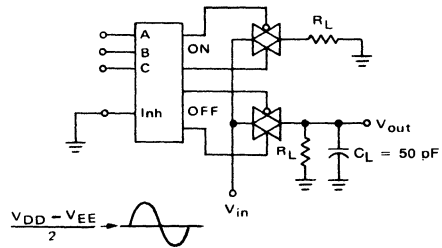


FIGURE 9 — CROSSTALK, CONTROL INPUT TO COMMON O/I

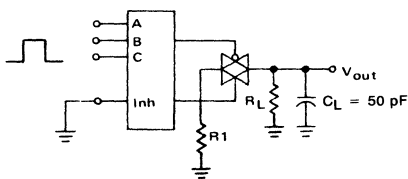
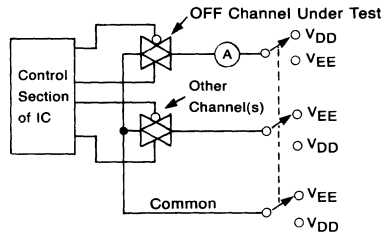
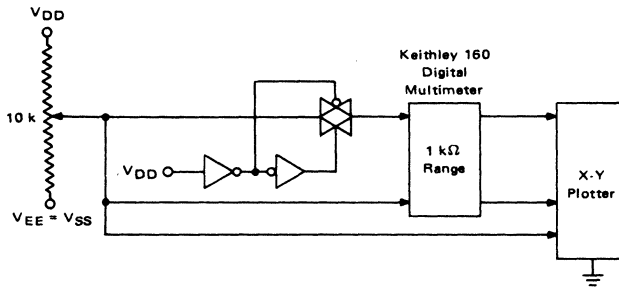


FIGURE 10 — OFF CHANNEL LEAKAGE



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FIGURE 11 – CHANNEL RESISTANCE ( $R_{ON}$ ) TEST CIRCUIT



## TYPICAL RESISTANCE CHARACTERISTICS

FIGURE 12 –  $V_{DD} = 7.5\text{ V}$ ,  $V_{EE} = -7.5\text{ V}$

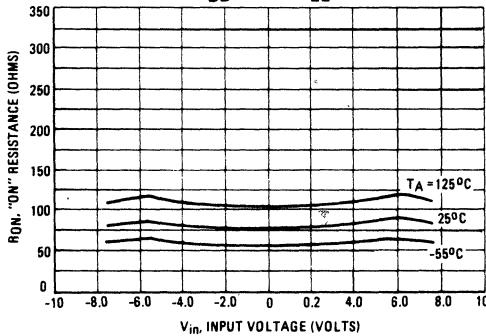


FIGURE 13 –  $V_{DD} = 5.0\text{ V}$ ,  $V_{EE} = -5.0\text{ V}$

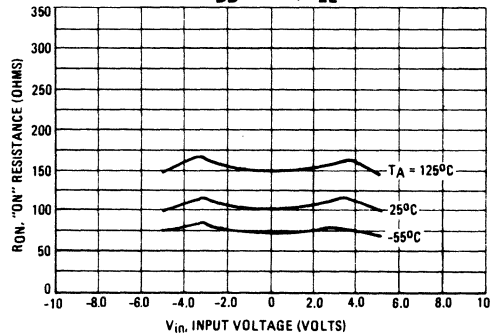


FIGURE 14 –  $V_{DD} = 2.5\text{ V}$ ,  $V_{EE} = -2.5\text{ V}$

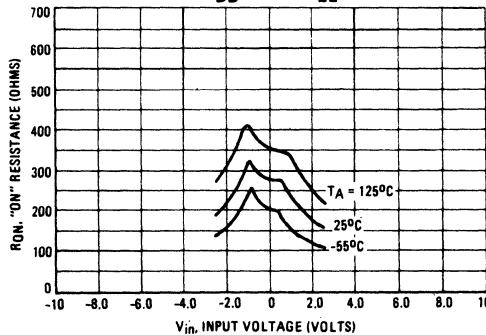
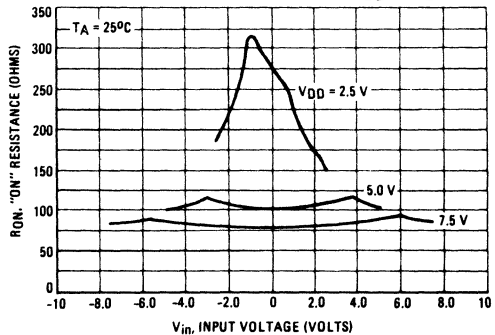
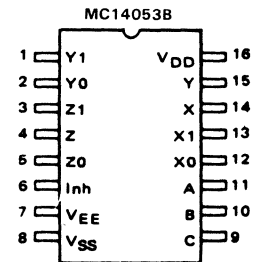
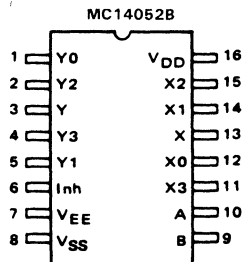
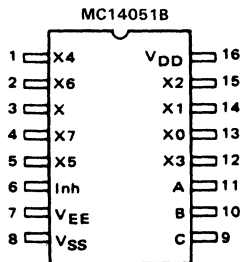


FIGURE 15 – COMPARISON AT  $25^\circ\text{C}$ ,  $V_{DD} = -V_{EE}$



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## PIN ASSIGNMENT



# MC14051B•MC14052B•MC14053B

## APPLICATIONS INFORMATION

Figure A illustrates use of the on-chip level converter detailed in Figures 2, 3, and 4. The 0-to-5 V Digital Control signal is used to directly control a 9  $V_{p-p}$  analog signal.

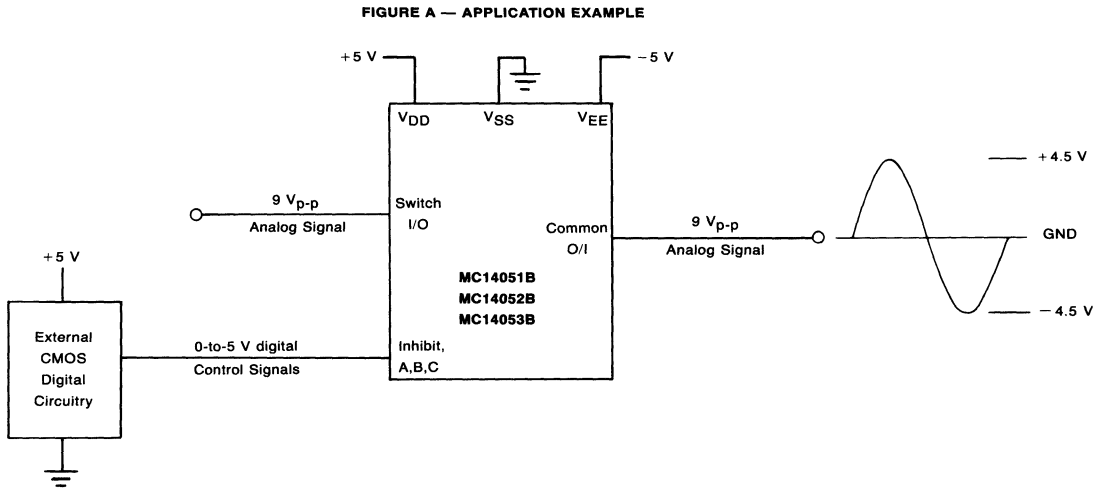
The digital control logic levels are determined by  $V_{DD}$  and  $V_{SS}$ . The  $V_{DD}$  voltage is the logic high voltage; the  $V_{SS}$  voltage is logic low. For the example,  $V_{DD} = +5 V =$  logic high at the control inputs;  $V_{SS} = GND = 0 V =$  logic low.

The maximum analog signal level is determined by  $V_{DD}$  and  $V_{EE}$ . The  $V_{DD}$  voltage determines the maximum recommended peak above  $V_{SS}$ . The  $V_{EE}$  voltage determines the maximum swing below  $V_{SS}$ . For the example,  $V_{DD} - V_{SS} = 5 V$  maximum swing above  $V_{SS}$ ;  $V_{SS} - V_{EE} = 5 V$  maximum swing below  $V_{SS}$ . The example shows a  $\pm 4.5 V$

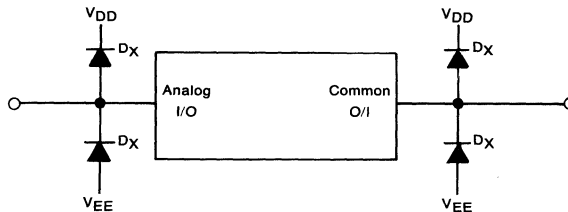
signal which allows a  $\frac{1}{2}$  volt margin at each peak. If voltage transients above  $V_{DD}$  and/or below  $V_{EE}$  are anticipated on the analog channels, external diodes ( $D_x$ ) are recommended as shown in Figure B. These diodes should be small signal types able to absorb the maximum anticipated current surges during clipping.

The *absolute* maximum potential difference between  $V_{DD}$  and  $V_{EE}$  is 18.0 V. Most parameters are specified up to 15 V which is the *recommended* maximum difference between  $V_{DD}$  and  $V_{EE}$ .

Balanced supplies are not required. However,  $V_{SS}$  must be greater than or equal to  $V_{EE}$ . For example,  $V_{DD} = +10 V$ ,  $V_{SS} = +5 V$ , and  $V_{EE} = -3 V$  is acceptable. See the Table below.



**FIGURE B — EXTERNAL GERMANIUM OR SCHOTTKY CLIPPING DIODES**



### POSSIBLE SUPPLY CONNECTIONS

$V_{DD}$ In Volts	$V_{SS}$ In Volts	$V_{EE}$ In Volts	Control Inputs Logic High/Logic Low In Volts	Maximum Analog Signal Range In Volts
+8	0	-8	+8/0	+8 to -8 = 16 $V_{p-p}$
+5	0	-12	+5/0	+5 to -12 = 17 $V_{p-p}$
+5	0	0	+5/0	+5 to 0 = 5 $V_{p-p}$
+5	0	-5	+5/0	+5 to -5 = 10 $V_{p-p}$
+10	+5	-5	+10/+5	+10 to -5 = 15 $V_{p-p}$



# MC14060B

## 14-BIT BINARY COUNTER AND OSCILLATOR

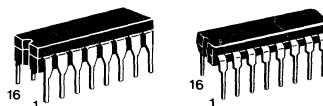
The MC14060B is a 14-stage binary ripple counter with an on-chip oscillator buffer. The oscillator configuration allows design of either RC or crystal oscillator circuits. Also included on the chip is a reset function which places all outputs into the zero state and disables the oscillator. A negative transition on Clock will advance the counter to the next state. Schmitt trigger action on the input line permits very slow input rise and fall times. Applications include time delay circuits, counter controls, and frequency dividing circuits.

- Fully static operation
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Buffered Outputs Available from Stages 4 Through 10 and 12 Through 14
- Common Reset Line
- Pin-for-Pin Replacement for CD4060B

## CMOS MSI

(LOW POWER COMPLEMENTARY MOS)

## 14-BIT BINARY COUNTER AND OSCILLATOR



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

**A Series:** -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

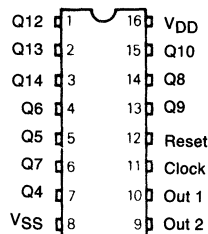
**C Series:** -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### TRUTH TABLE

Clock	RESET	Output State
	L	No Change
	L	Advance to next state
X	H	All Outputs are low

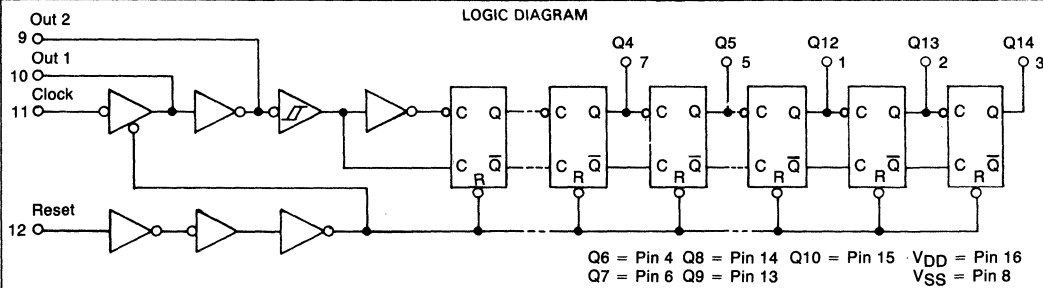
X = Don't Care

### PIN ASSIGNMENT



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### LOGIC DIAGRAM



# MC14060B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	V
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	V
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)  (V <sub>O</sub> = 0.5 or 4.5 V) (V <sub>O</sub> = 1.0 or 9.0 V) (V <sub>O</sub> = 1.5 or 13.5 V)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	V
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	V
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Input Voltage (V <sub>O</sub> = 4.5 Vdc) (For Input 11 and Output 10) (V <sub>O</sub> = 9.0 Vdc) (V <sub>O</sub> = 13.5 Vdc)  (V <sub>O</sub> = 0.5 Vdc) (V <sub>O</sub> = 1.0 Vdc) (V <sub>O</sub> = 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc
		10	—	2.0	—	4.50	2.0	—	2.0	
		15	—	2.5	—	6.75	2.5	—	2.5	
	V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
		10	8.0	—	8.0	5.50	—	8.0	—	
		15	12.5	—	12.5	8.25	—	12.5	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 V) (Except Source (V <sub>OH</sub> = 4.6 V) Pins 9 and 10) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V)  (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA
		10	-0.64	—	-0.51	-0.88	—	-0.36	—	
		15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (Except Source (V <sub>OH</sub> = 4.6 V) Pins 9 and 10) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V)  (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA
		10	-0.52	—	-0.44	-0.88	—	-0.36	—	
		15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.0001	±0.3	—	±1.0	μA
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current** (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.25 μA/kHz) f + I <sub>DD</sub>							μA
		10	I <sub>T</sub> = (0.54 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.



# MC14060B

SWITCHING CHARACTERISTICS ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ #	Max	Unit	
Output Rise Time (Counter Outputs)	$t_{TLH}$	5.0	—	40	200	ns	
		10	—	25	100		
		15	—	20	80		
Output Fall Time (Counter Outputs)	$t_{THL}$	5.0	—	50	200	ns	
		10	—	30	100		
		15	—	20	80		
Propagation Delay Time Clock to Q4	$t_{PLH}$	5.0	—	415	740	ns	
		10	—	175	300		
		15	—	125	200		
	Clock to Q14	$t_{PHL}$	5.0	—	1.5	2.7	$\mu\text{s}$
			10	—	0.7	1.3	
			15	—	0.4	1.0	
Clock Pulse Width	$t_{WH}$	5.0	100	65	—	ns	
		10	40	30	—		
		15	30	20	—		
Clock Pulse Frequency	$f_\phi$	5.0	—	5	3.5	MHz	
		10	—	14	8		
		15	—	17	12		
Clock Rise and Fall Time	$t_{TLH}$ $t_{THL}$	5.0	No Limit			ns	
		10					
		15					
Reset Pulse Width	$t_w$	5.0	120	40	—	ns	
		10	60	15	—		
		15	40	10	—		
Propagation Delay Time Reset to Qn	$t_{PHL}$	5.0	—	170	360	ns	
		10	—	80	160		
		15	—	60	100		

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 — POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

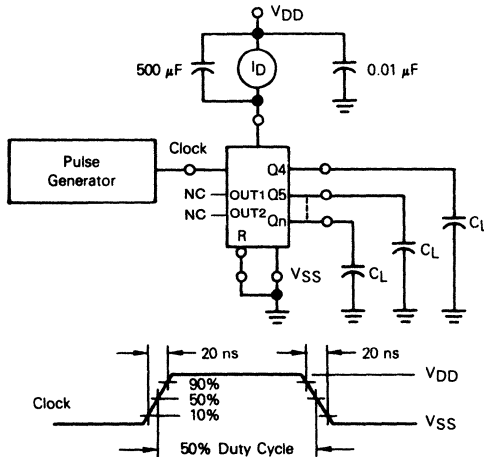
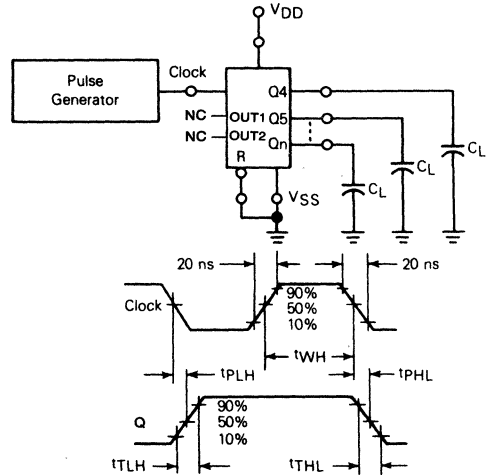
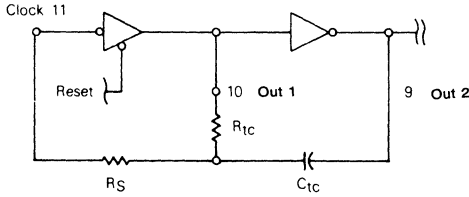


FIGURE 2 — SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



# MC14060B

FIGURE 3 — OSCILLATOR CIRCUIT USING RC CONFIGURATION



$$f \approx \frac{1}{2.3 R_{1C} C_{1C}}$$

if  $1 \text{ kHz} \leq f \leq 100 \text{ kHz}$   
and  $2R_{1C} < R_S < 10R_{1C}$   
(f in Hz, R in ohms, C in farads)

The formula may vary for other frequencies. Recommended maximum value for the resistors is 1 MΩ.

## TYPICAL RC OSCILLATOR CHARACTERISTICS

FIGURE 4 — RC OSCILLATOR STABILITY

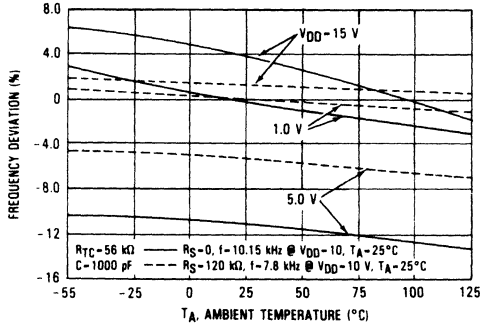


FIGURE 5 — RC OSCILLATOR FREQUENCY AS A FUNCTION OF  $R_{1C}$  AND C

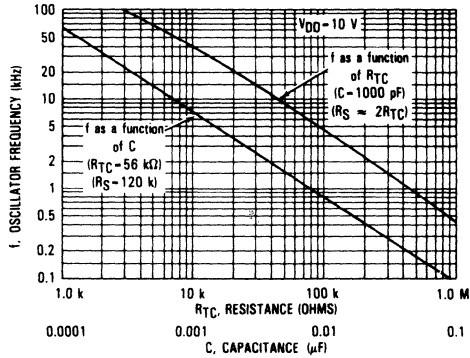


FIGURE 6 — TYPICAL CRYSTAL OSCILLATOR CIRCUIT

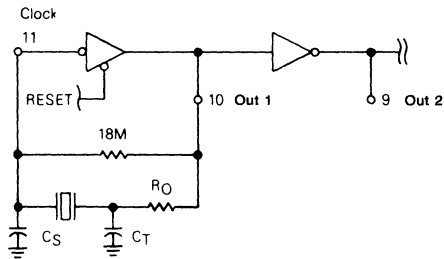


FIGURE 7 — TYPICAL DATA FOR CRYSTAL OSCILLATOR CIRCUIT

Characteristic	500 kHz Circuit	32 kHz Circuit	Unit
<b>Crystal Characteristics</b>			
Resonant Frequency	500	32	kHz
Equivalent Resistance, $R_S$	1.0	6.2	kΩ
<b>External Resistor/Capacitor Values</b>			
$R_0$	47	750	kΩ
$C_T$	82	82	pF
$C_S$	20	20	pF
<b>Frequency Stability</b>			
Frequency Changes as a Function of $V_{DD}$ ( $T_A = 25^\circ\text{C}$ )			
$V_{DD}$ Change from 5.0 V to 10 V	+6.0	+2.0	ppm
$V_{DD}$ Change from 10 V to 15 V	+2.0	+2.0	ppm
Frequency Change as a Function of Temperature ( $V_{DD} = 10 \text{ V}$ )			
$T_A$ Change from $-55^\circ\text{C}$ to $+25^\circ\text{C}$			
Complete Oscillator*	+100	+120	ppm
$T_A$ Change from $+25^\circ\text{C}$ to $+125^\circ\text{C}$			
Complete Oscillator*	-160	-560	ppm

\*Complete oscillator includes crystal, capacitors, and resistors.



**MOTOROLA**

**MC14066B**

**QUAD ANALOG SWITCH/QUAD MULTIPLEXER**

The MC14066B consists of four independent switches capable of controlling either digital or analog signals. This quad bilateral switch is useful in signal gating, chopper, modulator, demodulator and CMOS logic implementation.

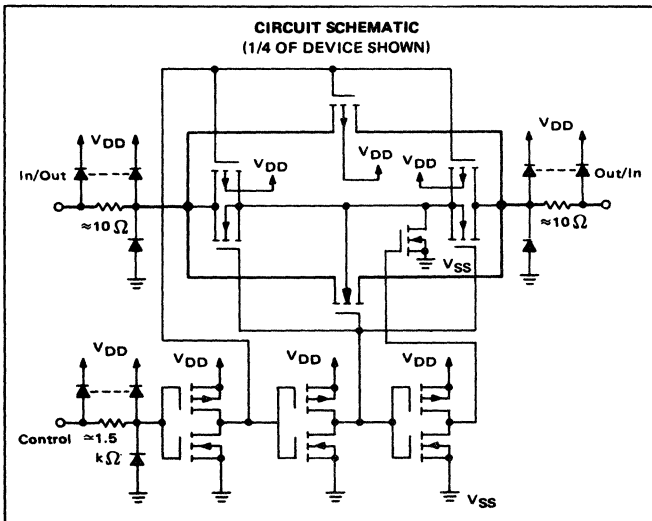
The MC14066B is designed to be pin-for-pin compatible with the MC14016B, but has much lower ON resistance. Input voltage swings as large as the full supply voltage can be controlled via each independent control input.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Linearized Transfer Characteristics
- Low Noise – 12 nV/ $\sqrt{\text{Cycle}}$ ,  $f \geq 1$  kHz typical
- Pin-for-Pin Replacement for CD4016, CD4066, MC14016B
- For Lower  $R_{ON}$ , Use The HC4066 High-Speed CMOS Device

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Control Pin	$\pm 10$	mA
$I_{sw}$	Switch Through Current	$\pm 25$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

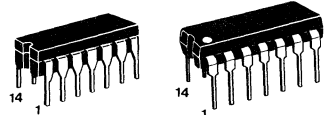
\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C



**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**QUAD ANALOG SWITCH  
QUAD MULTIPLEXER**



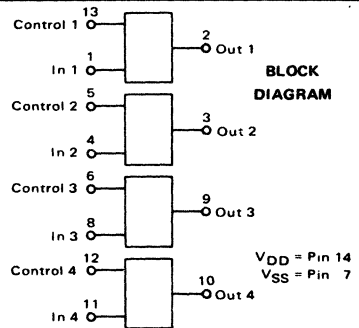
**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

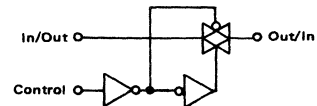
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)



**LOGIC DIAGRAM AND TRUTH TABLE (1/4 OF DEVICE SHOWN)**



Control	Switch
0 = $V_{SS}$	OFF
1 = $V_{DD}$	ON

Logic Diagram Restrictions  
 $V_{SS} \leq V_{in} \leq V_{DD}$   
 $V_{SS} \leq V_{out} \leq V_{DD}$

# MC14066B

## ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub>	Test Conditions	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
				Min	Max	Min	Typ#	Max	Min	Max	

### SUPPLY REQUIREMENTS (Voltages Referenced to V<sub>SS</sub>)

Power Supply Voltage Range	V <sub>DD</sub>	—		3	18	3	—	18	3	18	V
Quiescent Current Per Package (AL Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> ; Switch I/O: V <sub>SS</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> ; and ΔV <sub>switch</sub> ≤ 500 mV**	—	0.25	—	0.005	0.25	—	7.5	μA
		10		—	0.50	—	0.010	0.50	—	15	
		15		—	1.00	—	0.015	1.00	—	30	
Quiescent Current Per Package (CL/CP Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> ; Switch I/O: V <sub>SS</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> ; and ΔV <sub>switch</sub> ≤ 500 mV**	—	1.0	—	0.005	1.0	—	7.5	μA
		10		—	2.0	—	0.010	2.0	—	15	
		15		—	4.0	—	0.015	4.0	—	30	
Total Supply Current (Dynamic Plus Quiescent, Per Package)	I <sub>D(AV)</sub>	5	T <sub>A</sub> = 25°C only (The channel component, (V <sub>in</sub> - V <sub>out</sub> )/R <sub>on1</sub> , is not included.)	Typical { (0.07 μA/kHz)f + I <sub>DD</sub> (0.20 μA/kHz)f + I <sub>DD</sub> (0.36 μA/kHz)f + I <sub>DD</sub>							μA
		10									
		15									

### CONTROL INPUTS (Voltages Referenced to V<sub>SS</sub>)

Low-Level Input Voltage	V <sub>IL</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	—	1.5	—	2.25	1.5	—	1.5	V
		10		—	3.0	—	4.50	3.0	—	3.0	
		15		—	4.0	—	6.75	4.0	—	4.0	
High-Level Input Voltage	V <sub>IH</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	3.5	—	3.5	2.75	—	3.5	—	V
		10		7.0	—	7.0	5.50	—	7.0	—	
		15		11.0	—	11.0	8.25	—	11.0	—	
Input Leakage Current (AL Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Leakage Current (CL/CP Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance	C <sub>in</sub>	—		—	—	—	5.0	7.5	—	—	pF

### SWITCHES IN AND OUT (Voltages Referenced to V<sub>SS</sub>)

Recommended Peak-to-Peak Voltage Into or Out of the Switch	V <sub>I/O</sub>	—	Channel On or Off	0	V <sub>DD</sub>	0	—	V <sub>DD</sub>	0	V <sub>DD</sub>	V <sub>p-p</sub>
Recommended Static or Dynamic Voltage Across the Switch** (Figure 1)	ΔV <sub>switch</sub>	—	Channel On	0	600	0	—	600	0	300	mV
Output Offset Voltage	V <sub>OO</sub>	—	V <sub>in</sub> = 0 V, No load	—	—	—	10	—	—	—	μV
ON Resistance (AL Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	800	—	250	1050	—	1300	Ω
		10		—	400	—	120	500	—	550	
		15		—	220	—	80	280	—	320	
ON Resistance (CL/CP Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	880	—	250	1050	—	1200	Ω
		10		—	450	—	120	500	—	520	
		15		—	250	—	80	280	—	300	
Δ ON Resistance Between Any Two Channels in the Same Package	ΔR <sub>on</sub>	5		—	70	—	25	70	—	135	Ω
		10		—	50	—	10	50	—	95	
		15		—	45	—	10	45	—	65	
Off-Channel Leakage Current (AL Device) (Figure 6)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±100	—	±0.05	±100	—	±1000	nA
Off-Channel Leakage Current (CL/CP Device) (Figure 6)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±300	—	±0.05	±300	—	±1000	nA
Capacitance, Switch I/O	C <sub>I/O</sub>	—	Switch Off	—	—	—	10	15	—	—	pF
Capacitance, Feedthrough (Switch Off)	C <sub>I/O</sub>	—		—	—	—	0.47	—	—	—	pF

\* T<sub>low</sub> = -55°C for AL Device, -40° for CL/CP Device  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

# Data labeled "Typ" is not to be used for design purposes, but is intended as an indication of the IC's potential performance.

\*\*For voltage drops across the switch (ΔV<sub>switch</sub>) >600 mV (>300 mV at high temperature), excessive V<sub>DD</sub> current may be drawn; i.e. the current out of the switch may contain both V<sub>DD</sub> and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded. (See first page of this data sheet.)

# MC14066B

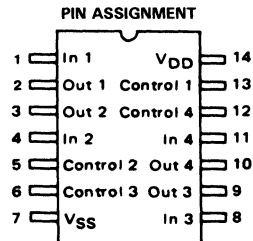
## ELECTRICAL CHARACTERISTICS\* ( $C_L = 50$ pF, $T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ #	Max	Unit
Propagation Delay Times Input to Output ( $R_L = 10$ k $\Omega$ ) $V_{SS} = 0$ Vdc $t_{PLH}, t_{PHL} = (0.17 \text{ ns/pF}) C_L + 15.5 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.08 \text{ ns/pF}) C_L + 6.0 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.06 \text{ ns/pF}) C_L + 4.0 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	20 10 7.0	40 20 15	ns
Control to Output ( $R_L = 1$ k $\Omega$ ) (Figure 2) Output "1" to High Impedance	$t_{PHZ}$	5.0 10 15	— — —	40 35 30	80 70 60	ns
Output "0" to High Impedance	$t_{PLZ}$	5.0 10 15	— — —	40 35 30	80 70 60	ns
High Impedance to Output "1"	$t_{PZH}$	5.0 10 15	— — —	60 20 15	120 40 30	ns
High Impedance to Output "0"	$t_{PZL}$	5.0 10 15	— — —	60 20 15	120 40 30	ns
Second Harmonic Distortion ( $V_{in} = 1.77$ Vdc, RMS Centered @ 0.0 Vdc, $R_L = 10$ k $\Omega$ , $f = 1.0$ kHz) $V_{SS} = -5$ Vdc	—	5.0	—	0.1	—	%
Bandwidth (Switch ON) (Figure 3) ( $R_L = 1$ k $\Omega$ , $20 \text{ Log } \frac{V_{out}}{V_{in}} = -3$ dB, $C_L = 50$ pF, $V_{in} = 5$ V $_{p-p}$ ) $V_{SS} = -5$ Vdc	—	5.0	—	65	—	MHz
Feedthrough Attenuation (Switch OFF) ( $V_{in} = 5$ V $_{p-p}$ , $R_L = 1$ k $\Omega$ , $f_{in} = 1.0$ MHz) (Figure 3) $V_{SS} = -5$ Vdc	—	5.0	—	-50	—	dB
Channel Separation (Figure 4) ( $V_{in} = 5$ V $_{p-p}$ , $R_L = 1$ k $\Omega$ , $f_{in} = 8.0$ MHz) (Switch A ON, Switch B OFF) $V_{SS} = -5$ Vdc	—	5.0	—	-50	—	dB
Crosstalk, Control Input to Signal Output (Figure 5) ( $R_1 = 1$ k $\Omega$ , $R_L = 10$ k $\Omega$ , Control $t_{TLH} = t_{THL} = 20$ ns) $V_{SS} = -5$ Vdc	—	5.0	—	300	—	mV $_{p-p}$

\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .  
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

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This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



## TEST CIRCUITS

FIGURE 1 —  $\Delta V$  ACROSS SWITCH

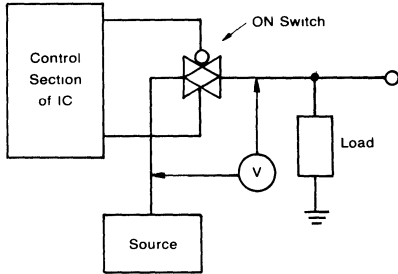


FIGURE 3 — BANDWIDTH AND FEEDTHROUGH ATTENUATION

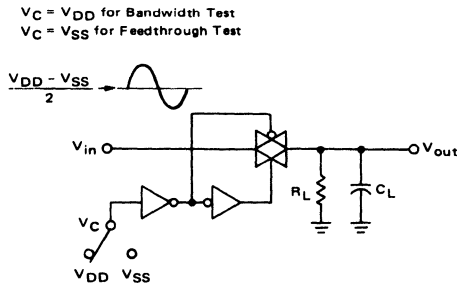


FIGURE 5 — CROSSTALK, CONTROL TO OUTPUT

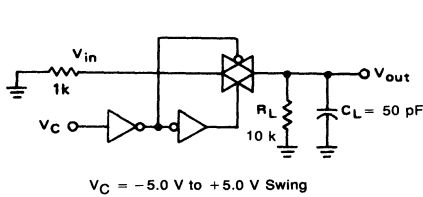


FIGURE 2 — TURN-ON DELAY TIME TEST CIRCUIT AND WAVEFORMS

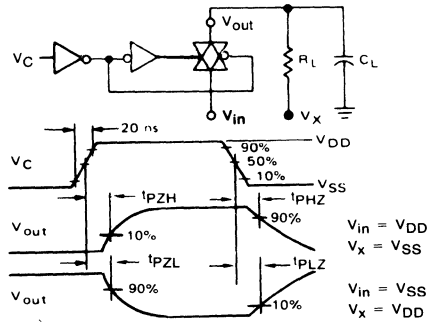


FIGURE 4 — CHANNEL SEPARATION

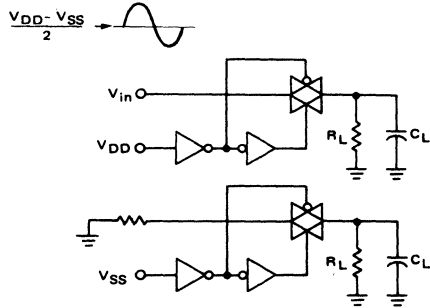
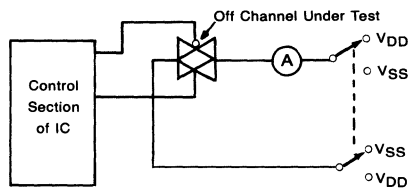
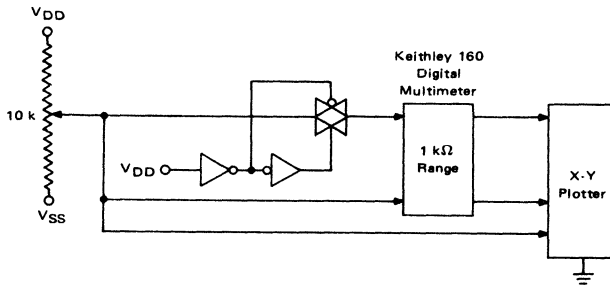


FIGURE 6 — OFF CHANNEL LEAKAGE



# MC14066B

FIGURE 7 – CHANNEL RESISTANCE ( $R_{ON}$ ) TEST CIRCUIT



## TYPICAL RESISTANCE CHARACTERISTICS

FIGURE 8 –  $V_{DD} = 7.5\text{ V}$ ,  $V_{SS} = -7.5\text{ V}$

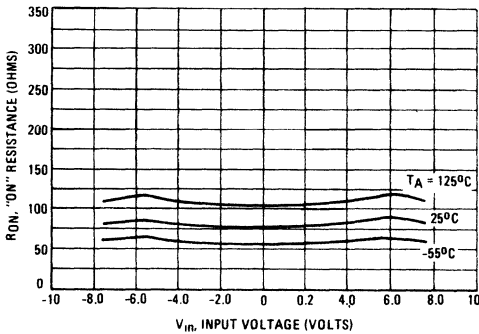


FIGURE 9 –  $V_{DD} = 5.0\text{ V}$ ,  $V_{SS} = -5.0\text{ V}$

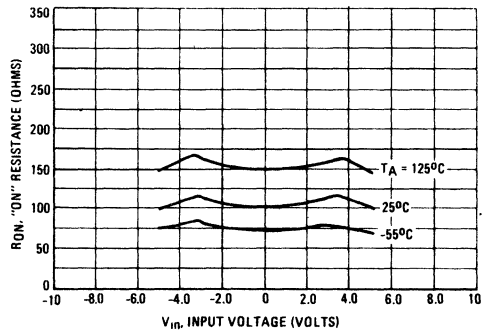


FIGURE 10 –  $V_{DD} = 2.5\text{ V}$ ,  $V_{SS} = -2.5\text{ V}$

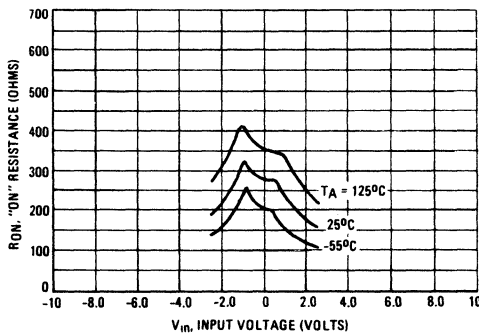
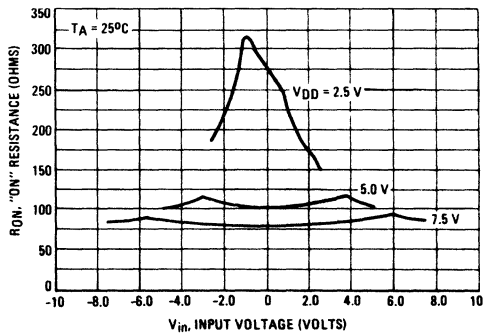


FIGURE 11 – COMPARISON AT 25°C,  $V_{DD} = -V_{SS}$



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# MC14066B

## APPLICATIONS INFORMATION

Figure A illustrates use of the Analog Switch. The 0-to-5 volt digital control signal is used to directly control a 5 volt peak-to-peak analog signal.

The digital control logic levels are determined by  $V_{DD}$  and  $V_{SS}$ . The  $V_{DD}$  voltage is the logic high voltage; the  $V_{SS}$  voltage is logic low. For the example,  $V_{DD} = +5\text{ V} = \text{logic high}$  at the control inputs;  $V_{SS} = \text{GND} = 0\text{ V} = \text{logic low}$ .

The maximum analog signal level is determined by  $V_{DD}$  and  $V_{SS}$ . The analog voltage must not swing higher than  $V_{DD}$  or lower than  $V_{SS}$ .

The example shows a 5 volt peak-to-peak signal which allows no margin at either peak. If voltage transients above  $V_{DD}$  and/or below  $V_{SS}$  are anticipated on the analog channels, external diodes ( $D_x$ ) are recommended as shown in Figure B. These diodes should be small signal types able to absorb the maximum anticipated current surges during clipping.

The *absolute* maximum potential difference between  $V_{DD}$  and  $V_{SS}$  is 18.0 volts. Most parameters are specified up to 15 volts which is the *recommended* maximum difference between  $V_{DD}$  and  $V_{SS}$ .

FIGURE A — APPLICATION EXAMPLE

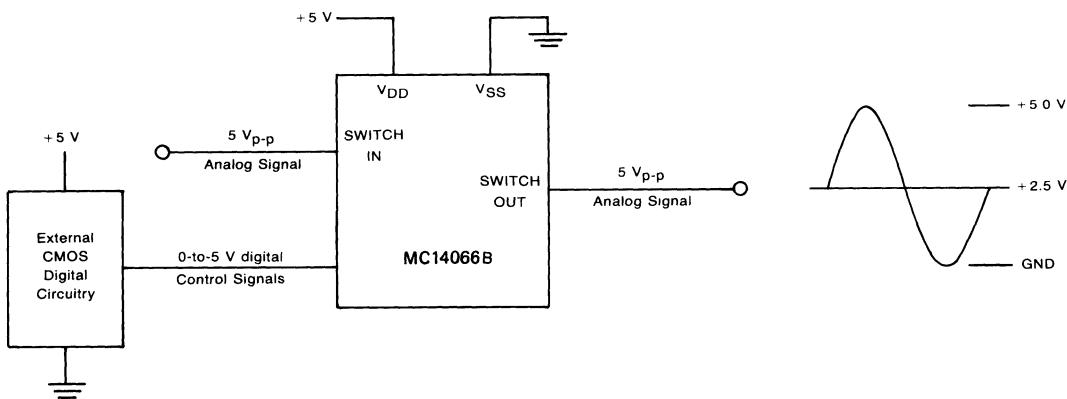
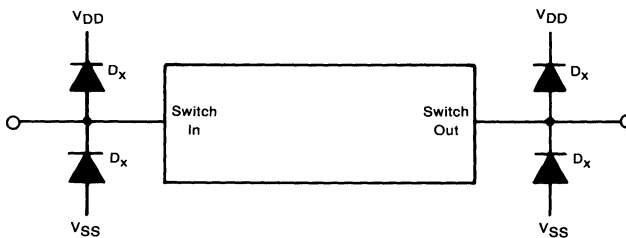


FIGURE B — EXTERNAL GERMANIUM OR SCHOTTKY CLIPPING DIODES







**MOTOROLA**

**MC14067B  
MC14097B**

**ANALOG MULTIPLEXERS/DEMULPLEXERS**

The MC14067 and MC14097 multiplexers/demultiplexers are digitally controlled analog switches featuring low ON resistance and very low leakage current. These devices can be used in either digital or analog applications.

The MC14067 is a 16-channel multiplexer/demultiplexer with an inhibit and four binary control inputs A, B, C, and D. These control inputs select 1-of-16 channels by turning ON the appropriate analog switch (see MC14067 truth table.)

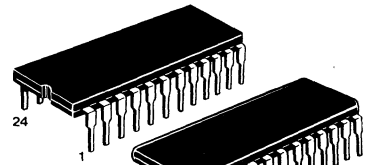
The MC14097 is a differential 8-channel multiplexer/demultiplexer with an inhibit and three binary control inputs A, B, and C. These control inputs select 1 of 8 pairs of channels by turning ON the appropriate analog switches (see MC14097 truth table).

- Low OFF Leakage Current
- Matched Channel Resistance
- Low Quiescent Power Consumption
- Low Crosstalk Between Channels
- Wide Operating Voltage Range: 3 to 18 V
- Low Noise
- Pin for Pin Replacement for CD4067B and CD4097B

**CMOS**

(LOW-POWER COMPLEMENTARY MOS)

**ANALOG MULTIPLEXERS/  
DEMULPLEXERS**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 623

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 709

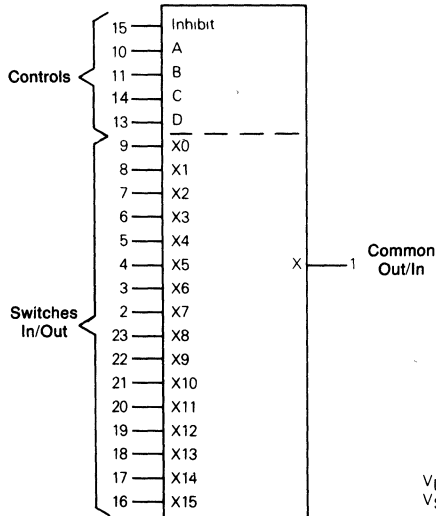
**ORDERING INFORMATION**

**A Series: -55°C to +125°C**  
MC14XXXBAL (Ceramic Package Only)

**C Series: -40°C to +85°C**  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

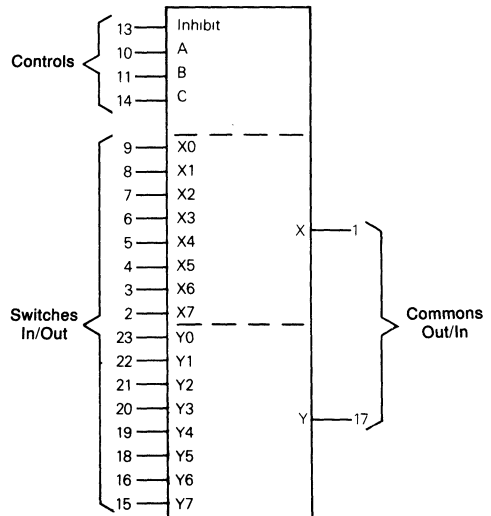
6

**MC14067B**  
16-Channel Analog  
Multiplexer/Demultiplexer



V<sub>DD</sub> = Pin 24  
V<sub>SS</sub> = Pin 12

**MC14097B**  
Dual 8-Channel Analog  
Multiplexer/Demultiplexer



# MC14067B·MC14097B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub>	Input Current (DC or Transient), per Control Pin	± 10	mA
I <sub>sw</sub>	Switch Through Current	± 25	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

MC14067 TRUTH TABLE

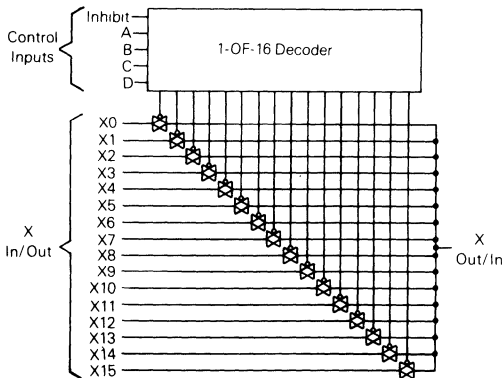
Control Inputs					Selected Channel
A	B	C	D	Inh	
X	X	X	X	1	None
0	0	0	0	0	X0
1	0	0	0	0	X1
0	1	0	0	0	X2
1	1	0	0	0	X3
0	0	1	0	0	X4
1	0	1	0	0	X5
0	1	1	0	0	X6
1	1	1	0	0	X7
0	0	0	1	0	X8
1	0	0	1	0	X9
0	1	0	1	0	X10
1	1	0	1	0	X11
0	0	1	1	0	X12
1	0	1	1	0	X13
0	1	1	1	0	X14
1	1	1	1	0	X15

MC14097 TRUTH TABLE

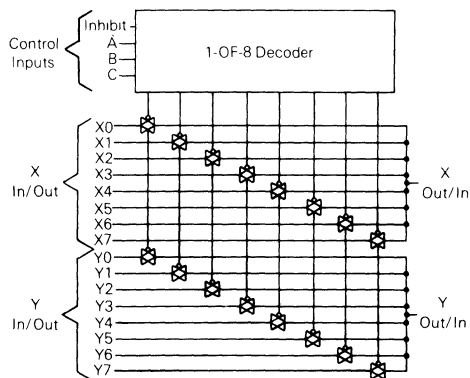
Control Inputs				Selected Channels
A	B	C	Inh	
X	X	X	1	None
0	0	0	0	X0 Y0
1	0	0	0	X1 Y1
0	1	0	0	X2 Y2
1	1	0	0	X3 Y3
0	0	1	0	X4 Y4
1	0	1	0	X5 Y5
0	1	1	0	X6 Y6
1	1	1	0	X7 Y7

X = Don't Care

MC14067 FUNCTIONAL DIAGRAM



MC14097 FUNCTIONAL DIAGRAM



# MC14067B-MC14097B

## ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub>	Test Conditions	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
				Min	Max	Min	Typ#	Max	Min	Max	
<b>SUPPLY REQUIREMENTS (Voltages Referenced to V<sub>SS</sub>)</b>											
Power Supply Voltage Range	V <sub>DD</sub>	—		3	18	3	—	18	3	18	V
Quiescent Current Per Package (AL Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>SS</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	5	—	0.005	5	—	150	μA
		10		—	10	—	0.010	10	—	300	
		15		—	20	—	0.015	20	—	600	
Quiescent Current Per Package (CL/CP Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>EE</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	20	—	0.005	20	—	150	μA
		10		—	40	—	0.010	40	—	300	
		15		—	80	—	0.015	80	—	600	
Total Supply Current (Dynamic Plus Quiescent, Per Package)	I <sub>D(AV)</sub>	5 10 15	T <sub>A</sub> = 25°C only (The channel component, (V <sub>in</sub> - V <sub>out</sub> )/R <sub>on</sub> , is not included.)	Typical { (0.07 μA/kHz)f + I <sub>DD</sub> (0.20 μA/kHz)f + I <sub>DD</sub> (0.36 μA/kHz)f + I <sub>DD</sub>						μA	

## CONTROL INPUTS — INHIBIT, A, B, C, D (Voltages Referenced to V<sub>SS</sub>)

Low-Level Input Voltage	V <sub>IL</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	—	1.5	—	2.25	1.5	—	1.5	V
		10		—	3.0	—	4.50	3.0	—	3.0	
		15		—	4.0	—	6.75	4.0	—	4.0	
High-Level Input Voltage	V <sub>IH</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	3.5	—	3.5	2.75	—	3.5	—	V
		10		7.0	—	7.0	5.50	—	7.0	—	
		15		11.0	—	11.0	8.25	—	11.0	—	
Input Leakage Current (AL Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Leakage Current (CL/CP Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance	C <sub>in</sub>	—		—	—	—	5.0	7.5	—	—	pF

## SWITCHES IN/OUT AND COMMONS OUT/IN - X, Y (Voltages Referenced to V<sub>SS</sub>)

Recommended Peak-to-Peak Voltage Into or Out of the Switch	V <sub>I/O</sub>	—	Channel On or Off	0	V <sub>DD</sub>	0	—	V <sub>DD</sub>	0	V <sub>DD</sub>	V <sub>pp</sub>
Recommended Static or Dynamic Voltage Across the Switch** (Figure 1)	ΔV <sub>switch</sub>	—	Channel On	0	600	0	—	600	0	300	mV
Output Offset Voltage	V <sub>OO</sub>	—	V <sub>in</sub> = 0 V, No load	—	—	—	10	—	—	—	μV
ON Resistance (AL Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	800	—	250	1050	—	1300	Ω
		10		—	400	—	120	500	—	550	
		15		—	220	—	80	280	—	320	
ON Resistance (CL/CP Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	880	—	250	1050	—	1200	Ω
		10		—	450	—	120	500	—	520	
		15		—	250	—	80	280	—	300	
Δ ON Resistance Between Any Two Channels in the Same Package	ΔR <sub>on</sub>	5		—	70	—	25	70	—	135	Ω
		10		—	50	—	10	50	—	95	
		15		—	45	—	10	45	—	65	
Off-Channel Leakage Current (AL Device) (Figure 2)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±100	—	±0.05	±100	—	±1000	nA
Off-Channel Leakage Current (CL/CP Device) (Figure 2)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±300	—	±0.05	±300	—	±1000	nA
Capacitance, Switch I/O	C <sub>I/O</sub>	—	Inhibit = V <sub>DD</sub>	—	—	—	10	—	—	—	pF
Capacitance, Common O/I	C <sub>O/I</sub>	—	Inhibit = V <sub>DD</sub> (MC14067B) (MC14097B)	—	—	—	100 60	—	—	—	pF
Capacitance, Feedthrough (Channel Off)	C <sub>I/O</sub>	—	Pins Not Adjacent	—	—	—	0.15	—	—	—	pF
		—	Pins Adjacent	—	—	—	0.47	—	—	—	

\* T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

# Data labeled "Typ" is not to be used for design purposes, but is intended as an indication of the IC's potential performance.

\*\*For voltage drops across the switch (ΔV<sub>switch</sub>) > 600 mV (> 300 mV at high temperature), excessive V<sub>DD</sub> current may be drawn; i.e. the current out of the switch may contain both V<sub>DD</sub> and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded (See second page of this data sheet.)

# MC14067B•MC14097B

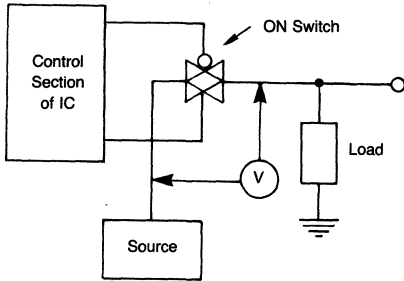
## ELECTRICAL CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> - V <sub>SS</sub> V <sub>dC</sub>	Typ #	Max	Unit
Propagation Delay Times Channel Input-to-Channel Output (R <sub>L</sub> = 200kΩ) MC14067B	t <sub>PLH</sub> , t <sub>PHL</sub>  (Figure 3)	5.0	35	90	ns
		10	15	40	
MC14097B		5.0	25	65	ns
		10	10	25	
		15	7	18	
Control Input-to-Channel Output Channel Turn-On Time (R <sub>L</sub> = 10 kΩ) MC14067B/097B	t <sub>PZH</sub> , t <sub>PZL</sub>  (Figure 4)	5.0	240	600	ns
		10	115	290	
		15	75	190	
Channel Turn-Off Time (R <sub>L</sub> = 300 kΩ) MC14067B/097B	t <sub>PHZ</sub> , t <sub>PLZ</sub>  (Figure 4)	5.0	250	625	ns
		10	120	300	
		15	75	190	
Any Pair of Address Inputs to Output MC14067B	t <sub>PLH</sub> , t <sub>PHL</sub>  (Figure 10)	5.0	280	700	ns
		10	115	290	
MC14097B		15	85	215	ns
		5.0	250	625	
		10	100	250	
		15	75	190	
Second Harmonic Distortion (R <sub>L</sub> = 10 kΩ, f = 1 kHz, V <sub>in</sub> = 5 V <sub>p-p</sub> )	—	10	0.3	—	%
ON Channel Bandwidth [R <sub>L</sub> = 1 kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> - V <sub>SS</sub> ) p-p(sine-wave)] 20 Log <sub>10</sub> $\frac{V_{out}}{V_{in}}$ = -3 dB	BW  (Figure 5)	10	15	—	MHz
MC14067B		10	25	—	
MC14097B		10	—	—	
Off Channel Feedthrough Attenuation [R <sub>L</sub> = 1 kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> - V <sub>SS</sub> ) p-p(sine-wave)] f <sub>in</sub> = 20 MHz - MC14067B f <sub>in</sub> = 12 MHz - MC14097B	—  (Figure 5)	10	-40	—	dB
Channel Separation [R <sub>L</sub> = 1 kΩ, V <sub>in</sub> = 1/2 (V <sub>DD</sub> - V <sub>SS</sub> ) p-p(sine-wave)] f <sub>in</sub> = 20 MHz	—  (Figure 6)	10	-40	—	dB
Crosstalk, Control Inputs-to-Common O/I (R <sub>1</sub> = 1kΩ, R <sub>L</sub> = 10 kΩ, Control t <sub>r</sub> = t <sub>f</sub> = 20 ns, Inhibit = V <sub>SS</sub> )	—  (Figure 7)	10	30	—	mV

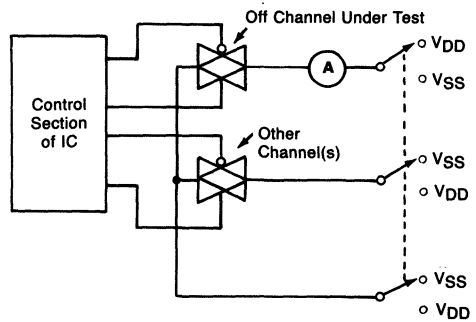
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14067B·MC14097B

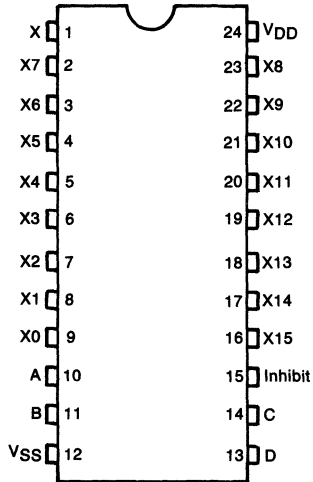
**FIGURE 1 —  $\Delta V$  ACROSS SWITCH**



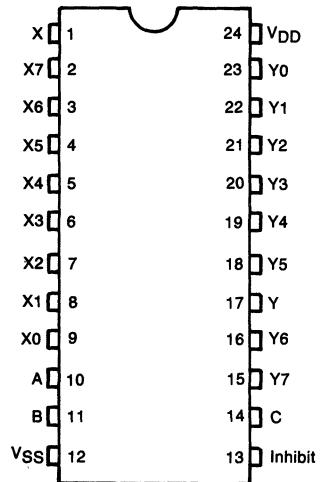
**FIGURE 2 — OFF CHANNEL LEAKAGE**



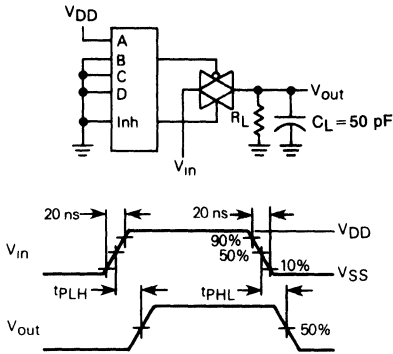
**MC14067B  
PIN ASSIGNMENT**



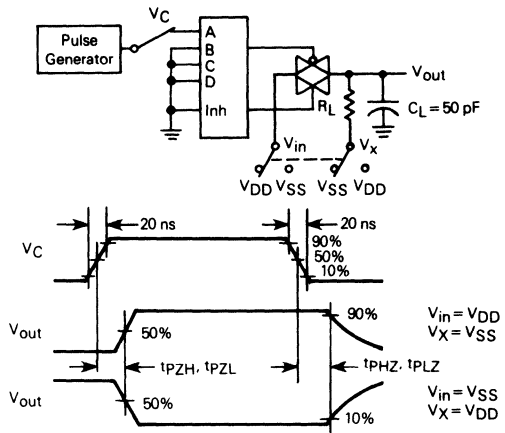
**MC14097B  
PIN ASSIGNMENT**



**FIGURE 3 — PROPAGATION DELAY TEST CIRCUIT AND WAVEFORMS  $V_{in}$  to  $V_{out}$**

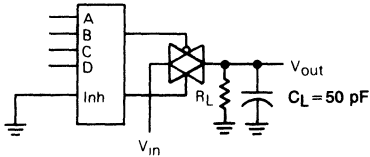


**FIGURE 4 — TURN-ON AND DELAY TURN-OFF TEST CIRCUIT AND WAVEFORMS**

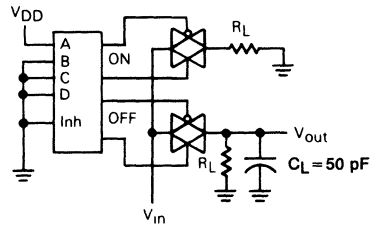


**FIGURE 5 — BANDWIDTH AND OFF-CHANNEL FEEDTHROUGH ATTENUATION**

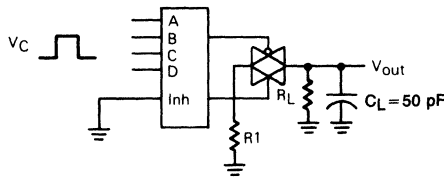
A, B, and C inputs used to turn ON or OFF the switch under test.



**FIGURE 6 — CHANNEL SEPARATION (Adjacent Channels Used for Setup)**

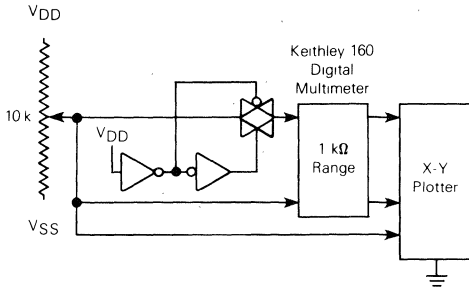


**FIGURE 7 — CROSSTALK, CONTROL TO COMMON O/I**

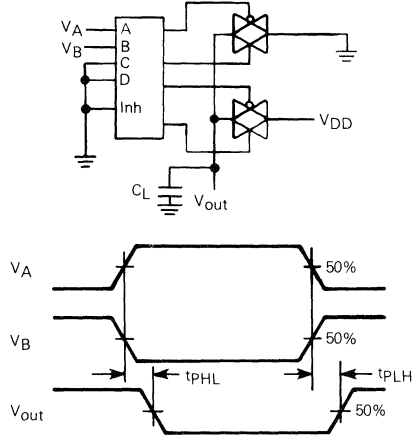


# MC14067B-MC14097B

**FIGURE 9 — CHANNEL RESISTANCE ( $R_{ON}$ ) TEST CIRCUIT**

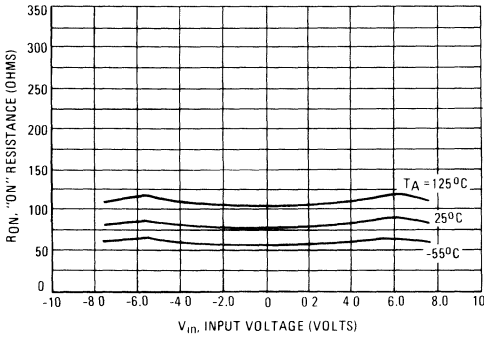


**FIGURE 10 — PROPAGATION DELAY, ANY PAIR OF ADDRESS INPUTS to OUTPUT**

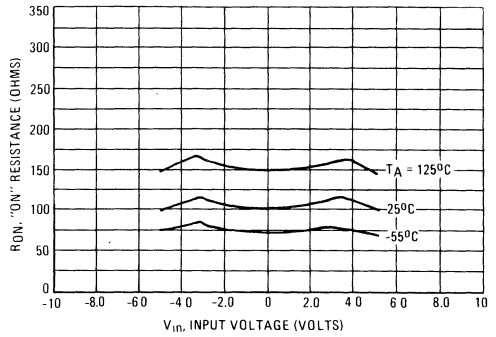


**TYPICAL RESISTANCE CHARACTERISTICS**

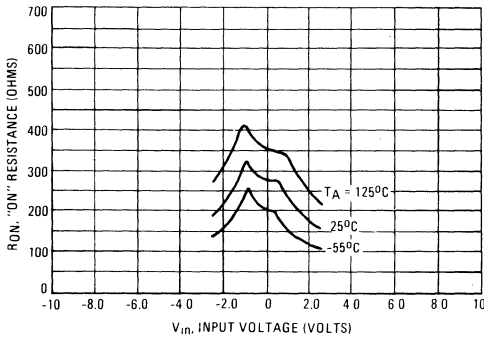
**FIGURE 11 —  $V_{DD} = 7.5 \text{ V}$ ,  $V_{SS} = -7.5 \text{ V}$**



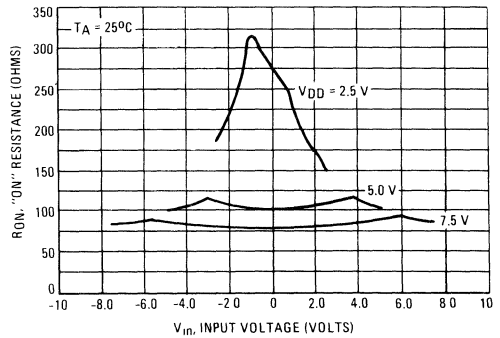
**FIGURE 12 —  $V_{DD} = 5.0 \text{ V}$ ,  $V_{SS} = -5.0 \text{ V}$**



**FIGURE 13 —  $V_{DD} = 2.5 \text{ V}$ ,  $V_{SS} = -2.5 \text{ V}$**



**FIGURE 14 — COMPARISON AT 25°C,  $V_{DD} = -V_{SS}$**



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# MC14067B•MC14097B

## APPLICATIONS INFORMATION

Figure A illustrates use of the Analog Multiplexer/Demultiplexer. The 0-to-5 volt Digital Control signal is used to directly control a 5 V<sub>p-p</sub> analog signal.

The digital control logic levels are determined by V<sub>DD</sub> and V<sub>SS</sub>. The V<sub>DD</sub> voltage is the logic high voltage; the V<sub>SS</sub> voltage is logic low. For the example, V<sub>DD</sub> = +5 V = logic high at the control inputs; V<sub>SS</sub> = GND = 0 V = logic low.

The maximum analog signal level is determined by V<sub>DD</sub> and V<sub>SS</sub>. The analog voltage must swing neither higher than V<sub>DD</sub> nor lower than V<sub>SS</sub>. The example

shows a 5 V<sub>p-p</sub> signal which allows no margin at either peak. If voltage transients above V<sub>DD</sub> and/or below V<sub>SS</sub> are anticipated on the analog channels, external diodes (D<sub>x</sub>) are recommended as shown in Figure B. These diodes should be small signal types able to absorb the maximum anticipated current surges during clipping.

The *absolute* maximum potential difference between V<sub>DD</sub> and V<sub>SS</sub> is 18.0 volts. Most parameters are specified up to 15 V which is the *recommended* maximum difference between V<sub>DD</sub> and V<sub>SS</sub>.

FIGURE A — APPLICATION EXAMPLE

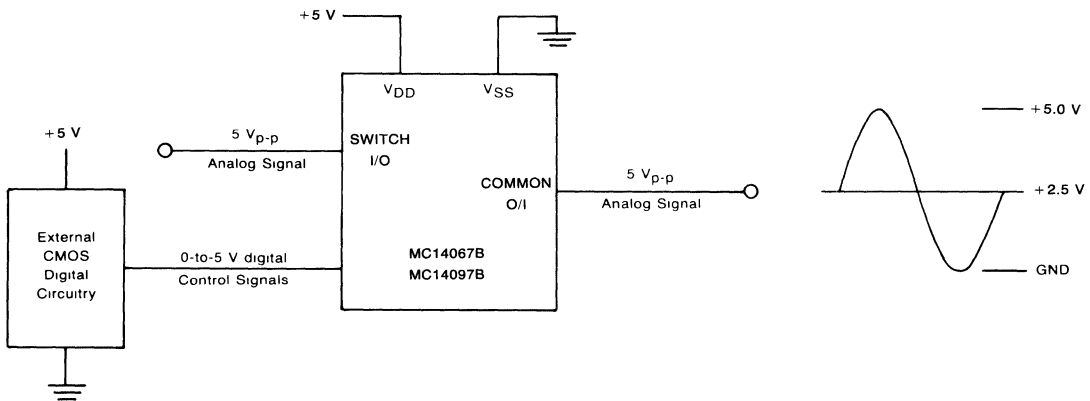
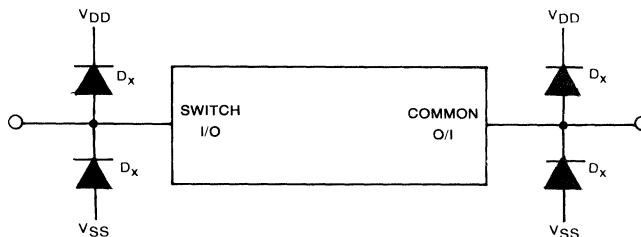


FIGURE B — EXTERNAL GERMANIUM OR SCHOTTKY CLIPPING DIODES







**MOTOROLA**

**MC14068B**  
See Page 6-5

**MC14069UB**

**CMOS SSI**  
(LOW-POWER COMPLEMENTARY MOS)  
**HEX INVERTER**

**HEX INVERTER**

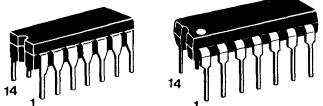
The MC14069UB hex inverter is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These inverters find primary use where low power dissipation and/or high noise immunity is desired. Each of the six inverters is a single stage to minimize propagation delays.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Double Diode Protection on All Inputs
- Pin-for-Pin Replacement for CD4069UB
- Meets JEDEC UB Specifications

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	- 0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	- 0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	- 65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package: - 12mW/°C from 100°C to 125°C



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

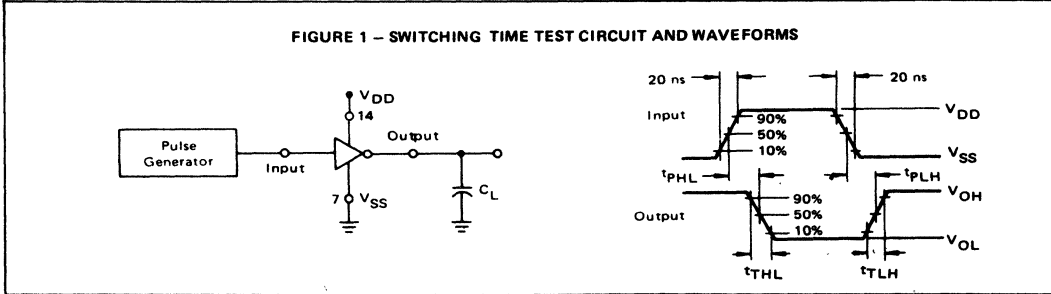
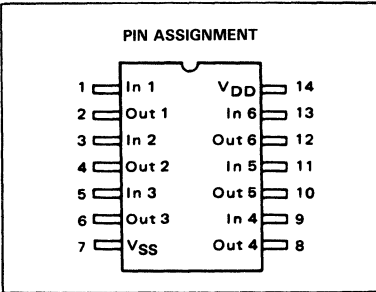
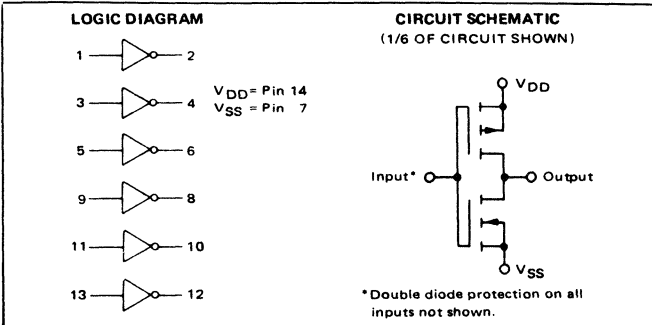
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: - 55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

C Series: - 40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

**6**



# MC14069UB

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub>  V <sub>in</sub> = 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 Vdc) (V <sub>O</sub> = 9.0 Vdc) (V <sub>O</sub> = 13.5 Vdc)  (V <sub>O</sub> = 0.5 Vdc) (V <sub>O</sub> = 1.0 Vdc) (V <sub>O</sub> = 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc
		10	—	2.0	—	4.50	2.0	—	2.0	
		15	—	2.5	—	6.75	2.5	—	2.5	
	"1" Level V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
		10	8.0	—	8.0	5.50	—	8.0	—	
		15	12.5	—	12.5	8.25	—	12.5	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA
		10	-0.64	—	-0.51	-0.88	—	-0.36	—	
		15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA
		10	-0.52	—	-0.44	-0.88	—	-0.36	—	
		15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μA
		10	—	0.50	—	0.0010	0.50	—	15	
		15	—	1.00	—	0.0015	1.00	—	30	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μA
		10	—	2.0	—	0.0010	2.0	—	15	
		15	—	4.0	—	0.0015	4.0	—	30	
Total Supply Current**† (Dynamic plus Quiescent, Per Gate) (C <sub>L</sub> = 50 pF)	I <sub>T</sub>	5.0				I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub> /6			μA	
10				I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub> /6						
15				I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub> /6						
Output Rise and Fall Times** (C <sub>L</sub> = 50 pF) †t <sub>TLH</sub> , †t <sub>THL</sub> = (1.35 ns/pF) C <sub>L</sub> + 33 ns †t <sub>TLH</sub> , †t <sub>THL</sub> = (0.60 ns/pF) C <sub>L</sub> + 20 ns †t <sub>TLH</sub> , †t <sub>THL</sub> = (0.40 ns/pF) C <sub>L</sub> + 20 ns	†t <sub>TLH</sub> , †t <sub>THL</sub>	5.0	—	—	—	100	200	—	—	ns
		10	—	—	—	50	100	—	—	
		15	—	—	—	40	80	—	—	
		15	—	—	—	40	80	—	—	
Propagation Delay Times** (C <sub>L</sub> = 50 pF) †t <sub>PLH</sub> , †t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 20 ns †t <sub>PLH</sub> , †t <sub>PHL</sub> = (0.36 ns/pF) C <sub>L</sub> + 22 ns †t <sub>PLH</sub> , †t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 17 ns	†t <sub>PLH</sub> , †t <sub>PHL</sub>	5.0	—	—	—	65	125	—	—	ns
		10	—	—	—	40	75	—	—	
		15	—	—	—	30	55	—	—	
		15	—	—	—	30	55	—	—	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

†T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V/k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>IH</sub> and V<sub>Out</sub> should be constrained

to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



**MOTOROLA**

**CMOS SSI**

**QUAD EXCLUSIVE "OR" AND "NOR" GATES**

The MC14070B quad exclusive OR gate and the MC14077B quad exclusive NOR gate are constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired.

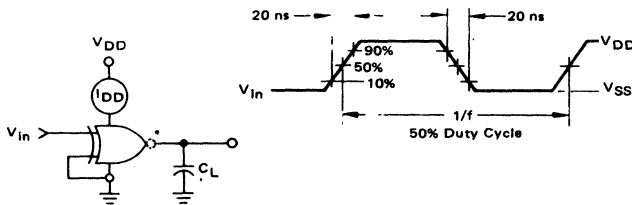
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- All Outputs Buffered
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Double Diode Protection on All Inputs
- MC14070B — Replacement for CD4030B and CD4070B Types
- MC14077B — Replacement for CD4077B Type

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

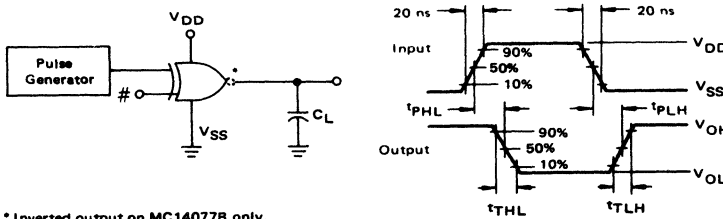
\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**FIGURE 1 — POWER DISSIPATION TEST CIRCUIT AND WAVEFORM**



\*Inverted output on MC14077B only.

**FIGURE 2 — SWITCHING TIME TEST CIRCUIT AND WAVEFORMS**



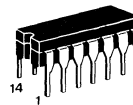
\* Inverted output on MC14077B only.  
 # Connect unused input to  $V_{DD}$  for MC14070B, to  $V_{SS}$  for MC14077B.

**MC14070B**

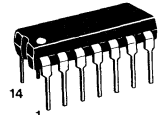
QUAD EXCLUSIVE "OR" GATE

**MC14077B**

QUAD EXCLUSIVE "NOR" GATE



CASE 632  
L SUFFIX  
CERAMIC PACKAGE



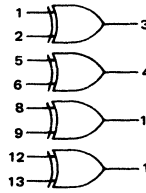
CASE 646  
P SUFFIX  
PLASTIC PACKAGE

**ORDERING INFORMATION**

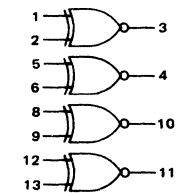
A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**MC14070B**  
Quad Exclusive OR Gate

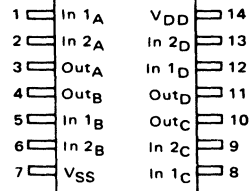


**MC14077B**  
Quad Exclusive NOR Gate



$V_{DD}$  = Pin 14  
 $V_{SS}$  = Pin 7  
 (Both Devices)

**PIN ASSIGNMENT**



# MC14070B•MC14077B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μA <sub>dc</sub>	
		10	—	0.50	—	0.0010	0.50	—	15		
		15	—	1.00	—	0.0015	1.00	—	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μA <sub>dc</sub>	
		10	—	2.0	—	0.0010	2.0	—	15		
		15	—	4.0	—	0.0015	4.0	—	30		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.3 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	
		10	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub>								
Output Rise and Fall Times** (C <sub>L</sub> = 50 pF) ‡TLH, †THL = (1.35 ns/pF) C <sub>L</sub> + 33 ns ‡TLH, †THL = (0.60 ns/pF) C <sub>L</sub> + 20 ns ‡TLH, †THL = (0.40 ns/pF) C <sub>L</sub> + 20 ns	‡TLH, †THL	5.0	—	—	—	100	200	—	—	ns	
		10	—	—	—	50	100	—	—		
		15	—	—	—	40	80	—	—		
		15	—	—	—	40	80	—	—		
Propagation Delay Times** (C <sub>L</sub> = 50 pF) ‡PLH, †PHL = (0.90 ns/pF) C <sub>L</sub> + 130 ns ‡PLH, †PHL = (0.36 ns/pF) C <sub>L</sub> + 57 ns ‡PLH, †PHL = (0.26 ns/pF) C <sub>L</sub> + 37 ns	‡PLH, †PHL	5.0	—	—	—	175	350	—	—	ns	
		10	—	—	—	75	150	—	—		
		15	—	—	—	55	110	—	—		
		15	—	—	—	55	110	—	—		

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V/k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



**MOTOROLA**

**MC14071B thru MC14073B,  
MC14075B  
See Page 6-5**

**MC14076B**

**4-BIT D-TYPE REGISTER  
with THREE-STATE OUTPUTS**

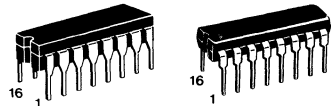
The MC14076B 4-Bit Register consists of four D-type flip-flops operating synchronously from a common clock. OR gated output-disable inputs force the outputs into a high-impedance state for use in bus organized systems. OR gated data-disable inputs cause the Q outputs to be fed back to the D inputs of the flip-flops. Thus they are inhibited from changing state while the clocking process remains undisturbed. An asynchronous master reset is provided to clear all four flip-flops simultaneously independent of the clock or disable inputs.

- Three-State Outputs with Gated Control Lines
- Fully Independent Clock Allows Unrestricted Operation for the Two Modes: Parallel Load and Do Nothing
- Asynchronous Master Reset
- Four Bus Buffer Registers
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Schottky TTL Load Over the Rated Temper

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**QUAD D-TYPE REGISTER  
with THREE STATE OUTPUTS**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**

**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL or UBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP or UBPCP (Plastic Package)  
MC14XXXBCL or UBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in, Vout</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in, Iout</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

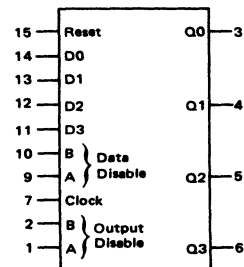
**FUNCTION TABLE**

INPUTS						OUTPUT Q
Reset	Clock	Data Disable		Data D	Q <sub>n</sub>	
		A	B			
1	X	X	X	X	0	
0	0	X	X	X	Q <sub>n</sub>	
0		1	X	X	Q <sub>n</sub>	
0		X	1	X	Q <sub>n</sub>	
0		0	0	0	0	
0		0	0	1	1	

When either output disable A or B (or both) is (are) high the output is disabled to the high-impedance state; however sequential operation of the flip-flops is not affected.

X = Don't Care.

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

# MC14076B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (0.75 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.50 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.25 μA/kHz) f + I <sub>DD</sub>							μAdc
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μAdc
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μAdc

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14076B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 215 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 92 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$ Reset to Q $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 215 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 92 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15  5.0 10 15	— — —  — — —	300 125 90  300 125 90	600 250 180  600 250 180	ns
3 State Propagation Delay, Output "1" or "0" to High Impedance	$t_{PHZ}, t_{PLZ}$	5.0 10 15	— — —	150 60 45	300 120 90	ns
3-State Propagation Delay, High Impedance to "1" or "0" Level	$t_{PZH}, t_{PZL}$	5.0 10 15	— — —	200 80 60	400 160 120	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	260 110 80	130 55 40	— — —	ns
Reset Pulse Width	$t_{WH}$	5.0 10 15	370 150 110	185 75 55	— — —	ns
Data Setup Time	$t_{su}$	5.0 10 15	30 10 4	15 5 2	— — —	ns
Data Hold Time	$t_h$	5.0 10 15	130 60 50	65 30 25	— — —	ns
Data Disable Setup Time	$t_{su}$	5.0 10 15	220 80 50	110 40 25	— — —	ns
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	3.6 9.0 12	1.8 4.5 6.0	MHz

\*The formulas given are for the typical characteristics only at 25°C.

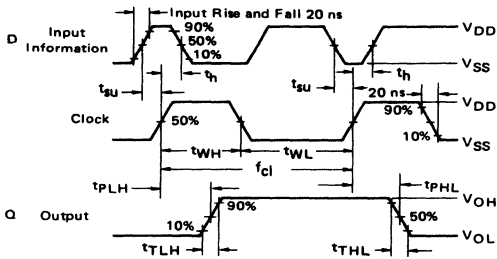
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{IN}$  and  $V_{OUT}$  should be constrained to the range  $V_{SS} \leq (V_{IN} \text{ or } V_{OUT}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

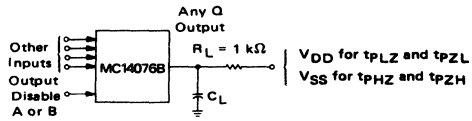
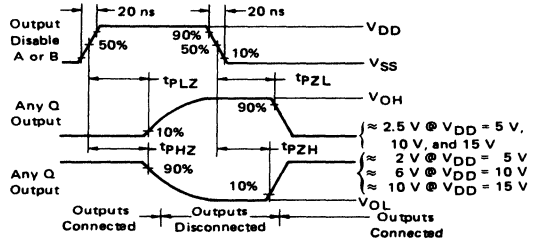
# MC14076B

FIGURE 1 – TIMING DIAGRAM

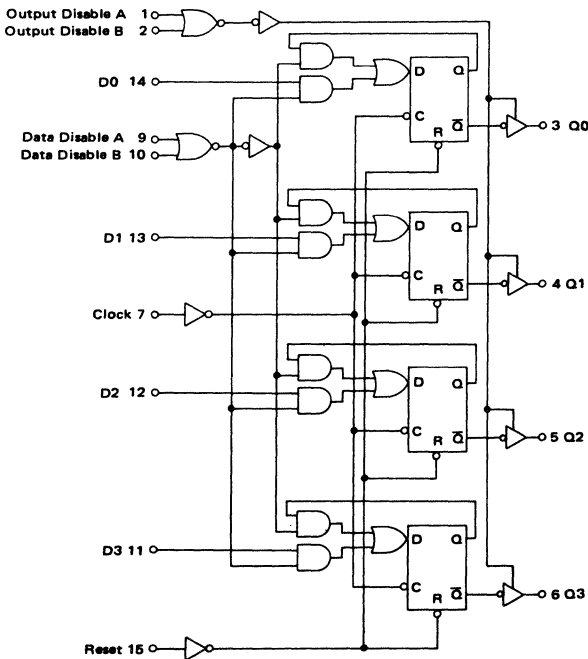


Reset = 0  
Data Disable A and B = 0  
Output Disable A and B = 0

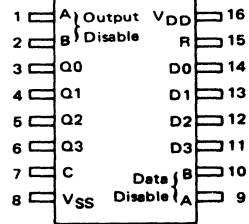
FIGURE 2 – THREE-STATE PROPAGATION DELAY WAVESHAVE AND CIRCUIT



EQUIVALENT  
FUNCTIONAL BLOCK DIAGRAM



PIN ASSIGNMENT







**MOTOROLA**

**MC14077B**  
See Page 6-156

**MC14078B, MC14081B,  
MC14082B**  
See Page 6-5

**MC14093B**

**CMOS SSI**  
(LOW-POWER COMPLEMENTARY MOS)  
**QUAD 2-INPUT "NAND" SCHMITT TRIGGER**

**QUAD 2-INPUT "NAND" SCHMITT TRIGGER**

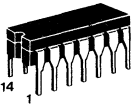
The MC14093B Schmitt trigger is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These devices find primary use where low power dissipation and/or high noise immunity is desired. The MC14093B may be used in place of the MC14011B quad 2-input NAND gate for enhanced noise immunity or to "square up" slowly changing waveforms.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Double Diode Protection on All Inputs
- Pin-for-Pin Compatible with CD4093
- Can be Used to Replace MC14011B

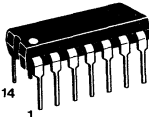
**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 85°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

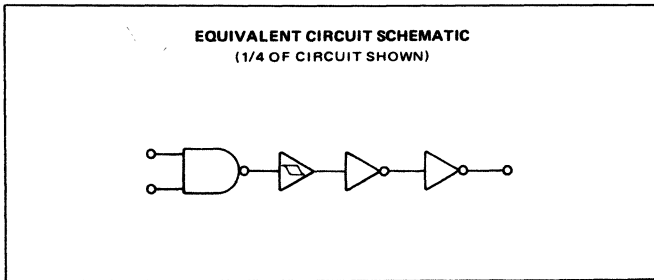


**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

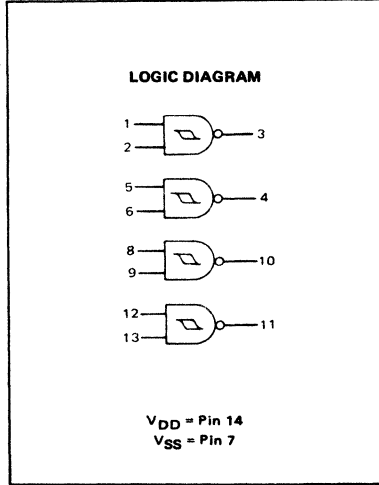
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



**6**

# MC14093B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
(V <sub>OL</sub> = 1.5 Vdc)		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc	
		10	—	0.5	—	0.0010	0.5	—	15		
		15	—	1.0	—	0.0015	1.0	—	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc	
		10	—	2.0	—	0.0010	2.0	—	15		
		15	—	4.0	—	0.0015	4.0	—	30		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF, on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>								
Hysteresis Voltage (Pins 1, 5, 8 and 12 held high or Pins 2, 6, 9 and 13 held high)	V <sub>H</sub>	5.0	0.20	0.62	0.17	0.26	0.6	0.13	0.6	Vdc	
		10	0.29	0.85	0.25	0.38	0.8	0.20	0.8		
		15	0.39	1.20	0.33	0.50	1.1	0.27	1.1		
Threshold Voltage (Pins 2, 5, 9, 12 held high or Pins 1, 6, 8, 13 held high) Positive-Going	V <sub>T+</sub>	5.0	1.90	4.15	1.80	2.70	4.05	1.70	4.05	Vdc	
		10	3.05	6.75	2.95	4.43	6.65	2.85	6.65		
		15	4.12	9.15	4.02	6.03	9.05	3.92	9.05		
	Negative-Going	V <sub>T-</sub>	5.0	1.63	3.76	1.63	2.44	3.66	1.53	3.66	Vdc
			10	2.70	6.18	2.70	4.05	6.08	2.60	6.08	
			15	3.59	8.40	3.69	5.53	8.30	3.70	8.30	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) Vfk$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

# MC14093B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise Time	t <sub>TLH</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time	t <sub>THL</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Propagation Delay Time	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	125	250	ns
		10	—	50	100	
		15	—	40	80	

#Data labeled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT AND WAVE FORMS

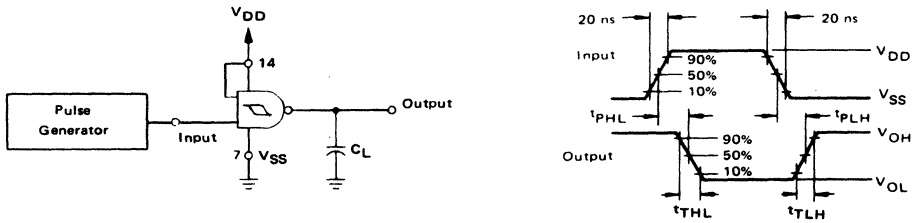
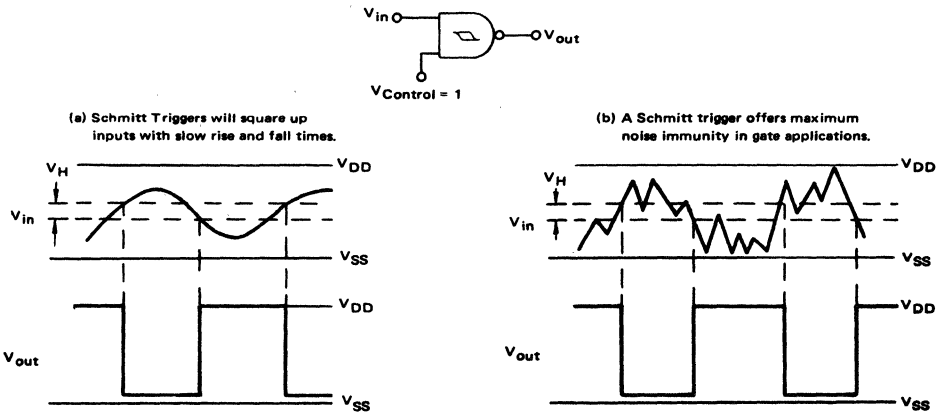


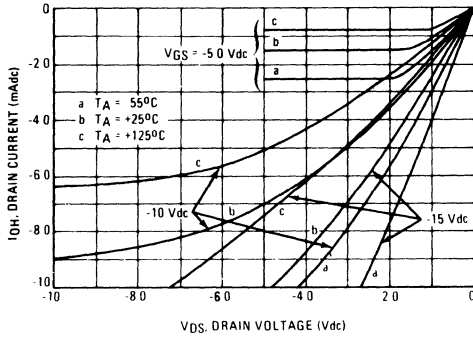
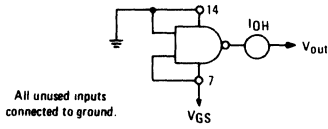
FIGURE 2 – TYPICAL SCHMITT TRIGGER APPLICATIONS



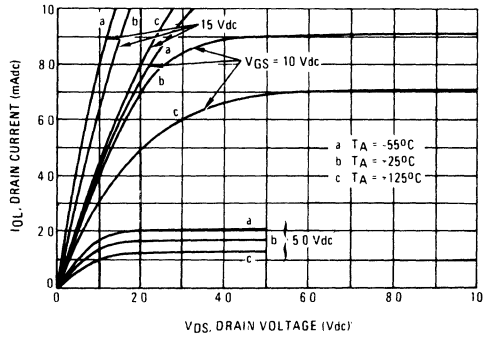
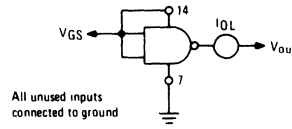
6

# MC14093B

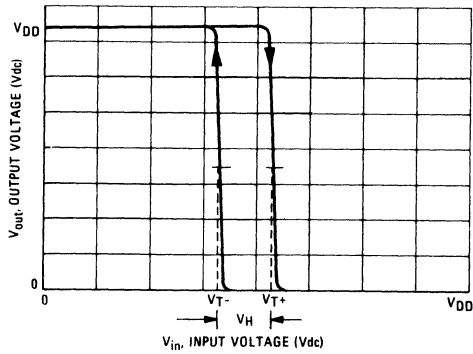
**FIGURE 3 – TYPICAL OUTPUT SOURCE CHARACTERISTICS TEST CIRCUIT**



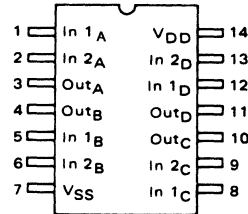
**FIGURE 4 – TYPICAL OUTPUT SINK CHARACTERISTICS TEST CIRCUIT**



**FIGURE 5 – TYPICAL TRANSFER CHARACTERISTICS**



**PIN ASSIGNMENT**





**MOTOROLA**

**MC14094B**

**8-STAGE SHIFT/STORE REGISTER  
WITH THREE-STATE OUTPUTS**

The MC14094B combines an 8-stage shift register with a data latch for each stage and a three-state output from each latch.

Data is shifted on the positive clock transition and is shifted from the seventh stage to two serial outputs. The  $Q_S$  output data is for use in high-speed cascaded systems. The  $Q'_S$  output data is shifted on the following negative clock transition for use in low-speed cascaded systems.

Data from each stage of the shift register is latched on the negative transition of the strobe input. Data propagates through the latch while strobe is high.

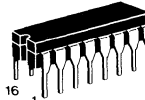
Outputs of the eight data latches are controlled by three-state buffers which are placed in the high-impedance state by a logic Low on Output Enable.

- Three-State Outputs
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Input Diode Protection
- Data Latch
- Dual Outputs for Data Out on Both Positive and Negative Clock Transitions
- Useful for Serial-to-Parallel Data Conversion
- Pin-for-Pin Compatible with CD4094B

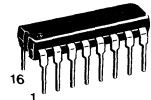
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**8-STAGE SHIFT/STORE REGISTER**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**



**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

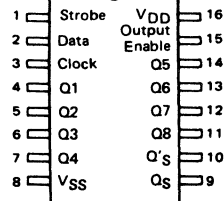
**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**PIN ASSIGNMENT**



Clock	Output Enable	Strobe	Data	Parallel Outputs		Serial Outputs	
				$Q_1$	$Q_N$	$Q_S^*$	$Q'_S$
	0	X	X	Z	Z	Q7	No Chg.
	0	X	X	Z	Z	No Chg.	Q7
	1	0	X	No Chg.	No Chg.	Q7	No Chg.
	1	1	0	0	$Q_N-1$	Q7	No Chg.
	1	1	1	1	$Q_N-1$	Q7	No Chg.
	1	1	1	No Chg.	No Chg.	No Chg.	Q7

Z = High Impedance

X = Don't Care

\*At the positive clock edge, information in the 7th shift register stage is transferred to  $Q_B$  and  $Q_S$ .

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

# MC14094B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current** † (Dynamic plus Quiescent, Per Package). (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (4.1 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (14 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (140 μA/kHz) f + I <sub>DD</sub>								
3-State Output Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±3.0	μA	
3-State Output Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	—	±1.0	—	±7.5	μA	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{tk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14094B

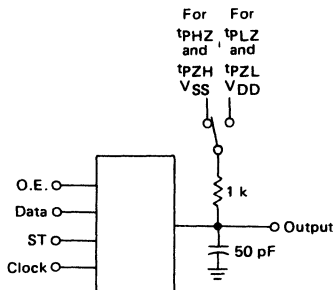
## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit		
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.35 \text{ ns/pF}) C_L + 33 \text{ ns}$ $t_{TLH}, t_{THL} = (0.6 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH}, t_{THL} = (0.4 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH},$ $t_{THL}$	5.0	—	100	200	ns		
		10	—	50	100			
		15	—	40	80			
		15	—	40	80			
Propagation Delay Time Clock to Serial out Q <sub>S</sub> $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 305 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 107 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 82 \text{ ns}$ Clock to Serial out Q'S $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 350 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 149 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 62 \text{ ns}$ Clock to Parallel out $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 375 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.35 \text{ ns/pF}) C_L + 177 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 122 \text{ ns}$ Strobe to Parallel out $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 245 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 127 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 87 \text{ ns}$ Output Enable to Output $t_{PHZ}, t_{PZL} = (0.90 \text{ ns/pF}) C_L + 95 \text{ ns}$ $t_{PHZ}, t_{PZL} = (0.36 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{PHZ}, t_{PZL} = (0.26 \text{ ns/pF}) C_L + 42 \text{ ns}$ $t_{PLZ}, t_{PZH} = (0.90 \text{ ns/pF}) C_L + 180 \text{ ns}$ $t_{PLZ}, t_{PZH} = (0.36 \text{ ns/pF}) C_L + 77 \text{ ns}$ $t_{PLZ}, t_{PZH} = (0.26 \text{ ns/pF}) C_L + 57 \text{ ns}$	$t_{PLH},$ $t_{PHL}$	5.0	—	350	600	ns		
		10	—	125	250			
		15	—	95	190			
		5.0	—	230	460			
		10	—	110	220			
		15	—	75	150			
		5.0	—	420	840			
		10	—	195	390			
		15	—	135	270			
		5.0	—	290	580			
	$t_{PHZ}, t_{PZL}$	5.0	—	140	280	ns		
			10	—	75		150	
			15	—	55		110	
		$t_{PLZ}, t_{PZH}$	5.0	—	225	450	ns	
				10	—	95		190
				15	—	70		140
	Setup Time Data in to Clock	$t_{su}$	5.0	125	60	—	ns	
			10	55	30	—		
			15	35	20	—		
	Hold Time Clock to Data	$t_h$	5.0	0	-40	—	ns	
10			20	-10	—			
15			20	0	—			
Clock Pulse Width, High	$t_{WH}$	5.0	200	100	—	ns		
		10	100	50	—			
		15	83	40	—			
Clock Rise and Fall Time	$t_r(c)$ $t_f(c)$	5	—	—	15	μs		
		10	—	—	5.0			
		15	—	—	4.0			
Clock Pulse Frequency	$f_{cl}$	5.0	—	2.5	1.25	MHz		
		10	—	5.0	2.5			
		15	—	6.0	3.0			
Strobe Pulse Width	$t_{WL}$	5.0	200	100	—	ns		
		10	80	40	—			
		15	70	35	—			

\*The formulas given are for the typical characteristics only at 25°C.

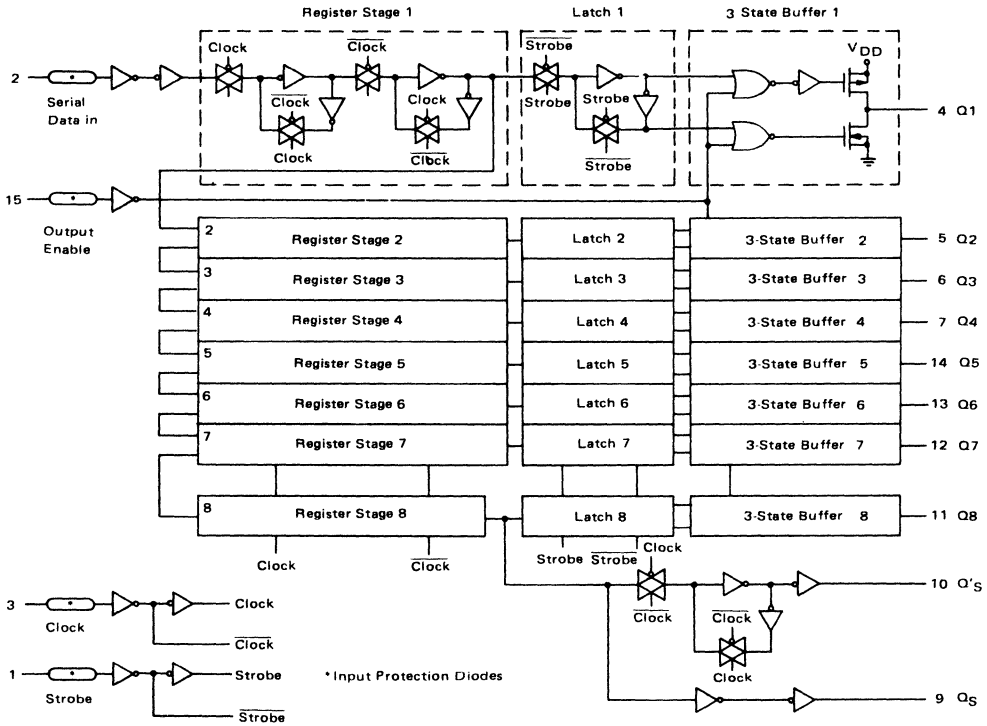
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

### 3-STATE TEST CIRCUIT

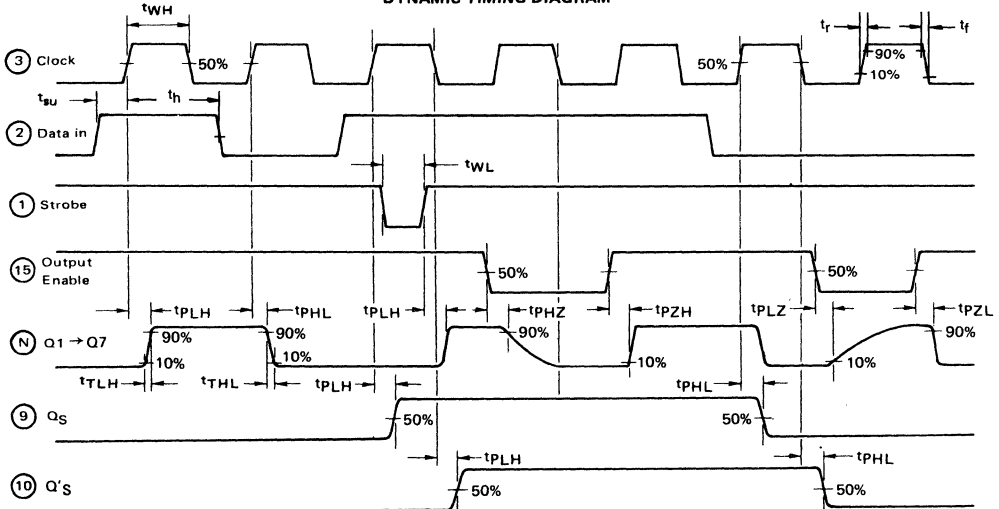


# MC14094B

## BLOCK DIAGRAM



## DYNAMIC TIMING DIAGRAM







# MOTOROLA

## 8-BIT ADDRESSABLE LATCHES

The MC14099B and MC14599B are 8-bit addressable latches. Data is entered in serial form when the appropriate latch is addressed (via address pins A0, A1, A2) and write disable is in the low state. Chip enable must be high for writing into MC14599B. For the MC14599B the data pin is a bidirectional data port and for the MC14099B the input is a unidirectional write only port. The Write/Read line controls this port in the MC14599B.

The data is presented in parallel at the output of the eight latches independently of the state of Write Disable, Write/Read or Chip Enable.

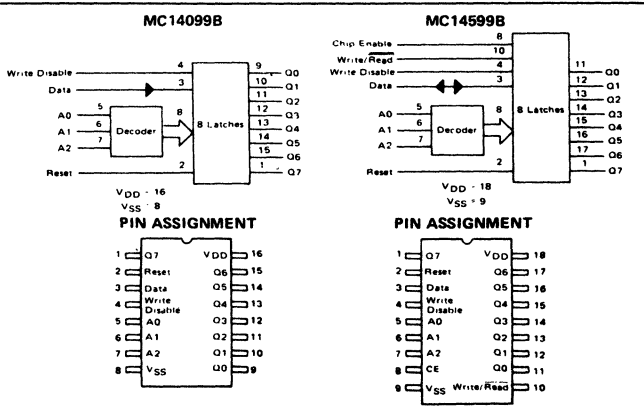
A Master Reset capability is available on both parts.

- Serial Data Input
- Parallel Output
- Master Reset
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load over the Rated Temperature Range
- MC14099B pin for pin compatible with CD4099B

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
 †Temperature Derating. Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C



## MC14097B

See Page 6-146

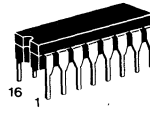
## MC14099B MC14599B

### CMOS MSI

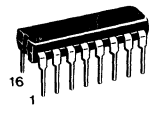
(LOW-POWER COMPLEMENTARY MOS)

### 8-BIT ADDRESSABLE LATCH

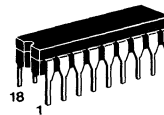
MC14599B WITH BIDIRECTIONAL PORT



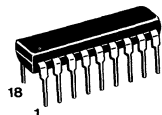
L SUFFIX  
CERAMIC PACKAGE  
CASE 620



P SUFFIX  
PLASTIC PACKAGE  
CASE 648



L SUFFIX  
CERAMIC PACKAGE  
CASE 726



P SUFFIX  
PLASTIC PACKAGE  
CASE 707

### ORDERING INFORMATION

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXBCP (Plastic Package)  
 MC14XXBCL (Ceramic Package)

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14099B•MC14599B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc)	5.0	-3.0	—	-2.4	-4.2	—	-1.7	mAdc
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.64	—	-0.51	-0.88	—	-0.36	
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.6	—	-1.3	-2.25	—	-0.9	
		(V <sub>OH</sub> = 13.5 Vdc)	15	-4.2	—	-3.4	-8.8	—	-2.4	
		(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.64	—	0.51	0.88	—	0.36	
		(V <sub>OL</sub> = 0.5 Vdc)	10	1.6	—	1.3	2.25	—	0.9	
	Sink I <sub>OL</sub>	(V <sub>OL</sub> = 1.5 Vdc)	15	4.2	—	3.4	8.8	—	2.4	mAdc
		(V <sub>OH</sub> = 2.5 Vdc)	5.0	-2.5	—	-2.1	-4.2	—	-1.7	
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.52	—	-0.44	-0.88	—	-0.36	
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.3	—	-1.1	-2.25	—	-0.9	
		(V <sub>OH</sub> = 13.5 Vdc)	15	-3.6	—	-3.0	-8.8	—	-2.4	
		(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.52	—	0.44	0.88	—	0.36	
Sink I <sub>OL</sub>	(V <sub>OL</sub> = 0.5 Vdc)	10	1.3	—	1.1	2.25	—	0.9	mAdc	
	(V <sub>OL</sub> = 1.5 Vdc)	15	3.6	—	3.0	8.8	—	2.4		
	(V <sub>OL</sub> = 1.5 Vdc)	15	3.6	—	3.0	8.8	—	2.4		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Input Capacitance MC14599B — Data (pin 3) (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	15.0	22.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.5 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (3.0 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (4.5 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14099B•MC14599B

SWITCHING CHARACTERISTICS \* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

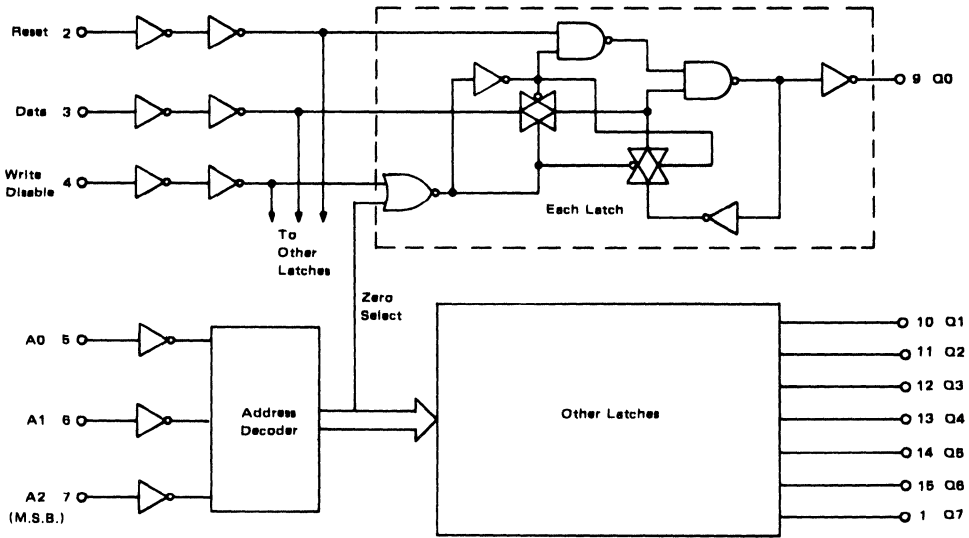
Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{PLH}, t_{PHL} = (1.35 \text{ ns/pF}) C_L + 32 \text{ ns}$ $t_{TLH}, t_{THL} = (0.6 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH}, t_{THL} = (0.4 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{PLH}, t_{PHL}$ $t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Data to Output Q	$t_{PHL}, t_{PLH}$	5.0 10 15	— — —	200 75 50	400 150 100	ns
Write Disable to Output Q		5.0 10 15	— — —	200 80 60	400 160 120	ns
Reset to Output Q		5.0 10 15	— — —	175 80 65	350 160 130	ns
CE to Output Q (MC14599B only)		5.0 10 15	— — —	225 100 75	450 200 150	ns
Propagation Delay Time, MC14599B only Chip Enable, Write/Read to Data	$t_{PHL}, t_{PLH}$	5.0 10 15	— — —	200 80 65	400 160 130	ns
Address to Data		5.0 10 15	— — —	200 90 75	400 180 150	ns
Pulse Widths Reset	$t_{w(H)}, t_{w(L)}$	5.0 10 15	150 75 50	75 40 25	— — —	ns
Write Disable		5.0 10 15	320 160 120	160 80 60	— — —	ns
Set Up Time Data to Write Disable	$t_{su}$	5.0 10 15	100 50 35	50 25 20	— — —	ns
Hold Time Write Disable to Data	$t_h$	5.0 10 15	150 75 50	75 40 25	— — —	ns
Set Up Time Address to Write Disable	$t_{su}$	5.0 10 15	100 80 40	45 30 10	— — —	ns
Removal Time Write Disable to Address	$t_{rem}$	5.0 10 15	0 0 0	-80 -40 -40	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14099B•MC14599B

## MC14099B FUNCTION DIAGRAM



### TRUTH TABLE

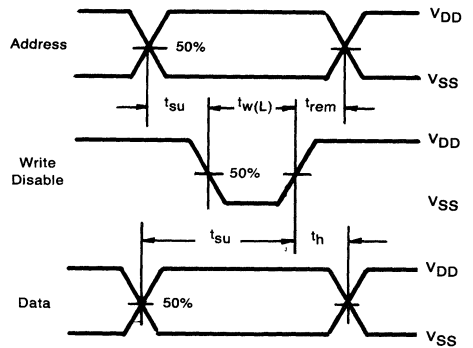
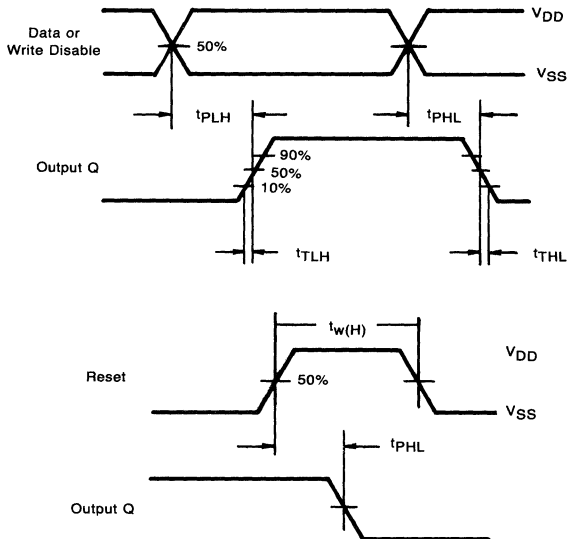
Write Disable	Reset	Addressed Latch	Unaddressed Latches
0	0	Data	$Q_n^*$
0	1	Data	Reset†
1	0	$Q_n^*$	$Q_n^*$
1	1	Reset	Reset

\*  $Q_n$  is previous state of latch.

† Reset to zero state.

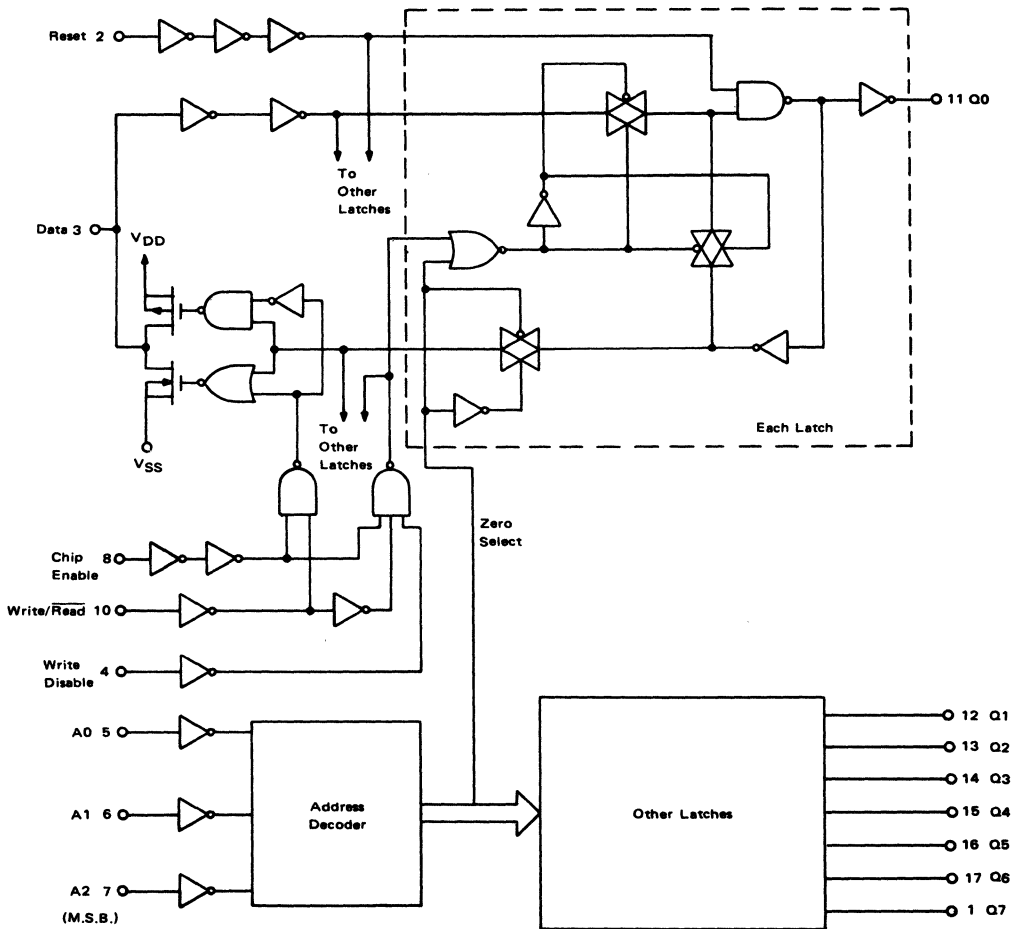
**CAUTION:** To avoid unintentional data changes in the latches, Write Disable must be active (high) during transitions on the address inputs A0, A1, and A2.

### SWITCHING WAVEFORMS



# MC14099B•MC14599B

MC14599B  
FUNCTION DIAGRAM



TRUTH TABLE

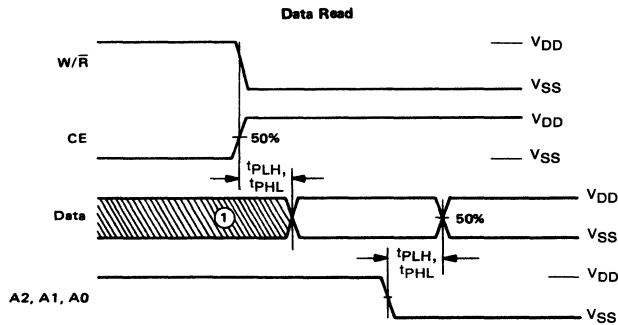
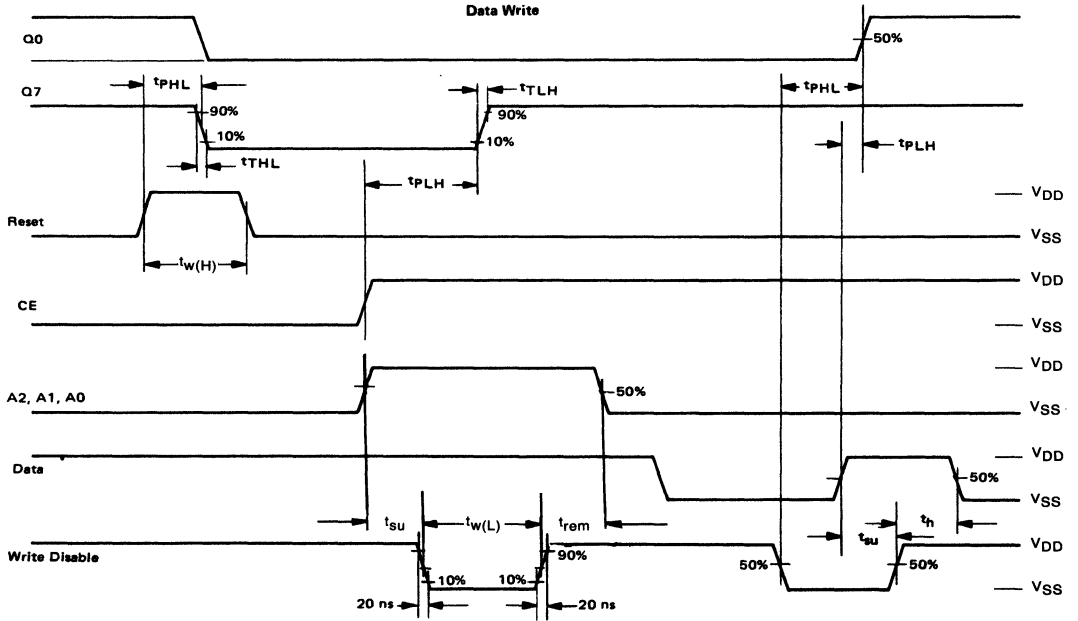
Chip Enable	Write/Read	Write Disable	Reset	Addressed Latch	Other Latches	Data Pin
0	X	X	0	*	*	Z
1	1	0	0	Data	*	Input
1	1	1	0	*	*	Z
1	0	X	0	*	*	$Q_n$
X	X	X	1	0	0	Z/0

X = Don't care.  
 \* = No change in state of latch.  
 Z = High impedance.  
 $Q_n$  = State of addressed latch.

**CAUTION:** To avoid unintentional data changes in the latches, Write Disable must be active (high) during transitions on the address inputs A0, A1, and A2.

# MC14099B•MC14599B

## MC14599B SWITCHING WAVEFORMS



NOTE: 1. Invalid Data Output  
2. Reset in LOW State



**MOTOROLA**

**MC14106B**

**HEX SCHMITT TRIGGER**

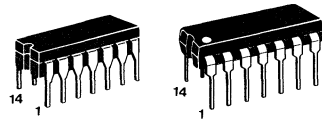
The MC14106B hex Schmitt Trigger is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These devices find primary use where low power dissipation and/or high noise immunity is desired. The MC14106B may be used in place of the MC14069UB hex inverter for enhanced noise immunity or to "square up" slowly changing waveforms.

- Increased Hysteresis Voltage Over the MC14584B
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD40106B and MM74C14
- Can Be Used to Replace the MC14584B or MC14069UB

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**HEX SCHMITT TRIGGER**



L SUFFIX  
CERAMIC PACKAGE  
CASE 632

P SUFFIX  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

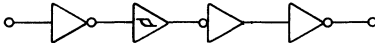
**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

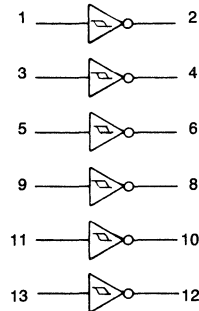
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**EQUIVALENT CIRCUIT SCHEMATIC**  
(1/6 OF CIRCUIT SHOWN)



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**LOGIC DIAGRAM**



$V_{DD}$  = Pin 14  
 $V_{SS}$  = Pin 7

# MC14106B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub>	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Hysteresis Voltage	V <sub>H†</sub>	5.0	0.3	2.0	0.3	1.1	2.0	0.3	2.0	Vdc	
		10	1.2	3.4	1.2	1.7	3.4	1.2	3.4		
		15	1.6	5.0	1.6	2.1	5.0	1.6	5.0		
Threshold Voltage Positive-Going	V <sub>T+</sub>	5.0	2.2	3.6	2.2	2.9	3.6	2.2	3.6	Vdc	
		10	4.6	7.1	4.6	5.9	7.1	4.6	7.1		
		15	6.8	10.8	6.8	8.8	10.8	6.8	10.8		
	Negative-Going	V <sub>T-</sub>	5.0	0.9	2.8	0.9	1.9	2.8	0.9	2.8	Vdc
			10	2.5	5.2	2.5	3.9	5.2	2.5	5.2	
			15	4.0	7.4	4.0	5.8	7.4	4.0	7.4	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	0.36	—		
		10	-1.6	—	-1.3	-2.25	—	0.9	—		
		15	-4.2	—	-3.4	-8.8	—	2.4	—		
	(V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
	(V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±0.1	μAdc	
		15	—	±0.3	—	±0.00001	±0.3	—	±0.1		
		15	—	±0.3	—	±0.00001	±0.3	—	±0.1		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc	
		10	—	0.50	—	0.0010	0.50	—	15		
		15	—	1.00	—	0.0015	1.00	—	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc	
		10	—	2.0	—	0.0010	2.0	—	15		
		15	—	4.0	—	0.0015	4.0	—	34		
Total Supply Current**† (Dynamic Plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.8 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (5.4 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

†V<sub>H</sub> = V<sub>T+</sub> - V<sub>T-</sub> (But maximum variation of V<sub>H</sub> is specified as less than V<sub>T+</sub> + max - V<sub>T-</sub> - min).



# MC14106B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit
Output Rise Time	t <sub>TLH</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time	t <sub>THL</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Propagation Delay Time	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	125	250	ns
		10	—	50	100	
		15	—	40	80	

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 — SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

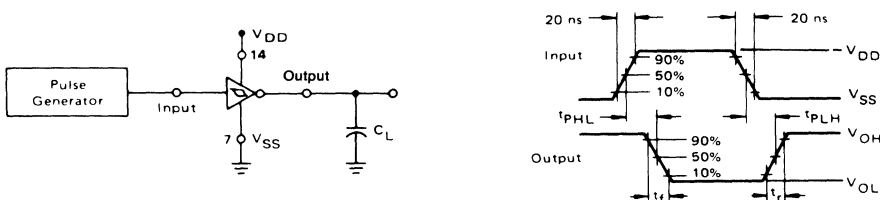
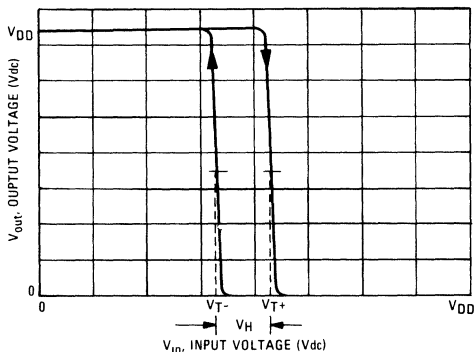
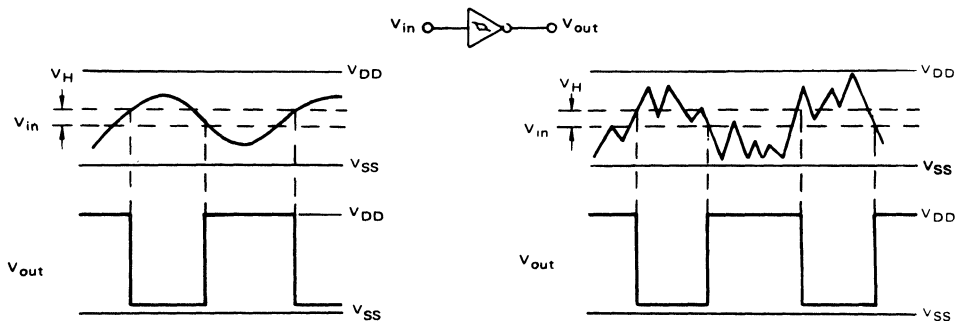


FIGURE 2 — TYPICAL TRANSFER CHARACTERISTICS



## APPLICATIONS



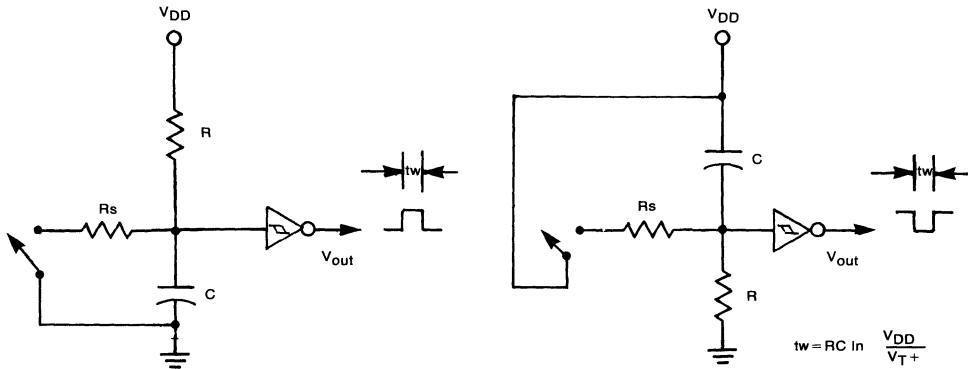
(a) Schmitt Triggers will square up inputs with slow rise and fall times.

(b) A Schmitt trigger offers maximum noise immunity in gate applications.

FIGURE 3

# MC14106B

FIGURE 4 — MONOSTABLE MULTIVIBRATOR



Useful as Pushbutton/Keyboard Debounce Circuit.

FIGURE 5 — ASTABLE MULTIVIBRATOR

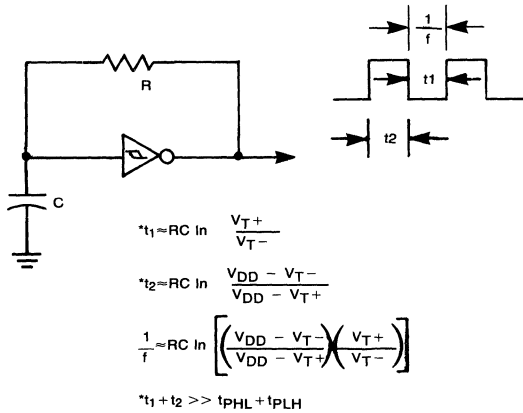
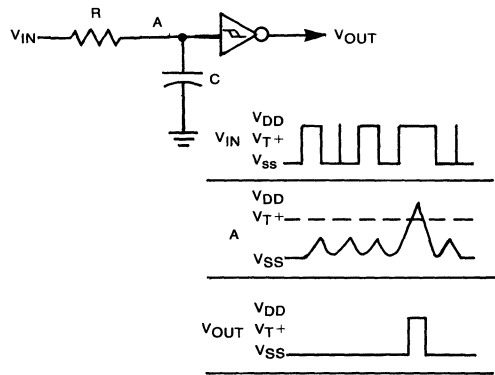
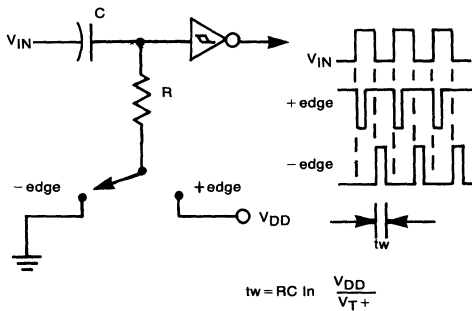


FIGURE 6 — INTEGRATOR



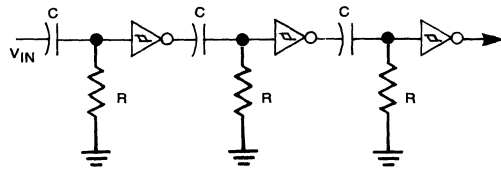
Useful in discriminating against short pulse durations.

FIGURE 7 — DIFFERENTIATOR



Useful as an edge detector circuit.

FIGURE 8 — POSITIVE EDGE TIME DELAY CIRCUIT





**MOTOROLA**

**CMOS MSI**

**SYNCHRONOUS PRESETTABLE 4-BIT COUNTERS**

The MC14160B – MC14163B are synchronous programmable counters constructed with complementary MOS P-Channel and N-Channel enhancement mode devices in a single monolithic structure. These counters are functionally equivalent to the 74160–74163 TTL counters.

Two are synchronous programmable BCD counters with asynchronous and synchronous clear inputs respectively (MC14160B, MC14162B). The other two are synchronous programmable 4-bit binary counters with the asynchronous and synchronous clear respectively (MC14161B, MC14163B).

- Internal Look-Ahead for Fast Counting
- Carry Output for N-Bit Cascading
- Synchronously Programmable
- Synchronous Counting
- Load Control Line
- Synchronous or Asynchronous Clear
- Positive Edge Clocked

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	± 10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**MC14160B**

BCD COUNTER  
with Asynchronous Clear

**MC14161B**

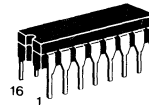
4-BIT BINARY COUNTER  
with Asynchronous Clear

**MC14162B**

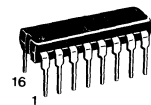
BCD COUNTER  
with Synchronous Clear

**MC14163B**

4-BIT BINARY COUNTER  
with Synchronous Clear



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



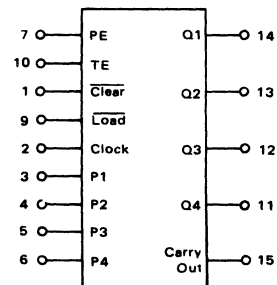
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

# MC14160B thru MC14163B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.56 μA/kHz) f + I <sub>DD</sub>						μA <sub>dc</sub>		
10	I <sub>T</sub> = (1.1 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

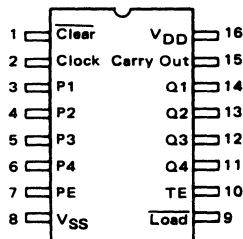
$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

### PIN ASSIGNMENT



# MC14160B thru MC14163B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	Min	Typ #	Max	Unit			
Output Rise Time	t <sub>TLH</sub>	5.0	—	100	200	ns			
		10	—	50	100				
		15	—	40	80				
Output Fall Time	t <sub>THL</sub>	5.0	—	100	200	ns			
		10	—	50	100				
		15	—	40	80				
Propagation Delay Time  Clock to Q t <sub>PLH</sub> , t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 305 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.36 ns/pF) C <sub>L</sub> + 132 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 87 ns Clock to Carry Out t <sub>PLH</sub> , t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 395 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.36 ns/pF) C <sub>L</sub> + 167 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 112 ns TE to Carry Out t <sub>PLH</sub> , t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 225 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.36 ns/pF) C <sub>L</sub> + 112 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 77 ns Clear to Q (MC14106B, MC14161B only) t <sub>PLH</sub> , t <sub>PHL</sub> = (0.90 ns/pF) C <sub>L</sub> + 110 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.36 ns/pF) C <sub>L</sub> + 37 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.26 ns/pF) C <sub>L</sub> + 22 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	350	700	ns			
		10	—	150	300				
		15	—	100	200				
		5.0	—	440	880				
		10	—	185	370				
		15	—	125	250				
		5.0	—	300	600				
		10	—	130	260				
		15	—	90	180				
		5.0	—	350	700				
		10	—	150	300				
		15	—	100	200				
		Setup Times  Data to Clock  Load to Clock  Enable to Clock (PE or TE)  Clear to Clock (MC14162B, MC14163B only)	t <sub>su</sub>	5.0	320		160	—	ns
				10	130		65	—	
				15	90		45	—	
5.0	600			300	—				
10	260			130	—				
15	180			90	—				
5.0	420			210	—				
10	170			85	—				
15	120			60	—				
5.0	310			155	—				
10	110			55	—				
15	70			35	—				
Hold Times  Clock to Data  Clock to Load  Clock to PE  Clock to TE  Clock to Clear (MC14162B, MC14163B only)	t <sub>h</sub>	5.0	-10	-60	—	ns			
		10	-5	-25	—				
		15	0	-15	—				
		5.0	-40	-195	—				
		10	-10	-80	—				
		15	-5	-50	—				
		5.0	-40	-175	—				
		10	-10	-70	—				
		15	0	-40	—				
		5.0	-150	-280	—				
		10	-30	-130	—				
		15	-20	-80	—				
		5.0	80	40	—				
		10	30	15	—				
		15	-10	-70	—				
		Clear Removal Time (MC14160B, MC14161B only)	t <sub>rem</sub>	5.0	90		30	—	ns
				10	65		20	—	
				15	55		20	—	

## MC14160B thru MC14163B

### SWITCHING CHARACTERISTICS ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ ) (Continued)

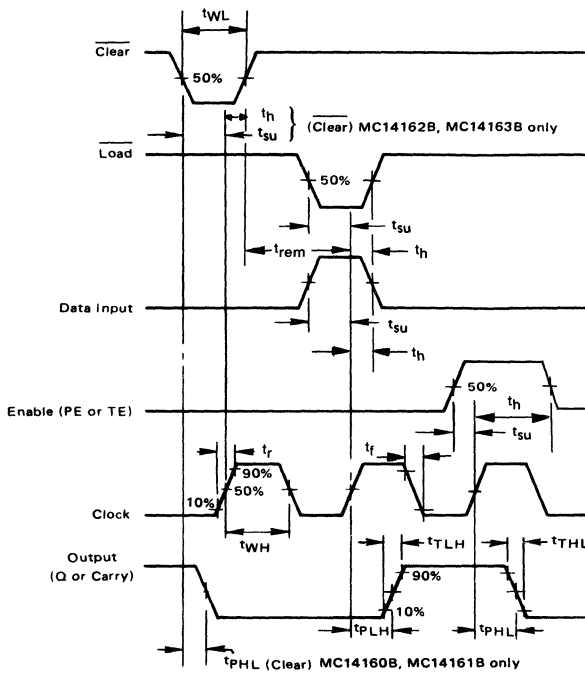
Characteristic	Symbol	$V_{DD}$ $V_{dc}$	Min	Typ #	Max	Unit
Clear Pulse Width, Low (MC14160B, MC14161B only)	$t_{WL}$	5.0	200	100	—	ns
		10	90	45	—	
		15	60	30	—	
Clock Pulse Width, High	$t_{WH}$	5.0	250	125	—	ns
		10	100	50	—	
		15	70	35	—	
Clock Rise and Fall Time	$t_r$ $t_f$	5	—	—	15	$\mu\text{s}$
		10	—	—	5	
		15	—	—	4	
Clock Pulse Frequency	$f_{cl}$	5.0	—	2.0	1.0	MHz
		10	—	5.0	2.5	
		15	—	8.0	4.0	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14160B thru MC14163B

## SWITCHING WAVEFORMS



## FUNCTIONAL DESCRIPTION

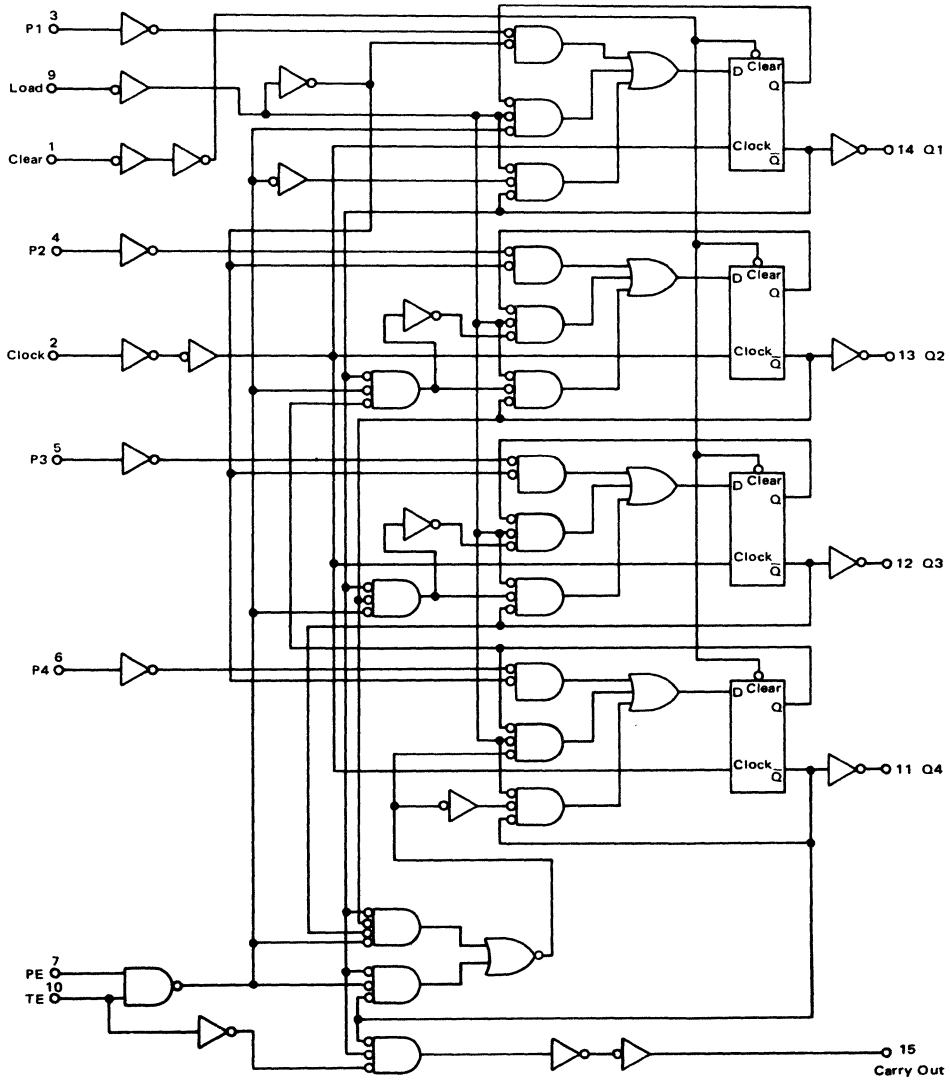
These counters are fully programmable; that is the outputs may be preset to either level. As presetting is synchronous, setting up a low level at the load input disables the counter and causes the outputs to agree with the setup data after the next clock pulse regardless of the levels of the enable inputs. The clear function for the MC14160B, MC14161B is asynchronous and a low level at the clear input sets all four of the flip-flop outputs low regardless of the levels of the clock, load or enable inputs. The clear function for the MC14162B and MC14163B is synchronous and a low level at the clear inputs sets all four of the flip-flop outputs low after the next clock pulse, regardless of the levels of the enable inputs. This synchronous clear allows the count length to be modified easily; decoding the maximum count de-

sired can be accomplished with one external NAND gate. The gate output is connected to the clear input to synchronously clear the counter to 0000 (LLLL).

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications without additional gating. Instrumental in accomplishing this function are two count-enable inputs and a carry output. Both count-enable inputs (PE, TE) must be high to count, and enable input TE fed forward to enable the carry output. The carry output thus enabled will produce a positive output pulse with a duration approximately equal to the positive portion of the Q1 output. This positive overflow carry pulse can be used to enable successive cascaded stages.

# MC14160B thru MC14163B

MC14160B, MC14162B LOGIC DIAGRAM  
(Clear is synchronous for MC14162B)



6

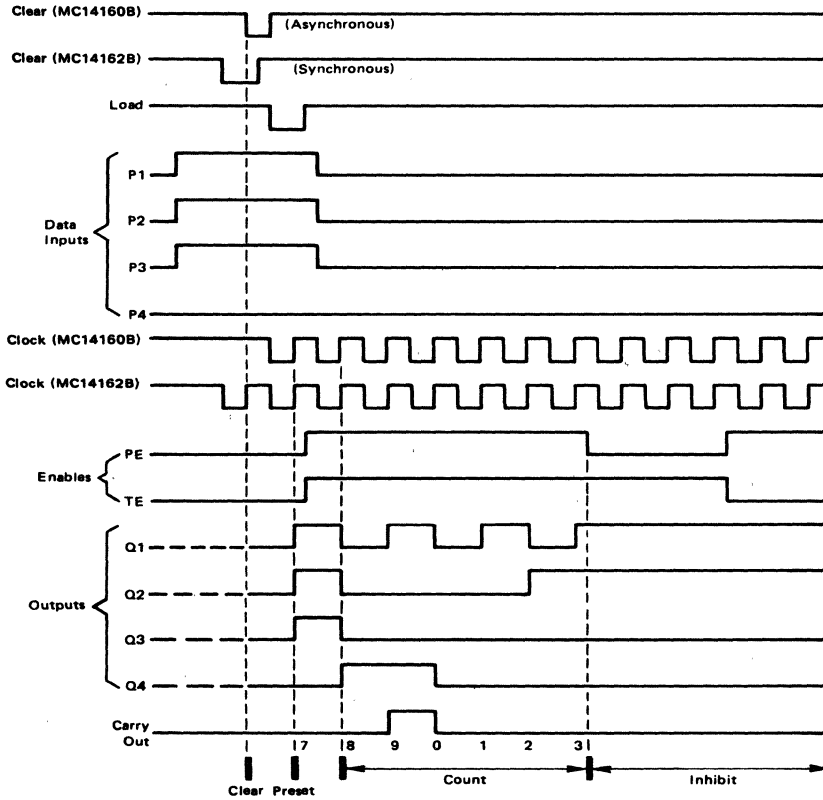


# MC14160B thru MC14163B

## MC14160B, MC14162B TIMING DIAGRAM

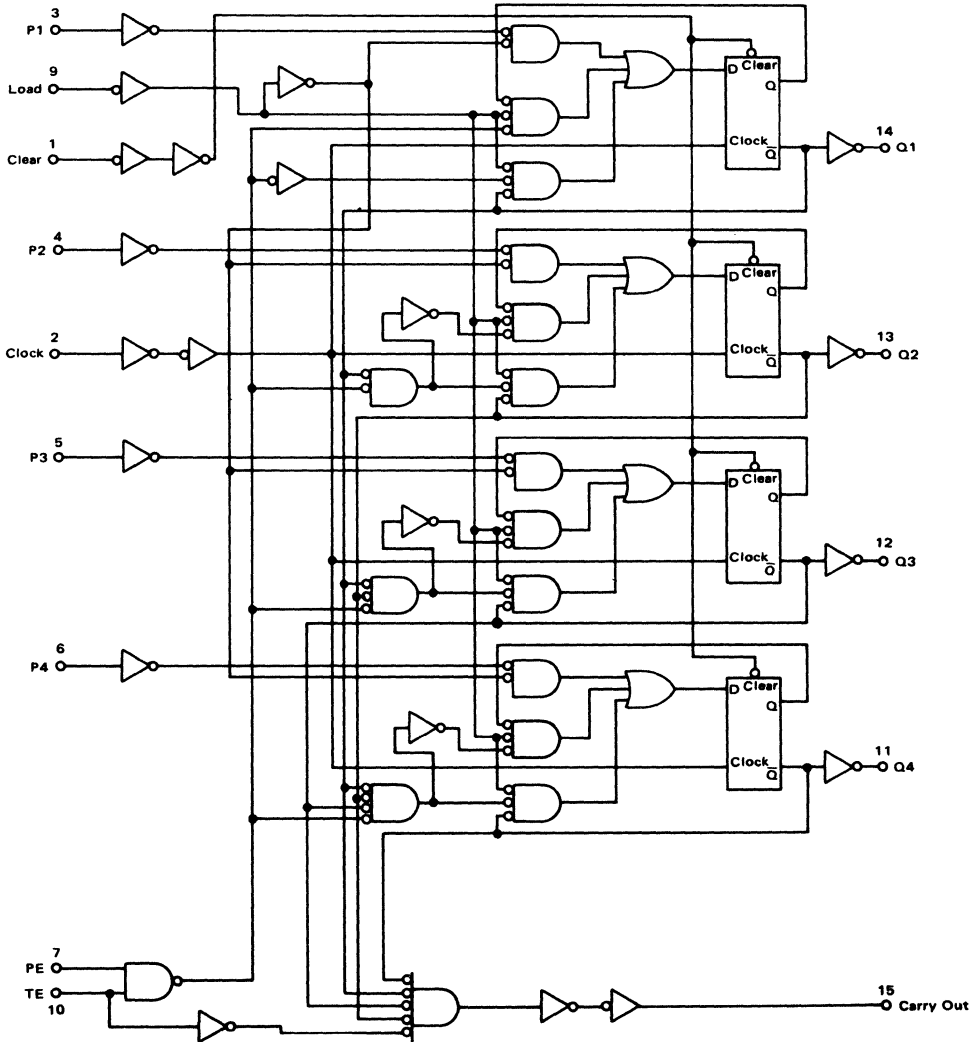
Sequence illustrated in waveforms:

1. Clear outputs to zero.
2. Preset to BCD seven.
3. Count to eight, nine, zero, one, two, and three.
4. Inhibit



# MC14160B thru MC14163B

MC14161B, MC14163B LOGIC DIAGRAM  
(Clear is Synchronous for MC14163B)



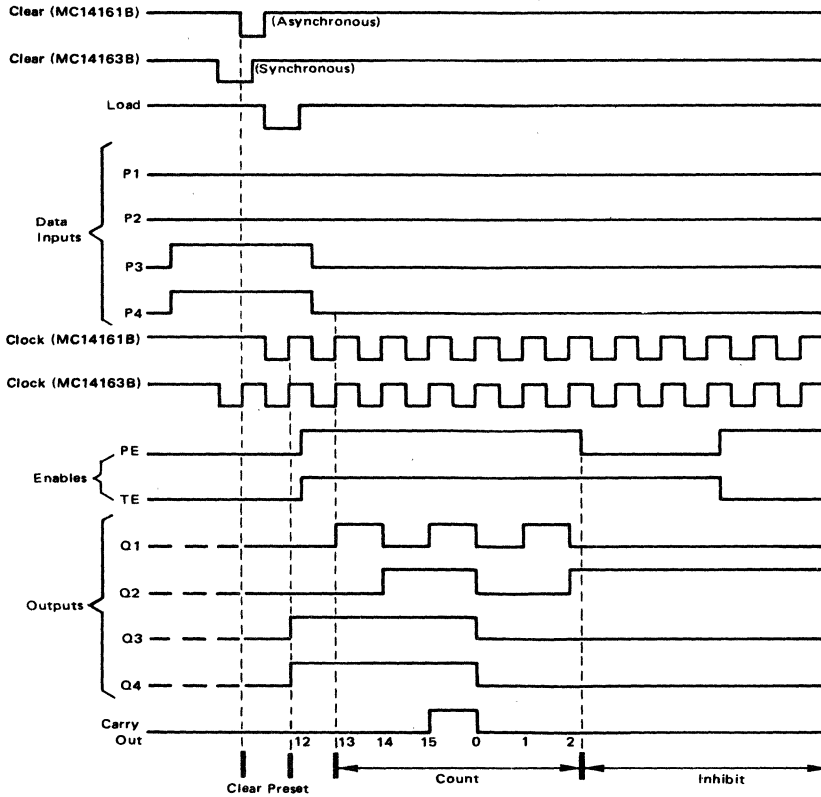
6

# MC14160B thru MC14163B

## MC14161B, MC14163B TIMING DIAGRAM

Sequence illustrated in waveforms:

1. Clear outputs to zero.
2. Preset to binary twelve.
3. Count to thirteen, fourteen, fifteen, zero, one, and two.
4. Inhibit



6



**MOTOROLA**

**MC14174B**

**HEX TYPE D FLIP-FLOP**

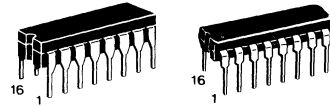
The MC14174B hex type D flip-flop is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Data on the D inputs which meets the setup time requirements is transferred to the Q outputs on the positive edge of the clock pulse. All six flip-flops share common clock and reset inputs. The reset is active low, and independent of the clock.

- Static Operation
- All Inputs and Outputs Buffered
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load over the Rated Temperature Range
- Functional Equivalent to TTL 74174

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**HEX TYPE D FLIP-FLOP**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

- A Series: -55°C to +125°C**  
MC14XXXBAL (Ceramic Package Only)
- C Series: -40°C to +85°C**  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

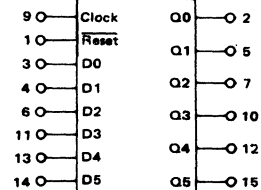
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating Plastic "P" Package - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package - 12mW/°C from 100°C to 125°C

**TRUTH TABLE**  
(Positive Logic)

Clock	INPUTS			Q	No Change
	Data	Reset			
	0	1		0	
	1	1		1	
	X	1		Q	
X	X	0		0	

X = Don't Care

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14174B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc)	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	(V <sub>OH</sub> = 13.5 Vdc)	15	-4.2	—	-3.4	-8.8	—	-2.4	—	mAdc
		(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.64	—	0.51	0.88	—	0.36	—	
		(V <sub>OL</sub> = 0.5 Vdc)	10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device)	Source I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc)	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		(V <sub>OH</sub> = 9.5 Vdc)	10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	(V <sub>OH</sub> = 13.5 Vdc)	15	-3.6	—	-3.0	-8.8	—	-2.4	—	mAdc
		(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.52	—	0.44	0.88	—	0.36	—	
		(V <sub>OL</sub> = 0.5 Vdc)	10	1.3	—	1.1	2.25	—	0.9	—	
(V <sub>OL</sub> = 1.5 Vdc)	15	3.6	—	3.0	8.8	—	2.4	—			
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.1 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (2.3 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (3.7 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.003.

# MC14174B

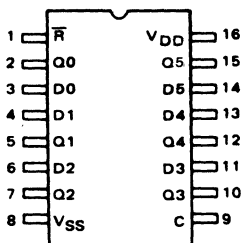
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.35 \text{ ns/pF}) C_L + 32 \text{ ns}$ $t_{TLH}, t_{THL} = (0.6 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH}, t_{THL} = (0.4 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time — Clock to Q $t_{PLH}, t_{PHL} = (0.9 \text{ ns/pF}) C_L + 165 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 64 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 52 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	210 85 65	400 160 120	ns
Propagation Delay Time — Reset to Q $t_{PHL} = (0.9 \text{ ns/pF}) C_L + 205 \text{ ns}$ $t_{PHL} = (0.36 \text{ ns/pF}) C_L + 79 \text{ ns}$ $t_{PHL} = (0.26 \text{ ns/pF}) C_L + 62 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	250 100 75	500 200 150	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	150 90 70	75 45 35	— — —	ns
Reset Pulse Width	$t_{WL}$	5.0 10 15	200 100 80	100 50 40	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	7.0 12.0 15.5	2.0 5.0 6.5	MHz
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	1.5 5.0 4.0	$\mu\text{s}$
Data Setup Time	$t_{su}$	5.0 10 15	40 20 15	20 10 0	— — 8	ns
Data Hold Time	$t_h$	5.0 10 15	80 40 30	40 20 15	— — —	ns
Reset Removal Time	$t_{rem}$	5.0 10 15	250 100 80	125 50 40	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

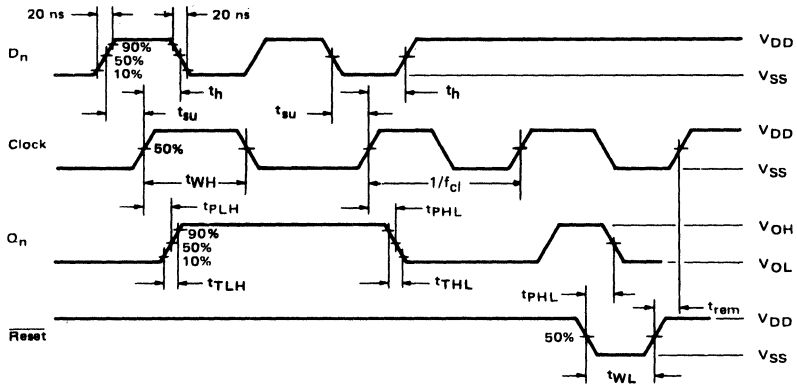
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

### PIN ASSIGNMENT

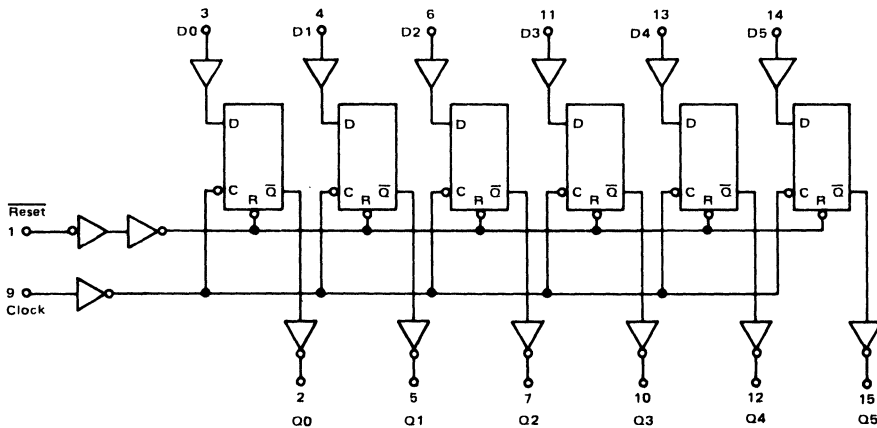


# MC14174B

## TIMING DIAGRAM



## FUNCTIONAL BLOCK DIAGRAM



6



# MOTOROLA

## MC14175B

### QUAD TYPE D FLIP-FLOP

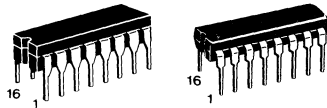
The MC14175B quad type D flip-flop is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each of the four flip-flops is positive-edge triggered by a common clock input (C). An active-low reset input ( $\bar{R}$ ) asynchronously resets all flip-flops. Each flip-flop has independent Data (D) inputs and complementary outputs (Q and  $\bar{Q}$ ). These devices may be used as shift register elements or as type T flip-flops for counter and toggle applications.

- Complementary Outputs
- Static Operation
- All Inputs and Outputs Buffered
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Output Compatible with Two Low-Power TTL Loads or One Low-Power Schottky TTL Load
- Functional Equivalent to TTL 74175

### CMOS SSI

(LOW-POWER COMPLEMENTARY MOS)

### QUAD TYPE D FLIP-FLOP



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

#### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

#### MAXIMUM RATINGS\* (Voltages Referenced to $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	± 10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

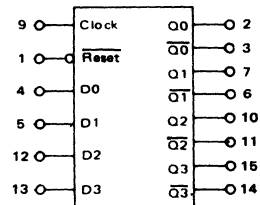
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package - 12mW/°C from 100°C to 125°C

#### TRUTH TABLE

INPUTS			OUTPUTS		
Clock	Data	Reset	Q	$\bar{Q}$	
	0	1	0	1	No Change
	1	1	1	0	
	X	1	Q	$\bar{Q}$	
X	X	0	0	1	

X = Don't Care

#### BLOCK DIAGRAM



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For

proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



# MC14175B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (3.4 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (5.0 μA/kHz) f + I <sub>DD</sub>						μAdc		

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

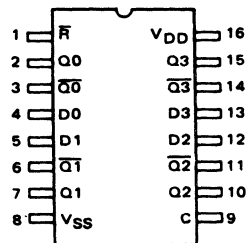
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

### PIN ASSIGNMENT



# MC14175B

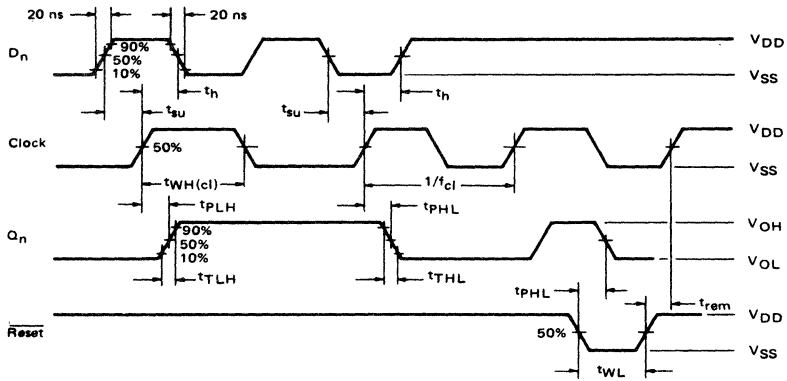
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.35 \text{ ns/pF}) C_L + 32 \text{ ns}$ $t_{TLH}, t_{THL} = (0.6 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH}, t_{THL} = (0.4 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time — Clock to Q, $\bar{Q}$ $t_{PLH}, t_{PHL} = (0.9 \text{ ns/pF}) C_L + 175 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 72 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 57 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	220 90 70	400 160 120	ns
Propagation Delay Time — Reset to Q, $\bar{Q}$ $t_{PHL} = (0.9 \text{ ns/pF}) C_L + 280 \text{ ns}$ $t_{PHL} = (0.36 \text{ ns/pF}) C_L + 112 \text{ ns}$ $t_{PHL} = (0.26 \text{ ns/pF}) C_L + 87 \text{ ns}$	$t_{PHL}, t_{PLH}$	5.0 10 15	— — —	325 130 100	500 200 150	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	250 100 75	110 45 35	— — —	ns
Reset Pulse Width	$t_{WL}$	5.0 10 15	200 80 60	100 40 30	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	4.5 11 14	2.0 5.0 6.5	MHz
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$
Data Setup Time	$t_{su}$	5.0 10 15	120 50 40	60 25 20	— — —	ns
Data Hold Time	$t_h$	5.0 10 15	80 40 30	40 20 15	— — —	ns
Reset Removal Time	$t_{rem}$	5.0 10 15	250 100 80	125 50 40	— — —	ns

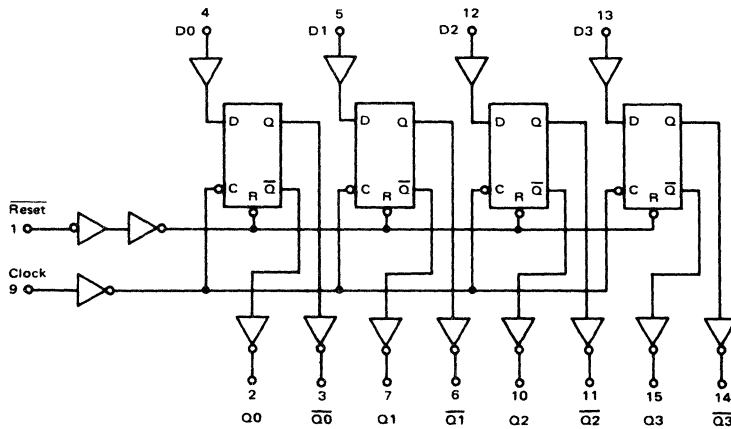
\*The formulas given are for the typical characteristics only at 25°C.  
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14175B

## TIMING DIAGRAM



## FUNCTIONAL BLOCK DIAGRAM





**MOTOROLA**

**MC14194B**

**4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTER**

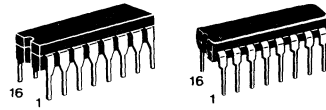
The MC14194B is a 4-bit static shift register capable of operating in the parallel load, serial shift left, serial shift right, or hold mode. The asynchronous  $\overline{\text{Reset}}$  input, when at a low level, overrides all other inputs, resets all stages, and forces all outputs low. When  $\overline{\text{Reset}}$  is at a logic 1 level, the two mode control inputs, S0 and S1, control the operating mode as shown in the truth table. Both serial and parallel operation are triggered on the positive-going transition of the Clock input. The Parallel Data, Data Shift, and mode control inputs must be stable for the specified setup and hold times before and after the positive-going Clock transition.

- Synchronous Right/Left Serial Operation
- Synchronous Parallel Load
- Asynchronous Hold (Do Nothing) Mode
- Functional Pin for Pin Equivalent of LS194

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

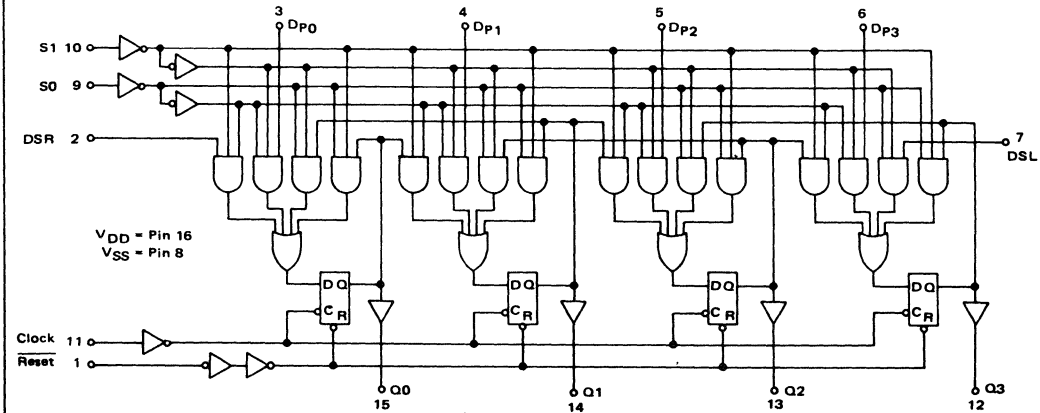
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**LOGIC DIAGRAM**



# MC14194B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	12.0	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.95 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.9 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

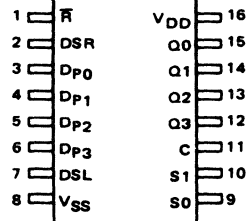
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

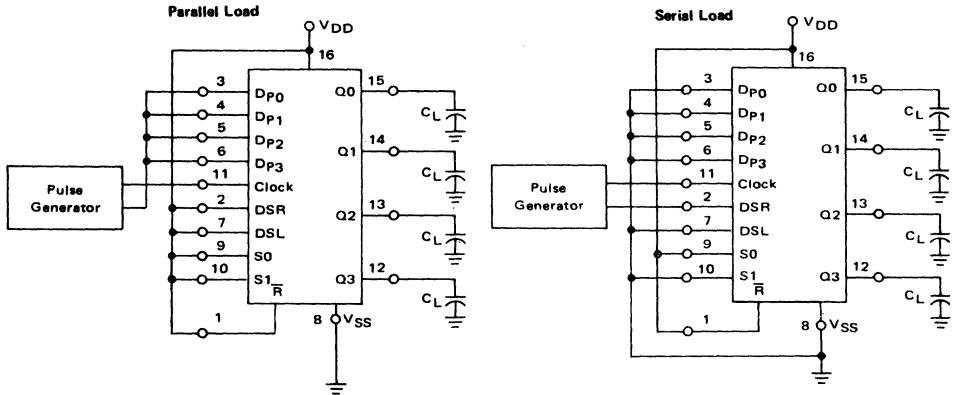
### PIN ASSIGNMENT



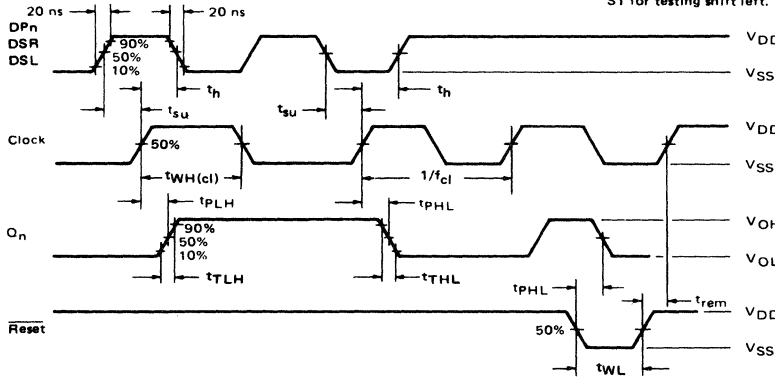


# MC14194B

FIGURE 1 – SWITCHING TIME TEST CIRCUITS AND WAVEFORMS

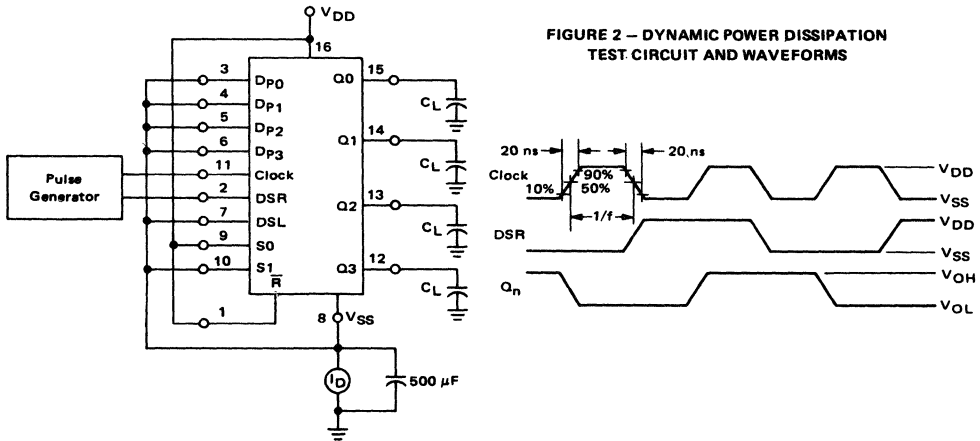


NOTE: Interchange DSR with DSL and S0 with S1 for testing shift left.



6

FIGURE 2 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS





**MOTOROLA**

**MC14415**

**QUAD PRECISION TIMER/DRIVER**

The MC14415 quad timer/driver is constructed with complementary MOS enhancement mode devices. The output pulse width of each digital timer is a function of the input clock frequency. Once the proper input sequence is detected the output buffer is set (turned on), and after 100 clock pulses are counted, the output buffer is reset (turned off).

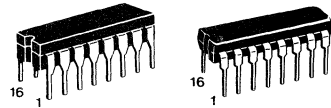
The MC14415 was designed specifically for application in high speed line printers to provide the critical timing of the hammer drivers, but may be used in many applications requiring precision pulse widths.

- Four Precision Digital Time Delays
- Schmitt Trigger Clock Conditioning
- NPN Bipolar Output Drivers
- Timing Disable Capability Using Inhibit Output
- Positive or Negative Edge Strobing on the Inputs
- Synchronous Polynomial Counters Used for Delay Counting
- Power Supply Operating Range  
3.0 Vdc to 18 Vdc (MC14415EFL/FL/FP)  
3.0 Vdc to 6.0 Vdc (MC14415EVL/VL/VP)

**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

**QUAD PRECISION  
TIMER/DRIVER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

Operating Range: -55°C to +125°C  
MC14415EFL (3 to 18 V, Ceramic Package)  
MC14415EVL (3 to 6 V, Ceramic Package)

Operating Range: -40°C to +85°C  
MC14415FL (3 to 18 V, Ceramic Package)  
MC14415FP (3 to 18 V, Plastic Package)  
MC14415VL (3 to 6 V, Ceramic Package)  
MC14415VP (3 to 6 V, Plastic Package)

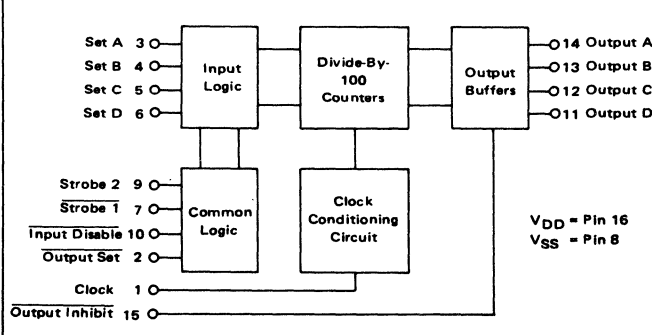
**6**

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

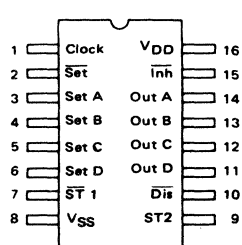
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage - MC14415EFL/FL/FP MC14415EVL/VL/VP	-0.5 to +18.0 -0.5 to +6.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub>	Input Current (DC or Transient), per Pin	± 10	mA
I <sub>out</sub>	Output Current (DC or Transient), per Pin	± 20	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**BLOCK DIAGRAM**



**PIN ASSIGNMENT**





# MC14415

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage (No Load)	"0" Level V <sub>OL</sub>	5.0	—	0.01	—	0	0.01	—	0.05	V <sub>dC</sub>	
		10	—	0.01	—	0	0.01	—	0.05		
		15	—	—	—	—	—	—	—		
	"1" Level V <sub>OH</sub>	5.0	—	—	3.0	4.14	—	—	—	V <sub>dC</sub>	
		10	—	—	8.0	9.09	—	—	—		
		15	—	—	—	14.12	—	—	—		
Noise Immunity ( $\Delta V_{out} \leq 1.5$ V <sub>dC</sub> ) ( $\Delta V_{out} \leq 3.0$ V <sub>dC</sub> ) ( $\Delta V_{out} \leq 4.5$ V <sub>dC</sub> )	V <sub>NL</sub>	5.0	1.5	—	1.5	2.25	—	1.4	—	V <sub>dC</sub>	
		10	3.0	—	3.0	4.50	—	2.9	—		
		15	—	—	—	6.75	—	—	—		
	V <sub>NH</sub>	5.0	1.4	—	1.5	2.25	—	1.5	—	V <sub>dC</sub>	
		10	2.9	—	3.0	4.50	—	3.0	—		
		15	—	—	—	6.75	—	—	—		
Output Drive Voltage (NPN Driver) Source	V <sub>OH</sub>	5.0	—	—	3.0	4.14	—	—	—	V <sub>dC</sub>	
			(I <sub>OH</sub> = 0 mA)	—	—	2.7	3.44	—	—		—
			(I <sub>OH</sub> = 5.0 mA)	—	—	2.5	3.30	—	—		—
			(I <sub>OH</sub> = 10 mA)	—	—	2.2	3.08	—	—		—
			(I <sub>OH</sub> = 15 mA)	—	—	—	—	—	—		—
			(I <sub>OH</sub> = 0 mA)	10	—	—	8.0	9.09	—		—
		(I <sub>OH</sub> = 5.0 mA)	—	—	7.7	8.45	—	—	—	V <sub>dC</sub>	
		(I <sub>OH</sub> = 10 mA)	—	—	7.5	8.30	—	—	—		
		(I <sub>OH</sub> = 15 mA)	—	—	7.1	8.14	—	—	—		
		(I <sub>OH</sub> = 0 mA)	15	—	—	—	14.12	—	—		—
		(I <sub>OH</sub> = 5.0 mA)	—	—	—	13.81	—	—	—		V <sub>dC</sub>
		(I <sub>OH</sub> = 10 mA)	—	—	—	13.70	—	—	—		
(I <sub>OH</sub> = 15 mA)	—	—	—	13.61	—	—	—	—			
Output Drive Current (V <sub>OL</sub> = 0.4 V <sub>dC</sub> ) (V <sub>OL</sub> = 0.5 V <sub>dC</sub> ) (V <sub>OL</sub> = 1.5 V <sub>dC</sub> )	I <sub>OL</sub>	5.0	0.23	—	0.20	0.78	—	0.16	—	mAdc	
		10	0.60	—	0.50	2.0	—	0.40	—		
		15	—	—	—	7.8	—	—	—		
Input Leakage Current	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	—	—	—	pF	
Quiescent Dissipation	P <sub>Q</sub>	5.0	—	0.25	—	0.00005	0.25	—	3.5	mW	
		10	—	1.0	—	0.00022	1.0	—	14		
		15	—	—	—	—	0.00050	—	—		—
Power Dissipation** (Dynamic plus Quiescent) (C <sub>L</sub> = 15 pF)	P <sub>D</sub>	5.0	P <sub>D</sub> = (56 mW/MHz) f + P <sub>Q</sub> P <sub>D</sub> = (225 mW/MHz) f + P <sub>Q</sub> P <sub>D</sub> = (510 mW/MHz) f + P <sub>Q</sub>							mW	
		10									
		15									

\*T<sub>low</sub> = -55°C for MC14415EFL, EVL; -40°C for MC14415FL, FP, VL, VP  
T<sub>high</sub> = +125°C for MC14415EFL, EVL; +85°C for MC14415FL, FP, VL, VP

\*\*The formulas given are for the typical characteristics only.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14415

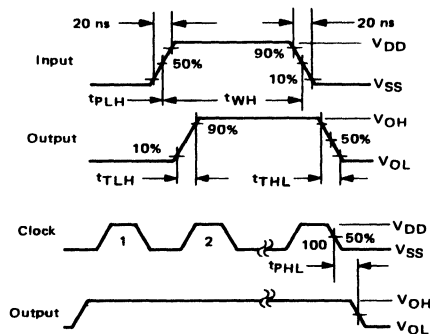
## SWITCHING CHARACTERISTICS\* ( $C_L = 15 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub> V <sub>dc</sub>	Min	Typ #	Max	Unit
Output Rise Time $t_{TLH} = (2.0 \text{ ns/pF}) C_L + 10 \text{ ns}$ $t_{TLH} = (1.25 \text{ ns/pF}) C_L + 6 \text{ ns}$ $t_{TLH} = (1.10 \text{ ns/pF}) C_L + 3 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	40 25 20	85 60 —	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 47 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 24 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 17 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	70 35 25	150 80 —	ns
Turn-Off Delay Time $t_{PLH} = (2.7 \text{ ns/pF}) C_L + 560 \text{ ns}$ $t_{PLH} = (1.2 \text{ ns/pF}) C_L + 282 \text{ ns}$ $t_{PLH} = (0.91 \text{ ns/pF}) C_L + 286 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	600 300 150	1200 600 —	ns
Turn-On Delay Time $t_{PHL} = (2.4 \text{ ns/pF}) C_L + 564 \text{ ns}$ $t_{PHL} = (1.0 \text{ ns/pF}) C_L + 285 \text{ ns}$ $t_{PHL} = (0.75 \text{ ns/pF}) C_L + 289 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	600 300 150	1200 600 —	ns
Turn-On Delay Time (Inhibit to Output)	$t_{PHL}$	5.0 10 15	— — —	300 225 110	550 425 —	ns
Turn-Off Delay Time (Inhibit to Output)	$t_{PLH}$	5.0 10 15	— — —	300 225 110	550 425 —	ns
Input Pulse Coincidence (Figure 3)	$PC_{min}$	5.0 10 15	500 450 —	450 350 —	— — —	ns
Input Pulse Width (Figure 1)	$t_{WH}$	5.0 10 15	500 450 —	450 350 —	— — —	ns
Input Clock Frequency	$f_{cl}$	5.0 10 15	— — —	0.7 1.0 1.5	— — —	MHz
Clock Input Rise and Fall Times (Figure 1)	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5.0 4.0	$\mu\text{s}$

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

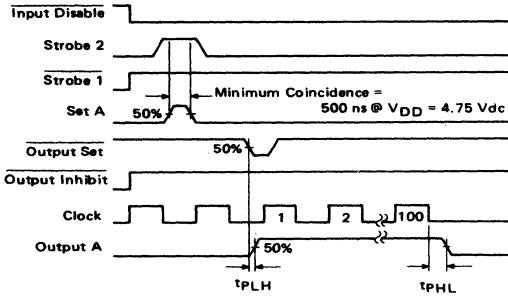
FIGURE 1 – SWITCHING CHARACTERISTICS – WAVEFORM RELATIONSHIPS



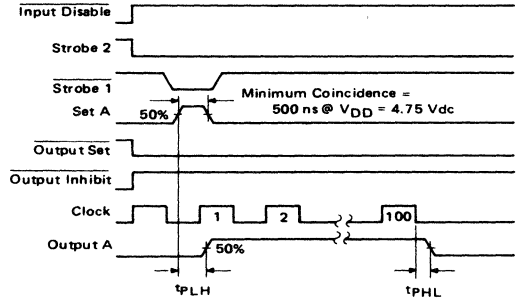
# MC14415

FIGURE 2 — TYPICAL OPERATION MODES AND FUNCTIONAL TIMING DIAGRAM

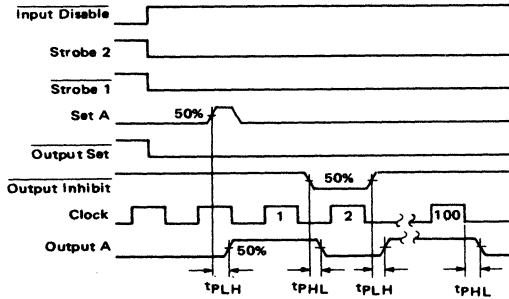
## MODE 1 — OUTPUT SET INITIATES TIME DELAY



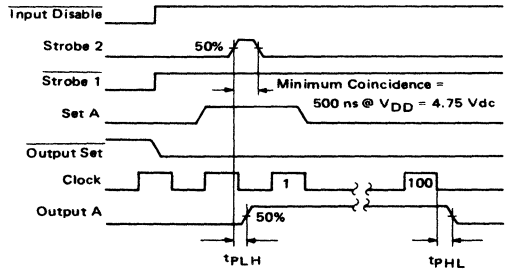
## MODE 2 : SET A INITIATES TIME DELAY



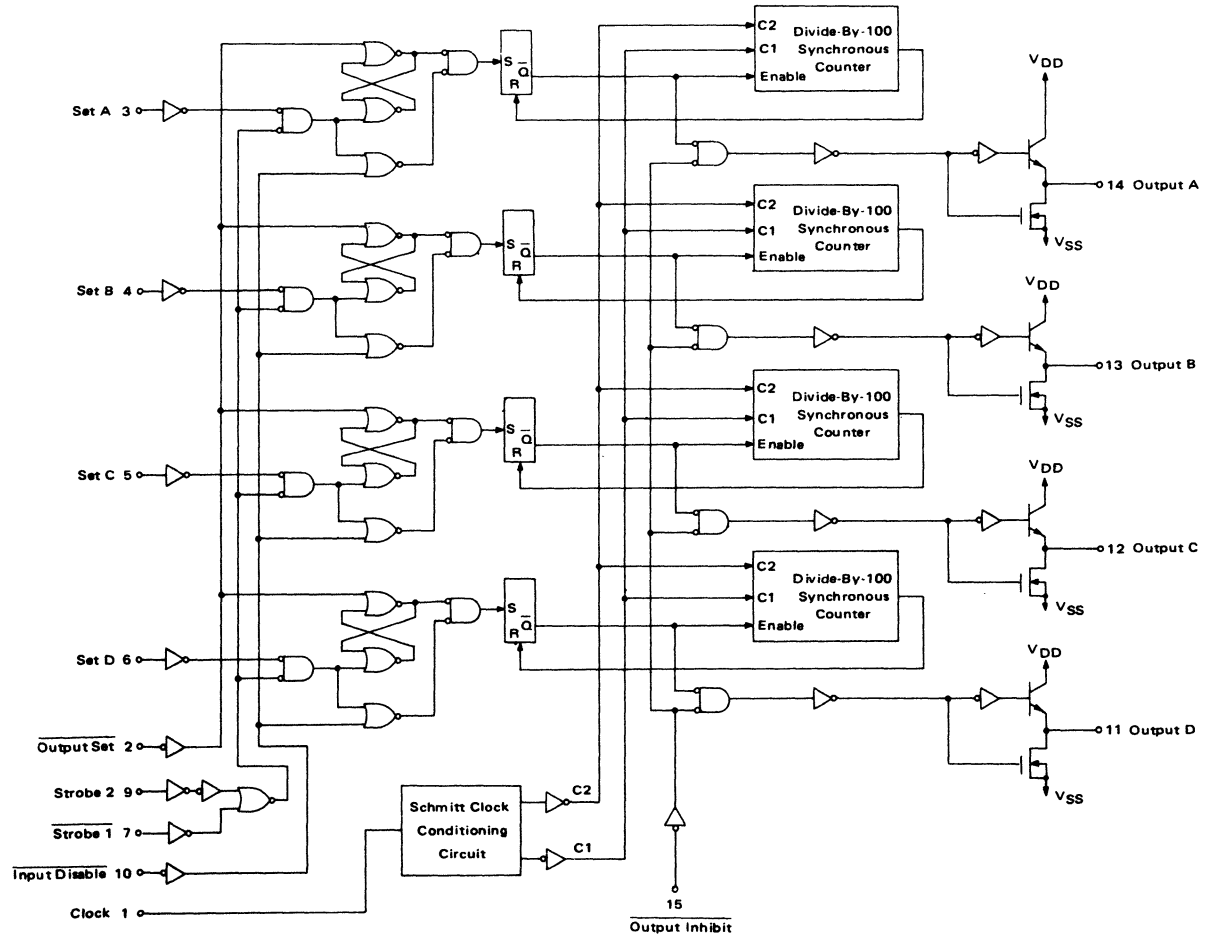
## MODE 3: OUTPUT INHIBIT DISABLES TIME DELAY



## MODE 4: POSITIVE-EDGE STROBE (ST2) INITIATES TIME DELAY



LOGIC DIAGRAM





**MOTOROLA**

**MC14490**

**HEX CONTACT BOUNCE ELIMINATOR**

The MC14490 is constructed with complementary MOS enhancement mode devices, and is used for the elimination of extraneous level changes that result when interfacing with mechanical contacts. The digital contact bounce eliminator circuit takes an input signal from a bouncing contact and generates a clean digital signal four clock periods after the input has stabilized. The bounce eliminator circuit will remove bounce on both the "make" and the "break" of a contact closure. The clock for operation of the MC14490 is derived from an internal R-C oscillator which requires only an external capacitor to adjust for the desired operating frequency (bounce delay). The clock may also be driven from an external clock source or the oscillator of another MC14490 (see Figure 5).

NOTE: Immediately after power-up, the outputs of the MC14490 are in indeterminate states.

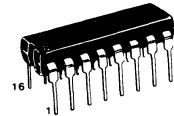
- Diode Protection on All Inputs
- Six Debouncers Per Package
- Internal Pullups on All Data Inputs
- Can Be Used as a Digital Integrator, System Synchronizer, or Delay Line
- Internal Oscillator (R-C), or External Clock Source
- TTL Compatible Data Inputs/Outputs
- Single Line Input, Debounces Both "Make" and "Break" Contacts
- Does Not Require "Form C" (Single Pole Double Throw) Input Signal
- Cascadable for Longer Time Delays
- Schmitt Trigger on Clock Input (Pin 7)
- Supply Voltage Range = 3.0 V to 18 V
- Chip Complexity: 546 FETs or 136.5 Equivalent Gates

**CMOS LSI**  
(LOW-POWER COMPLEMENTARY MOS)  
**HEX CONTACT BOUNCE ELIMINATOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648



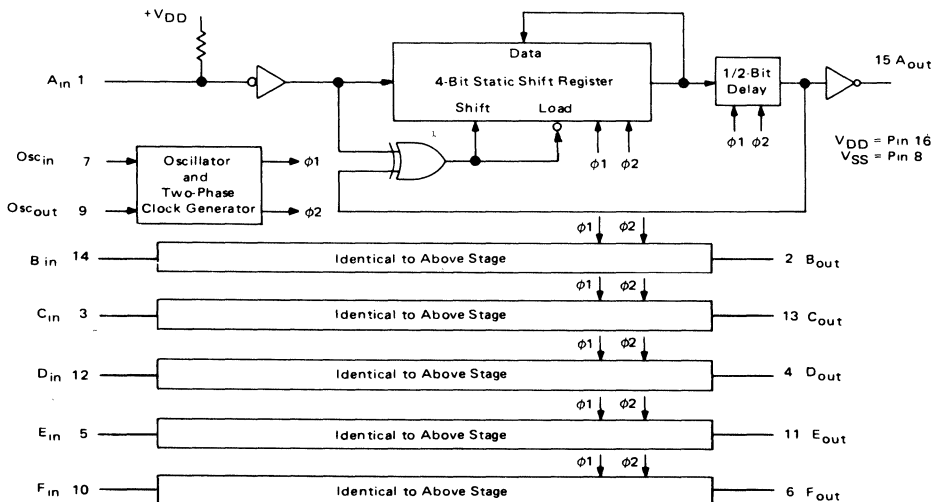
**ORDERING INFORMATION**

CERAMIC PACKAGE: MC14490L  
(-55°C to +125°C)

PLASTIC PACKAGE: MC14490P  
(-40°C to 85°C)

6

**BLOCK DIAGRAM**



# MC14490

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

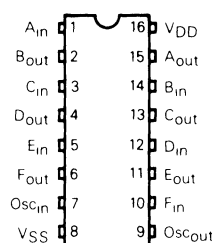
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub>	Input Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

## PIN ASSIGNMENT



## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ.#	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	-	0.05	-	0	0.05	-	0.05	V	
		10	-	0.05	-	0	0.05	-	0.05		
		15	-	0.05	-	0	0.05	-	0.05		
	"1" Level V <sub>OH</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	-	4.95	5.0	-	4.95	-	V
			10	9.95	-	9.95	10	-	9.95	-	
			15	14.95	-	14.95	15	-	14.95	-	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level V <sub>IL</sub>	5.0	-	1.5	-	2.25	1.5	-	1.5	V	
		10	-	3.0	-	4.50	3.0	-	3.0		
		15	-	4.0	-	6.75	4.0	-	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 V) (V <sub>O</sub> = 1.0 or 9.0 V) (V <sub>O</sub> = 1.5 or 13.5 V)	V <sub>IH</sub>	5.0	3.5	-	3.5	2.75	-	3.5	-	V
			10	7.0	-	7.0	5.50	-	7.0	-	
			15	11.0	-	11.0	8.25	-	11.0	-	
Output Drive Current Source Oscillator Output (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) Debounce Outputs (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) Sink Oscillator Output (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V) Debounce Outputs (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	I <sub>OH</sub>	5.0	-0.6	-	-0.5	-1.5	-	-0.4	-	mA	
		5.0	-0.12	-	-0.1	-0.3	-	-0.08	-		
		10	-0.23	-	-0.20	-0.8	-	-0.16	-		
		15	-1.4	-	-1.2	-3.0	-	-1.0	-		
		5.0	-0.9	-	-0.75	-2.2	-	-0.6	-		
		5.0	-0.19	-	-0.16	-0.46	-	-0.12	-		
	I <sub>OL</sub>	5.0	-0.60	-	-0.50	-1.2	-	-0.4	-	mA	
		10	-1.8	-	-1.5	-4.5	-	-1.2	-		
		5.0	0.36	-	0.30	0.9	-	0.24	-		
		10	0.9	-	0.75	2.3	-	0.6	-		
		15	4.2	-	3.5	10	-	2.8	-		
		5.0	2.6	-	2.2	4.0	-	1.8	-		
Input Current Debounce Inputs (V <sub>in</sub> = V <sub>DD</sub> )	I <sub>IH</sub>	15	-	2	-	0.2	2	-	11	μA	
		15	-	± 620	-	± 255	± 400	-	± 250	μA	
		15	-	± 620	-	± 255	± 400	-	± 250	μA	
Pullup Resistor Source Current Debounce Inputs (V <sub>in</sub> = V <sub>SS</sub> )	I <sub>IL</sub>	5.0	210	375	140	190	255	70	130	μA	
		10	415	740	280	380	500	145	265		
		15	610	1100	415	570	750	215	400		
Input Capacitance	C <sub>in</sub>	-	-	-	-	5.0	7.5	-	-	pF	
Quiescent Current (V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , I <sub>out</sub> = 0 μA)	I <sub>SS</sub>	5.0	-	150	-	40	100	-	90	μA	
		10	-	280	-	90	225	-	180		
		15	-	840	-	225	650	-	550		

\*T<sub>low</sub> = -55°C for L Device, -40°C for P Device.

T<sub>high</sub> = +125°C for L Device, +85°C for P Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14490

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit
Output Rise Time All Outputs	t <sub>TLH</sub>	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time Oscillator Output	t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Debounce Outputs	t <sub>THL</sub>	5.0 10 15	— — —	60 30 20	120 60 40	ns
Propagation Delay Time Oscillator Input to Debounce Outputs	t <sub>PHL</sub>	5.0 10 15	— — —	285 120 95	570 240 190	ns
Clock Frequency (50% Duty Cycle) (External Clock)	f <sub>cl</sub>	5.0 10 15	— — —	2.8 6 9	1.4 3.0 4.5	MHz
Setup Time (See Figure 1)	t <sub>su</sub>	5.0 10 15	100 80 60	50 40 30	— — —	ns
Maximum External Clock Input Rise and Fall Time Oscillator Input	t <sub>r</sub> , t <sub>f</sub>	5.0 10 15	No Limit			ns
Oscillator Frequency OSC <sub>out</sub> C <sub>ext</sub> ≥ 100 pF*	f <sub>osc, typ</sub>	5.0	$\frac{1.5}{C_{ext} \text{ (in } \mu\text{F)}}$ $\frac{4.5}{C_{ext} \text{ (in } \mu\text{F)}}$ $\frac{6.5}{C_{ext} \text{ (in } \mu\text{F)}}$			Hz

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

### \*POWER-DOWN CONSIDERATIONS

Large values of C<sub>ext</sub> may cause problems when powering down the MC14490 because of the amount of energy stored in the capacitor. When a system containing this device is powered down, the capacitor may discharge through the input protection diodes at Pin 7 or the parasitic diodes at Pin 9. Current through these internal diodes must be limited to 10 mA, therefore the turn-off time of the power supply must not be faster than  $t = (V_{DD} - V_{SS}) \cdot C_{ext} / (10 \text{ mA})$ . For example, if V<sub>DD</sub> - V<sub>SS</sub> = 15 V and C<sub>ext</sub> = 1 μF, the power supply must turn off no faster than  $t = (15 \text{ V}) \cdot (1 \mu\text{F}) / 10 \text{ mA} = 1.5 \text{ ms}$ . This is usually not a problem because power supplies are heavily filtered and cannot discharge at this rate.

When a more rapid decrease of the power supply to zero volts occurs, the MC14490 may sustain damage. To avoid this possibility, use external clamping diodes, D1 and D2, connected as shown in Figure 2.

FIGURE 1 — SWITCHING WAVEFORMS

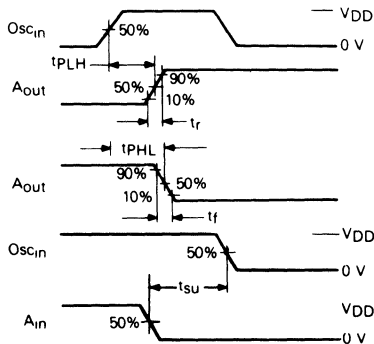
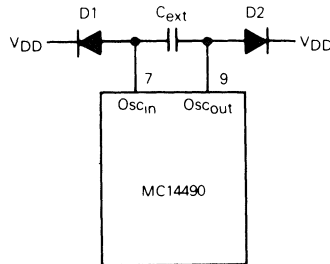


FIGURE 2 — DISCHARGE PROTECTION DURING POWER DOWN



## THEORY OF OPERATION

The MC14490 Hex Contact Bounce Eliminator is basically a digital integrator. The circuit can integrate both up and down. This enables the circuit to eliminate bounce on both the leading and trailing edges of the signal, shown in the timing diagram of Figure 3.

Each of the six Bounce Eliminators is composed of a  $4\frac{1}{2}$ -bit register (the integrator) and logic to compare the input with the contents of the shift register, as shown in Figure 4. The shift register requires a series of timing pulses in order to shift the input signal into each shift register location. These timing pulses (the clock signal) are represented in the upper waveform of Figure 3. Each of the six Bounce Eliminator circuits has an internal resistor as shown in Figure 4. A pullup resistor was incorporated rather than a pulldown resistor in order to implement switched ground input signals, such as those coming from relay contacts and push buttons. By switching ground, rather than a power supply lead, system faults (such as shorts to ground on the signal input leads) will not cause excessive currents in the wiring and contacts. Signal lead shorts to ground are much more probable than shorts to a power supply lead.

When the relay contact is closed, (see Figure 4) the low level is inverted, and the shift register is loaded with a high on each positive edge of the clock signal. To understand the operation, we assume all bits of the shift register are loaded with lows and the output is at a high level.

At clock edge 1 (Figure 3) the input has gone low and a high has been loaded into the first bit or storage location of the shift register. Just after the positive edge of clock 1, the input signal has bounced back to a high. This causes the shift register to be reset to lows in all four bits — thus starting the timing sequence over again.

During clock edges 3 to 6 the input signal has stayed low. Thus, a high has been shifted into all four shift register bits and, as shown, the output goes low during the positive edge of clock pulse 6.

It should be noted that there is a  $3\frac{1}{2}$  to  $4\frac{1}{2}$  clock period delay between the clean input signal and output signal. In this example there is a delay of 3.8 clock periods from the beginning of the clean input signal.

After some time period of  $N$  clock periods, the contact is opened and at  $N+1$  a low is loaded into the first bit. Just after  $N+1$ , when the input bounces low, all bits are set to a high. At  $N+2$  nothing happens because the input and output are low and all bits of the shift register are high. At time  $N+3$  and thereafter the input signal is a high, clean signal. At the positive edge of  $N+6$  the output goes high as a result of four lows being shifted into the shift register.

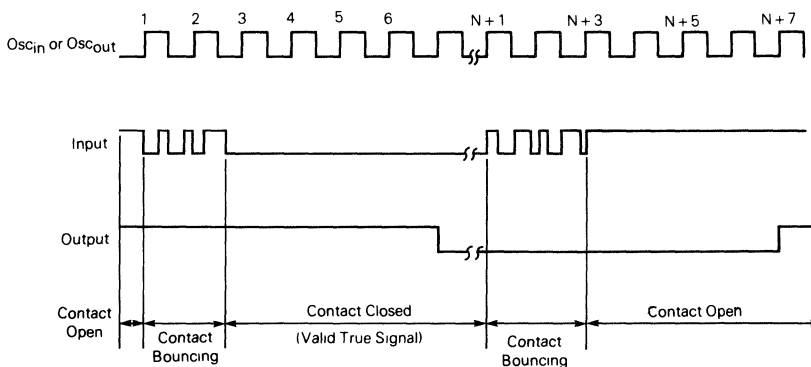
Assuming the input signal is long enough to be clocked through the Bounce Eliminator, the output signal will be no longer or shorter than the clean input signal plus or minus one clock period.

The amount of time distortion between the input and output signals is a function of the difference in bounce characteristics on the edges of the input signal and the clock frequency. Since most relay contacts have more bounce when making as compared to breaking, the overall delay, counting bounce period, will be greater on the leading edge of the input signal than on the trailing edge. Thus, the output signal will be shorter than the input signal — if the leading edge bounce is included in the overall timing calculation.

The only requirement on the clock frequency in order to obtain a bounce free output signal is that four clock periods do not occur while the input signal is in a false state. Referring to Figure 3, a false state is seen to occur three times at the beginning of the input signal. The input signal goes low three times before it finally settles down to a valid low state. The first three low pulses are referred to as false states.

If the user has an available clock signal of the proper frequency, it may be used by connecting it to the oscillator input (pin 7). However, if an external clock is not available the user can place a small capacitor across the oscillator input and output pins in order to start up an internal clock source (as shown in Figure 4). The clock signal at the oscillator output pin may then be used to clock other MC14490 Bounce Eliminator packages. With the use of the MC14490, a large number of signals can be cleaned up, with the requirement of only one small capacitor external to the Hex Bounce Eliminator packages.

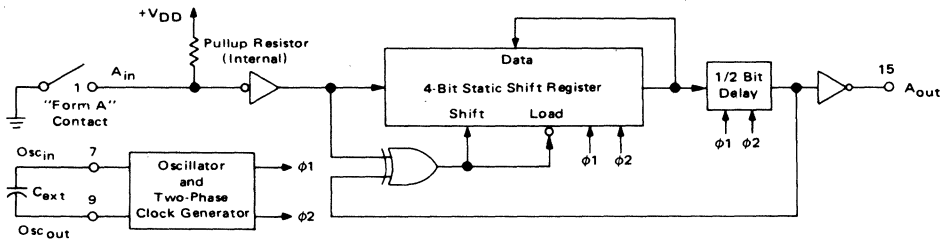
FIGURE 3 — TIMING DIAGRAM





# MC14490

**FIGURE 4 – TYPICAL "FORM A" CONTACT DEBOUNCE CIRCUIT**  
(Only One Debouncer Shown)



## OPERATING CHARACTERISTICS

The single most important characteristic of the MC14490 is that it works with a single signal lead as an input, making it directly compatible with mechanical contacts (Form A and B).

The circuit has a built in pullup resistor on each input. The worst case value of the pullup resistor (determined from the Electrical Characteristics table) is used to calculate the contact wetting current. If more contact current is required, an external resistor may be connected between  $V_{DD}$  and the input.

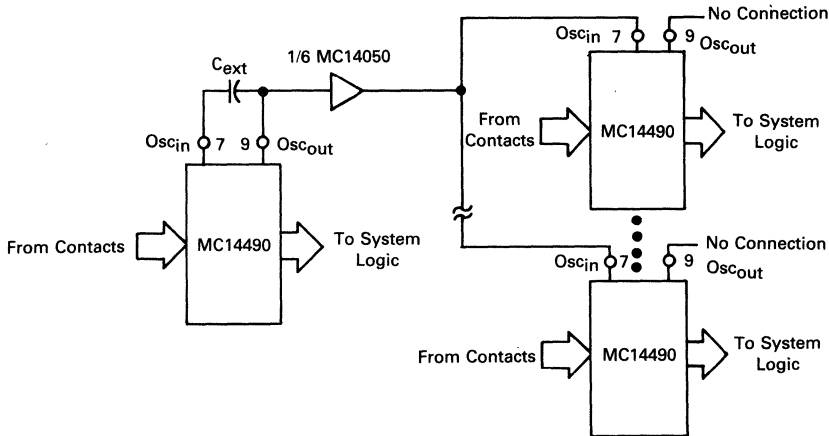
Because of the built-in pullup resistors, the inputs cannot be driven with a single standard CMOS gate when  $V_{DD}$  is below 5 V. At this voltage, the input should be driven with

paralleled standard gates or by the MC14049 or MC14050 buffers.

The clock input circuit (pin 7) has Schmitt trigger shaping such that proper clocking will occur even with very slow clock edges, eliminating any need for clock preshaping. In addition, other MC14490 oscillator inputs can be driven from a single oscillator output buffered by an MC14050 (see Figure 5). Up to six MC14490s may be driven by a single buffer.

The MC14490 is TTL compatible on both the inputs and the outputs. When  $V_{DD}$  is at 4.5 V, the buffered outputs can sink 1.6 mA at 0.4 V. The inputs can be driven with TTL as a result of the internal input pullup resistors.

**FIGURE 5 – TYPICAL SINGLE OSCILLATOR DEBOUNCE SYSTEM**



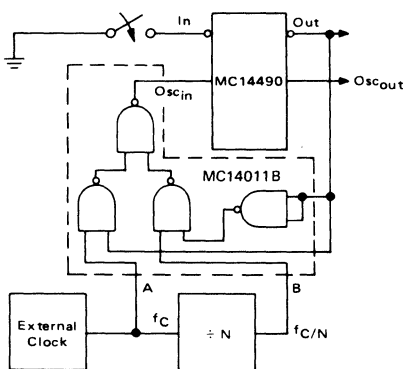
# MC14490

## TYPICAL APPLICATIONS

### ASYMMETRICAL TIMING

In applications where different leading and trailing edge delays are required (such as a fast attack/slow release timer.) Clocks of different frequencies can be gated into the MC14490 as shown in Figure 6. In order to produce a slow attack/fast release circuit leads A and B should be interchanged. The clock out lead can then be used to feed clock signals to the other MC14490 packages where the asymmetrical input/output timing is required.

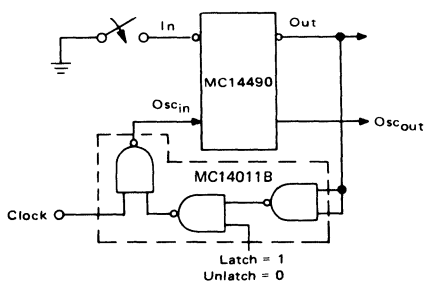
FIGURE 6 - FAST ATTACK/SLOW RELEASE CIRCUIT



### LATCHED OUTPUT

The contents of the Bounce Eliminator can be latched by using several extra gates as shown in Figure 7. If the latch lead is high the clock will be stopped when the output goes low. This will hold the output low even though the input has returned to the high state. Any time the clock is stopped the outputs will be representative of the input signal four clock periods earlier.

FIGURE 7 - LATCHED OUTPUT CIRCUIT

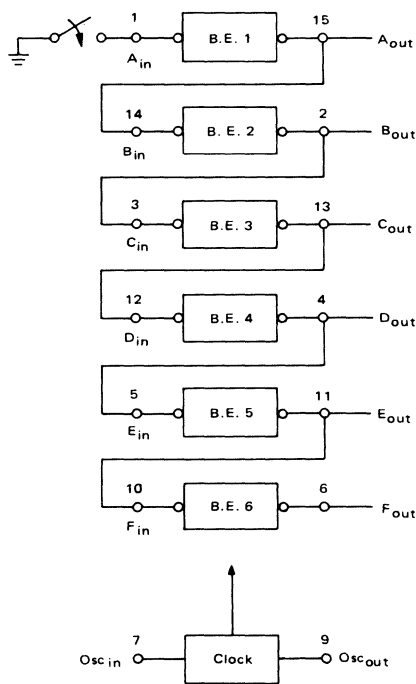


### MULTIPLE TIMING SIGNALS

As shown in Figure 8, the Bounce Eliminator circuits can be connected in series. In this configuration each output is delayed by four clock periods relative to its respective input. This configuration may be used to generate multiple timing signals such as a delay line, for programming other timing operations.

One application of the above is shown in Figure 9, where it is required to have a single pulse output for a single operation (make) of the push button or relay contact. This only requires the series connection of two Bounce Eliminator circuits, one inverter, and one NOR gate in order to generate the signal  $\overline{AB}$  as shown in Figures 9 and 10. The signal  $\overline{AB}$  is four clock periods in length. If the inverter is switched to the A output, the pulse  $\overline{AB}$  will be generated upon release or break of the contact. With the use of a few additional parts many different pulses and waveshapes may be generated.

FIGURE 8 - MULTIPLE TIMING CIRCUIT CONNECTIONS



# MC14490

FIGURE 9 – SINGLE PULSE OUTPUT CIRCUIT

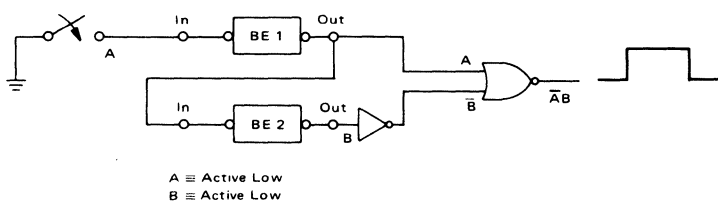
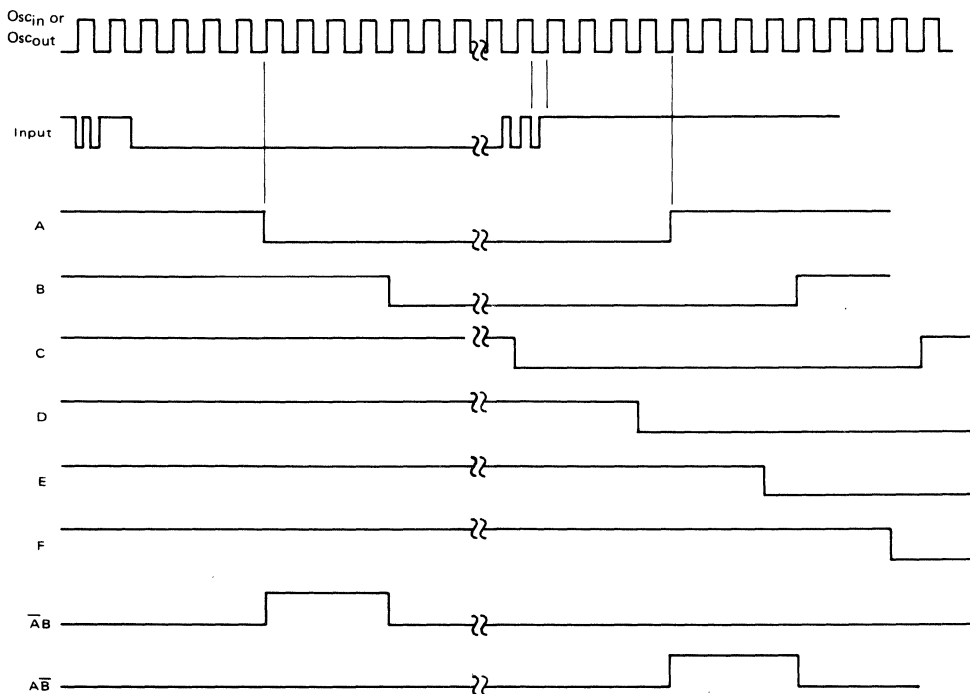


FIGURE 10 – MULTIPLE OUTPUT SIGNAL TIMING DIAGRAM



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



**MOTOROLA**

**MC14500B**

**INDUSTRIAL CONTROL UNIT**

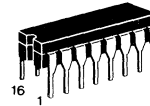
The MC14500B Industrial Control Unit (ICU) is a single-bit CMOS processor. The ICU is designed for use in systems requiring decisions based on successive single-bit information. An external ROM stores the control program. With a program counter (and output latches and input multiplexers, if required) the ICU in a system forms a stored-program controller that replaces combinatorial logic. Applications include relay logic processing, serial data manipulation and control. The ICU also may control an MPU or be controlled by an MPU.

- 16 Instructions
- DC to 1.0 MHz Operation at  $V_{DD} = 5\text{ V}$
- On-Chip Clock (Oscillator)
- Executes One Instruction per Clock Cycle
- 3 to 18 V Operation
- Low Quiescent Current Characteristic of CMOS Devices
- Capable of Driving One Low-Power Schottky Load or Two Low-Power TTL Loads over Full Temperature Range

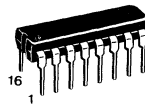
**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

**INDUSTRIAL CONTROL UNIT**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



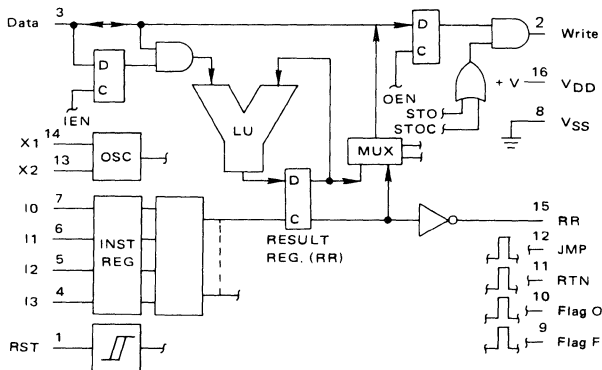
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

**A Series:**  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$   
MC14XXXBAL (Ceramic Package Only)

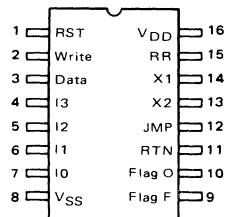
**C Series:**  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



X1 — Oscillator Output  
X2 — Oscillator Input

**PIN ASSIGNMENT**



# MC14500B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	-	0.05	-	0	0.05	-	0.05	V	
		10	-	0.05	-	0	0.05	-	0.05		
		15	-	0.05	-	0	0.05	-	0.05		
	"1" Level V <sub>OH</sub>	5.0	4.95	-	4.95	5.0	-	4.95	-	V	
		10	9.95	-	9.95	10	-	9.95	-		
		15	14.95	-	14.95	15	-	14.95	-		
Input Voltage RST, D, X2 (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level V <sub>IL</sub>	5.0	-	1.5	-	2.25	1.5	-	1.5	V	
		10	-	3.0	-	4.50	3.0	-	3.0		
		15	-	4.0	-	6.75	4.0	-	4.0		
	"1" Level V <sub>IH</sub>	5.0	3.5	-	3.5	2.75	-	3.5	-	V	
		10	7.0	-	7.0	5.50	-	7.0	-		
		15	11.0	-	11.0	8.25	-	11.0	-		
Input Voltage # I0, I1, I2, I3 (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level V <sub>IL</sub>	5.0	-	0.8	-	1.1	0.8	-	0.8	V	
		10	-	1.6	-	2.2	1.6	-	1.6		
		15	-	2.4	-	3.4	2.4	-	2.4		
	"1" Level V <sub>IH</sub>	5.0	2.0	-	2.0	1.9	-	2.0	-	V	
		10	6.0	-	6.0	3.1	-	6.0	-		
		15	10	-	10	4.3	-	10	-		
Output Drive Current Data, Write (AL/CL/CP Device) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	-1.2	-	-1.0	-2.0	-	-0.7	-	mA	
		10	-3.6	-	-3.0	-6.0	-	-2.1	-		
		15	-7.2	-	-6.0	-12	-	-4.2	-		
		5.0	1.9	-	1.6	3.2	-	1.1	-		
		10	3.6	-	3.0	6.0	-	2.1	-		
		15	7.2	-	6.0	12	-	4.2	-		
	Output Drive Current Other Outputs (AL Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	-3.0	-	-2.4	-4.2	-	-1.7	-	mA
			5.0	-0.64	-	-0.51	-0.88	-	-0.36	-	
			10	-1.6	-	-1.3	-2.25	-	-0.9	-	
			15	-4.2	-	-3.4	8.8	-	-2.4	-	
			5.0	0.64	-	0.51	0.88	-	0.36	-	
			10	1.6	-	1.3	2.25	-	0.9	-	
15		4.2	-	3.4	8.8	-	2.4	-			
Output Drive Current Other Outputs (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)		Source I <sub>OH</sub>	5.0	-2.5	-	-2.1	-4.2	-	-1.7	-	mA
			5.0	-0.52	-	-0.44	-0.88	-	-0.36	-	
			10	-1.3	-	-1.1	-2.25	-	-0.9	-	
			15	-3.6	-	-3.0	-8.8	-	-2.4	-	
			5.0	0.52	-	0.44	0.88	-	0.36	-	
	10		1.3	-	1.1	2.25	-	0.9	-		
	15	3.6	-	3.0	8.8	-	2.4	-			

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

# MC14500B

## ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	V <sub>DD</sub> V	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Input Current, RST (AL/CL/CP Device)	I <sub>in</sub>	15	25	—	—	150	—	—	250	μA
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance (Data)	C <sub>in</sub>	—	—	—	—	15	—	—	—	pF
Input Capacitance (All Other Inputs)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package) I <sub>out</sub> = 0 μA, V <sub>in</sub> =0 or V <sub>DD</sub>	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package) I <sub>out</sub> = 0 μA, V <sub>in</sub> =0 or V <sub>DD</sub>	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
**Total Supply Current at an External Load Capacitance (C <sub>L</sub> ) on All Outputs	I <sub>T</sub>	—	I <sub>T</sub> = (1.5 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (3.0 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (4.5 μA/kHz) f + I <sub>DD</sub>						μA	

\* T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\* The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

**SWITCHING CHARACTERISTICS** (T<sub>A</sub> = 25°C, t<sub>r</sub> = t<sub>f</sub> = 20 ns for X and I inputs; C<sub>L</sub> = 50 pF for JMP, X1, RR, Flag O, Flag F; C<sub>L</sub> = 130 pF + 1 TTL load for Data and Write.)

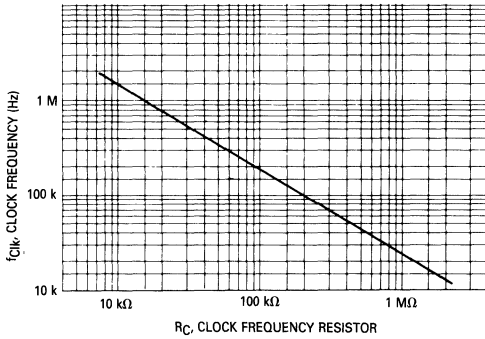
Characteristic	Symbol	V <sub>DD</sub> Vdc	All Types			Unit
			Min	Typ #	Max	
Propagation Delay Time, X1 to RR	tp <sub>LH</sub> , tp <sub>HL</sub>	5.0	—	250	500	ns
		10	—	125	250	
		15	—	100	200	
X1 to Flag F, Flag O, RTN, JMP		5.0	—	200	400	
		10	—	100	200	
		15	—	85	170	
X1 to Write		5.0	—	225	450	
		10	—	125	250	
		15	—	100	200	
X1 to Data		5.0	—	250	500	
		10	—	120	240	
		15	—	100	200	
RST to RR		5.0	—	250	500	
		10	—	125	250	
		15	—	100	200	
RST to X1		5.0	—	450	Note 1	
		10	—	200		
		15	—	150		
RST to Flag F, Flag O, RTN, JMP		5.0	—	400	800	
		10	—	200	400	
		15	—	150	300	
RST to Write, Data		5.0	—	450	900	
		10	—	225	450	
		15	—	175	350	
Clock Pulse Width, X1	t <sub>W(c)</sub>	5.0	400	200	—	ns
		10	200	100	—	
		15	180	90	—	
Reset Pulse Width, RST	t <sub>W(R)</sub>	5.0	500	250	—	ns
		10	250	125	—	
		15	200	100	—	
Setup Time — Instruction	t <sub>su(I)</sub>	5.0	400	200	—	ns
		10	250	125	—	
		15	180	90	—	
Data	t <sub>su(D)</sub>	5.0	200	100	—	
		10	100	50	—	
		15	80	40	—	
Hold Time — Instruction	t <sub>h(I)</sub>	5.0	100	0	—	ns
		10	50	0	—	
		15	50	0	—	
Data	t <sub>h(D)</sub>	5.0	200	100	—	
		10	100	50	—	
		15	100	50	—	

NOTE 1. Maximum Reset Delay may extend to one-half clock period.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14500B

FIGURE 1 – TYPICAL CLOCK FREQUENCY versus RESISTOR ( $R_C$ )



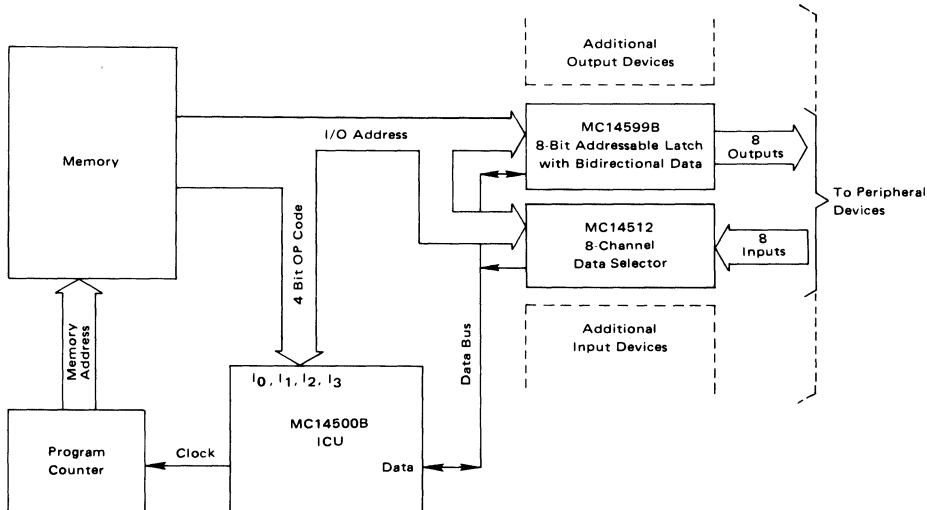
Pin No.	Function	Symbols
1	Chip Reset	RST
2	Write Pulse	Write
3	Data In/Out	Data
4	MSB Instruction Word	I <sub>3</sub>
5	Bit 2 Instruction Word	I <sub>2</sub>
6	Bit 1 Instruction Word	I <sub>1</sub>
7	LSB Instruction Word	I <sub>0</sub>
8	Negative Supply (Ground)	VSS
9	Flag on NOP F	Flag F
10	Flag on NOP O	Flag O
11	Subroutine Return Flag	RTN
12	Jump Instruction Flag	JMP
13	Oscillator Input	X2
14	Oscillator Output	X1
15	Result Register	RR
16	Positive Supply	VDD

TABLE 1. MC14500B INSTRUCTION SET

Instruction Code	Mnemonic	Action
0 0000	NOPO	No change in registers. RR → RR, Flag O → $\overline{1}$
1 0001	LD	Load result register. Data → RR
2 0010	LDC	Load complement. $\overline{\text{Data}} \rightarrow \text{RR}$
3 0011	AND	Logical AND. RR · Data → RR
4 0100	ANDC	Logical AND complement. $\text{RR} \cdot \overline{\text{Data}} \rightarrow \text{RR}$
5 0101	OR	Logical OR. RR + Data → RR
6 0110	ORC	Logical OR complement. $\text{RR} + \overline{\text{Data}} \rightarrow \text{RR}$
7 0111	XNOR	Exclusive NOR. If RR = Data, RR → 1
8 1000	STO	Store. RR → Data Pin, Write → $\overline{1}$
9 1001	STOC	Store complement. $\overline{\text{RR}} \rightarrow \text{Data Pin, Write} \rightarrow \overline{1}$
A 1010	IEN	Input enable. Data → IEN Register
B 1011	OEN	Output enable. Data → OEN Register
C 1100	JMP	Jump. JMP Flag → $\overline{1}$
D 1101	RTN	Return. RTN Flag → $\overline{1}$ and skip next instruction
E 1110	SKZ	Skip next instruction if RR = 0
F 1111	NOPF	No change in registers. RR → RR, Flag F → $\overline{1}$

6

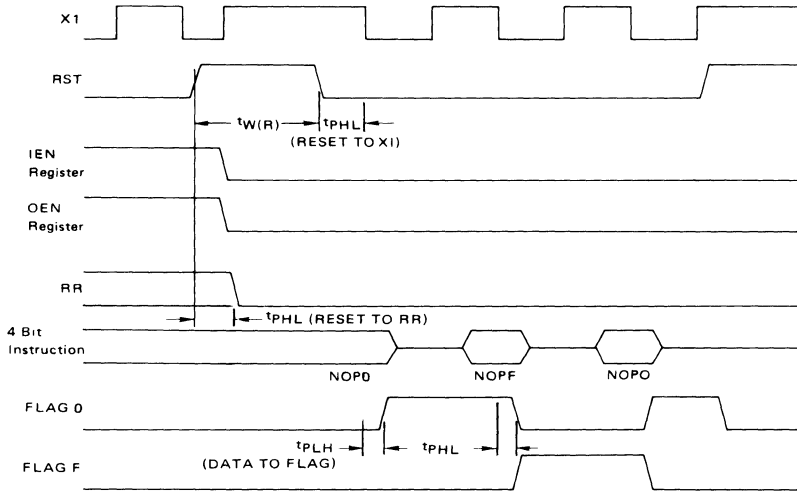
FIGURE 2 – OUTLINE OF A TYPICAL ORGANIZATION FOR A MC14500B-BASED SYSTEM



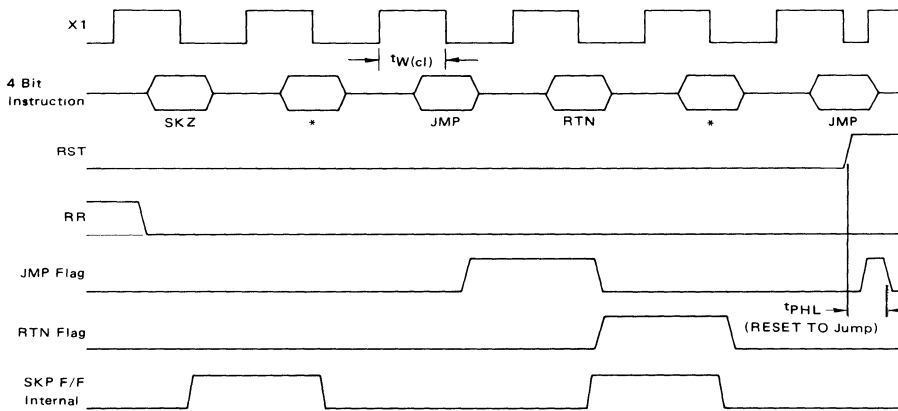
# MC14500B

## TIMING WAVEFORMS

Instructions **NOPO, NOPF**  
RR, IEN, OEN remain unaffected



Instructions **SKZ, JMP, RTN**  
RR, IEN, OEN remain unaffected



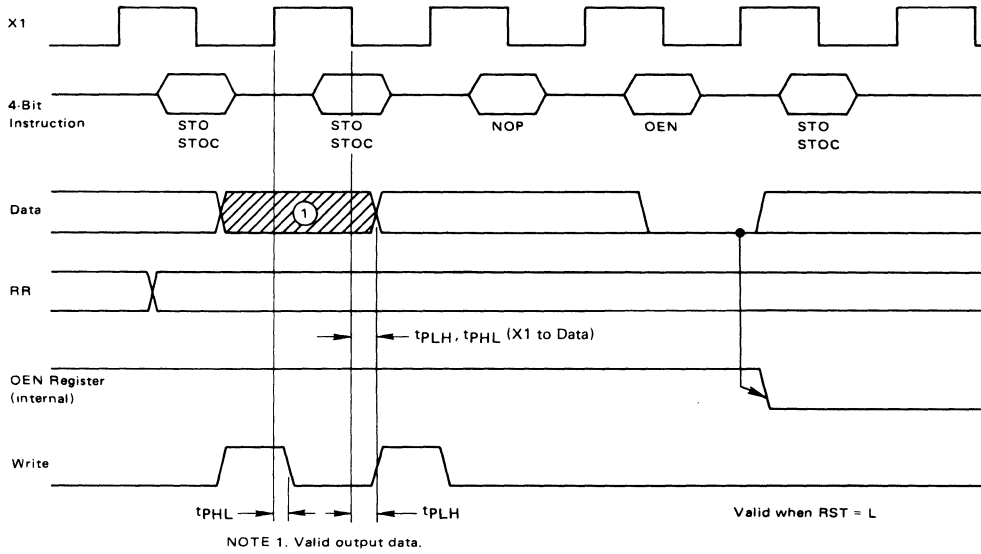
\* Instructions ignored.



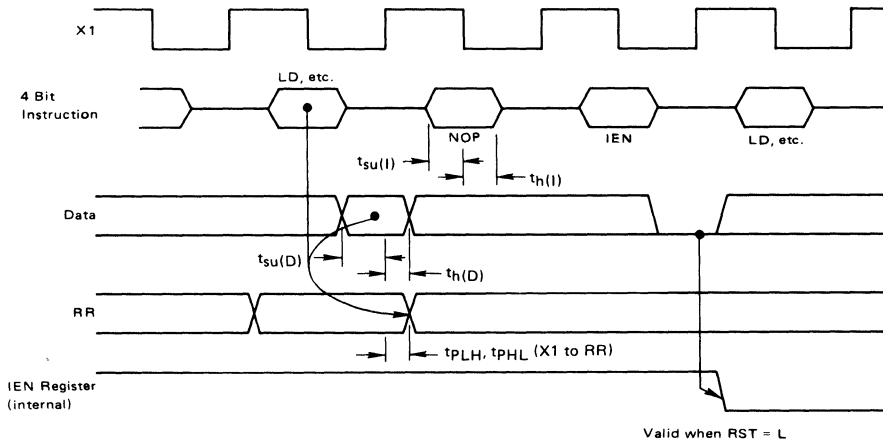
# MC14500B

## TIMING WAVEFORMS

Instructions STO, STOC, OEN



Instructions LD, LDC, AND, ANDC  
OR, ORC, XNOR, IEN



6



**MOTOROLA**

**MC14501UB**

**TRIPLE GATE**

**DUAL 4-INPUT "NAND" GATE  
2-INPUT "NOR/OR" GATE  
8-INPUT "AND/NAND" GATE**

The MC14501UB is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired. Additional characteristics can be found on the Family Data Sheet.

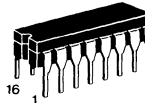
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Swing Independent of Fanout
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**CMOS SSI**

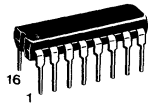
(LOW-POWER COMPLEMENTARY MOS)

**TRIPLE GATE**

**DUAL 4-INPUT "NAND" GATE  
2-INPUT "NOR/OR" GATE  
8-INPUT "AND/NAND" GATE**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**



**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

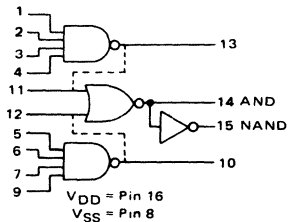
**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

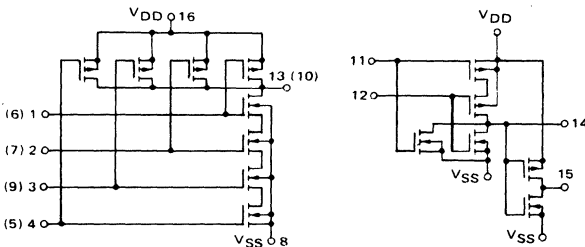
**LOGIC DIAGRAM  
(POSITIVE LOGIC)**



Use Dotted Connection Externally to Obtain 8-Input AND/NAND

Note: Pin 14 must not be used as an input to the inverter.

**CIRCUIT SCHEMATIC**



Numbers in parenthesis are for second 4-input gate.

**6**

# MC14501UB

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to $V_{SS}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	$T_{low}^*$		25°C			$T_{high}^*$		Unit			
			Min	Max	Min	Typ #	Max	Min	Max				
Output Voltage $V_{in} = V_{DD}$ or 0  $V_{in} = 0$ or $V_{DD}$	"0" Level $V_{OL}$	5.0	—	0.05	—	0	0.05	—	0.05	Vdc			
		10	—	0.05	—	0	0.05	—	0.05				
		15	—	0.05	—	0	0.05	—	0.05				
	"1" Level $V_{OH}$	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc			
		10	9.95	—	9.95	10	—	9.95	—				
		15	14.95	—	14.95	15	—	14.95	—				
Input Voltage $(V_O = 3.6$ or $1.4$ Vdc) $(V_O = 7.2$ or $2.8$ Vdc) $(V_O = 11.5$ or $3.5$ Vdc)  $(V_O = 1.4$ or $3.6$ Vdc) $(V_O = 2.8$ or $7.2$ Vdc) $(V_O = 3.5$ or $11.5$ Vdc)	"0" Level $V_{IL}$	5.0	—	1.5	—	2.25	1.5	—	1.4	Vdc			
		10	—	3.0	—	4.50	3.0	—	2.9				
		15	—	3.75	—	6.75	3.75	—	3.6				
	"1" Level $V_{IH}$	5.0	3.6	—	3.5	2.75	—	3.5	—	Vdc			
		10	7.1	—	7.0	5.50	—	7.0	—				
		15	11.4	—	11.25	8.25	—	11.0	—				
Output Drive Current (AL Device) $(V_{OH} = 2.5$ Vdc) Source $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) NAND* $(V_{OH} = 13.5$ Vdc) $(V_{OH} = 2.5$ Vdc) NOR $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) $(V_{OH} = 13.5$ Vdc) $(V_{OH} = 2.5$ Vdc) NOR- $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) Inverter $(V_{OH} = 13.5$ Vdc)  $(V_{OL} = 0.4$ Vdc) Sink $(V_{OL} = 0.5$ Vdc) NAND* $(V_{OL} = 1.5$ Vdc) $(V_{OL} = 0.4$ Vdc) NOR $(V_{OL} = 0.5$ Vdc) $(V_{OL} = 1.5$ Vdc) $(V_{OL} = 0.4$ Vdc) NOR- $(V_{OL} = 0.5$ Vdc) Inverter $(V_{OL} = 1.5$ Vdc)	$I_{OH}$	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc			
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—				
		10	-0.62	—	-0.5	-0.9	—	-0.35	—				
		15	-1.8	—	-1.5	-3.5	—	-1.1	—				
		5.0	-2.1	—	-1.75	-3.0	—	-1.22	—		mAdc		
		5.0	-0.42	—	-0.35	-0.63	—	-0.24	—				
		10	-1.06	—	-0.88	-1.58	—	-0.62	—				
		15	-3.1	—	-2.63	-6.12	—	-1.84	—				
		5.0	-3.6	—	-3.0	-5.1	—	-2.1	—		mAdc		
		5.0	-0.72	—	-0.6	-1.08	—	-0.42	—				
		10	-1.8	—	-1.5	-2.7	—	-1.05	—				
		15	-5.4	—	-4.5	-10.5	—	-3.15	—		—		
	$I_{OL}$	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc			
		10	1.6	—	1.3	2.25	—	0.9	—				
		15	4.2	—	3.4	8.8	—	2.4	—				
		5.0	0.92	—	0.77	1.32	—	0.54	—		mAdc		
		10	2.34	—	1.95	3.37	—	1.36	—				
		15	6.12	—	5.1	13.2	—	3.57	—				
		5.0	1.54	—	1.28	2.2	—	0.90	—		mAdc		
		10	3.90	—	3.25	5.63	—	2.27	—				
		15	10.2	—	8.5	22	—	5.95	—				
		Output Drive Current (CL/CP Device) $(V_{OH} = 2.5$ Vdc) Source $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) NAND* $(V_{OH} = 13.5$ Vdc) $(V_{OH} = 2.5$ Vdc) NOR $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) $(V_{OH} = 13.5$ Vdc) $(V_{OH} = 2.5$ Vdc) NOR- $(V_{OH} = 4.6$ Vdc) $(V_{OH} = 9.5$ Vdc) Inverter $(V_{OH} = 13.5$ Vdc)  $(V_{OL} = 0.4$ Vdc) Sink $(V_{OL} = 0.5$ Vdc) NAND* $(V_{OL} = 1.5$ Vdc) $(V_{OL} = 0.4$ Vdc) NOR $(V_{OL} = 0.5$ Vdc) $(V_{OL} = 1.5$ Vdc) $(V_{OL} = 0.4$ Vdc) NOR- $(V_{OL} = 0.5$ Vdc) Inverter $(V_{OL} = 1.5$ Vdc)	$I_{OH}$	5.0	-1.0	—	-0.8	-1.7	—		-0.6	—	mAdc
				5.0	-0.2	—	-0.16	-0.36	—		-0.12	—	
				10	-0.5	—	-0.4	-0.9	—		-0.3	—	
15	-1.4			—	-1.2	-3.5	—	-1.0	—				
5.0	-1.68			—	-1.4	-3.0	—	-1.05	—	mAdc			
5.0	-0.34			—	-0.28	-0.63	—	-0.21	—				
10	-0.84			—	-0.7	-1.58	—	-0.52	—				
15	-2.52			—	-2.1	-6.12	—	-1.57	—				
5.0	-2.88			—	-2.4	-5.1	—	-1.8	—	mAdc			
5.0	-0.58			—	-0.48	-1.08	—	-0.36	—				
10	-1.44			—	-1.2	-2.7	—	-0.9	—				
15	-4.32			—	-3.6	-10.5	—	-2.7	—	—			
$I_{OL}$	5.0		0.52	—	0.44	0.88	—	0.36	—	mAdc			
	10		1.3	—	1.1	2.25	—	0.9	—				
	15		3.6	—	3.0	8.8	—	2.4	—				
	5.0		0.79	—	0.66	1.32	—	0.54	—		mAdc		
	10		1.98	—	1.65	3.37	—	1.36	—				
	15		5.4	—	4.5	13.2	—	3.57	—				
	5.0		1.32	—	1.1	2.2	—	0.90	—		mAdc		
	10		3.3	—	2.75	5.63	—	2.27	—				
	15		9.0	—	7.5	22.0	—	5.95	—				

#Data labeled "Typ" is not to be used for design purposes, but is intended as an indication of the IC's potential performance.

\*The output drive current of Pin 15 is tested with Pin 14 open-circuited.

# MC14501UB

## ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc
		10	—	0.50	—	0.0010	0.50	—	15.0	
		15	—	1.00	—	0.0015	1.00	—	30.0	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc
		10	—	2.0	—	0.0010	2.0	—	15.0	
		15	—	4.0	—	0.0015	4.0	—	30.0	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.

## SWITCHING CHARACTERISTICS\*\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Figure	Symbol	V <sub>DD</sub>	Typ #	Max	Unit
Output Rise Time t <sub>TLH</sub> = (3.0 ns/pF) C <sub>L</sub> + 30 ns t <sub>TLH</sub> = (1.5 ns/pF) C <sub>L</sub> + 15 ns t <sub>TLH</sub> = (1.1 ns/pF) C <sub>L</sub> + 10 ns	2, 3	t <sub>TLH</sub>	5.0	180	360	ns
			10	90	180	
			15	65	130	
			15	65	130	
Output Fall Time t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	2, 3	t <sub>THL</sub>	5.0	100	200	ns
			10	50	100	
			15	40	80	
			15	40	80	
Output Rise Time t <sub>TLH</sub> = (1.35 ns/pF) C <sub>L</sub> + 32.5 ns t <sub>TLH</sub> = (0.60 ns/pF) C <sub>L</sub> + 20 ns t <sub>TLH</sub> = (0.40 ns/pF) C <sub>L</sub> + 17 ns	3	t <sub>TLH</sub>	5.0	100	200	ns
			10	50	100	
			15	40	80	
			15	40	80	
Output Fall Time t <sub>THL</sub> = (0.67 ns/pF) C <sub>L</sub> + 26.5 ns t <sub>THL</sub> = (0.45 ns/pF) C <sub>L</sub> + 17.5 ns t <sub>THL</sub> = (0.37 ns/pF) C <sub>L</sub> + 11.5 ns	3	t <sub>THL</sub>	5.0	60	120	ns
			10	40	80	
			15	30	60	
			15	30	60	
Propagation Delay Time	2	t <sub>PLH</sub> , t <sub>PHL</sub>	NAND			ns
			NAND			
			NAND			
			NAND			
			NAND			
			NAND			
	3	t <sub>PLH</sub> , t <sub>PHL</sub>	NOR			ns
			NOR			
			NOR			
			NOR			
			NOR			
			NOR			
3	t <sub>PLH</sub> , t <sub>PHL</sub>	NOR-Inverter			ns	
		NOR-Inverter				
		NOR-Inverter				
		NOR-Inverter				
		NOR-Inverter				
		NOR-Inverter				

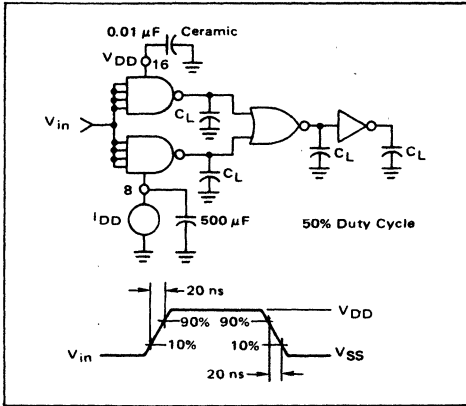
\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14501UB

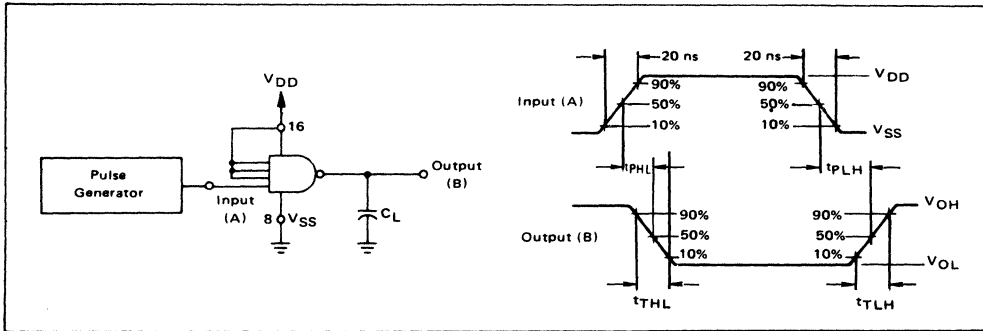
**FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM**



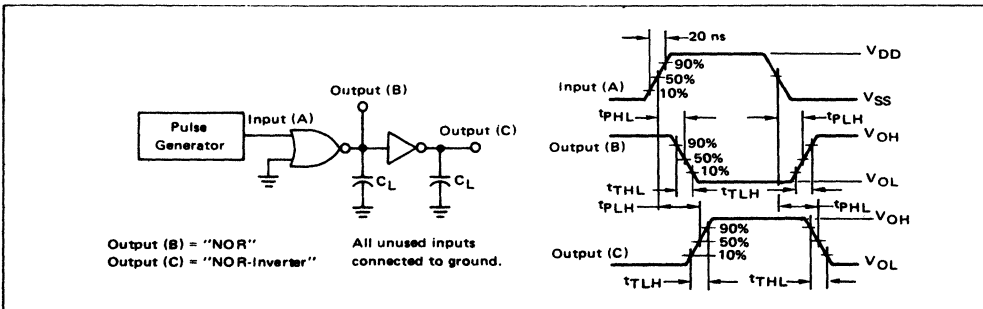
**PIN ASSIGNMENT**

1	In 1A	V <sub>DD</sub>	16
2	In 2A	OutB	15
3	In 3A	OutB	14
4	In 4A	OutA	13
5	In 1C	In 2B	12
6	In 2C	In 1B	11
7	In 3C	OutC	10
8	V <sub>SS</sub>	In 4C	9

**FIGURE 2 – 4-INPUT “NAND” GATE SWITCHING TIME TEST CIRCUIT AND WAVEFORMS**



**FIGURE 3 – “NOR” GATE and “NOR-INVERTER” SWITCHING TIME TEST CIRCUIT AND WAVEFORMS**



6



**MOTOROLA**

**MC14502B**

**STROBED HEX INVERTER/BUFFER**

The MC14502B is a strobed hex buffer/inverter with 3-state outputs, an inhibit control, and guaranteed TTL drive over the temperature range. The 3-state output simplifies design by allowing a common bus.

- Separate Output Disable Control
- 3-State Output
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving 4LSTTL Loads Over the Rated Temperature Range

**CMOS MSI**

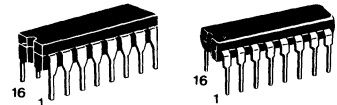
(LOW-POWER COMPLEMENTARY MOS)

**STROBED HEX INVERTER/BUFFER**

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Pin	$\pm 10$	mA
$I_{out}$	Output Current (DC or Transient), per Pin	+30	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620

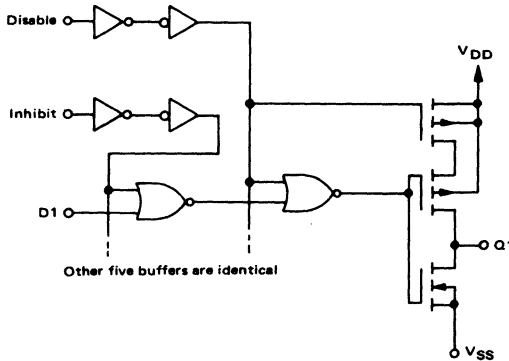
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

**ORDERING INFORMATION**

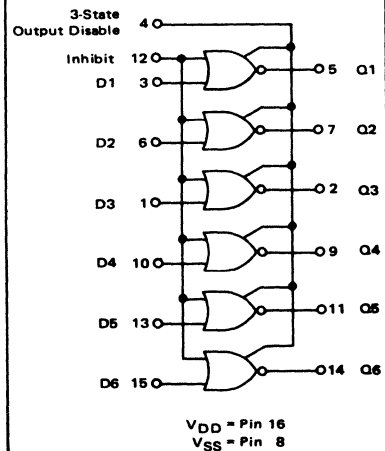
A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**CIRCUIT DIAGRAM**



**LOGIC DIAGRAM**



**TRUTH TABLE**

$D_n$	Inhibit	Disable	$Q_n$
0	0	0	1
1	0	0	0
X	1	0	0
X	X	1	High Impedance

X = Don't Care

# MC14502B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	3.5	—	2.8	6.6	—	2.0	—	mAdc
			10	7.8	—	6.3	17	—	4.4	—	
			15	29	—	24	66	—	16	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	2.3	—	1.9	6.6	—	1.6	—	mAdc
			10	5.0	—	4.2	17	—	3.4	—	
			15	19	—	16	66	—	13	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc	
		10	—	2.0	—	0.004	2.0	—	60		
		15	—	4.0	—	0.006	4.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc	
		10	—	8.0	—	0.004	8.0	—	60		
		15	—	16	—	0.006	16	—	120		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (2.7 μA/kHz) f + I <sub>DD</sub>						μAdc		
10	I <sub>T</sub> = (5.3 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (8.0 μA/kHz) f + I <sub>DD</sub>										
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μAdc	
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

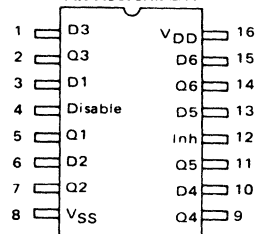
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.006.

### PIN ASSIGNMENT



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14502B

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	All Types			Unit
			Min	Typ #	Max	
Output Rise Time	$t_{TLH}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time	$t_{THL}$	5.0	—	40	80	ns
		10	—	20	40	
		15	—	15	30	
Propagation Delay Time Data to Q	$t_{PHL}$	5.0	—	135	270	ns
		10	—	55	110	
		15	—	40	80	
Propagation Delay Time, Inhibit to Q	$t_{PHL}$	5.0	—	335	670	ns
		10	—	145	290	
		15	—	95	190	
Propagation Delay Time Data to Q, Inhibit to Q	$t_{PLH}$	5.0	—	295	590	ns
		10	—	130	260	
		15	—	95	190	
3-State Propagation Delay, Output "1" to High Impedance	$t_{PHZ}$	5.0	—	65	130	ns
		10	—	30	60	
		15	—	25	50	
3-State Propagation Delay, High Impedance to "1" Level	$t_{PZH}$	5.0	—	260	520	ns
		10	—	105	210	
		15	—	80	160	
3-State Propagation Delay, Output "0" to High Impedance	$t_{PLZ}$	5.0	—	150	300	ns
		10	—	70	140	
		15	—	55	110	
3-State Propagation Delay, High Impedance to "0" Level	$t_{PZL}$	5.0	—	160	320	ns
		10	—	65	130	
		15	—	50	100	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – TYPICAL OUTPUT SOURCE CURRENT TEST CIRCUIT ( $I_{OH}$ )

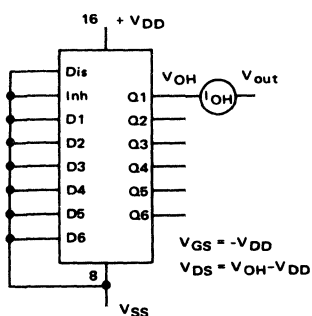
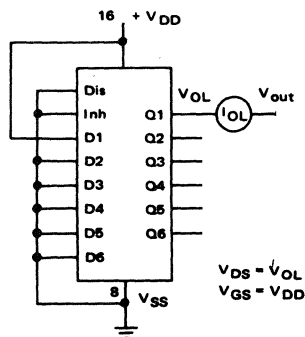


FIGURE 2 – TYPICAL OUTPUT SINK CURRENT TEST CIRCUIT ( $I_{OL}$ )





# MC14502B

FIGURE 3 — POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

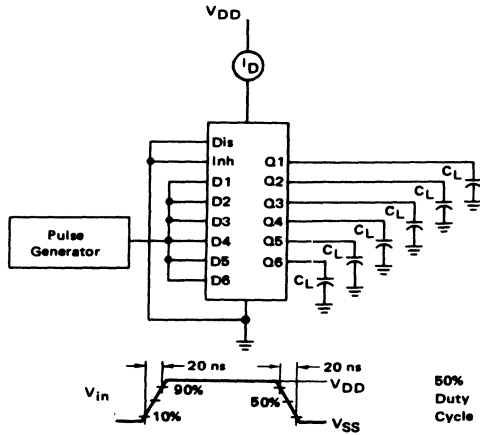
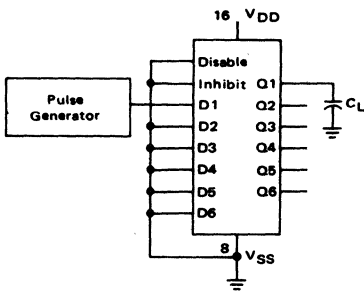


FIGURE 4 — AC TEST CIRCUIT AND WAVEFORMS ( $t_{TLH}$ ,  $t_{THL}$ ,  $t_{PLH}$ , and  $t_{PLL}$ )



For all  $t_{TLH}$ ,  $t_{THL}$ ,  $t_{PLH}$ , and  $t_{PLL}$  measurements  $V_{in}$  may be applied to any other  $D_n$  input or to Inhibit.

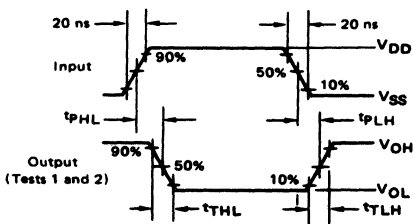
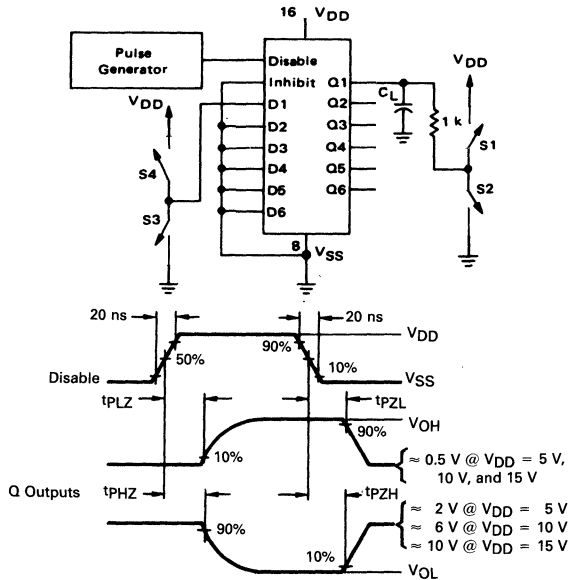


FIGURE 5 — 3-STATE AC TEST CIRCUIT AND WAVEFORMS ( $t_{PHZ}$ ,  $t_{PLZ}$ ,  $t_{PZH}$ ,  $t_{PZL}$ )

Switch Positions for 3-State Test

TEST	S1	S2	S3	S4
$t_{PHZ}$	Open	Closed	Closed	Open
$t_{PLZ}$	Closed	Open	Open	Closed
$t_{PZL}$	Closed	Open	Open	Closed
$t_{PZH}$	Open	Closed	Closed	Open



6



**MOTOROLA**

**MC14503B**

**HEX NON-INVERTING 3-STATE BUFFER**

The MC14503B is a hex non-inverting buffer with 3-state outputs, and a high current source and sink capability. The 3-state outputs make it useful in common bussing applications. Two disable controls are provided. A high level on the Disable A input causes the outputs of buffers 1 through 4 to go into a high impedance state and a high level on the Disable B input causes the outputs of buffers 5 and 6 to go into a high impedance state.

- 3-State Outputs
- TTL Compatible – Will Drive One TTL Load Over Full Temperature Range
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Two Disable Controls for Added Versatility
- Pin for Pin Replacement for MM80C97 and 340097

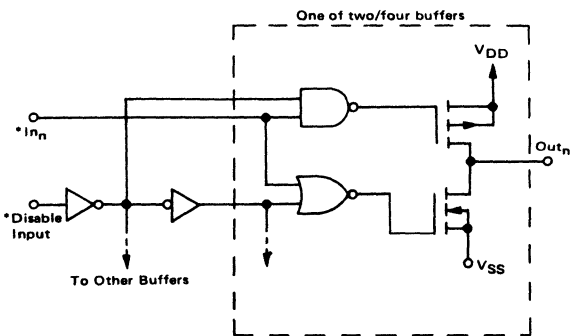
**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub>	Input Current (DC or Transient), per Pin	±10	mA
I <sub>out</sub>	Output Current (DC or Transient), per Pin	±25	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 85°C to 125°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CIRCUIT DIAGRAM**



\*Diode protection on all inputs (not shown)

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,

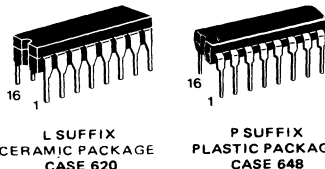
V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**HEX 3-STATE BUFFER**



**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

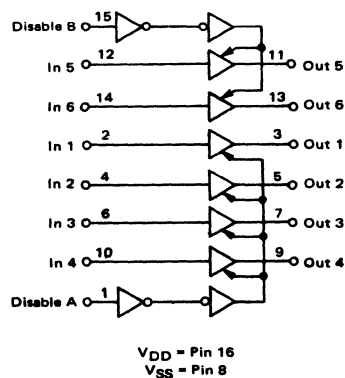
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**TRUTH TABLE**

In <sub>n</sub>	Appropriate Disable Input	Out <sub>n</sub>
0	0	0
1	0	1
X	1	High Impedance

X = Don't Care

**LOGIC DIAGRAM**



# MC14503B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 3.6 or 1.4 Vdc) (V <sub>O</sub> = 7.2 or 2.8 Vdc) (V <sub>O</sub> = 11.5 or 3.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level V <sub>IH</sub>	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.5	—	7.0	—	
			15	11	—	11	8.25	—	11	—	
Output Drive Current (AL Device)*** (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	4.5	-4.3	—	-3.6	-5.0	—	-2.5	—	mAdc
			5.0	-5.8	—	-4.80	-6.1	—	-3.0	—	
			10	-1.2	—	-1.02	-1.4	—	-0.7	—	
			15	-3.1	—	-2.60	-3.7	—	-1.8	—	
			5.0	-8.2	—	-6.80	-14.1	—	-4.8	—	
			15	-8.2	—	-6.80	-14.1	—	-4.8	—	
	Sink	I <sub>OL</sub>	4.5	2.2	—	1.8	2.1	—	1.2	—	mAdc
			5.0	2.6	—	2.1	2.3	—	1.3	—	
			10	6.5	—	5.5	6.2	—	3.8	—	
			15	19.2	—	16.10	25.00	—	11.2	—	
			4.5	2.2	—	1.8	2.1	—	1.2	—	
			15	19.2	—	16.10	25.00	—	11.2	—	
Output Drive Current (CL/CP Device)*** (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	4.75	-4.0	—	-3.60	-5.5	—	-2.4	—	mAdc
			5.0	-4.6	—	-4.20	-6.1	—	-3.0	—	
			10	-1.0	—	-0.88	-1.4	—	-0.7	—	
			15	-2.4	—	-2.20	-3.7	—	-1.8	—	
			5.0	-6.6	—	-6.00	-14.1	—	-4.8	—	
			15	-6.6	—	-6.00	-14.1	—	-4.8	—	
	Sink	I <sub>OL</sub>	4.75	2.1	—	1.95	2.2	—	1.25	—	mAdc
			5.0	2.3	—	2.10	2.3	—	1.3	—	
			10	6.0	—	5.45	6.2	—	3.8	—	
			15	15.2	—	13.80	25.00	—	11.2	—	
			4.75	2.1	—	1.95	2.2	—	1.25	—	
			15	15.2	—	13.80	25.00	—	11.2	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>Q</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc	
		10	—	2.0	—	0.004	2.0	—	60		
		15	—	4.0	—	0.006	4.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc	
		10	—	8.0	—	0.004	8.0	—	60		
		15	—	16	—	0.006	16	—	120		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs) (All outputs switching, 50% Duty Cycle)	I <sub>T</sub>	5.0	I <sub>T</sub> = (2.5 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (6.0 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (10 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10									
		15									
3-State Output Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±3.0	μAdc	
3-State Output Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.0001	±1.0	—	±7.5	μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 †T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.006.

\*\*The formulas given are for the typical characteristics only at 25°C.

\*\*\*Care must be taken not to exceed maximum current ratings (see maximum ratings table)

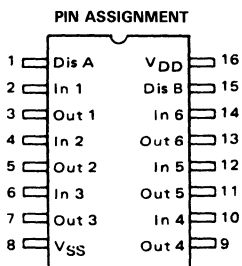
# MC14503B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}, T_A = 25^\circ \text{C}$ )

Characteristic	Symbol	V <sub>DD</sub> V <sub>CC</sub>	All Types		Unit
			Typ #	Max	
Output Rise Time $t_{TLH} = (0.5 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH} = (0.3 \text{ ns/pF}) C_L + 8.0 \text{ ns}$ $t_{TLH} = (0.2 \text{ ns/pF}) C_L + 8.0 \text{ ns}$	$t_{TLH}$	5.0	45	90	ns
		10	23	45	
		15	18	35	
Output Fall Time $t_{THL} = (0.5 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{THL} = (0.3 \text{ ns/pF}) C_L + 8.0 \text{ ns}$ $t_{THL} = (0.2 \text{ ns/pF}) C_L + 8.0 \text{ ns}$	$t_{THL}$	5.0	45	90	ns
		10	23	45	
		15	18	35	
Turn-Off Delay Time, all Outputs $t_{PLH} = (0.3 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{PLH} = (0.15 \text{ ns/pF}) C_L + 27 \text{ ns}$ $t_{PLH} = (0.1 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{PLH}$	5.0	75	150	ns
		10	35	70	
		15	25	50	
Turn-On Delay Time, all Outputs $t_{PHL} = (0.3 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{PHL} = (0.15 \text{ ns/pF}) C_L + 27 \text{ ns}$ $t_{PHL} = (0.1 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{PHL}$	5.0	75	150	ns
		10	35	70	
		15	25	50	
3-State Propagation Delay Time Output "1" to High Impedance	$t_{PHZ}$	5.0	75	150	ns
		10	40	80	
		15	35	70	
Output "0" to High Impedance	$t_{PLZ}$	5.0	80	160	ns
		10	40	80	
		15	35	70	
High Impedance to "1" Level	$t_{PZH}$	5.0	65	130	ns
		10	25	50	
		15	20	40	
High Impedance to "0" Level	$t_{PZL}$	5.0	100	200	ns
		10	35	70	
		15	25	50	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.



# MC14503B

FIGURE 1 — SWITCHING TIME TEST CIRCUIT AND WAVEFORMS  
( $t_{TLH}$ ,  $t_{THL}$ ,  $t_{PHL}$ , and  $t_{PLH}$ )

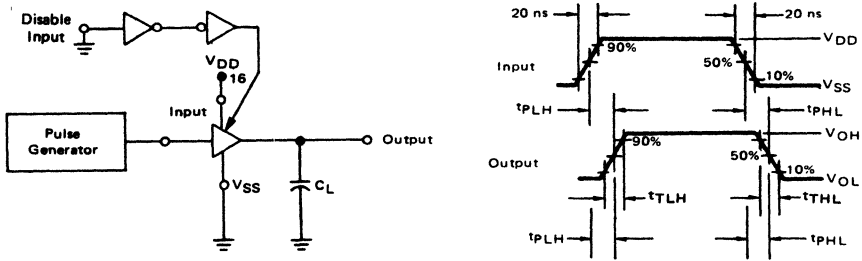
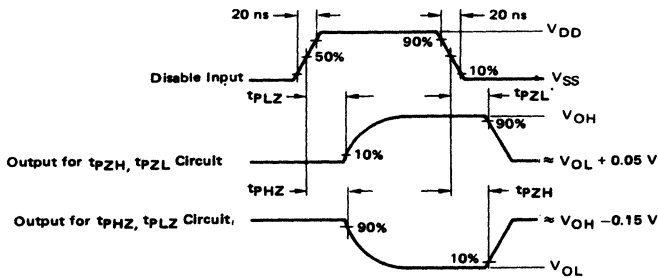
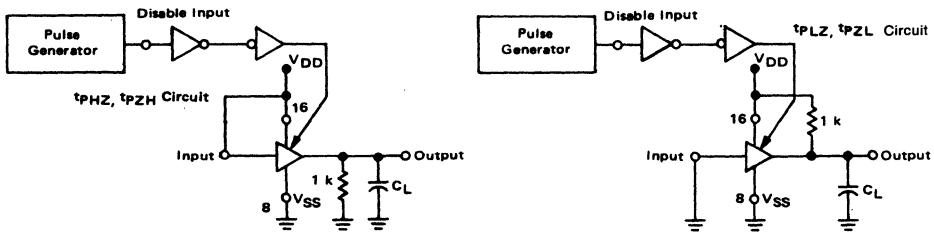


FIGURE 2 — 3 STATE AC TEST CIRCUITS AND WAVEFORMS  
( $t_{PLZ}$ ,  $t_{PHZ}$ ,  $t_{PZH}$ ,  $t_{PZL}$ )



6



**MOTOROLA**

**MC14504B**

**CMOS SSI**

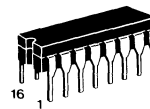
(LOW-POWER COMPLEMENTARY MOS)

**TTL or CMOS to CMOS  
HEX LEVEL SHIFTER**

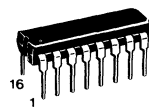
**HEX LEVEL SHIFTER FOR  
TTL to CMOS or CMOS to CMOS**

The MC14504B is a hex non-inverting level shifter using CMOS technology. The level shifter will shift a TTL signal to CMOS logic levels for any CMOS supply voltage between 5 and 15 volts. A control input also allows interface from CMOS to CMOS at one logic level to another logic level. Either up or down level translating is accomplished by selection of power supply levels  $V_{DD}$  and  $V_{CC}$ . The  $V_{CC}$  level sets the input signal levels while  $V_{DD}$  selects the output voltage levels.

- UP Translates from a Low to a High Voltage or DOWN Translates from a High to a Low Voltage
- Input Threshold Can Be Shifted for TTL Compatibility
- No Sequencing Required on Power Supplies or Inputs for Power Up or Power Down
- 3 to 18 Vdc Operation for  $V_{DD}$  and  $V_{CC}$
- Diode Protected Inputs to  $V_{SS}$
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**



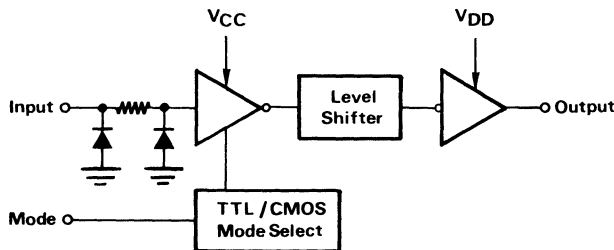
**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$   
MC14XXXBAL (Ceramic Package Only)

C Series:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

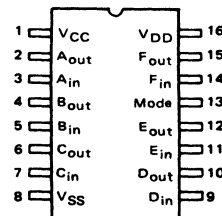
**LOGIC DIAGRAM**



Mode Select	Input Logic Levels	Output Logic Levels
1 ( $V_{CC}$ )	TTL	CMOS
0 ( $V_{SS}$ )	CMOS	CMOS

1/6 of package shown.

**PIN ASSIGNMENT**



This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields **referenced to the  $V_{SS}$  pin, only**. Extra precautions must be taken to avoid applications of any voltage higher than the maximum rated voltages to this high-impedance circuit. For proper operation, the ranges  $V_{SS} \leq V_{in} \leq 18\text{ V}$  and  $V_{SS} \leq V_{out} \leq V_{DD}$  are recommended.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**6**

# MC14504B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>CC</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub>	Input Voltage (DC or Transient)	-0.5 to +18.0	V
V <sub>out</sub>	Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package**	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum ratings are those values beyond which damage to the device may occur.

\*\*Power dissipation temperature derating: Plastic "P" package: -12 mW/°C from 65°C to 85°C.  
Ceramic "L" package: -12 mW/°C from 100°C to 125°C.

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>CC</sub> Vdc	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
				Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage "0" Level V <sub>in</sub> = 0 V	V <sub>OL</sub>	-	5.0	-	0.05	-	0	0.05	-	0.05	Vdc		
			10	-	0.05	-	0	0.05	-	0.05			
			15	-	0.05	-	0	0.05	-	0.05			
			5.0	4.95	-	4.95	5.0	-	4.95	-		-	
V <sub>in</sub> = V <sub>CC</sub> "1" Level	V <sub>OH</sub>	-	10	9.95	-	9.95	10	-	9.95	-	Vdc		
			15	14.95	-	14.95	15	-	14.95	-			
			5	10	-	0.8	-	1.3	0.8	-		0.8	Vdc
			5	15	-	0.8	-	1.3	0.8	-		0.8	
5	10	-	1.5	-	2.25	1.5	-	1.4					
5	15	-	1.5	-	2.25	1.5	-	1.5					
V <sub>OL</sub> = 1.5 Vdc) CMOS-CMOS (V <sub>OL</sub> = 1.5 Vdc) CMOS-CMOS	V <sub>IL</sub>	-	10	15	-	3.0	-	4.5	3.0	-	2.9		
			5	10	2.0	-	2.0	1.5	-	2.0	-	Vdc	
			5	15	2.0	-	2.0	1.5	-	2.0	-		
			5	10	3.6	-	3.5	2.75	-	3.5	-		
V <sub>OH</sub> = 13.5 Vdc) TTL-CMOS (V <sub>OH</sub> = 9.0 Vdc) CMOS-CMOS (V <sub>OH</sub> = 13.5 Vdc) CMOS-CMOS (V <sub>OH</sub> = 13.5 Vdc) CMOS-CMOS	V <sub>IH</sub>	-	5	15	3.6	-	3.5	2.75	-	3.5	-		
			5	15	7.1	-	7.0	5.5	-	7.0	-		
			10	15	7.1	-	7.0	5.5	-	7.0	-		
			5	10	3.6	-	3.5	2.75	-	3.5	-		
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source	I <sub>OH</sub>	-	5.0	-3.0	-	-2.4	-4.2	-	-1.7	-	mA <sub>dc</sub>	
			-	5.0	-0.64	-	-0.51	-0.88	-	-0.36	-		
			-	10	-1.6	-	-1.3	-2.25	-	-0.9	-		
			-	15	-4.2	-	-3.4	-8.8	-	-2.4	-		
	Sink	I <sub>OL</sub>	-	5.0	0.64	-	0.51	0.88	-	0.36	-	mA <sub>dc</sub>	
			-	10	1.6	-	1.3	2.25	-	0.9	-		
			-	15	4.2	-	3.4	8.8	-	2.4	-		
			-	5.0	-2.5	-	-2.1	-4.2	-	-1.7	-		mA <sub>dc</sub>
Source	I <sub>OH</sub>	-	5.0	-0.52	-	-0.44	-0.88	-	-0.36	-			
		-	10	-1.3	-	-1.1	-2.25	-	-0.9	-			
		-	15	-3.6	-	-3.0	-8.8	-	-2.4	-			
		-	5.0	0.52	-	0.44	0.88	-	0.36	-			
Sink	I <sub>OL</sub>	-	10	1.3	-	1.1	2.25	-	0.9	-			
		-	15	3.6	-	3.0	8.8	-	2.4	-			
		-	15	-	-	-	5.0	7.5	-	-	pF		
		-	15	-	-	-	5.0	7.5	-	-			
Quiescent Current (AL Device) (Per Package) CMOS-CMOS Mode	I <sub>DD</sub> or I <sub>CC</sub>	-	5.0	-	0.05	-	0.0005	0.05	-	1.5	μA <sub>dc</sub>		
-	10	-	0.10	-	0.0010	0.10	-	3.0					
-	15	-	0.20	-	0.0015	0.20	-	6.0					
Quiescent Current (CL/CP Device) (Per Package) CMOS-CMOS Mode	I <sub>DD</sub> or I <sub>CC</sub>	-	5.0	-	0.5	-	0.0005	0.5	-	3.8	μA <sub>dc</sub>		
		-	10	-	1.0	-	0.0010	1.0	-	7.5			
		-	15	-	2.0	-	0.0015	2.0	-	15.0			
Quiescent Current (AL/CL/CP Device) (Per Package) TTL-CMOS Mode	I <sub>DD</sub>	5.0	5.0	-	0.5	-	0.0005	0.5	-	3.8	μA <sub>dc</sub>		
		5.0	10	-	1.0	-	0.0010	1.0	-	7.5			
		5.0	15	-	2.0	-	0.0015	2.0	-	15.0			
Quiescent Current (AL/CL/CP Device) (Per Package) TTL-CMOS Mode	I <sub>CC</sub>	5.0	5.0	-	5.0	-	2.5	5.0	-	6.0	mA <sub>dc</sub>		
		5.0	10	-	5.0	-	2.5	5.0	-	6.0			
		5.0	15	-	5.0	-	2.5	5.0	-	6.0			

\*T<sub>LOW</sub> = -55°C for AL Device, -40°C for CL/CP Device  
T<sub>HIGH</sub> = +125°C for AL Device, +85°C for CL/CP Device

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14504B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	Shifting Mode	V <sub>CC</sub> Vdc	V <sub>DD</sub> Vdc	Limits			Units
					Min	Typ #	Max	
Propagation Delay, High to Low	t <sub>PHL</sub>	TTL-CMOS	5.0	10	—	140	280	ns
		V <sub>DD</sub> > V <sub>CC</sub>	5.0	15	—	140	280	
		CMOS-CMOS	5.0	10	—	120	240	
		V <sub>DD</sub> > V <sub>CC</sub>	5.0	15	—	120	240	
		CMOS-CMOS	10	5.0	—	185	370	
		V <sub>CC</sub> > V <sub>DD</sub>	15	5.0	—	185	370	
Propagation Delay, Low to High	t <sub>PLH</sub>	TTL-CMOS	5.0	10	—	170	340	ns
		V <sub>DD</sub> > V <sub>CC</sub>	5.0	15	—	160	320	
		CMOS-CMOS	5.0	10	—	170	340	
		V <sub>DD</sub> > V <sub>CC</sub>	5.0	15	—	170	340	
		CMOS-CMOS	10	5.0	—	275	550	
		V <sub>CC</sub> > V <sub>DD</sub>	15	5.0	—	275	550	
Output Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	ALL	—	5.0	—	100	200	ns
			—	10	—	50	100	
			—	15	—	40	80	

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – INPUT SWITCHPOINT CMOS to CMOS MODE

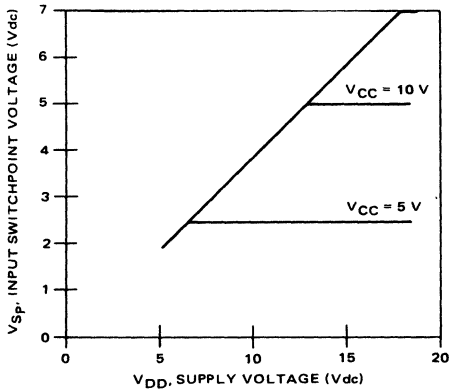


FIGURE 2 – INPUT SWITCHPOINT TTL to CMOS MODE

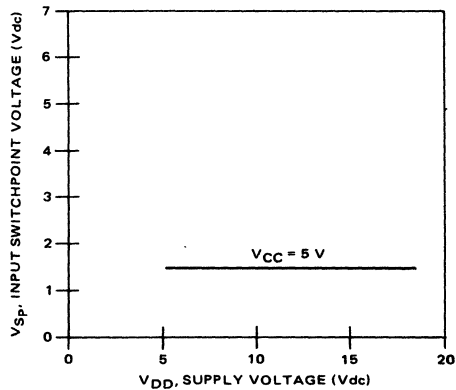


FIGURE 3 – OPERATING BOUNDARY CMOS to CMOS MODE

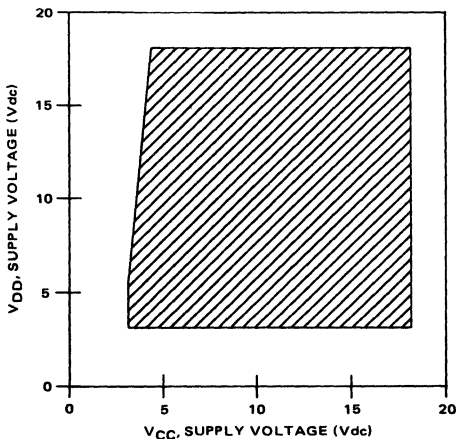
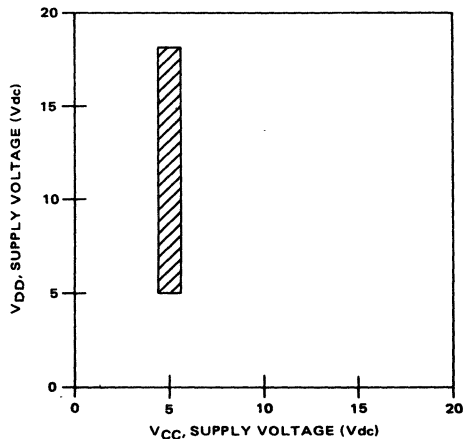


FIGURE 4 – OPERATING BOUNDARY TTL to CMOS MODE







**MOTOROLA**

**MC14506UB**

**DUAL 2-WIDE, 2-INPUT EXPANDABLE AND-OR-INVERT GATE**

The MC14506UB is an expandable AND-OR-INVERT gate with inhibit and 3-state output. The expand option allows cascading with any other gate, which may be carried as far as desired as long as the propagation delay added with each gate is considered. For example, the second AOI gate in this device may be used to expand the first gate, giving an expanded 4-wide, 2-input AOI gate. This device is useful in data control and digital multiplexing applications.

- 3-State Output
- Separate Inhibit Line
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	± 10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

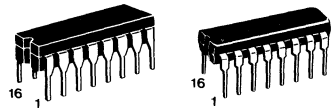
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL EXPANDABLE AND-OR-INVERT GATE**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

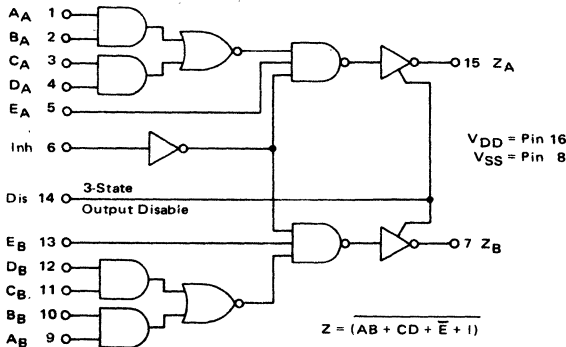
A Series: -55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**LOGIC DIAGRAM**



**TRUTH TABLE**

A	B	C	D	E	INHIBIT	DISABLE	Z
0	0	0	0	1	0	0	1
0	X	0	X	1	0	0	1
0	X	X	0	1	0	0	1
X	0	0	X	1	0	0	1
X	0	X	0	1	0	0	1
X	1	X	X	X	X	X	0
X	X	1	1	X	X	X	0
X	X	X	0	X	X	X	0
X	X	X	X	X	1	0	0
X	X	X	X	X	X	1	High Impedance

X = Don't Care

# MC14506UB

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc
			10	—	2.0	—	4.50	2.0	—	2.0	
			15	—	2.5	—	6.75	2.5	—	2.5	
	"1" Level	V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
			10	8.0	—	8.0	5.50	—	8.0	—	
			15	12.5	—	12.5	8.25	—	12.5	—	
Output Drive Current (AL Device)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
			10	-1.6	—	-1.3	-2.25	—	-0.9	—	
			15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
15	4.2	—	3.4	8.8	—	2.4	—	—	—		
										—	
Output Drive Current (CL/CP Device)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
			10	-1.3	—	-1.1	-2.25	—	-0.9	—	
			15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
15	3.6	—	3.0	8.8	—	2.4	—	—			
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.002	1.0	—	30	μAdc	
		10	—	2.0	—	0.004	2.0	—	60		
		15	—	4.0	—	0.006	4.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	4.0	—	0.002	4.0	—	30	μAdc	
		10	—	8.0	—	0.004	8.0	—	60		
		15	—	16	—	0.006	16	—	120		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (1.1 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>										
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μAdc	
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

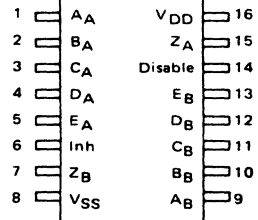
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

### PIN ASSIGNMENT



# MC14506UB

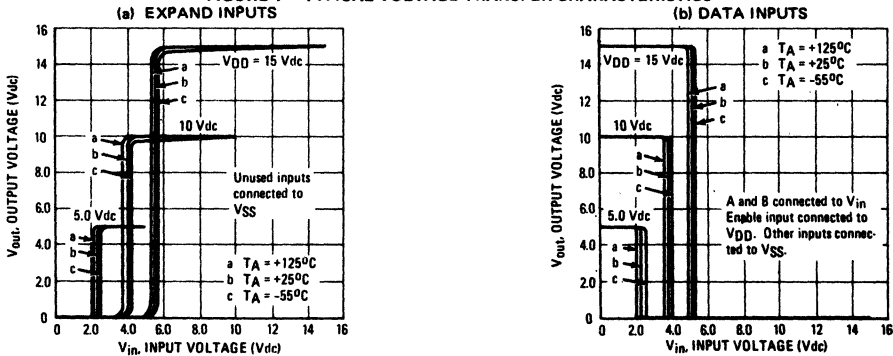
SWITCHING CHARACTERISTICS\* ( $C_L = 50$  pF,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Data Propagation Delay Time $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 210 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 77 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 50 \text{ ns}$ $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 185 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 62 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 40 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	— — —  — — —	295 110 75  270 95 65	580 225 180  480 175 140	ns
Expand Propagation Delay Time $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 95 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 115 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 47 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 30 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	— — —  — — —	180 75 50  200 80 55	430 160 125  330 110 90	ns
Inhibit Propagation Delay Time $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 135 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 67 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 40 \text{ ns}$ $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 145 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 62 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}$    $t_{PHL}$	5.0 10 15  5.0 10 15	— — —  — — —	220 100 65  230 95 60	500 225 160  400 175 150	ns
3-State Propagation Delay Time "1" to High Impedance  "0" to High Impedance  High Impedance to "1"  High Impedance to "0"	$t_{PHZ}$     $t_{PLZ}$     $t_{PZH}$     $t_{PZL}$	5.0 10 15  5.0 10 15  5.0 10 15  5.0 10 15	— — —  — — —  — — —  — — —	60 45 35  90 55 40  110 50 40  170 70 50	150 110 90  225 140 100  300 125 100  425 175 125	ns

\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – TYPICAL VOLTAGE TRANSFER CHARACTERISTICS



# MC14506UB

FIGURE 2 – TYPICAL OUTPUT SOURCE CHARACTERISTICS TEST CIRCUIT

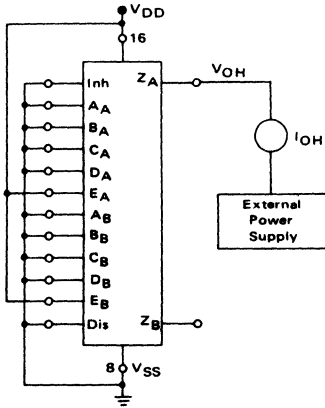


FIGURE 3 – TYPICAL OUTPUT SINK CHARACTERISTICS TEST CIRCUIT

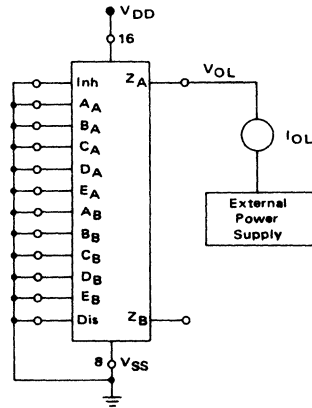


FIGURE 4 – 3-STATE LEAKAGE CURRENT TEST CIRCUIT

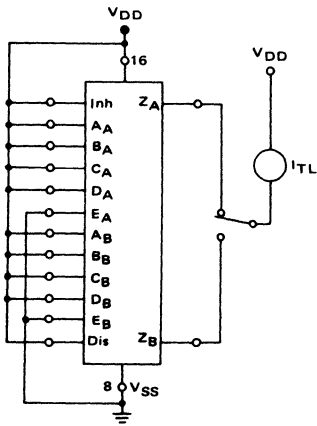
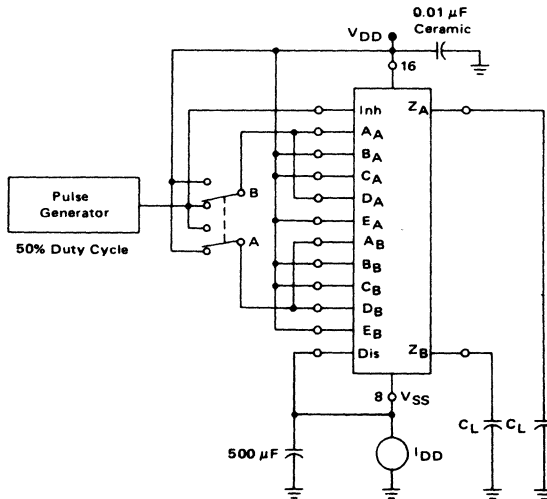
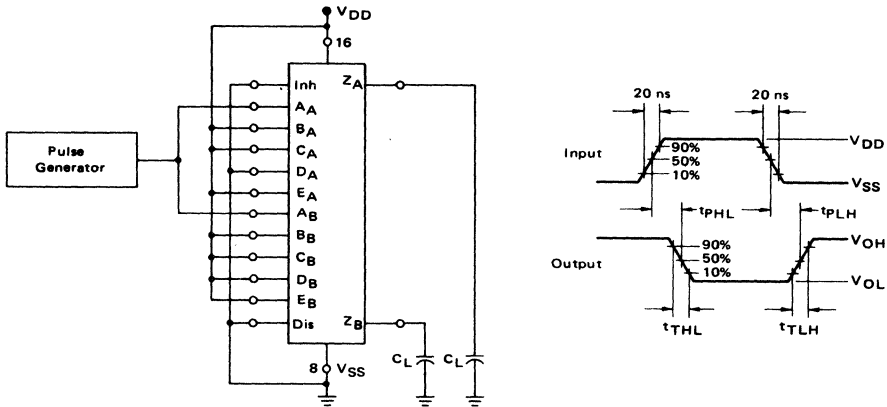


FIGURE 5 – TYPICAL POWER DISSIPATION TEST CIRCUIT

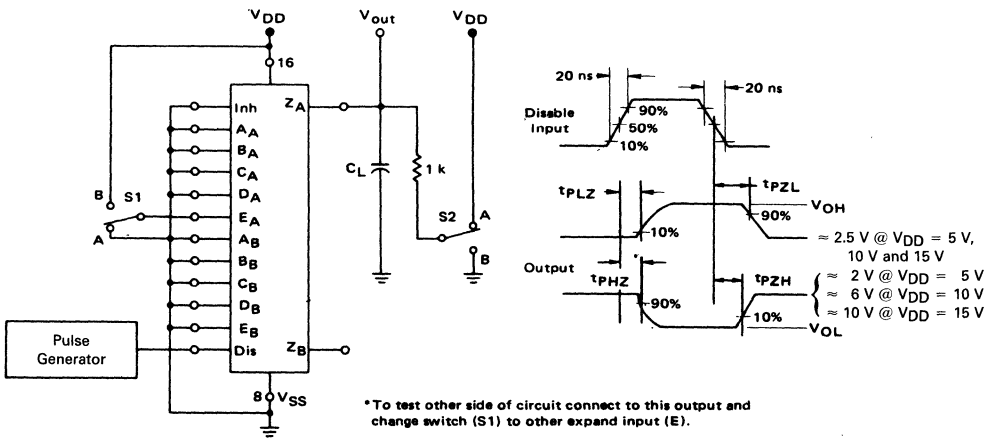


# MC14506UB

**FIGURE 6 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS (Data Inputs)**



**FIGURE 7 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS (For 3-State Output)**



**SWITCH POSITIONS**

TEST	S1	S2
tPLZ	A	A
tPHZ	B	B
tPZL	A	A
tPZH	B	B

6



**MOTOROLA**

**MC14508B**

**DUAL 4-BIT LATCH**

The MC14508B dual 4-bit latch is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. The part consists of two identical, independent 4-bit latches with separate Strobe (ST) and Master Reset (MR) controls. Separate Disable inputs force the outputs to a high impedance state and allow the devices to be used in time sharing bus line applications.

These complementary MOS latches find primary use in buffer storage, holding register, or general digital logic functions where low power dissipation and/or high noise immunity is desired.

- 3-State Output
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range.

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

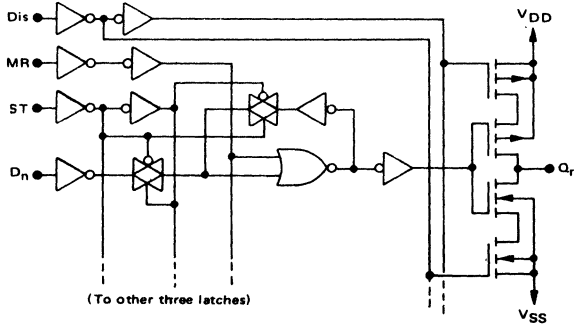
\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

MR	ST	Disable	D3	D2	D1	D0	Q3	Q2	Q1	Q0
0	1	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	1	0	0	0	1
0	1	0	0	0	1	0	0	0	1	0
0	1	0	0	1	0	0	0	1	0	0
0	1	0	1	0	0	0	1	0	0	0
0	1	0	1	1	0	0	0	1	0	0
0	0	0	X	X	X	X				Latched
1	X	0	X	X	X	X	0	0	0	0
X	X	1	X	X	X	X				High Impedance

X = Don't Care

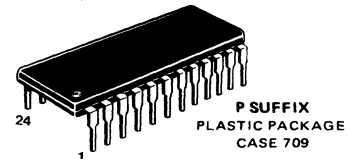
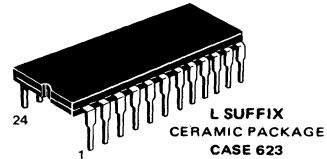
**CIRCUIT DIAGRAM**



**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL 4-BIT LATCH**

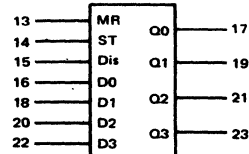
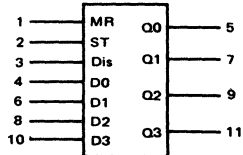


**ORDERING INFORMATION**

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 24  
 V<sub>SS</sub> = Pin 12

# MC14508B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	VDD Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	(V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>	
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>	
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (1.46 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.91 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (4.37 μA/kHz) f + I <sub>DD</sub>						μA <sub>dc</sub>		
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μA <sub>dc</sub>	
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μA <sub>dc</sub>	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{fk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.008.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

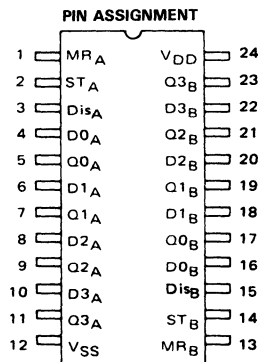
# MC14508B

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Propagation Delay Time, Dn or MR to Q $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 135 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	220	440	ns
		10	—	90	180	
		15	—	60	120	
Master Reset Pulse Width	$t_{WH(R)}$	5.0	200	100	—	ns
		10	100	50	—	
		15	70	35	—	
Master Reset Removal Time	$t_{rem}$	5.0	30	-15	—	ns
		10	25	0	—	
		15	20	0	—	
Strobe Pulse Width	$t_{WH(S)}$	5.0	140	70	—	ns
		10	70	35	—	
		15	40	20	—	
Setup Time Data to Strobe	$t_{su}$	5.0	50	25	—	ns
		10	20	10	—	
		15	10	5.0	—	
Hold Time Strobe to Data	$t_h$	5.0	50	20	—	ns
		10	35	10	—	
		15	35	10	—	
3-State Propagation Delay Time Output "1" to High Impedance  Output "0" to High Impedance  High Impedance to "1" Level  High Impedance to "0" Level	$t_{PHZ}$	5.0	—	55	170	ns
		10	—	35	100	
		15	—	30	70	
	$t_{PLZ}$	5.0	—	75	170	
		10	—	40	100	
		15	—	35	70	
	$t_{PZH}$	5.0	—	80	170	
		10	—	35	100	
		15	—	30	70	
	$t_{PZL}$	5.0	—	105	210	
		10	—	50	100	
		15	—	35	70	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labeled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.





# MC14508B

FIGURE 1 – AC WAVEFORMS

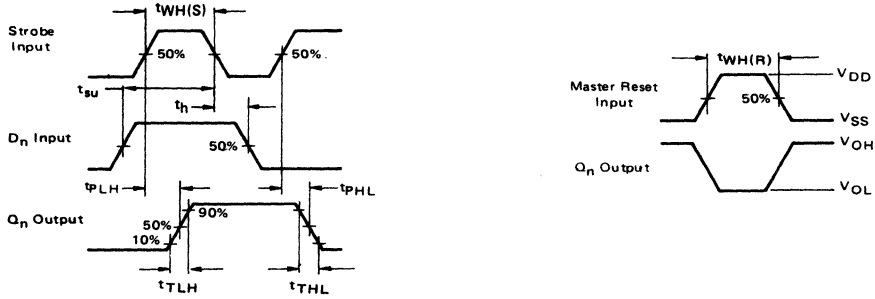
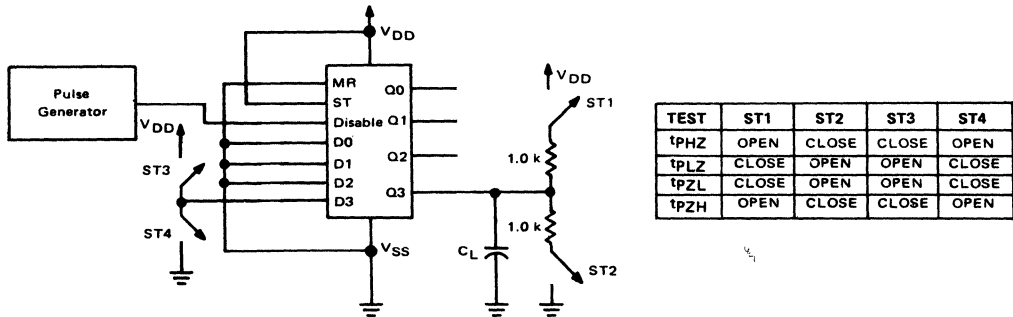
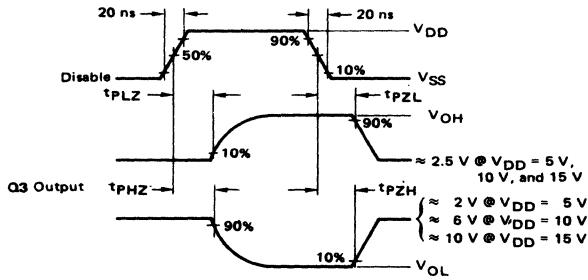


FIGURE 2 – 3-STATE AC TEST CIRCUIT AND WAVEFORMS



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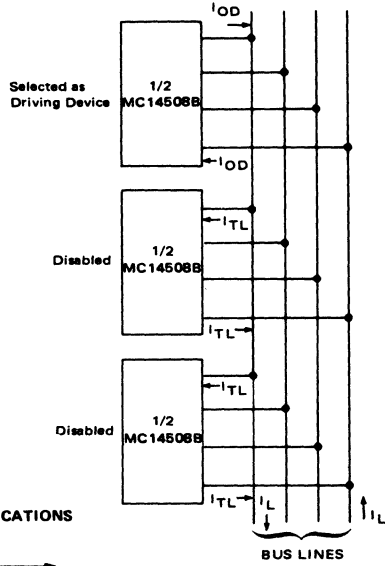
# MC14508B

## 3-STATE MODE OF OPERATION

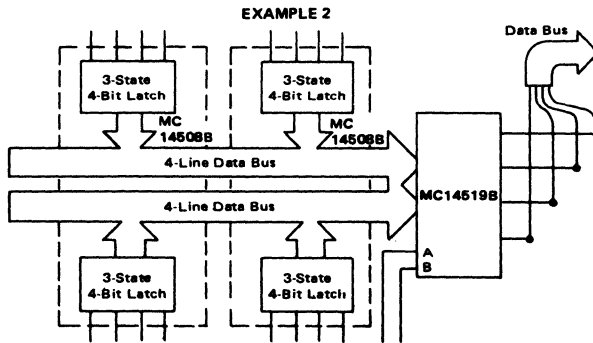
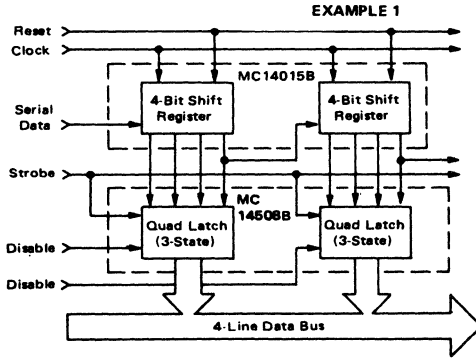
The MC14508B can be used in bussed systems as shown. The output terminals of N 4-bit latches can be directly wired to a bus line, and to one of the 4-bit latches selected. The selected latch controls the logic state of the bus line, and the remaining (N-1) 4-bit latches are disabled into a high impedance "off" state. The number of latches, N, which may be connected to a bus line is determined from the output drive current,  $I_{OD}$ , the 3-state or disabled output leakage current,  $I_{TL}$ , and the load current,  $I_L$ , required to drive the bus line (including fanout to other device inputs) and can be calculated by the following:

$$N = \frac{I_{OD} - I_L}{I_{TL}} + 1$$

N must be calculated for both high and low logic states of the bus line.



## TYPICAL 3-STATE APPLICATIONS





# MOTOROLA

## MC14510B

### BCD UP/DOWN COUNTER

The MC14510B synchronous up/down BCD counter is constructed with MOS P-channel and N-channel enhancement mode devices in a monolithic structure. The counter consists of type D flip-flop stages with a gating structure to provide type T flip-flop capability.

This counter can be preset by applying the desired value in BCD to the Preset inputs (P1, P2, P3, P4) and then bringing the Preset Enable (PE) high. The direction of counting is controlled by applying a high (for up counting) or a low (for down counting) to the UP/DOWN input. The state of the counter changes on the positive transition of the clock input.

Cascading can be accomplished by connecting the Carry Out to the Carry In of the next stage while clocking each counter in parallel. The outputs (Q1, Q2, Q3, Q4) can be reset to a low state by applying a high to the Reset (R) pin.

This CMOS counter finds primary use in up/down and difference counting. Other applications include: (1) Frequency synthesizer applications where low power dissipation and/or high noise immunity is desired, (2) Analog-to-digital and digital-to-analog conversions, and (3) Magnitude and sign generation.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Internally Synchronous for High Speed
- Logic Edge-Clocked Design – Count Occurs on Positive Going Edge of Clock
- Asynchronous Preset Enable Operation
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range.

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

### TRUTH TABLE

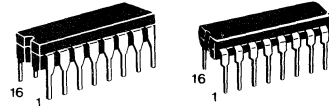
Carry In	Up/Down	Preset Enable	Reset	Clock	Action
1	X	0	0	X	No Count
0	1	0	0		Count Up
0	0	0	0		Count Down
X	X	1	0	X	Preset
X	X	X	1	X	Reset

X = Don't Care

Note: When counting up, the Carry Out signal is normally high, and is low only when Q1 and Q4 are high and Carry In is low. When counting down, Carry Out is low only when Q1 through Q4 and Carry In are low.

### CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)  
BCD UP/DOWN COUNTER



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

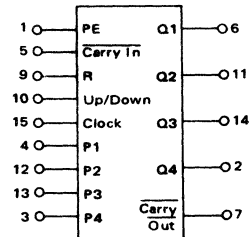
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### BLOCK DIAGRAM



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14510B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
			10	—	3.0	—	4.50	3.0	—	3.0	
			15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>							μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

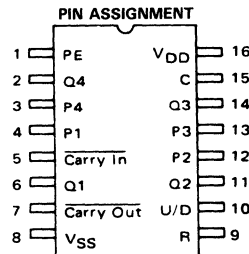
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.001.



# MC14510B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50$ pF, $T_A = 25^\circ\text{C}$ , See Figure 2)

Characteristic	Symbol	$V_{DD}$	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ Clock to Carry Out $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ Carry In to Carry Out $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 47 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$ Preset or Reset to Q $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 230 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 97 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$ Preset or Reset to Carry Out $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 192 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 125 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	315 130 100	630 260 200	ns
Reset Pulse Width	$t_{w(H)}$	5.0 10 15	360 210 160	180 105 80	— — —	ns
Clock Pulse Width	$t_{w(H)}$	5.0 10 15	350 170 140	200 100 75	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	3.0 6.0 8.0	1.5 3.0 4.0	MHz
Preset or Reset Removal Time The Preset or Reset Signal must be low prior to a positive-going transition of the clock.	$t_{rem}$	5.0 10 15	650 230 180	325 115 90	— — —	ns
Clock Rise and Fall Time	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$
Setup Time Carry In to Clock	$t_{su}$	5.0 10 15	260 120 100	130 60 50	— — —	ns
Hold Time Clock to Carry In	$t_h$	5.0 10 15	0 10 10	-50 -15 -5	— — —	ns
Setup Time Up/Down to Clock	$t_{su}$	5.0 10 15	500 200 175	250 100 75	— — —	ns
Hold Time Clock to Up/Down	$t_h$	5.0 10 15	-70 -30 -20	-140 -80 -50	— — —	ns
Setup Time Pn to PE	$t_{su}$	5.0 10 15	-50 -30 -25	-100 -65 -55	— — —	ns
Hold Time PE to Pn	$t_h$	5.0 10 15	480 410 410	240 205 205	— — —	ns
Preset Enable Pulse Width	$t_{wH}$	5.0 10 15	200 100 80	100 50 40	— — —	ns

\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14510B

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

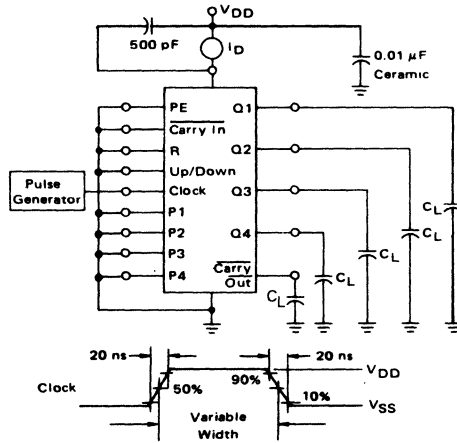
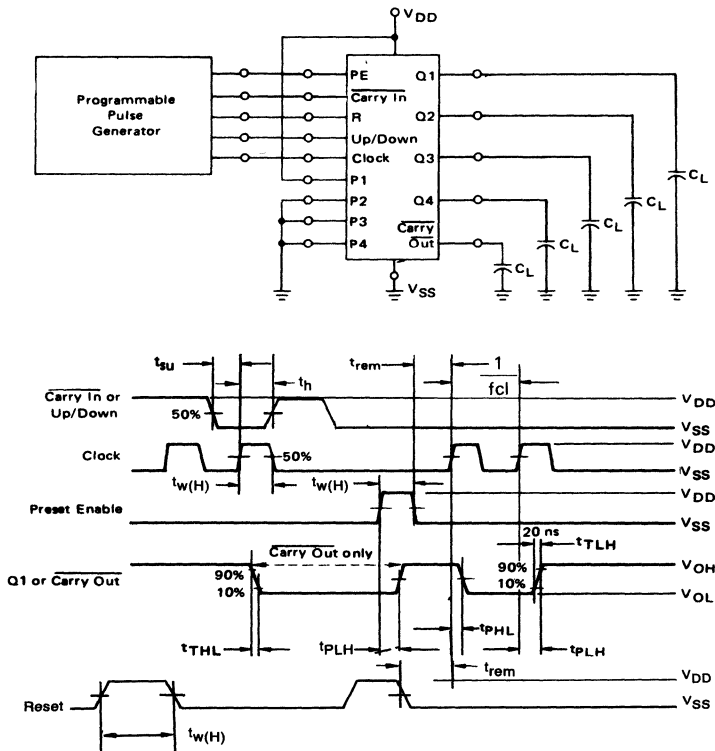


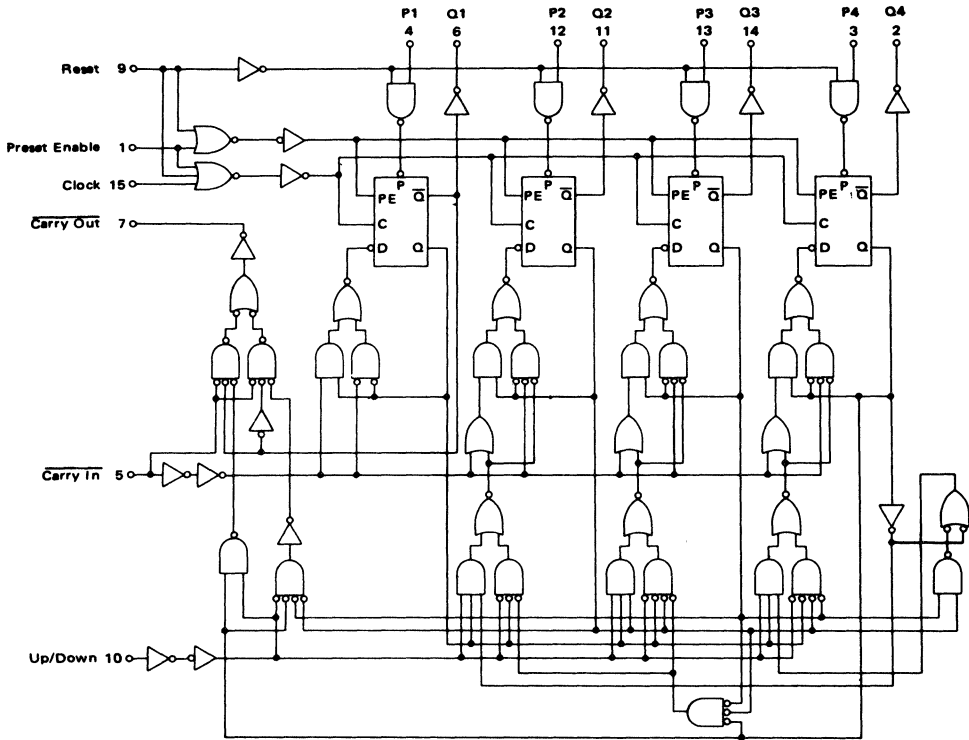
FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



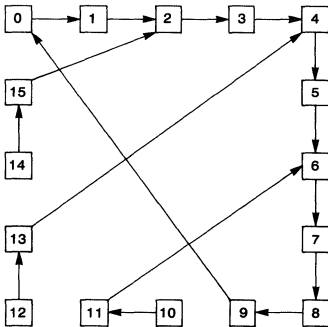
6

# MC14510B

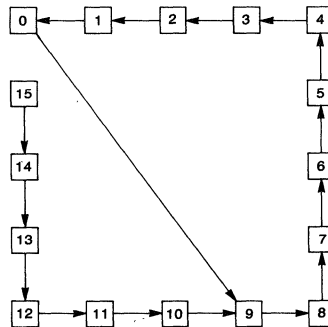
LOGIC DIAGRAM



STATE DIAGRAM FOR UP COUNTING



STATE DIAGRAM FOR DOWN COUNTING



6

# MC14510B

## PIN DESCRIPTIONS

### INPUTS

**P1, P2, P3, P4, Preset Inputs (Pins 4, 12, 13, 3)** — Data on these inputs is loaded into the counter when PE is taken high.

**Carry In, (Pin 5)** — Active-low input used when cascading stages. Usually connected to Carry Out of the previous stage. While high, clock is inhibited.

**Clock, (Pin 15)** — BCD data is incremented or decremented, depending on the direction of count, on the positive transition of this signal.

### OUTPUTS

**Q1, Q2, Q3, Q4, BCD outputs (Pins 6, 11, 14, 2)** — BCD data is present on these outputs with Q1 corresponding to the least significant bit.

**Carry Out, (Pin 7)** — Used when cascading stages, this pin is usually connected to Carry In of the next stage. This synchronous output is active low and may also be used to indicate terminal count.

### CONTROLS

**PE, Preset Enable (Pin 1)** — Asynchronously loads data on the Preset Inputs. This pin is active high and will inhibit the clock when high.

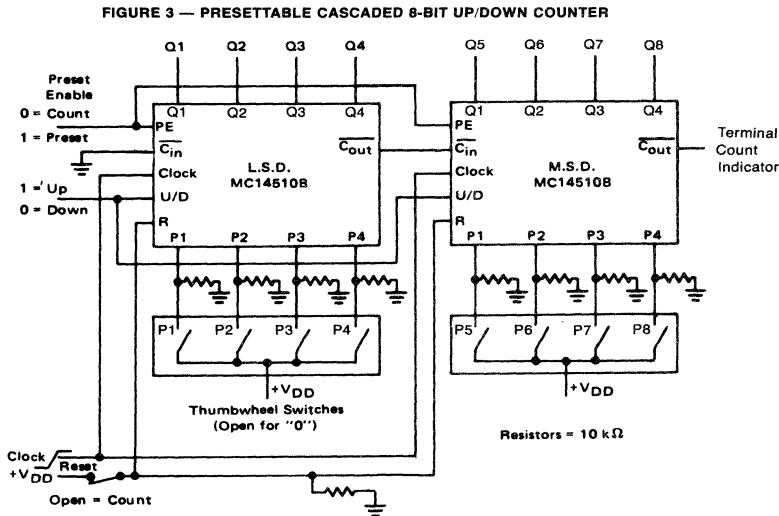
**R, Reset, (Pin 9)** — Asynchronously resets the Q outputs to a low state. This pin is active high and will inhibit the clock when high.

**Up/Down, (Pin 10)** — Controls the direction of count: high for up count, low for down count.

### SUPPLY PINS

**V<sub>SS</sub>, Negative Supply Voltage, (Pin 8)** — This pin is usually connected to ground.

**V<sub>DD</sub>, Positive Supply Voltage, (Pin 16)** — This pin is connected to a positive supply voltage ranging from 3.0 Vdc to 18.0 Vdc.

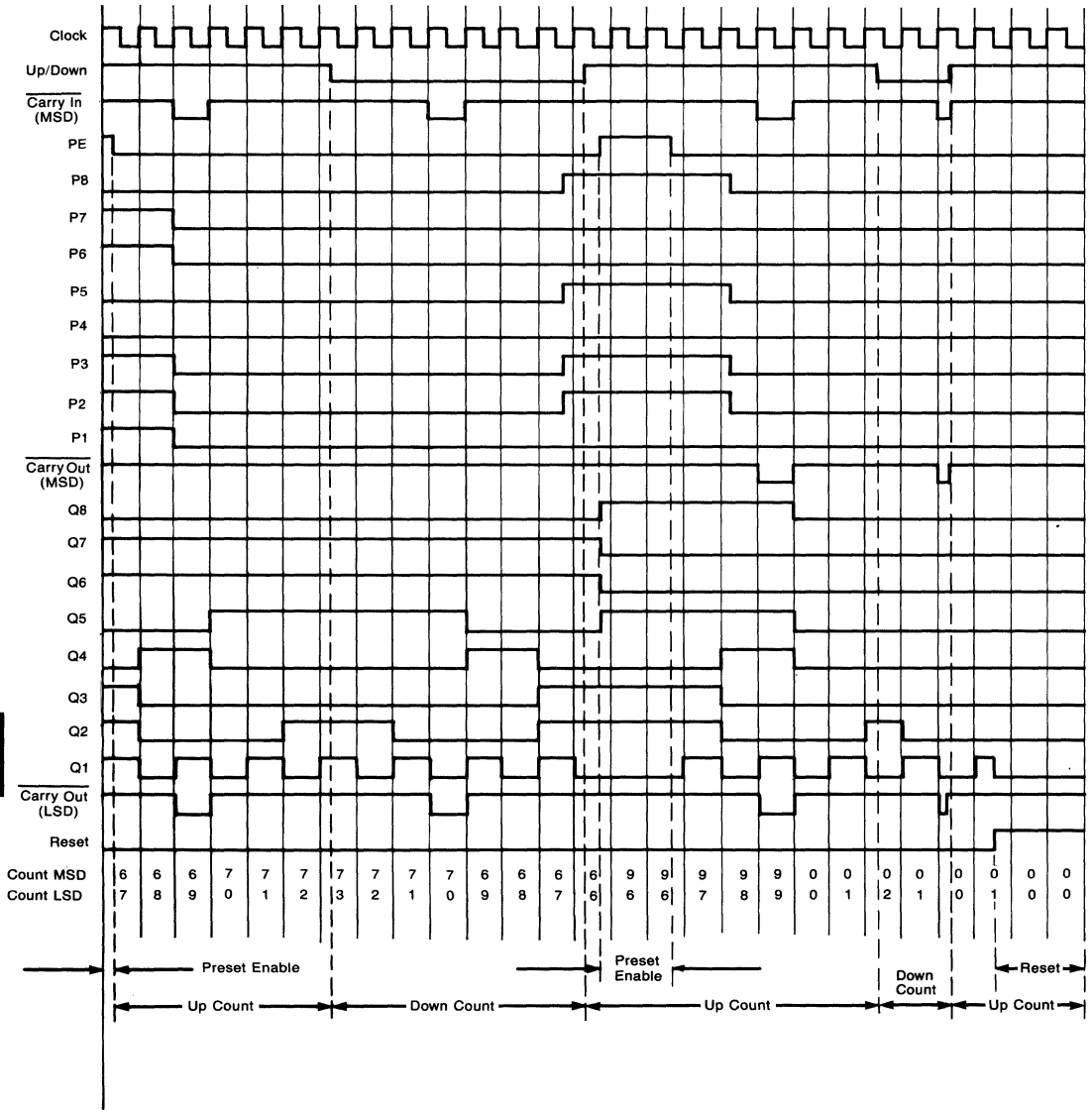


**Note:** The Least Significant Digit (L.S.D.) counts from a preset value once Preset Enable (PE) goes low. The Most Significant Digit (M.S.D.) does not change while  $\overline{C}_{in}$  is high. When the count of the L.S.D. reaches 0 (count down mode) or reaches 9 (count up mode),  $\overline{C}_{out}$  goes low for one complete clock cycle, thus allowing the next counter to decrement/increment one count. The L.S.D. now counts through another cycle (10 clock pulses) and the above cycle is repeated.



# MC14510B

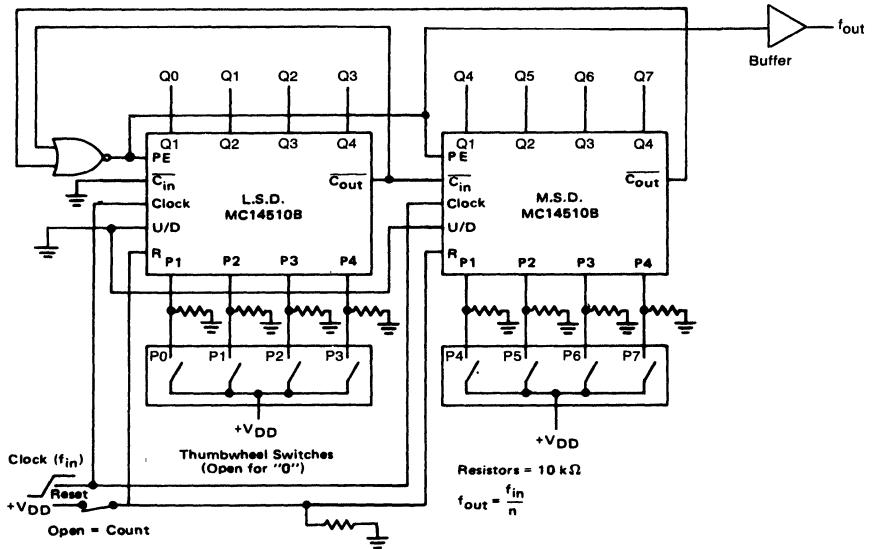
## TIMING DIAGRAM FOR THE PRESETTABLE CASCADED 8-BIT UP/DOWN COUNTER



6

# MC14510B

FIGURE 4 — PROGRAMMABLE CASCADED FREQUENCY DIVIDER



**Note:** The programmable frequency divider can be set by applying the desired divide ratio, in BCD, to the preset inputs. For example, the maximum divide ratio of 99 may be obtained by applying a 10011001 to the preset inputs P0 to P7. For this divide operation, both counters should be configured in the count down mode. The divide ratio of zero is an undefined state and should be avoided.



**MOTOROLA**

**BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER**

The MC14511B BCD-to-seven segment latch/decoder/driver is constructed with complementary MOS (CMOS) enhancement mode devices and NPN bipolar output drivers in a single monolithic structure. The circuit provides the functions of a 4-bit storage latch, an 8421 BCD-to-seven segment decoder, and an output drive capability. Lamp test ( $\overline{LT}$ ), blanking ( $\overline{BI}$ ), and latch enable (LE) inputs are used to test the display, to turn-off or pulse modulate the brightness of the display, and to store a BCD code, respectively. It can be used with seven-segment light emitting diodes (LED), incandescent, fluorescent, gas discharge, or liquid crystal readouts either directly or indirectly.

Applications include instrument (e.g., counter, DVM, etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

- Low Logic Circuit Power Dissipation
- High-Current Sourcing Outputs (Up to 25 mA)
- Latch Storage of Code
- Blanking Input
- Lamp Test Provision
- Readout Blanking on all Illegal Input Combinations
- Lamp Intensity Modulation Capability
- Time Share (Multiplexing) Facility
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-power TTL Loads, One Low-power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range.
- Chip Complexity: 216 FETs or 54 Equivalent Gates

**MAXIMUM RATINGS** (Voltages referenced to  $V_{SS}$ ).

Rating	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	-0.5 to +18	V
Input Voltage, All Inputs	$V_{in}$	-0.5 to $V_{DD} + 0.5$	V
DC Current Drain per Input Pin	I	10	mA
Operating Temperature Range — AL Device	$T_A$	-55 to +125	°C
CL/CP Device		-40 to +85	
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Maximum Output Drive Current (Source) per Output	$I_{OHmax}$	25	mA
Maximum Continuous Output Power (Source) per Output †	$P_{OHmax}$	50	mW

†  $P_{OHmax} = I_{OH} (V_{DD} - V_{OH})$

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. A destructive high current mode may occur if  $V_{in}$  and  $V_{out}$  are not constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Due to the sourcing capability of this circuit, damage can occur to the device if  $V_{DD}$  is applied, and the outputs are shorted to  $V_{SS}$  and are at a logical 1 (See Maximum Ratings).

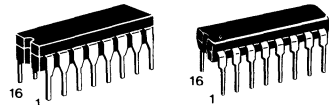
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ).

**MC14511B**

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

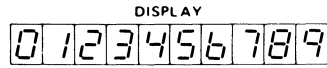
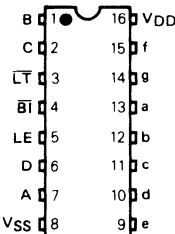
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**PIN ASSIGNMENT**



**DISPLAY**  
0 1 2 3 4 5 6 7 8 9

**TRUTH TABLE**

INPUTS				OUTPUTS							
LE	$\overline{BI}$	$\overline{LT}$	D C B A	a	b	c	d	e	f	g	DISPLAY
X	X	0	X X X X	1	1	1	1	1	1	1	Blank
X	0	1	X X X X	0	0	0	0	0	0	0	Blank
0	1	1	0 0 0 0	1	1	1	1	1	1	0	0
0	1	1	0 0 0 1	0	1	1	0	0	0	0	1
0	1	1	0 0 1 0	1	1	0	1	0	1	0	2
0	1	1	0 0 1 1	1	1	1	0	0	1	0	3
0	1	1	0 1 0 0	0	1	1	0	0	1	1	4
0	1	1	0 1 0 1	1	0	1	1	0	1	1	5
0	1	1	0 1 1 0	0	0	0	0	0	0	0	6
0	1	1	0 1 1 1	1	1	1	0	0	0	0	7
0	1	1	1 0 0 0	1	1	1	1	1	1	1	8
0	1	1	1 0 0 1	1	1	1	0	0	1	1	9
0	1	1	1 0 1 0	0	0	0	0	0	0	0	Blank
0	1	1	1 0 1 1	0	0	0	0	0	0	0	Blank
0	1	1	1 1 0 0	0	0	0	0	0	0	0	Blank
0	1	1	1 1 0 1	0	0	0	0	0	0	0	Blank
0	1	1	1 1 1 0	0	0	0	0	0	0	0	Blank
0	1	1	1 1 1 1	0	0	0	0	0	0	0	Blank
1	1	1	X X X X	-	-	-	-	-	-	-	-

X = Don't Care

\* Depends upon the BCD code previously applied when LE = 0

# MC14511B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	V		
		10	—	0.05	—	0	0.05	—	0.05			
		15	—	0.05	—	0	0.05	—	0.05			
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level V <sub>OH</sub>	5.0	4.1	—	4.1	4.57	—	4.1	—	V	
			10	9.1	—	9.1	9.58	—	9.1	—		
			15	14.1	—	14.1	14.59	—	14.1	—		
Input Voltage <sup>#</sup>	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	V		
		10	—	3.0	—	4.50	3.0	—	3.0			
		15	—	4.0	—	6.75	4.0	—	4.0			
	V <sub>O</sub> = 3.8 or 0.5 V V <sub>O</sub> = 8.8 or 1.0 V V <sub>O</sub> = 13.8 or 1.5 V	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	V	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Voltage (AL Device) Source	V <sub>OH</sub>	5.0	4.10	—	4.10	4.57	—	4.1	—	V		
			—	—	—	4.24	—	—	—			
			3.90	—	3.90	4.12	—	3.5	—			
			—	—	—	3.94	—	—	—			
			3.40	—	3.40	3.70	—	3.0	—			
			—	—	—	3.54	—	—	—			
		10	9.10	—	9.10	9.58	—	9.1	—	V		
			—	—	—	9.26	—	—	—			
			9.00	—	9.00	9.17	—	8.6	—			
			—	—	—	9.04	—	—	—			
			8.60	—	8.60	8.90	—	8.2	—			
			—	—	—	8.70	—	—	—			
		15	14.1	—	14.1	14.59	—	14.1	—	V		
			—	—	—	14.27	—	—	—			
			14.0	—	14.0	14.18	—	13.6	—			
			—	—	—	14.07	—	—	—			
			13.6	—	13.6	13.95	—	13.2	—			
			—	—	—	13.70	—	—	—			
		Output Drive Voltage (CL/CP Device) Source	V <sub>OH</sub>	5.0	4.10	—	4.10	4.57	—	4.1	—	V
					—	—	—	4.24	—	—	—	
					3.60	—	3.60	4.12	—	3.3	—	
					—	—	—	3.94	—	—	—	
					2.80	—	2.80	3.75	—	2.5	—	
					—	—	—	3.54	—	—	—	
10	9.10			—	9.10	9.58	—	9.1	—	V		
	—			—	—	9.26	—	—	—			
	8.75			—	8.75	9.17	—	8.45	—			
	—			—	—	9.04	—	—	—			
	8.10			—	8.10	8.90	—	7.8	—			
	—			—	—	8.75	—	—	—			
15	14.1			—	14.1	14.59	—	14.1	—	V		
	—			—	—	14.27	—	—	—			
	13.75			—	13.75	14.18	—	13.45	—			
	—			—	—	14.07	—	—	—			
	13.1			—	13.1	13.95	—	12.8	—			
	—			—	—	13.80	—	—	—			
Output Drive Current (AL Device) Sink	I <sub>OL</sub>			5.0	0.64	—	0.51	0.88	—	0.36	—	mA
				10	1.6	—	1.3	2.25	—	0.9	—	
				15	4.2	—	3.4	8.8	—	2.4	—	
				—	—	—	—	—	—	—	—	
Output Drive Current (CL/CP Device) Sink	I <sub>OL</sub>			5.0	0.52	—	0.44	0.88	—	0.36	—	mA
				10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—			
		—	—	—	—	—	—	—	—			

(Continued)

# MC14511B

## ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ	Max	Min	Max	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub>							μA
		10	I <sub>T</sub> = (3.8 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (5.7 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Noise immunity specified for worst-case input combination.

Noise Margin for both "1" and "0" level =

1.0 Vdc min @ V<sub>DD</sub> = 5.0 Vdc

2.0 Vdc min @ V<sub>DD</sub> = 10 Vdc

2.5 Vdc min @ V<sub>DD</sub> = 15 Vdc

†To calculate total supply current at loads other than 50 pF:

I<sub>T</sub>(C<sub>L</sub>) = I<sub>T</sub>(50 pF) + 3.5 × 10<sup>-3</sup> (C<sub>L</sub> - 50) V<sub>DD</sub>f

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in Vdc, and f in kHz is input frequency.

\*\*The formulas given are for the typical characteristics only at 25°C.

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ	Max	Unit
Output Rise Time t <sub>TLH</sub> = (0.40 ns/pF) C <sub>L</sub> + 20 ns t <sub>TLH</sub> = (0.25 ns/pF) C <sub>L</sub> + 17.5 ns t <sub>TLH</sub> = (0.20 ns/pF) C <sub>L</sub> + 15 ns	t <sub>TLH</sub>	5.0	—	40	80	ns
		10	—	30	60	
		15	—	25	50	
Output Fall Time t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 50 ns t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 37.5 ns t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 37.5 ns	t <sub>THL</sub>	5.0	—	125	250	ns
		10	—	75	150	
		15	—	65	130	
Data Propagation Delay Time t <sub>PLH</sub> = (0.40 ns/pF) C <sub>L</sub> + 620 ns t <sub>PLH</sub> = (0.25 ns/pF) C <sub>L</sub> + 237.5 ns t <sub>PLH</sub> = (0.20 ns/pF) C <sub>L</sub> + 165 ns t <sub>PHL</sub> = (1.3 ns/pF) C <sub>L</sub> + 655 ns t <sub>PHL</sub> = (0.60 ns/pF) C <sub>L</sub> + 260 ns t <sub>PHL</sub> = (0.35 ns/pF) C <sub>L</sub> + 182.5 ns	t <sub>PLH</sub>	5.0	—	640	1280	ns
		10	—	250	500	
		15	—	175	350	
	t <sub>PHL</sub>	5.0	—	720	1440	
		10	—	290	580	
		15	—	200	400	
Blank Propagation Delay Time t <sub>PLH</sub> = (0.30 ns/pF) C <sub>L</sub> + 685 ns t <sub>PLH</sub> = (0.25 ns/pF) C <sub>L</sub> + 187.5 ns t <sub>PLH</sub> = (0.15 ns/pF) C <sub>L</sub> + 142.5 ns t <sub>PHL</sub> = (0.85 ns/pF) C <sub>L</sub> + 442.5 ns t <sub>PHL</sub> = (0.45 ns/pF) C <sub>L</sub> + 177.5 ns t <sub>PHL</sub> = (0.35 ns/pF) C <sub>L</sub> + 142.5 ns	t <sub>PLH</sub>	5.0	—	600	750	ns
		10	—	200	300	
		15	—	150	220	
	t <sub>PHL</sub>	5.0	—	485	970	
		10	—	200	400	
		15	—	160	320	
Lamp Test Propagation Delay Time t <sub>PLH</sub> = (0.45 ns/pF) C <sub>L</sub> + 290.5 ns t <sub>PLH</sub> = (0.25 ns/pF) C <sub>L</sub> + 112.5 ns t <sub>PLH</sub> = (0.20 ns/pF) C <sub>L</sub> + 80 ns t <sub>PHL</sub> = (1.3 ns/pF) C <sub>L</sub> + 248 ns t <sub>PHL</sub> = (0.45 ns/pF) C <sub>L</sub> + 102.5 ns t <sub>PHL</sub> = (0.35 ns/pF) C <sub>L</sub> + 72.5 ns	t <sub>PLH</sub>	5.0	—	313	625	ns
		10	—	125	250	
		15	—	90	180	
	t <sub>PHL</sub>	5.0	—	313	625	
		10	—	125	250	
		15	—	90	180	
Setup Time	t <sub>su</sub>	5.0	100	—	—	ns
		10	40	—	—	
		15	30	—	—	
Hold Time	t <sub>h</sub>	5.0	60	—	—	ns
		10	40	—	—	
		15	30	—	—	
Latch Enable Pulse Width	t <sub>WL</sub>	5.0	520	260	—	ns
		10	220	110	—	
		15	130	65	—	

\*The formulas given are for the typical characteristics only.

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FIGURE 1 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORMS

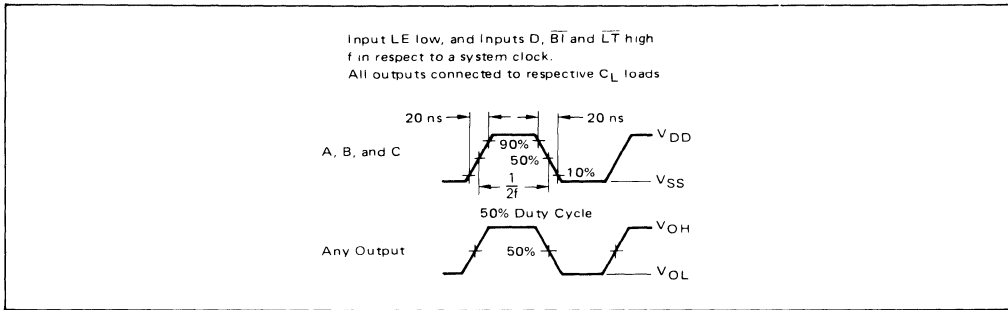
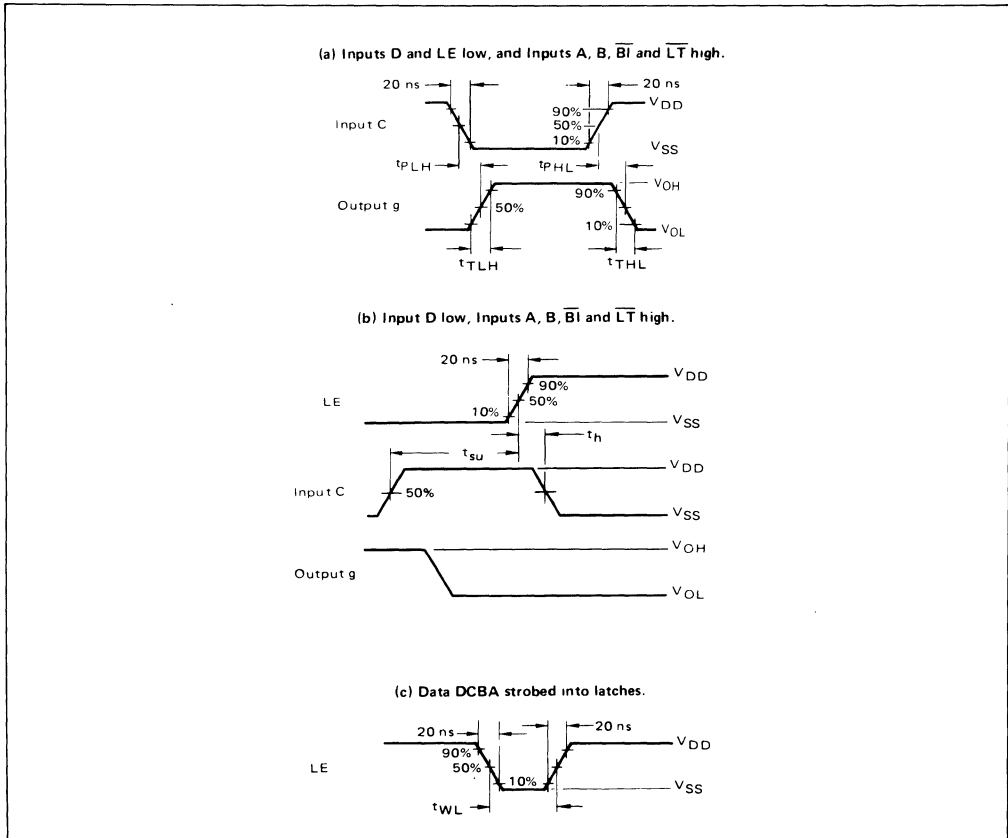
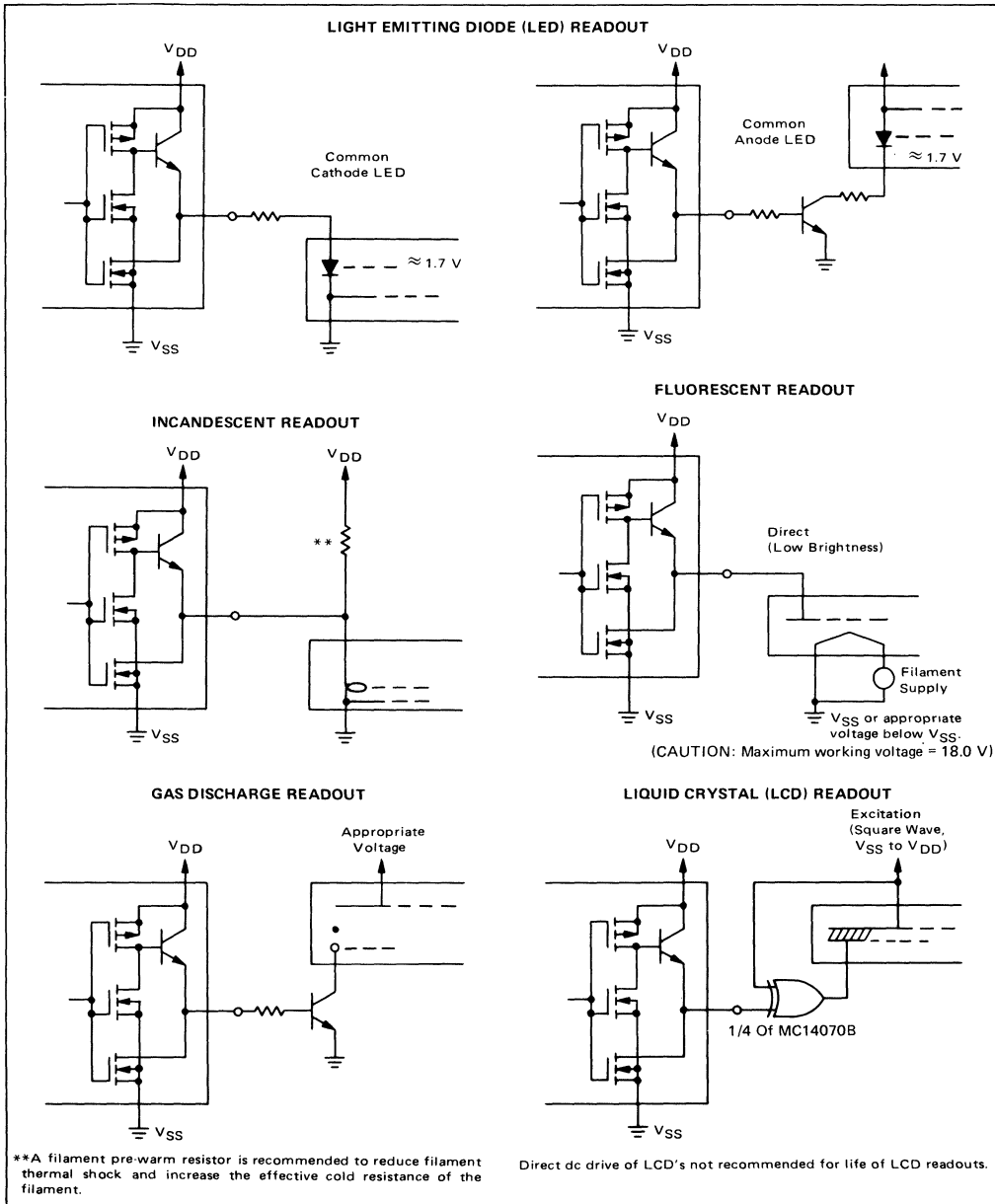


FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS



# MC14511B

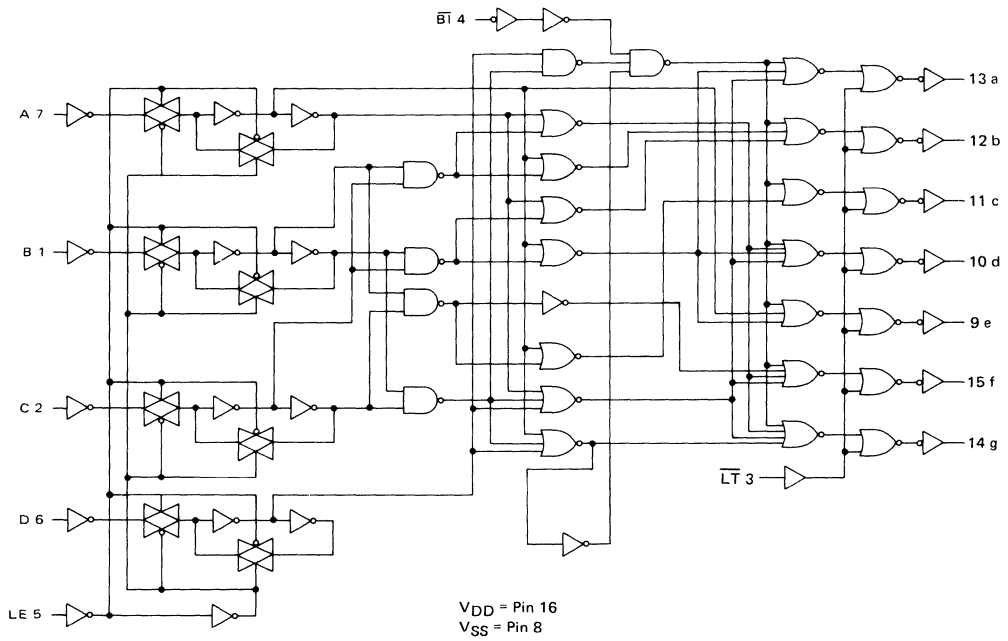
## CONNECTIONS TO VARIOUS DISPLAY READOUTS



6

# MC14511B

## LOGIC DIAGRAM







**MOTOROLA**

**MC14512B**

**8-CHANNEL DATA SELECTOR**

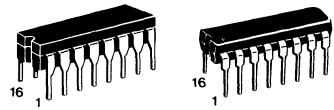
The MC14512B is an 8-channel data selector constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. This data selector finds primary application in signal multiplexing functions. It may also be used for data routing, digital signal switching, signal gating, and number sequence generation.

- Diode Protection on All Inputs
- Single Supply Operation
- 3-State Output (Logic "1", Logic "0", High Impedance)
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**8-CHANNEL DATA SELECTOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$i_{in}, i_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

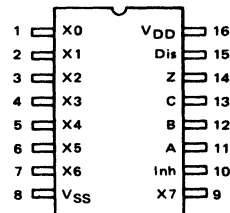
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

C	B	A	INHIBIT	DISABLE	Z
0	0	0	0	0	X0
0	0	1	0	0	X1
0	1	0	0	0	X2
0	1	1	0	0	X3
1	0	0	0	0	X4
1	0	1	0	0	X5
1	1	0	0	0	X6
1	1	1	0	0	X7
X	X	X	1	0	0
X	X	X	X	1	High Impedance

X = Don't Care

**PIN ASSIGNMENT**



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

# MC14512B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
			10	—	0.05	—	0	0.05	—	0.05		
			15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
				10	9.95	—	9.95	10	—	9.95	—	
				15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
			10	—	3.0	—	4.50	3.0	—	3.0		
			15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
			10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
			10	1.6	—	1.3	2.25	—	0.9	—		
			15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
			10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
			10	1.3	—	1.1	2.25	—	0.9	—		
			15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc		
		10	—	10	—	0.010	10	—	300			
		15	—	20	—	0.015	20	—	600			
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc		
		10	—	40	—	0.010	40	—	300			
		15	—	80	—	0.015	80	—	600			
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.8 μA/kHz) f + I <sub>DD</sub>						μAdc			
		10	I <sub>T</sub> = (1.6 μA/kHz) f + I <sub>DD</sub>									
		15	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>									
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μAdc		
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μAdc		

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 †T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V}f/k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.



# MC14512B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C, See Figure 1)

Characteristic	Symbol	V <sub>DD</sub>	All Types		Unit
			Typ #	Max	
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	100	200	ns
		10	50	100	
		15	40	80	
Propagation Delay Time (Figure 2) Inhibit, Control, or Data to Z	t <sub>PLH</sub>	5.0	330	650	ns
		10	125	250	
		15	85	170	
Propagation Delay Time (Figure 2) Inhibit, Control, or Data to Z	t <sub>PHL</sub>	5.0	330	650	ns
		10	125	250	
		15	85	170	
3-State Output Delay Times (Figure 3) "1" or "0" to High Z, and High Z to "1" or "0"	t <sub>PHZ</sub> , t <sub>PLZ</sub> , t <sub>PZH</sub> , t <sub>PZL</sub>	5.0	60	150	ns
		10	35	100	
		15	30	75	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 - POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

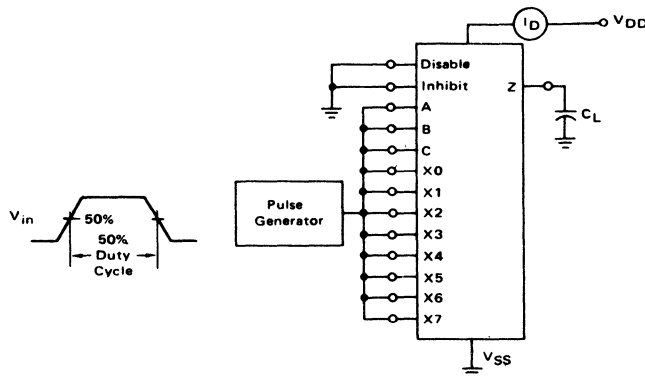
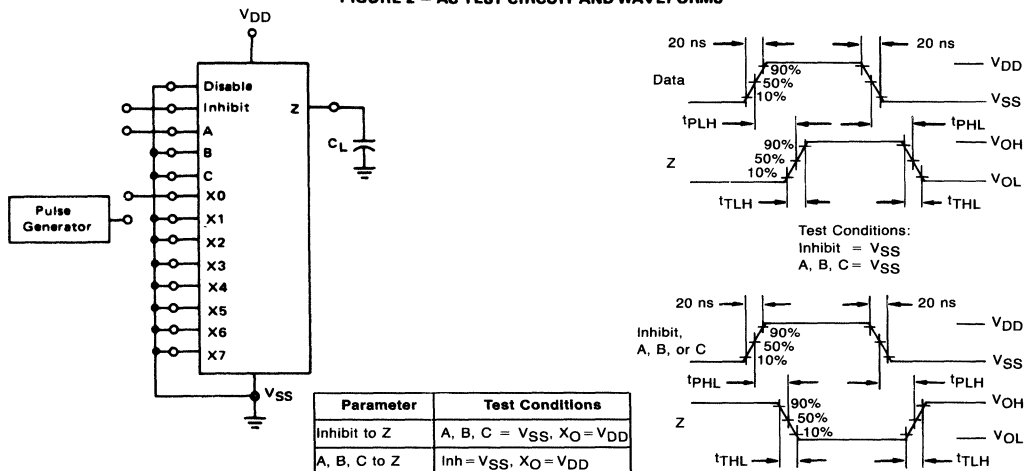
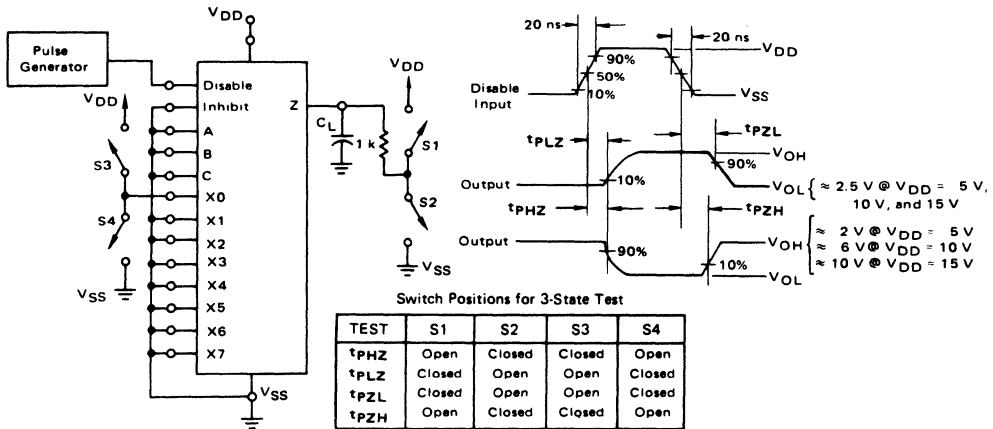


FIGURE 2 - AC TEST CIRCUIT AND WAVEFORMS

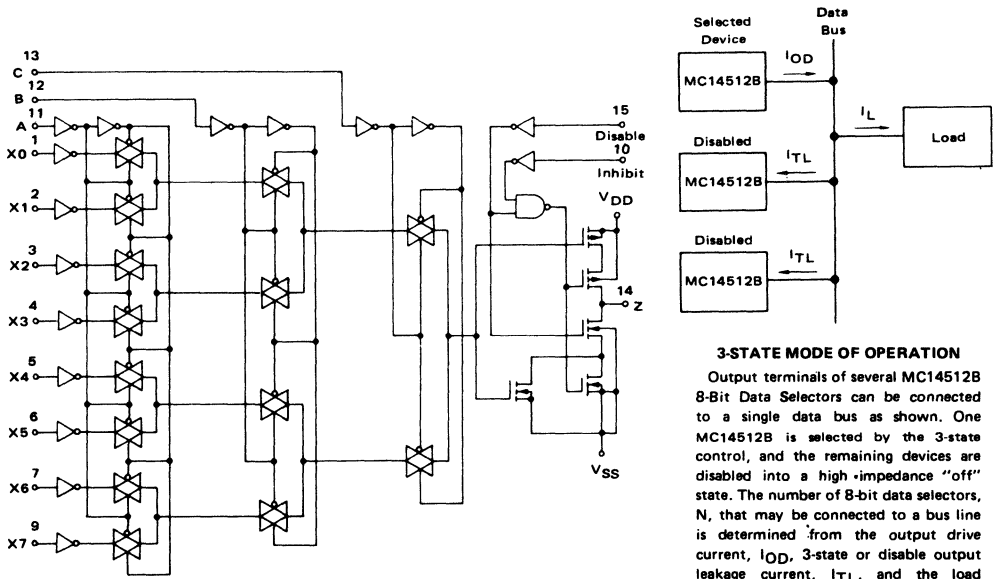


# MC14512B

FIGURE 3 - 3-STATE AC TEST CIRCUIT AND WAVEFORM



## LOGIC DIAGRAM

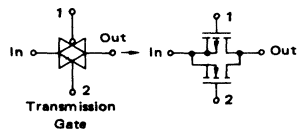


### 3-STATE MODE OF OPERATION

Output terminals of several MC14512B 8-Bit Data Selectors can be connected to a single data bus as shown. One MC14512B is selected by the 3-state control, and the remaining devices are disabled into a high impedance "off" state. The number of 8-bit data selectors, N, that may be connected to a bus line is determined from the output drive current,  $I_{OD}$ , 3-state or disable output leakage current,  $I_{TL}$ , and the load current,  $I_L$ , required to drive the bus line (including fanout to other device inputs), and can be calculated by:

$$N = \frac{I_{OD} - I_L}{I_{TL}} + 1$$

N must be calculated for both high and low logic state of the bus line.





**MOTOROLA**

**MC14513B**

**BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER**

The MC14513B BCD-to-seven segment latch/decoder/driver is constructed with complementary MOS (CMOS) enhancement mode devices and NPN bipolar output drivers in a single monolithic structure. The circuit provides the functions of a 4-bit storage latch, an 8421 BCD-to-seven segment decoder, and has output drive capability. Lamp test (LT), blanking (BI), and latch enable (LE) inputs are used to test the display, to turn-off or pulse modulate the brightness of the display, and to store a BCD code, respectively. The Ripple Blanking Input (RBI) and Ripple Blanking Output (RBO) can be used to suppress either leading or trailing zeroes. It can be used with seven-segment light emitting diodes (LED), incandescent, fluorescent, gas discharge, or liquid crystal readouts either directly or indirectly.

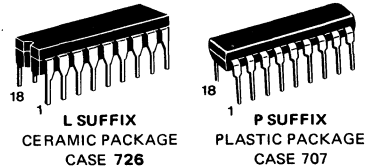
Applications include instrument (e.g., counter, DVM, etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

- Low Logic Circuit Power Dissipation
- High-current Sourcing Outputs (Up to 25 mA)
- Latch Storage of Binary Input
- Blanking Input
- Lamp Test Provision
- Readout Blanking on all Illegal Input Combinations
- Lamp Intensity Modulation Capability
- Time Share (Multiplexing) Capability
- Adds Ripple Blanking In, Ripple Blanking Out to MC14511B
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-Power TTL Loads, One Low-power Schottky TTL Load to Two HTL Loads Over the Rated Temperature Range.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER WITH RIPPLE BLANKING**



**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

6

**MAXIMUM RATINGS** (Voltages referenced to  $V_{SS}$ )

Rating	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	-0.5 to +18	V
Input Voltage, All Inputs	$V_{in}$	-0.5 to $V_{DD} + 0.5$	V
DC Current Drain per Input Pin	I	10	mA
Operating Temperature Range — AL Device	$T_A$	-55 to +125	°C
CL/CP Device		-40 to +85	
Storage Temperature Range	$T_{stg}$	-65 to +150	°C
Maximum Continuous Output Drive Current (Source) per Output	$I_{OHmax}$	25	mA
Maximum Continuous Output Power (Source) per Output ‡	$POHmax$	50	mW

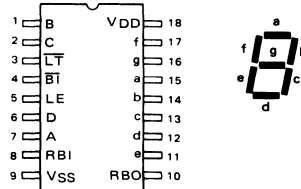
‡  $POHmax = I_{OH} (V_{DD} - V_{OH})$

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. A destructive high current mode may occur if  $V_{in}$  and  $V_{out}$  is not constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Due to the sourcing capability of this circuit, damage can occur to the device if  $V_{DD}$  is applied, and the outputs are shorted to  $V_{SS}$  and are at a logical 1 (see Maximum Ratings).

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ).

**PIN ASSIGNMENT**



**TRUTH TABLE**

INPUTS				OUTPUTS												
RBI	LE	BI	LT	D	C	B	A	RBO	a	b	c	d	e	f	g	DISPLAY
X	X	X	0	X	X	X	X	+	1	1	1	1	1	1	1	Blank
X	X	0	1	X	X	X	X	+	0	0	0	0	0	0	0	Blank
0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	Blank
0	0	1	1	0	0	0	0	0	1	1	1	1	0	0	0	0
X	0	1	1	0	0	0	1	0	0	1	1	0	0	0	0	1
X	0	1	1	0	0	1	0	0	1	1	0	1	0	0	1	2
X	0	1	1	0	1	0	0	0	1	1	1	0	0	0	1	3
X	0	1	1	0	1	0	1	0	0	1	1	0	0	1	1	4
X	0	1	1	0	1	0	1	0	1	0	1	1	0	1	1	5
X	0	1	1	0	1	1	0	0	0	1	0	1	1	1	1	6
X	0	1	1	0	1	1	1	0	1	1	0	0	0	0	0	7
X	0	1	1	1	0	0	0	0	1	1	1	1	1	1	1	8
X	0	1	1	1	0	0	1	0	1	1	1	0	0	1	1	9
X	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	Blank
X	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	Blank
X	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	Blank
X	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	Blank
X	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	Blank
X	1	1	1	X	X	X	X	†	+	+	+	+	+	+	+	+

X = Don't Care  
† RBO = RBI (D, C, B, A), indicated by other rows of table  
+ Depends upon the BCD code previously applied when LE = 0

# MC14513B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to $V_{SS}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	$T_{low}^*$		25°C			$T_{high}^*$		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage – Segment Outputs “0” Level $V_{in} = V_{DD}$ or 0	$V_{OL}$	5.0	–	0.05	–	0	0.05	–	0.05	V	
		10	–	0.05	–	0	0.05	–	0.05		
		15	–	0.05	–	0	0.05	–	0.05		
	$V_{in} = 0$ or $V_{DD}$ “1” Level	$V_{OH}$	5.0	4.1	–	4.1	5.0	–	4.1	–	V
			10	9.1	–	9.1	10	–	9.1	–	
			15	14.1	–	14.1	15	–	14.1	–	
Output Voltage – RBO Output “0” Level $V_{in} = V_{DD}$ or 0	$V_{OL}$	5.0	–	0.05	–	0	0.05	–	0.05	V	
		10	–	0.05	–	0	0.05	–	0.05		
		15	–	0.05	–	0	0.05	–	0.05		
	$V_{in} = 0$ or $V_{DD}$ “1” Level	$V_{OH}$	5.0	4.95	–	4.95	5.0	–	4.95	–	V
			10	9.95	–	9.95	10	–	9.95	–	
			15	14.95	–	14.95	15	–	14.95	–	
Input Voltage <sup>†</sup> “0” Level ( $V_O = 3.8$ or $0.5$ V) ( $V_O = 8.8$ or $1.0$ V) ( $V_O = 13.8$ or $1.5$ V)	$V_{IL}$	5.0	–	1.5	–	2.25	1.5	–	1.5	V	
		10	–	3.0	–	4.50	3.0	–	3.0		
		15	–	4.0	–	6.75	4.0	–	4.0		
	$V_{IH}$	5.0	3.5	–	3.5	2.75	–	3.5	–	V	
		10	7.0	–	7.0	5.50	–	7.0	–		
		15	11.0	–	11.0	8.25	–	11.0	–		
Output Drive Voltage – Segments (AL Device) Source: ( $I_{OH} = 0$ mA) ( $I_{OH} = 5.0$ mA) ( $I_{OH} = 10$ mA) ( $I_{OH} = 15$ mA) ( $I_{OH} = 20$ mA) ( $I_{OH} = 25$ mA)	$V_{OH}$	5.0	4.10	–	4.10	4.57	–	4.1	–	V	
			–	–	–	4.24	–	–	–		
			3.90	–	3.90	4.12	–	3.5	–		
			–	–	–	3.94	–	–	–		
			3.40	–	3.40	3.75	–	3.0	–		
			–	–	–	3.54	–	–	–		
	10	9.10	–	9.10	9.58	–	9.1	–	V		
		–	–	–	9.26	–	–	–			
		9.00	–	9.00	9.17	–	8.6	–			
		–	–	–	9.04	–	–	–			
		8.60	–	8.60	8.90	–	8.2	–			
		–	–	–	8.75	–	–	–			
	15	14.1	–	14.1	14.59	–	14.1	–	V		
		–	–	–	14.27	–	–	–			
		14.0	–	14.0	14.18	–	13.6	–			
		–	–	–	14.07	–	–	–			
		13.6	–	13.6	13.95	–	13.2	–			
		–	–	–	13.80	–	–	–			
	Output Drive Voltage – Segments (CL/CP Device) Source: ( $I_{OH} = 0$ mA) ( $I_{OH} = 5.0$ mA) ( $I_{OH} = 10$ mA) ( $I_{OH} = 15$ mA) ( $I_{OH} = 20$ mA) ( $I_{OH} = 25$ mA)	$V_{OH}$	5.0	4.10	–	4.10	4.57	–	4.1	–	V
				–	–	–	4.24	–	–	–	
				3.60	–	3.60	4.12	–	3.3	–	
				–	–	–	3.94	–	–	–	
				2.80	–	2.80	3.75	–	2.5	–	
				–	–	–	3.54	–	–	–	
10		9.10	–	9.10	9.58	–	9.1	–	V		
		–	–	–	9.26	–	–	–			
		8.75	–	8.75	9.17	–	8.45	–			
		–	–	–	9.04	–	–	–			
		8.10	–	8.10	8.90	–	7.8	–			
		–	–	–	8.75	–	–	–			
15		14.1	–	14.1	14.59	–	14.1	–	V		
		–	–	–	14.27	–	–	–			
		13.75	–	13.75	14.18	–	13.45	–			
		–	–	–	14.07	–	–	–			
		13.1	–	13.1	13.95	–	12.8	–			
		–	–	–	13.80	–	–	–			

# MC14513B

## ELECTRICAL CHARACTERISTICS (Continued)

	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Drive Current – RBO Output (AL Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source	5.0	-0.40	–	-0.32	-0.64	–	-0.22	–	mA	
		10	-0.21	–	-0.17	-0.34	–	-0.12	–		
		15	-0.81	–	-0.66	-1.3	–	-0.46	–		
	Sink	I <sub>OL</sub>	5.0	0.18	–	0.15	0.29	–	0.10		–
			10	0.47	–	0.38	0.75	–	0.26		–
			15	1.8	–	1.5	2.9	–	1.0		–
Output Drive Current – RBO Output (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source	5.0	-0.25	–	-0.21	-0.64	–	-0.17	–	mA	
		10	-0.13	–	-0.11	-0.34	–	-0.092	–		
		15	-0.52	–	-0.44	-1.3	–	-0.36	–		
	Sink	I <sub>OL</sub>	5.0	0.12	–	0.098	0.29	–	0.080		–
			10	0.30	–	0.25	0.75	–	0.21		–
			15	1.2	–	0.98	2.9	–	0.80		–
Output Drive Current – Segments (AL Device) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Sink	I <sub>OL</sub>	5.0	0.64	–	0.51	0.88	–	0.36	–	mA
10	1.6	–	1.3	2.25	–	0.9	–				
15	4.2	–	3.4	8.8	–	2.4	–				
Output Drive Current – Segments (CL/CP Device) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Sink	I <sub>OL</sub>	5.0	0.52	–	0.44	0.88	–	0.36	–	mA
10	1.3	–	1.1	2.25	–	0.9	–				
15	3.6	–	3.0	8.8	–	2.4	–				
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA	
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA	
Input Capacitance	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF	
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> = 0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	5.0	–	0.005	5.0	–	150	μA	
		10	–	10	–	0.010	10	–	300		
		15	–	20	–	0.015	20	–	600		
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> = 0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	20	–	0.005	20	–	150	μA	
		10	–	40	–	0.010	40	–	300		
		15	–	80	–	0.015	80	–	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub>							μA	
		10	I <sub>T</sub> = (3.8 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (5.7 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +25°C for CL/CP Device.

≠ Noise immunity specified for worst-case input combination.

Noise Margin for both "1" and "0" level =

1.0 V min @ V<sub>DD</sub> = 5.0 V

2.0 V min @ V<sub>DD</sub> = 10 V

2.5 V min @ V<sub>DD</sub> = 15 V

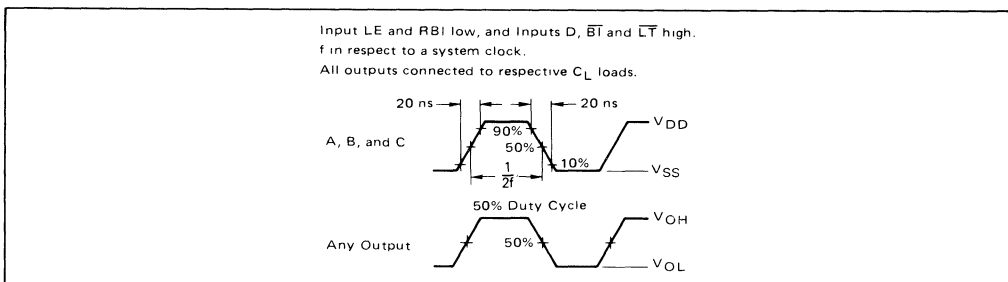
† To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + 3.5 \times 10^{-3} (C_L - 50) V_{DD} f$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in V,  
and f in kHz is input frequency.

\*\* The formulas given are for the typical characteristics  
only at 25°C.

FIGURE 1 – DYNAMIC POWER DISSIPATION  
SIGNAL WAVEFORMS



# MC14513B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	All Types			Unit	
			Min	Typ	Max		
Output Rise Time—Segment Outputs	$t_{TLH}$	5.0	—	40	80	ns	
		10	—	30	60		
		15	—	25	50		
Output Rise Time—RBO Output	$t_{TLH}$	5.0	—	480	960	ns	
		10	—	240	480		
		15	—	190	380		
Output Fall Time—Segment Outputs*	$t_{THL}$	5.0	—	125	250	ns	
		10	—	75	150		
		15	—	65	130		
		$t_{THL} = (1.5 \text{ ns/pF}) C_L + 50 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 37.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 37.5 \text{ ns}$					
Output Fall Time—RBO Outputs	$t_{THL}$	5.0	—	270	540	ns	
		10	—	135	270		
		15	—	110	220		
		$t_{THL} = (3.25 \text{ ns/pF}) C_L + 107.5 \text{ ns}$ $t_{THL} = (1.35 \text{ ns/pF}) C_L + 67.5 \text{ ns}$ $t_{THL} = (0.95 \text{ ns/pF}) C_L + 62.5 \text{ ns}$					
Propagation Delay Time—A, B, C, D Inputs*	$t_{PLH}$	5.0	—	640	1280	ns	
		10	—	250	500		
		15	—	175	350		
	$t_{PHL}$	5.0	—	720	1440	ns	
		10	—	290	580		
		15	—	200	400		
	Propagation Delay Time—RBI and $\overline{\text{BI}}$ Inputs*	$t_{PLH}$	5.0	—	600	750	ns
			10	—	200	300	
15			—	150	220		
$t_{PHL}$		5.0	—	485	970	ns	
		10	—	200	400		
		15	—	160	320		
Propagation Delay Time— $\overline{\text{LT}}$ Input*		$t_{PLH}$	5.0	—	313	625	ns
			10	—	125	250	
	15		—	90	180		
	$t_{PHL}$	5.0	—	313	625	ns	
		10	—	125	250		
		15	—	90	180		
	Setup Time	$t_{su}$	5.0	100	—	—	ns
			10	40	—	—	
15			30	—	—		
Hold Time	$t_h$	5.0	60	—	—	ns	
		10	40	—	—		
		15	30	—	—		
Latch Enable Pulse Width	$t_{WL(LE)}$	5.0	520	260	—	ns	
		10	220	110	—		
		15	130	65	—		

\*The formulas given are for the typical characteristics only.

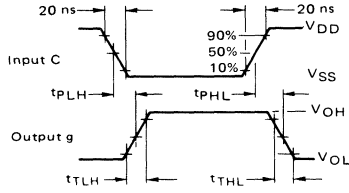




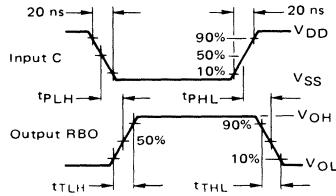
# MC14513B

FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS

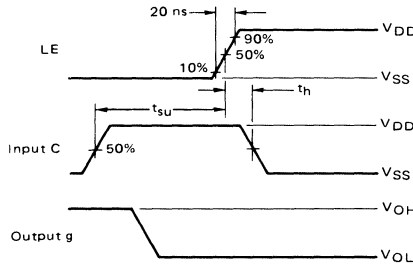
a. Data Propagation Delay: Inputs RBI, D and LE low, and Inputs A, B,  $\overline{B\overline{T}}$  and  $\overline{L\overline{T}}$  high.



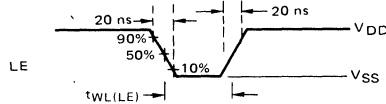
b. Inputs A, B, D and LE low, and Inputs RBI,  $\overline{B\overline{T}}$  and  $\overline{L\overline{T}}$  high.



c. Setup and Hold Times: Input RBI and D low, Inputs A, B,  $\overline{B\overline{T}}$  and  $\overline{L\overline{T}}$  high.

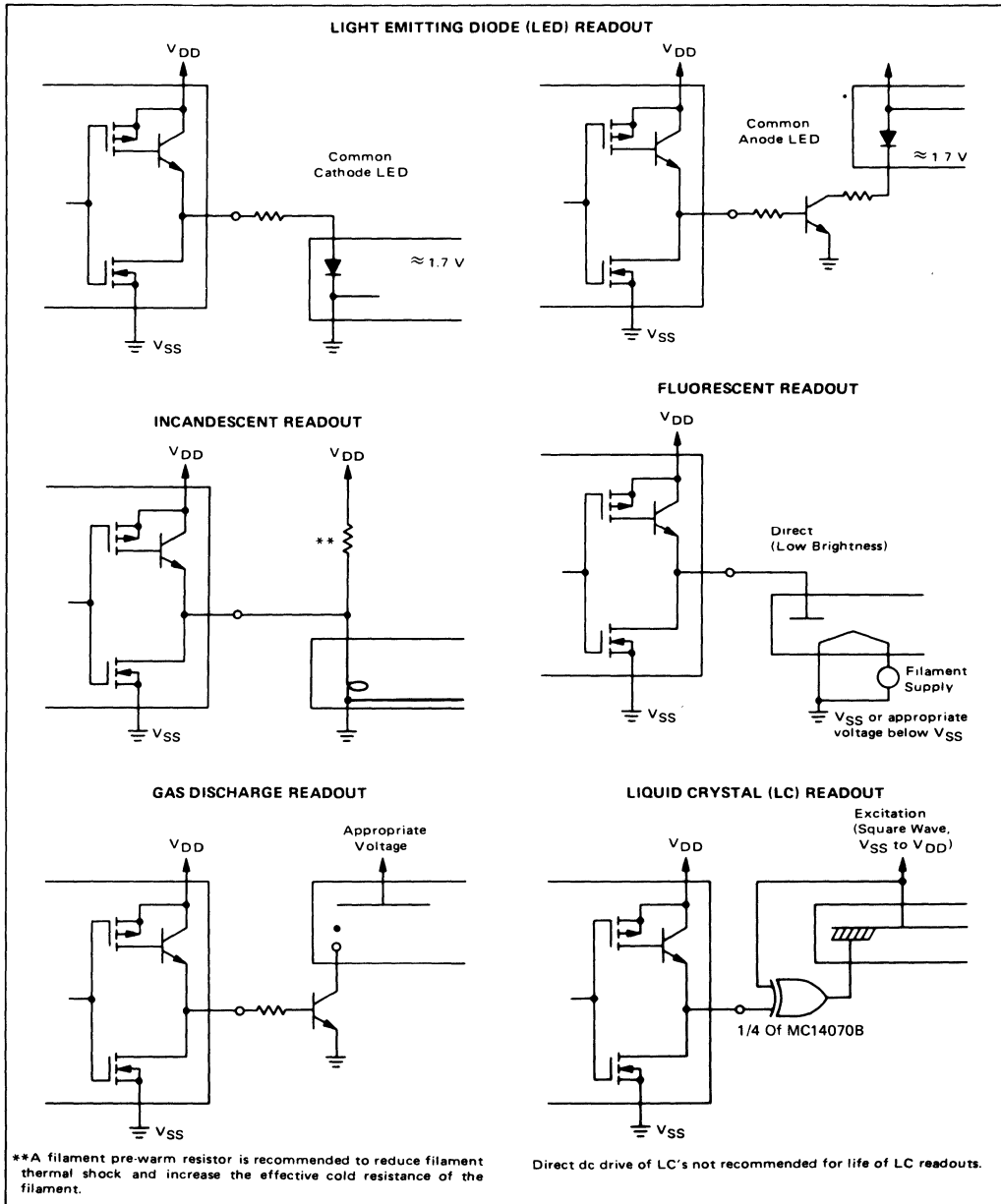


d. Pulse Width: Data DCBA strobed into latches.



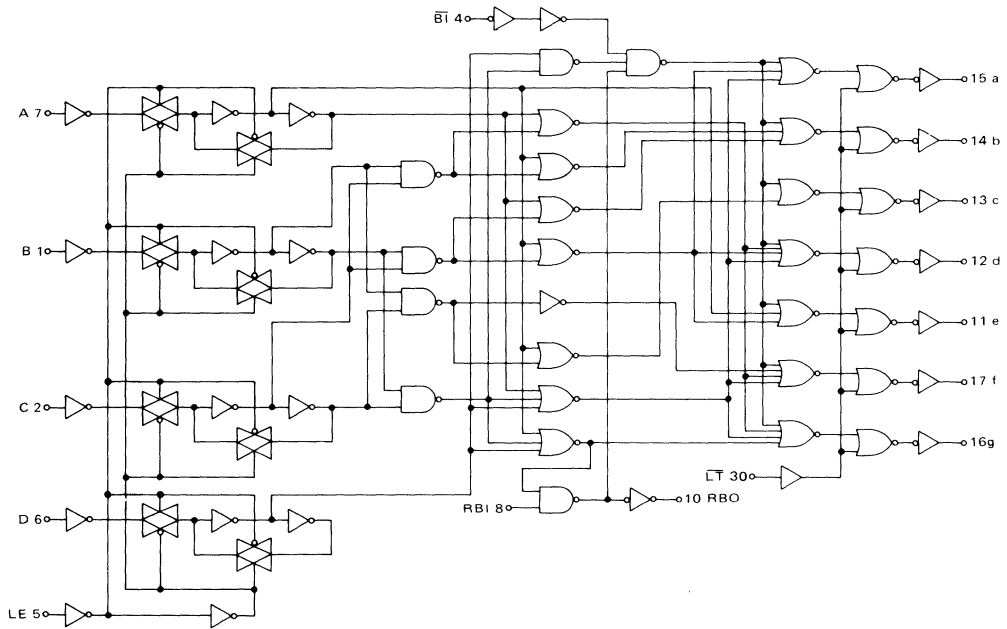
# MC14513B

## CONNECTIONS TO VARIOUS DISPLAY READOUTS



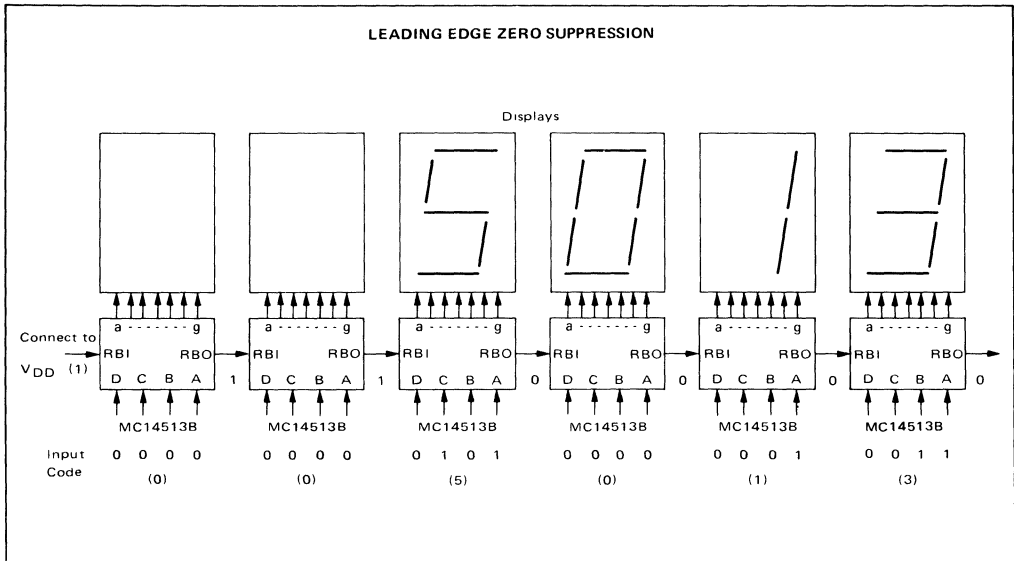
# MC14513B

## LOGIC DIAGRAM



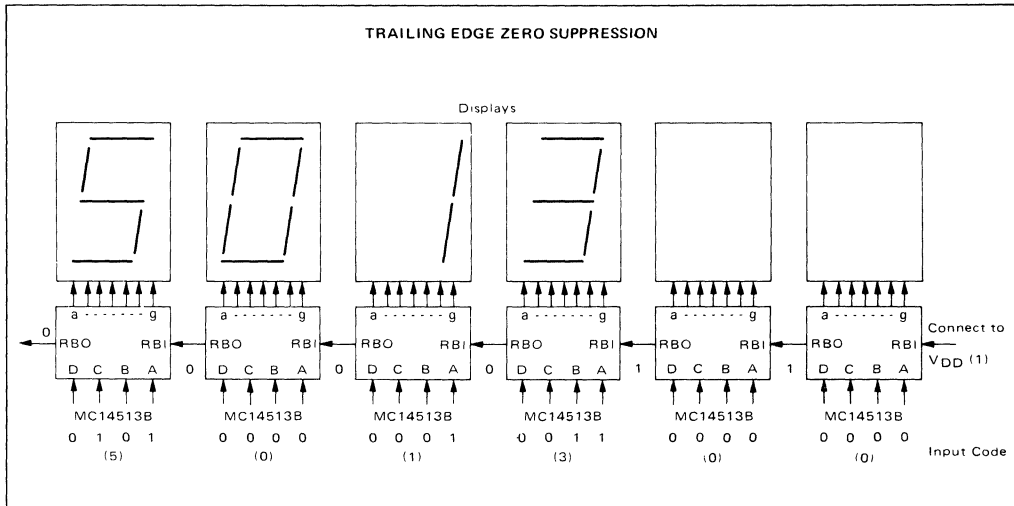
## TYPICAL APPLICATIONS FOR RIPPLE BLANKING

### LEADING EDGE ZERO SUPPRESSION



# MC14513B

## TYPICAL APPLICATIONS FOR RIPPLE BLANKING (Cont)





**MOTOROLA**

**MC14514B  
MC14515B**

**4-BIT TRANSPARENT LATCH/4-TO-16 LINE DECODER**

The MC14514B and MC14515B are two output options of a 4 to 16 line decoder with latched inputs. The MC14514B (output active high option) presents a logical "1" at the selected output, whereas the MC14515B (output active low option) presents a logical "0" at the selected output. The latches are R-S type flip-flops which hold the last input data presented prior to the strobe transition from "1" to "0". These high and low options of a 4-bit latch/4 to 16 line decoder are constructed with N-channel and P-channel enhancement mode devices in a single monolithic structure. The latches are R-S type flip-flops and data is admitted upon a signal incident at the strobe input, decoded, and presented at the output.

These complementary circuits find primary use in decoding applications where low power dissipation and/or high noise immunity is desired.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in, Vout</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in, Iout</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

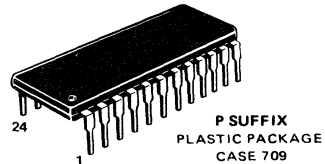
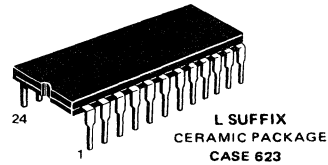
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT TRANSPARENT LATCH/4-TO-16 LINE DECODER**



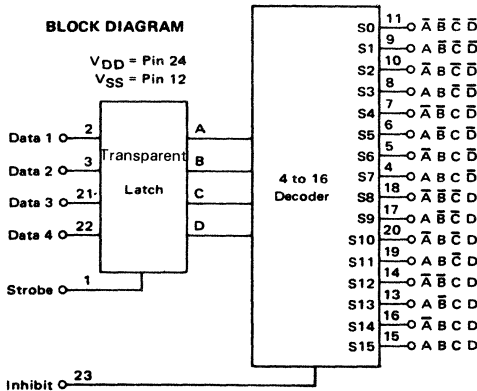
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

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**BLOCK DIAGRAM**



**DECODE TRUTH TABLE (Strobe = 1)\***

INHIBIT	DATA INPUTS				SELECTED OUTPUT MC14514 = Logic "1" MC14515 = Logic "0"
	D	C	B	A	
0	0	0	0	0	S0
0	0	0	0	1	S1
0	0	0	1	0	S2
0	0	0	1	1	S3
0	0	1	0	0	S4
0	0	1	0	1	S5
0	0	1	1	0	S6
0	0	1	1	1	S7
0	1	0	0	0	S8
0	1	0	0	1	S9
0	1	0	1	0	S10
0	1	0	1	1	S11
0	1	1	0	0	S12
0	1	1	0	1	S13
0	1	1	1	0	S14
0	1	1	1	1	S15
1	X	X	X	X	All Outputs = 0, MC14514 All Outputs = 1, MC14515

X = Don't Care

\*Strobe = 0, Data is latched

# MC14514B•MC14515B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level  V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level  V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level  V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level  V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)  Source    Sink	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—	
		10	-0.62	—	-0.5	-0.9	—	-0.35	—	
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)  Source    Sink	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mAdc
		5.0	-0.2	—	-0.16	-0.36	—	-0.12	—	
		10	-0.5	—	-0.4	-0.9	—	-0.3	—	
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.35 μA/kHz) f + I <sub>DD</sub>							μAdc
10	I <sub>T</sub> = (2.70 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (4.05 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V_{I_k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.  
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14514B•MC14515B

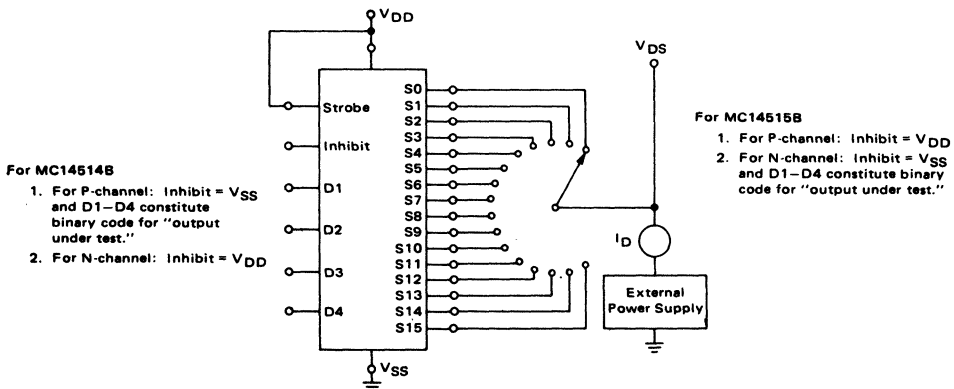
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	All Types			Unit
			Min	Typ #	Max	
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time; Data, Strobe to S $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 192 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 125 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	550 225 150	1100 450 300	ns
Inhibit Propagation Delay Times $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 117 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	400 150 100	800 300 200	ns
Setup Time Data to Strobe	$t_{su}$	5.0 10 15	250 100 75	125 50 38	— — —	ns
Hold Time Strobe to Data	$t_h$	5.0 10 15	-20 0 10	-100 -40 -30	— — —	ns
Strobe Pulse Width	$t_{WH}$	5.0 10 15	350 100 75	175 50 38	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DRAIN CHARACTERISTICS TEST CIRCUIT



# MC14514B•MC14515B

FIGURE 2 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

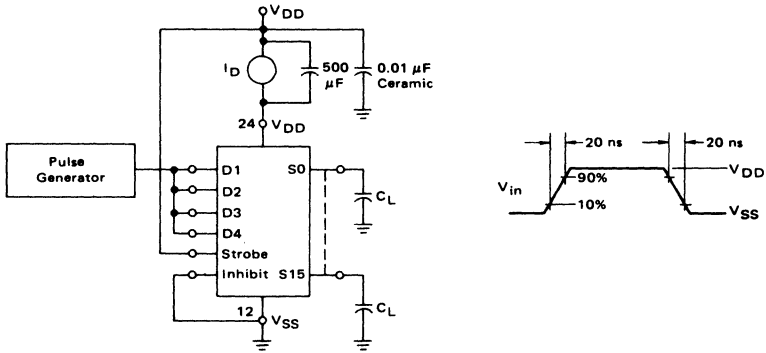
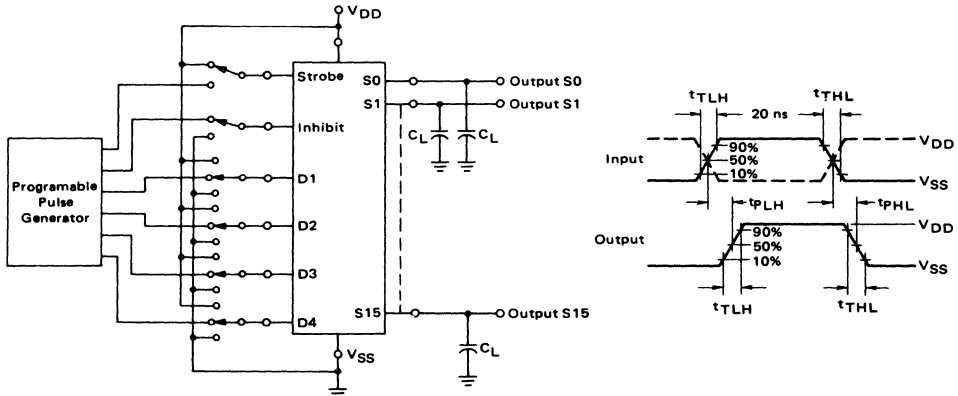
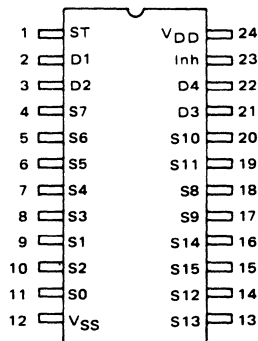


FIGURE 3 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

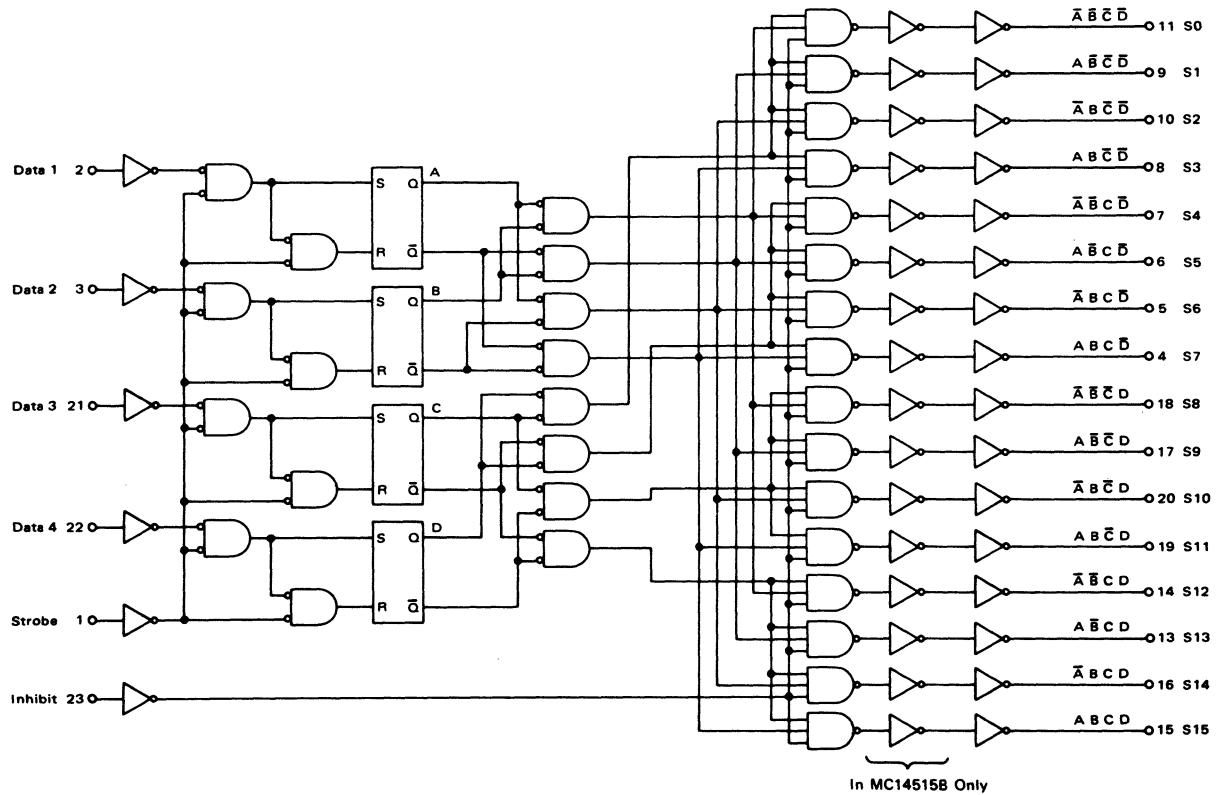


## PIN ASSIGNMENT





## LOGIC DIAGRAM



# MC14514B•MC14515B

## COMPLEX DATA ROUTING

Two MC14512 eight-channel data selectors are used here with the MC14514B four-bit latch/decoder to effect a complex data routing system. A total of 16 inputs from data registers are selected and transferred via a 3-state data bus to a data distributor for rearrangement and entry into 16 output registers. In this way sequential data can be re-routed or intermixed according to patterns determined by data select and distribution inputs.

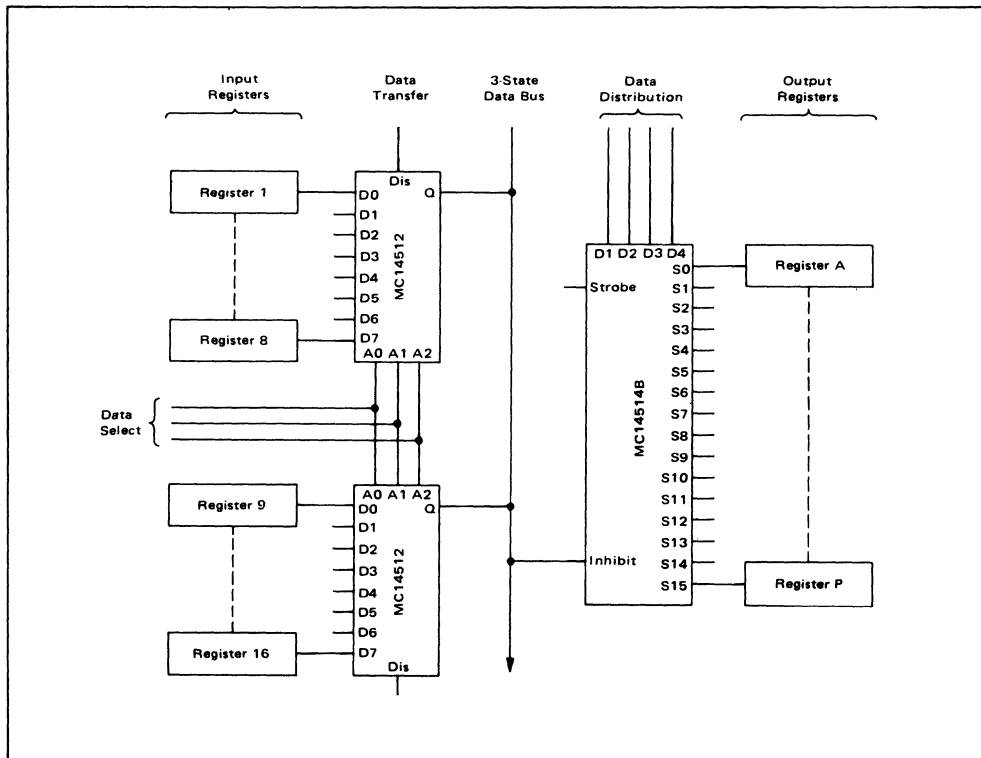
Data is placed into the routing scheme via the eight inputs on both MC14512 data selectors. One register is assigned to each input. The signals on A0, A1, and A2 choose one of eight inputs for transfer out to the 3-state data bus. A fourth signal, labelled Dis, disables one of the MC14512 selectors, assuring transfer of data from only one register.

In addition to a choice of input registers, 1 thru 16, the rate of transfer of the sequential information can also be varied. That is, if the MC14512 were addressed at a rate that is eight times faster

than the shift frequency of the input registers, the most significant bit (MSB) from each register could be selected for transfer to the data bus. Therefore, all of the most significant bits from all of the registers can be transferred to the data bus before the next most significant bit is presented for transfer by the input registers.

Information from the 3-state bus is redistributed by the MC14514B four-bit latch/decoder. Using the four-bit address, D1 thru D4, the information on the inhibit line can be transferred to the addressed output line to the desired output registers, A thru P. This distribution of data bits to the output registers can be made in many complex patterns. For example, all of the most significant bits from the input registers can be routed into output register A, all of the next most significant bits into register B, etc. In this way horizontal, vertical, or other methods of data slicing can be implemented.

DATA ROUTING SYSTEM





**MOTOROLA**

**MC14516B**

**BINARY UP/DOWN COUNTER**

The MC14516B synchronous up/down binary counter is constructed with MOS P-channel and N-channel enhancement mode devices in a monolithic structure.

This counter can be preset by applying the desired value, in binary, to the Preset inputs (P0, P1, P2, P3) and then bringing the Preset Enable (PE) high. The direction of counting is controlled by applying a high (for up counting) or a low (for down counting) to the UP/DOWN input. The state of the counter changes on the positive transition of the clock input.

Cascading can be accomplished by connecting the Carry Out to the Carry In of the next stage while clocking each counter in parallel. The outputs (Q0, Q1, Q2, Q3) can be reset to a low state by applying a high to the reset (R) pin.

This CMOS counter finds primary use in up/down and difference counting. Other applications include: (1) Frequency synthesizer applications where low power dissipation and/or high noise immunity is desired, (2) Analog-to-digital and digital-to-analog conversions, and (3) Magnitude and sign generation.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Internally Synchronous for High Speed
- Logic Edge-Clocked Design – Count Occurs on Positive Going Edge of Clock
- Single Pin Reset
- Asynchronous Preset Enable Operation
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

Carry In	Up/Down	Preset Enable	Reset	Clock	Action
1	X	0	0	X	No Count
0	1	0	0		Count Up
0	0	0	0		Count Down
X	X	1	0	X	Preset
X	X	X	1	X	Reset

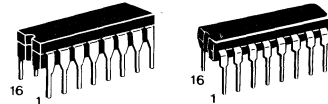
X = Don't Care

Note: When counting up, the Carry Out signal is normally high and is low only when Q0 through Q3 are high and Carry In is low. When counting down, Carry Out is low only when Q0 through Q3 and Carry In are low.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BINARY UP/DOWN COUNTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

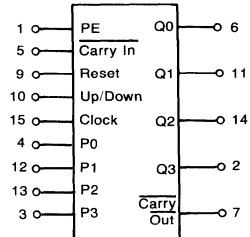
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14516B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit			
			Min	Max	Min	Typ #	Max	Min	Max				
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc		
			10	—	0.05	—	0	0.05	—	0.05			
			15	—	0.05	—	0	0.05	—	0.05			
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
				10	9.95	—	9.95	10	—	9.95	—		
				15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc		
			10	—	3.0	—	4.50	3.0	—	3.0			
			15	—	4.0	—	6.75	4.0	—	4.0			
	(V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
				10	7.0	—	7.0	5.50	—	7.0	—		
				15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device)	Source	I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc)	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
			(V <sub>OH</sub> = 9.5 Vdc)	10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	(V <sub>OH</sub> = 13.5 Vdc)	Sink	I <sub>OL</sub>	(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
				(V <sub>OL</sub> = 0.5 Vdc)	10	1.6	—	1.3	2.25	—	0.9	—	
				(V <sub>OL</sub> = 1.5 Vdc)	15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)	Source	I <sub>OH</sub>	(V <sub>OH</sub> = 2.5 Vdc)	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			(V <sub>OH</sub> = 4.6 Vdc)	5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
			(V <sub>OH</sub> = 9.5 Vdc)	10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	(V <sub>OH</sub> = 13.5 Vdc)	Sink	I <sub>OL</sub>	(V <sub>OL</sub> = 0.4 Vdc)	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
				(V <sub>OL</sub> = 0.5 Vdc)	10	1.3	—	1.1	2.25	—	0.9	—	
				(V <sub>OL</sub> = 1.5 Vdc)	15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>			
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>			
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF			
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>			
		10	—	10	—	0.010	10	—	300				
		15	—	20	—	0.015	20	—	600				
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>			
		10	—	40	—	0.010	40	—	300				
		15	—	80	—	0.015	80	—	600				
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>						μA <sub>dc</sub>				

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

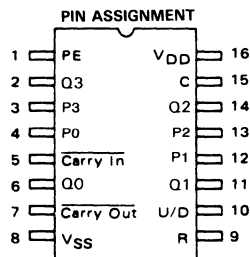
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.001.



# MC14516B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

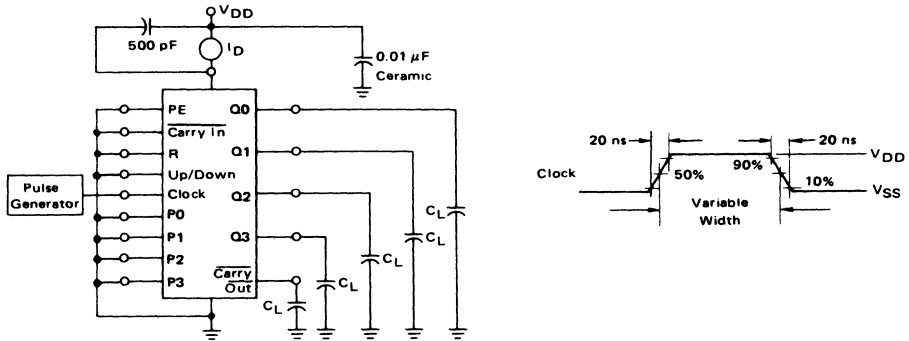
Characteristic	Symbol	V <sub>DD</sub>	All Types			Unit
			Min	Typ #	Max	
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 230 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns Clock to Carry Out t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 230 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns Carry In to Carry Out t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 230 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns Preset or Reset to Q t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 230 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns Preset or Reset to Carry Out t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 465 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 192 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 125 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	315 130 100	630 260 200	ns
Reset Pulse Width	t <sub>w</sub>	5.0 10 15	380 200 160	190 100 80	— — —	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	350 170 140	200 100 75	— — —	ns
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	3.0 6.0 8.0	1.5 3.0 4.0	MHz
Preset or Reset Removal Time The Preset or Reset signal must be low prior to a positive-going transition of the clock.	t <sub>rem</sub>	5.0 10 15	650 230 180	325 115 90	— — —	ns
Clock Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	— — —	15 5 4	μs
Setup Time Carry In to Clock	t <sub>su</sub>	5.0 10 15	260 120 100	130 60 50	— — —	ns
Hold Time Clock to Carry In	t <sub>h</sub>	5.0 10 15	0 20 20	-60 -20 0	— — —	ns
Setup Time Up/Down to Clock	t <sub>su</sub>	5.0 10 15	500 200 150	250 100 75	— — —	ns
Hold Time Clock to Up/Down	t <sub>h</sub>	5.0 10 15	-70 -10 0	-160 -60 -40	— — —	ns
Setup Time Pn to PE	t <sub>su</sub>	5.0 10 15	-40 -30 -25	-120 -70 -50	— — —	ns
Hold Time PE to Pn	t <sub>h</sub>	5.0 10 15	480 420 420	240 210 210	— — —	ns
Preset Enable Pulse Width	t <sub>WH</sub>	5.0 10 15	200 100 80	100 50 40	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

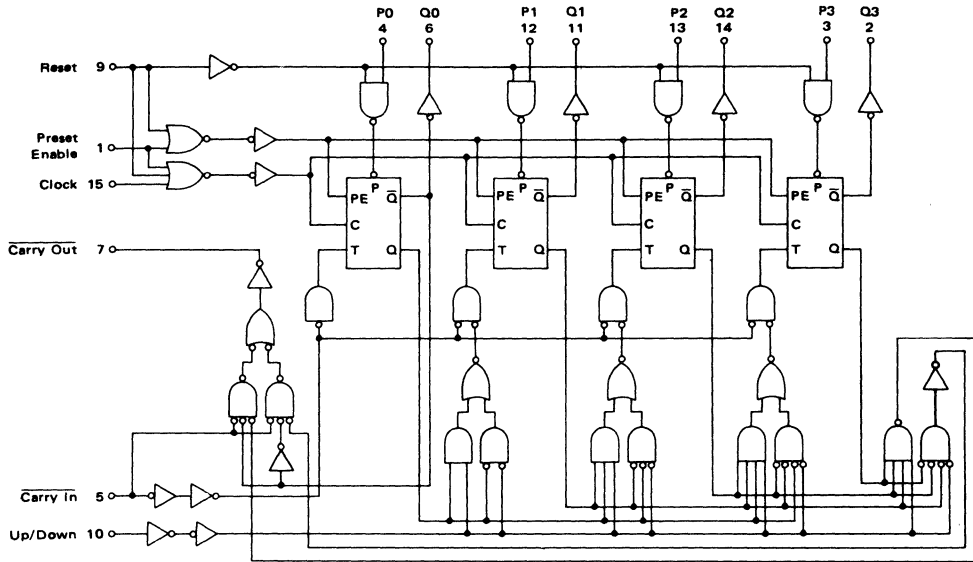
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14516B

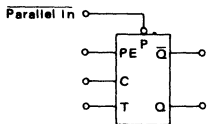
FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



## LOGIC DIAGRAM



### TOGGLE FLIP-FLOP



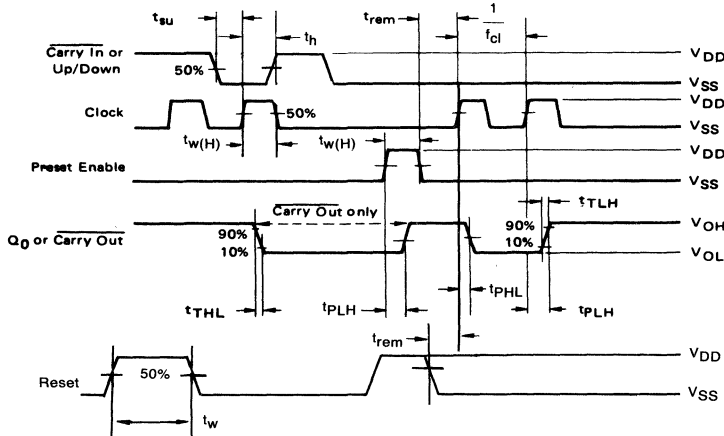
### FLIP-FLOP FUNCTIONAL TRUTH TABLE

PRESET ENABLE	CLOCK	T	Q <sub>n+1</sub>
1	X	X	Parallel In
0		0	Q <sub>n</sub>
0		1	$\bar{Q}_n$
0		X	Q <sub>n</sub>

X = Don't Care

# MC14516B

FIGURE 2 – SWITCHING TIME WAVEFORMS



## PIN DESCRIPTIONS

### INPUTS

**P0, P1, P2, P3, Preset Inputs (Pins 4, 12, 13, 3)** — Data on these inputs is loaded into the counter when PE is taken high.

**Carry In, (Pin 5)** — This active-low input is used when cascading stages. Carry In is usually connected to Carry Out of the previous stage. While high, Clock is inhibited.

**Clock, (Pin 15)** — Binary data is incremented or decremented, depending on the direction of count, on the positive transition of this input.

### OUTPUTS

**Q0, Q1, Q2, Q3, Binary outputs (Pins 6, 11, 14, 2)** — Binary data is present on these outputs with Q0 corresponding to the least significant bit.

**Carry Out, (Pin 7)** — Used when cascading stages, Carry Out is usually connected to Carry In of the next stage. This synchronous output is active low and may also be used to indicate terminal count.

### CONTROLS

**PE, Preset Enable, (Pin 1)** — Asynchronously loads data on the Preset Inputs. This pin is active high and inhibits the clock when high.

**R, Reset, (Pin 9)** — Asynchronously resets the Q outputs to a low state. This pin is active high and inhibits the clock when high.

**Up/Down, (Pin 10)** — Controls the direction of count, high for up count, low for down count.

### SUPPLY PINS

**VSS, Negative Supply Voltage, (Pin 8)** — This pin is usually connected to ground.

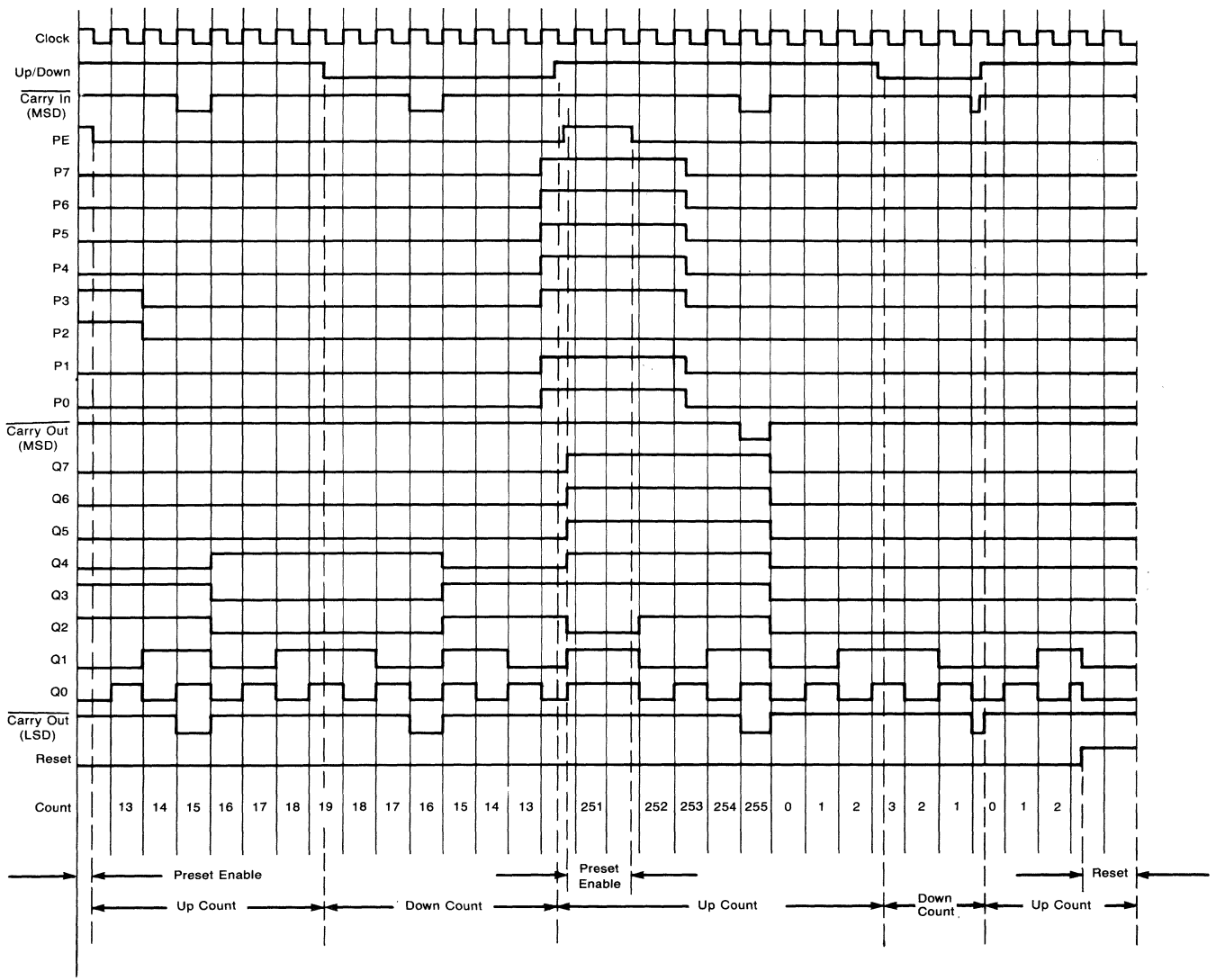
**VDD, Positive Supply Voltage, (Pin 16)** — This pin is connected to a positive supply voltage ranging from 3.0 volts to 18.0 volts.

6



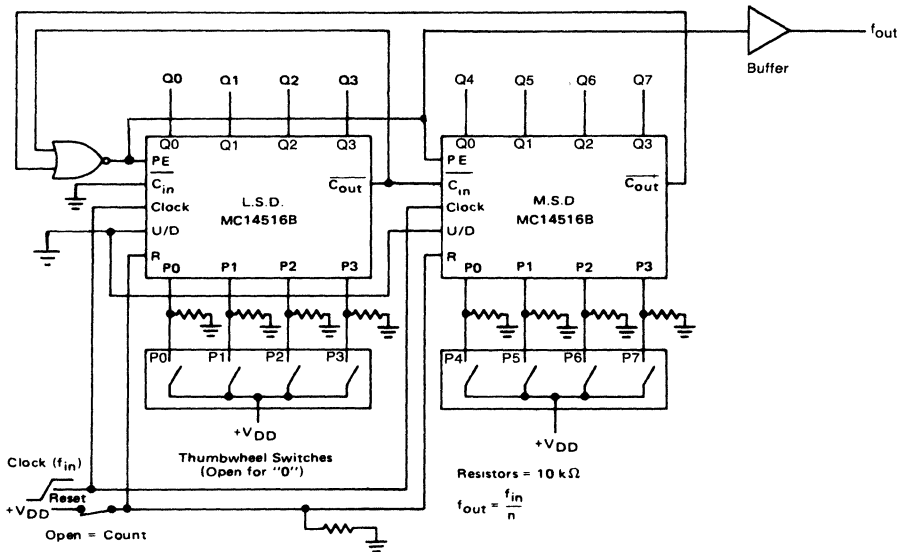


TIMING DIAGRAM FOR THE PRESETTABLE  
CASCADED 8-BIT UP/DOWN COUNTER



# MC14516B

FIGURE 4 — PROGRAMMABLE CASCADED FREQUENCY DIVIDER



**Note:** The programmable frequency divider can be set by applying the desired divide ratio, in binary, to the preset inputs. For example, the maximum divide ratio of 255 may be obtained by applying a 1111 1111 to the preset inputs P0 to P7. For this divide operation, both counters should be configured in the count down mode. The divide ratio of zero is an undefined state and should be avoided.



**MOTOROLA**

**MC14517B**

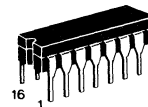
**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

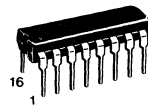
**DUAL 64-BIT STATIC SHIFT REGISTER**

The MC14517B dual 64-bit static shift register consists of two identical, independent, 64-bit registers. Each register has separate clock and write enable inputs, as well as outputs at bits 16, 32, 48, and 64. Data at the data input is entered by clocking, regardless of the state of the write enable input. An output is disabled (open circuited) when the write enable input is high. During this time, data appearing at the data input as well as the 16-bit, 32-bit, and 48-bit taps may be entered into the device by application of a clock pulse. This feature permits the register to be loaded with 64 bits in 16 clock periods, and also permits bus logic to be used. This device is useful in time delay circuits, temporary memory storage circuits, and other serial shift register applications.

- Diode Protection on All Inputs
- Fully Static Operation
- Output Transitions Occur on the Rising Edge of the Clock Pulse
- Exceedingly Slow Input Transition Rates May Be Applied to the Clock Input
- 3-State Output at 64th-Bit Allows Use in Bus Logic Applications
- Shift Registers of any Length may be Fully Loaded with 16 Clock Pulses
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



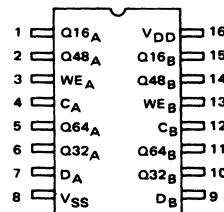
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**PIN ASSIGNMENT**



**MAXIMUM RATINGS** (Voltages referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

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**FUNCTIONAL TRUTH TABLE**

CLOCK	WRITE ENABLE	DATA	16-BIT TAP	32-BIT TAP	48-BIT TAP	64-BIT TAP
0	0	X	Content of 16-Bit Displayed	Content of 32-Bit Displayed	Content of 48-Bit Displayed	Content of 64-Bit Displayed
0	1	X	High Impedance	High Impedance	High Impedance	High Impedance
1	0	X	Content of 16-Bit Displayed	Content of 32-Bit Displayed	Content of 48-Bit Displayed	Content of 64-Bit Displayed
1	1	X	High Impedance	High Impedance	High Impedance	High Impedance
	0	Data entered into 1st Bit	Content of 16-Bit Displayed	Content of 32-Bit Displayed	Content of 48-Bit Displayed	Content of 64-Bit Displayed
	1	Data entered into 1st Bit	Data at tap entered into 17-Bit	Data at tap entered into 33-Bit	Data at tap entered into 49-Bit	High Impedance
	0	X	Content of 16-Bit Displayed	Content of 32-Bit Displayed	Content of 48-Bit Displayed	Content of 64-Bit Displayed
	1	X	High Impedance	High Impedance	High Impedance	High Impedance

X = Don't Care

# MC14517B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	(V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	(V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (4.2 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (8.8 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (13.7 μA/kHz) f + I <sub>DD</sub>							μAdc	
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μAdc	
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where, I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14517B

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

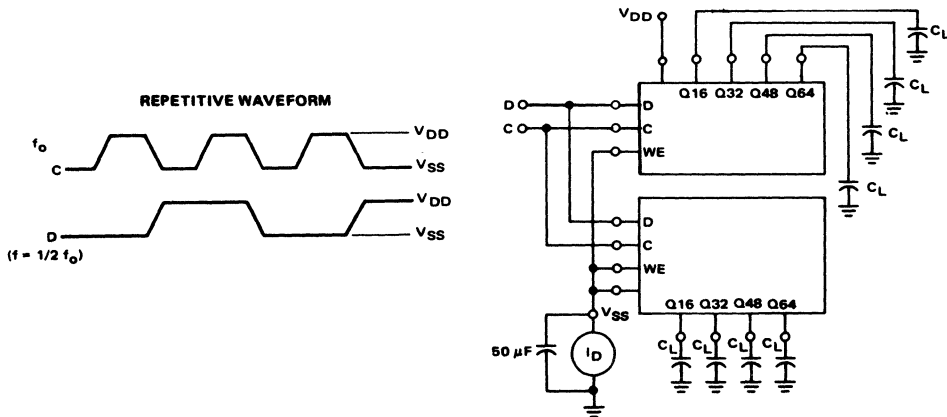
Characteristic	Symbol	$V_{DD}$	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 390 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 177 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 115 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	475 210 140	770 300 215	ns
Clock Pulse Width	$t_{WH}$	5.0 10 15	330 125 100	170 75 60	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	3.0 6.7 8.3	1.5 4.0 5.3	MHz
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	**See Note			—
Data to Clock Setup Time	$t_{su}$	5.0 10 15	0 10 15	-40 -15 0	— — —	ns
Data to Clock Hold Time	$t_h$	5.0 10 15	150 75 35	75 25 10	— — —	ns
Write Enable to Clock Setup Time	$t_{su}$	5.0 10 15	400 200 110	170 65 50	— — —	ns
Write Enable to Clock Release Time	$t_{rel}$	5.0 10 15	380 180 100	160 55 40	— — —	ns

\* The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

# Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

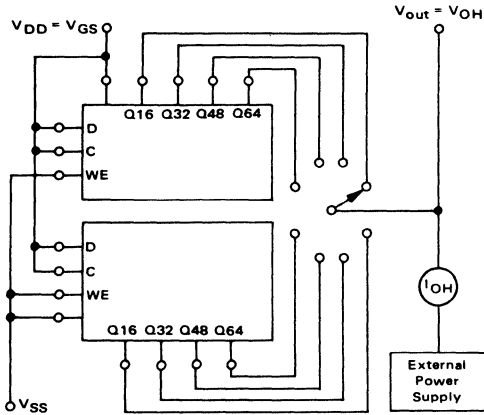
\*\* When shift register sections are cascaded, the maximum rise and fall time of the clock input should be equal to or less than the rise and fall time of the data outputs, driving data inputs, plus the propagation delay of the output driving stage.

FIGURE 1 - POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



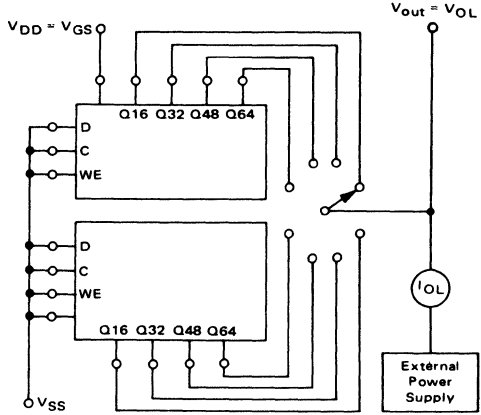
# MC14517B

**FIGURE 2 – TYPICAL OUTPUT SOURCE CURRENT CHARACTERISTICS TEST CIRCUIT**



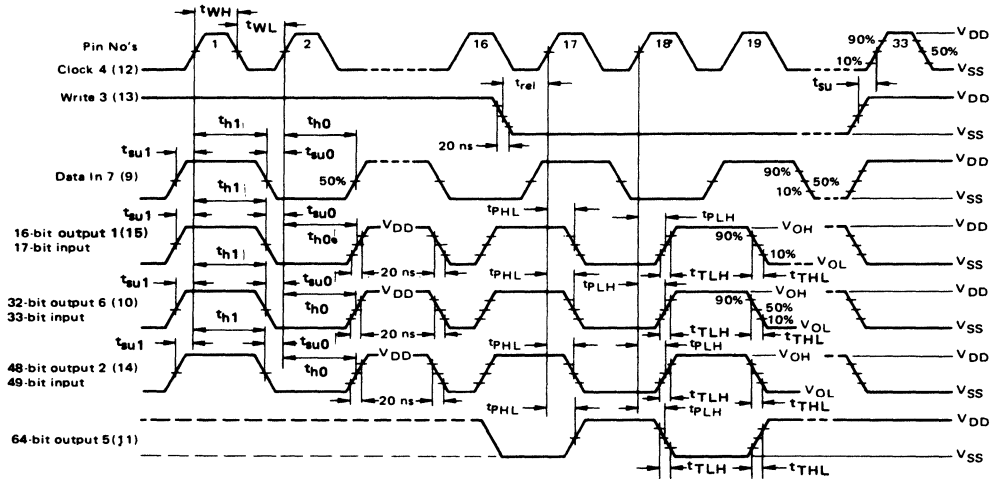
(Output being tested should be in the high-logic state).

**FIGURE 3 – TYPICAL OUTPUT SINK CURRENT CHARACTERISTICS TEST CIRCUIT**

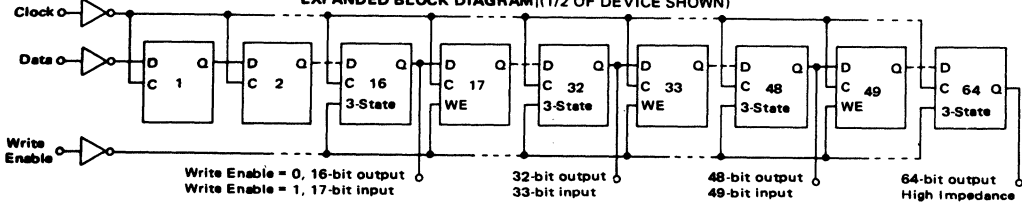


(Output being tested should be in the low-logic state).

**FIGURE 4 – AC TEST WAVEFORMS**



**EXPANDED BLOCK DIAGRAM (1/2 OF DEVICE SHOWN)**





**MOTOROLA**

**MC14518B  
MC14520B**

**DUAL UP COUNTERS**

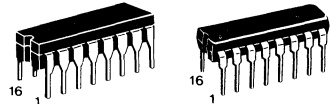
The MC14518B dual BCD counter and the MC14520B dual binary counter are constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Each consists of two identical, independent, internally synchronous 4-stage counters. The counter stages are type D flip-flops, with interchangeable Clock and Enable lines for incrementing on either the positive-going or negative-going transition as required when cascading multiple stages. Each counter can be cleared by applying a high level on the Reset line. In addition, the MC14518B will count out of all undefined states within two clock periods. These complementary MOS up counters find primary use in multi-stage synchronous or ripple counting applications requiring low power dissipation and/or high noise immunity.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Internally Synchronous for High Internal and External Speeds
- Logic Edge-Clocked Design – Incremented on Positive Transition of Clock or Negative Transition on Enable
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL BCD UP COUNTER  
(MC14518B)  
DUAL BINARY UP COUNTER  
(MC14520B)**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**

**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

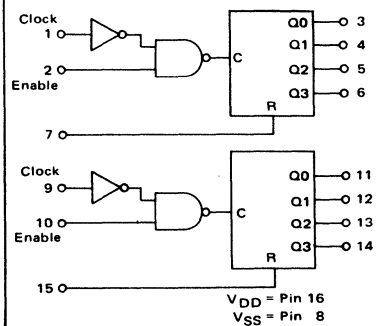
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

CLOCK	ENABLE	RESET	ACTION
	1	0	Increment Counter
0		0	Increment Counter
	X	0	No Change
X		0	No Change
	0	0	No Change
1		0	No Change
X	X	1	Q0 thru Q3 = 0

X = Don't Care

**BLOCK DIAGRAM**



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14518B•MC14520B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub>						μAdc	
		10	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF.

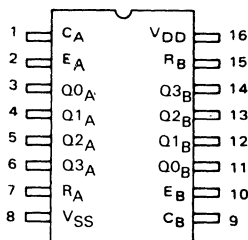
$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002

\*\*The formulas given are for the typical characteristics only at 25°C.

### PIN ASSIGNMENT







# MC14518B•MC14520B

FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

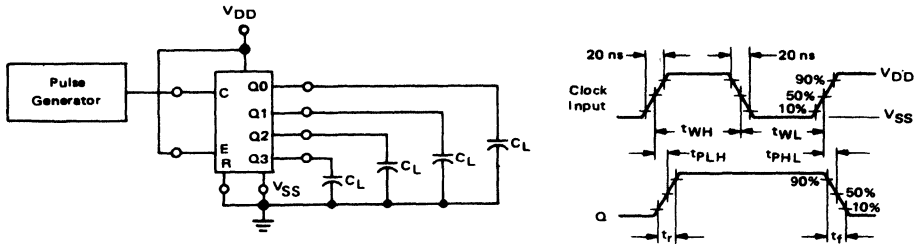
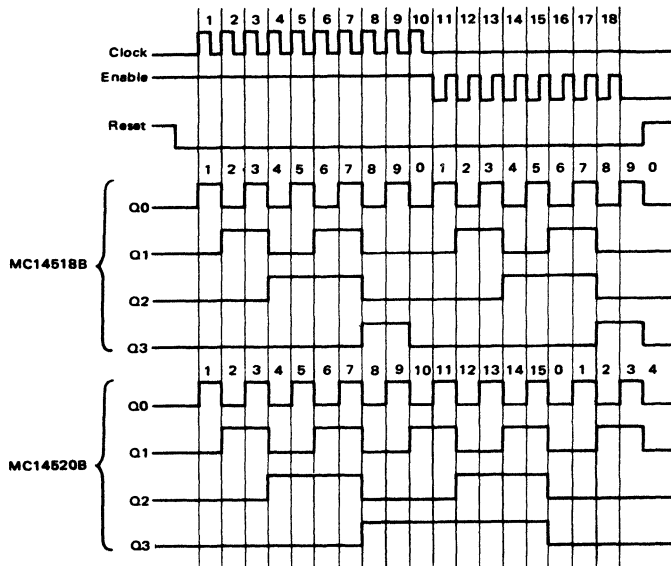


FIGURE 3 – TIMING DIAGRAM



# MC14518B•MC14520B

FIGURE 4 – DECADE COUNTER (MC14518B) LOGIC DIAGRAM  
(1/2 OF DEVICE SHOWN)

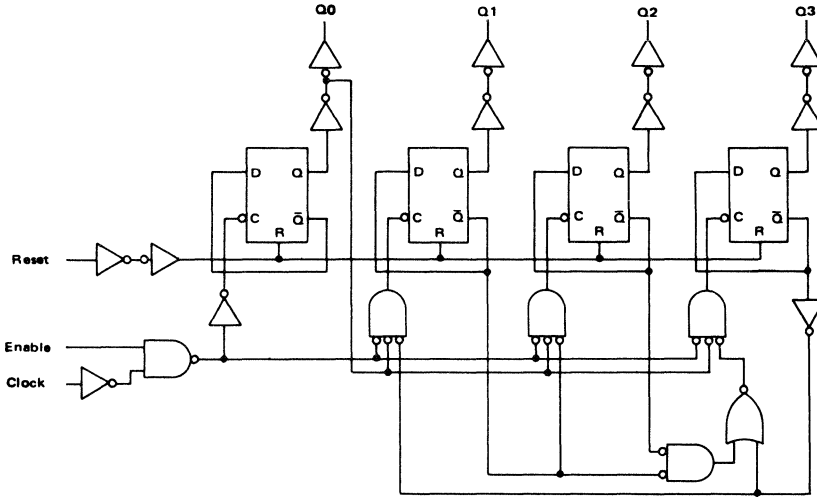
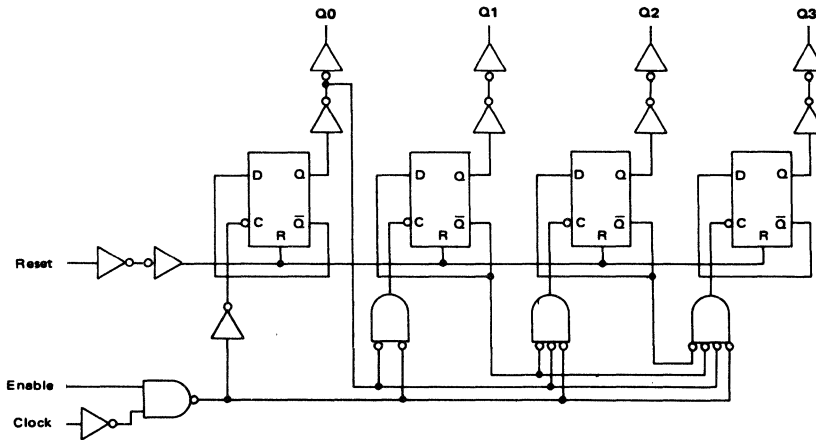


FIGURE 5 – BINARY COUNTER (MC14520B) LOGIC DIAGRAM  
(1/2 OF DEVICE SHOWN)





**MOTOROLA**

**MC14519B**

**4-BIT AND/OR SELECTOR  
or  
QUAD 2-CHANNEL DATA SELECTOR  
or  
QUAD EXCLUSIVE "NOR" GATE**

The MC14519B is constructed with MOS P-channel and N-channel enhancement mode devices in a monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired.

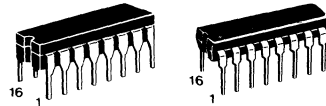
This device provides three functions in one package; a 4-Bit AND/OR Selector, a Quad 2-Channel Data Selector, or a Quad Exclusive NOR Gate.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Plug-In Replacement for CD4019 in Most Applications

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT AND/OR SELECTOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

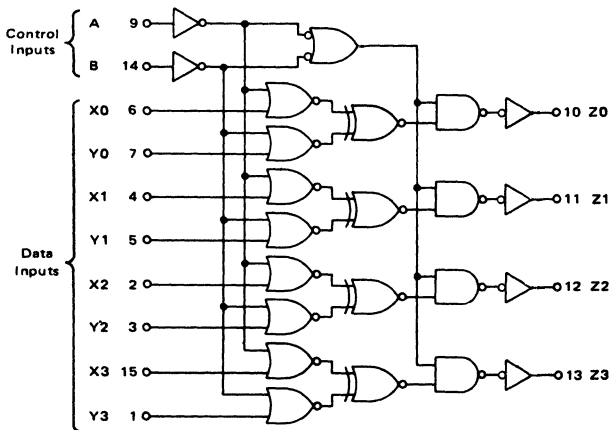
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**LOGIC DIAGRAM**



**TRUTH TABLE**

CONTROL INPUTS		OUTPUT
A	B	Z <sub>n</sub>
0	0	0
0	1	Y <sub>n</sub>
1	0	X <sub>n</sub>
1	1	X <sub>n</sub> ⊕ Y <sub>n</sub>

Note:

X<sub>n</sub> ⊕ Y<sub>n</sub> means X<sub>n</sub> (Exclusive-NOR) Y<sub>n</sub>

# MC14519B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

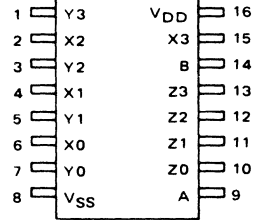
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

## PIN ASSIGNMENT



## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source IOH	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink IOL	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)	Source IOH	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink IOL	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14519B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		5.0	—	100	200	
$t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$					ns
$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 165 \text{ ns}$		5.0	—	250	500	
$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 82$		10	—	115	225	
$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$		15	—	90	165	

\*The formulas given are for the typical characteristics only at 25°C

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

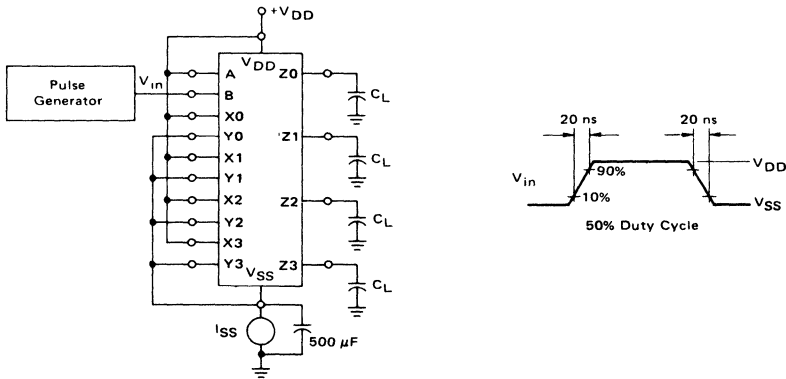
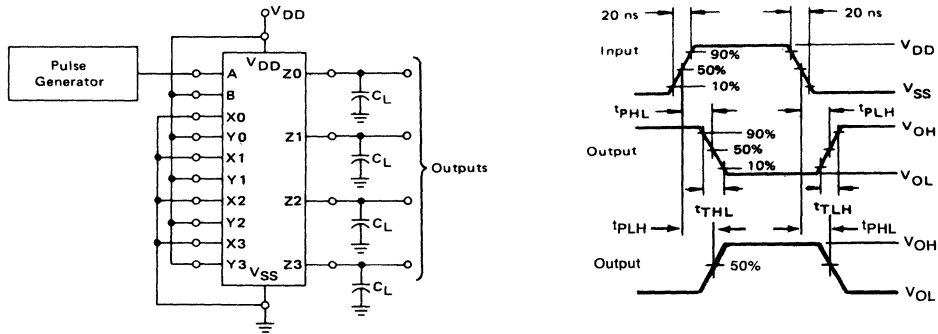


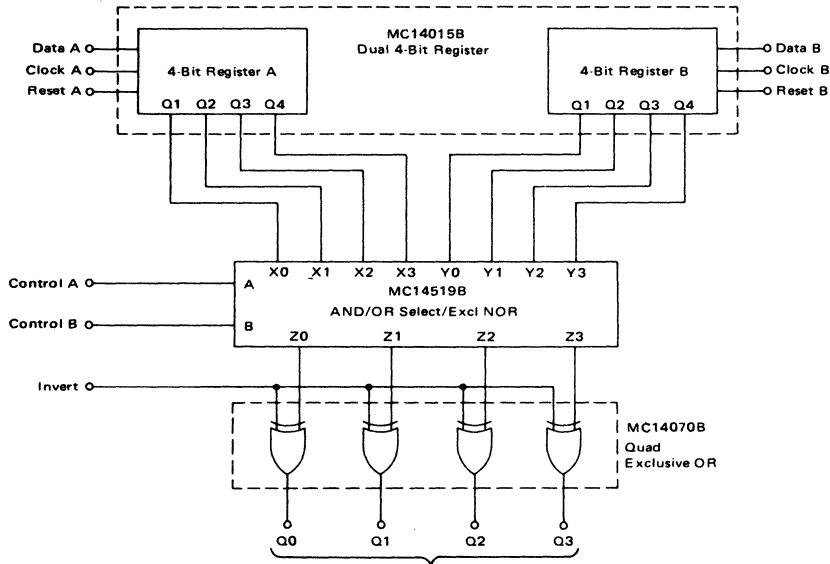
FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



# MC14519B

## TYPICAL CIRCUIT APPLICATIONS

### DATA REGISTER SELECTION COMPARISON



CONVERSION TABLE

OPERATION CODE			OUTPUT				FUNCTION
A	B	INV	Q0	Q1	Q2	Q3	
0	0	0	0	0	0	0	Inhibit, all zeros
0	0	1	1	1	1	1	Inhibit, all ones
1	0	0	X0	X1	X2	X3	Control A
1	0	1	$\bar{X}0$	$\bar{X}1$	$\bar{X}2$	$\bar{X}3$	Control A and Invert
0	1	0	Y0	Y1	Y2	Y3	Control B
0	1	1	$\bar{Y}0$	$\bar{Y}1$	$\bar{Y}2$	$\bar{Y}3$	Control B and Invert
1	1	0	$X0 \oplus Y0$	$X1 \oplus Y1$	$X2 \oplus Y2$	$X3 \oplus Y3$	Exclusive NOR
1	1	1	$X0 \oplus Y0$	$X1 \oplus Y1$	$X2 \oplus Y2$	$X3 \oplus Y3$	Exclusive OR

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



**MOTOROLA**

**MC14520B**  
See Page 6-288

**MC14521B**

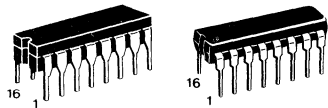
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)  
**24-STAGE FREQUENCY DIVIDER**

**24-STAGE FREQUENCY DIVIDER**

The MC14521B consists of a chain of 24 flip-flops with an input circuit that allows three modes of operation. The input will function as a crystal oscillator, an RC oscillator, or as an input buffer for an external oscillator. Each flip-flop divides the frequency of the previous flip-flop by two, consequently this part will count up to  $2^{24} = 16,777,216$ . The count advances on the negative going edge of the clock. The outputs of the last seven-stages are available for added flexibility.

- All Stages are Resettable
- Reset Disables the RC Oscillator for Low Standby Power Drain
- RC and Crystal Oscillator Outputs Are Capable of Driving External Loads
- Test Mode to Reduce Test Time
- $V_{DD}'$  and  $V_{SS}'$  Pins Brought Out on Crystal Oscillator Inverter to Allow the Connection of External Resistors for Low-Power Operation
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range.



**L SUFFIX CERAMIC PACKAGE**      **P SUFFIX PLASTIC PACKAGE**  
CASE 620      CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

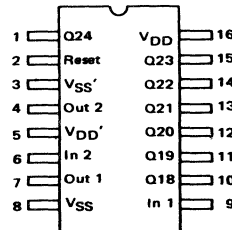
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	± 10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

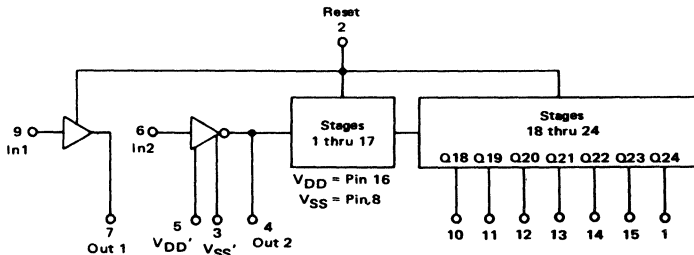
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**PIN ASSIGNMENT**



6

**BLOCK DIAGRAM**



OUTPUT	COUNT CAPACITY
Q18	$2^{18} = 262,144$
Q19	$2^{19} = 524,288$
Q20	$2^{20} = 1,048,576$
Q21	$2^{21} = 2,097,152$
Q22	$2^{22} = 4,194,304$
Q23	$2^{23} = 8,388,608$
Q24	$2^{24} = 16,777,216$

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.



# MC14521B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit			
			Min	Max	Min	Typ #	Max	Min	Max				
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0  "1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc			
		10	—	0.05	—	0	0.05	—	0.05				
		15	—	0.5	—	0	0.05	—	0.05				
	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc			
		10	9.95	—	9.95	10	—	9.95	—				
		15	14.95	—	14.95	15	—	14.95	—				
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  "1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc			
		10	—	3.0	—	4.50	3.0	—	3.0				
		15	—	4.0	—	6.75	4.0	—	4.0				
	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc			
		10	7.0	—	7.0	5.50	—	7.0	—				
		15	11.0	—	11.0	8.25	—	11.0	—				
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 4 & 7 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 1, 10, (V <sub>OH</sub> = 9.5 Vdc) 11, 12, 13, 14 (V <sub>OH</sub> = 13.5 Vdc) and 15  (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc			
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—				
		10	-0.62	—	-0.5	-0.9	—	-0.35	—				
		15	-1.8	—	-1.5	-3.5	—	-1.1	—				
		5.0	-3.0	—	-2.4	-4.2	—	-1.7	—		mAdc		
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—				
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc			
		10	1.6	—	1.3	2.25	—	0.9	—				
		15	4.2	—	3.4	8.8	—	2.4	—				
		Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 4 & 7 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 1, 10, (V <sub>OH</sub> = 9.5 Vdc) 11, 12, 13, 14 (V <sub>OH</sub> = 13.5 Vdc) and 15  (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—		-0.6	—	mAdc
				5.0	-0.2	—	-0.16	-0.36	—		-0.12	—	
				10	-0.5	—	-0.4	-0.9	—		-0.3	—	
15	-1.4			—	-1.2	-3.5	—	-1.0	—				
I <sub>OL</sub>	5.0		-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc			
	5.0		-0.52	—	-0.44	-0.88	—	-0.36	—				
I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc				
	10	1.3	—	1.1	2.25	—	0.9	—					
	15	3.6	—	3.0	8.8	—	2.4	—					
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc			
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc			
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF			
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc			
		10	—	10	—	0.010	10	—	300				
		15	—	20	—	0.015	20	—	600				
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc			
		10	—	40	—	0.010	40	—	300				
		15	—	80	—	0.015	80	—	600				
Total Supply Current * *† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.42 μA/kHz) f + I <sub>DD</sub>							μAdc			
10	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>												
15	I <sub>T</sub> = (1.4 μA/kHz) f + I <sub>DD</sub>												

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ V1k}$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.003.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14521B

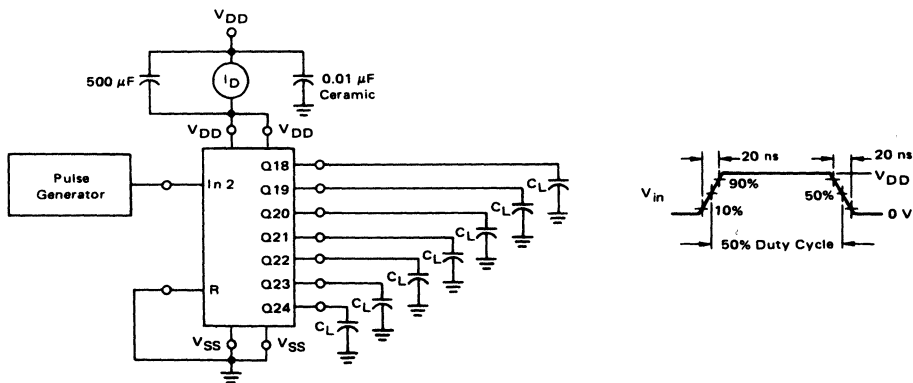
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$ $V_{dc}$	Min	Typ #	Max	Unit
Output Rise and Fall Time (Counter Outputs) $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q18 $t_{PHL}, t_{PLH} = (1.7 \text{ ns/pF}) C_L + 4415 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.66 \text{ ns/pF}) C_L + 1667 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.5 \text{ ns/pF}) C_L + 1275 \text{ ns}$ Clock to Q24 $t_{PHL}, t_{PLH} = (1.7 \text{ ns/pF}) C_L + 5915 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.66 \text{ ns/pF}) C_L + 2167 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.5 \text{ ns/pF}) C_L + 1675 \text{ ns}$	$t_{PHL}, t_{PLH}$	5.0 10 15	— — —	4.5 1.7 1.3	9.0 3.5 2.7	$\mu\text{s}$
Propagation Delay Time Reset to $Q_n$ $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 1215 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 467 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 350 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	1300 500 375	2600 1000 750	ns
Clock Pulse Width	$t_{WH(c)}$	5.0 10 15	385 150 120	140 55 40	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	3.5 9.0 12	2.0 5.0 6.5	MHz
Clock Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	— — —	15 5.0 4.0	$\mu\text{s}$
Reset Pulse Width	$t_{WH(R)}$	5.0 10 15	1400 600 450	700 300 225	— — —	ns
Reset Removal Time	$t_{rem}$	5.0 10 15	30 0 —40	—200 —160 —110	— — —	ns

\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



# MC14521B

FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

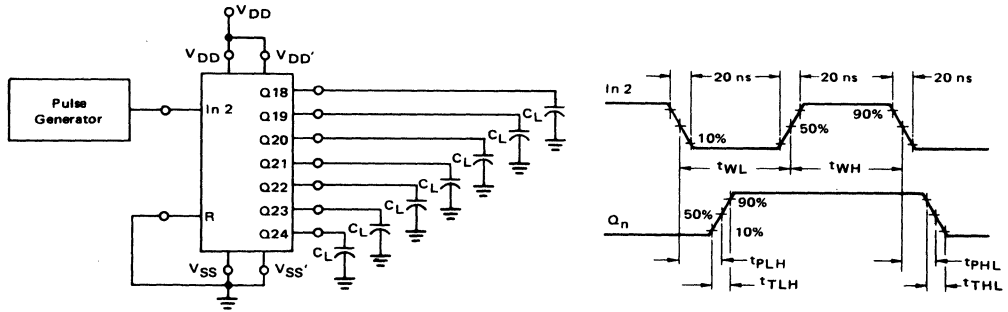
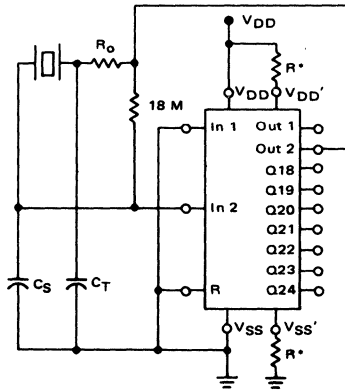


FIGURE 3 – CRYSTAL OSCILLATOR CIRCUIT



\* Optional for low power operation.  
 $10 \text{ k}\Omega < R < 70 \text{ k}\Omega$

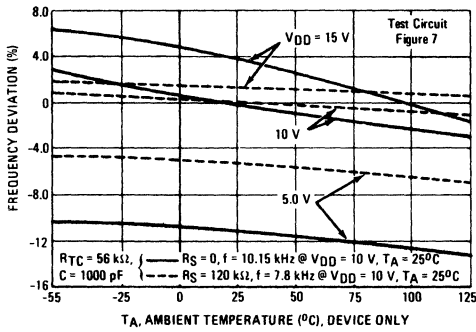
FIGURE 4 – TYPICAL DATA FOR CRYSTAL OSCILLATOR CIRCUIT

CHARACTERISTIC	500 kHz CIRCUIT	50 kHz CIRCUIT	UNIT
<b>Crystal Characteristics</b>			
Resonant Frequency	500	50	kHz
Equivalent Resistance, $R_S$	1.0	6.2	k $\Omega$
<b>External Resistor/Capacitor Values</b>			
$R_O$	47	750	k $\Omega$
$C_T$	82	82	pF
$C_S$	20	20	pF
<b>Frequency Stability</b>			
Frequency Change as a Function of $V_{DD}$ ( $T_A = 25^\circ\text{C}$ )			
$V_{DD}$ Change from 5.0 V to 10 V	+6.0	+2.0	ppm
$V_{DD}$ Change from 10 V to 15 V	+2.0	+2.0	ppm
Frequency Change as a Function of Temperature ( $V_{DD} = 10 \text{ V}$ )			
$T_A$ Change from $-55^\circ\text{C}$ to $+25^\circ\text{C}$			
MC14521 only	-4.0	-2.0	ppm
Complete Oscillator*	+100	+120	ppm
$T_A$ Change from $+25^\circ\text{C}$ to $+125^\circ\text{C}$			
MC14521 only	-2.0	-2.0	ppm
Complete Oscillator*	-160	-560	ppm

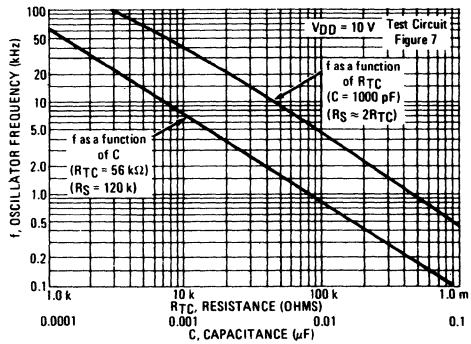
\* Complete oscillator includes crystal, capacitors, and resistors.

# MC14521B

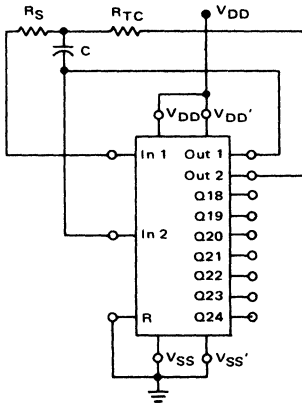
**FIGURE 5 – RC OSCILLATOR STABILITY**



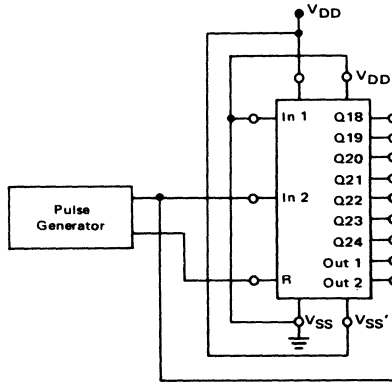
**FIGURE 6 – RC OSCILLATOR FREQUENCY AS A FUNCTION OF  $R_{TC}$  AND  $C$**



**FIGURE 7 – RC OSCILLATOR CIRCUIT**



**FIGURE 8 – FUNCTIONAL TEST CIRCUIT**



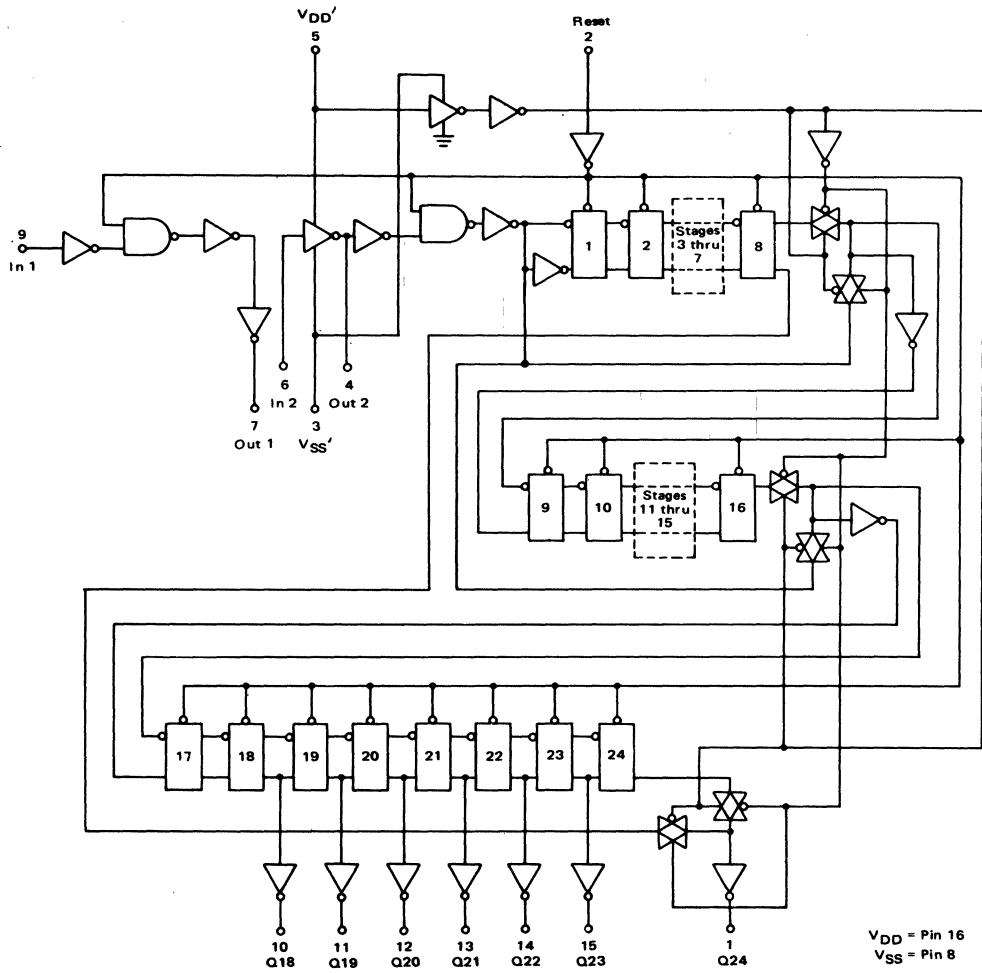
**FUNCTIONAL TEST SEQUENCE**

	INPUTS		OUTPUTS		COMMENTS	
	Reset	In 2	Out 2	$V_{SS}'$ $V_{DD}'$ Q18 thru Q24		
	1	0	0	$V_{DD}$ Gnd	Counter is in three 8-stage sections in parallel mode. Counter is reset. In 2 and Out 2 are connected together.	
↓	0	1	1	$V_{DD}$ ↓ Gnd ↓ $V_{DD}$ ↓	First "0" to "1" transition on In 2, Out 2 node.	
	0	1	0		255 "0" to "1" transitions are clocked into this In 2, Out 2 node.	
	1	1	1		1	The 255th "0" to "1" transition.
	0	0	0		1	Counter converted back to 24-stages in series mode.
	1	0	0		1	Out 2 converts back to an output.
↓	0	0	1		Counter ripples from an all "1" state to an all "0" stage.	

A test function (see Figure 8) has been included for the reduction of test time required to exercise all 24 counter stages. This test function divides the counter into three 8-stage sections in parallel. All flip-flops are now at a logic "1". The counter is now returned to the normal 24-stages in series configuration. One more pulse is entered into Input 2 (In 2) which will cause the counter to ripple from an all "1" state to an all "0" state.

# MC14521B

## LOGIC DIAGRAM



6



**MOTOROLA**

**PRESETTABLE 4-BIT DOWN COUNTERS**

The MC14522B BCD counter and the MC14526B binary counter are constructed with MOS P-channel and N-channel enhancement mode devices in a monolithic structure.

These devices are presettable, cascadable, synchronous down counters with a decoded "0" state output for divide-by-N applications. In single stage applications the "0" output is applied to the Preset Enable input. The Cascade Feedback input allows cascade divide-by-N operation with no additional gates required. The Inhibit input allows disabling of the pulse counting function. Inhibit may also be used as a negative edge clock.

These complementary MOS counters can be used in frequency synthesizers, phase-locked loops, and other frequency division applications requiring low power dissipation and/or high noise immunity.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Logic Edge-Clocked Design — Incremented on Positive Transition of Clock or Negative Transition of Inhibit
- Asynchronous Preset Enable
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**FUNCTION TABLE**

Inputs					Output	Resulting Function
Clock	Reset	Inhibit	Preset Enable	Cascade Feedback	"0"	
X	H	X	L	L	L	Asynchronous reset*
X	H	X	H	L	H	Asynchronous reset
X	H	X	X	H	H	Asynchronous reset
X	L	X	H	X	L	Asynchronous preset
	L	H	L	X	L	Decrement inhibited
	L	L	L	X	L	Decrement inhibited
	L		L	L	L	No change** (inactive edge)
	L		L	L	L	No change** (inactive edge)
	L		L	L	L	Decrement**
	L		L	L	L	Decrement**

X = Don't Care

Notes:

\* Output "0" is low when reset goes high only if PE and CF are low.

\*\* Output "0" is high when reset is low, only if CF is high and count is 0000.

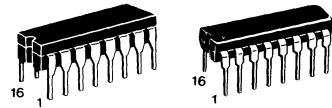
**MC14522B  
MC14526B**

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**PRESETTABLE  
4-BIT DOWN COUNTERS**

**BCD — MC14522B  
Binary — MC14526B**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**

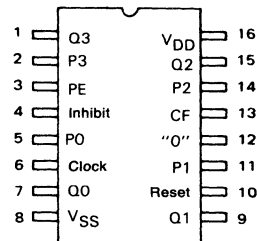
**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**PIN ASSIGNMENT**



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14522B•MC14526B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source IOH	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink IOL	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source IOH	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink IOL	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (3.4 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (5.1 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V1k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14522B•MC14526B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub> (Figures 4, 5)	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time (Inhibit Used as Negative-Edge Clock) Clock or Inhibit to Q t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 465 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 197 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 135 ns Clock or Inhibit to "0" t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 155 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 87 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 65 ns	t <sub>PLH</sub> , t <sub>PHL</sub> (Figures 4, 5, 6)	5.0 10 15  5.0 10 15	— — —  — — —	550 225 160  240 130 100	1100 450 320  480 260 200	ns
Propagation Delay Time Pn to Q	t <sub>PLH</sub> , t <sub>PHL</sub> (Figures 4, 7)	5.0 10 15	— — —	260 120 100	520 240 200	ns
Propagation Delay Time Reset to Q	t <sub>PHL</sub> (Figure 8)	5.0 10 15	— — —	250 110 80	500 220 160	ns
Propagation Delay Time Preset Enable to "0"	t <sub>PHL</sub> , t <sub>PLH</sub> (Figures 4, 9)	5.0 10 15	— — —	220 100 80	440 200 160	ns
Clock or Inhibit Pulse Width	t <sub>w</sub> (Figures 5, 6)	5.0 10 15	250 100 80	125 50 40	— — —	ns
Clock Pulse Frequency (with PE = low)	f <sub>max</sub> (Figures 4, 5, 6)	5.0 10 15	— — —	2.0 5.0 6.6	1.5 3.0 4.0	MHz
Clock or Inhibit Rise and Fall Time	t <sub>r</sub> , t <sub>f</sub> (Figures 5, 6)	5.0 10 15	— — —	— — —	15 5 4	μs
Setup Time Pn to Preset Enable	t <sub>su</sub> (Figure 10)	5.0 10 15	90 50 40	40 15 10	— — —	ns
Hold Time Preset Enable to Pn	t <sub>h</sub> (Figure 10)	5.0 10 15	30 30 30	-15 -5 0	— — —	ns
Preset Enable Pulse Width	t <sub>w</sub> (Figure 10)	5.0 10 15	250 100 80	125 50 40	— — —	ns
Reset Pulse Width	t <sub>w</sub> (Figure 8)	5.0 10 15	350 250 200	175 125 100	— — —	ns
Reset Removal Time	t <sub>rem</sub> (Figure 8)	5.0 10 15	10 20 30	-110 -30 -20	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

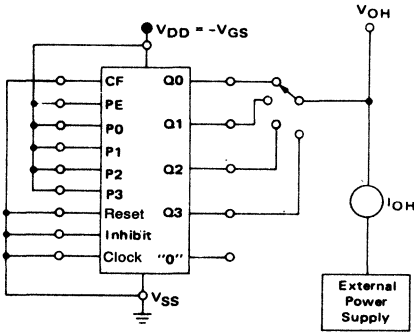
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.



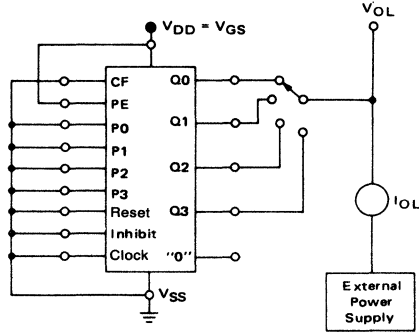


# MC14522B•MC14526B

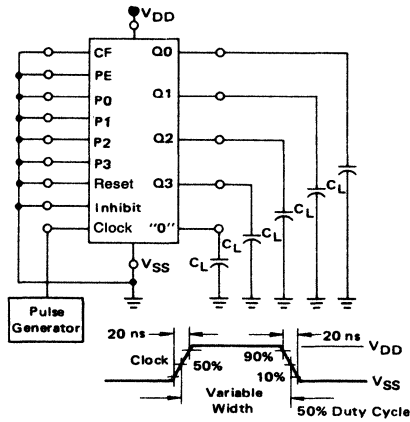
**FIGURE 1 – TYPICAL OUTPUT SOURCE CHARACTERISTICS TEST CIRCUIT**



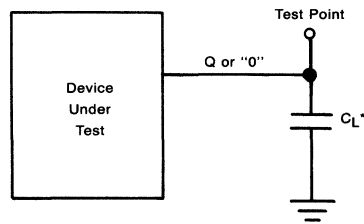
**FIGURE 2 – TYPICAL OUTPUT SINK CHARACTERISTICS TEST CIRCUIT**



**FIGURE 3 – POWER DISSIPATION**



**FIGURE 4 – TEST CIRCUIT**



\*Includes all probe and jig capacitance.

SWITCHING WAVEFORMS

FIGURE 5

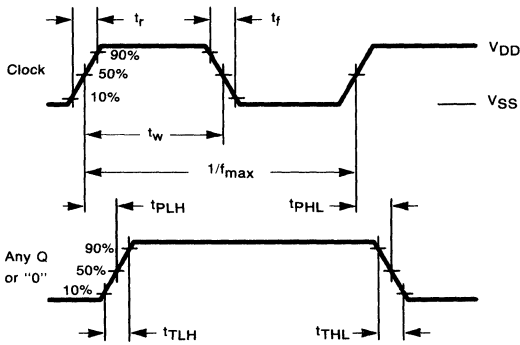


FIGURE 6

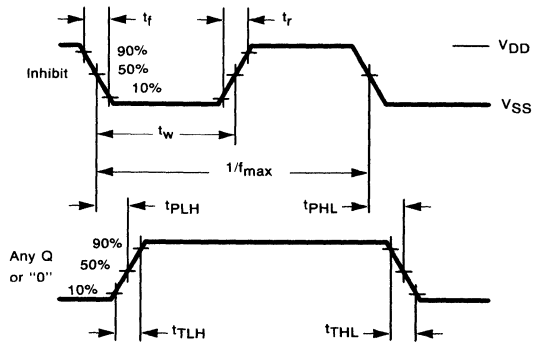


FIGURE 7

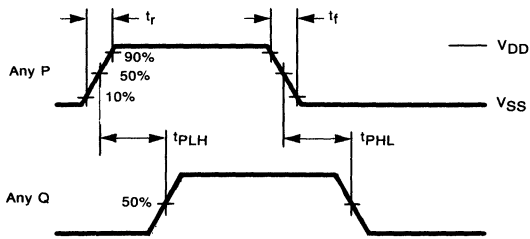


FIGURE 8

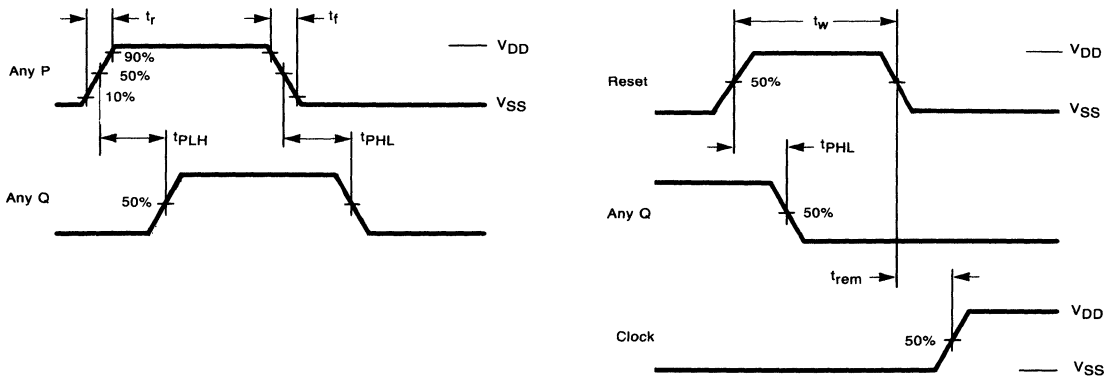


FIGURE 9

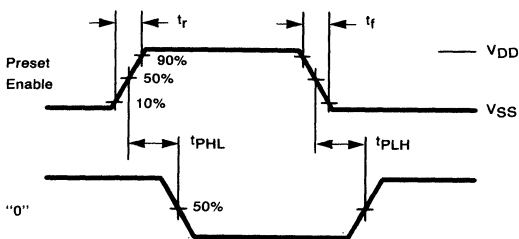
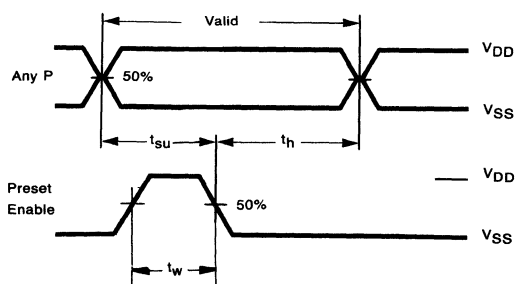


FIGURE 10



6

# MC14522B•MC14526B

## PIN DESCRIPTIONS

**Preset Enable (Pin 3)** — If Reset is low, a high level on the Preset Enable input asynchronously loads the counter with the programmed values on P0, P1, P2, and P3.

**Inhibit (Pin 4)** — A high level on the Inhibit input prevents the Clock from decrementing the counter. With Clock (pin 6) held high, Inhibit may be used as a negative edge clock input.

**Clock (Pin 6)** — The counter decrements by one for each rising edge of Clock. See the Function Table for level requirements on the other inputs.

**Reset (Pin 10)** — A high level on Reset asynchronously forces Q0, Q1, Q2, and Q3 low and, if Cascade Feedback is high, causes the "0" output to go high.

**"0" (Pin 12)** — The "0" (Zero) output issues a pulse one clock period wide when the counter reaches terminal count (Q0 = Q1 = Q2 = Q3 = low) if Cascade Feedback is high and Preset Enable is low. When presetting the

counter to a value other than all zeroes, the "0" output is valid after the rising edge of Preset Enable (when Cascade Feedback is high). See the Function Table.

**Cascade Feedback (Pin 13)** — If the Cascade Feedback input is high, a high level is generated at the "0" output when the count is all zeroes. If Cascade Feedback is low, the "0" output depends on the Preset Enable input level. See the Function Table.

**P0, P1, P2, P3 (Pins 5, 11, 14, 2)** — These are the preset data inputs. P0 is the LSB.

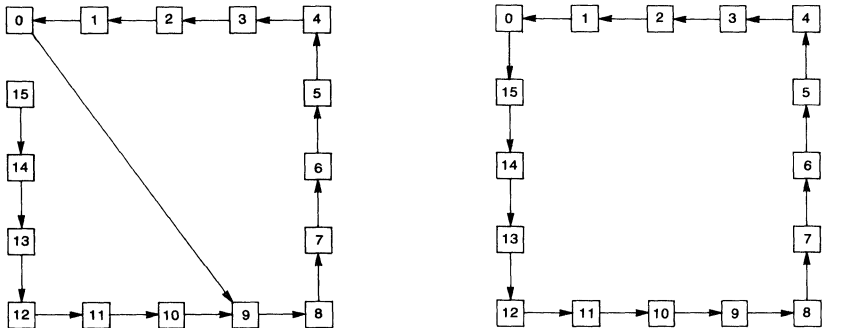
**Q0, Q1, Q2, Q3 (Pins 7, 9, 15, 1)** — These are the synchronous counter outputs. Q0 is the LSB.

**VSS (Pin 8)** — The most negative power supply potential. This pin is usually ground.

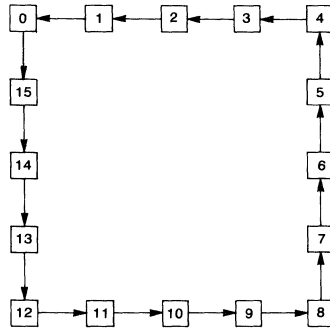
**VDD (Pin 16)** — The most positive power supply potential. VDD may range from 3 to 18 V with respect to VSS.

## STATE DIAGRAMS

MC14522B

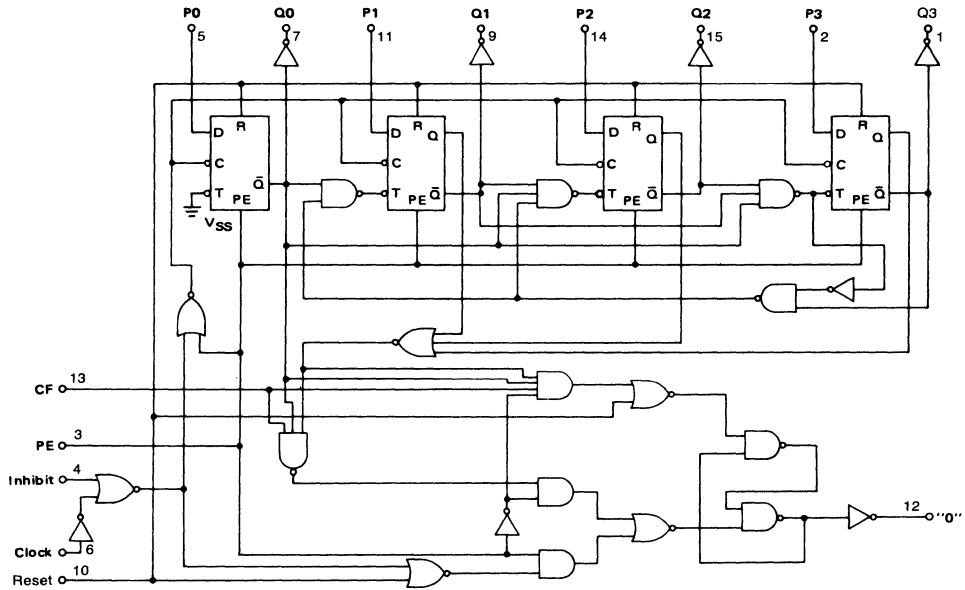


MC14526B

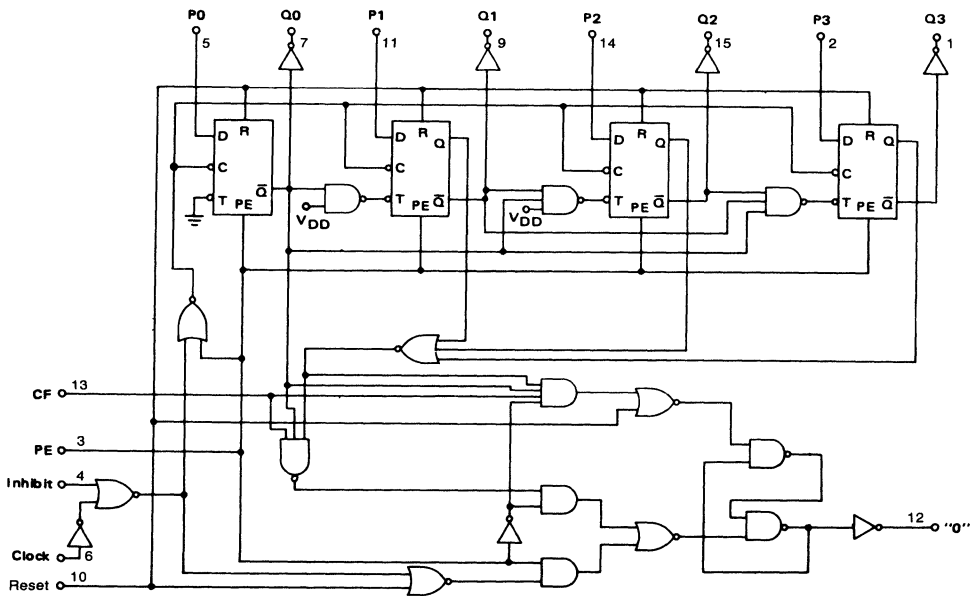


# MC14522B•MC14526B

## MC14522B LOGIC DIAGRAM (BCD Down Counter)



## MC14526B LOGIC DIAGRAM (Binary Down Counter)



# MC14522B•MC14526B

## APPLICATIONS INFORMATION

### Divide-By-N, Single Stage

Figure 11 shows a single stage divide-by-N application. The MC14522B (BCD version) can accept a number greater than 9 and count down in binary fashion. Hence, the BCD and binary single stage divide-by-N counters (as shown in Figure 11) function the same.

To initialize counting a number, N is set on the parallel inputs (P0, P1, P2, and P3) and reset is taken high asynchronously. A zero is forced into the master and slave of each bit and, at the same time, the "0" output goes high. Because Preset Enable is tied to the "0" output, preset is enabled. Reset must be released while the Clock is high so the slaves of each bit may receive N before the Clock goes low. When the Clock goes low and Reset is low, the "0" output goes low (if P0 through P3 are unequal to zero).

The counter downcounts with each rising edge of the Clock. When the counter reaches the zero state, an output pulse occurs on "0" which presets N. The propagation delays from the Clock's rising and falling edges to the "0" output's rising and falling edges are about equal, making the "0" output pulse approximately equal to that of the Clock pulse.

The Inhibit pin may be used to stop pulse counting. When this pin is taken high, decrementing is inhibited.

### Cascaded, Presetable Divide-By-N

Figure 12 shows a three stage cascade application. Taking Reset high loads N. Only the first stage's Reset pin (least significant counter) must be taken high to cause the preset for all stages, but all pins could be tied together, as shown.

When the first stage's Reset pin goes high, the "0" output is latched in a high state. Reset must be released while Clock is high and time allowed for Preset Enable to load N into all stages before Clock goes low.

When Preset Enable is high and Clock is low, time must be allowed for the zero digits to propagate a Cascade Feedback to the first non-zero stage. Worst case is from the most significant bit (M.S.B.) to the L.S.B., when the L.S.B. is equal to one (i.e. N = 1).

After N is loaded, each stage counts down to zero with each rising edge of Clock. When any stage reaches zero and the leading stages (more significant bits) are zero, the "0" output goes high and feeds back to the preceding stage. When all stages are zero, the Preset Enable automatically loads N while the Clock is high and the cycle is renewed.

FIGURE 11 — ÷N COUNTER

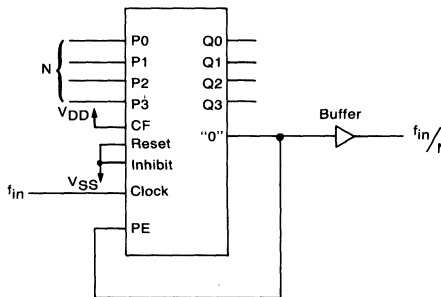
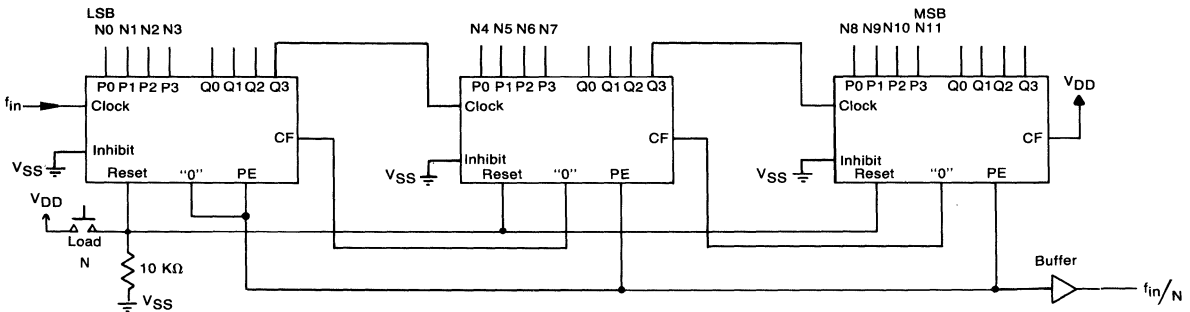


FIGURE 12 — 3 STAGES CASCADED





**MOTOROLA**

**MC14527B**

**BCD RATE MULTIPLIER**

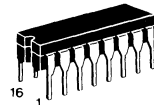
The MC14527B BCD rate multiplier (DRM) provides an output pulse rate based upon the BCD input number. For example, if 6 is the BCD input number, there will be six output pulses for every ten input pulses. This part may be used for arithmetic operations including multiplication and division. Typical applications include digital filters, motor speed control and frequency synthesizers.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Output Clocked on the Negative Going Edge of Clock
- Strobe for Inhibiting or Enabling Outputs
- Enable and Cascade Inputs for Cascade Operation of Two or More DRM's
- "9" Output for the Parallel Enable Configuration and DRM's in Cascade
- Complementary Outputs
- Clear and Set to Nine Inputs

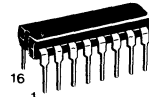
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BCD RATE MULTIPLIER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

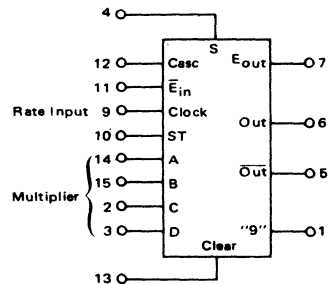
**TRUTH TABLE**

INPUTS										OUTPUT			
										LOGIC LEVEL			
										NUMBER OF PULSES			
D <sup>†</sup>	C	B	A	No. of Clock Pulses	$\bar{E}_{in}$	STROBE	CASCADE	CLEAR	SET	OUT	OUT	E <sub>out</sub>	"9"
0	0	0	0	10	0	0	0	0	0	0	1	1	1
0	0	0	1	10	0	0	0	0	0	0	1	1	1
0	0	1	0	10	0	0	0	0	0	0	2	2	1
0	0	1	1	10	0	0	0	0	0	0	3	3	1
0	1	0	0	10	0	0	0	0	0	0	4	4	1
0	1	0	1	10	0	0	0	0	0	0	5	5	1
0	1	1	0	10	0	0	0	0	0	0	6	6	1
0	1	1	1	10	0	0	0	0	0	0	7	7	1
1	0	0	0	10	0	0	0	0	0	0	8	8	1
1	0	0	1	10	0	0	0	0	0	0	9	9	1
1	0	1	0	10	0	0	0	0	0	0	8	8	1
1	0	1	1	10	0	0	0	0	0	0	9	9	1
1	1	0	0	10	0	0	0	0	0	0	8	8	1
1	1	0	1	10	0	0	0	0	0	0	9	9	1
1	1	1	0	10	0	0	0	0	0	0	9	9	1
1	1	1	1	10	0	0	0	0	0	0	9	9	1
X	X	X	X	10	1	0	0	0	0	-	-	-	-
X	X	X	X	10	0	1	0	0	0	0	1	1	1
X	X	X	X	10	0	0	1	0	0	0	1	1	1
X	X	X	X	10	0	0	0	1	0	0	10	10	1
X	X	X	X	10	0	0	0	0	1	0	0	1	1
X	X	X	X	10	0	0	0	0	1	0	0	1	0
X	X	X	X	10	0	0	0	0	1	0	0	1	0

X = Don't Care

†D = Most Significant Bit

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

# MC14527B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
			10	—	3.0	—	4.50	3.0	—	3.0	
			15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
			10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
			10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (1.75 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (2.6 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 †T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

††To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

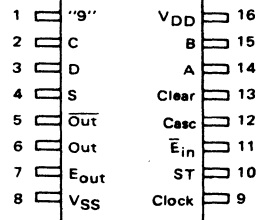
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.0012.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT







# MC14527B

FIGURE 1 – TEST CIRCUIT AND TIMING DIAGRAM

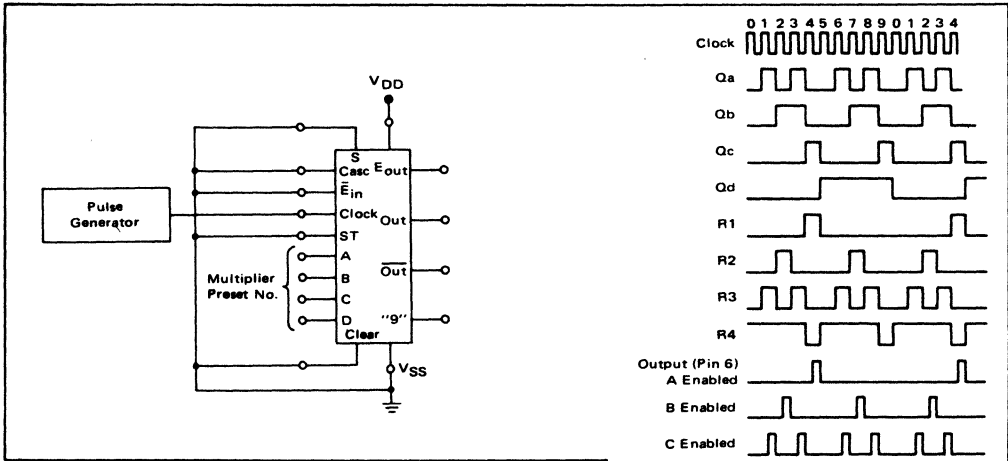
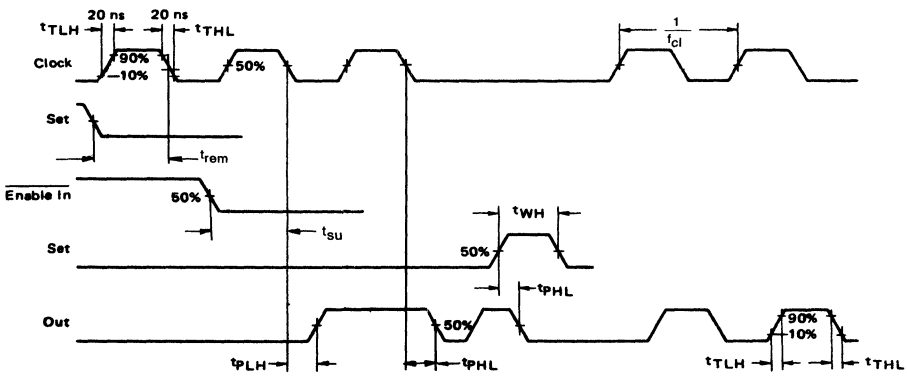
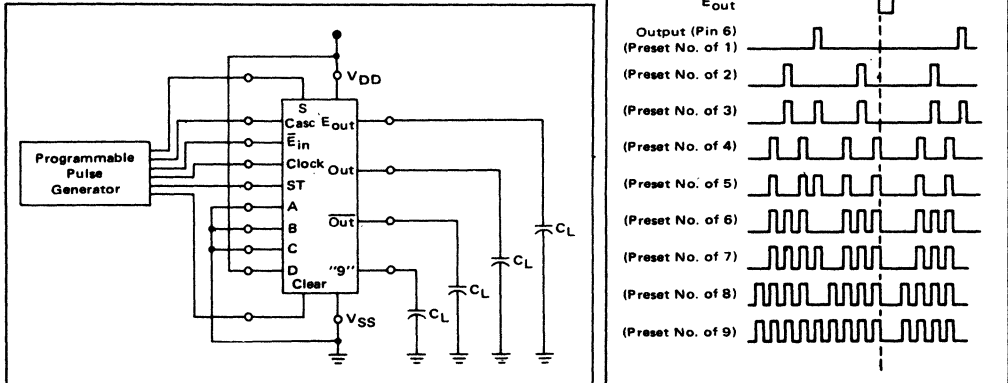


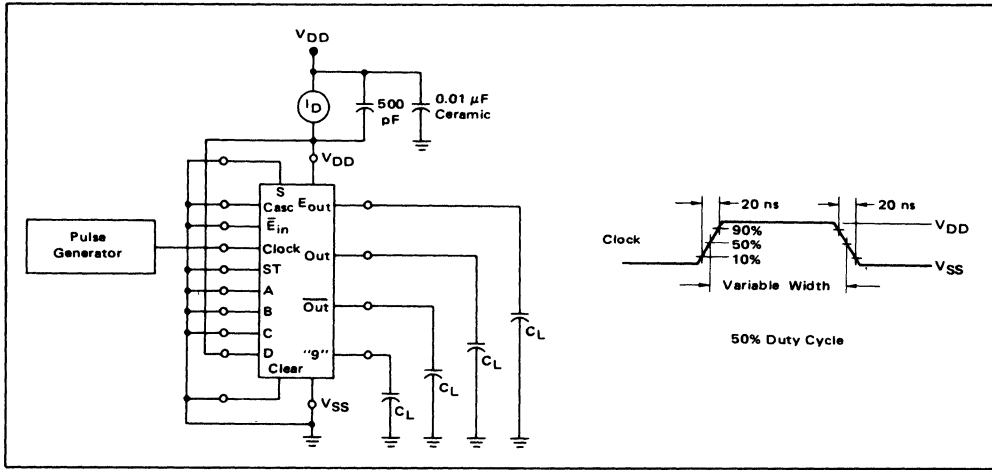
FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



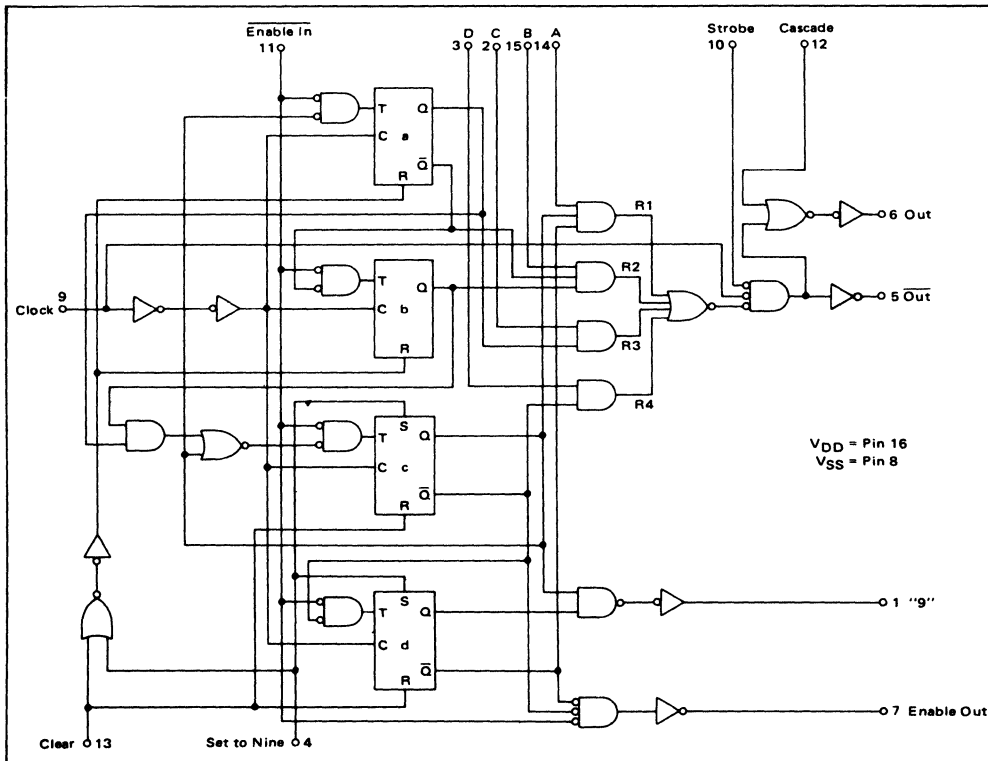
6

# MC14527B

FIGURE 3 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



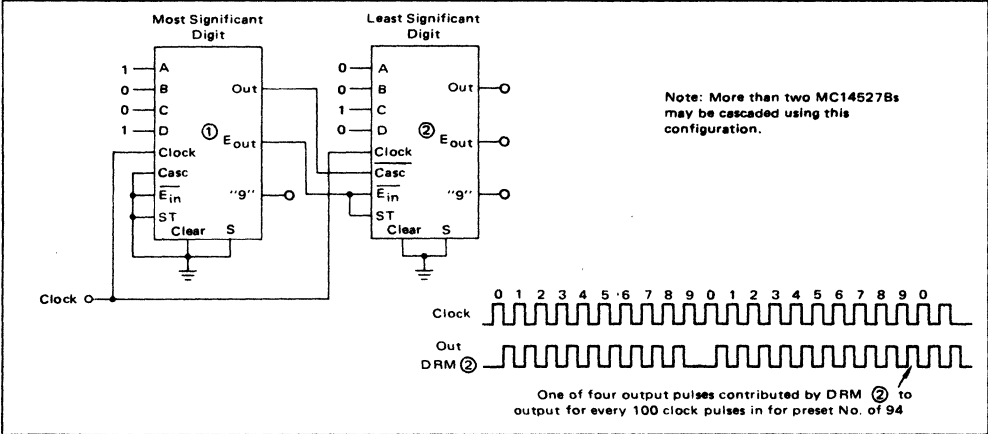
## LOGIC DIAGRAM



6

# MC14527B

FIGURE 4 – TWO MC14527Bs IN CASCADE WITH PRESET NO. of 94





**MOTOROLA**

**MC14528B**

**DUAL MONOSTABLE MULTIVIBRATOR**

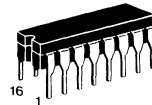
The MC14528B is a dual, retriggerable, resettable monostable multivibrator. It may be triggered from either edge of an input pulse, and produces an output pulse over a wide range of widths, the duration of which is determined by the external timing components,  $C_X$  and  $R_X$ .

- Separate Reset Available
- Diode Protection on All Inputs
- Triggerable from Leading or Trailing Edge Pulse
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-Pin Replacement with the MC14538B and MC14548B.

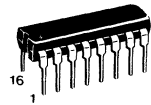
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL RETRIGGERABLE/RESETTABLE MONOSTABLE MULTIVIBRATOR**



**L SUFFIX CERAMIC PACKAGE**  
CASE 620



**P SUFFIX PLASTIC PACKAGE**  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

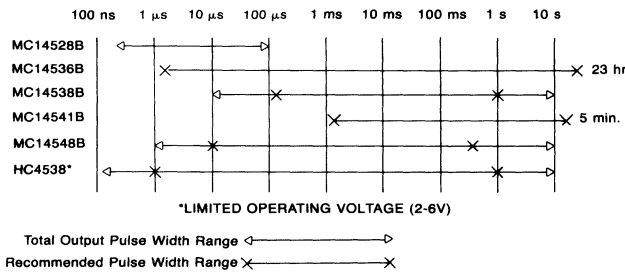
**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

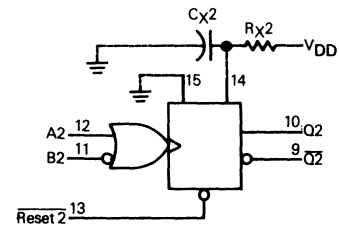
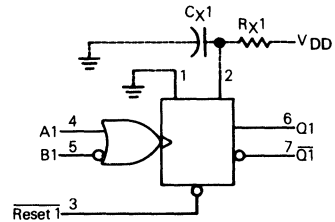
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**THE MC14528B IS NOT RECOMMENDED FOR NEW DESIGNS**

**ONE-SHOT SELECTION GUIDE**



**BLOCK DIAGRAM**



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 1, Pin 8, Pin 15  
 $R_X$  and  $C_X$  are external components

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# MC14528B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mA
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.0	—	-0.8	-0.7	—	-0.6	—	mA
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
**Total Supply Current at an external load Capacitance (C <sub>L</sub> ) and at external timing capacitance (C <sub>X</sub> ), use the formula —	I <sub>T</sub>	—	I <sub>T</sub> (C <sub>L</sub> , C <sub>X</sub> ) = [(C <sub>L</sub> + 0.36C <sub>X</sub> )V <sub>DD</sub> f + 2x10 <sup>-8</sup> R <sub>X</sub> C <sub>X</sub> (V <sub>DD</sub> <sup>-2</sup> )] x 10 <sup>-3</sup> where: I <sub>T</sub> in μA (per circuit), C <sub>L</sub> and C <sub>X</sub> in pF, R <sub>X</sub> in megohms, V <sub>DD</sub> in Vdc, f in kHz is input frequency.							

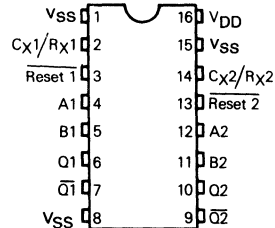
\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\* The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14528B

SWITCHING CHARACTERISTICS\*\* ( $C_L = 50$  pF,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$C_X$ pF	$R_X$ k $\Omega$	$V_{DD}$ Vdc	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH},$ $t_{THL}$	—	—	5.0 10 15	— — —	100 50 40	200 100 80	ns
Turn-Off, Turn-On Delay Time — A or B to Q or $\bar{Q}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 240 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 87 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$	$t_{PLH},$ $t_{PHL}$	15	5.0	5.0 10 15	— — —	325 120 90	650 240 180	ns
Turn-Off, Turn-On Delay Time — A or B to Q or $\bar{Q}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 620 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 257 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 185 \text{ ns}$	$t_{PLH},$ $t_{PHL}$	1000	10	5.0 10 15	— — —	705 290 210	— — —	ns
Input Pulse Width — A or B	$t_{WH}$	15	5.0	5.0 10 15	150 75 55	70 30 30	— — —	ns
	$t_{WL}$	1000	10	5.0 10 15	— — —	70 30 30	— — —	ns
Output Pulse Width — Q or $\bar{Q}$ (For $C_X < 0.01 \mu\text{F}$ use graph for appropriate $V_{DD}$ level.)	$t_W$	15	5.0	5.0 10 15	— — —	550 350 300	— — —	ns
Output Pulse Width — Q or $\bar{Q}$ (For $C_X > 0.01 \mu\text{F}$ use formula: $t_W = 0.2 R_X C_X \ln (V_{DD} - V_{SS})\dagger$ )	$t_W$	10,000	10	5.0 10 15	15 10 15	30 50 55	45 90 95	$\mu\text{s}$
Pulse Width Match between Circuits in the same package	$t_1 - t_2$	10,000	10	5.0 10 15	— — —	6.0 8.0 8.0	25 35 35	%
Reset Propagation Delay — Reset to Q or $\bar{Q}$	$t_{PLH},$ $t_{PHL}$	15	5.0	5.0 10 15	— — —	325 90 60	600 225 170	ns
		1000	10	5.0 10 15	— — —	1000 300 250	— — —	ns
Retrigger Time	$t_{rr}$	15	5.0	5.0 10 15	0 0 0	— — —	— — —	ns
		1000	10	5.0 10 15	0 0 0	— — —	— — —	ns
External Timing Resistance	$R_X$	—	—	—	5.0	—	1000	k $\Omega$
External Timing Capacitance	$C_X$	—	—	—	—	No Limits*		$\mu\text{F}$

†  $R_X$  is in Ohms,  $C_X$  is in farads,  $V_{DD}$  and  $V_{SS}$  in volts,  $PW_{out}$  in seconds.

\* If  $C_X > 15 \mu\text{F}$ , Use Discharge Protection Diode  $D_X$ , per Fig. 9.

\*\*The formulas given are for the typical characteristics only at  $25^\circ\text{C}$ .

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

## FUNCTION TABLE

Reset	Inputs		Outputs	
	A	B	Q	$\bar{Q}$
H				
H	L	H		
H		L	Not Triggered	Not Triggered
H	H		Not Triggered	Not Triggered
H	L, H,	H	Not Triggered	Not Triggered
H	L	L, H,	Not Triggered	Not Triggered
L	X	X	L	H
	X	X	Not Triggered	Not Triggered

# MC14528B

FIGURE 1 – OUTPUT SOURCE CURRENT TEST CIRCUIT

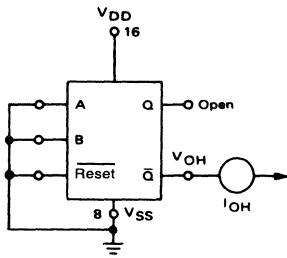


FIGURE 2 – OUTPUT SINK CURRENT TEST CIRCUIT

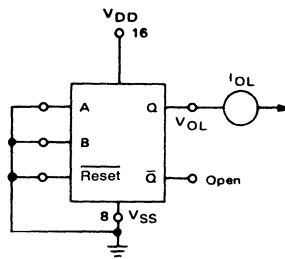


FIGURE 3 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS

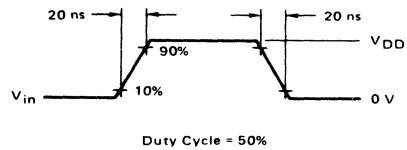
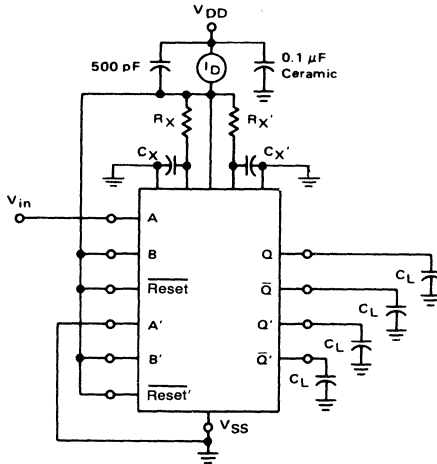
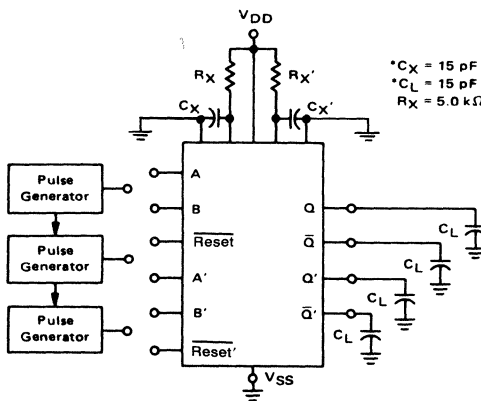


FIGURE 4 – AC TEST CIRCUIT

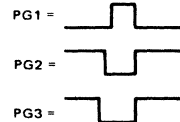


### INPUT CONNECTIONS

CHARACTERISTICS	Reset	A	B
$t_{PLH}, t_{PHL}, t_{TLH}, t_{THL}$ $t_W$	$V_{DD}$	PG1	$V_{DD}$
$t_{PLH}, t_{PHL}, t_{TLH}, t_{THL}$ $t_W$	$V_{DD}$	$V_{SS}$	PG2
$t_{PLH(R)}, t_{PHL(R)}, t_W$	PG3	PG1	PG2

\*Includes capacitance of probes, wiring, and fixture parasitic.

NOTE: AC test waveforms for PG1, PG2, and PG3 on next page.



# MC14528B

FIGURE 5 — AC TEST WAVEFORMS

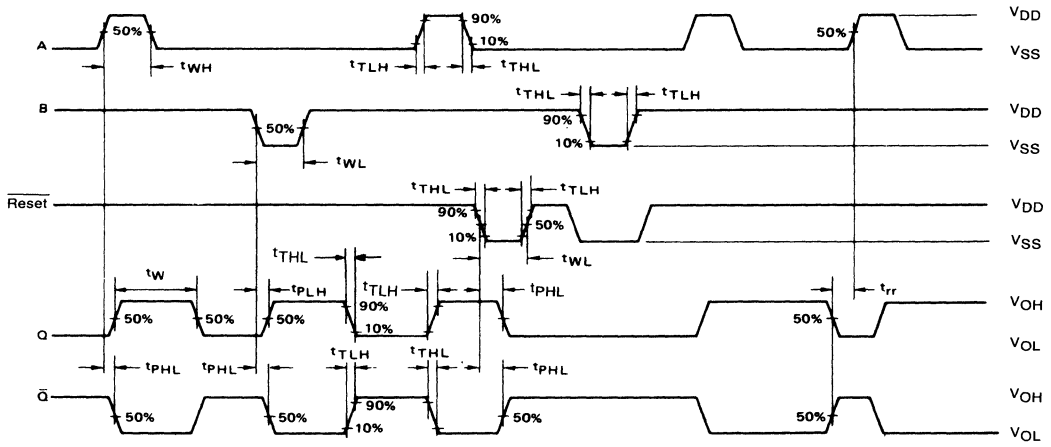
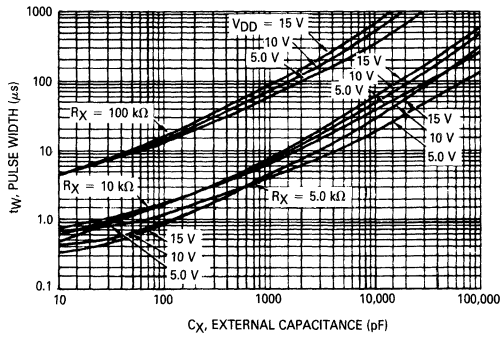


FIGURE 6 — PULSE WIDTH versus  $C_X$

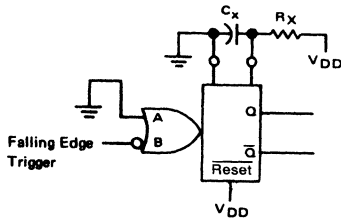
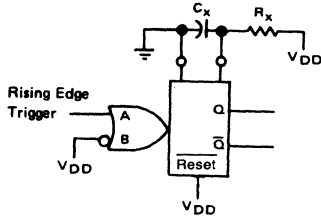




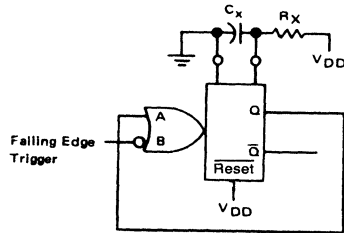
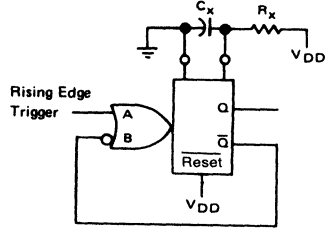
# MC14528B

## TYPICAL APPLICATIONS

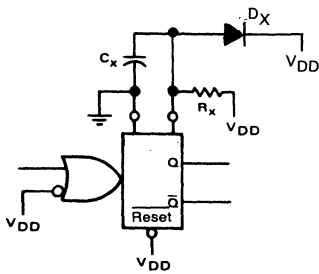
**FIGURE 7 — RETRIGGERABLE MONOSTABLES CIRCUITRY**



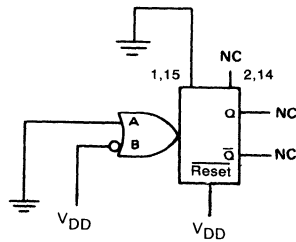
**FIGURE 8 — NON-RETRIGGERABLE MONOSTABLES CIRCUITRY**



**FIGURE 9 — USE OF A DIODE TO LIMIT POWER DOWN CURRENT SURGE**



**FIGURE 10 — CONNECTION OF UNUSED SECTIONS**





**MOTOROLA**

**MC14529B**

**DUAL 4-CHANNEL ANALOG DATA SELECTOR**

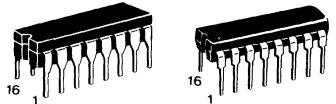
The MC14529B analog data selector is a dual 4-channel or single 8-channel device depending on the input coding. The device is suitable for digital as well as analog application, including various one-of-four and one-of-eight data selector functions. Since the device has bidirectional analog characteristics it can also be used as a dual binary to 1-of-4 or a binary to 1-of-8 decoder.

- Data Paths Are Bidirectional
- 3-State Outputs
- Linear "On" Resistance
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL 4-CHANNEL ANALOG DATA SELECTOR OR 8-CHANNEL ANALOG DATA SELECTOR**



**L SUFFIX CERAMIC PACKAGE CASE 620**

**P SUFFIX PLASTIC PACKAGE CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package. -12mW/°C from 65°C to 85°C  
Ceramic "L" Package. -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

ST <sub>X</sub>	ST <sub>Y</sub>	B	A	Z	W
1	1	0	0	X0	Y0
1	1	0	1	X1	Y1
1	1	1	0	X2	Y2
1	1	1	1	X3	Y3
1	0	0	0	X0	
1	0	0	1	X1	
1	0	1	0	X2	
1	0	1	1	X3	
0	1	0	0		Y0
0	1	0	1		Y1
0	1	1	0		Y2
0	1	1	1		Y3
0	0	X	X		High Impedance

Dual 4-Channel Mode  
2 Outputs

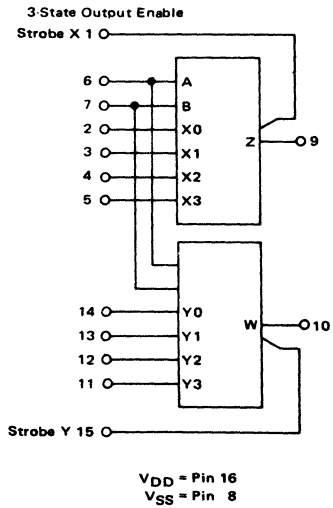
Single 8-Channel Mode  
1 Output  
(Z and W tied together)

X = Don't Care

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**BLOCK DIAGRAM**



# MC14529B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to $V_{SS}$ )

Characteristic	Figure	Symbol	$V_{SS}$ Vdc	$V_{DD}$ Vdc	$T_{low}^*$		25°C			$T_{high}^*$		Unit
					Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage $V_{in} = 0$	"0" Level	$V_{OL}$	0.0	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05		
	15	—	0.05	—	0	0.05	—	0.05	—			
	"1" Level	$V_{OH}$	0.0	5.0	4.95	—	4.95	5.0	—	4.95	—	
10			9.95	—	9.95	10	—	9.95	—			
$V_{in} = V_{DD}$	"0" Level	$V_{IL}$	0.0	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
			10	—	3.0	—	4.50	3.0	—	3.0		
$V_{in} = V_{DD}$	"1" Level	$V_{IH}$	0.0	5.0	3.5	—	3.5	2.75	—	3.5	—	
			10	7.0	—	7.0	5.50	—	7.0	—		
$V_{in} = 1.0$ or 9.0 Vdc	"0" Level	$V_{IL}$	15	—	4.0	—	6.75	4.0	—	4.0	—	
			$V_{IH}$	15	11	—	11	8.25	—	11	—	
$V_{in} = 1.5$ or 13.5 Vdc	"1" Level	$V_{IH}$		15	11	—	11	8.25	—	11	—	
Input Current (AL Device) Control		$I_{in}$	0.0	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device) Control		$I_{in}$	0.0	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance ( $V_{in} = 0$ )		$C_{in}$	0.0									pF
Control								5.0	7.5			
Switch Input								8.0				
Switch Output								20				
Feed Through								0.3				
Quiescent Current (AL Device) (Per Package)	3	$I_{DD}$	—	5.0	—	1.0	—	0.001	1.0	—	60	μAdc
			10	—	1.0	—	0.002	1.0	—	60		
			15	—	2.0	—	0.003	2.0	—	120		
Quiescent Current (CL/CP Device) (Per Package)	3	$I_{DD}$	—	5.0	—	5.0	—	0.001	5.0	—	70	μAdc
			10	—	5.0	—	0.002	5.0	—	70		
			15	—	10	—	0.003	10	—	140		
"ON" Resistance (AL Device) ( $V_C = V_{DD}$ , $R_L = 10$ kΩ)	4,5,6	$R_{ON}$	-5.0	5.0	—	400	—	200	480	—	640	Ω
					—	400	—	200	480	—	640	
					—	400	—	190	480	—	640	
			-7.5	7.5	—	240	—	160	270	—	400	
					—	240	—	160	270	—	400	
					—	240	—	120	270	—	400	
			0	10	—	400	—	180	480	—	640	
					—	400	—	180	480	—	640	
					—	400	—	220	480	—	640	
			0	15	—	250	—	180	270	—	400	
					—	250	—	180	270	—	400	
					—	250	—	215	270	—	400	
			"ON" Resistance (CL/CP Device) ( $V_C = V_{DD}$ , $R_L = 10$ kΩ)	4,5,6	$R_{ON}$	-5.0	5.0	—	410	—	200	
—	410	—						200	480	—	560	
—	410	—						190	480	—	560	
-7.5	7.5	—				250	—	160	270	—	350	
		—				250	—	160	270	—	350	
		—				250	—	120	270	—	350	
0	10	—				410	—	180	480	—	560	
		—				410	—	180	480	—	560	
		—				410	—	220	480	—	560	
0	15	—				250	—	180	270	—	350	
		—				250	—	180	270	—	350	
		—				250	—	215	270	—	350	
Δ"ON" Resistance Between any 2 circuits in a common package	—	Δ $R_{ON}$				-5.0	5.0	—	—	—	15	—
			—	—	—			10	—	—		
			-7.5	7.5	—			—	—	—	—	—

\* $T_{low}$  = -55°C for AL Device, -40°C for CL/CP Device

\* $T_{high}$  = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14529B

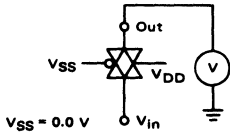
## SWITCHING CHARACTERISTICS (T<sub>A</sub> = 25°C)

Characteristic	Figure	Symbol	V <sub>SS</sub>	V <sub>DD</sub>	Min	Typ #	Max	Unit
V <sub>in</sub> to V <sub>out</sub> Propagation Delay Time (C <sub>L</sub> = 50 pF, R <sub>L</sub> = 1.0 kΩ)	7	t <sub>PLH</sub> , t <sub>PHL</sub>	0.0	5.0 10 15	— — —	20 10 8.0	40 20 15	ns
Propagation Delay Time, Control to Output, V <sub>in</sub> = V <sub>DD</sub> or V <sub>SS</sub> (C <sub>L</sub> = 50 pF, R <sub>L</sub> = 1.0 kΩ)	8	t <sub>PLZ</sub> , t <sub>PZL</sub> , t <sub>PHZ</sub> , t <sub>PZH</sub>	0.0	5.0 10 15	— — —	140 70 50	400 160 120	ns
Crosstalk, Control to Output (C <sub>L</sub> = 50 pF, R <sub>L</sub> = 1.0 kΩ, R <sub>out</sub> = 10 kΩ)	9	—	0.0	5.0 10 15	— — —	5.0 5.0 5.0	— — —	mV
Control Input Pulse Frequency (C <sub>L</sub> = 50 pF, R <sub>L</sub> = 1.0 kΩ)	10	f <sub>in</sub>	0.0	5.0 10 15	— — —	5.0 10 12	2.5 6.2 8.3	MHz
Noise Voltage (f = 100 Hz)	11,12	—	0.0	5.0 10 15  5.0 10 15	— — —  — — —	24 25 30  12 12 15	— — —  — — —	$\frac{nV}{\sqrt{\text{cycle}}}$
Sine Wave Distortion (V <sub>in</sub> = 1.77 Vdc RMS Centered @ 0.0 Vdc, R <sub>L</sub> = 10 kΩ, f = 1.0 kHz)	—	—	-5.0	5.0	—	0.36	—	%
Off-Channel Leakage Current (V <sub>in</sub> = +5.0 Vdc, V <sub>out</sub> = -5.0 Vdc) (V <sub>in</sub> = -5.0 Vdc, V <sub>out</sub> = +5.0 Vdc) (V <sub>in</sub> = +7.5 Vdc, V <sub>out</sub> = -7.5 Vdc) (V <sub>in</sub> = -7.5 Vdc, V <sub>out</sub> = +7.5 Vdc)	—	I <sub>off</sub>	-5.0 -5.0 -7.5 -7.5	5.0 5.0 7.5 7.5	— — — —	±0.001 ±0.001 ±0.0015 ±0.0015	±125 ±125 ±250 ±250	nA
Insertion Loss (V <sub>in</sub> = 1.77 Vdc RMS centered @ 0.0 Vdc, f = 1.0 MHz)  I <sub>loss</sub> = 20 Log <sub>10</sub> $\frac{V_{out}}{V_{in}}$  (R <sub>L</sub> = 1.0 kΩ) (R <sub>L</sub> = 10 kΩ) (R <sub>L</sub> = 100 kΩ) (R <sub>L</sub> = 1.0 MΩ)	13	—	-5.0	5.0	— — — —	2.0 0.8 0.25 0.01	— — — —	dB
Bandwidth (-3 dB) (V <sub>in</sub> = 1.77 Vdc RMS centered @ 0.0 Vdc)  (R <sub>L</sub> = 1.0 kΩ) (R <sub>L</sub> = 10 kΩ) (R <sub>L</sub> = 100 kΩ) (R <sub>L</sub> = 1.0 MΩ)	—	BW	-5.0	5.0	— — — —	35 28 27 26	— — — —	MHz
Feedthrough and Crosstalk  20 Log <sub>10</sub> $\frac{V_{out}}{V_{in}}$ = -50 dB  (R <sub>L</sub> = 1.0 kΩ) (R <sub>L</sub> = 10 kΩ) (R <sub>L</sub> = 100 kΩ) (R <sub>L</sub> = 1.0 MΩ)	—	—	-5.0	5.0	— — — —	850 100 12 1.5	— — — —	MHz

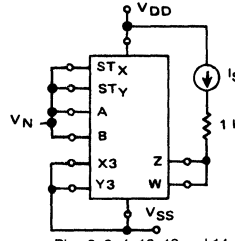
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14529B

**FIGURE 1 - OUTPUT VOLTAGE TEST CIRCUIT**



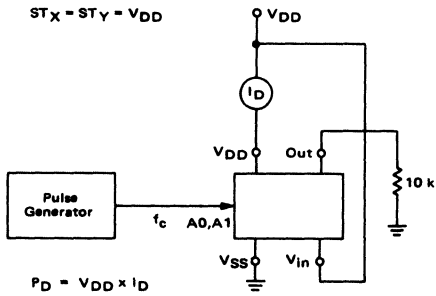
**FIGURE 2 - NOISE IMMUNITY TEST CIRCUIT**



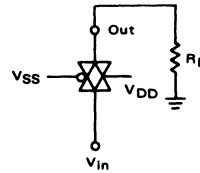
Pins 2, 3, 4, 12, 13 and 14 are left open.  
 $V_{IL}$ :  $V_C$  is raised from  $V_{SS}$  until  $V_C = V_{IL}$ .  
 at  $V_C = V_{IL}$ :  $I_S = \pm 10 \mu A$  with  $V_{in} = V_{SS}$ ,  $V_{out} = V_{DD}$  or  $V_{in} = V_{DD}$ ,  $V_{out} = V_{SS}$ .

$V_{IH}$ : When  $V_C = V_{IH}$  to  $V_{DD}$ , the switch is ON and the  $R_{ON}$  specifications are met.

**FIGURE 3 - QUIESCENT POWER DISSIPATION TEST CIRCUIT**

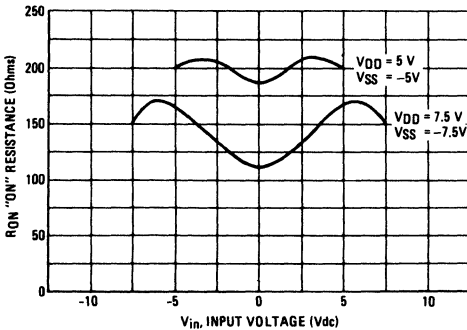


**FIGURE 4 - RON CHARACTERISTICS TEST CIRCUIT**

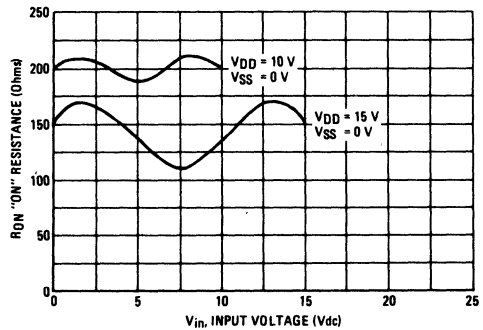


## TYPICAL RON versus INPUT VOLTAGE

**FIGURE 5**

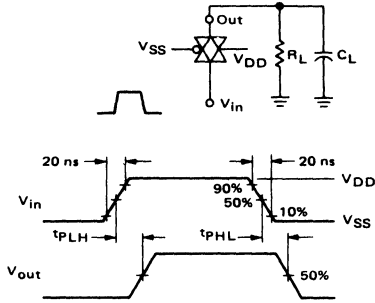


**FIGURE 6**

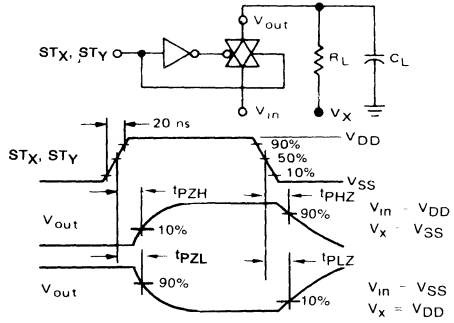


# MC14529B

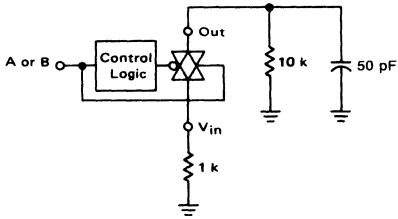
**FIGURE 7 – PROPAGATION DELAY TEST CIRCUIT AND WAVEFORMS**



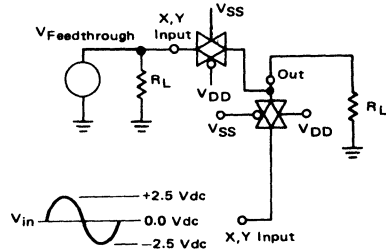
**FIGURE 8 – TURN-ON DELAY TIME TEST CIRCUIT AND WAVEFORMS**



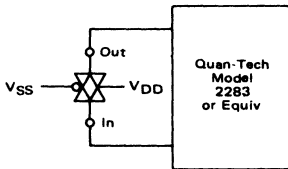
**FIGURE 9 – CROSSTALK TEST CIRCUIT**



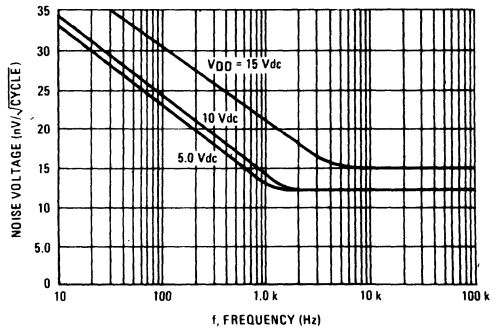
**FIGURE 10 – FREQUENCY RESPONSE TEST CIRCUIT**



**FIGURE 11 – NOISE VOLTAGE TEST CIRCUIT**

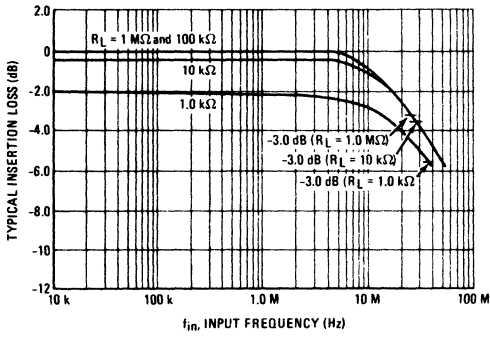


**FIGURE 12 – TYPICAL NOISE CHARACTERISTICS**

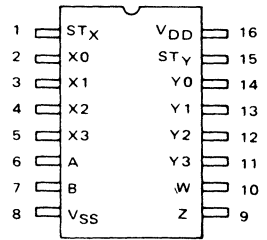


# MC14529B

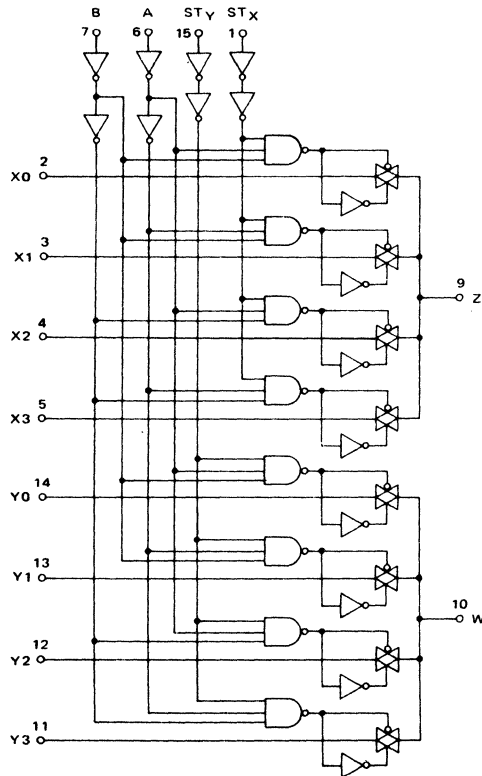
FIGURE 13 – TYPICAL INSERTION LOSS/BANDWIDTH CHARACTERISTICS



PIN ASSIGNMENT



LOGIC DIAGRAM



V<sub>DD</sub> = Pin 16  
 V<sub>SS</sub> = Pin 8



**MOTOROLA**

**DUAL 5-INPUT MAJORITY LOGIC GATE**

The MC14530B dual five-input majority logic gate is constructed with P-channel and N-channel enhancement mode devices in a single monolithic structure. Combinational and sequential logic expressions are easily implemented with the majority logic gate, often resulting in fewer components than obtainable with the more basic gates. This device can also provide numerous logic functions by using the W and some of the logic (A thru E) inputs as control inputs.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**LOGIC TABLE**

INPUTS A B C D E	W	Z
For all combinations of inputs where three or more inputs are logical "0".	0	1
	1	0
For all combinations of inputs where three or more inputs are logical "1".	0	0
	1	1

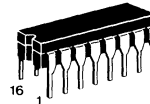
This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

**MC14530B**

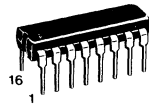
**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL 5-INPUT MAJORITY LOGIC GATE**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620



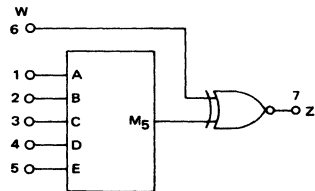
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

**ORDERING INFORMATION**

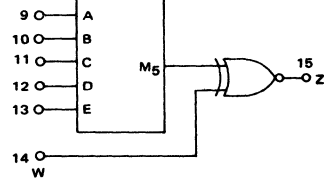
A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



\*  $Z = M_5 \odot W = (ABC + ABD + ABE + ACD + ACE + ADE + BCD + BCE + BDE + CDE) \odot W$



\*M<sub>5</sub> is a logical "1" if any three or more inputs are logical "1".

⊙ ≡ Exclusive NOR    ≡ Exclusive OR

**TRUTH TABLE**

M <sub>5</sub>	W	Z
0	0	1
0	1	0
1	0	0
1	1	1

V<sub>DD</sub> = Pin 16  
 V<sub>SS</sub> = Pin 8



# MC14530B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.2	—	2.25	1.25	—	1.15	Vdc
			10	—	2.5	—	4.50	2.5	—	2.4	
			15	—	3.0	—	6.75	3.0	—	2.9	
	"1" Level	V <sub>IH</sub>	5.0	3.85	—	3.75	2.75	—	3.75	—	Vdc
			10	7.6	—	7.5	5.50	—	7.5	—	
			15	12.1	—	12	8.25	—	12	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μA <sub>dc</sub>	
		10	—	0.50	—	0.0010	0.50	—	15		
		15	—	1.00	—	0.0015	1.00	—	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μA <sub>dc</sub>	
		10	—	2.0	—	0.0010	2.0	—	15		
		15	—	4.0	—	0.0015	4.0	—	30		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.75 μA/KHz) f + I <sub>DD</sub>						μA <sub>dc</sub>		
10	I <sub>T</sub> = (1.50 μA/KHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (2.25 μA/KHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

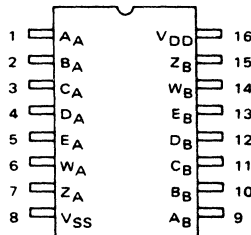
$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

### PIN ASSIGNMENT



# MC14530B

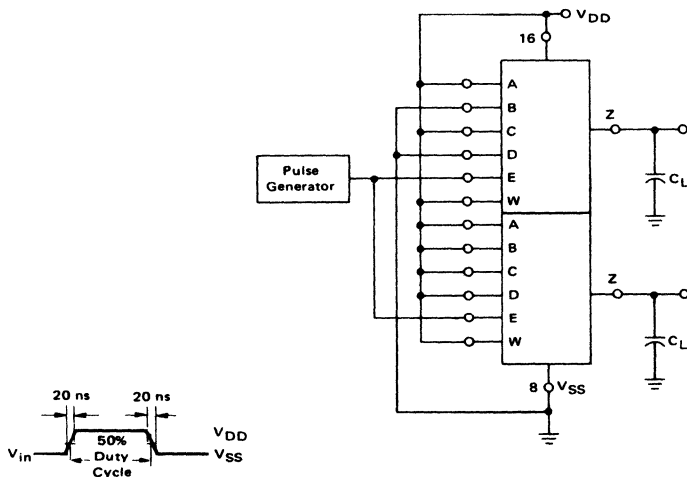
SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
<b>Output Rise and Fall Time</b>	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
<b>Propagation Delay Time</b>	$t_{PLH}$					ns
A, C, W = V <sub>DD</sub> ; B, E = Gnd; D = Pulse Generator						
$t_{PLH} = (1.7 \text{ ns/pF}) C_L + 290 \text{ ns}$		5.0	—	375	960	
$t_{PLH} = (0.66 \text{ ns/pF}) C_L + 127 \text{ ns}$		10	—	160	400	
$t_{PLH} = (0.5 \text{ ns/pF}) C_L + 85 \text{ ns}$		15	—	110	300	
$t_{PHL} = (1.7 \text{ ns/pF}) C_L + 345 \text{ ns}$	$t_{PHL}$	5.0	—	430	1200	ns
$t_{PHL} = (0.66 \text{ ns/pF}) C_L + 162 \text{ ns}$		10	—	195	540	
$t_{PHL} = (0.5 \text{ ns/pF}) C_L + 95 \text{ ns}$		15	—	120	410	
A, B, C, D, E = Pulse Generator; W = V <sub>DD</sub>	$t_{PLH}$					ns
$t_{PLH} = (1.7 \text{ ns/pF}) C_L + 170 \text{ ns}$		5.0	—	255	640	
$t_{PLH} = (0.66 \text{ ns/pF}) C_L + 87 \text{ ns}$		10	—	120	300	
$t_{PLH} = (0.5 \text{ ns/pF}) C_L + 60 \text{ ns}$		15	—	85	210	
$t_{PHL} = (1.7 \text{ ns/pF}) C_L + 195 \text{ ns}$	$t_{PHL}$	5.0	—	280	750	ns
$t_{PHL} = (0.66 \text{ ns/pF}) C_L + 92 \text{ ns}$		10	—	125	330	
$t_{PHL} = (0.5 \text{ ns/pF}) C_L + 75 \text{ ns}$		15	—	100	250	
A, B, C, D, E = Gnd; W = Pulse Generator	$t_{PLH}$ , $t_{PHL}$					ns
$t_{PHL}$ , $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 145 \text{ ns}$		5.0	—	230	575	
$t_{PHL}$ , $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 72 \text{ ns}$		10	—	105	265	
$t_{PHL}$ , $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 50 \text{ ns}$		15	—	75	190	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

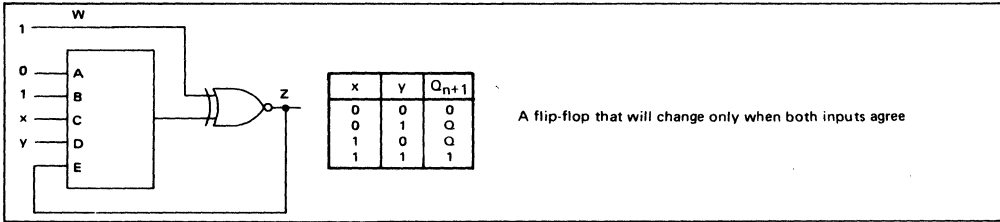
FIGURE 1 – POWER DISSIPATION TEST  
CIRCUIT AND WAVEFORM



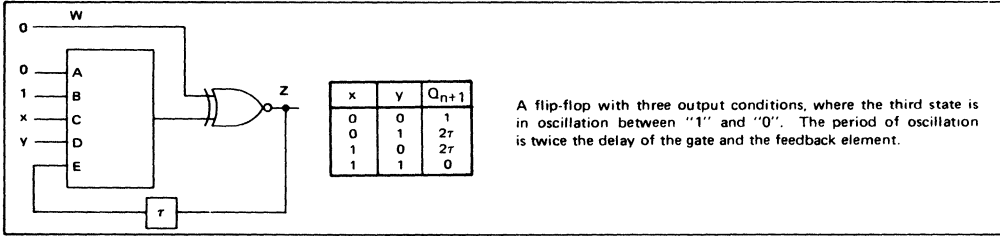
# MC14530B

## SEQUENTIAL LOGIC APPLICATIONS

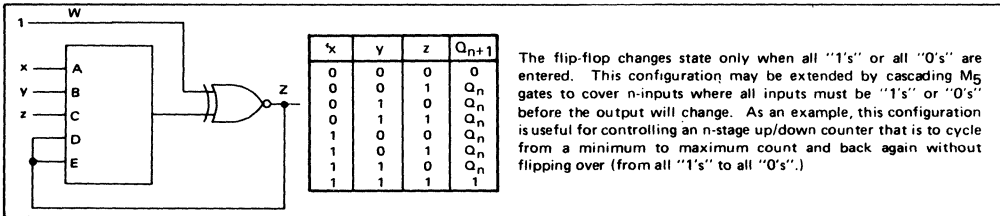
### COINCIDENT FLIP-FLOP



### ASTABLE MULTIVIBRATOR

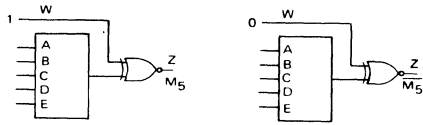


### COINCIDENT FLIP-FLOP

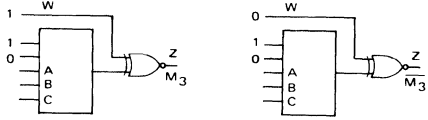


# MC14530B

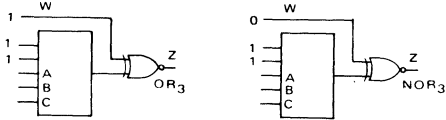
## BASIC COMBINATIONAL FUNCTIONS



5-Input Majority Gates

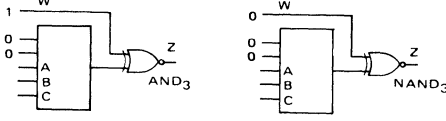


3-Input Majority Gates



3-Input OR Gate

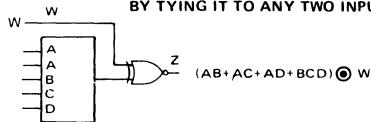
3-Input NOR Gate



3-Input AND Gate

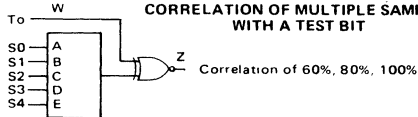
3-Input NAND Gate

## DOUBLING THE WEIGHT OF INPUT VARIABLE A BY TYING IT TO ANY TWO INPUTS

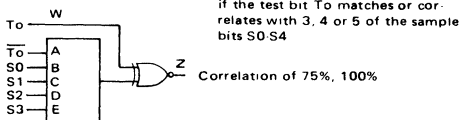


$$(AB + AC + AD + BCD) \odot W$$

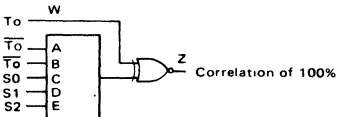
## CORRELATION OF MULTIPLE SAMPLES WITH A TEST BIT



Correlation of 60%, 80%, 100%



Correlation of 75%, 100%



Correlation of 100%

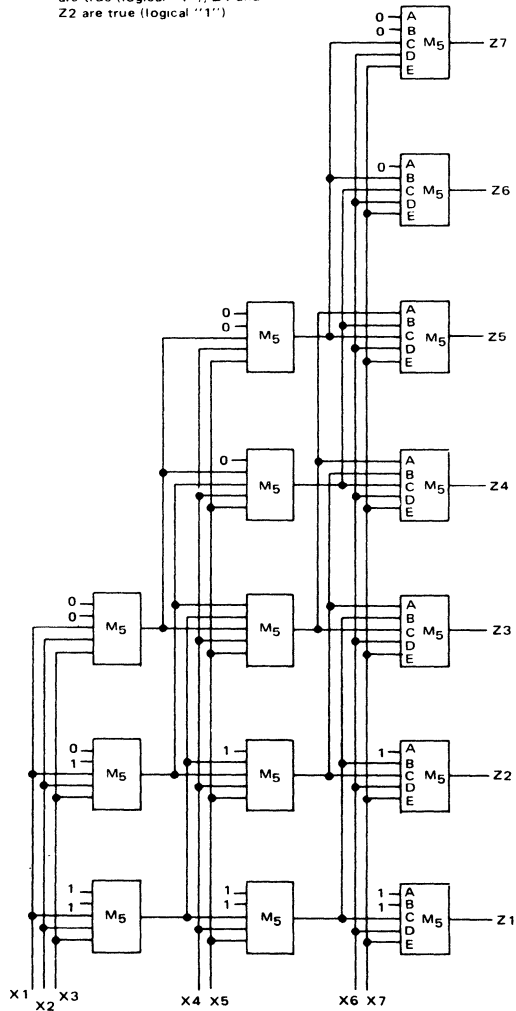
The gate will have a "1" output if the test bit To matches or correlates with 3, 4 or 5 of the sample bits S0-S4

## 5-INPUT MAJORITY LOGIC GATE APPLICATIONS

Each package labeled M<sub>5</sub> is a single majority logic gate using five inputs, A thru E, and one output Z.

- Majority Logic Gate Array yielding the symmetric function of 1 thru 7 variables true, out of 7 input variables (X<sub>1</sub> - X<sub>7</sub>)

(e.g., if any two input variables are true (logical "1"), Z<sub>1</sub> and Z<sub>2</sub> are true (logical "1"))





# MC14531B

## 12-BIT PARITY TREE

The MC14531B 12-bit parity tree is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. The circuit consists of 12 data-bit inputs (D0 thru D11), and even or odd parity selection input (W) and an output (Q). The parity selection input can be considered as an additional bit. Words of less than 13 bits can generate an even or odd parity output if the remaining inputs are selected to contain an even or odd number of ones, respectively. Words of greater than 12-bits can be accommodated by cascading other MC14531B devices by using the W input. Applications include checking or including a redundant (parity) bit to a word for error detection/correction systems, controller for remote digital sensors or switches (digital event detection/correction), or as a multiple input summer without carries.

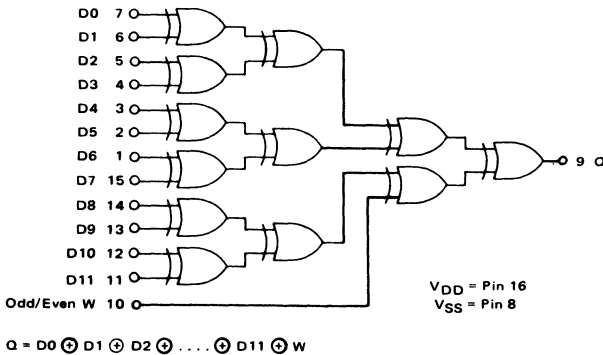
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- All Outputs Buffered
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range
- Variable Word Length
- Diode Protection on All Inputs

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

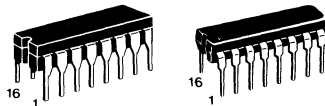
### LOGIC DIAGRAM



## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

### 12-BIT PARITY TREE



**L SUFFIX** CERAMIC PACKAGE CASE 620  
**P SUFFIX** PLASTIC PACKAGE CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

### TRUTH TABLE

INPUTS								OUTPUT
W	D11	D10	...	D2	D1	D0	DECIMAL (OCTAL) EQUIVALENT	Q*
0	0	0	...	0	0	0	0 (0)	0
0	0	0	...	0	0	1	1 (1)	1
0	0	0	...	0	1	0	2 (2)	1
0	0	0	...	0	1	1	3 (3)	0
0	0	0	...	1	0	0	4 (4)	1
0	0	0	...	1	0	1	5 (5)	0
0	0	0	...	1	1	0	6 (6)	0
0	0	0	...	1	1	1	7 (7)	1
...	...	...	...	...	...	...	...	...
1	1	1	...	0	0	0	8184 (17770)	0
1	1	1	...	0	0	1	8185 (17771)	1
1	1	1	...	0	1	0	8186 (17772)	1
1	1	1	...	0	1	1	8187 (17773)	0
1	1	1	...	1	0	0	8188 (17774)	1
1	1	1	...	1	0	1	8189 (17775)	0
1	1	1	...	1	1	0	8190 (17776)	0
1	1	1	...	1	1	1	8191 (17777)	1

0 = Even Parity Note: May redefine to suit application by manipulating W and/or other available D's  
 1 = Odd Parity

# MC14531B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	"0" Level I <sub>OH</sub>	5.0	—3.0	—	—2.4	—4.2	—	—1.7	—	mAdc
		5.0	—0.64	—	—0.51	—0.88	—	—0.36	—	
		10	—1.6	—	—1.3	—2.25	—	—	—	
		10	—1.6	—	—1.3	—2.25	—	—	—	
		15	—4.2	—	—3.4	—8.8	—	—2.4	—	
		15	—4.2	—	—3.4	—8.8	—	—2.4	—	
	"1" Level I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	"0" Level I <sub>OH</sub>	5.0	—2.5	—	—2.1	—4.2	—	—1.7	—	mAdc
		5.0	—0.52	—	—0.44	—0.88	—	—0.36	—	
		10	—1.3	—	—1.1	—2.25	—	—0.9	—	
		10	—1.3	—	—1.1	—2.25	—	—0.9	—	
		15	—3.6	—	—3.0	—8.8	—	—2.4	—	
"1" Level I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
	10	1.3	—	1.1	2.25	—	0.9	—		
	10	1.3	—	1.1	2.25	—	0.9	—		
	15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.25 μA/kHz) f + I <sub>DD</sub>							μAdc
10	I <sub>T</sub> = (0.50 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (0.75 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.  
†To calculate total supply current at loads other than 50 pF:

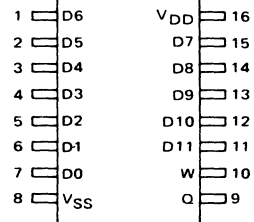
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.001.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14531B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$					ns
Data to Q						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 355 \text{ ns}$		5.0	—	440	1320	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 142 \text{ ns}$		10	—	175	525	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 95 \text{ ns}$		15	—	120	360	
Odd/Even to Q						
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 165 \text{ ns}$		5.0	—	250	750	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 67 \text{ ns}$		10	—	100	300	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 45 \text{ ns}$		15	—	70	210	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORM

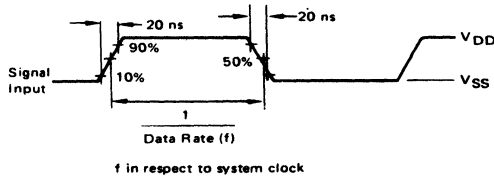
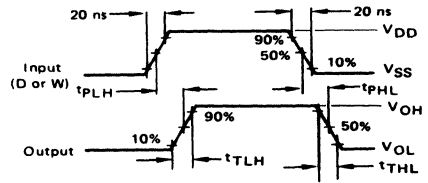


FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS





**MOTOROLA**

**MC14532B**

**8-BIT PRIORITY ENCODER**

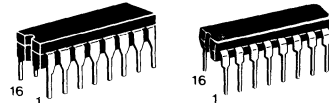
The MC14532B is constructed with complementary MOS (CMOS) enhancement mode devices. The primary function of a priority encoder is to provide a binary address for the active input with the highest priority. Eight data inputs (D0 thru D7) and an enable input ( $E_{in}$ ) are provided. Five outputs are available, three are address outputs (Q0 thru Q2), one group select (GS) and one enable output ( $E_{out}$ ).

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**8-BIT PRIORITY ENCODER**



**L SUFFIX CERAMIC PACKAGE CASE 620**  
**P SUFFIX PLASTIC PACKAGE CASE 648**

**ORDERING INFORMATION**

- A Series: -55°C to +125°C**  
 MC14XXXBAL (Ceramic Package Only)
- C Series: -40°C to +85°C**  
 MC14XXBCP (Plastic Package)  
 MC14XXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
 †Temperature Derating Plastic "P" Package -12mW/°C from 85°C to 125°C  
 Ceramic "L" Package -12mW/°C from 100°C to 125°C

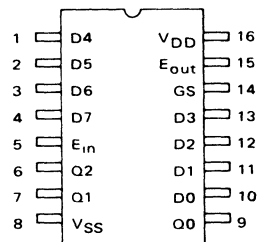
**TRUTH TABLE**

INPUT								OUTPUT					
$E_{in}$	D7	D6	D5	D4	D3	D2	D1	D0	GS	Q2	Q1	Q0	$E_{out}$
0	X	X	X	X	X	X	X	X	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	X	X	X	X	X	X	X	1	1	1	1	0
1	0	1	X	X	X	X	X	X	1	1	1	0	0
1	0	0	1	X	X	X	X	X	1	1	0	1	0
1	0	0	0	1	X	X	X	X	1	1	0	0	0
1	0	0	0	0	1	X	X	X	1	0	1	1	0
1	0	0	0	0	0	1	X	X	1	0	1	0	0
1	0	0	0	0	0	0	1	X	1	0	0	1	0
1	0	0	0	0	0	0	0	1	1	0	0	0	0

X = Don't Care

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**PIN ASSIGNMENT**





# MC14532B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub> "1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-2.4	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.74 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (3.65 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (5.73 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
 †T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
 f in kHz is input frequency, and k = 0.005.

# MC14532B

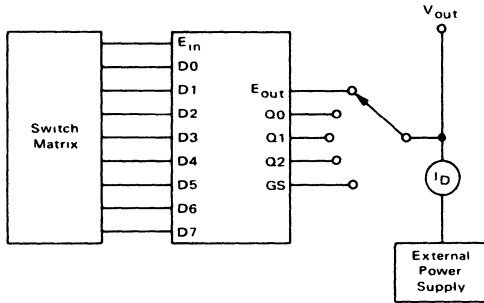
## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time t <sub>PLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>PLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time — E <sub>in</sub> to E <sub>out</sub> t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 120 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 77 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 55 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	205 110 80	410 220 160	ns
Propagation Delay Time (E <sub>in</sub> to GS) t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 90 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 57 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 40 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	175 90 65	350 180 130	ns
Propagation Delay Time — E <sub>in</sub> to Q <sub>n</sub> t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 195 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 107 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns	t <sub>PHL</sub> , t <sub>PLH</sub>	5.0 10 15	— — —	280 140 100	560 280 200	ns
Propagation Delay Time — D <sub>n</sub> to Q <sub>n</sub> t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 265 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 137 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 85 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	300 170 110	600 340 220	ns
Propagation Delay Time — D <sub>n</sub> to GS t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 195 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 107 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	280 140 100	560 280 200	ns

\*The formulas given are for the typical characteristics only at 25°C.

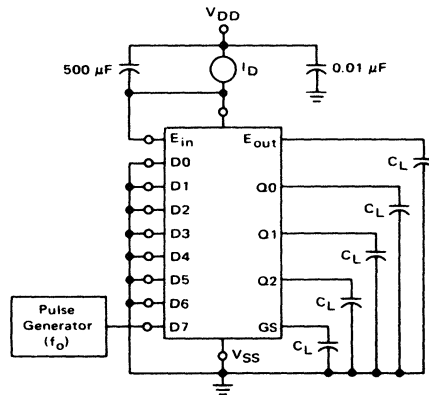
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 — TYPICAL SINK AND SOURCE CURRENT CHARACTERISTICS



Output Under Test	V <sub>GS</sub> = V <sub>DD</sub> V <sub>DS</sub> = V <sub>out</sub> Sink Current			V <sub>GS</sub> = -V <sub>DD</sub> V <sub>DS</sub> = V <sub>out</sub> - V <sub>DD</sub> Source Current		
	D0 thru D7	E <sub>in</sub>	D0 thru D6	D7	E <sub>in</sub>	
E <sub>out</sub>	X	0	0	0	1	
Q0	X	0	0	1	1	
Q1	X	0	0	1	1	
Q2	X	0	0	1	1	
GS	X	0	0	1	1	

FIGURE 2 — TYPICAL POWER DISSIPATION TEST CIRCUIT





# MC14532B

## LOGIC DIAGRAM (Positive Logic)

### LOGIC EQUATIONS

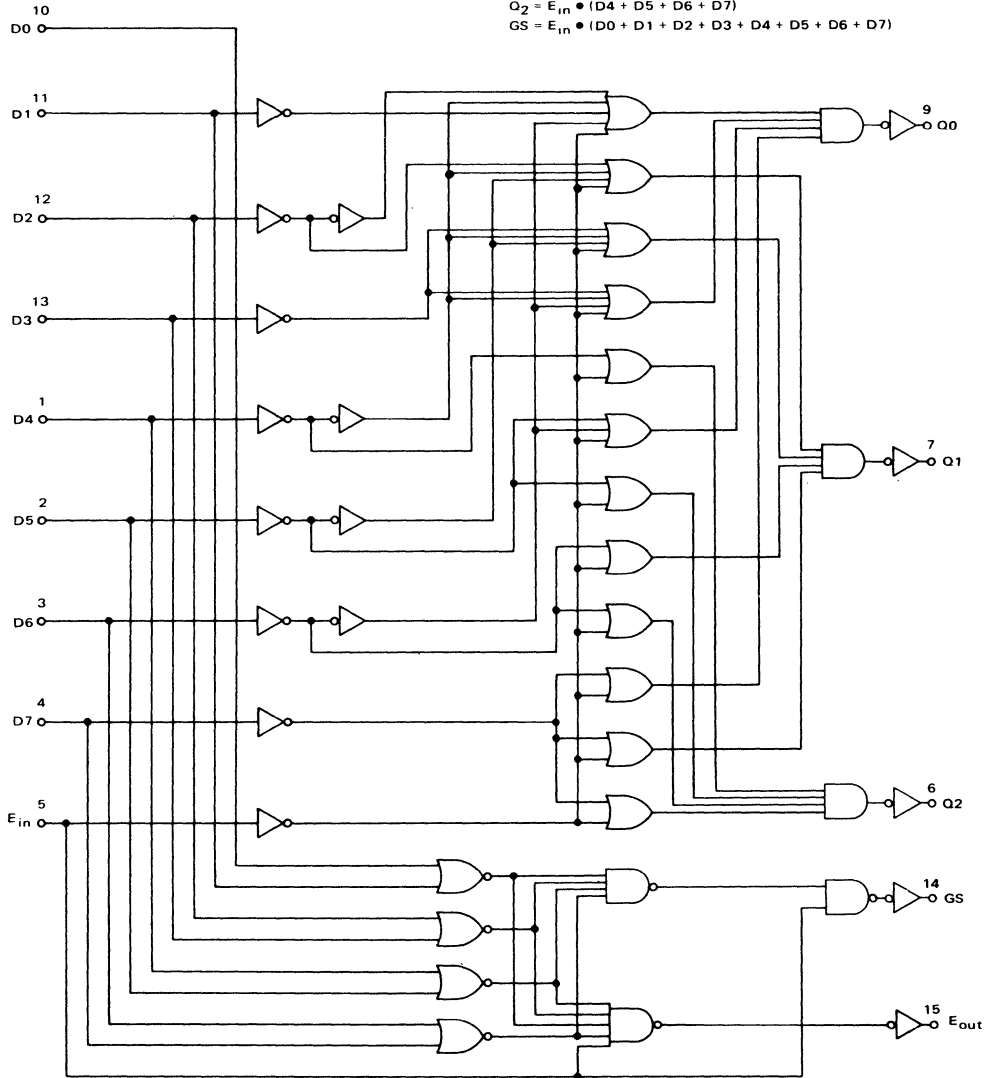
$$E_{out} = E_{in} \cdot \bar{D}_0 \cdot \bar{D}_1 \cdot \bar{D}_2 \cdot \bar{D}_3 \cdot \bar{D}_4 \cdot \bar{D}_5 \cdot \bar{D}_6 \cdot \bar{D}_7$$

$$Q_0 = E_{in} \cdot (D_1 \cdot \bar{D}_2 \cdot \bar{D}_4 \cdot \bar{D}_6 + D_3 \cdot \bar{D}_4 \cdot \bar{D}_6 + D_5 \cdot \bar{D}_6 + D_7)$$

$$Q_1 = E_{in} \cdot (D_2 \cdot \bar{D}_4 \cdot \bar{D}_5 + D_3 \cdot \bar{D}_4 \cdot \bar{D}_5 + D_6 + D_7)$$

$$Q_2 = E_{in} \cdot (D_4 + D_5 + D_6 + D_7)$$

$$GS = E_{in} \cdot (D_0 + D_1 + D_2 + D_3 + D_4 + D_5 + D_6 + D_7)$$



6

# MC14532B

FIGURE 4 – TWO MC14532B's CASCADED FOR 4-BIT OUTPUT

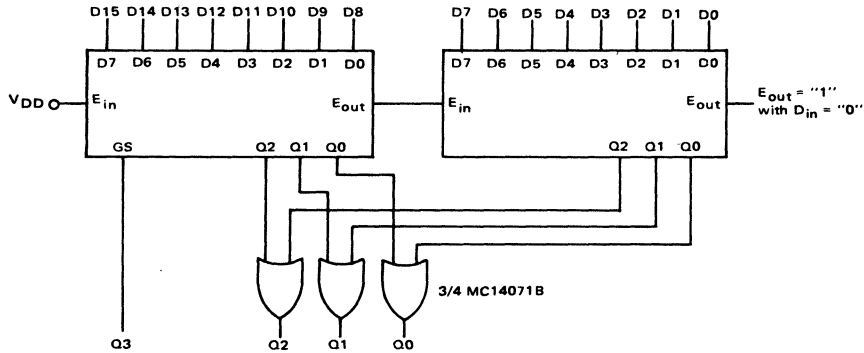


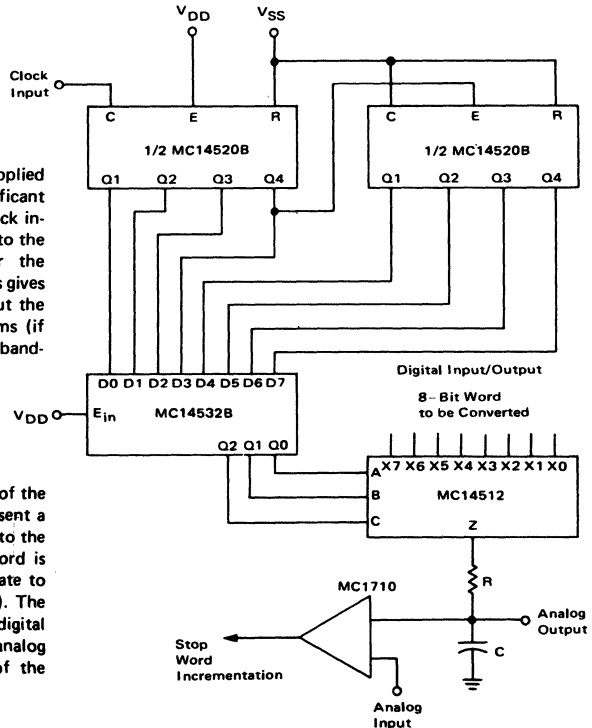
FIGURE 5 – DIGITAL TO ANALOG AND ANALOG TO DIGITAL CONVERTER

## DIGITAL TO ANALOG CONVERSION

The digital eight-bit word to be converted is applied to the inputs of the MC14512 with the most significant bit at X7 and the least significant bit at X0. A clock input of up to 2.5 MHz (at  $V_{DD} = 10\text{ V}$ ) is applied to the MC14520B. A compromise between  $I_{bias}$  for the MC1710 and  $\Delta R$  between N and P-channel outputs gives a value of R of 33 k ohms. In order to filter out the switching frequencies, RC should be about 1.0 ms (if  $R = 33\text{ k ohms}$ ,  $C \approx 0.03\text{ }\mu\text{F}$ ). The analog 3.0 dB bandwidth would then be dc to 1.0 kHz.

## ANALOG TO DIGITAL CONVERSION

An analog signal is applied to the analog input of the MC1710. A digital eight-bit word known to represent a digitized level less than the analog input is applied to the MC14512 as in the D to A conversion. The word is incremented at rates sufficient to allow steady state to be reached between incrementations (i.e. 3.0 ms). The output of the MC1710 will change when the digital input represents the first digitized level above the analog input. This word is the digital representation of the analog word.





**MOTOROLA**

**MC14534B**

**CMOS LSI**

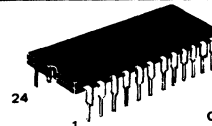
(LOW-POWER COMPLEMENTARY MOS)

**5 CASCADED BCD COUNTERS**

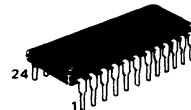
**5 CASCADED BCD COUNTERS**

The MC14534B is composed of five BCD ripple counters that have their respective outputs multiplexed using an internal scanner. Outputs of each counter are selected by the scanner and appear on four (BCD) pins. Selection is indicated by a logic high on the appropriate digit select pin. Both BCD and digit select outputs have three-state controls providing an "open-circuit" when these controls are high and allowing multiplexing. Cascading may be accomplished by using the carry-out pin. The counters and scanner can be independently reset by applying a high to the counter master reset (MR) and the scanner reset (SR). The MC14534B was specifically designed for application in real time or event counters where continual updating and multiplexed displays are used.

- Four Operating Modes (See truth table)
- Input Error Detection Circuit
- Clock Conditioning Circuits for Slow Transition Inputs
- Counter Sequences on Positive Transition of Clock A
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range



**L SUFFIX  
CERAMIC PACKAGE  
CASE 623**



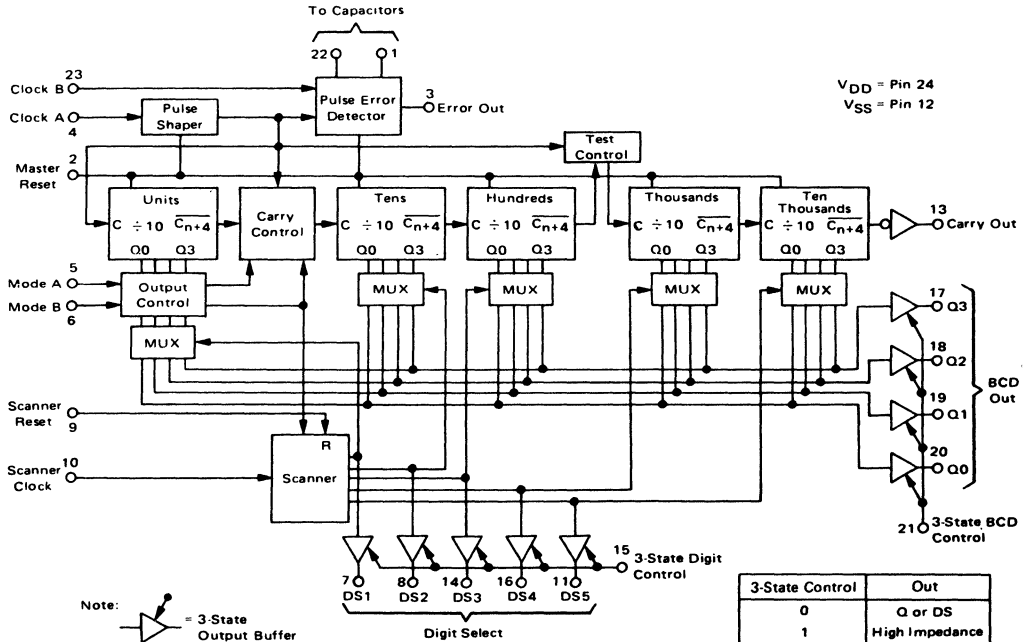
**P SUFFIX  
PLASTIC PACKAGE  
CASE 709**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXBCP (Plastic Package)  
MC14XXBCL (Ceramic Package)

**BLOCK DIAGRAM**



**6**

# MC14534B

## MAXIMUM RATINGS (Voltages referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C		T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min		Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	-	0.05	-	0	0.05	-	0.05	Vdc	
		10	-	0.05	-	0	0.05	-	0.05		
		15	-	0.05	-	0	0.05	-	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	-	4.95	5.0	-	4.95	-	Vdc
			10	9.95	-	9.95	10	-	9.95	-	
			15	14.95	-	14.95	15	-	14.95	-	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	-	1.0	-	1.5	1.0	-	1.0	Vdc	
		10	-	2.0	-	3.0	2.0	-	2.0		
		15	-	3.0	-	4.5	3.0	-	3.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	4.0	-	4.0	3.5	-	4.0	-	Vdc
			10	8.0	-	8.0	7.0	-	8.0	-	
			15	12	-	12	11	-	12	-	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	-	-2.4	-4.2	-	-1.7	-	mA <sub>dc</sub>	
		5.0	-0.64	-	-0.51	-0.88	-	-0.36	-		
		10	-1.6	-	-1.3	-2.25	-	-0.9	-		
	Sink I <sub>OL</sub>	5.0	0.64	-	0.51	0.88	-	0.36	-	mA <sub>dc</sub>	
		10	1.6	-	1.3	2.25	-	0.9	-		
		15	4.2	-	3.4	8.8	-	2.4	-		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	-	-2.1	-4.2	-	-1.7	-	mA <sub>dc</sub>	
		5.0	-0.52	-	-0.44	-0.88	-	-0.36	-		
		10	-1.3	-	-1.1	-2.25	-	-0.9	-		
	Sink I <sub>OL</sub>	5.0	0.52	-	0.44	0.88	-	0.36	-	mA <sub>dc</sub>	
		10	1.3	-	1.1	2.25	-	0.9	-		
		15	3.6	-	3.0	8.8	-	2.4	-		
Output Drive Current -- Pins 1 and 22 (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-0.31	-	-0.25	-0.8	-	-0.17	-	mA <sub>dc</sub>	
		10	-0.31	-	-0.25	-0.4	-	-0.17	-		
		15	-0.9	-	-0.75	-1.6	-	-0.51	-		
	Sink I <sub>OL</sub>	5.0	0.024	-	0.02	0.03	-	0.014	-	mA <sub>dc</sub>	
		10	0.06	-	0.05	0.09	-	0.035	-		
		15	1.3	-	0.25	1.63	-	0.175	-		
Output Drive Current -- Pins 1 and 22 (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-0.11	-	-0.10	-0.8	-	-0.08	-	mA <sub>dc</sub>	
		10	-0.11	-	-0.10	-0.4	-	-0.08	-		
		15	-0.33	-	-0.30	-1.6	-	-0.24	-		
	Sink I <sub>OL</sub>	5.0	0.012	-	0.01	0.02	-	0.008	-	mA <sub>dc</sub>	
		10	0.03	-	0.025	0.05	-	0.02	-		
		15	0.14	-	0.12	1.35	-	0.10	-		
Input Current (AL Device)	I <sub>in</sub>	15	-	±0.1	-	±0.00001	±0.1	-	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	-	±0.3	-	±0.00001	±0.3	-	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	-	-	-	-	5.0	7.5	-	-	pF	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14534B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>) (continued)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μA <sub>dc</sub>
		10	—	10	—	0.020	10	—	300	
		15	—	20	—	0.030	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μA <sub>dc</sub>
		10	—	100	—	0.020	100	—	750	
		15	—	200	—	0.030	200	—	1500	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	$I_T = (0.5 \mu A/kHz) f + I_{DD}$ $I_T = (1.0 \mu A/kHz) f + I_{DD}$ $I_T = (1.5 \mu A/kHz) f + I_{DD}$							μA <sub>dc</sub>
Scan Oscillator Frequency = 1 kHz										
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	± 0.1	—	0.00001	± 0.1	—	± 3.0	μA <sub>dc</sub>
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	± 1.0	—	0.00001	± 1.0	—	± 7.5	μA <sub>dc</sub>

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V/fk$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.



# MC14534B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50$ pF, $T_A = 25^\circ\text{C}$ , See Figure 1)

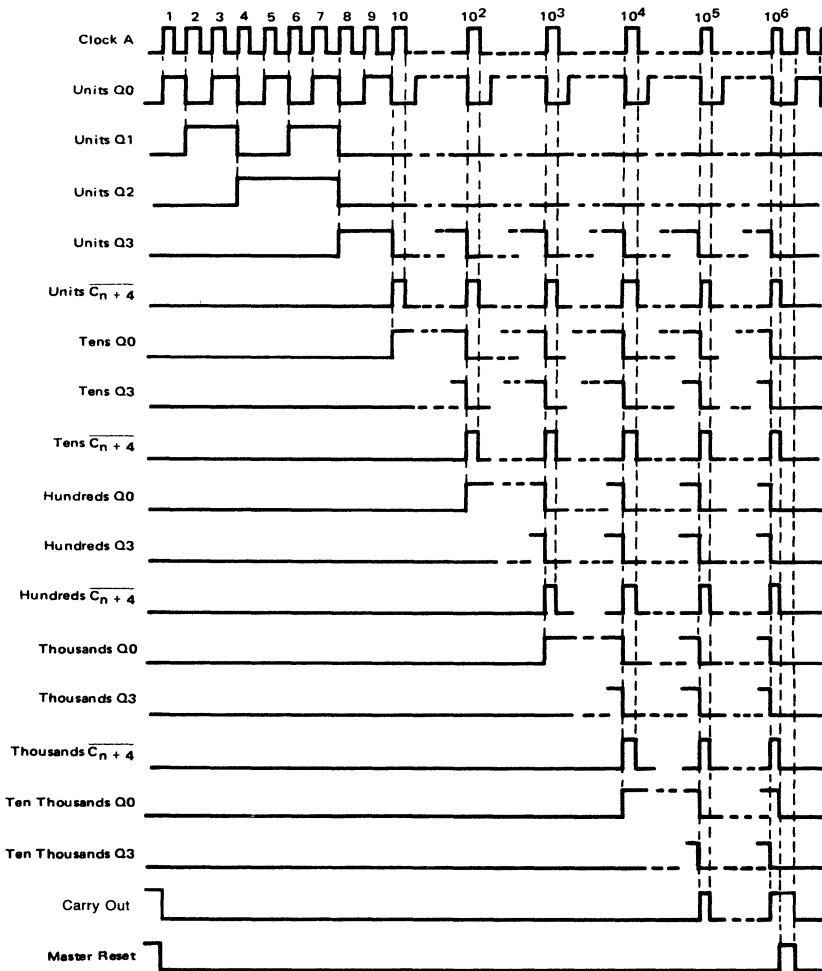
Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit	
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	ns	
		10	—	50	100		
		15	—	40	80		
Propagation Delay Time, Clock to Q $t_{PLH}, t_{PHL} = (1.8 \text{ ns/pF}) C_L + 4.0 \mu\text{s}$ $t_{PLH}, t_{PHL} = (0.8 \text{ ns/pF}) C_L + 1.5 \mu\text{s}$ $t_{PLH}, t_{PHL} = (0.6 \text{ ns/pF}) C_L + 1.0 \mu\text{s}$ Clock to Carry Out $t_{PLH} = (1.8 \text{ ns/pF}) C_L + 3.3 \mu\text{s}$ $t_{PLH} = (0.8 \text{ ns/pF}) C_L + 1.1 \mu\text{s}$ $t_{PLH} = (0.6 \text{ ns/pF}) C_L + 0.8 \mu\text{s}$ Master Reset to Q $t_{PHL} = (1.8 \text{ ns/pF}) C_L + 1.8 \mu\text{s}$ $t_{PHL} = (0.8 \text{ ns/pF}) C_L + 0.6 \mu\text{s}$ $t_{PHL} = (0.6 \text{ ns/pF}) C_L + 0.5 \mu\text{s}$ Master Reset to Error Out $t_{PHL} = (1.8 \text{ ns/pF}) C_L + 0.57 \mu\text{s}$ $t_{PHL} = (0.8 \text{ ns/pF}) C_L + 0.19 \mu\text{s}$ $t_{PHL} = (0.6 \text{ ns/pF}) C_L + 0.11 \mu\text{s}$ Scanner Clock to Q $t_{PLH}, t_{PHL} = (1.8 \text{ ns/pF}) C_L + 1.8 \mu\text{s}$ $t_{PLH}, t_{PHL} = (0.8 \text{ ns/pF}) C_L + 0.6 \mu\text{s}$ $t_{PLH}, t_{PHL} = (0.6 \text{ ns/pF}) C_L + 0.5 \mu\text{s}$ Scanner Clock to Digit Select $t_{PHL}, t_{PLH} = (1.8 \text{ ns/pF}) C_L + 1.5 \mu\text{s}$ $t_{PHL}, t_{PLH} = (0.8 \text{ ns/pF}) C_L + 0.5 \mu\text{s}$ $t_{PHL}, t_{PLH} = (0.6 \text{ ns/pF}) C_L + 0.4 \mu\text{s}$	$t_{PLH}$ , $t_{PHL}$	5.0	—	4.0	8.0	$\mu\text{s}$	
		10	—	1.5	3.0		
		15	—	1.0	2.25		
		$t_{PLH}$	5.0	—	3.3	6.6	$\mu\text{s}$
			10	—	1.1	2.2	
			15	—	0.8	1.7	
		$t_{PHL}$	5.0	—	1.8	3.6	$\mu\text{s}$
			10	—	0.6	1.2	
			15	—	0.5	0.9	
		$t_{PHL}$	5.0	—	0.6	1.5	$\mu\text{s}$
			10	—	0.2	.5	
			15	—	0.12	0.38	
	$t_{PLH}$ , $t_{PHL}$	5.0	—	1.8	3.6	$\mu\text{s}$	
		10	—	0.6	1.2		
		15	—	0.5	0.9		
	$t_{PLH}$ , $t_{PLH}$	5.0	—	1.5	3.0	$\mu\text{s}$	
		10	—	0.5	1.0		
		15	—	0.4	0.75		
Propagation Delay Time 3-State Control to Q	$t_{PHZ}$	5.0	—	75	150	ns	
		10	—	45	90		
		15	—	40	80		
	$t_{PZH}$	5.0	—	120	240	ns	
		10	—	55	110		
		15	—	40	80		
	$t_{PLZ}$	5.0	—	120	240	ns	
		10	—	55	110		
		15	—	45	90		
	$t_{PZL}$	5.0	—	160	320	ns	
		10	—	70	140		
		15	—	45	90		
Clock Pulse Frequency	$f_{cl}$	5.0	—	1.0	0.5	MHz	
		10	—	3.0	1.0		
		15	—	5.0	1.2		
Clock or Scanner Clock Pulse Width	$t_{WH}$	5.0	1000	500	—	ns	
		10	500	190	—		
		15	375	125	—		
Scanner Reset Pulse Width	$t_w$	5.0	320	160	—	ns	
		10	130	65	—		
		15	80	40	—		
Scanner Reset Removal Time	$t_{rem}$	5.0	900	270	—	ns	
		10	150	80	—		
		15	100	50	—		
Master Reset Pulse Width	$t_{WH(R)}$	5.0	2000	900	—	ns	
		10	600	300	—		
		15	450	250	—		
Master Reset Removal Time	$t_{rem}$	5.0	1060	550	—	ns	
		10	350	205	—		
		15	250	140	—		

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14534B

COUNTER TIMING DIAGRAM



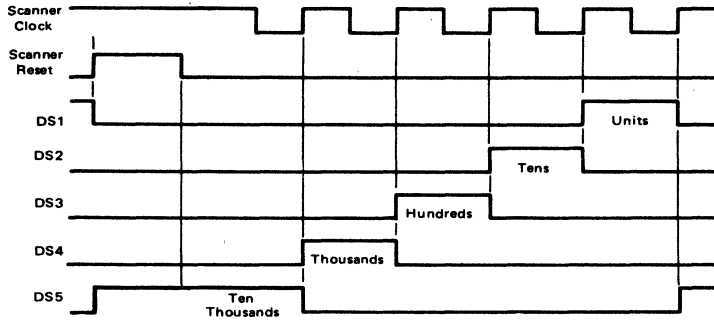
6

MODE CONTROL TRUTH TABLE

Mode A	Mode B	First Stage Output	Carry to Second Stage	Application
0	0	Normal Count and Display	At 9 to 0 transition of first stage	5-digit Counter
0	1	Inhibited	Input Clock	Test Mode: Clock directly into stages 1, 2, and 4.
1	1	Inhibited	At 4 to 5 transition of first stage	4-digit counter with $\pm 10$ and roundoff at front end.
1	0	Counts 3, 4, 5, 6, 7 = 5 Counts 8, 9, 0, 1, 2 = 0	At 7 to 8 transition of first stage	4-digit counter with 1/2 pence capability.

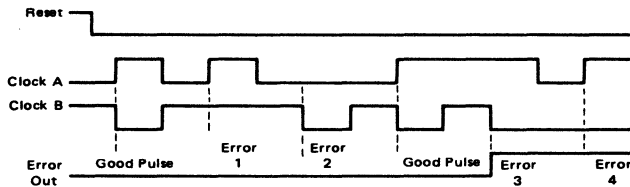
# MC14534B

## SCANNER TIMING DIAGRAM



Note: If Mode B = 1, the first decade is inhibited and S1 will not go high, and the cycle will be shortened to four stages.  
DS5 is selected automatically when Scanner Reset goes high.

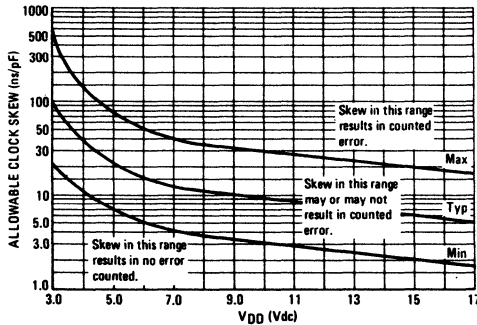
## ERROR DETECTION TIMING DIAGRAM



Note: Error detector looks for inverted pulse on Clock B. Whenever a positive edge at Clock A is not accompanied by a negative pulse at Clock B (or vice-versa) within a time period of the one-shots an error is counted. Three errors result in Error Out to go to a "1". If error detection is not needed, tie Clock B high or low and leave Pins 1 and 22 unconnected.

6

## CLOCK SKEW RANGE



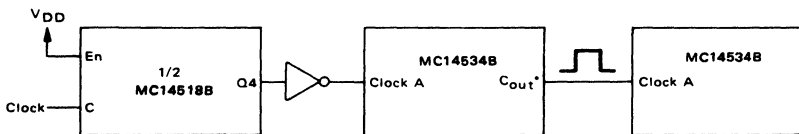
### Notes:

1. The skew is the time difference between the low-to-high transition of CA to the high-to-low transition of CB or vice-versa. Capacitors C1 = C22 tied from pins 1 and 22 to VSS.
2. This graph is accurate for C1 = C22  $\geq$  100 pF.
3. When the error detection circuitry is not used, pins 1 and 22 are left open.

# MC14534B

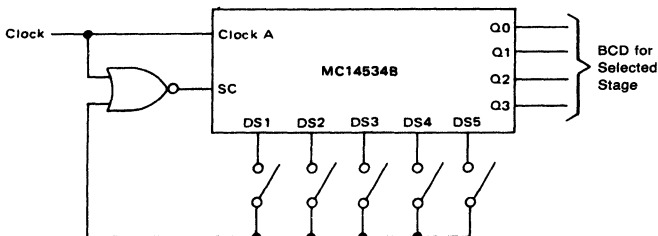
## APPLICATIONS INFORMATION

FIGURE 1 – CASCADE OPERATION



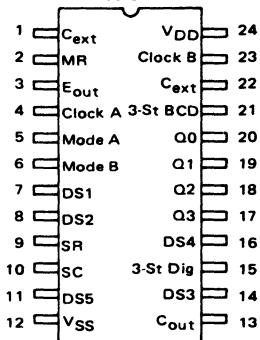
\*Carry Out is high for a single clock period when all five BCD stages go to zero. (Carry Out also goes high when MR is applied.)

FIGURE 2 — FORCING A BCD STAGE TO THE Q OUTPUTS



When the Q outputs of a given stage are required, this configuration will lock up the selected stage within four clock cycles. The select line feedback may be hardwired or switched.

### PIN ASSIGNMENT





# MOTOROLA

## MC14536B

### PROGRAMMABLE TIMER

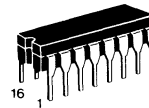
The MC14536B programmable timer is a 24-stage binary ripple counter with 16 stages selectable by a binary code. Provisions for an on-chip RC oscillator or an external clock are provided. An on-chip monostable circuit incorporating a pulse-type output has been included. By selecting the appropriate counter stage in conjunction with the appropriate input clock frequency, a variety of timing can be achieved.

- 24 Flip-Flop Stages – Will Count From  $2^0$  to  $2^{24}$
- Last 16 Stages Selectable By Four-Bit Select Code
- 8-Bypass Input Allows Bypassing of First Eight Stages
- Set and Reset Inputs
- Clock Inhibit and Oscillator Inhibit Inputs
- On-Chip RC Oscillator Provisions
- On-Chip Monostable Output Provisions
- Clock Conditioning Circuit Permits Operation With Very Long Rise and Fall Times
- Test Mode Allows Fast Test Sequence
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

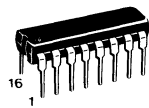
### CMOS LSI

(LOW-POWER COMPLEMENTARY MOS)

### PROGRAMMABLE TIMER



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### MAXIMUM RATINGS\* (Voltages Referenced to $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

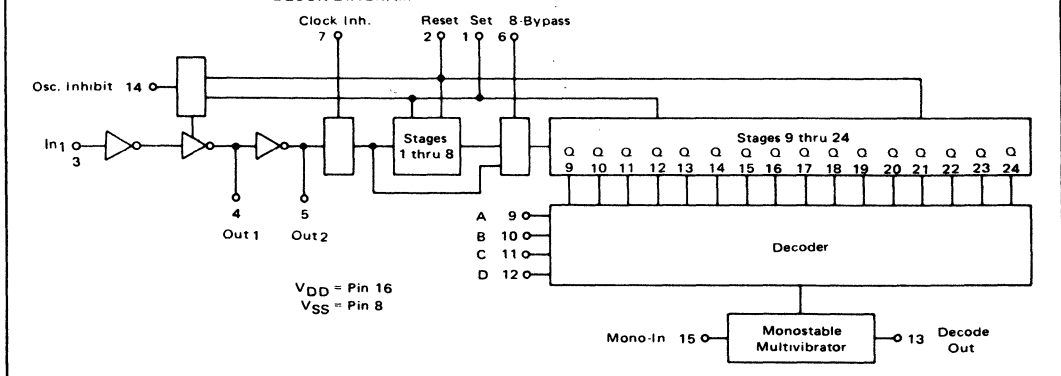
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### BLOCK DIAGRAM



# MC14536B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 4 & 5 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc	
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—		
		10	-0.62	—	-0.5	-0.9	—	-0.35	—		
		15	-1.8	—	-1.5	-3.5	—	-1.1	—		
		5.0	-3.0	—	-2.4	-4.2	—	-1.7	—		mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
	Source Pin 13 (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	1.0	-1.6	—	-1.3	-2.25	—	-0.9	—	mAdc
			15	-4.2	—	-3.4	-8.8	—	-2.4	—	
			5.0	0.64	—	0.51	0.88	—	0.36	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
			5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) Pins 4 & 5 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mAdc	
		5.0	-0.2	—	-0.16	-0.36	—	-0.12	—		
		10	-0.5	—	-0.4	-0.9	—	-0.3	—		
Source Pin 13 (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	15	-1.4	—	-1.2	-3.5	—	-1.0	—	mAdc	
		5.0	-2.5	—	-2.1	-4.2	—	-1.7	—		
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	10	-1.3	—	-1.1	-2.25	—	-0.9	—	mAdc	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
		5.0	0.52	—	0.44	0.88	—	0.36	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μAdc	
		10	—	10	—	0.020	10	—	300		
		15	—	20	—	0.030	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μAdc	
		10	—	100	—	0.020	100	—	750		
		15	—	200	—	0.030	200	—	1500		
Total Supply Current* *† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.15 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (2.3 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (3.55 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.003.

\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14536B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time (Pin 13) t <sub>TLH</sub> , t <sub>FHL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>FHL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>FHL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>FHL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q1, 8-Bypass (Pin 6) High t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 1715 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 617 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 425 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	1800 650 450	3600 1300 1000	ns
Clock to Q1, 8-Bypass (Pin 6) Low t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 3715 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 1467 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 1075 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15	— — —	3.8 1.5 1.1	7.6 3.0 2.3	μs
Clock to Q16 t <sub>PHL</sub> , t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 6915 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 2967 ns t <sub>PHL</sub> , t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 2175 ns	t <sub>PHL</sub> , t <sub>PLH</sub>	5.0 10 15	— — —	7.0 3.0 2.2	14 6.0 4.5	μs
Reset to Q <sub>n</sub> t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 1415 ns t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 567 ns t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 425 ns	t <sub>PHL</sub>	5.0 10 15	— — —	1500 600 450	3000 1200 900	ns
Clock Pulse Width	t <sub>WH</sub>	5.0 10 15	600 200 170	300 100 85	— — —	ns
Clock Pulse Frequency (50% Duty Cycle)	f <sub>cl</sub>	5.0 10 15	— — —	1.2 3.0 5.0	0.4 1.5 2.0	MHz
Clock Rise and Fall Time	t <sub>TLH</sub> , t <sub>FHL</sub>	5.0 10 15	No Limit			—
Reset Pulse Width	t <sub>WH</sub>	5.0 10 15	1000 400 300	500 200 150	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

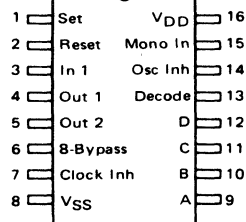
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

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This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### PIN ASSIGNMENT



# MC14536B

## PIN DESCRIPTIONS

### INPUTS

**SET (Pin 1)** — A high on Set asynchronously forces Decode Out to a high level. This is accomplished by setting an output conditioning latch to a high level while at the same time resetting the 24 flip-flop stages. After Set goes low (inactive), the occurrence of the first negative clock transition on  $IN_1$  causes Decode Out to go low. The counter's flip-flop stages begin counting on the second negative clock transition of  $IN_1$ . When Set is high, the on-chip RC oscillator is disabled. This allows for very low-power standby operation.

**RESET (Pin 2)** — A high on Reset asynchronously forces Decode Out to a low level; all 24 flip-flop stages are also reset to a low level. Like the Set input, Reset disables the on-chip RC oscillator for standby operation.

**$IN_1$  (Pin 3)** — The device's internal counters advance on the negative-going edge of this input.  $IN_1$  may be used as an external clock input or used in conjunction with  $OUT_1$  and  $OUT_2$  to form an RC oscillator. When an external clock is used, both  $OUT_1$  and  $OUT_2$  may be left unconnected or used to drive 1 LSTTL or several CMOS loads.

**8-BYPASS (Pin 6)** — A high on this input causes the first 8 flip-flop stages to be bypassed. This device essentially becomes a 16-stage counter with all 16 stages selectable. Selection is accomplished by the A, B, C, and D inputs. (See the truth tables.)

**CLOCK INHIBIT (Pin 7)** — A high on this input disconnects the first counter stage from the clocking source. This holds the present count and inhibits further counting. However, the clocking source may continue to run. Therefore, when Clock Inhibit is brought low, no oscillator start-up time is required. When Clock Inhibit is low, the counter will start counting on the occurrence of the first negative edge of the clocking source at  $IN_1$ .

**OSC INHIBIT (Pin 14)** — A high level on this pin stops the RC oscillator which allows for very low-power

standby operation. May also be used, in conjunction with an external clock, with essentially the same results as the Clock Inhibit input.

**MONO-IN (Pin 15)** — Used as the timing pin for the on-chip monostable multivibrator. If the Mono-In input is connected to  $V_{SS}$ , the monostable circuit is disabled, and Decode Out is directly connected to the selected Q output. The monostable circuit is enabled if a resistor is connected between Mono-In and  $V_{DD}$ . This resistor and the device's internal capacitance will determine the minimum output pulse widths. With the addition of an external capacitor to  $V_{SS}$ , the pulse width range may be extended. For reliable operation the resistor value should be limited to the range of 5 k $\Omega$  to 100 k $\Omega$  and the capacitor value should be limited to a maximum of 1000 pf. (See figures 3, 4, 5, and 10).

**A, B, C, D (Pins 9, 10, 11, 12)** — These inputs select the flip-flop stage to be connected to Decode Out. (See the truth tables.)

### OUTPUTS

**$OUT_1$ ,  $OUT_2$  (Pin 4, 5)** — Outputs used in conjunction with  $IN_1$  to form an RC oscillator. These outputs are buffered and may be used for 2<sup>0</sup> frequency division of an external clock.

**DECODE OUT (Pin 13)** — Output function depends on configuration. When the monostable circuit is disabled, this output is a 50% duty cycle square wave during free run.

### TEST MODE

The test mode configuration divides the 24 flip-flop stages into three 8-stage sections to facilitate a fast test sequence. The test mode is enabled when 8-Bypass, Set and Reset are at a high level. (See Figure 8.)



# MC14536B

## TRUTH TABLES

Input					Stage Selected For Decode Out
8-Bypass	D	C	B	A	
0	0	0	0	0	9
0	0	0	0	1	10
0	0	0	1	0	11
0	0	0	1	1	12
0	0	1	0	0	13
0	0	1	0	1	14
0	0	1	1	0	15
0	0	1	1	1	16
0	1	0	0	0	17
0	1	0	0	1	18
0	1	0	1	0	19
0	1	0	1	1	20
0	1	1	0	0	21
0	1	1	0	1	22
0	1	1	1	0	23
0	1	1	1	1	24

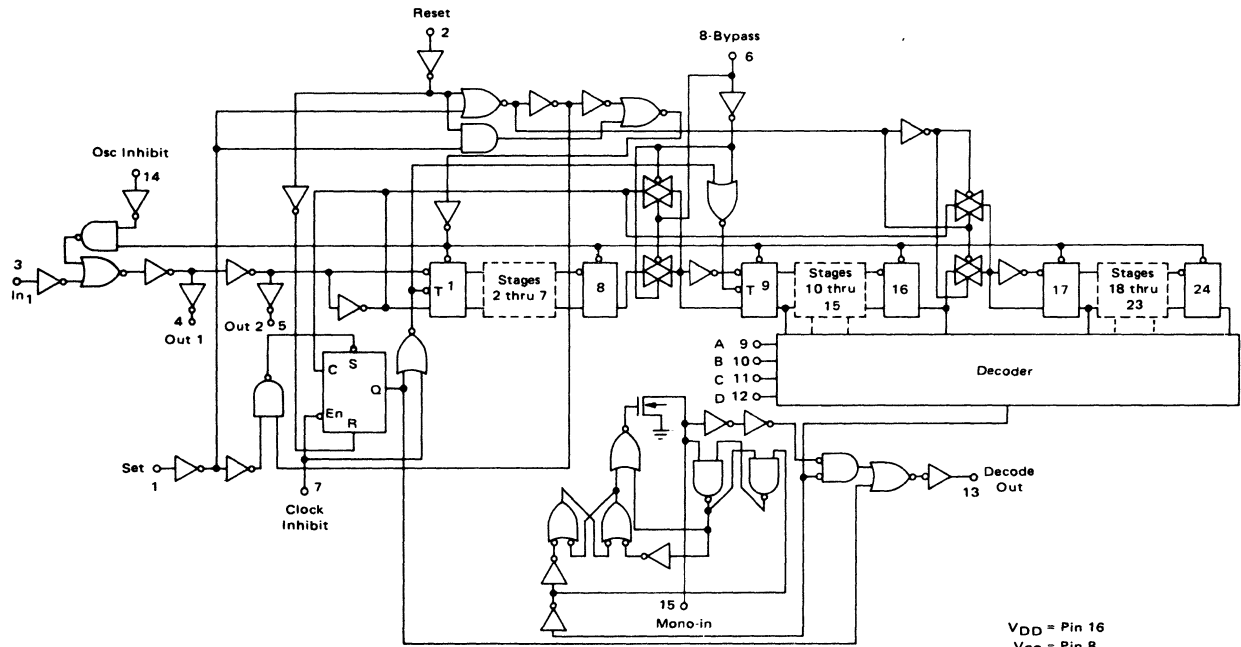
Input					Stage Selected For Decode Out
8-Bypass	D	C	B	A	
1	0	0	0	0	1
1	0	0	0	1	2
1	0	0	1	0	3
1	0	0	1	1	4
1	0	1	0	0	5
1	0	1	0	1	6
1	0	1	1	0	7
1	0	1	1	1	8
1	1	0	0	0	9
1	1	0	0	1	10
1	1	0	1	0	11
1	1	0	1	1	12
1	1	1	0	0	13
1	1	1	0	1	14
1	1	1	1	0	15
1	1	1	1	1	16

## FUNCTION TABLE

In <sub>1</sub>	Set	Reset	Clock Inh	OSC Inh	Out 1	Out 2	Decode Out
	0	0	0	0			No Change
	0	0	0	0			Advance to next state
X	1	0	0	0	0	1	1
X	0	1	0	0	0	1	0
X	0	0	1	0	—	—	No Change
X	0	0	0	1	0	1	No Change
0	0	0	0	X	0	1	No Change
1	0	0	0				Advance to next state

X = Don't Care

LOGIC DIAGRAM



MC14536B

V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

# MC14536B

## TYPICAL RC OSCILLATOR CHARACTERISTICS (For Circuit Diagram See Figure 11 In Application)

FIGURE 1 — RC OSCILLATOR STABILITY

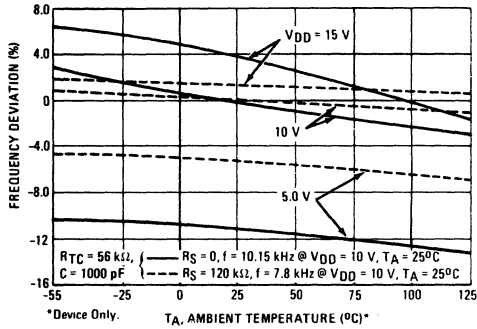
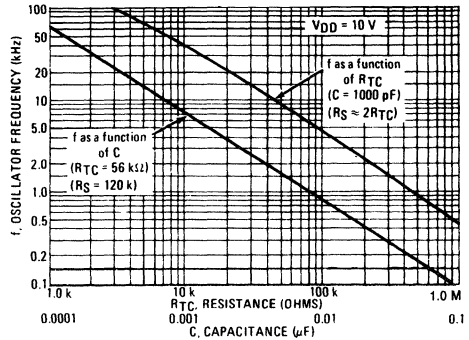


FIGURE 2 — RC OSCILLATOR FREQUENCY AS A FUNCTION OF  $R_{TC}$  AND C



## MONOSTABLE CHARACTERISTICS (For Circuit Diagram See Figure 10 In Application)

FIGURE 3 — TYPICAL  $C_X$  versus PULSE WIDTH @  $V_{DD} = 5.0 \text{ V}$

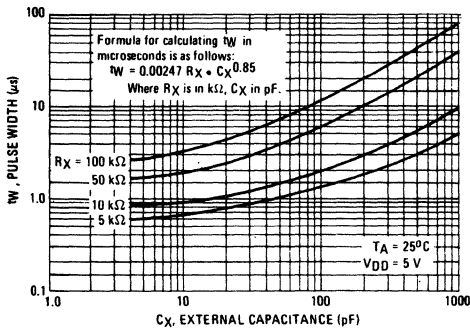


FIGURE 4 — TYPICAL  $C_X$  versus PULSE WIDTH @  $V_{DD} = 10 \text{ V}$

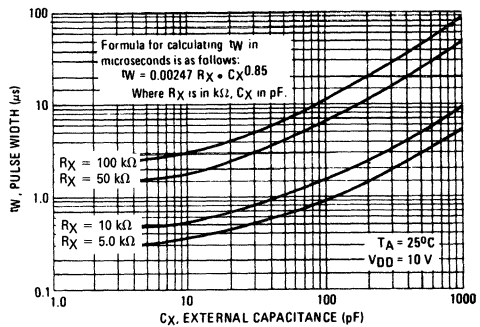
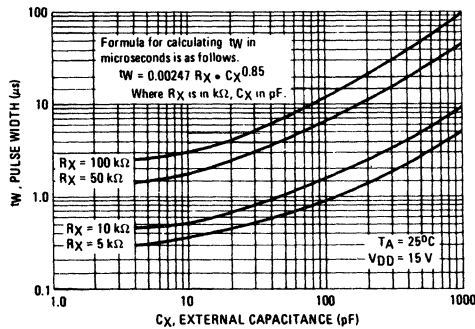


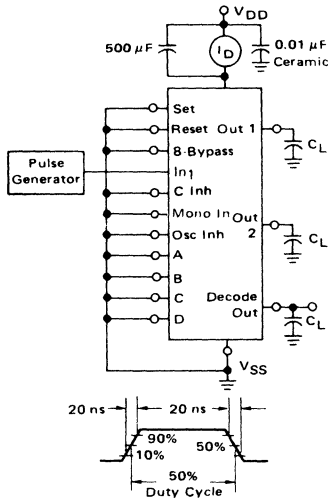
FIGURE 5 — TYPICAL  $C_X$  versus PULSE WIDTH @  $V_{DD} = 15 \text{ V}$



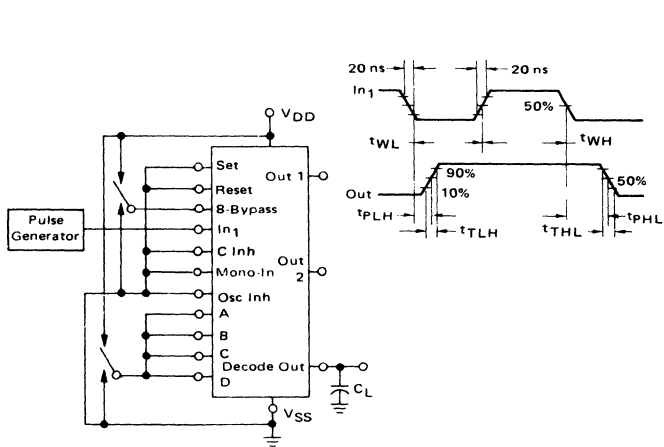
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# MC14536B

**FIGURE 6 — POWER DISSIPATION TEST CIRCUIT AND WAVEFORM**



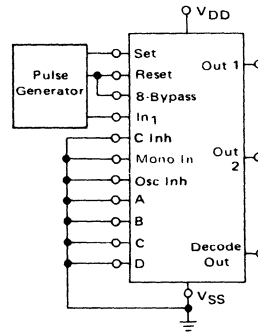
**FIGURE 7 — SWITCHING TIME TEST CIRCUIT AND WAVEFORMS**



**FIGURE 8 — FUNCTIONAL TEST CIRCUIT**

## FUNCTIONAL TEST SEQUENCE

Test function (Figure 8) has been included for the reduction of test time required to exercise all 24 counter stages. This test function divides the counter into three 8-stage sections and 255 counts are loaded in each of the 8-stage sections in parallel. All flip-flops are now at a "1". The counter is now returned to the normal 24-stages in series configuration. One more pulse is entered into In<sub>1</sub> which will cause the counter to ripple from an all "1" state to an all "0" state.

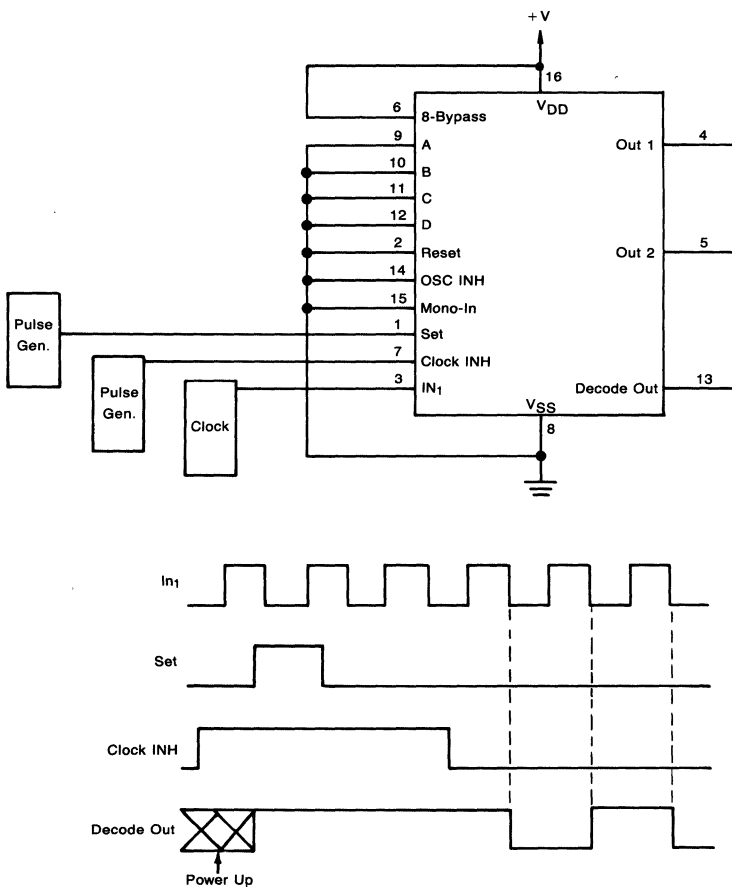


## FUNCTIONAL TEST SEQUENCE

INPUTS				OUTPUTS	COMMENTS
In <sub>1</sub>	Set	Reset	8-Bypass	Decode Out Q1 thru Q24	
1	0	1	1	0	All 24 stages are in Reset mode.
1	1	1	1	0	Counter is in three 8 stage sections in parallel mode
0	1	1	1	0	First "1" to "0" transition of clock
1 0 — — —	1	1	1		255 "1" to "0" transitions are clocked in the counter
0	1	1	1	1	The 255 "1" to "0" transition.
0	0	0	0	1	Counter converted back to 24 stages in series mode. Set and Reset must be connected together and simultaneously go from "1" to "0"
1	0	0	0	1	In <sub>1</sub> Switches to a "1".
0	0	0	0	0	Counter Ripples from an all "1" state to an all "0" state

# MC14536B

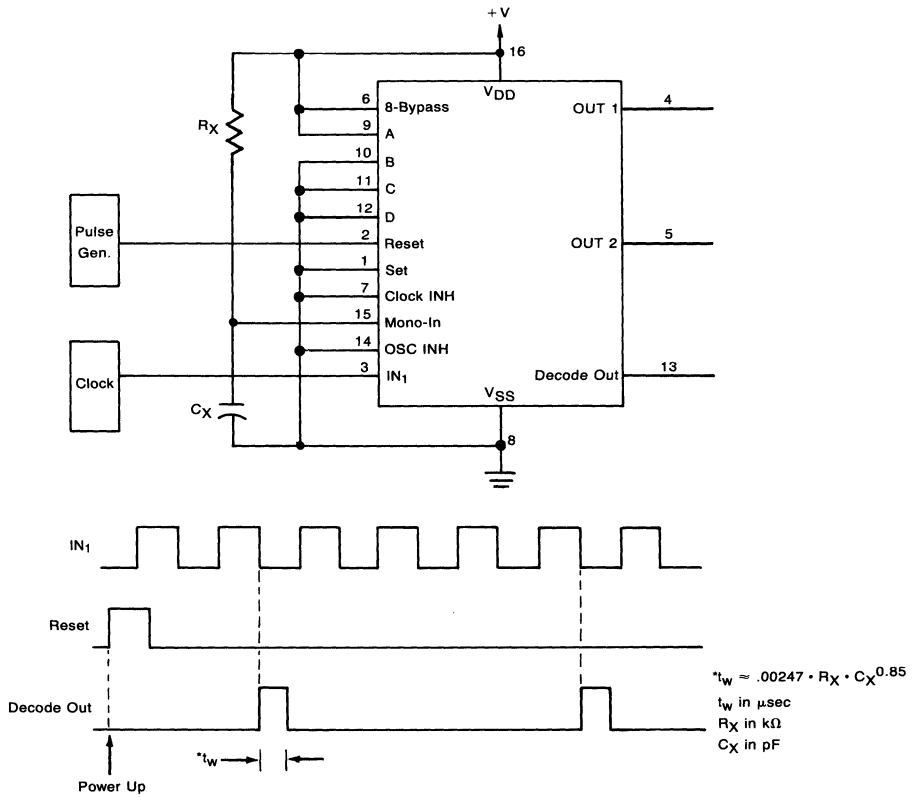
FIGURE 9 — TIME INTERVAL CONFIGURATION USING AN EXTERNAL CLOCK, SET, AND CLOCK INHIBIT FUNCTIONS (DIVIDE-BY-2 CONFIGURED)



Note: When power is first applied to the device, Decode Out can be either at a high or low state. On the rising edge of a Set pulse the output goes high if initially at a low state. The output remains high if initially at a high state. Because Clock Inh is held high, the clock source on the input pin has no effect on the output. Once Clock Inh is taken low, the output goes low on the first negative clock transition. The output returns high depending on the 8-Bypass, A, B, C, and D inputs, and the clock input period. A  $2^n$  frequency division (where  $n$  = the number of stages selected from the truth table) is obtainable at Decode Out. A  $2^0$ -divided output of  $IN_1$  can be obtained at  $OUT_1$  and  $OUT_2$ .

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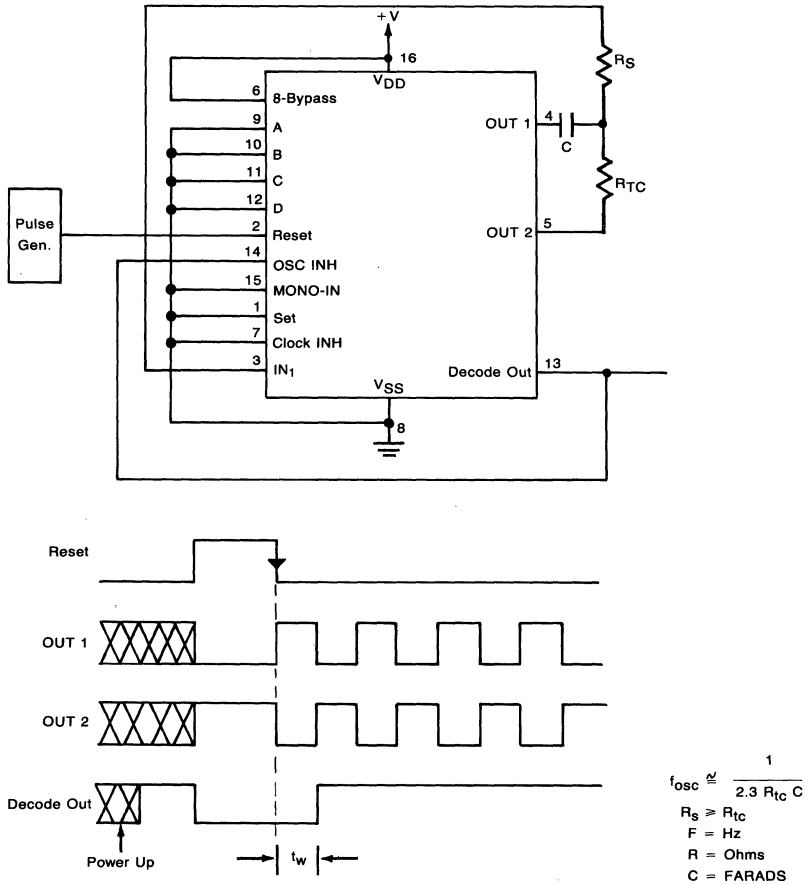
FIGURE 10 — TIME INTERVAL CONFIGURATION USING AN EXTERNAL CLOCK, RESET, AND OUTPUT MONOSTABLE TO ACHIEVE A PULSE OUTPUT. (DIVIDE-BY-4 CONFIGURED).



Note: When Power is first applied to the device with the Reset input going high, Decode Out initializes low. Bringing the Reset input low enables the chip's internal counters. After Reset goes low, the  $2^{n/2}$  negative transition of the clock input causes Decode Out to go high. Since the Mono-In input is being used, the output becomes monostable. The pulse width of the output is dependent on the external timing components. The second and all subsequent pulses occur at  $2^n \times$  (the clock period) intervals where  $n =$  the number of stages selected from the truth table.

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FIGURE 11 — TIME INTERVAL CONFIGURATION USING ON-CHIP RC OSCILLATOR AND RESET INPUT TO INITIATE TIME INTERVAL (DIVIDE-BY-2 CONFIGURED)



Note: This circuit is designed to use the on-chip oscillation function. The oscillator frequency is determined by the external R and C components. When power is first applied to the device, Decode Out initializes to a high state. Because this output is tied directly to the Osc-Inh input, the oscillator is disabled. This puts the device in a low-current standby condition. The rising edge of the Reset pulse will cause the output to go low. This in turn causes Osc-Inh to go low. However, while Reset is high, the oscillator is still disabled (i.e.: standby condition). After Reset goes low, the output remains low for  $2^{1/2}$  of the oscillator's period. After the part times out, the output again goes high.



**MOTOROLA**

**MC14538B**

**DUAL PRECISION RETRIGGERABLE/RESETTABLE MONOSTABLE MULTIVIBRATOR**

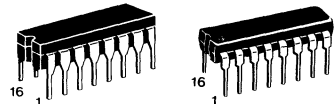
The MC14538B is a dual, retriggerable, resettable monostable multivibrator. It may be triggered from either edge of an input pulse, and produces an accurate output pulse over a wide range of widths, the duration and accuracy of which are determined by the external timing components,  $C_X$  and  $R_X$ .

- Unlimited Rise and Fall Time Allowed on the A Trigger Input
- Pulse Width Range = 10  $\mu$ s to 10 s
- Latched Trigger Inputs
- Separate Latched Reset Inputs
- 3.0 Vdc to 18 Vdc Operational Limits
- Retriggerable from Positive (A Input) or Negative-Going Edge (B-Input)
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin-for-pin Compatible with MC14528B and CD4528B (CD4098)
- Use the MC54/74HC4538 for Pulse Widths Less Than 10  $\mu$ s with Supplies Up to 6 V.

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL PRECISION RETRIGGERABLE/RESETTABLE MONOSTABLE MULTIVIBRATOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

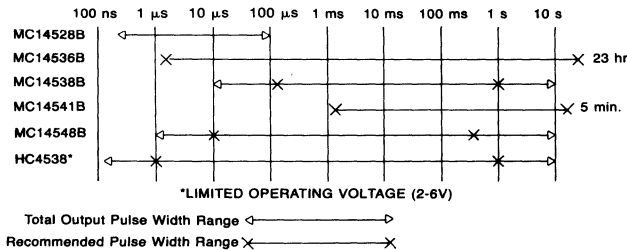
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

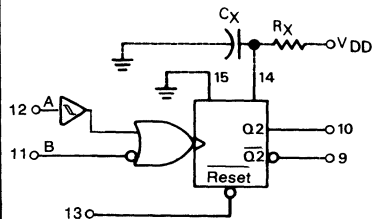
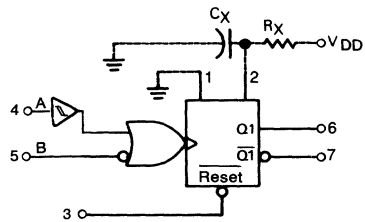
Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**ONE-SHOT SELECTION GUIDE**



**BLOCK DIAGRAM**



$R_X$  and  $C_X$  are external components.  
 $V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8, Pin 1, Pin 15

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# MC14538B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA
			10	-1.6	—	-1.3	-2.25	—	-0.9	—	
			15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA
			10	-1.3	—	-1.1	-2.25	—	-0.9	—	
			15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current, Pin 2 or 14	I <sub>in</sub>	15	—	±0.05	—	±0.00001	±.05	—	±0.5	μA	
Input Current, Other Inputs (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA	
Input Current, Other Inputs (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA	
Input Capacitance, Pin 2 or 14	C <sub>in</sub>	—	—	—	—	25	—	—	—	pF	
Input Capacitance, Other Inputs (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package) Q = Low, Q̄ = High	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package) Q = Low, Q̄ = High	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Quiescent Current, Active State (Both) (Per Package) Q = High, Q̄ = Low	I <sub>DD</sub>	5	—	2.0	—	.04	.20	—	2.0	mA	
		10	—	2.0	—	.08	.45	—	2.0		
		15	—	2.0	—	.13	.70	—	2.0		
**Total Supply Current at an external load capacitance (C <sub>L</sub> ) and at external timing network (R <sub>X</sub> , C <sub>X</sub> )	I <sub>T</sub>	5.0 10.0 15.0	$I_T = (3.5 \times 10^{-2}) R_X C_X f + 4 C_X f + 1 \times 10^{-5} C_L f$ $I_T = (8 \times 10^{-2}) R_X C_X f + 9 C_X f + 2 \times 10^{-5} C_L f$ $I_T = (1.25 \times 10^{-1}) R_X C_X f + 12 C_X f + 3 \times 10^{-5} C_L f$ where: I <sub>T</sub> in μA (one monostable switching only), C <sub>X</sub> in μF, C <sub>L</sub> in pF, R <sub>X</sub> in k ohms, and f in Hz is the input frequency.								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14538B

SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub> V <sub>dc</sub>	All Types			Unit
			Min	Typ #	Max	
Output Rise Time $t_{TLH} = (1.35 \text{ ns/pF}) C_L + 33 \text{ ns}$ $t_{TLH} = (0.60 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{TLH} = (0.40 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Output Fall Time $t_{THL} = (1.35 \text{ ns/pF}) C_L + 33 \text{ ns}$ $t_{THL} = (0.60 \text{ ns/pF}) C_L + 20 \text{ ns}$ $t_{THL} = (0.40 \text{ ns/pF}) C_L + 20 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time A or B to Q or $\bar{Q}$ $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 255 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 132 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 87 \text{ ns}$ Reset to Q or $\bar{Q}$ $t_{PLH}, t_{PHL} = (0.90 \text{ ns/pF}) C_L + 205 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.36 \text{ ns/pF}) C_L + 107 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.26 \text{ ns/pF}) C_L + 82 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15  5.0 10 15	— — —  — — —	300 150 100  250 125 95	600 300 220  500 250 190	ns  ns
Input Rise and Fall Times Reset  B Input  A Input	$t_r, t_f$	5 10 15  5 10 15  5 10 15	— — —  — — —  No Limit	— — —  300 1.2 0.4	15 5 4  1.0 0.1 0.05	$\mu\text{s}$  ms  —
Input Pulse Width A, B, or Reset	$t_{WH}, t_{WL}$	5.0 10 15	170 90 80	85 45 40	— — —	ns
Retrigger Time	$t_{rr}$	5.0 10 15	0 0 0	— — —	— — —	ns
Output Pulse Width — Q or $\bar{Q}$ Refer to Figures 8 and 9 $C_X = 0.002 \mu\text{F}, R_X = 100 \text{ k}\Omega$  $C_X = 0.1 \mu\text{F}, R_X = 100 \text{ k}\Omega$  $C_X = 10 \mu\text{F}, R_X = 100 \text{ k}\Omega$	T	5.0 10 15  5.0 10 15  5.0 10 15	198 200 202  9.3 9.4 9.5  0.91 0.92 0.93	210 212 214  9.86 10 10.14  0.965 0.98 0.99	230 232 234  10.5 10.6 10.7  1.03 1.04 1.06	$\mu\text{s}$  ms  s
Pulse Width Match between circuits in the same package. $C_X = 0.1 \mu\text{F}, R_X = 100 \text{ k}\Omega$	$100 \frac{(T_1 - T_2)}{T_1}$	5.0 10 15	— — —	$\pm 1.0$ $\pm 1.0$ $\pm 1.0$	$\pm 5.0$ $\pm 5.0$ $\pm 5.0$	%

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

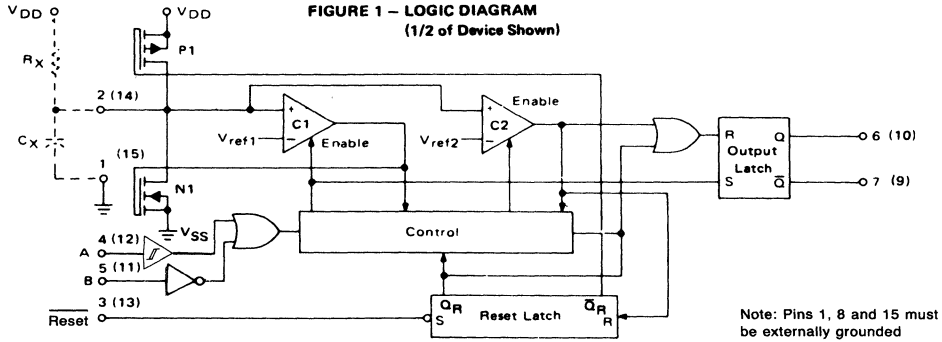
## OPERATING CONDITIONS

External Timing Resistance	$R_X$	—	5.0	—	*	k $\Omega$
External Timing Capacitance	$C_X$	—	0	—	No Limit†	$\mu\text{F}$

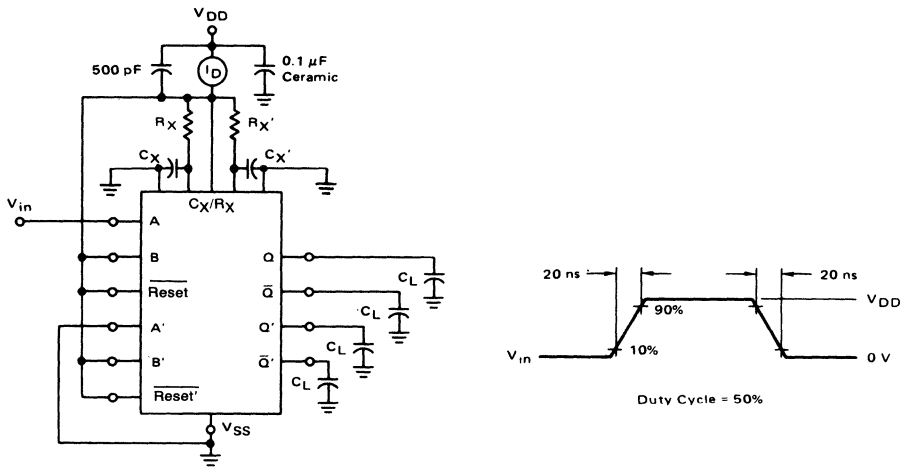
\* The maximum usable resistance  $R_X$  is a function of the leakage of the capacitor  $C_X$ , leakage of the MC14538B, and leakage due to board layout and surface resistance. Susceptibility to externally induced noise signals may occur for  $R_X > 1 \text{ M}\Omega$ .

† If  $C_X > 15 \mu\text{F}$ , use discharge protection diode per Fig. 11.

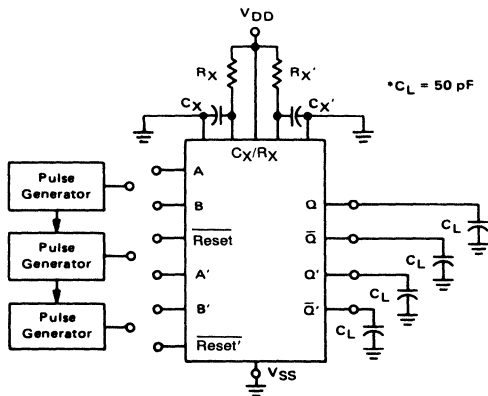
# MC14538B



**FIGURE 2 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS**



**FIGURE 3 – SWITCHING TEST CIRCUIT**

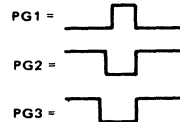


**INPUT CONNECTIONS**

CHARACTERISTICS	Reset	A	B
$t_{PLH}$ , $t_{PHL}$ , $t_{TLH}$ , $t_{THL}$ , $T$ , $\%WH$ , $\%WL$	$V_{DD}$	PG1	$V_{DD}$
$t_{PLH}$ , $t_{PHL}$ , $t_{TLH}$ , $t_{THL}$ , $T$ , $\%WH$ , $\%WL$	$V_{DD}$	$V_{SS}$	PG2
$t_{PLH(R)}$ , $t_{PHL(R)}$ , $T$ , $\%WH$ , $\%WL$	PG3	PG1	PG2

\*Includes capacitance of probes, wiring, and fixture parasitic.

NOTE: Switching test waveforms for PG1, PG2, PG3 are shown in Figure 4.



# MC14538B

FIGURE 4 – SWITCHING TEST WAVEFORMS

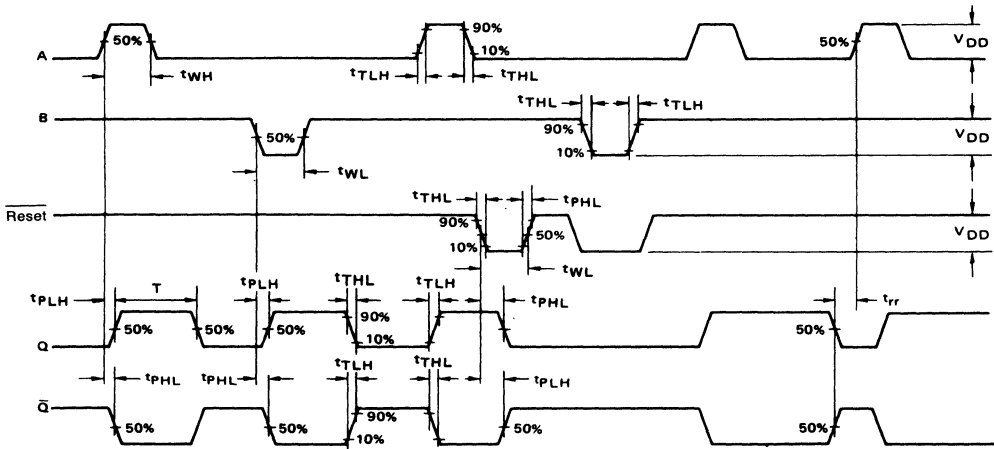


FIGURE 5 – TYPICAL NORMALIZED DISTRIBUTION OF UNITS FOR OUTPUT PULSE WIDTH

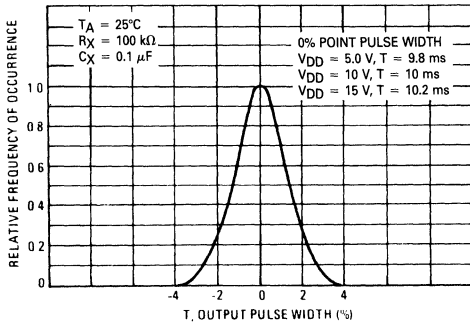


FIGURE 6 – TYPICAL PULSE WIDTH VARIATION AS A FUNCTION OF SUPPLY VOLTAGE  $V_{DD}$

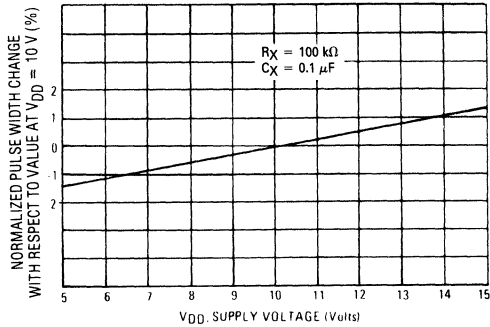
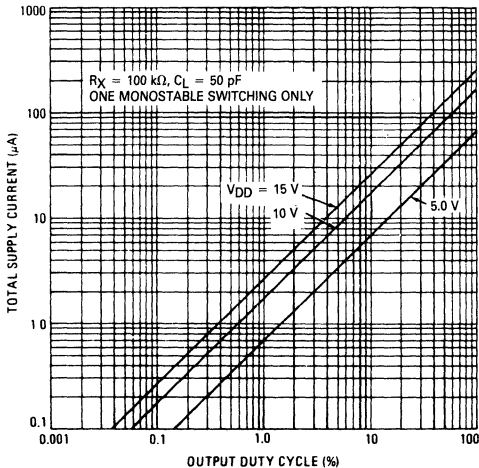


FIGURE 7 – TYPICAL TOTAL SUPPLY CURRENT versus OUTPUT DUTY CYCLE



FUNCTION TABLE

		Inputs		Outputs	
Reset		A	B	Q	$\bar{Q}$
H			H		
H		L			
H			L	Not Triggered	Not Triggered
H		H		Not Triggered	Not Triggered
H		L, H,	H	Not Triggered	Not Triggered
H		L	L, H,	Not Triggered	Not Triggered
L		X	X	L	H
		X	X	Not Triggered	Not Triggered

# MC14538B

FIGURE 8 — TYPICAL ERROR OF PULSE WIDTH EQUATION versus TEMPERATURE

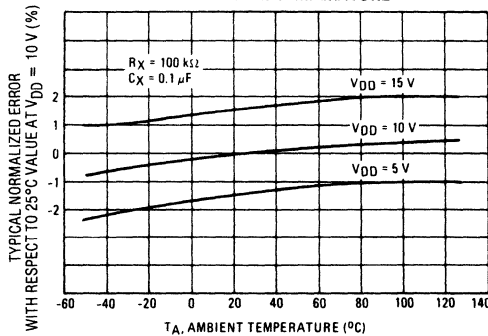
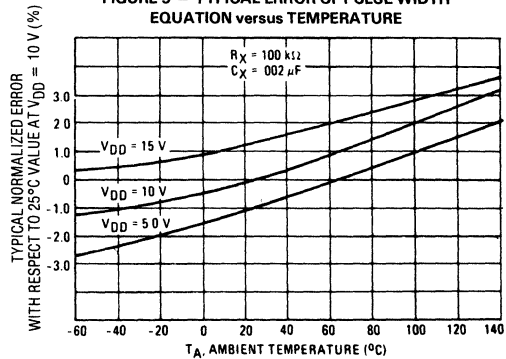
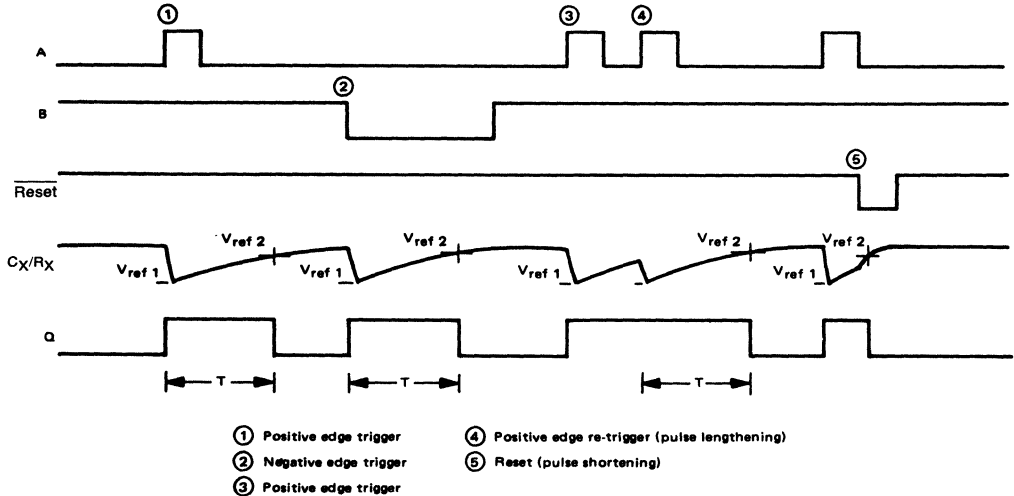


FIGURE 9 — TYPICAL ERROR OF PULSE WIDTH EQUATION versus TEMPERATURE



## THEORY OF OPERATION

FIGURE 10 — Timing Operation



## TRIGGER OPERATION

The block diagram of the MC14538B is shown in Figure 1, with circuit operation following.

As shown in Figure 1 and 10, before an input trigger occurs, the monostable is in the quiescent state with the Q output low, and the timing capacitor  $C_X$  completely charged to  $V_{DD}$ . When the trigger input A goes from  $V_{SS}$  to  $V_{DD}$  (while inputs B and Reset are held to  $V_{DD}$ ) a valid trigger is recognized, which turns on comparator C1 and N-channel transistor N1 ①. At the same time the output latch is set. With transistor N1 on, the capacitor  $C_X$  rapidly discharges toward  $V_{SS}$  until  $V_{ref1}$  is reached. At this point the output of comparator C1 changes state and transistor N1 turns off. Comparator C1 then turns off while at the same time comparator C2 turns on. With transistor N1 off, the capacitor  $C_X$  begins

to charge through the timing resistor,  $R_X$ , toward  $V_{DD}$ . When the voltage across  $C_X$  equals  $V_{ref2}$ , comparator C2 changes state, causing the output latch to reset (Q goes low) while at the same time disabling comparator C2 ②. This ends at the timing cycle with the monostable in the quiescent state, waiting for the next trigger.

In the quiescent state,  $C_X$  is fully charged to  $V_{DD}$  causing the current through resistor  $R_X$  to be zero. Both comparators are "off" with total device current due only to reverse junction leakages. An added feature of the MC14538B is that the output latch is set via the input trigger without regard to the capacitor voltage. Thus, propagation delay from trigger to Q is independent of the value of  $C_X$ ,  $R_X$ , or the duty cycle of the input waveform.

# MC14538B

## RETRIGGER OPERATION

The MC14538B is retriggered if a valid trigger occurs ③ followed by another valid trigger ④ before the Q output has returned to the quiescent (zero) state. Any retrigger, after the timing node voltage at pin 2 or 14 has begun to rise from  $V_{ref 1}$ , but has not yet reached  $V_{ref 2}$ , will cause an increase in output pulse width T. When a valid retrigger is initiated ④, the voltage at  $C_X/R_X$  will again drop to  $V_{ref 1}$  before progressing along the RC charging curve toward  $V_{DD}$ . The Q output will remain high until time T, after the last valid retrigger.

## RESET OPERATION

The MC14538B may be reset during the generation of the output pulse. In the reset mode of operation, an input pulse on  $\overline{Reset}$  sets the reset latch and causes the capacitor to be fast charged to  $V_{DD}$  by turning on transistor P1 ⑤. When the voltage on the capacitor reaches  $V_{ref 2}$ , the reset latch will clear, and will then be ready to accept another pulse. If the  $\overline{Reset}$  input is held low, any trigger inputs that occur will be inhibited and the Q and  $\overline{Q}$  outputs of the output latch will not change. Since the Q output is reset when an input low level is

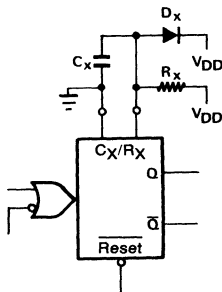
detected on the  $\overline{Reset}$  input, the output pulse T can be made significantly shorter than the minimum pulse width specification.

## POWER-DOWN CONSIDERATIONS

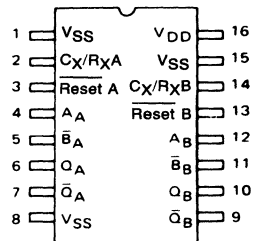
Large capacitance values can cause problems due to the large amount of energy stored. When a system containing the MC14538B is powered down, the capacitor voltage may discharge from  $V_{DD}$  through the standard protection diodes at pin 2 or 14. Current through the protection diodes should be limited to 10 mA and therefore the discharge time of the  $V_{DD}$  supply must not be faster than  $(V_{DD}) \cdot (C)/(10 \text{ mA})$ . For example, if  $V_{DD} = 10 \text{ V}$  and  $C_X = 10 \mu\text{F}$ , the  $V_{DD}$  supply should discharge no faster than  $(10 \text{ V}) \times (10 \mu\text{F})/(10 \text{ mA}) = 10 \text{ ms}$ . This is normally not a problem since power supplies are heavily filtered and cannot discharge at this rate.

When a more rapid decrease of  $V_{DD}$  to zero volts occurs, the MC14538B can sustain damage. To avoid this possibility use an external clamping diode,  $D_X$ , connected as shown in Fig. 11.

FIGURE 11 — USE OF A DIODE TO LIMIT POWER DOWN CURRENT SURGE



## PIN ASSIGNMENT



# MC14538B

## TYPICAL APPLICATIONS

FIGURE 12 — RETRIGGERABLE MONOSTABLES CIRCUITRY

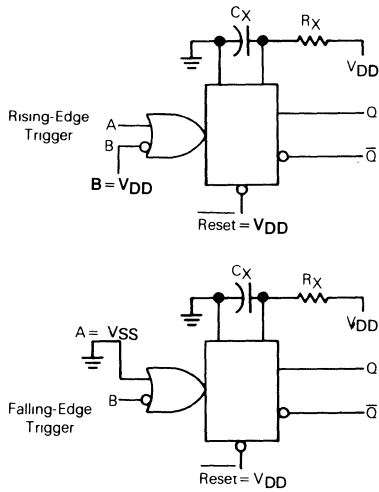


FIGURE 13 — NON-RETRIGGERABLE MONOSTABLES CIRCUITRY

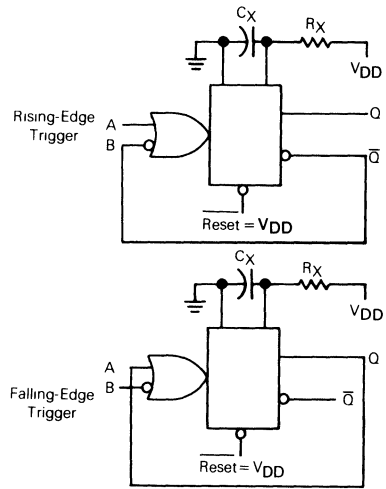
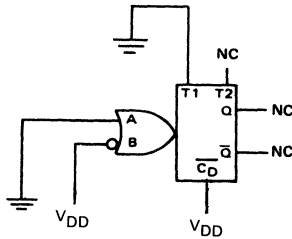


FIGURE 14 — CONNECTION OF UNUSED SECTIONS





**MOTOROLA**

**MC14539B**

**DUAL 4-CHANNEL DATA SELECTOR/MULTIPLEXER**

The MC14539B data selector/multiplexer is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. The circuit consists of two sections of four inputs each. One input from each section is selected by the address inputs A and B. A "high" on the Strobe input will cause the output to remain "low".

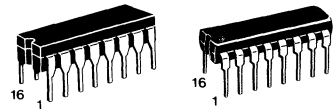
This device finds primary application in signal multiplexing functions. It permits multiplexing from N-lines to I-line, and can also perform parallel-to-serial conversion. The Strobe input allows cascading of n-lines to n-lines.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL 4-CHANNEL DATA SELECTOR/MULTIPLEXER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

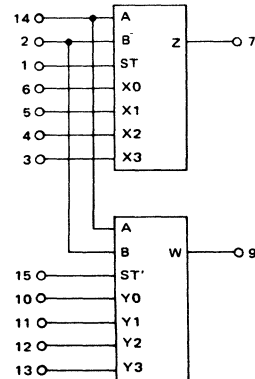
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

ADDRESS INPUTS		DATA INPUTS				ST, ST'	OUTPUTS Z, W
B	A	X3 Y3	X2 Y2	X1 Y1	X0 Y0		
X	X	X	X	X	X	1	0
0	0	X	X	X	0	0	0
0	0	X	X	X	1	0	1
0	1	X	X	0	X	0	0
0	1	X	X	1	X	0	1
1	0	X	0	X	X	0	0
1	0	X	1	X	X	0	1
1	1	0	X	X	X	0	0
1	1	1	X	X	X	0	1

X = Don't Care

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8



# MC14539B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
			10	—	0.05	—	0	0.05	—	0.05		
			15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
				10	9.95	—	9.95	10	—	9.95	—	
				15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
			10	—	3.0	—	4.50	3.0	—	3.0		
			15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
			10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
			10	1.6	—	1.3	2.25	—	0.9	—		
			15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
			10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
			10	1.3	—	1.1	2.25	—	0.9	—		
			15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc		
		10	—	10	—	0.010	10	—	300			
		15	—	20	—	0.015	20	—	600			
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc		
		10	—	40	—	0.010	40	—	300			
		15	—	80	—	0.015	80	—	600			
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							μAdc		
		10	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>									
		15	I <sub>T</sub> = (2.6 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14539B

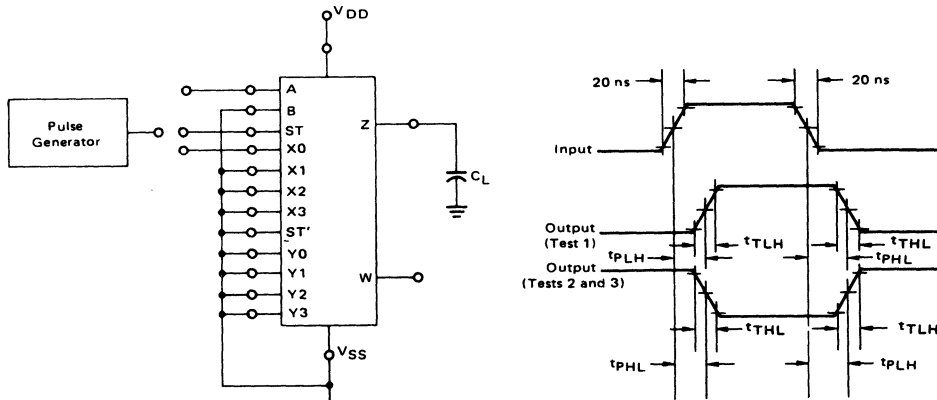
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit	
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0	—	100	200	ns	
		10	—	50	100		
		15	—	40	80		
Propagation Delay Time X, Y Input to Output $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 125 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.55 \text{ ns/pF}) C_L + 45 \text{ ns}$ A Input to Output $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 140 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 77 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 160 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 82 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$ Strobe Input to Output $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0	—	210	420	ns	
		10	—	90	180		
		15	—	70	140		
	A Input to Output $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 140 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 77 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 60 \text{ ns}$	$t_{PLH}$	5.0	—	225	450	ns
			10	—	110	220	
			15	—	85	170	
	Strobe Input to Output $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 160 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 82 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 65 \text{ ns}$	$t_{PHL}$	5.0	—	245	490	ns
			10	—	115	230	
			15	—	90	180	
	Strobe Input to Output $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 60 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 42 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 35 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0	—	145	290	ns
			10	—	75	150	
			15	—	60	120	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 — AC TEST CIRCUIT AND WAVEFORMS

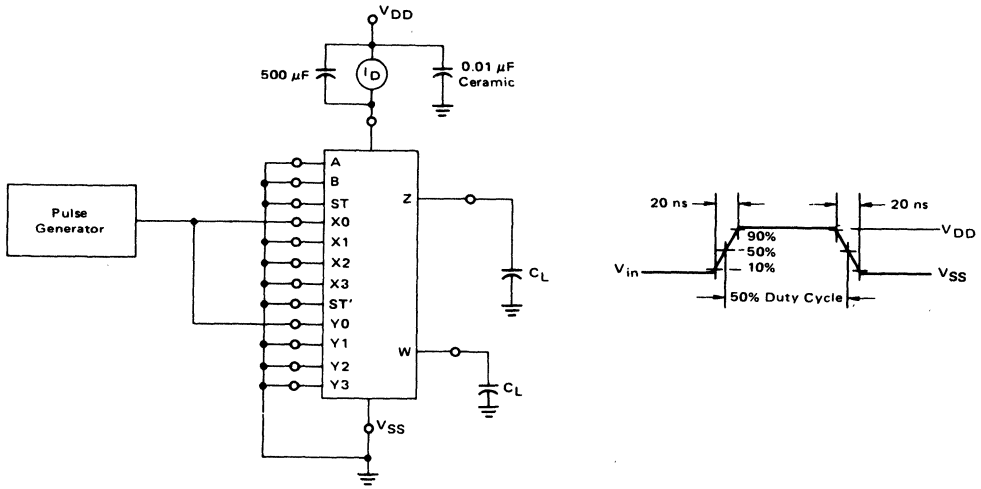


Input Connections for  $t_{TLH}$ ,  $t_{THL}$ ,  $t_{PHL}$ ,  $t_{PLH}$

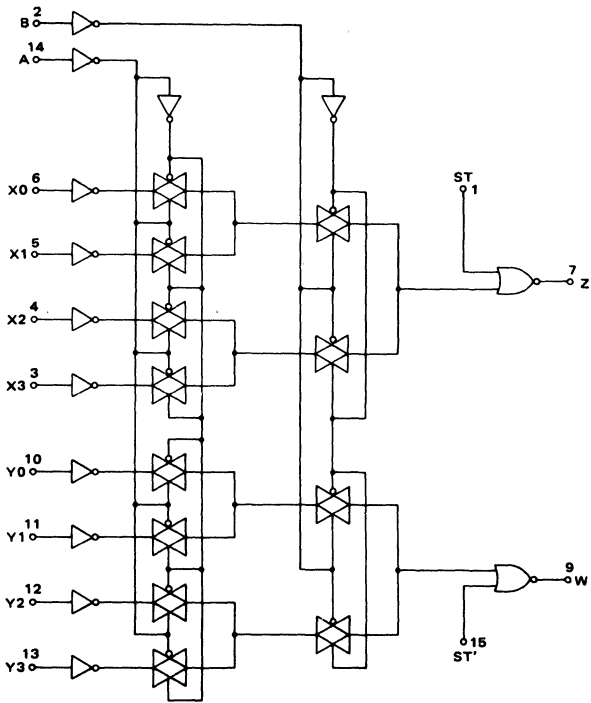
TEST	STROBE	A	X0
1	Gnd	Gnd	P. G
2	P. G.	Gnd	V <sub>DD</sub>
3	Gnd	P. G.	V <sub>DD</sub>

# MC14539B

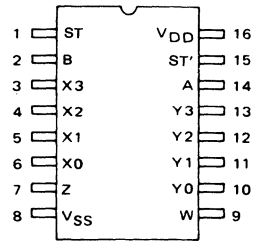
FIGURE 2 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



## LOGIC DIAGRAM



## PIN ASSIGNMENT



6



**MOTOROLA**

**MC14541B**

**PROGRAMMABLE TIMER**

The MC14541B programmable timer consists of a 16-stage binary counter, an integrated oscillator for use with an external capacitor and two resistors, an automatic power-on reset circuit, and output control logic.

Timing is initialized by turning on power, whereupon the power-on reset is enabled and initializes the counter, within the specified  $V_{DD}$  range. With the power already on, an external reset pulse can be applied. Upon release of the initial reset command, the oscillator will oscillate with a frequency determined by the external RC network. The 16-stage counter divides the oscillator frequency ( $f_{OSC}$ ) with the  $n^{th}$  stage frequency being  $f_{OSC}/2^n$ .

- Available Outputs 2<sup>8</sup>, 2<sup>10</sup>, 2<sup>13</sup> or 2<sup>16</sup>
- Increments on Positive Edge Clock Transitions
- Built-in Low Power RC Oscillator  
(± 2% accuracy over temperature range and ± 20% supply and ± 3% over processing at < 10 kHz)
- Oscillator May Be Bypassed if External Clock Is Available (Apply external clock to Pin 3)
- External Master Reset Totally Independent of Automatic Reset Operation
- Operates as 2<sup>n</sup> Frequency Divider or Single Transition Timer
- Q/ $\bar{Q}$  Select Provides Output Logic Level Flexibility
- Reset (auto or master) Disables Oscillator During Resetting to Provide No Active Power Dissipation
- Clock Conditioning Circuit Permits Operation with Very Slow CLock Rise and Fall Times
- Automatic Reset Initializes All Counters On Power Up
- Supply Voltage Range = 3.0 Vdc to 18 Vdc with Auto Reset Disabled (Pin 5 =  $V_{DD}$ )  
= 8.5 Vdc to 18 Vdc with Auto Reset Enabled (Pin 5 =  $V_{SS}$ )

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

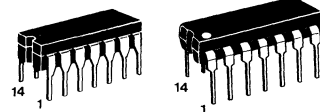
Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Pin	± 10	mA
$I_{out}$	Output Current (DC or Transient), per Pin	± 45	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**OSCILLATOR/TIMER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

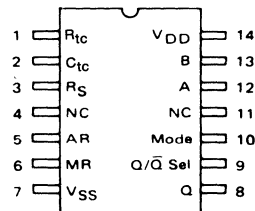
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**PIN ASSIGNMENT**



NC = No Connection

# MC14541B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-7.96	—	-6.42	-12.83	—	-4.49	—	mA <sub>dc</sub>	
		10	-4.19	—	-3.38	-6.75	—	-2.37	—		
		15	-16.3	—	-13.2	-26.33	—	-9.24	—		
	Sink I <sub>OL</sub>	5.0	1.93	—	1.56	3.12	—	1.09	—	mA <sub>dc</sub>	
		10	4.96	—	4.0	8.0	—	2.8	—		
		15	19.3	—	15.6	31.2	—	10.9	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-5.1	—	-4.27	-12.83	—	-3.5	—	mA <sub>dc</sub>	
		10	-2.69	—	-2.25	-6.75	—	-1.85	—		
		15	-10.5	—	-8.8	-26.33	—	-7.22	—		
	Sink I <sub>OL</sub>	5.0	1.24	—	1.04	3.12	—	0.85	—	mA <sub>dc</sub>	
		10	3.18	—	2.66	8.0	—	2.18	—		
		15	12.4	—	10.4	31.2	—	8.50	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Pin 5 is High) Auto Reset Disabled	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Pin 5 is High) Auto Reset Disabled	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Auto Reset Quiescent Current (Pin 5 is low)	I <sub>DDR</sub>	10	—	250	—	30	250	—	1500	μA <sub>dc</sub>	
		15	—	500	—	82	500	—	2000		
Supply Current**† (Dynamic plus Quiescent)	I <sub>D</sub>	5.0	I <sub>D</sub> = (0.4 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	
10	I <sub>D</sub> = (0.8 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>D</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†When using the on chip oscillator the total supply current (in μA<sub>dc</sub>) becomes: I<sub>T</sub> = I<sub>D</sub> + 2 C<sub>IC</sub> V<sub>DD</sub> f × 10<sup>-3</sup> where I<sub>D</sub> is in μA, C<sub>IC</sub> is in pF, V<sub>DD</sub> in Volts DC, and f in kHz. (see fig. 3)  
Dissipation during power-on with automatic reset enabled is typically 50μA @ V<sub>DD</sub> = 10Vdc.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14541B

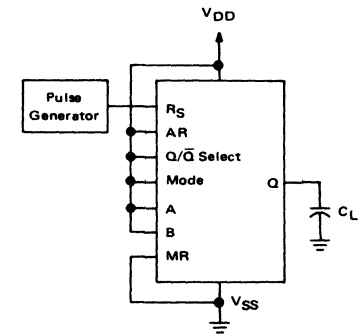
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	$V_{DD}$	Min	Typ #	Max	Unit
<b>Output Rise and Fall Time</b> $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay, Clock to Q ( $2^8$ Output) $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 3415 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 1217 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 875 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	3.5 1.25 0.9	10.5 3.8 2.9	$\mu\text{s}$
Propagation Delay, Clock to Q ( $2^{16}$ Output) $t_{PHL}, t_{PLH} = (1.7 \text{ ns/pF}) C_L + 5915 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.66 \text{ ns/pF}) C_L + 3467 \text{ ns}$ $t_{PHL}, t_{PLH} = (0.5 \text{ ns/pF}) C_L + 2475 \text{ ns}$	$t_{PHL}, t_{PLH}$	5.0 10 15	— — —	6.0 3.5 2.5	18 10 7.5	$\mu\text{s}$
Clock Pulse Width	$t_{WH}(cl)$	5.0 10 15	900 300 225	300 100 85	— — —	ns
Clock Pulse Frequency (50% Duty Cycle)	$f_{cl}$	5.0 10 15	— — —	1.5 4.0 6.0	0.75 2.0 3.0	MHz
MR Pulse Width	$t_{WH}(R)$	5.0 10 15	900 300 225	300 100 85	— — —	ns
Master Reset Removal Time	$t_{rem}$	5.0 10 15	420 200 200	210 100 100	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



( $R_{TC}$  and  $C_{TC}$  outputs are left open)

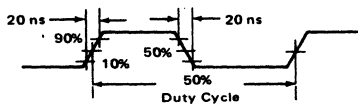
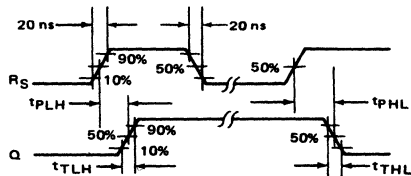
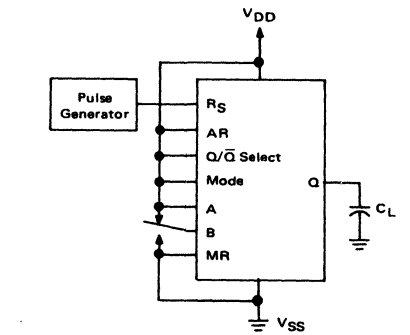


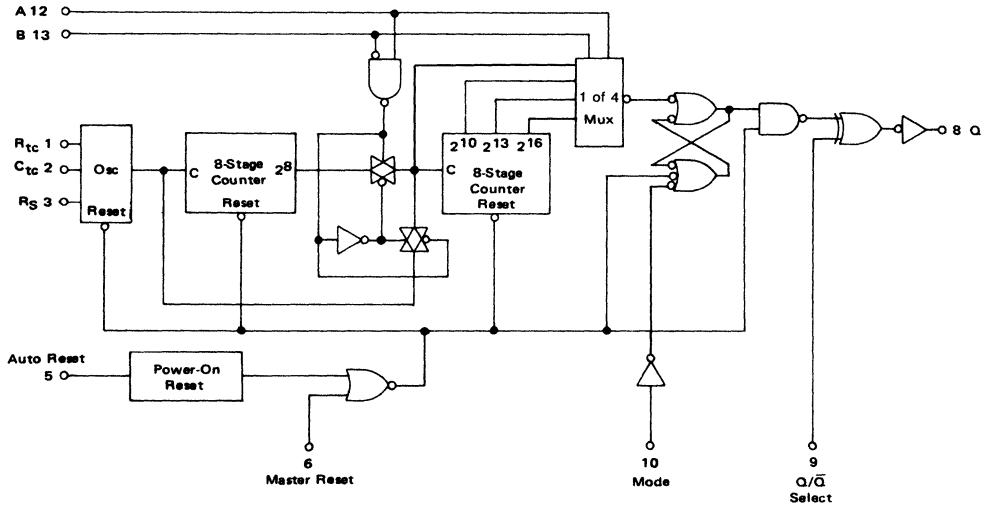
FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



6

# MC14541B

## EXPANDED BLOCK DIAGRAM



$V_{DD}$  = Pin 14  
 $V_{SS}$  = Pin 7

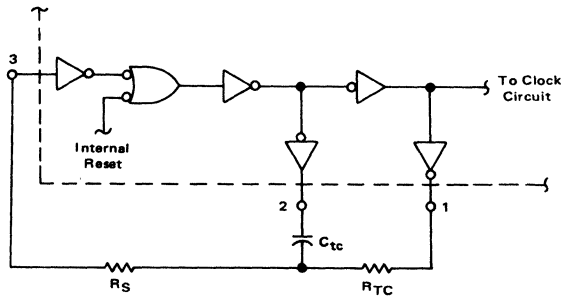
**FREQUENCY SELECTION TABLE**

A	B	Number of Counter Stages n	Count $2^n$
0	0	13	8192
0	1	10	1024
1	0	8	256
1	1	16	65536

**TRUTH TABLE**

Pin	State	
	0	1
Auto Reset, 5	Auto Reset Operating	Auto Reset Disabled
Master Reset, 6	Timer Operational	Master Reset On
$Q/\bar{Q}$ , 9	Output Initially Low After Reset	Output Initially High After Reset
Mode, 10	Single Cycle Mode	Recycle Mode

**FIGURE 3 – OSCILLATOR CIRCUIT USING RC CONFIGURATION**



# MC14541B

## TYPICAL RC OSCILLATOR CHARACTERISTICS

FIGURE 4 — RC OSCILLATOR STABILITY

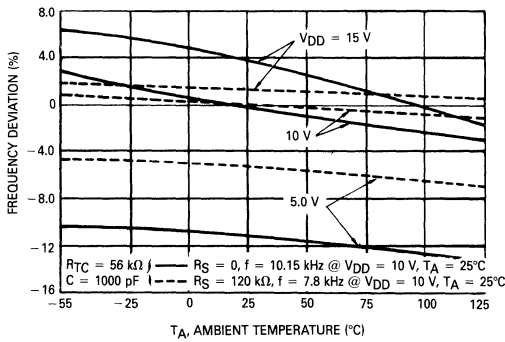
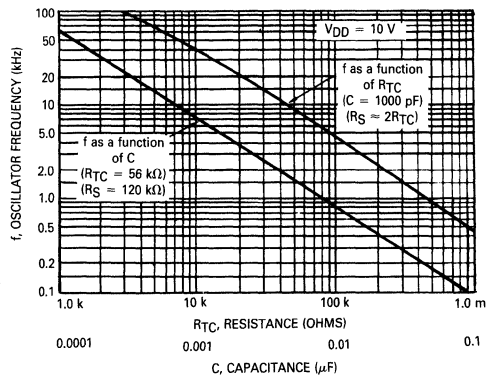


FIGURE 5 — RC OSCILLATOR FREQUENCY AS A FUNCTION OF  $R_{TC}$  AND  $C_{TC}$



## OPERATING CHARACTERISTICS

With Auto Reset pin set to a "0" the counter circuit is initialized by turning on power. Or with power already on, the counter circuit is reset when the Master Reset pin is set to a "1". Both types of reset will result in synchronously resetting all counter stages independent of counter state. Auto Reset pin when set to a "1" provides a low power operation.

The RC oscillator as shown in Figure 3 will oscillate with a frequency determined by the external RC network i.e.,

$$f = \frac{1}{2.3 R_{tc} C_{tc}} \quad \text{if } (1 \text{ kHz} \leq f \leq 100 \text{ kHz})$$

and  $R_S \approx 2 R_{tc}$  where  $R_S \geq 10 \text{ k}\Omega$

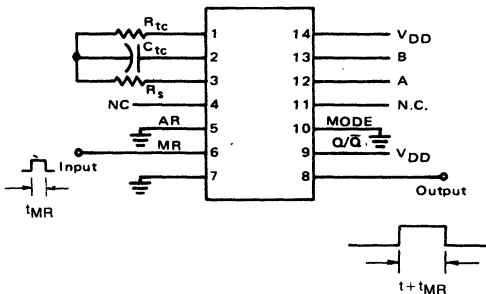
The time select inputs (A and B) provide a two-bit address to output any one of four counter stages (28, 210, 213 and 216). The  $2^n$  counts as shown in the Frequency Selection Table represents the Q output of the  $N^{\text{th}}$  stage of the counter. When A is "1", 216 is selected for both

states of B. However, when B is "0", normal counting is interrupted and the 9th counter stage receives its clock directly from the oscillator (i.e., effectively outputting 28).

The  $Q/\bar{Q}$  select output control pin provides for a choice of output level. When the counter is in a reset condition and  $Q/\bar{Q}$  select pin is set to a "0" the Q output is a "0", correspondingly when  $Q/\bar{Q}$  select pin is set to a "1" the Q output is a "1".

When the mode control pin is set to a "1", the selected count is continually transmitted to the output. But, with mode pin "0" and after a reset condition the RS flip-flop (see Expanded Block Diagram) resets, counting commences, and after  $2^{n-1}$  counts the RS flip-flop sets which causes the output to change state. Hence, after another  $2^{n-1}$  counts the output will not change. Thus, a Master Reset pulse must be applied or a change in the mode pin level is required to reset the single cycle operation.

## DIGITAL TIMER APPLICATION



When Master Reset (MR) receives a positive pulse, the internal counters and latch are reset. The Q output goes high and remains high until the selected (via A and B) number of clock pulses are counted, the Q output then goes low and remains low until another input pulse is received.

This "one shot" is fully retriggerable and as accurate as the input frequency. An external clock can be used (pin 3 is the clock input, pins 1 and 2 are outputs) if additional accuracy is needed.

Notice that a setup time equal to the desired pulse width output is required immediately following initial power up, during which time Q output will be high.





**MOTOROLA**

# MC14543B

## BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER for LIQUID CRYSTALS

The MC14543B BCD-to-seven segment latch/decoder/driver is designed for use with liquid crystal readouts, and is constructed with complementary MOS (CMOS) enhancement mode devices. The circuit provides the functions of a 4-bit storage latch and an 8421 BCD-to-seven segment decoder and driver. The device has the capability to invert the logic levels of the output combination. The phase (Ph), blanking (BI), and latch disable (LD) inputs are used to reverse the truth table phase, blank the display, and store a BCD code, respectively. For liquid crystal (LC) readouts, a square wave is applied to the Ph input of the circuit and the electrically common backplane of the display. The outputs of the circuit are connected directly to the segments of the LC readout. For other types of readouts, such as light-emitting diode (LED), incandescent, gas discharge, and fluorescent readouts, connection diagrams are given on this data sheet.

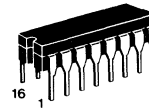
Applications include instrument (e.g., counter, DVM etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

- Latch Storage of Code
- Blanking Input
- Readout Blanking on All Illegal Input Combinations
- Direct LED (Common Anode or Cathode) Driving Capability
- Supply Voltage Range = 3.0 V to 18 V
- Capable of Driving Two Low-power TTL Loads, One Low-power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range
- Pin-for-Pin Replacement for CD4056A (with Pin 7 Tied to V<sub>SS</sub>).
- Chip Complexity: 207 FETs or 52 Equivalent Gates

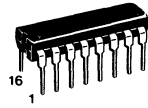
## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

## BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER for LIQUID CRYSTALS



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXBCP (Plastic Package)  
MC14XXBCL (Ceramic Package)

### TRUTH TABLE

INPUTS					OUTPUTS									
LD	BI	Ph*	D	C	B	A	a	b	c	d	e	f	g	Display
X	1	0	X	X	X	X	0	0	0	0	0	0	0	Blank
1	0	0	0	0	0	0	1	1	1	1	1	1	0	0
1	0	0	0	0	0	1	0	1	1	0	0	0	0	1
1	0	0	0	0	1	0	1	1	0	1	1	0	1	2
1	0	0	0	0	1	1	1	1	1	0	0	0	1	3
1	0	0	0	1	0	0	0	1	1	0	0	1	1	4
1	0	0	0	1	0	1	1	0	1	1	0	1	1	5
1	0	0	0	1	1	0	1	0	1	1	1	1	1	6
1	0	0	0	1	1	1	1	1	1	0	0	0	0	7
1	0	0	1	0	0	0	1	1	1	1	1	1	1	8
1	0	0	1	0	0	1	1	1	1	1	0	1	1	9
1	0	0	1	0	1	0	0	0	0	0	0	0	0	Blank
1	0	0	1	0	1	1	0	0	0	0	0	0	0	Blank
1	0	0	1	1	0	0	0	0	0	0	0	0	0	Blank
1	0	0	1	1	1	0	0	0	0	0	0	0	0	Blank
1	0	0	1	1	1	1	0	0	0	0	0	0	0	Blank
0	0	0	X	X	X	X	**	**	**	**	**	**	**	**
†	†	1	†	†	†	†	Inverse of Output Combinations Above							Display as above

X = Don't care  
† = Above Combinations  
\* = For liquid crystal readouts, apply a square wave to Ph  
For common cathode LED readouts, select Ph = 0  
For common anode LED readouts, select Ph = 1  
\*\* = Depends upon the BCD code previously applied when LD = 1

### MAXIMUM RATINGS (Voltages referenced to V<sub>SS</sub>)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +18	V
Input Voltage, All Inputs	V <sub>in</sub>	-0.5 to V <sub>DD</sub> + 0.5	V
DC Input Current per Pin	I <sub>in</sub>	±10	mA
Operating Temperature Range — AL Device CL/CP Device	T <sub>A</sub>	-55 to +125 -40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Maximum Continuous Output Drive Current (Source or Sink) per Output	I <sub>OHmax</sub> I <sub>OLmax</sub>	10	mA
Maximum Continuous Output Power* (Source or Sink) per Output	P <sub>OHmax</sub> P <sub>OLmax</sub>	70	mW

\*P<sub>OHmax</sub> = I<sub>OH</sub> (V<sub>OH</sub> - V<sub>DD</sub>) and P<sub>OLmax</sub> = I<sub>OL</sub> (V<sub>OL</sub> - V<sub>SS</sub>)

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# MC14543B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> V <sub>dC</sub>	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage V <sub>in</sub> V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	V	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	V	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage <sup>†</sup> (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	V	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 V) (V <sub>O</sub> = 1.0 or 9.0 V) (V <sub>O</sub> = 1.5 or 13.5 V)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	V
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 0.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 9.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	—	—	—	-10.1	—	—	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
		15	-4.2	—	-3.4	-8.8	—	-2.4	—		
		15	—	—	—	—	—	—	—		
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA	
		10	1.6	—	1.3	2.25	—	0.9	—		
		10	—	—	—	10.1	—	—	—		
		10	—	—	—	—	—	—	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
		15	—	—	—	—	—	—	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 0.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 9.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	—	—	—	-10.1	—	—	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
		15	-3.6	—	-3.0	-8.8	—	-2.4	—		
		15	—	—	—	—	—	—	—		
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA	
		10	1.3	—	1.1	2.25	—	0.9	—		
		10	—	—	—	10.1	—	—	—		
		10	—	—	—	—	—	—	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
		15	—	—	—	—	—	—	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA	
Input Capacitance	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> =50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> =(1.6 μA/kHz) f + I <sub>DD</sub>						μA		
		10	I <sub>T</sub> =(3.1 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> =(4.7 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> +125°C for AL Device, +85°C for CL/CP Device.

†Noise immunity specified for worst-case input combination

Noise Margin for both "1" and "0" level = 1.0 V min @ V<sub>DD</sub> = 5.0 V

2.0 V min @ V<sub>DD</sub> = 10 V

2.5 V min @ V<sub>DD</sub> = 15 V

†To calculate total supply current at loads other than 50 pF.

$$I_T(C_L) = I_T(50 \text{ pF}) + 3.5 \times 10^{-3} (C_L - 50) V_{DD} f$$

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in V, and f in kHz is input frequency.

\*\*The formulas given are for the typical characteristics only at 25°C.

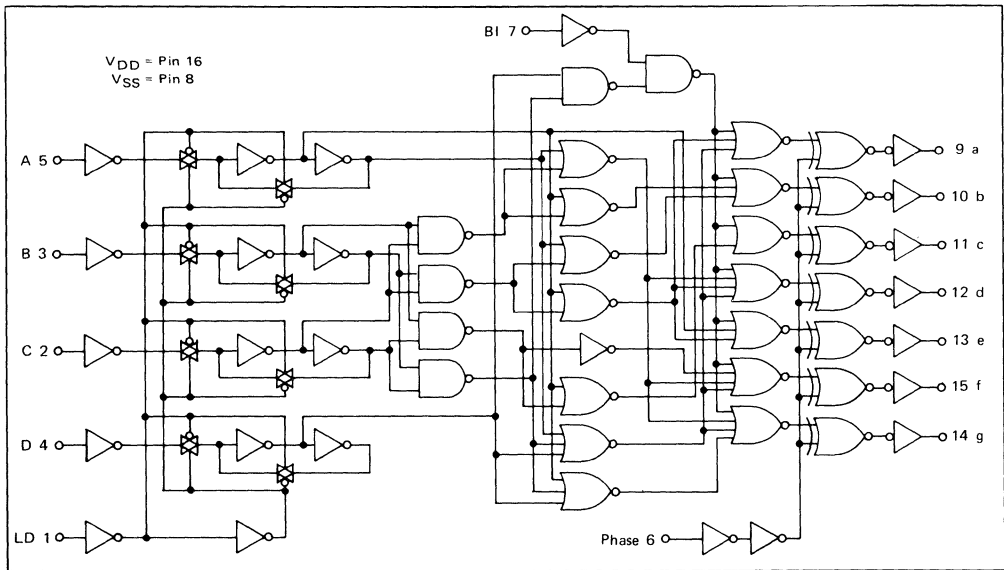
# MC14543B

**SWITCHING CHARACTERISTICS\*** ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	Min	Typ	Max	Unit
Output Rise Time $t_{\text{PLH}} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{\text{PLH}} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{\text{PLH}} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{\text{PLH}}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Output Fall Time $t_{\text{THL}} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{\text{THL}} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{\text{THL}} = (0.55 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	$t_{\text{THL}}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Turn-Off Delay Time $t_{\text{pLH}} = (1.7 \text{ ns/pF}) C_L + 520 \text{ ns}$ $t_{\text{pLH}} = (0.66 \text{ ns/pF}) C_L + 217 \text{ ns}$ $t_{\text{pLH}} = (0.5 \text{ ns/pF}) C_L + 160 \text{ ns}$	$t_{\text{pLH}}$	5.0 10 15	— — —	605 250 185	1210 500 370	ns
Turn-On Delay Time $t_{\text{pHL}} = (1.7 \text{ ns/pF}) C_L + 420 \text{ ns}$ $t_{\text{pHL}} = (0.66 \text{ ns/pF}) C_L + 172 \text{ ns}$ $t_{\text{pHL}} = (0.5 \text{ ns/pF}) C_L + 130 \text{ ns}$	$t_{\text{pHL}}$	5.0 10 15	— — —	505 205 155	1650 660 495	ns
Setup Time	$t_{\text{su}}$	5.0 10 15	350 450 500	— — —	— — —	ns
Hold Time	$t_{\text{h}}$	5.0 10 15	40 30 20	— — —	— — —	ns
Latch Disable Pulse Width (Strobing Data)	$t_{\text{WH}}$	5.0 10 15	250 100 80	125 50 40	— — —	ns

\*The formulas given are for the typical characteristics only.

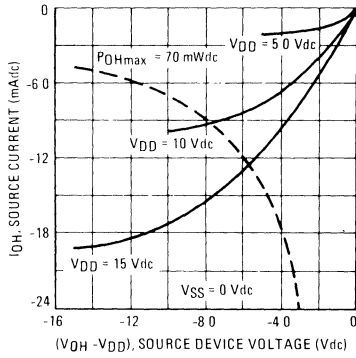
## LOGIC DIAGRAM



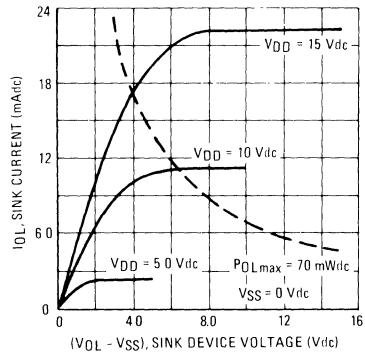
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# MC14543B

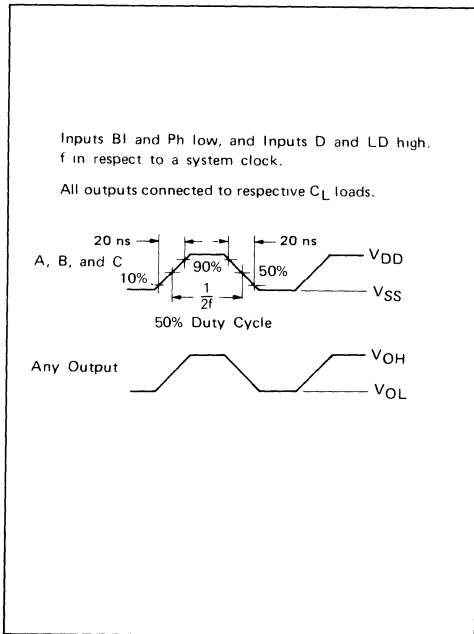
**FIGURE 1 – TYPICAL OUTPUT SOURCE CHARACTERISTICS**



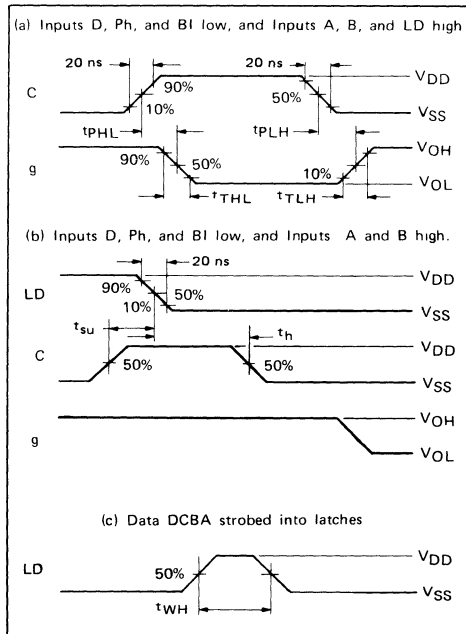
**FIGURE 2 – TYPICAL OUTPUT SINK CHARACTERISTICS**



**FIGURE 3 – DYNAMIC POWER DISIPATION SIGNAL WAVEFORMS**

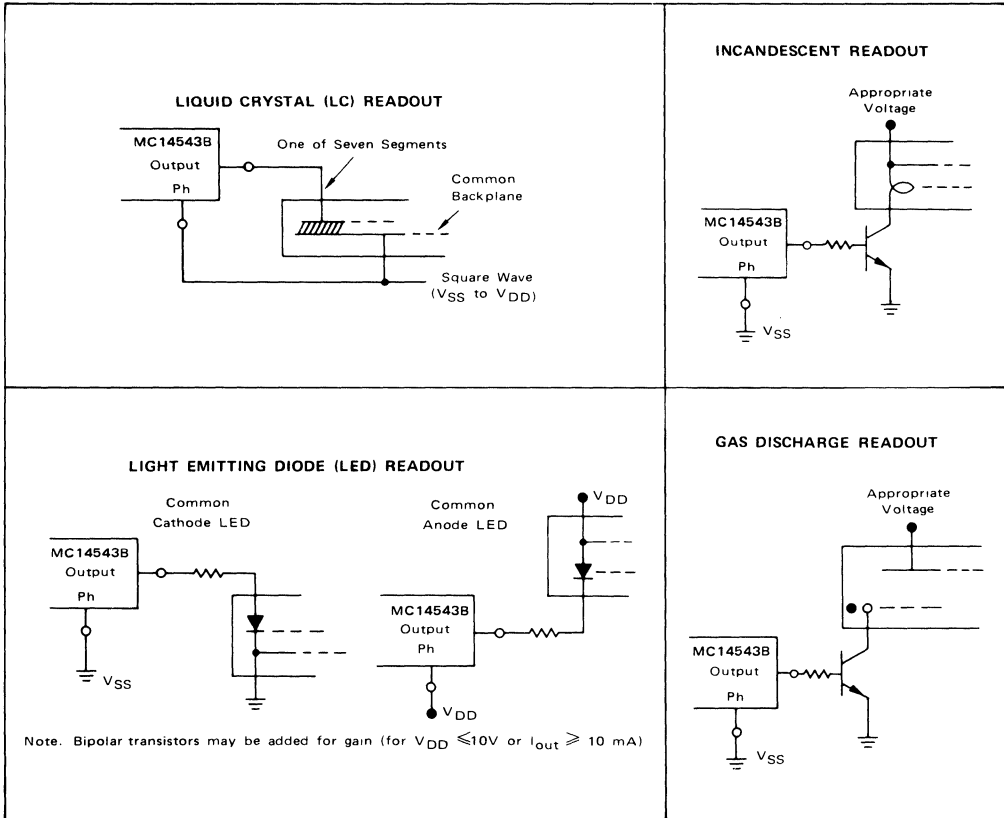


**FIGURE 4 – DYNAMIC SIGNAL WAVEFORMS**



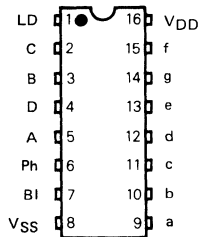
# MC14543B

## CONNECTIONS TO VARIOUS DISPLAY READOUTS



6

### PIN ASSIGNMENT

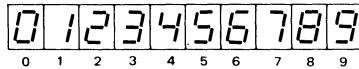


### CONNECTIONS TO SEGMENTS



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

### DISPLAY





# MC14544B

## BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER FOR LIQUID CRYSTALS

The MC14544B BCD-to-seven segment latch/decoder/driver is designed for use with liquid crystal readouts, and is constructed with complementary MOS (CMOS) enhancement mode devices. The circuit provides the functions of a 4-bit storage latch and an 8421 BCD-to-seven segment decoder and driver. The device has the capability to invert the logic levels of the output combination. The phase (Ph), blanking (BI), and latch disable (LD) inputs are used to reverse the truth table phase, blank the display, and store a BCD code, respectively. For liquid crystal (LC) readouts, a square wave is applied to the Ph input of the circuit and the electrically common backplane of the display. The outputs of the circuit are connected directly to the segments of the LC readout. The Ripple Blanking Input (RBI) and the Ripple Blanking Output (RBO) can be used to suppress either leading or trailing zeroes.

For other types of readouts, such as light-emitting diode (LED), incandescent, gas discharge, and fluorescent readouts, connection diagrams are given on this data sheet.

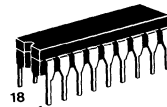
Applications include instrument (e.g., counter, DVM etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

- Latch Storage of Code
- Blanking Input
- Readout Blanking on All Illegal Input Combinations
- Direct LED (Common Anode or Cathode) Driving Capability
- Supply Voltage Range = 3.0 V to 18 V
- Capability for Suppression of Non-significant zero
- Capable of Driving Two Low-power TTL Loads, One Low-power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range

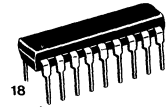
## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

## BCD-TO-SEVEN SEGMENT LATCH/DECODER/DRIVER WITH RIPPLE BLANKING



18 1  
**L SUFFIX**  
CERAMIC PACKAGE  
CASE 726



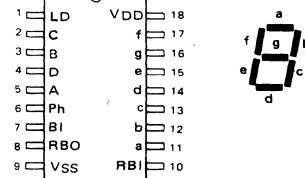
18 1  
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 707

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### PIN ASSIGNMENT



### MAXIMUM RATINGS (Voltages referenced to V<sub>SS</sub>)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +18	Vdc
Input Voltage, All Inputs	V <sub>in</sub>	-0.5 to V <sub>DD</sub> + 0.5	Vdc
DC Input Current per Pin	I <sub>in</sub>	±10	mA <sub>dc</sub>
Operating Temperature Range — AL Device CL/CP Device	T <sub>A</sub>	-55 to +125 -40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Maximum Continuous Output Drive Current (Source or Sink) per Output	I <sub>OHmax</sub> I <sub>OLmax</sub>	10	mA <sub>dc</sub>
Maximum Continuous Output Power* (Source or Sink) per Output	POHmax POLmax	70	mW

\*POHmax = I<sub>OH</sub> (V<sub>OH</sub> - V<sub>DD</sub>) and POLmax = I<sub>OL</sub> (V<sub>OL</sub> - V<sub>SS</sub>)

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V<sub>in</sub> and V<sub>out</sub> be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>).

# MC14544B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	V	
		10	–	0.05	–	0	0.05	–	0.05		
		15	–	0.05	–	0	0.05	–	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	V
			10	9.95	–	9.95	10	–	9.95	–	
			15	14.95	–	14.95	15	–	14.95	–	
Input Voltage# (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level V <sub>IL</sub>	5.0	–	1.5	–	2.25	1.5	–	1.5	V	
		10	–	3.0	–	4.50	3.0	–	3.0		
		15	–	4.0	–	6.75	4.0	–	4.0		
	"1" Level V <sub>IH</sub>	V <sub>IH</sub>	5.0	3.5	–	3.5	2.75	–	3.5	–	V
			10	7.0	–	7.0	5.50	–	7.0	–	
			15	11.0	–	11.0	8.25	–	11.0	–	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 0.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 9.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	–3.0	–	–2.4	–4.2	–	–1.7	–	mA	
		5.0	–0.64	–	–0.51	–0.88	–	–0.36	–		
		10	–	–	–	–10.1	–	–	–		
		10	–1.6	–	–1.3	–2.25	–	–0.9	–		
		15	–4.2	–	–3.4	–8.8	–	–2.4	–		
		15	–	–	–	–	–	–	–		
	Sink I <sub>OL</sub>	5.0	0.64	–	0.51	0.88	–	0.36	–	mA	
		10	1.6	–	1.3	2.25	–	0.9	–		
		10	–	–	–	10.1	–	–	–		
		10	–	–	–	–	–	–	–		
		15	4.2	–	3.4	8.8	–	2.4	–		
		15	–	–	–	–	–	–	–		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 0.5 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 9.5 V) (V <sub>OL</sub> = 1.5 V)	Source I <sub>OH</sub>	5.0	–2.5	–	–2.1	–4.2	–	–1.7	–	mA	
		5.0	–0.52	–	–0.44	–0.88	–	–0.36	–		
		10	–	–	–	–10.1	–	–	–		
		10	–1.3	–	–1.1	–2.25	–	–0.9	–		
		15	–3.6	–	–3.0	–8.8	–	–2.4	–		
		15	–	–	–	–	–	–	–		
	Sink I <sub>OL</sub>	5.0	0.52	–	0.44	0.88	–	0.36	–	mA	
		10	1.3	–	1.1	2.25	–	0.9	–		
		10	–	–	–	10.1	–	–	–		
		10	–	–	–	–	–	–	–		
		15	3.6	–	3.0	8.8	–	2.4	–		
		15	–	–	–	–	–	–	–		
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μA	
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μA	
Input Capacitance	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF	
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	5.0	–	0.005	5.0	–	150	μA	
		10	–	10	–	0.010	10	–	300		
		15	–	20	–	0.015	20	–	600		
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> =0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	–	20	–	0.005	20	–	150	μA	
		10	–	40	–	0.010	40	–	300		
		15	–	80	–	0.015	80	–	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	–	–	–	I <sub>T</sub> (1.6 μA/kHz) f + I <sub>DD</sub>	–	–	–	μA	
		10	–	–	–	I <sub>T</sub> (3.1 μA/kHz) f + I <sub>DD</sub>	–	–	–		
		15	–	–	–	I <sub>T</sub> (4.7 μA/kHz) f + I <sub>DD</sub>	–	–	–		

\*T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Noise immunity specified for worst-case input combination

Noise Margin for both "1" and "0" level = 1.0 V min @ V<sub>DD</sub> = 5.0 V

2.0 V min @ V<sub>DD</sub> = 10 V

2.5 V min @ V<sub>DD</sub> = 15 V

†To calculate total supply current at loads other than 50 pF

$$I_T(C_L) = I_T(50 \text{ pF}) + 3.5 \times 10^{-3} (C_L - 50) V_{DD} f$$

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in Vdc, and f in kHz is input frequency.

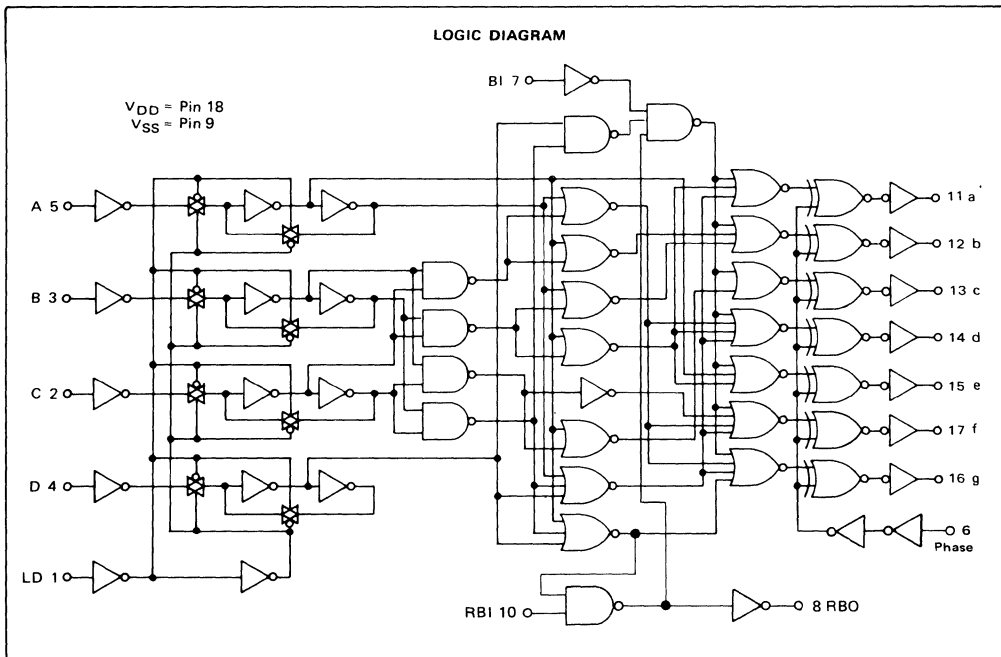
\*\*The formulas given are for the typical characteristics only at 25°C.

# MC14544B

**SWITCHING CHARACTERISTICS\*** ( $C_L = 50 \text{ pF}$ ,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ	Max	Unit
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
		—	—	—	—	
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 12.5 \text{ ns}$	$t_{THL}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
		—	—	—	—	
Turn-Off Delay Time $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 520 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 217 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 160 \text{ ns}$	$t_{PLH}$	5.0	—	605	1210	ns
		10	—	250	500	
		15	—	185	370	
		—	—	—	—	
Turn-On Delay Time $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 420 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 172 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 130 \text{ ns}$	$t_{PHL}$	5.0	—	505	1650	ns
		10	—	205	660	
		15	—	155	495	
		—	—	—	—	
Setup Time	$t_{su}$	5.0	0	-40	—	ns
		10	0	-15	—	
		15	0	-10	—	
Hold Time	$t_h$	5.0	80	40	—	ns
		10	30	15	—	
		15	20	10	—	
Latch Disable Pulse Width (Strobing Data)	$t_{WH}$	5.0	250	125	—	ns
		10	100	50	—	
		15	80	40	—	

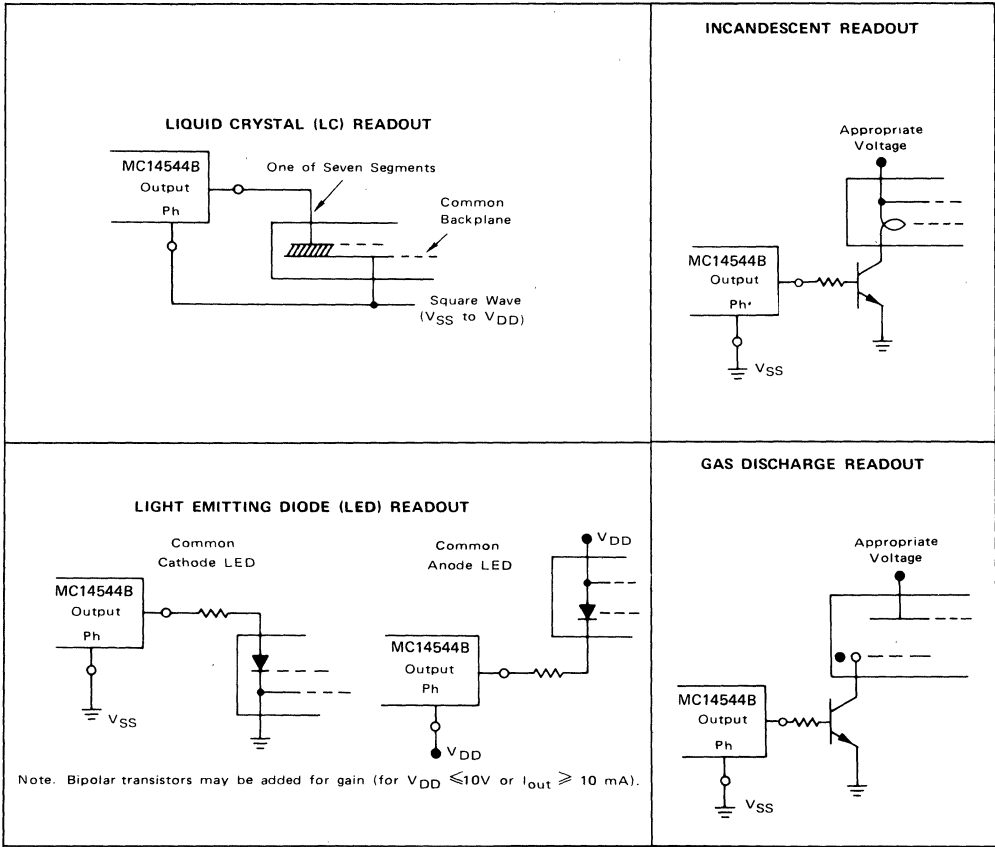
\*The formulas given are for the typical characteristics only.





# MC14544B

## CONNECTIONS TO VARIOUS DISPLAY READOUTS



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### TRUTH TABLE

INPUTS					OUTPUTS											
RBI	LD	BI	Ph*	D	C	B	A	RBO	a	b	c	d	e	f	g	DISPLAY
X	X	1	0	X	X	X	X	1	0	0	0	0	0	0	0	Blank
0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	Blank
X	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1
X	1	0	0	0	0	1	0	0	1	1	0	1	0	1	2	
X	1	0	0	0	0	1	1	0	0	1	1	1	0	0	1	3
X	1	0	0	0	1	1	0	0	0	1	1	0	0	1	1	4
X	1	0	0	0	1	0	1	0	0	1	0	1	1	1	5	
X	1	0	0	0	1	1	1	0	0	1	0	1	1	1	1	6
X	1	0	0	0	1	1	1	1	0	1	1	0	0	0	0	7
X	1	0	0	1	1	0	0	0	0	1	1	1	1	1	1	8
X	1	0	0	1	0	0	1	0	0	1	1	1	0	1	1	9
X	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	Blank
X	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	Blank
X	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	Blank
X	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	Blank
X	0	0	0	X	X	X	X	†	†	†	†	†	†	†	†	†
†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†

X Don't Care

† Above Combinations

\* For liquid crystal readouts, apply a square wave to Ph. For common cathode LED readouts, select Ph = 0. For common anode LED readouts, select Ph = 1.

\*\* Depends upon the BCD Code previously applied when LD = 1.

≠ RBO = RBI • (A $\bar{B}\bar{C}\bar{D}$ )

FIGURE 1 – TYPICAL OUTPUT SOURCE CHARACTERISTICS

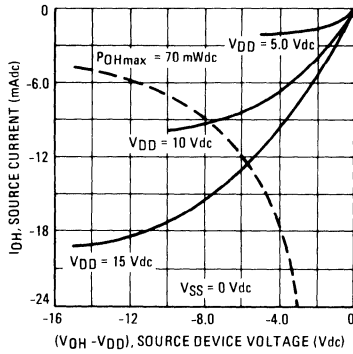


FIGURE 2 – TYPICAL OUTPUT SINK CHARACTERISTICS

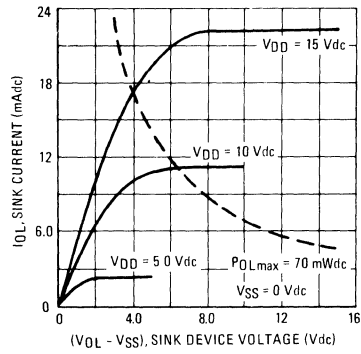


FIGURE 3 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORMS

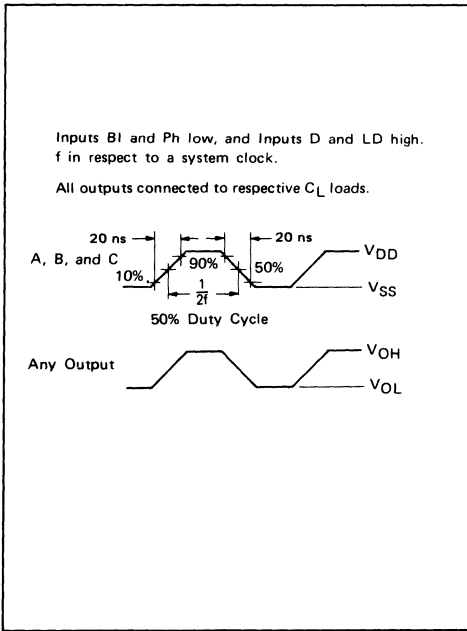
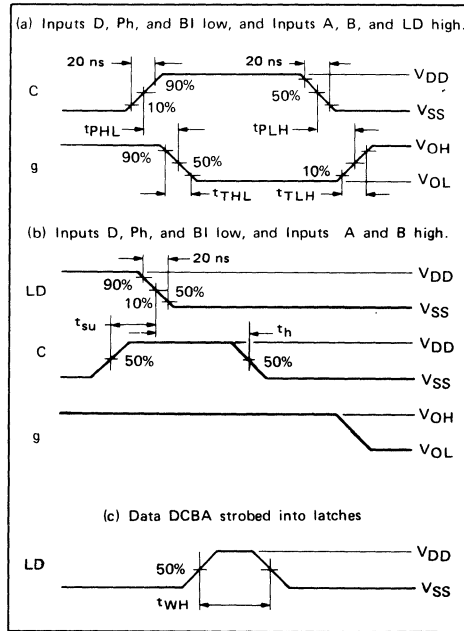
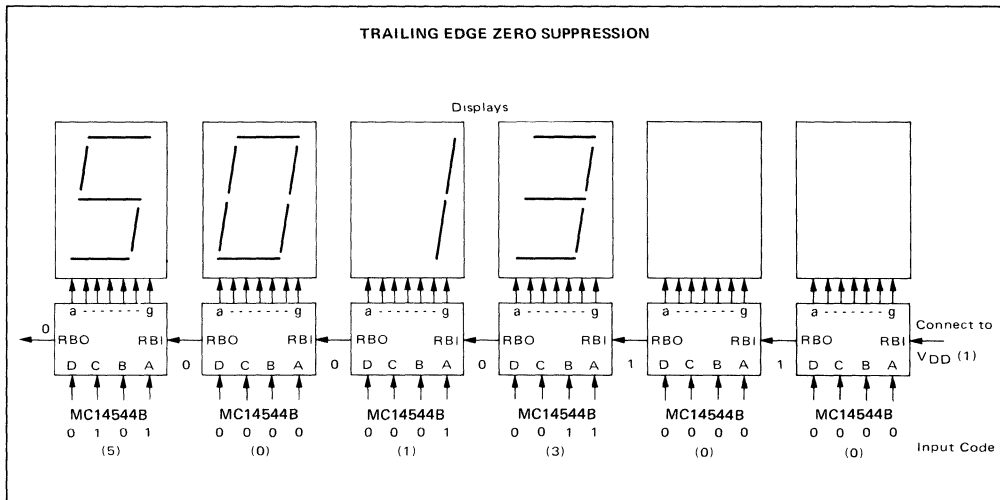
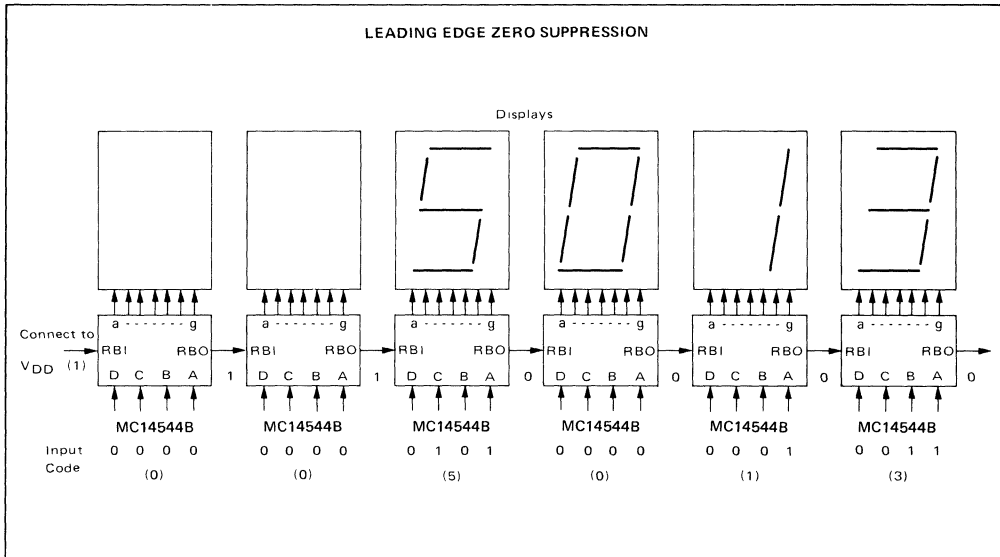


FIGURE 4 – DYNAMIC SIGNAL WAVEFORMS



# MC14544B

## TYPICAL APPLICATIONS FOR RIPPLE BLANKING



6



**MOTOROLA**

# MC14547B

## HIGH CURRENT BCD-TO-SEVEN SEGMENT DECODER/DRIVER

The MC14547 BCD-to-seven segment decoder/driver is constructed with complementary MOS (CMOS) enhancement mode devices and NPN bipolar output drivers in a single monolithic structure. The circuit provides the functions of an 8421 BCD-to-seven segment decoder with high output drive capability. Blanking (BI), can be used to turn off or pulse modulate the brightness of the display. The MC14547 can drive seven-segment light-emitting diodes (LED), incandescent, fluorescent or gas discharge readouts either directly or indirectly.

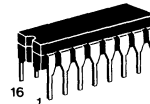
Applications include instrument (e.g., counter, DVM, etc.) display driver, computer/calculator display driver, cockpit display driver, and various clock, watch, and timer uses.

- High Current Sourcing Outputs (Up to 65 mA)
- Low Logic Circuit Power Dissipation
- Supply Voltage Range = +3.0 V to +18 V
- Blanking Input
- Readout Blanking on All Illegal Combinations
- Lamp Intensity Modulation Capability
- Multiplexing Capability
- Capable of Driving Two Low-Power TTL Loads, One Low-Power Schottky TTL Load or Two HTL Loads over the Rated Temperature Range
- Use MC14511B for Applications Requiring Data Latches

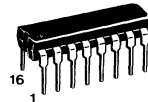
## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

## HIGH CURRENT BCD-TO-SEVEN SEGMENT DECODER/DRIVER



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### MAXIMUM RATINGS\* (Voltage referenced to V<sub>SS</sub>, Pin 8)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +18	V
Input Voltage, All Inputs	V <sub>in</sub>	-0.5 to V <sub>DD</sub> + 0.5	V
Operating Temperature Range	T <sub>A</sub>	MC14547BAL	-55 to +125
		MC14547BCL/CP	-40 to +85
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Maximum Continuous Output Drive Current (Source) per Output	I <sub>OHmax</sub>	65	mA
Maximum Continuous Power Dissipation	P <sub>OHmax</sub>	1200*	mW

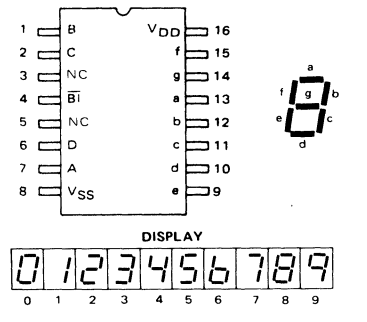
\* Maximum Ratings are those values beyond which damage to the device may occur

\*See power derating curve (Figure 1).

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. A destructive high current mode may occur if V<sub>in</sub> and V<sub>out</sub> is not constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Due to the sourcing capability of this circuit, damage can occur to the device if V<sub>DD</sub> is applied, and the outputs are shorted to V<sub>SS</sub> and are at a logical 1 (See Maximum Ratings).

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>).



### TRUTH TABLE

INPUTS				OUTPUTS							
BI	D	C	B A	a	b	c	d	e	f	g	DISPLAY
0	X	X	X	0	0	0	0	0	0	0	Blank
1	0	0	0 0	1	1	1	1	1	0	0	0
1	0	0	0 1	0	1	1	0	0	0	0	1
1	0	0	1 0	1	1	0	1	0	1	0	2
1	0	0	1 1	1	1	1	1	0	0	1	3
1	0	1	0 0	0	1	1	0	0	1	1	4
1	0	1	0 1	1	0	1	1	0	1	1	5
1	0	1	1 0	0	0	1	1	1	1	1	6
1	0	1	1 1	1	1	1	0	0	0	0	7
1	1	0	0 0	1	1	1	1	1	1	1	8
1	1	0	0 1	1	1	1	0	0	1	1	9
1	1	0	1 0	0	0	0	0	0	0	0	Blank
1	1	0	1 1	0	0	0	0	0	0	0	Blank
1	1	1	0 0	0	0	0	0	0	0	0	Blank
1	1	1	0 1	0	0	0	0	0	0	0	Blank
1	1	1	1 0	0	0	0	0	0	0	0	Blank
1	1	1	1 1	0	0	0	0	0	0	0	Blank

X = Don't care



# MC14547B

## ELECTRICAL CHARACTERISTICS (Continued)

Characteristic	Symbol	VDD Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ	Max	Min	Max	
Input Current (AL Device)	I <sub>in</sub>	15	—	± 0.1	—	± 0.00001	± 0.1	—	± 1.0	μA
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	± 0.3	—	± 0.00001	± 0.3	—	± 1.0	μA
Input Capacitance	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> =0 or VDD, I <sub>out</sub> =0 μA	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> =0 or VDD, I <sub>out</sub> =0 μA	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.9 μA/kHz) f + I <sub>DD</sub>							μA
		10	I <sub>T</sub> = (3.8 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (5.7 μA/kHz) f + I <sub>DD</sub>							

\* T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

† To calculate total supply current at loads other than 50 pF:

$$I_T (C_L) = I_T (50 \text{ pF}) + 3.5 \times 10^{-3} (C_L - 50) V_{DD} f$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in V,  
and f in kHz is input frequency.

\*\* The formulas given are for the typical  
characteristics only at 25°C.

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	VDD Vdc	Min	Typ	Max	Unit
Output Rise Time	t <sub>TLH</sub>	5.0	—	40	80	ns
		10	—	40	80	
		15	—	40	80	
Output Fall Time	t <sub>THL</sub>	5.0	—	125	250	ns
		10	—	75	150	
		15	—	70	140	
Data Propagation Delay Time	t <sub>PLH</sub>	5.0	—	750	1500	ns
		10	—	300	600	
		15	—	200	400	
	t <sub>PHL</sub>	5.0	—	750	1500	
		10	—	300	600	
		15	—	200	400	
Blank Propagation Delay Time	t <sub>PLH</sub>	5.0	—	750	1500	ns
		10	—	300	600	
		15	—	200	400	
	t <sub>PHL</sub>	5.0	—	500	1000	
		10	—	250	500	
		15	—	170	340	

# MC14547B

## LOGIC DIAGRAM

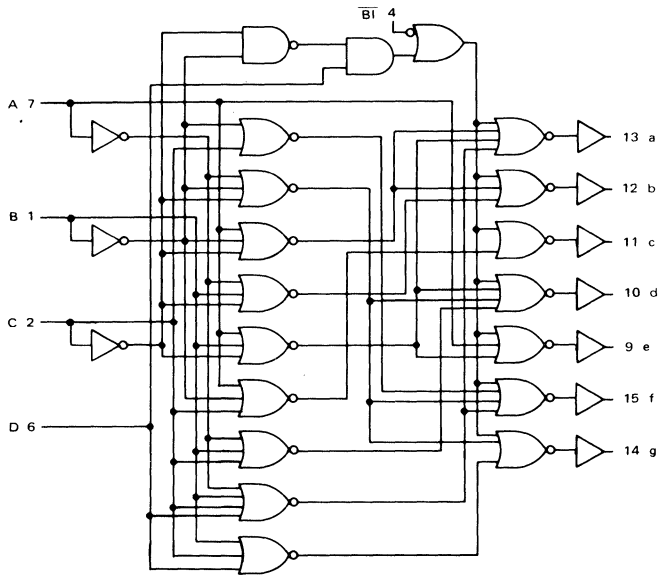
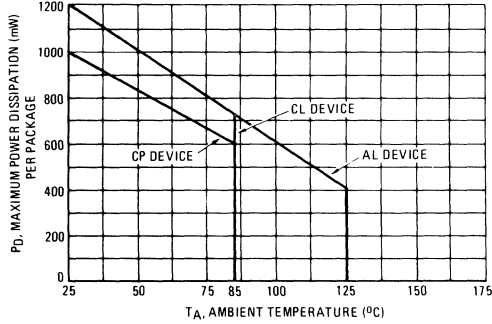


FIGURE 1 – AMBIENT TEMPERATURE POWER DERATING

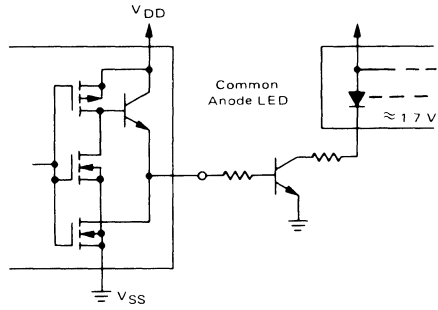
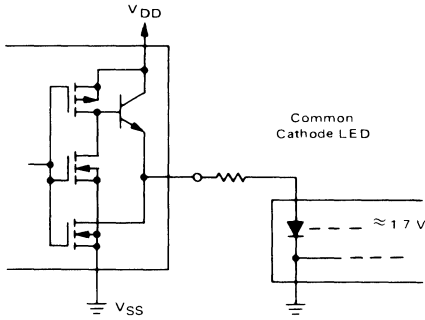


6

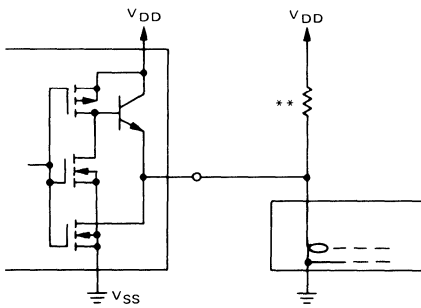
# MC14547B

## CONNECTIONS TO VARIOUS DISPLAY READOUTS

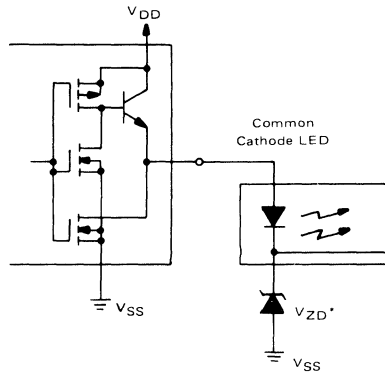
### LIGHT EMITTING DIODE (LED) READOUT



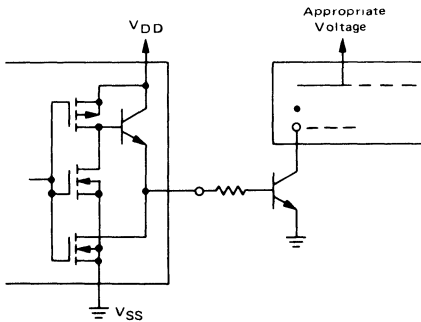
### INCANDESCENT READOUT



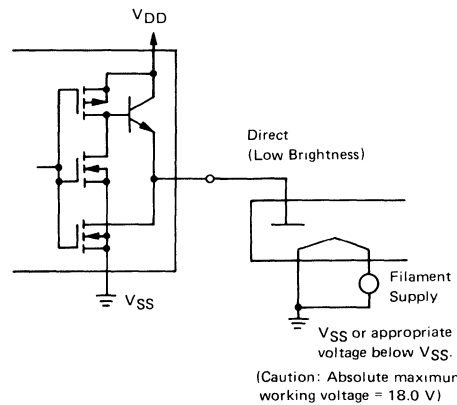
### LIGHT-EMITTING DIODE (LED) READOUT USING A ZENER DIODE TO REPLACE DROPPING RESISTORS



### GAS DISCHARGE READOUT



### FLUORESCENT READOUT



\*  $V_{ZD}$  should be set at  $V_{DD} - 1.3 \text{ V} - V_{LED}$ . Wattage of zener diode must be calculated for number of segments and worst-case conditions

\*\* A filament pre-warm resistor is recommended to reduce filament thermal shock and increase the effective cold resistance of the filament





# MC14549B MC14559B

## CMOS MSI

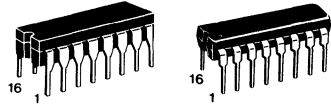
(LOW-POWER COMPLEMENTARY MOS)  
SUCCESSIVE APPROXIMATION  
REGISTERS

### SUCCESSIVE APPROXIMATION REGISTERS

The MC14549B and MC14559B successive approximation registers are 8-bit registers providing all the digital control and storage necessary for successive approximation analog-to-digital conversion systems. These parts differ in only one control input. The Master Reset (MR) on the MC14549B is required in the cascaded mode when more than 8 bits are desired. The Feed Forward (FF) of the MC14559B is used for register shortening where End-of-Conversion (EOC) is required after less than eight cycles.

Applications for the MC14549B and MC14559B include analog-to-digital conversion, with serial and parallel outputs.

- Totally Synchronous Operation
- All Outputs Buffered
- Single Supply Operation
- Serial Output
- Retriggerable
- Compatible with a Variety of Digital and Analog Systems such as the MC1408 8-Bit D/A Converter
- All Control Inputs Positive-Edge Triggered
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads, One Low-Power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range
- Chip Complexity: 488 FETs or 122 Equivalent Gates



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

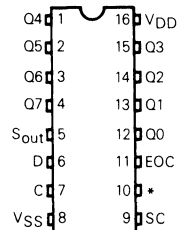
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### PIN ASSIGNMENT



\* For MC14549B Pin 10 is MR input  
For MC14559B Pin 10 is FF input

### MAXIMUM RATINGS (Voltages referenced to V<sub>SS</sub>)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +18	Vdc
Input Voltage, All Inputs	V <sub>in</sub>	-0.5 to V <sub>DD</sub> + 0.5	Vdc
DC Input Current, per Pin	I <sub>in</sub>	±10	mAdc
Operating Temperature Range - AL Device	T <sub>A</sub>	-55 to +125	°C
CL/CP Device		-40 to +85	
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C

6

### TRUTH TABLES

MC14549B					
SC	SC <sub>(t-1)</sub>	MR	MR <sub>(t-1)</sub>	Clock	Action
X	X	X	X		None
X	X	1	X		Reset
1	0	0	0		Start Conversion
1	X	0	1		Start Conversion
1	1	0	0		Continue Conversion
0	X	0	X		Continue Previous Operation

X = Don't Care  
t-1 = State at Previous Clock

MC14559B					
SC	SC <sub>(t-1)</sub>	EOC	Clock	Action	
X	X	X		None	
1	0	0		Start Conversion	
X	1	0		Continue Conversion	
0	0	0		Continue Conversion	
0	X	1		Retain Conversion Result	
1	X	1		Start Conversion	

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields, however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V<sub>in</sub> and V<sub>out</sub> be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>).

# MC14549B, MC14559B

## ELECTRICAL CHARACTERISTICS (Voltages referenced to V<sub>SS</sub>)

Characteristic	Symbol	VDD Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	V
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	V
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage# (V <sub>O</sub> = 4.5 or 0.5 V) (V <sub>O</sub> = 9.0 or 1.0 V) (V <sub>O</sub> = 13.5 or 1.5 V)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	V
			10	—	3.0	—	4.50	3.0	—	3.0	
			15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 V) (V <sub>O</sub> = 1.0 or 9.0 V) (V <sub>O</sub> = 1.5 or 13.5 V)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	V
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mA
			10	-0.25	—	-0.2	-0.36	—	-0.14	—	
			15	-0.62	—	-0.5	-0.9	—	-0.35	—	
			15	-1.8	—	-1.5	-3.5	—	-1.1	—	
	Sink Q Outputs	I <sub>OL</sub>	5.0	1.28	—	1.02	1.76	—	0.72	—	mA
			10	3.2	—	2.6	4.5	—	1.8	—	
			15	8.4	—	6.8	17.6	—	4.8	—	
			15	0.64	—	0.51	0.88	—	0.36	—	
	Sink Pin 5, 11 only	I <sub>OL</sub>	5.0	1.6	—	1.3	2.25	—	0.9	—	mA
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 V) (V <sub>OH</sub> = 4.6 V) (V <sub>OH</sub> = 9.5 V) (V <sub>OH</sub> = 13.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V) (V <sub>OL</sub> = 0.4 V) (V <sub>OL</sub> = 0.5 V) (V <sub>OL</sub> = 1.5 V)	Source	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mA
			10	-0.2	—	-0.16	-0.36	—	-0.12	—	
			15	-0.5	—	-0.4	-0.9	—	-0.3	—	
			15	-1.4	—	-1.2	-3.5	—	-1.0	—	
	Sink Q Outputs	I <sub>OL</sub>	5.0	1.04	—	0.88	1.76	—	0.72	—	mA
			10	2.6	—	2.2	4.5	—	1.8	—	
			15	7.2	—	6.0	17.6	—	4.8	—	
			15	0.52	—	0.44	0.88	—	0.36	—	
	Sink Pin 5, 11 only	I <sub>OL</sub>	5.0	1.3	—	1.1	2.25	—	0.9	—	mA
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA	
Input Capacitance	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package) (Clock = 0 V, Other Inputs = V <sub>DD</sub> or 0 V, I <sub>out</sub> = 0 μA)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package) (Clock = 0 V, Other Inputs = V <sub>DD</sub> or 0 V, I <sub>out</sub> = 0 μA)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.8 μA/kHz) f + I <sub>DD</sub>							μA	
		10	I <sub>T</sub> = (1.6 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (2.4 μA/kHz) f + I <sub>DD</sub>								

\* T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

# Noise immunity specified for worst-case input combination

Noise Margin for both "1" and "0" level = 1.0 V min @ V<sub>DD</sub> = 5.0 V

2.0 V min @ V<sub>DD</sub> = 10 V

2.5 V min @ V<sub>DD</sub> = 15 V

† To calculate total supply current at loads other than 50 pF

I<sub>T</sub>(C<sub>L</sub>) = I<sub>T</sub>(50 pF) + 2 × 10<sup>-3</sup>(C<sub>L</sub> - 50) V<sub>DD</sub>f

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in V, and f in kHz is input freq

\*\* The formulas given are for the typical characteristics only at 25°C

# MC14549B, MC14559B

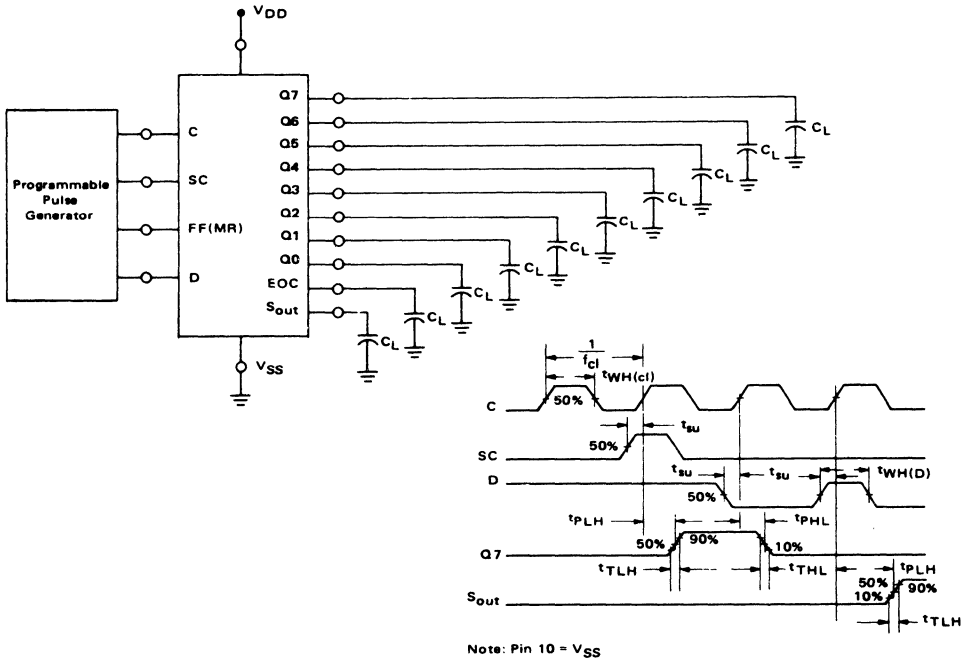
## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ	Max	Unit
Output Rise Time t <sub>TLH</sub> = (3.0 ns/pF) C <sub>L</sub> + 30 ns t <sub>TLH</sub> = (1.5 ns/pF) C <sub>L</sub> + 15 ns t <sub>TLH</sub> = (1.1 ns/pF) C <sub>L</sub> + 10 ns	t <sub>TLH</sub>	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 415 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 177 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 130 ns Clock to S <sub>out</sub> t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 665 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 277 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 195 ns Clock to EOC t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 215 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 75 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0 10 15  5.0 10 15  5.0 10 15	— — —  — — —  — — —	500 210 155  750 310 220  300 130 100	1000 420 310  1500 620 440  600 260 200	ns
SC, D, FF or MR Setup Time	t <sub>su</sub>	5.0 10 15	250 100 80	125 50 40	— — —	ns
Clock Pulse Width	t <sub>WH(cl)</sub>	5.0 10 15	700 270 200	350 135 100	— — —	ns
Pulse Width – D, SC, FF or MR	t <sub>WH</sub>	5.0 10 15	500 200 160	250 100 80	— — —	ns
Clock Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0 10 15	— — —	— — —	15 1.0 0.5	μs
Clock Pulse Frequency	f <sub>cl</sub>	5.0 10 15	— — —	1.5 3.0 4.0	0.8 1.5 2.0	MHz

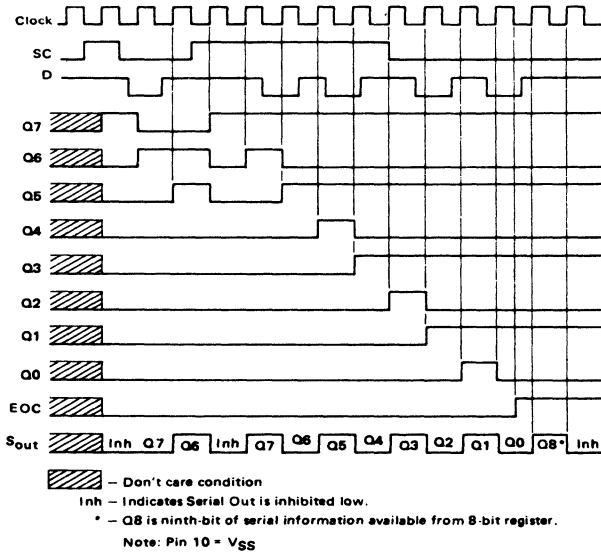
\* The formulae given are for the typical characteristics only.

# MC14549B, MC14559B

## SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



## TIMING DIAGRAM



# MC14549B, MC14559B

## OPERATING CHARACTERISTICS

Both the MC14549B and MC14559B can be operated in either the "free run" or "strobed operation" mode for conversion schemes with any number of bits. Reliable cascading and/or recirculating operation can be achieved if the End of Convert (EOC) output is used as the controlling function, since with  $EOC = 0$  (and with  $SC = 1$  for MC14549B but either 1 or 0 for MC14559B) no stable state exists under continual clocked operation. The MC14559B will automatically recirculate after  $EOC = 1$  during externally strobed operation, provided  $SC = 1$ .

All data and control inputs for these devices are triggered into the circuit on the positive edge of the clock pulse.

Operation of the various terminals is as follows:

**C = Clock** — A positive-going transition of the Clock is required for data on any input to be strobed into the circuit.

**SC = Start Convert** — A conversion sequence is initiated on the positive-going transition of the SC input on succeeding clock cycles.

**D = Data In** — Data on this input (usually from a comparator in A/D applications) is also entered into the circuit on a positive-going transition of the clock. This input is Schmitt triggered and synchronized to allow fast response and guaranteed quality of serial and parallel data.

**MR = Master Reset (MC14549B only)** — Resets all output to 0 on positive-going transitions of the clock. If removed while  $SC = 0$ , the circuit will remain reset until  $SC = 1$ . This allows easy cascading of circuits.

**FF = Feed Forward (MC14559B only)** — Provides register shortening by removing unwanted bits from a system.

For operation with less than 8 bits, tie the output following the least significant bit of the circuit to EOC.

E.g., for a 6-bit conversion, tie Q1 to FF; the part will respond as shown in the timing diagram less two bit times. Note that Q1 and Q0 will still operate and must be disregarded.

For 8-bit operation, FF is tied to  $V_{SS}$ .

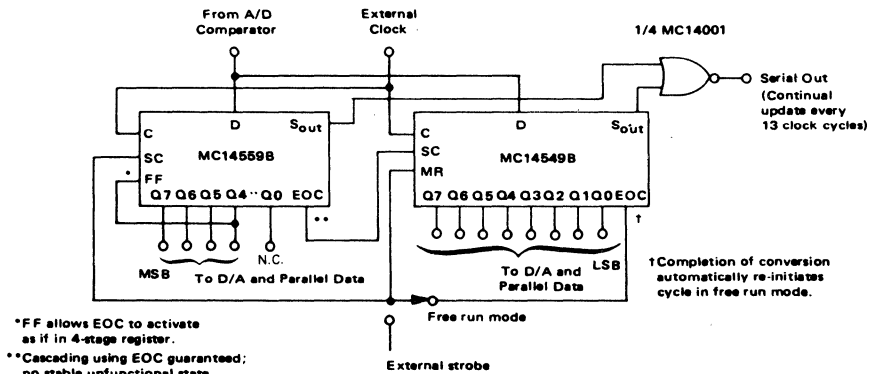
For applications with more than 8 but less than 16 bits, use the basic connections shown in Figure 1. The FF input of the MC14559B is used to shorten the setup. Tying FF directly to the least significant bit used in the MC14559B allows EOC to provide the cascading signal, and results in smooth transition of serial information from the MC14559B to the MC14549B. The Serial Out ( $S_{out}$ ) inhibit structure of the MC14559B remains inactive one cycle after EOC goes high, while  $S_{out}$  of the MC14549B remains inhibited until the second clock cycle of its operation.

**$Q_n$  = Data Outputs** — After a conversion is initiated the  $Q$ 's on succeeding cycles go high and are then conditionally reset dependent upon the state of the D input. Once conditionally reset they remain in the proper state until the circuit is either reset or reinitiated.

**EOC = End of Convert** — This output goes high on the negative-going transition of the clock following  $FF = 1$  (for the MC14559B) or the conditional reset of Q0. This allows settling of the digital circuitry prior to the End of Conversion indication. Therefore either level or edge triggering can indicate complete conversion.

**$S_{out}$  = Serial Out** — Transmits conversion in serial fashion. Serial data occurs during the clock period when the corresponding parallel data bit is conditionally reset. Serial Out is inhibited on the initial period of a cycle, when the circuit is reset, and on the second cycle after EOC goes high. This provides efficient operation when cascaded.

FIGURE 1 — 12-BIT CONVERSION SCHEME



# MC14549B, MC14559B

## TYPICAL APPLICATIONS

### Externally Controlled 6-Bit ADC (Figure 2)

Several features are shown in this application:

- Shortening of the register to six bits by feeding the seventh output bit into the FF input.
- Continuous conversion, if a continuous signal is applied to SC.
- Externally controlled updating (the start pulse must be shorter than the conversion cycle).
- The EOC output indicating that the parallel data are valid and that the serial output is complete.

### Continuously Cycling 8-Bit ADC (Figure 3)

This ADC is running continuously because the EOC signal is fed back to the SC input, immediately initiating a new cycle on the next clock pulse.

### Continuously Cycling 12-Bit ADC (Figure 4)

Because each successive approximation register (SAR) has a capability of handling only an eight-bit word, two must be cascaded to make an ADC with more than eight bits.

When it is necessary to cascade two SAR's, the second SAR must have a stable resettable state to remain in while awaiting a subsequent start signal. However, the first stage must not have a stable resettable state while recycling, because during switch-on or due to outside influences, the first stage has entered a reset state, the entire ADC will remain in a stable non-functional condition.

This 12-bit ADC is continuously recycling. The serial as well as the parallel outputs are updated every thirteenth clock pulse. The EOC pulse indicates the completion of

FIGURE 2 – EXTERNALLY CONTROLLED 6-BIT ADC

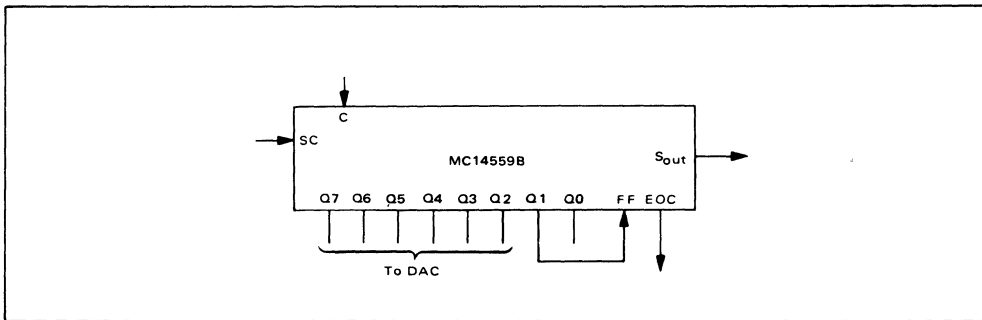
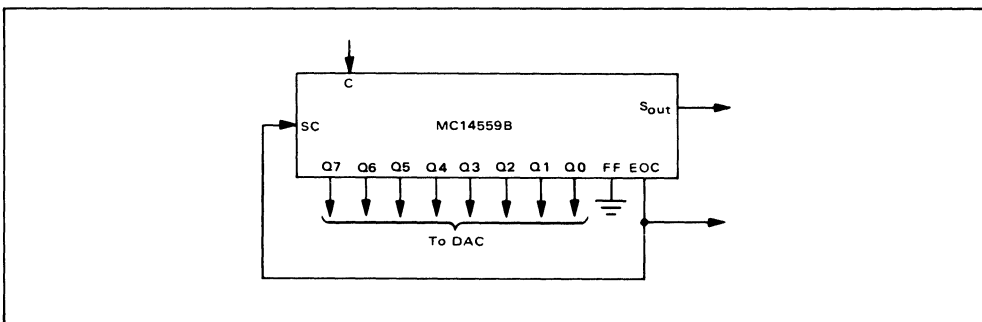
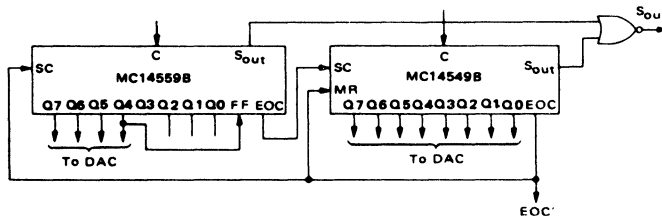


FIGURE 3 – CONTINUOUSLY CYCLING 8-BIT ADC



# MC14549B, MC14559B

FIGURE 4 – CONTINUOUSLY CYCLING 12-BIT ADC



the 12-bit conversion cycle, the end of the serial output word, and the validity of the parallel data output.

### Externally Controlled 12-Bit ADC (Figure 5)

In this circuit the external pulse starts the first SAR and simultaneously resets the cascaded second SAR. When Q4 of the first SAR goes high, the second SAR starts conversion, and the first one stops conversion. EOC indicates that the parallel data are valid and that the serial output is complete. Updating the output data is started with every external control pulse.

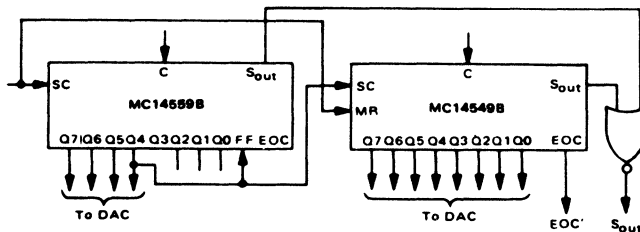
### Additional Motorola Parts for Successive Approximation ADC

**Monolithic digital-to-analog converters** – The MC1408/1508 converter has eight-bit resolution and is available with 6, 7, and 8-bit accuracy. **The amplifier-comparator block** – The MC1407/1507 contains a high speed operational amplifier and a high speed comparator with adjustable window.

With these two linear parts it is possible to construct SA-ADCs with an accuracy of up to eight bits, using as the register one MC14549B or one MC14559B. An additional CMOS block will be necessary to generate the clock frequency.

Additional information on successive approximation ADC is found in Motorola Application Note AN-716.

FIGURE 5 – EXTERNALLY CONTROLLED 12-BIT ADC





**MOTOROLA**

**MC14551B**

**QUAD 2-CHANNEL  
ANALOG MULTIPLEXER/DEMULPLEXER**

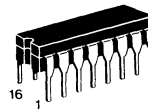
The MC14551B is a digitally-controlled analog switch. This device implements a 4PDT solid state switch with low ON impedance and very low OFF Leakage current. Control of analog signals up to the complete supply voltage range can be achieved.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Analog Voltage Range ( $V_{DD}-V_{EE}$ ) = 3 to 18 V  
Note:  $V_{EE}$  must be  $\leq V_{SS}$
- Linearized Transfer Characteristics
- Low Noise —  $12 \text{ nV}/\sqrt{\text{Cycle}}$ ,  $f \geq 1 \text{ kHz}$  typical
- For Lower  $R_{ON}$ , Use The HC4051, HC4052, or HC4053 High-Speed CMOS Devices

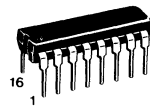
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**ANALOG MULTIPLEXER/  
DEMULPLEXER**



CASE 620  
L SUFFIX  
CERAMIC PACKAGE



CASE 648  
P SUFFIX  
PLASTIC PACKAGE

**ORDERING INFORMATION**

A Series:  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$   
MC14XXXBAL (Ceramic Package Only)

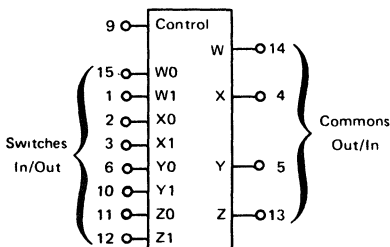
C Series:  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$   
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\***

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage (Referenced to $V_{EE}$ , $V_{SS} \geq V_{EE}$ )	$-0.5$ to $+18.0$	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient) (Referenced to $V_{SS}$ for Control Input & $V_{EE}$ for Switch I/O)	$-0.5$ to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Control Pin	$\pm 10$	mA
$I_{sw}$	Switch Through Current	$\pm 25$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	$-65$ to $+150$	$^{\circ}\text{C}$
$T_L$	Lead Temperature (8-Second Soldering)	260	$^{\circ}\text{C}$

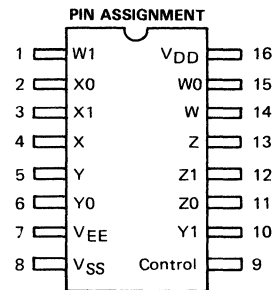
\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package:  $-12\text{mW}/^{\circ}\text{C}$  from  $65^{\circ}\text{C}$  to  $85^{\circ}\text{C}$   
Ceramic "L" Package:  $-12\text{mW}/^{\circ}\text{C}$  from  $100^{\circ}\text{C}$  to  $125^{\circ}\text{C}$

**6**



Control	ON
0	W0 X0 Y0 Z0
1	W1 X1 Y1 Z1

$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8  
 $V_{EE}$  = Pin 7



Note: Control input referenced to  $V_{SS}$ . Analog Inputs and Outputs reference to  $V_{EE}$ .  $V_{EE}$  must be  $\leq V_{SS}$ .



# MC14551B

## ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	V <sub>DD</sub>	Test Conditions	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
				Min	Max	Min	Typ#	Max	Min	Max	
<b>SUPPLY REQUIREMENTS</b> (Voltages Referenced to V <sub>EE</sub> )											
Power Supply Voltage Range	V <sub>DD</sub>	—	V <sub>DD</sub> - 3 ≥ V <sub>SS</sub> ≥ V <sub>EE</sub>	3	18	3	—	18	3	18	V
Quiescent Current Per Package (AL Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>EE</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	5	—	0.005	5	—	150	μA
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current Per Package (CL/CP Device)	I <sub>DD</sub>	5	Control Inputs: V <sub>in</sub> = V <sub>SS</sub> or V <sub>DD</sub> , Switch I/O: V <sub>EE</sub> ≤ V <sub>I/O</sub> ≤ V <sub>DD</sub> , and ΔV <sub>switch</sub> ≤ 500 mV**	—	20	—	0.005	20	—	150	μA
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current (Dynamic Plus Quiescent, Per Package)	I <sub>D(AV)</sub>	5 10 15	T <sub>A</sub> = 25°C only (The channel component, (V <sub>in</sub> - V <sub>out</sub> )/R <sub>on</sub> , is not included.)	Typical					(0.07 μA/kHz)f + I <sub>DD</sub> (0.20 μA/kHz)f + I <sub>DD</sub> (0.36 μA/kHz)f + I <sub>DD</sub>		μA

## CONTROL INPUT (Voltages Referenced to V<sub>SS</sub>)

Low-Level Input Voltage	V <sub>IL</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	—	1.5	—	2.25	1.5	—	1.5	V
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
High-Level Input Voltage	V <sub>IH</sub>	5	R <sub>on</sub> = per spec, I <sub>off</sub> = per spec	3.5	—	3.5	2.75	—	3.5	—	V
		10	—	7.0	—	7.0	5.50	—	7.0	—	
		15	—	11.0	—	11.0	8.25	—	11.0	—	
Input Leakage Current (AL Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA
Input Leakage Current (CL/CP Device)	I <sub>in</sub>	15	V <sub>in</sub> = 0 or V <sub>DD</sub>	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA
Input Capacitance	C <sub>in</sub>	—		—	—	—	5.0	7.5	—	—	pF

## SWITCHES IN/OUT AND COMMONS OUT/IN - W, X, Y, Z (Voltages Referenced to V<sub>EE</sub>)

Recommended Peak-to-Peak Voltage Into or Out of the Switch	V <sub>I/O</sub>	—	Channel On or Off	0	V <sub>DD</sub>	0	—	V <sub>DD</sub>	0	V <sub>DD</sub>	V <sub>p-p</sub>
Recommended Static or Dynamic Voltage Across the Switch** (Figure 3)	ΔV <sub>switch</sub>	—	Channel On	0	600	0	—	600	0	300	mV
Output Offset Voltage	V <sub>OO</sub>	—	V <sub>in</sub> = 0 V, No load	—	—	—	10	—	—	—	μV
ON Resistance (AL Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	800	—	250	1050	—	1300	Ω
		10	—	400	—	120	500	—	550		
		15	—	220	—	80	280	—	320		
ON Resistance (CL/CP Device)	R <sub>on</sub>	5	ΔV <sub>switch</sub> ≤ 500 mV**, V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control), and V <sub>in</sub> = 0 to V <sub>DD</sub> (Switch)	—	880	—	250	1050	—	1200	Ω
		10	—	450	—	120	500	—	520		
		15	—	250	—	80	280	—	300		
Δ ON Resistance Between Any Two Channels in the Same Package	ΔR <sub>on</sub>	5		—	70	—	25	70	—	135	Ω
		10		—	50	—	10	50	—	95	
		15		—	45	—	10	45	—	65	
Off-Channel Leakage Current (AL Device) (Figure 8)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±100	—	±0.05	±100	—	±1000	nA
Off-Channel Leakage Current (CL/CP Device) (Figure 8)	I <sub>off</sub>	15	V <sub>in</sub> = V <sub>IL</sub> or V <sub>IH</sub> (Control) Channel to Channel or Any One Channel	—	±300	—	±0.05	±300	—	±1000	nA
Capacitance, Switch I/O	C <sub>I/O</sub>	—	Switch Off	—	—	—	10	—	—	—	pF
Capacitance, Common O/I	C <sub>O/I</sub>	—		—	—	—	17	—	—	—	pF
Capacitance, Feedthrough (Channel Off)	C <sub>I/O</sub>	—	Pins Not Adjacent	—	—	—	0.15	—	—	—	pF
		—	Pins Adjacent	—	—	—	0.47	—	—	—	

\* T<sub>low</sub> = -55°C for AL Device, -40° for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

# Data labeled "Typ" is not to be used for design purposes, but is intended as an indication of the IC's potential performance.

\*\*For voltage drops across the switch (ΔV<sub>switch</sub>) > 300 mV (>300 mV at high temperature), excessive V<sub>DD</sub> current may be drawn; i.e. the current out of the switch may contain both V<sub>DD</sub> and switch input components. The reliability of the device will be unaffected unless the Maximum Ratings are exceeded. (See first page of this data sheet.)

# MC14551B

## ELECTRICAL CHARACTERISTICS ( $C_L = 50$ pF, $T_A = 25^\circ\text{C}$ , $V_{EE} \leq V_{SS}$ )

Characteristic	Symbol	$\frac{V_{DD} - V_{EE}}{V_{dc}}$	Min	Typ #	Max	Unit
Propagation Delay Times Switch Input to Switch Output ( $R_L = 10$ k $\Omega$ ) $t_{PLH}, t_{PHL} = (0.17 \text{ ns/pF}) C_L + 26.5 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.08 \text{ ns/pF}) C_L + 11 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.06 \text{ ns/pF}) C_L + 9.0 \text{ ns}$	$t_{PLH}, t_{PHL}$					ns
		5.0	—	35	90	
		10	—	15	40	
		15	—	12	30	
Control Input to Output ( $R_L = 10$ k $\Omega$ ) $V_{EE} = V_{SS}$ (Figure 4)	$t_{PLH}, t_{PHL}$					ns
		5.0	—	350	875	
		10	—	140	350	
		15	—	100	250	
Second Harmonic Distortion $R_L = 10$ k $\Omega$ , $f = 1$ kHz, $V_{in} = 5$ V <sub>p-p</sub>	—	10	—	0.07	—	%
Bandwidth (Figure 5) $R_L = 1$ k $\Omega$ , $V_{in} = 1/2 (V_{DD} - V_{EE})$ p-p, $20 \text{ Log } \frac{V_{out}}{V_{in}} = -3 \text{ dB}$ , $C_L = 50$ pF	BW	10	—	17	—	MHz
Off Channel Feedthrough Attenuation, Figure 5 $R_L = 1$ k $\Omega$ , $V_{in} = 1/2 (V_{DD} - V_{EE})$ p-p, $f_{in} = 55$ MHz	—	10	—	-50	—	dB
Channel Separation (Figure 6) $R_L = 1$ k $\Omega$ , $V_{in} = 1/2 (V_{DD} - V_{EE})$ p-p, $f_{in} = 3$ MHz	—	10	—	-50	—	dB
Crosstalk, Control Input to Common O/I, Figure 7 $R_1 = 1$ k $\Omega$ , $R_L = 10$ k $\Omega$ , Control $t_r = t_f = 20$ ns	—	10	—	75	—	mV

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$  for control inputs and  $V_{EE} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$  for Switch I/O.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$ ,  $V_{EE}$ , or  $V_{DD}$ ). Unused outputs must be left open.

# MC14551B

FIGURE 1 - SWITCH CIRCUIT SCHEMATIC

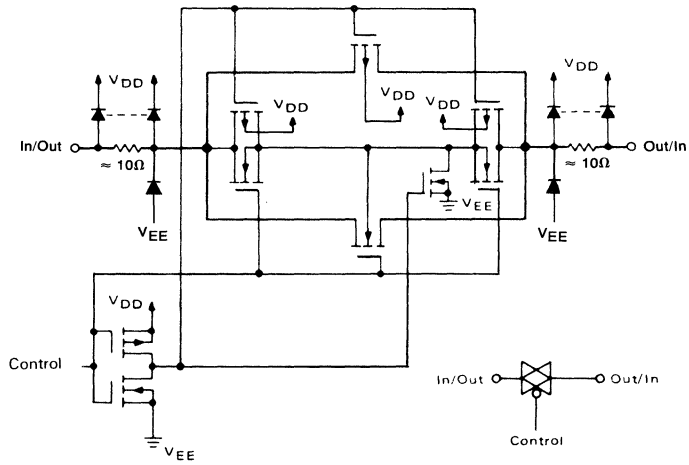
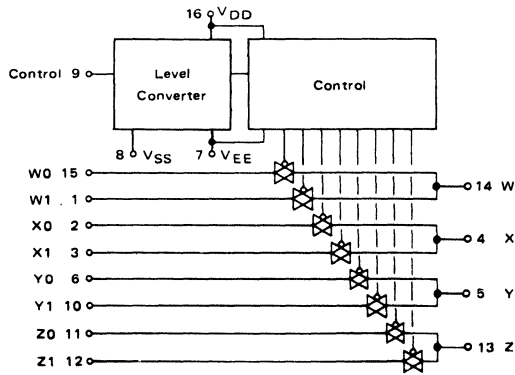


FIGURE 2 - MC14551B FUNCTIONAL DIAGRAM



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# MC14551B

## TEST CIRCUITS

FIGURE 3 —  $\Delta V$  ACROSS SWITCH

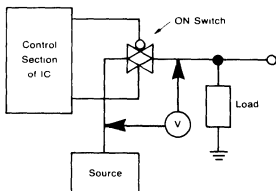


FIGURE 4 — PROPAGATION DELAY TIMES, CONTROL TO OUTPUT

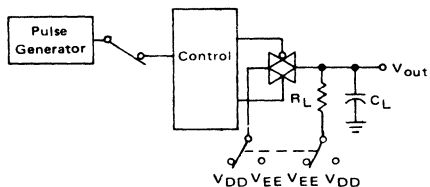


FIGURE 5 — BANDWIDTH AND OFF-CHANNEL FEEDTHROUGH ATTENUATION

Control input used to turn ON or OFF the switch under test.

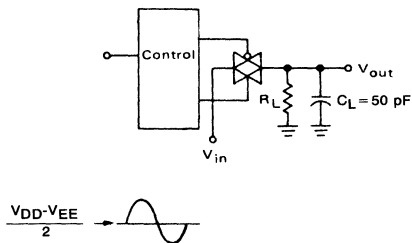


FIGURE 6 — CHANNEL SEPARATION (Adjacent Channels Used for Setup)

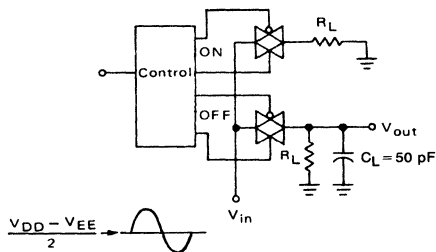


FIGURE 7 — CROSSTALK, CONTROL INPUT TO COMMON O/I

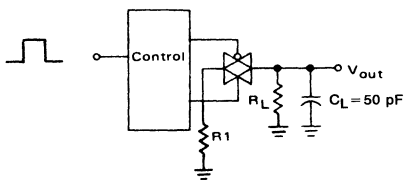
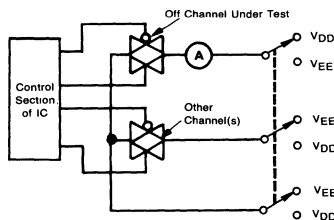


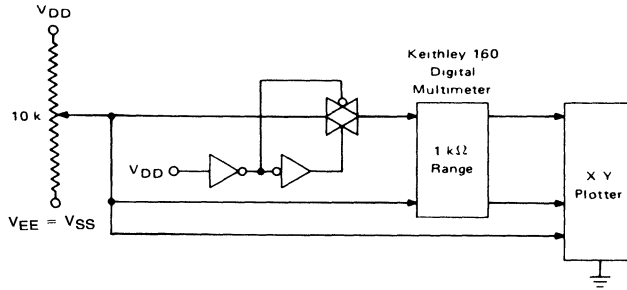
FIGURE 8 — OFF CHANNEL LEAKAGE



6

# MC14551B

FIGURE 9 – CHANNEL RESISTANCE ( $R_{ON}$ ) TEST CIRCUIT



## TYPICAL RESISTANCE CHARACTERISTICS

FIGURE 10 –  $V_{DD}$  @ 7.5 V,  $V_{EE}$  @ -7.5 V

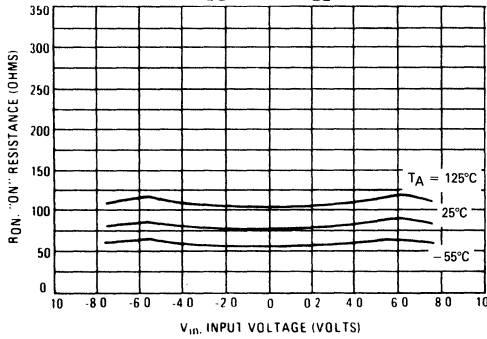


FIGURE 11 –  $V_{DD}$  @ 5.0 V,  $V_{EE}$  @ -5.0 V

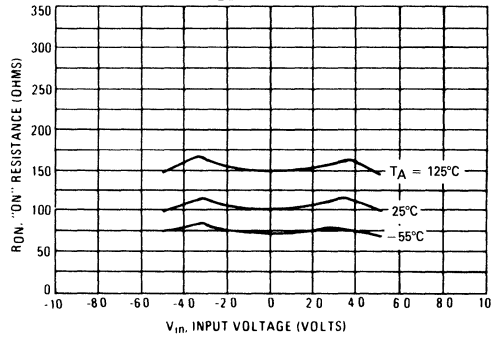


FIGURE 12 –  $V_{DD}$  @ 2.5 V,  $V_{EE}$  @ -2.5 V

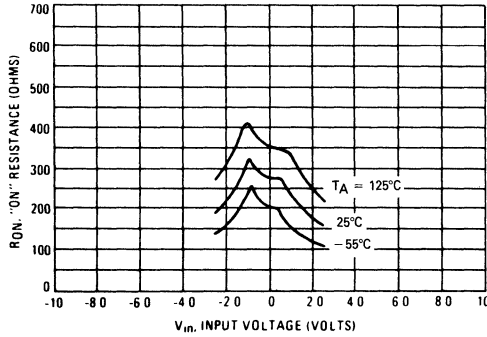
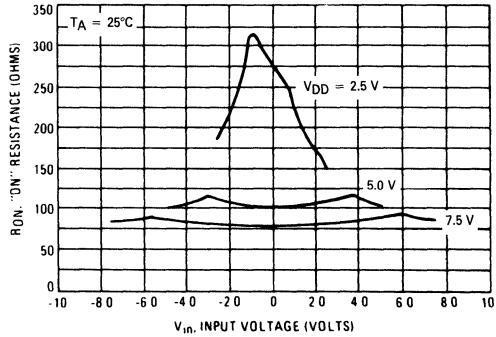


FIGURE 13 – COMPARISON at 25°C,  $V_{DD}$  @  $-V_{EE}$



# MC14551B

## APPLICATIONS INFORMATION

Figure A illustrates use of the on-chip level converter detailed in Figure 2. The 0-to-5 volt Digital Control signal is used to directly control a 9 V<sub>p-p</sub> analog signal.

The digital control logic levels are determined by V<sub>DD</sub> and V<sub>SS</sub>. The V<sub>DD</sub> voltage is the logic high voltage; the V<sub>SS</sub> voltage is logic low. For the example, V<sub>DD</sub> = +5 V = logic high at the control inputs; V<sub>SS</sub> = GND = 0 V = logic low.

The maximum analog signal level is determined by V<sub>DD</sub> and V<sub>EE</sub>. The V<sub>DD</sub> voltage determines the maximum recommended peak above V<sub>SS</sub>. The V<sub>EE</sub> voltage determines the maximum swing below V<sub>SS</sub>. For the example, V<sub>DD</sub> - V<sub>SS</sub> = 5 volt maximum swing above V<sub>SS</sub>; V<sub>SS</sub> - V<sub>EE</sub> = 5 volt maximum swing

below V<sub>SS</sub>. The example shows a ±4.5 volt signal which allows a 1/2 volt margin at each peak. If voltage transients above V<sub>DD</sub> and/or below V<sub>EE</sub> are anticipated on the analog channels, external diodes (D<sub>x</sub>) are recommended as shown in Figure B. These diodes should be small signal types able to absorb the maximum anticipated current surges during clipping.

The *absolute* maximum potential difference between V<sub>DD</sub> and V<sub>EE</sub> is 18.0 volts. Most parameters are specified up to 15 volts which is the *recommended* maximum difference between V<sub>DD</sub> and V<sub>EE</sub>.

Balanced supplies are not required. However, V<sub>SS</sub> must be greater than or equal to V<sub>EE</sub>. For example, V<sub>DD</sub> = +10 volts, V<sub>SS</sub> = +5 volts, and V<sub>EE</sub> = -3 volts is acceptable. See the table below.

FIGURE A — APPLICATION EXAMPLE

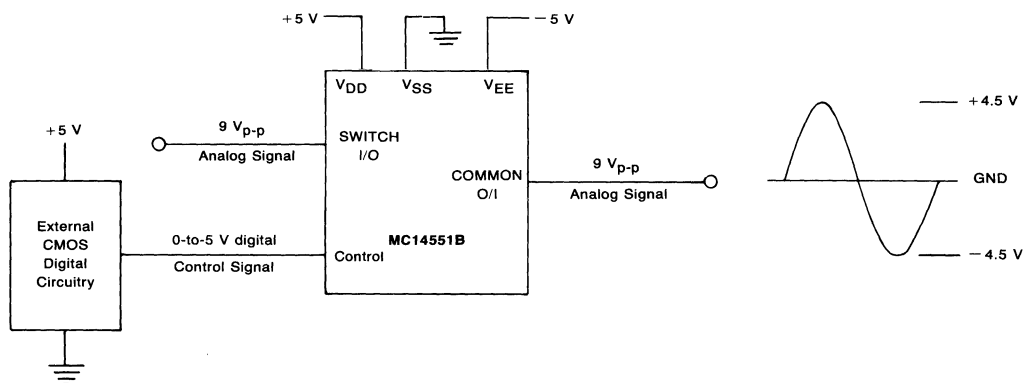
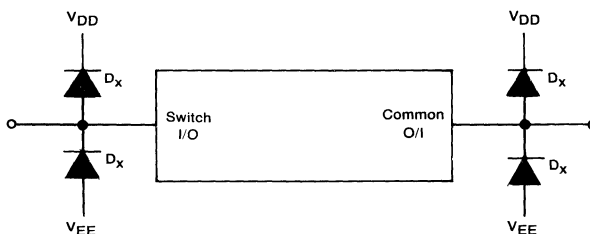


FIGURE B — EXTERNAL SCHOTTKY OR GERMANIUM CLIPPING DIODES



## POSSIBLE SUPPLY CONNECTIONS

V <sub>DD</sub> In Volts	V <sub>SS</sub> In Volts	V <sub>EE</sub> In Volts	Control Inputs Logic High/Logic Low in Volts	Maximum Analog Signal Range in Volts
+8	0	-8	+8/0	+8 to -8 = 16 V <sub>p-p</sub>
+5	0	-12	+5/0	+5 to -12 = 17 V <sub>p-p</sub>
+5	0	0	+5/0	+5 to 0 = 5 V <sub>p-p</sub>
+5	0	-5	+5/0	+5 to -5 = 10 V <sub>p-p</sub>
+10	+5	-5	+10/+5	+10 to -5 = 15 V <sub>p-p</sub>



**MOTOROLA**

**MC14553B**

**3-DIGIT BCD COUNTER**

The MC14553B 3-digit BCD counter consists of 3 negative edge triggered BCD counters that are cascaded synchronously. A quad latch at the output of each counter permits storage of any given count. The information is then time division multiplexed, providing one BCD number or digit at a time. Digit select outputs provide display control. All outputs are TTL compatible.

An on-chip oscillator provides the low-frequency scanning clock which drives the multiplexer output selector.

This device is used in instrumentation counters, clock displays, digital panel meters, and as a building block for general logic applications.

- TTL Compatible Outputs
- On-Chip Oscillator
- Cascadable
- Clock Disable Input
- Pulse Shaping Permits Very Slow Rise Times on Input Clock
- Output Latches
- Master Reset

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}$	Input Current (DC or Transient), per Pin	± 10	mA
$I_{out}$	Output Current (DC or Transient), per Pin	+20	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

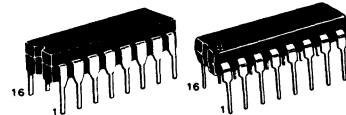
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

**3-DIGIT BCD COUNTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

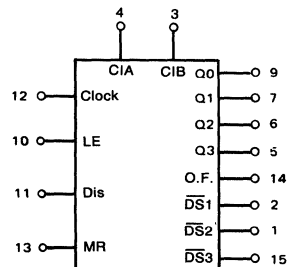
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**BLOCK DIAGRAM**



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

**TRUTH TABLE**

MASTER RESET	INPUTS			OUTPUTS
	CLOCK	DISABLE	LE	
0		0	0	No Change
0		0	0	Advance
0	X	1	X	No Change
0	1		0	Advance
0	1		0	No Change
0	0	X	X	No Change
0	X	X		Latched
0	X	X	1	Latched
1	X	X	0	$Q0 = Q1 = Q2 = Q3 = 0$

X = Don't Care

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

# MC14553B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level  V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level  V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level  V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level  V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 4.6 Vdc) Source - Pin 3 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OH</sub> = 4.6 Vdc) Source - Other Outputs (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink - Pin 3 (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink - Other Outputs (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-0.25	—	-0.20	-0.36	—	0.14	—	mAdc
		10	-0.62	—	-0.50	-0.9	—	0.35	—	
		15	-1.8	—	-1.5	-3.5	—	1.1	—	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
		15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	I <sub>OL</sub>	5.0	0.5	—	0.4	0.88	—	0.28	—	
		10	1.1	—	0.9	2.25	—	0.65	—	
		15	1.80	—	1.5	8.8	—	1.20	—	
		5.0	3.0	—	2.5	4.0	—	1.6	—	
		10	6.0	—	5.0	8.0	—	3.5	—	
		15	18	—	15	20	—	10	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 4.6 Vdc) Source - Pin 3 (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OH</sub> = 4.6 Vdc) Source-Other Outputs (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink - Pin 3 (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) Sink - Other Outputs (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-0.2	—	-0.16	-0.36	—	-0.12	—	mAdc
		10	-0.5	—	-0.4	-0.9	—	-0.3	—	
		15	-1.4	—	-1.2	-3.5	—	-1.0	—	
		5.0	-0.52	—	-0.44	0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	I <sub>OL</sub>	5.0	0.23	—	0.2	0.88	—	0.16	—	
		10	0.60	—	0.5	2.25	—	0.40	—	
		15	1.80	—	1.5	8.8	—	1.20	—	
		5.0	2.4	—	2.0	4.0	—	1.6	—	
		10	3.8	—	3.0	8.0	—	2.5	—	
		15	10	—	8.4	20	—	7.0	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package) MR = V <sub>DD</sub>	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μAdc
		10	—	10	—	0.020	10	—	300	
		15	—	20	—	0.030	20	—	600	
Quiescent Current (CL/CP Device) (Per Package) MR = V <sub>DD</sub>	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μAdc
		10	—	100	—	0.020	100	—	750	
		15	—	200	—	0.030	200	—	1500	
Total Supply Current**† (Dynamic Plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.35 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (1.50 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

\*\*The formulas given are for the typical characteristics only at 25°C.





# MC14553B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Figure	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	2a	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	—	100	200	ns
			10	—	50	100	
			15	—	40	80	
Clock to BCD Out	2a	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	900	1800	ns
			10	—	500	1000	
			15	—	200	400	
Clock to Overflow	2a	t <sub>PHL</sub>	5.0	—	600	1200	ns
			10	—	400	800	
			15	—	200	400	
Reset to BCD Out	2b	t <sub>PHL</sub>	5.0	—	900	1800	ns
			10	—	500	1000	
			15	—	300	600	
Clock to Latch Enable Setup Time Master Reset to Latch Enable Setup Time	2b	t <sub>su</sub>	5.0	600	300	—	ns
			10	400	200	—	
			15	200	100	—	
Removal Time Latch Enable to Clock	2b	t <sub>rem</sub>	5.0	-80	-200	—	ns
			10	-10	-70	—	
			15	0	-50	—	
Clock Pulse Width	2a	t <sub>WH(cl)</sub>	5.0	550	275	—	ns
			10	200	100	—	
			15	150	75	—	
Reset Pulse Width	2b	t <sub>WH(R)</sub>	5.0	1200	600	—	ns
			10	600	300	—	
			15	450	225	—	
Reset Removal Time	—	t <sub>rem</sub>	5.0	-80	-180	—	ns
			10	0	-50	—	
			15	20	-30	—	
Input Clock Frequency	2a	f <sub>cl</sub>	5.0	—	1.5	0.9	MHz
			10	—	5.0	2.5	
			15	—	7.0	3.5	
Input Clock Rise Time	2b	t <sub>TLH</sub>	5.0	No Limit			ns
			10				
			15				
Disable, MR, Latch Enable Rise and Fall Times	—	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	—	—	15	μs
			10	—	—	5.0	
			15	—	—	4.0	
Scan Oscillator Frequency (C <sub>1</sub> measured in μF)	1	f <sub>osc</sub>	5.0	—	1.5/C <sub>1</sub>	—	Hz
			10	—	4.2/C <sub>1</sub>	—	
			15	—	7.0/C <sub>1</sub>	—	

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.



# MC14553B

## OPERATING CHARACTERISTICS

The MC14553B three-digit counter, shown in Figure 3, consists of three negative edge-triggered BCD counters which are cascaded in a synchronous fashion. A quad latch at the output of each of the three BCD counters permits storage of any given count. The three sets of BCD outputs (active high), after going through the latches, are time division multiplexed, providing one BCD number or digit at a time. Digit select outputs (active low) are provided for display control. All outputs are TTL compatible.

An on-chip oscillator provides the low frequency scanning clock which drives the multiplexer output selector. The frequency of the oscillator can be controlled externally by a capacitor between pins 3 and 4, or it can be overridden and driven with an external clock at pin 4. Multiple devices can be cascaded using the overflow output, which provides one pulse for every 1000 counts.

The Master Reset input, when taken high, initializes the three BCD counters and the multiplexer scanning circuit. While Master Reset is high the digit scanner is set to digit one; but all three digit select outputs are disabled to prolong display life, and the scan oscillator is inhibited. The Disable input, when high, prevents the input clock from reaching the counters, while still retaining the last count. A pulse shaping circuit at the clock input permits the counters to continue operating on input pulses with very slow rise times. Information present in the counters when the latch input goes high, will be stored in the latches and will be retained while the latch input is high, independent of other inputs. Information can be recovered from the latches after the counters have been reset if Latch Enable remains high during the entire reset cycle.

FIGURE 3 — EXPANDED BLOCK DIAGRAM

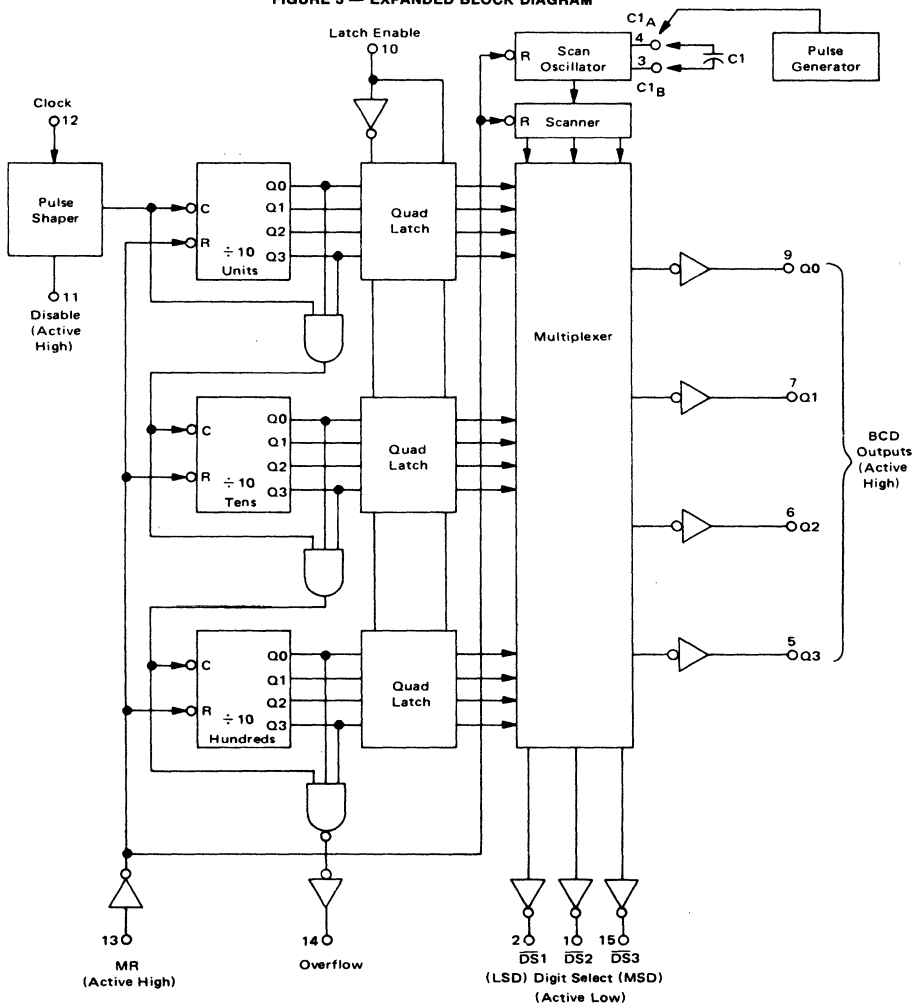
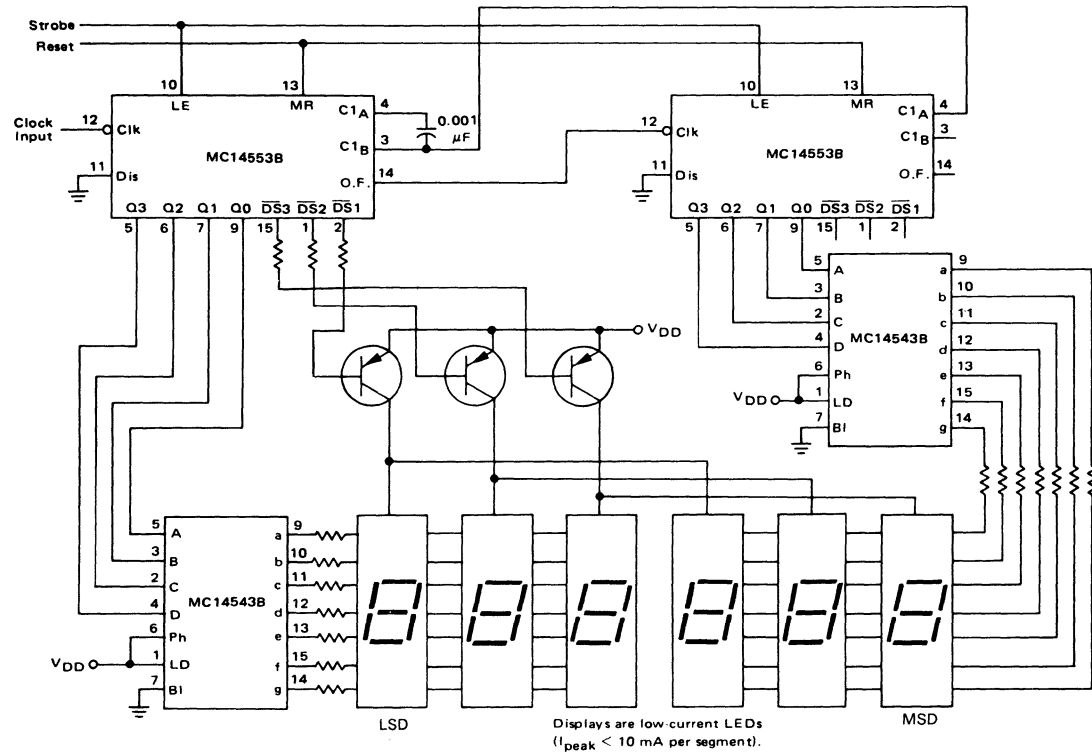


FIGURE 4 — SIX-DIGIT DISPLAY





**MOTOROLA**

**MC14554B**

**2-BIT BY 2-BIT PARALLEL BINARY MULTIPLIER**

The MC14554B 2 x 2-bit parallel binary multiplier is constructed with complementary MOS (CMOS) enhancement mode devices. The multiplier can perform the multiplication of two binary numbers and simultaneously add two other binary numbers to the product. The MC14554B has two multiplicand inputs (X0 and X1), two multiplier inputs (Y0 and Y1), five cascading or adding inputs (K0, K1, M0, M1, and M2), and five sum and carry outputs (S0, S1, S2, C1 [S3], and C0). The basic multiplier can be expanded into a straight-forward m-bit by n-bit parallel multiplier without additional logic elements.

Application areas include arithmetic processing (multiplying/adding, obtaining square roots, polynomial evaluation, obtaining reciprocals, and dividing), Fast Fourier Transform processing, digital filtering, communications (convolution and correlation), and process and machine controls.

- Diode Protection on All Inputs
- All Outputs Buffered
- Straight-forward m-Bit By n-Bit Expansion
- No Additional Logic Elements Needed for Expansion
- Multiplies and Adds Simultaneously
- Positive Logic Design
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

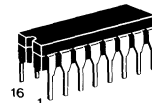
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

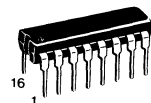
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**2-BIT BY 2-BIT PARALLEL BINARY MULTIPLIER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

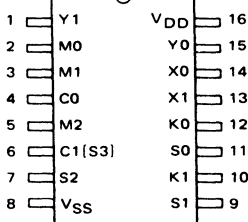
A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

**PIN ASSIGNMENT**



**EQUATIONS**

$S = (X \times Y) + K + M$

Where:

x Means Arithmetic Times.

+ Means Arithmetic Plus.

$S = S_3 S_2 S_1 S_0, X = X_1 X_0, Y = Y_1 Y_0,$

$K = K_1 K_0, M = M_1 M_0$  (Binary Numbers).

Example:

Given:  $X = 2(1), Y = 3(11)$

$K = 1(01), M = 2(10)$

Then:  $S = (2 \times 3) + 1 + 2 = 9$

$S = (10 \times 11) + 01 + 10 = 1001$

Note: C0 connected to M2 for this size multiplier.

See general expansion diagram for other size multipliers.

# MC14554B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to VSS)

Characteristic	Symbol	VDD Vdc	Tlow*		25°C			Thigh*		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage Vin = VDD or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (VO = 4.5 or 0.5 Vdc) (VO = 9.0 or 1.0 Vdc) (VO = 13.5 or 1.5 Vdc)	"0" Level VIL	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level VIH	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (VOH = 2.5 Vdc) (VOH = 4.6 Vdc) (VOH = 9.5 Vdc) (VOH = 13.5 Vdc)	Source IOH	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink IOL	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (VOH = 2.5 Vdc) (VOH = 4.6 Vdc) (VOH = 9.5 Vdc) (VOH = 13.5 Vdc)	Source IOH	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink IOL	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	Iin	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	Iin	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (Vin = 0)	Cin	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	IDD	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	IDD	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (CL = 50 pF on all outputs, all buffers switching)	IT	5.0	IT = (1.0 μA/kHz) f + IDD							μAdc
		10	IT = (2.0 μA/kHz) f + IDD							
		15	IT = (3.0 μA/kHz) f + IDD							

\*Tlow = -55°C for AL Device, -40°C for CL/CP Device.  
Thigh = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) Vfk$$

where: IT is in μA (per package), CL in pF, V = (VDD - VSS) in volts,  
f in kHz is input frequency, and k = 0.0035.

# MC14554B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit		
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$	5.0	—	100	200	ns		
		10	—	50	100			
		15	—	40	80			
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$	5.0	—	270	675	ns		
		10	—	115	290			
		15	—	85	215			
		K0 to C0						
		$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 185 \text{ ns}$						
		$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 82 \text{ ns}$						
M0 to S2								
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 595 \text{ ns}$		5.0	—	680	1700			
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 247 \text{ ns}$		10	—	280	750			
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 185 \text{ ns}$		15	—	210	570			

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION WAVEFORMS

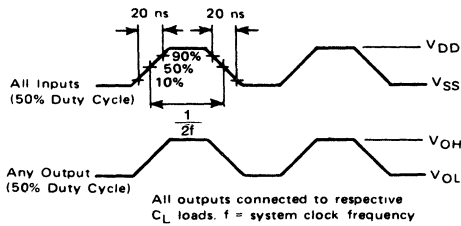
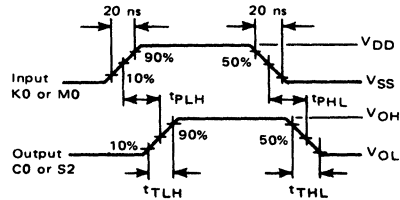


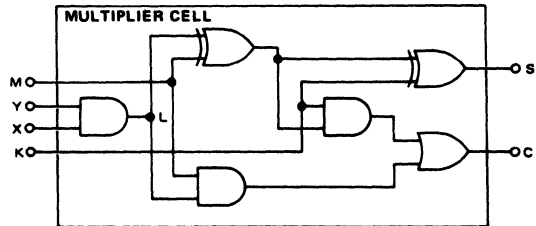
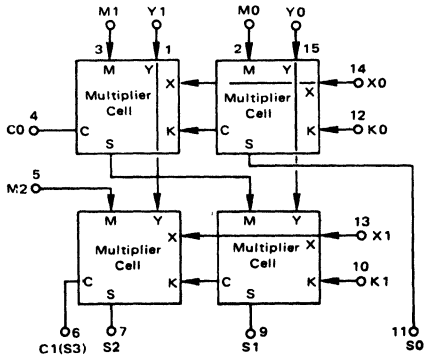
FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS



For K0 to C0:  
Inputs X0, X1, Y0, Y1, K1, and M2 low, and inputs M0 and M1 high.

For M0 to S2:  
Inputs X1, Y1, and K0 low, and inputs X0, Y0, K1, M1, and M2 high.

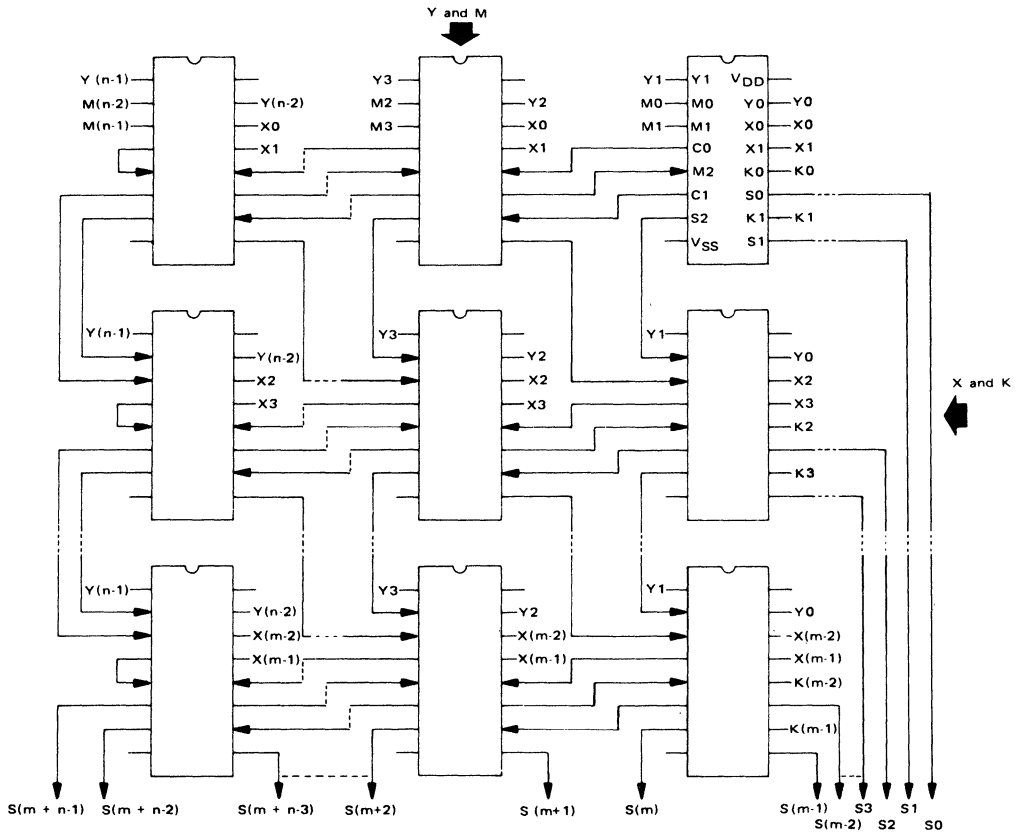
LOGIC DIAGRAM



# MC14554B

## EXPANSION DIAGRAM

m-Bit by n-Bit Parallel Binary Multiplier (Top View)



$S = (X \times Y) + K + M$  Where:  $\times$  means Arithmetic Times.  
 $+$  means Arithmetic Plus.

$S = S(m+n-1) S(m+n-2) \dots S_2 S_1 S_0$   
 $X = X(m-1) X(m-2) \dots X_2 X_1 X_0, Y = Y(n-1) Y(n-2) \dots Y_2 Y_1 Y_0$   
 $K = K(m-1) K(m-2) \dots K_2 K_1 K_0$  and  $M = M(n-1) M(n-2) \dots M_2 M_1 M_0$   
 (Binary Numbers).

Number of output binary digits =  $m + n$   
 Number of packages =  $mn/4$  (For  $m$  or  $n$  or both odd select next highest even number.)





**MOTOROLA**

**MC14555B  
MC14556B**

**DUAL BINARY TO 1-OF-4  
DECODER/DEMULTIPLEXER**

The MC14555B and MC14556B are constructed with complementary MOS (CMOS) enhancement mode devices. Each Decoder/Demultiplexer has two select inputs (A and B), an active low Enable input (E), and four mutually exclusive outputs (Q0, Q1, Q2, Q3). The MC14555B has the selected output go to the "high" state, and the MC14556B has the selected output go to the "low" state. Expanded decoding such as binary-to-hexadecimal (1-of-16), etc., can be achieved by using other MC14555B or MC14556B devices.

Applications include code conversion, address decoding, memory selection control, and demultiplexing (using the Enable input as a data input) in digital data transmission systems.

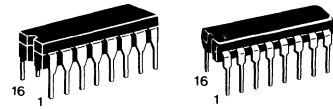
- Diode Protection on All Inputs
- Active High or Active Low Outputs
- Expandable
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- All Outputs Buffered
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**DUAL BINARY TO 1-OF-4  
DECODER/DEMULTIPLEXER**

Active High Outputs – MC14555B  
Active Low Outputs – MC14556B



**L SUFFIX** CERAMIC PACKAGE CASE 620  
**P SUFFIX** PLASTIC PACKAGE CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)  
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

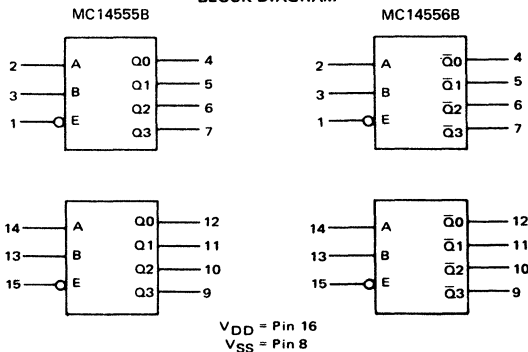
**TRUTH TABLE**

INPUTS			OUTPUTS MC14555B			OUTPUTS MC14556B			
ENABLE	SELECT		Q3	Q2	Q1	Q3	Q2	Q1	Q0
$\bar{E}$	B	A				$\bar{Q}3$	$\bar{Q}2$	$\bar{Q}1$	$\bar{Q}0$
0	0	0	0	0	1	1	1	1	0
0	0	1	0	0	1	0	1	1	0
0	1	0	0	1	0	1	0	1	1
0	1	1	1	0	0	0	1	1	1
1	X	X	0	0	0	0	1	1	1

X = Don't Care

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

**BLOCK DIAGRAM**



6

# MC14555B•MC14556B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	V <sub>in</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.85 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (1.7 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (2.6 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

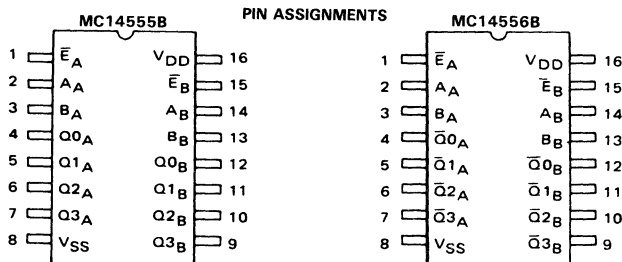
†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.002.

\*\*The formulas given are for the typical characteristics only at 25°C.



# MC14555B•MC14556B

SWITCHING CHARACTERISTICS\*(C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	—	100	200	ns
t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	10	—	50	100	ns
t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	15	—	40	80	ns
Propagation Delay Time – A, B to Output t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 135 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	220	440	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 62 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	95	190	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 45 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	70	140	ns
Propagation Delay Time – E to Output t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 115 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	200	400	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 52 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	85	170	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 40 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	65	130	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORMS

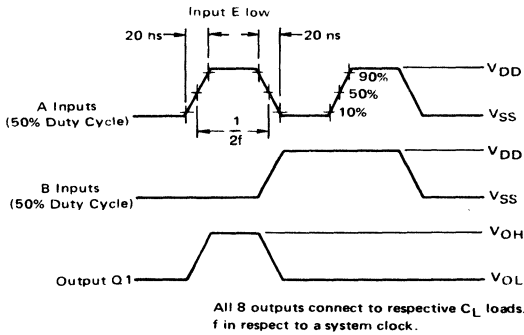
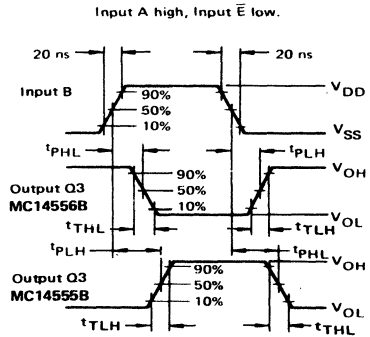
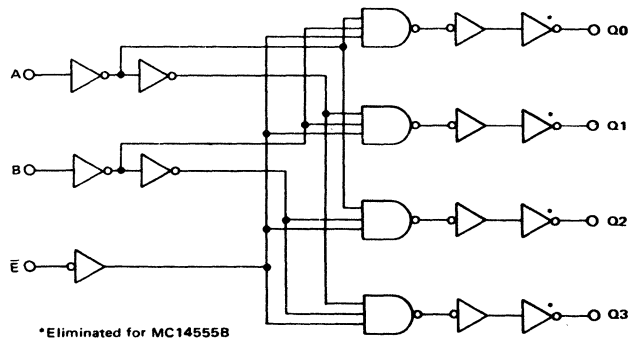


FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS



LOGIC DIAGRAM  
(1/2 of Dual)





**MOTOROLA**

**MC14557B**

**1-TO-64 BIT VARIABLE LENGTH SHIFT REGISTER**

The MC14557B is a static clocked serial shift register whose length may be programmed to be any number of bits between 1 and 64. The number of bits selected is equal to the sum of the subscripts of the enabled Length Control inputs (L1, L2, L4, L8, L16, and L32) plus one. Serial data may be selected from the A or B data inputs with the A/B select input. This feature is useful for recirculation purposes. A Clock Enable (CE) input is provided to allow gating of the clock or negative edge clocking capability.

The device can be effectively used for variable digital delay lines or simply to implement odd length shift registers.

- 1-64 Bit Programmable Length
- Q and  $\bar{Q}$  Serial Buffered Outputs
- Asynchronous Master Reset
- All Inputs Buffered
- No Limit On Clock Rise and Fall Times
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or one Low-power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$i_{in}, i_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**LENGTH SELECT TRUTH TABLE**

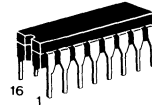
L32	L16	L8	L4	L2	L1	Register Length
0	0	0	0	0	0	1-Bit
0	0	0	0	0	1	2-Bits
0	0	0	0	1	0	3-Bits
0	0	0	0	1	1	4-Bits
0	0	0	1	0	0	5-Bits
0	0	0	1	0	1	6-Bits
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1	0	0	0	0	0	33-Bits
1	0	0	0	0	1	34-Bits
.	.	.	.	.	.	.
.	.	.	.	.	.	.
.	.	.	.	.	.	.
1	1	1	1	0	0	61-Bits
1	1	1	1	0	1	62-Bits
1	1	1	1	1	0	63-Bits
1	1	1	1	1	1	64-Bits

Note: Length equals the sum of the binary length control subscripts plus one.

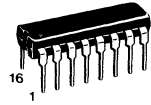
**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

**1-TO-64 BIT  
VARIABLE LENGTH  
SHIFT REGISTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



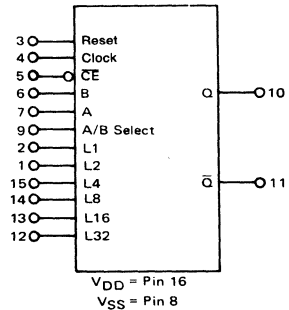
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14557BAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14557BCP (Plastic Package)  
MC14557BCL (Ceramic Package)

**BLOCK DIAGRAM**



**TRUTH TABLE**

Inputs				Output
Rst	A/B	Clock	$\bar{C}E$	Q
0	0		0	B
0	1		0	A
0	0	1		B
0	1	1		A
1	X	X	X	0

Q is the output of the first selected shift register stage.

X = Don't Care.

# MC14557B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
			10	—	0.05	—	0	0.05	—	0.05		
			15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
				10	9.95	—	9.95	10	—	9.95	—	
				15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
			10	—	3.0	—	4.50	3.0	—	3.0		
			15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
			10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>	
			10	1.6	—	1.3	2.25	—	0.9	—		
			15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
			10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>	
			10	1.3	—	1.1	2.25	—	0.9	—		
			15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μA <sub>dc</sub>		
		10	—	10	—	0.020	10	—	300			
		15	—	20	—	0.030	20	—	600			
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μA <sub>dc</sub>		
		10	—	100	—	0.020	100	—	750			
		15	—	200	—	0.030	200	—	1500			
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.75 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>		
		10	I <sub>T</sub> = (3.5 μA/kHz) f + I <sub>DD</sub>									
		15	I <sub>T</sub> = (5.25 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

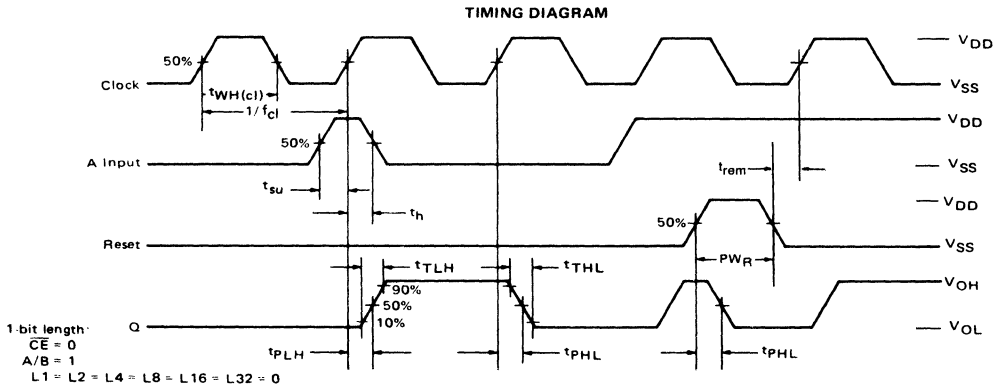
# MC14557B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

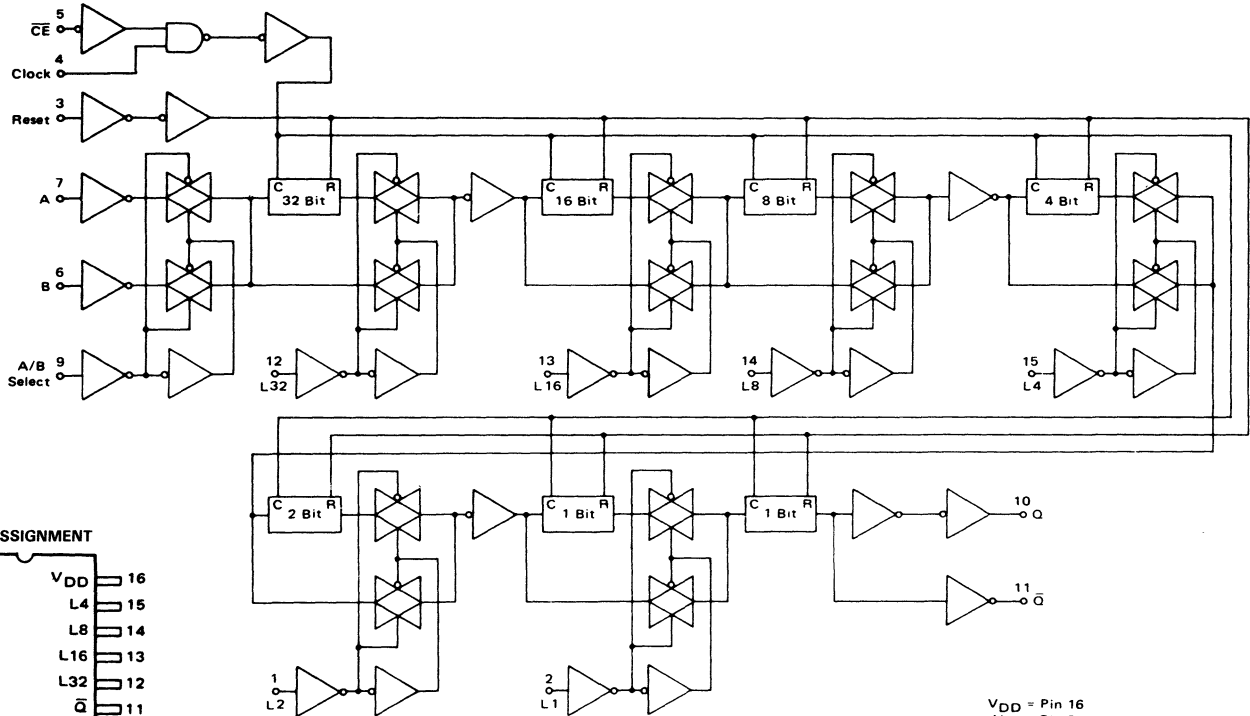
Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Rise and Fall Time, Q or $\bar{Q}$ Output t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	5 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay, Clock or $\bar{CE}$ to Q or $\bar{Q}$ t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 215 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 65 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5 10 15	— — —	300 130 90	600 260 180	ns
Propagation Delay, Reset to Q or $\bar{Q}$ t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 215 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 97 ns t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 70 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	5 10 15	— — —	300 130 95	600 260 190	ns
Pulse Width, Clock	t <sub>WH(cl)</sub>	5 10 15	200 100 75	95 45 35	— — —	ns
Pulse Width, Reset	t <sub>WH(rst)</sub>	5 10 15	300 140 100	150 70 50	— — —	ns
Clock Frequency (50% Duty Cycle)	f <sub>cl</sub>	5 10 15	— — —	3.0 7.5 13.0	1.7 5.0 6.7	MHz
Setup Time, A or B to Clock or $\bar{CE}$ Worst case condition: L1 = L2 = L4 = L8 = L16 = L32 = V <sub>SS</sub> (Register Length = 1)  Best case condition: L32 = V <sub>DD</sub> , L1 through L16 = Don't Care (Any register length from 33 to 64)	t <sub>su</sub>	5 10 15	700 290 145	350 130 85	— — —	ns
Hold Time, Clock or $\bar{CE}$ to A or B Best case condition: L1 = L2 = L4 = L8 = L16 = L32 = V <sub>SS</sub> (Register Length = 1)  Worst case condition: L32 = V <sub>DD</sub> , L1 through L16 = Don't Care (Any register length from 33 to 64)	t <sub>h</sub>	5 10 15	200 100 10	-150 -60 -50	— — —	ns
Rise and Fall Time, Clock	t <sub>r</sub> , t <sub>f</sub>	5 10 15	No Limit			—
Rise and Fall Time, Reset or $\bar{CE}$	t <sub>r</sub> , t <sub>f</sub>	5 10 15	— — —	— — —	15 5 4	μs
Removal Time, Reset to Clock or $\bar{CE}$	t <sub>rem</sub>	5 10 15	160 80 70	80 40 35	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

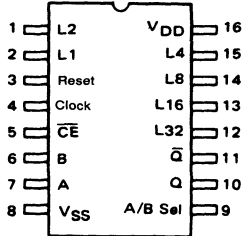
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.



LOGIC DIAGRAM



PIN ASSIGNMENT



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8



**MOTOROLA**

**MC14558B**

**BCD-TO-SEVEN SEGMENT DECODER**

The MC14558B decodes 4-bit binary coded decimal data dependent on the state of auxiliary inputs, Enable and  $\overline{RB}i$ , and provides an active-high seven-segment output for a display driver.

An auxiliary input truth table is shown, in addition to the BCD to seven-segment truth table, to indicate the functions available with the two auxiliary inputs.

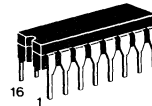
Leading Zero blanking is easily obtained with an external flip-flop in time division multiplexed systems displaying most significant decade first.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Segment Blanking for All Illegal Input Combinations
- Lamp Test Function
- Capability for Suppression of Non-Significant Zeros
- Lamp Intensity Function
- Capable of Driving Two Low-power TTL Loads, One Low-power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range

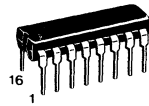
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**BCD-TO-SEVEN SEGMENT DECODER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

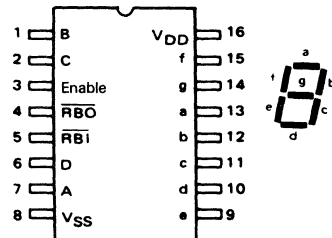
A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS** (Voltages referenced to  $V_{SS}$ )

Rating	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	-0.5 to +18	Vdc
Input Voltage, All Inputs	$V_{in}$	-0.5 to $V_{DD} + 0.5$	Vdc
DC Input Current, per Pin	$I_{in}$	$\pm 10$	mAdc
Operating Temperature Range -- AL Device	$T_A$	-55 to +125	°C
CL/CP Device		-40 to +85	
Storage Temperature Range	$T_{stg}$	-65 to +150	°C

**PIN ASSIGNMENT**



**AUXILIARY INPUT TRUTH TABLE**

Enable Pin 3	$\overline{RB}i$ Pin 5	BCD Input Code	$\overline{RBO}$ Pin 4	Function Performed
0	0	X	0	Lamp Test
0	1	X	1	Blank Segments
1	1	0	1	Display Zero
1	0	0	0	Blank Segments
1	X	1-9	1	1-9 Displayed

X = Don't Care  
 $\overline{RB}i$  = Ripple Blanking Input  
RBO = Ripple Blanking Output

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# MC14558B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to $V_{SS}$ )

Characteristic	Symbol	$V_{DD}$ Vdc	$T_{low}^*$		25°C			$T_{high}^*$		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage "0" Level $V_{in} = V_{DD}$ or 0	$V_{OL}$	5.0	-	0.05	-	0	0.05	-	0.05	Vdc	
		10	-	0.05	-	0	0.05	-	0.05		
		15	-	0.05	-	0	0.05	-	0.05		
	"1" Level $V_{in} = 0$ or $V_{DD}$	$V_{OH}$	5.0	4.95	-	4.95	5.0	-	4.95	-	Vdc
			10	9.95	-	9.95	10	-	9.95	-	
			15	14.95	-	14.95	15	-	14.95	-	
Input Voltage <sup>#</sup> "0" Level ( $V_O = 4.5$ or $0.5$ Vdc) ( $V_O = 9.0$ or $1.0$ Vdc) ( $V_O = 13.5$ or $1.5$ Vdc)	$V_{IL}$	5.0	-	1.5	-	2.25	1.5	-	1.5	Vdc	
		10	-	3.0	-	4.50	3.0	-	3.0		
		15	-	4.0	-	6.75	4.0	-	4.0		
	"1" Level ( $V_O = 0.5$ or $4.5$ Vdc) ( $V_O = 1.0$ or $9.0$ Vdc) ( $V_O = 1.5$ or $13.5$ Vdc)	$V_{IH}$	5.0	3.5	-	3.5	2.75	-	3.5	-	Vdc
			10	7.0	-	7.0	5.50	-	7.0	-	
			15	11.0	-	11.0	8.25	-	11.0	-	
Output Drive Current (AL Device) ( $V_{OH} = 2.5$ Vdc) Source ( $V_{OH} = 4.6$ Vdc) ( $V_{OH} = 9.5$ Vdc) ( $V_{OH} = 13.5$ Vdc)	$I_{OH}$	5.0	-3.0	-	-2.4	-4.2	-	-1.7	-	mA	
		10	-0.64	-	-0.51	-0.88	-	-0.36	-		
		15	-1.6	-	-1.3	-2.25	-	-0.9	-		
	Sink ( $V_{OL} = 0.4$ Vdc) ( $V_{OL} = 0.5$ Vdc) ( $V_{OL} = 1.5$ Vdc)	$I_{OL}$	5.0	0.64	-	0.51	0.88	-	0.36	-	mA
			10	1.6	-	1.3	2.25	-	0.9	-	
			15	4.2	-	3.4	8.8	-	2.4	-	
Output Drive Current (CL/CP Device) ( $V_{OH} = 2.5$ Vdc) Source ( $V_{OH} = 4.6$ Vdc) ( $V_{OH} = 9.5$ Vdc) ( $V_{OH} = 13.5$ Vdc)	$I_{OH}$	5.0	-2.5	-	-2.1	-4.2	-	-1.7	-	mA	
		10	-0.52	-	-0.44	-0.88	-	-0.36	-		
		15	-1.3	-	-1.1	-2.25	-	-0.9	-		
	Sink ( $V_{OL} = 0.4$ Vdc) ( $V_{OL} = 0.5$ Vdc) ( $V_{OL} = 1.5$ Vdc)	$I_{OL}$	5.0	0.52	-	0.44	0.88	-	0.36	-	mA
			10	1.3	-	1.1	2.25	-	0.9	-	
			15	3.6	-	3.0	8.8	-	2.4	-	
Input Current (AL Device)	$I_{in}$	15	-	$\pm 0.1$	-	$\pm 0.00001$	$\pm 0.1$	-	$\pm 1.0$	$\mu A$	
Input Current (CL/CP Device)	$I_{in}$	15	-	$\pm 0.3$	-	$\pm 0.00001$	$\pm 0.3$	-	$\pm 1.0$	$\mu A$	
Input Capacitance	$C_{in}$	-	-	-	-	5.0	7.5	-	-	pF	
Quiescent Current (AL Device) (Per Package) $V_{in} = 0$ or $V_{DD}$ $I_{out} = 0 \mu A$	$I_{DD}$	5.0	-	5.0	-	0.005	5.0	-	150	$\mu A$	
		10	-	10	-	0.010	10	-	300		
		15	-	20	-	0.015	20	-	600		
Quiescent Current (CL/CP Device) (Per Package) $V_{in} = 0$ or $V_{DD}$ $I_{out} = 0 \mu A$	$I_{DD}$	5.0	-	20	-	0.005	20	-	150	$\mu A$	
		10	-	40	-	0.010	40	-	300		
		15	-	80	-	0.015	80	-	600		
Total Supply Current** $I_T$ (Dynamic plus Quiescent, Per Package) ( $C_L = 50$ pF on all outputs, all buffers switching)	$I_T$	5.0	$I_T = (1.2 \mu A/kHz) f + I_{DD}$							$\mu A$	
		10	$I_T = (2.4 \mu A/kHz) f + I_{DD}$								
		15	$I_T = (3.6 \mu A/kHz) f + I_{DD}$								

\* $T_{low} = -55^\circ C$  for AL Device,  $-40^\circ C$  for CL/CP Device.

$T_{high} = +125^\circ C$  for AL Device,  $+85^\circ C$  for CL/CP Device

#Noise immunity specified for worst-case input combination

Noise Margin for both "1" and "0" level = 1.0 Vdc min @  $V_{DD} = 5.0$  Vdc

2.0 Vdc min @  $V_{DD} = 10$  Vdc

2.5 Vdc min @  $V_{DD} = 15$  Vdc

†To calculate total supply current at loads other than 50 pF

$I_T(C_L) = I_T(50 \text{ pF}) + 4 \times 10^{-3} (C_L - 50) V_{DD} f$

where  $I_T$  is in  $\mu A$  (per package),  $C_L$  in pF,  $V_{DD}$  in Vdc, and  $f$  in kHz is input frequency.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that  $V_{in}$  and  $V_{out}$  be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ).

# MC14558B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C; see Figure 1)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ	Max	Unit
Output Rise Time t <sub>TLH</sub> = (3.0 ns/pF) C <sub>L</sub> + 30 ns t <sub>TLH</sub> = (1.5 ns/pF) C <sub>L</sub> + 15 ns t <sub>TLH</sub> = (1.1 ns/pF) C <sub>L</sub> + 10 ns	t <sub>TLH</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Output Fall Time t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns	t <sub>THL</sub>	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time t <sub>PLH</sub> = (1.7 ns/pF) C <sub>L</sub> + 495 ns t <sub>PLH</sub> = (0.66 ns/pF) C <sub>L</sub> + 187 ns t <sub>PLH</sub> = (0.5 ns/pF) C <sub>L</sub> + 120 ns	t <sub>PLH</sub>	5.0 10 15	— — —	580 220 145	1160 440 230	ns
Propagation Delay Time t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 695 ns t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 242 ns t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 160 ns	t <sub>PHL</sub>	5.0 10 15	— — —	780 275 185	1560 550 370	ns

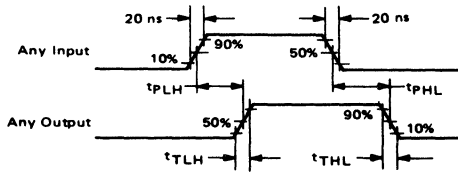
\* The formulae given are for the typical characteristics only.

### TRUTH TABLE

INPUTS						OUTPUTS*								
Enable Pin 3	$\overline{\text{RBI}}$ Pin 5	D Pin 6	C Pin 2	B Pin 1	A Pin 7	a Pin 13	b Pin 12	c Pin 11	d Pin 10	e Pin 9	f Pin 15	g Pin 14	$\overline{\text{RBO}}$ Pin 4	DISPLAY
1	1	0	0	0	0	1	1	1	1	1	1	0	1	0
1	x	0	0	0	1	0	0	0	0	1	1	0	1	1
1	x	0	0	1	0	1	1	0	1	1	0	1	1	2
1	x	0	0	1	1	1	1	1	1	0	0	1	1	3
1	x	0	1	0	0	0	1	1	0	0	1	1	1	4
1	x	0	1	0	1	1	0	1	1	0	1	1	1	5
1	x	0	1	1	0	0	0	1	1	1	1	1	1	6
1	x	0	1	1	1	1	1	1	0	0	0	0	1	7
1	x	1	0	0	0	1	1	1	1	1	1	1	1	8
1	x	1	0	0	1	1	1	1	0	0	1	1	1	9
1	0	0	0	0	0	0	0	0	0	0	0	0	0	Blank
0	0	x	x	x	x	1	1	1	1	1	1	1	0	8
0	1	x	x	x	x	0	0	0	0	0	0	0	1	Blank

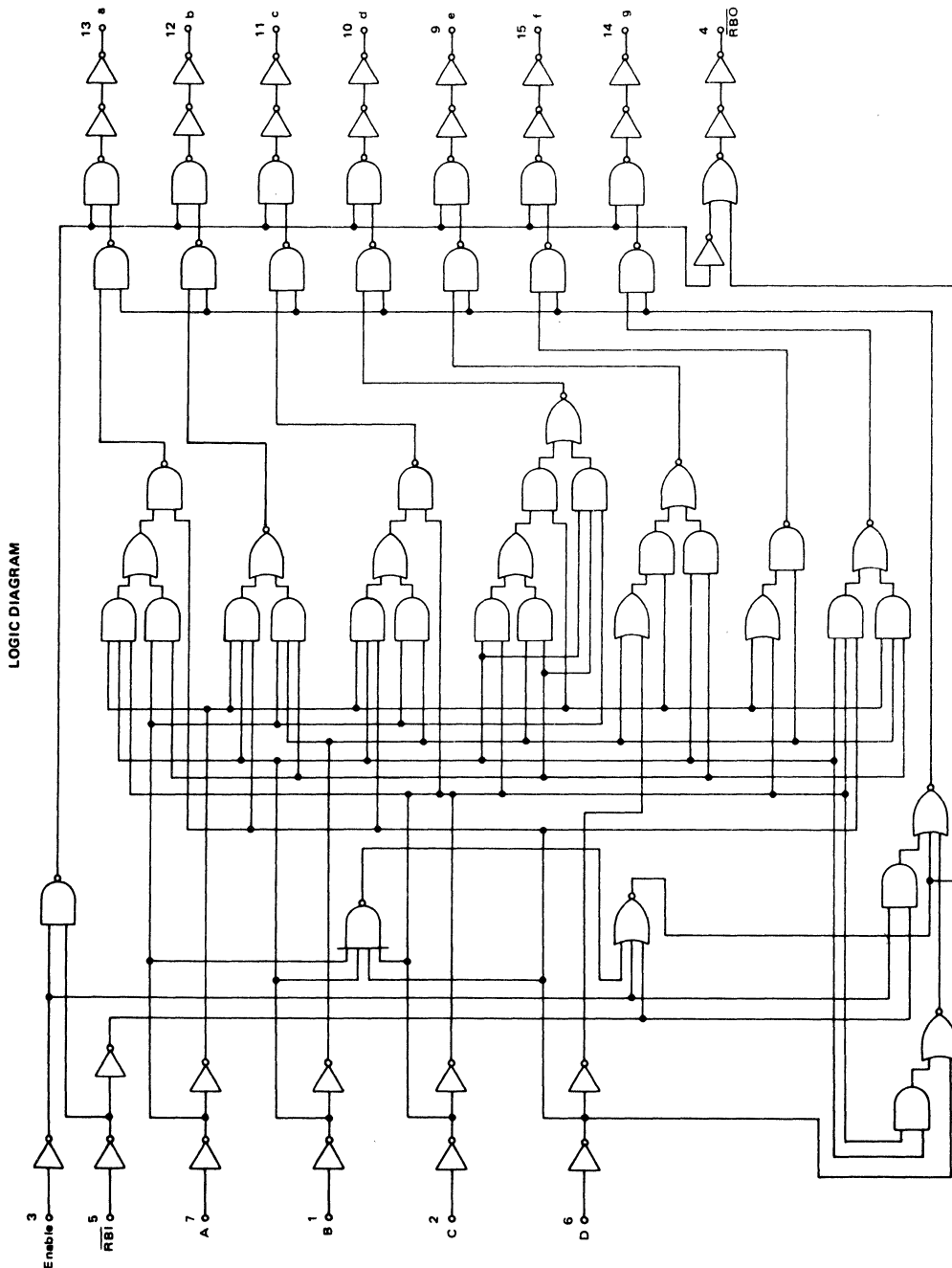
\* All non-valid BCD input codes produce a blank display  
x = Don't Care

FIGURE 1 – SIGNAL WAVEFORMS



6

# MC14558B

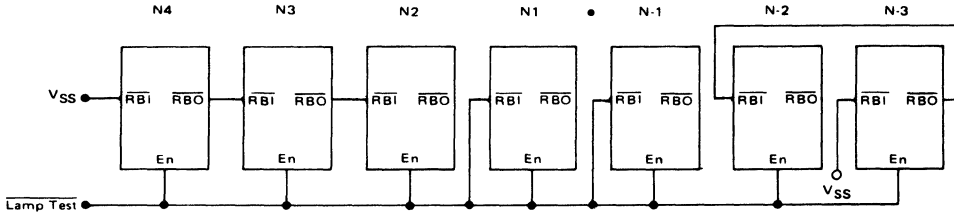


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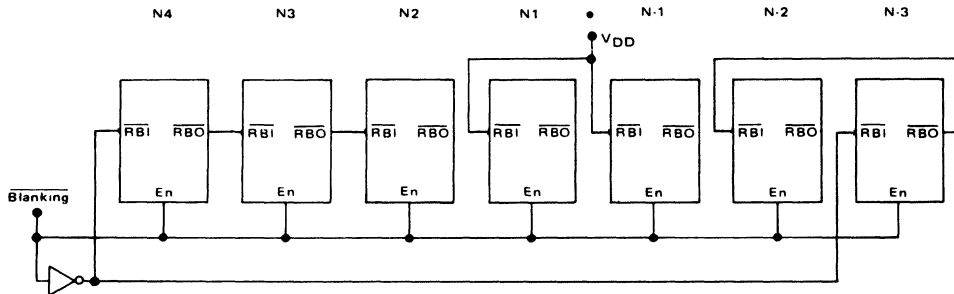
# MC14558B

## TYPICAL APPLICATIONS

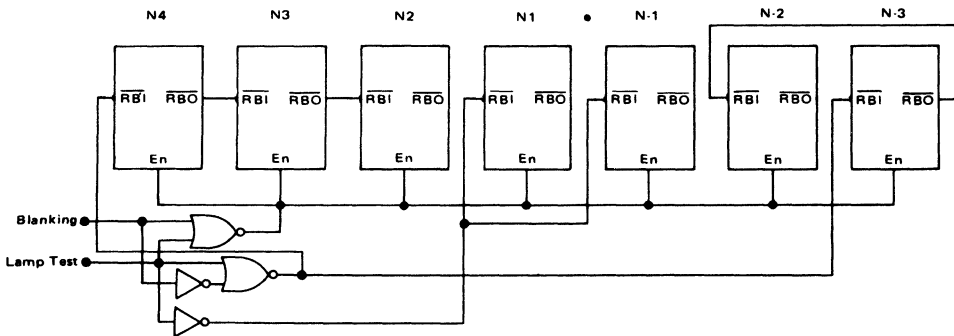
**FIGURE 2 – LEADING AND TRAILING ZERO SUPPRESSION WITH LAMP TEST**



**FIGURE 3 – LEADING AND TRAILING ZERO SUPPRESSION WITH PWM INTENSITY BLANKING AND NO LAMP TEST**



**FIGURE 4 – ZERO SUPPRESSION WITH LAMP TEST AND INTENSITY BLANKING**





**MC14559B**  
See Page 6-394

**MC14560B**

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**NBCD ADDER**

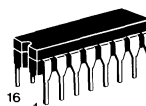
**NBCD ADDER**

The MC14560B adds two 4-bit numbers in NBCD (natural binary coded decimal) format, resulting in sum and carry outputs in NBCD code.

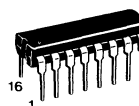
This device can also subtract when one set of inputs is complemented with a 9's Complementer (MC14561B).

All inputs and outputs are active high. The carry input for the least significant digit is connected to  $V_{SS}$  for no carry in.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

**A Series:** -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

**C Series:** -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	±10	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating: Plastic "P" Package - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package: - 12mW/°C from 100°C to 125°C

**TRUTH TABLE\***

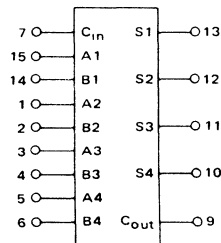
INPUT									OUTPUT				
A4	A3	A2	A1	B4	B3	B2	B1	$C_{in}$	$C_{out}$	S4	S3	S2	S1
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0	0	0	0	1
0	1	0	0	0	0	1	1	0	0	1	1	1	1
0	1	0	0	0	0	1	1	1	0	1	0	0	0
0	1	1	1	0	1	0	0	0	1	0	0	0	1
0	1	1	1	0	1	0	0	1	1	0	0	1	0
1	0	0	0	0	1	0	1	0	1	0	0	1	1
0	1	1	0	1	0	0	0	0	1	0	1	0	0
1	0	0	1	1	0	0	1	1	1	1	0	0	1

\*Partial truth table to show logic operation for representative input values

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ .

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

**BLOCK DIAGRAM**



$V_{DD}$  = Pin 16  
 $V_{SS}$  = Pin 8

# MC14560B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
			10	—	0.05	—	0	0.05	—	0.05	
			15	—	0.05	—	0	0.05	—	0.05	
	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
			10	—	3.0	—	4.50	3.0	—	3.0	
			15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			10	-0.64	—	-0.51	-0.88	—	-0.36	—	
			15	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			10	-0.52	—	-0.44	-0.88	—	-0.36	—	
			15	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.68 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (3.35 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (5.03 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

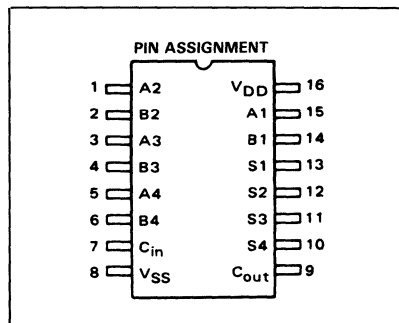
#Data labeled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.005.



# MC14560B

SWITCHING CHARACTERISTICS\* ( $C_L = 50$  pF,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time A or B to S $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 665 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 297 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 195 \text{ ns}$ A or B to C <sub>out</sub> $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 565 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 145 \text{ ns}$ C <sub>in</sub> to C <sub>out</sub> $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 465 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 187 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 135 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	750 330 220	2100 900 675	ns
Turn-Off Delay Time C <sub>in</sub> to S $t_{PLH} = (1.7 \text{ ns/pF}) C_L + 715 \text{ ns}$ $t_{PLH} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH} = (0.5 \text{ ns/pF}) C_L + 215 \text{ ns}$	$t_{PLH}$	5.0 10 15	— — —	800 350 240	2250 975 750	ns
Turn-On Delay Time C <sub>in</sub> to S $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 565 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 145 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	650 230 170	1800 600 450	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – POWER DISSIPATION WAVEFORMS

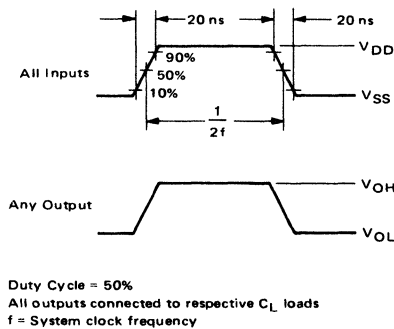
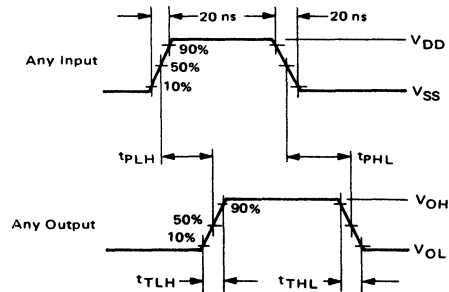


FIGURE 2 – SWITCHING TIME WAVEFORMS



# MC14560B

FUNCTIONAL EQUIVALENT LOGIC DIAGRAM

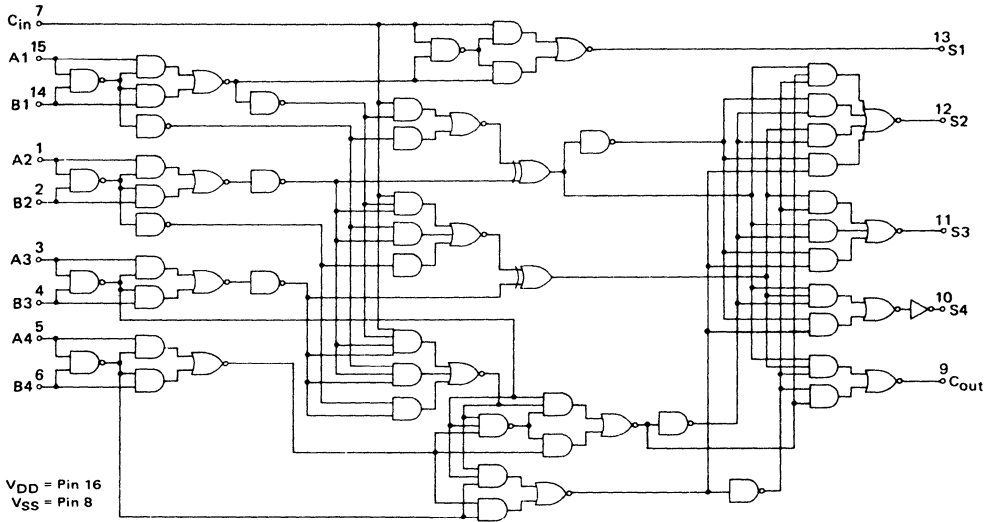
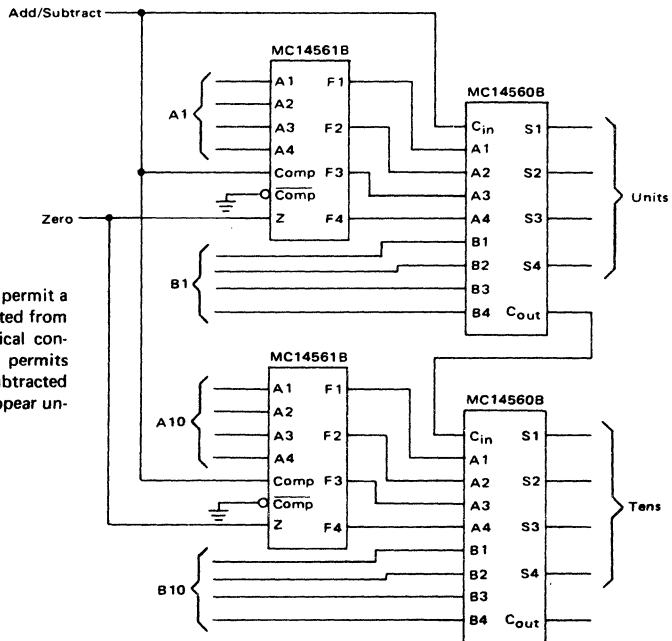


FIGURE 3 - PARALLEL ADD/SUBTRACT CIRCUIT



One MC14560B and MC14561B permit a BCD digit to be added to or subtracted from a second digit, such as in this typical configuration. A second MC14561B permits either digit to be added to or subtracted from the other, or either word to appear unmodified at the output.

TRUTH TABLE

Zero	Add/Subtract	Result
0	0	B plus A
0	1	B minus A
1	X	B

X = Don't Care



## APPLICATIONS INFORMATION

## INTRODUCTION

Frequently in small digital systems, simple decimal arithmetic is performed. Decimal data enters and leaves the system arithmetic unit in a binary coded decimal (BCD) format. The adder/subtractor in the arithmetic unit may be required to accept sign as well as magnitude, and generate sign, magnitude, and overflow. In the past, it has been cumbersome to build sign and magnitude adder/subtractors. Now, using Motorola's MSI CMOS functions, the MC14560 NBCD Adders and MC14561 9's Complementers, NBCD adder/subtractors may be built economically, with surprisingly low package count and moderate speed.

Some background information on BCD arithmetic is presented here, followed by simple circuits for unsigned adder/subtractors. The final circuit discussed is an adder/subtractor for signed numbers with complete overflow and sign correction logic.

## DECIMAL NUMBER REPRESENTATION

Because logic elements are binary or two-state devices, decimal digits are generally represented as a group of bits in a weighted format. There are many possible binary codes which can be used to represent a decimal number. One of the most popular codes using 4 binary digits to represent 0 thru 9 is Natural Binary Coded Decimal (NBCD or 8-4-2-1 code).

NBCD is a weighted code. If a value of "0" or "1" is assigned to each of the bit positions, where the rightmost position is  $2^0$  and the leftmost is  $2^3$ , and the values are summed for a given code, the result is equal to the decimal digit represented by the code. Thus, 0110 equals  $0 \cdot 2^3 + 1 \cdot 2^2 + 1 \cdot 2^1 + 0 \cdot 2^0 = 4 + 2 = 6$ . The 1010, 1011, 1100, 1101, 1110, and 1111 binary codes are not used. Because of these illegal states, the addition and subtraction of NBCD numbers is more complex than similar calculations on straight binary numbers.

## ADDITION OF UNSIGNED NBCD NUMBERS

When 2 NBCD digits, A and B, and a possible carry, C, are added, a total of 20 digit sums ( $A + B + C$ ) are possible as shown in Table 1.

The binary representations for the digit sums 10 thru 19 are offset by 6, the number of unused binary states, and are not correct. An algorithm for obtaining the correct sum is shown in Figure 1. A conventional method of implementing the BCD addition algorithm is shown in Figure 2(a). The NBCD digits, A and B, are summed by a 4 bit binary full adder. The resultant (sum and carry) is input to a binary/BCD code converter which generates the correct BCD code and carry.

An NBCD adder block which performs the above function is available in a single CMOS package (MC14560). Figure 2(b) shows n decades cascaded for addition of n digit unsigned NBCD numbers. Add time is typically  $0.1 + 0.2n \mu\text{s}$  for n decades. When the carry out of the most significant decade is a logical "1", an overflow is indicated.

## COMPLEMENT ARITHMETIC

Complement arithmetic is used in NBCD subtraction. That is, the "complement" of the subtrahend is added to the minuend. The complementing process amounts to biasing the subtrahend such that all possible sums are positive. Consider the subtraction of the NBCD numbers, A and B:

$$R = A - B$$

where R is the result. Now bias both sides of the equation by  $10^N - 1$  where N is the number of digits in A and B.

$$R + 10^N - 1 = A - B + 10^N - 1$$

Rearranging,

$$R + 10^N - 1 = A + (10^N - 1 - B)$$

The term  $(10^N - 1 - B)$ ,  $-B$  biased by  $10^N - 1$ , is known as the 9's complement of B. When  $A > B$ ,  $R + 10^N - 1 > 10^N - 1$ ; thus R is a positive number. To obtain R, 1 is added to  $R + 10^N - 1$ , and the carry term,  $10^N$ , is dropped. The addition of 1 is called End Around Carry (EAC).

When  $A < B$ ,  $R + 10^N - 1 < 10^N - 1$ , no EAC results and R is a negative number biased by  $10^N - 1$ ; thus  $R + 10^N - 1$  is the 9's complement of R.

## SUBTRACTION OF UNSIGNED NBCD NUMBERS

Nine's complement arithmetic requires an element to perform the complementing function. An NBCD 9's complementer may be implemented using a 4 bit binary adder and 4 inverters, or with combinatorial logic. The Motorola MC14561 9's complementer is available in a single package. It has true and inverted complement disable, which allow straight-through or complement modes of operation. A "zero" line forces the output to "0". Figure 3 shows an NBCD subtracter block using the MC14560 and MC14561. Also shown are n cascaded blocks for subtraction of n digit unsigned numbers. Subtract time is  $0.6 + 0.4n \mu\text{s}$  for n stages. Underflow (borrow) is indicated by a logical "0" on the carry output of the most significant digit. A "0" carry also indicates that the difference is a negative number in 9's complement form. If the result is input to a 9's complementer, as shown, and its mode controlled by the carry out of the most significant digit, the output of the complementer will be the correct negative magnitude. Note that the carry out of the most significant digit (MSD) is the input to carry in of the least significant digit (LSD). This End Around Carry is required because subtraction is done in 9's complement arithmetic.

By controlling the complement and overflow logic with an add/subtract line, both addition and subtraction are performed using the basic subtracter blocks (Figure 4).

# MC14560B

TABLE 1 – Sum = A + B + C

Binary Sums	Decimal Number	Corrected Binary Sums
0000	0	0000
0001	1	0001
0010	2	0010
0011	3	0011
0100	4	0100
0101	5	0101
0110	6	0110
0111	7	0111
1000	8	1000
1001	9	1001
1010	10	0000 + Carry
1011	11	0001 + Carry
1100	12	0010 + Carry
1101	13	0011 + Carry
1110	14	0100 + Carry
1111	15	0101 + Carry
0000 + Carry	16	0110 + Carry
0001 + Carry	17	0111 + Carry
0010 + Carry	18	1000 + Carry
0011 + Carry	19	1001 + Carry

## ADDITION AND SUBTRACTION OF SIGNED NBCD NUMBERS

Using MC14560 NBCD Adders and MC14561 9's Complementers, a sign and magnitude adder/subtractor can be configured (Figure 5). Inputs A and B are signed positive ( $A_S, B_S = "0"$ ) or negative ( $A_S, B_S = "1"$ ). B is added to or subtracted from A under control of an Add/Sub line (subtraction = "1"). The result, R, of the operation is positive signed, positive signed with overflow, negative signed, or negative signed with overflow. Add/subtract time is typically  $0.6 + 0.4n \mu s$  for n decades.

An exclusive-OR of Add/Sub line and  $B_S$  produces  $B'$ , which controls the B complementers. If  $B_S$ , the sign of B, is a logical "1" (B is negative) and the Add/Sub line is a "0" (add B to A), then the output of the exclusive-OR ( $B_S'$ ) is a logical "1" and B is complemented. If  $B_S = "1"$  and Add/Sub = "1", B is not complemented since subtracting a negative number is the same as adding a positive number. When Add/Sub is a "1" and  $B_S = "0"$ ,  $B_S'$  is a "1" and B is complemented. The A complementer is controlled by the A sign bit,  $A_S$ . When  $A_S = "1"$ , A is complemented.

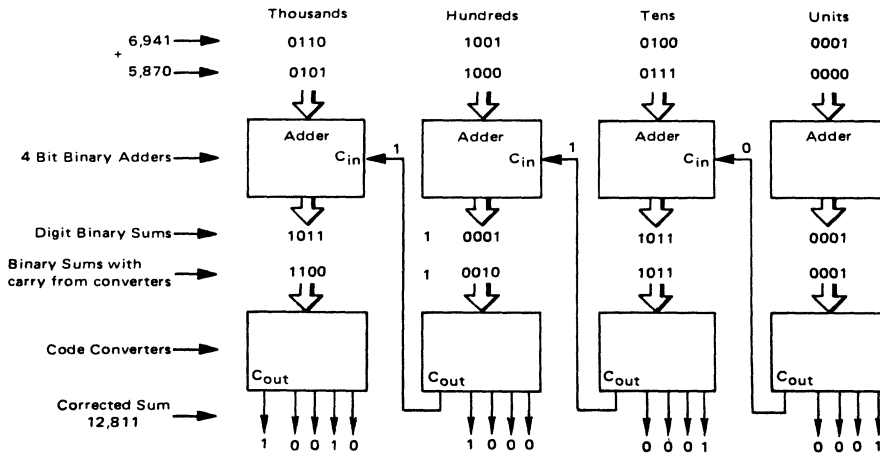


FIGURE 4 — Unsigned NBCD Addition Algorithm

6

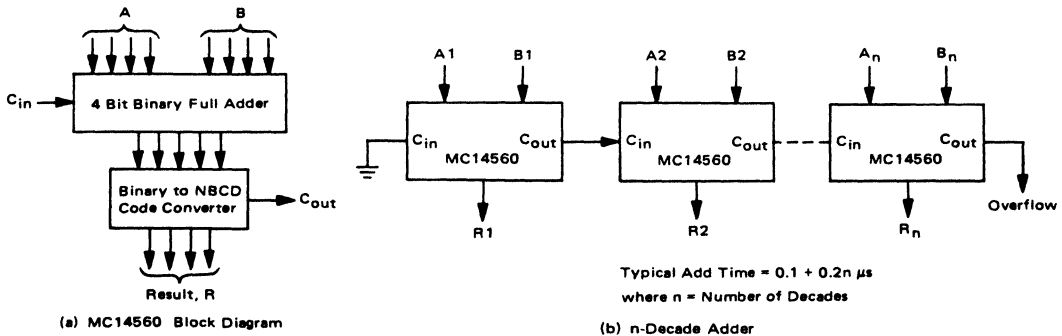


FIGURE 5 — Addition of Unsigned NBCD Numbers

# MC14560B

The truth table and Karnaugh maps for sign, overflow, and End Around Carry are shown in Figures 6 and 7. Note the use of  $B_S'$  from the exclusive-OR of Add/Sub and  $B_S$ .  $B_S'$  eliminates Add/Sub as a variable in the truth table. As an example of truth table generation, consider an  $n$  decade adder/subtractor where  $A_S = "0"$ ,  $B_S = "1"$ , and Add/Sub = "0".  $B$  is in 9's complement form,  $10^N - 1 - B$ . Thus  $A + (10^N - 1 - B) = 10^N - 1 + (A - B)$ . There is no carry when  $A \leq B$ , and the sign is negative (sign = "1"). When  $A_S$  and  $B_S$  are opposite states and Add/Sub is a "0" (add mode), no overflow can occur (overflow = "0"). The other output states are determined in a similar manner (see Figure 6).

From the Karnaugh maps it is apparent that End Around Carry is composed of the two symmetrical functions S2 and S3 of three variables with  $A_S B_S' C_{out}$  as the center of symmetry. This is the definition of the majority logic function  $M_3(ABC)$ . Similarly the Sign is composed of the symmetrical functions S2(3) and S3(3) but with the center of symmetry translated

to  $A_S B_S' C_{out}$ . This is equivalent to the majority function  $M_3(A_S B_S' \bar{C}_{out})$ . Further evaluation of the maps and truth table reveal that Overflow can be generated by the exclusive-OR function of End Around Carry and Carry Out. This analysis results in a minimum device count consisting of one exclusive-OR package and one dual Majority Logic package to implement  $B_S'$ , EAC, Sign and Overflow. The logic connections of these devices are shown in Figure 5.

The output sign,  $R_S$ , complements the result of the add/subtract operation when  $R_S = "1"$ . This is required because the adder performs 9's complement arithmetic. Complementing, when  $R_S$  indicates the result is negative, restores sign and magnitude convention.

Several variations of the adder/subtractor are possible. For example, 9's complement is available at the output of the NBCD adders, and output complementers are eliminated if sign and magnitude output is not required.

6

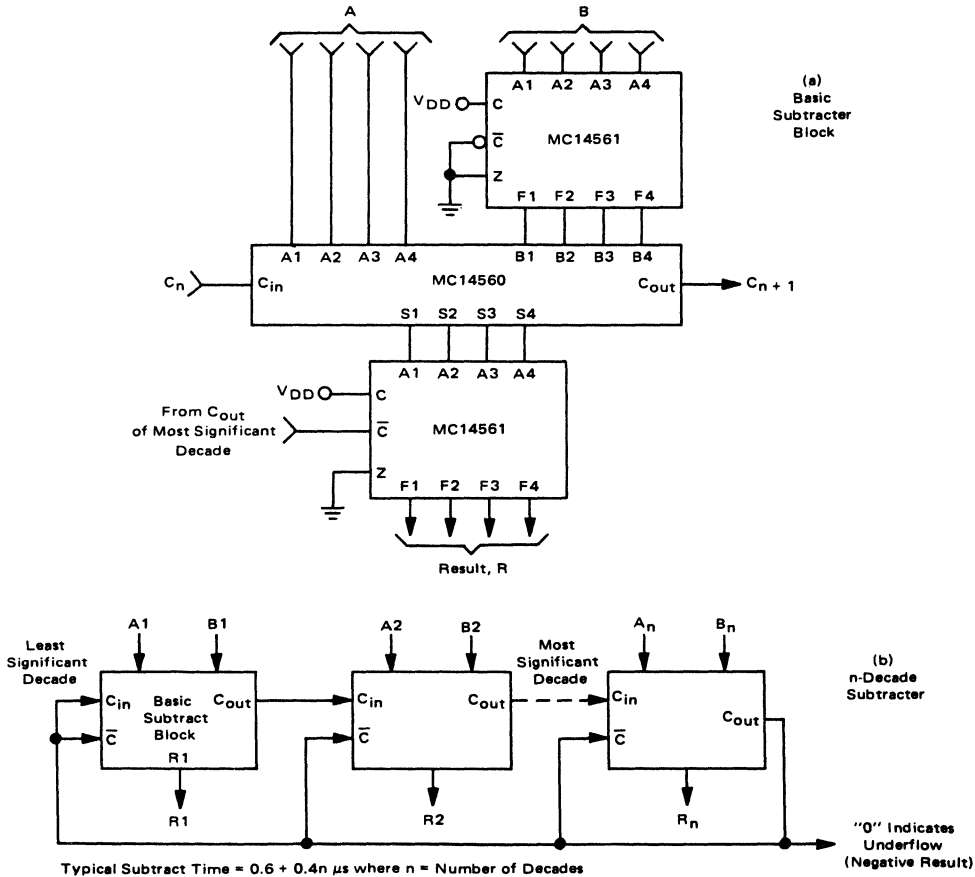


FIGURE 6 — Subtraction of Unsigned NBCD Numbers

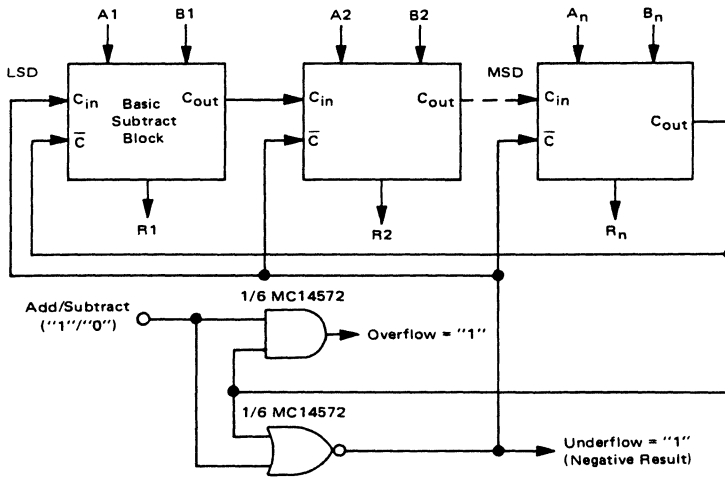
# MC14560B

## SUMMARY

The concepts of binary code representations for decimal numbers, addition, and complement subtraction were discussed in detail. Using the basic Adder and Complementer MSI blocks, adder/subtractors for both signed and unsigned numbers were illustrated with examples.

## REFERENCES

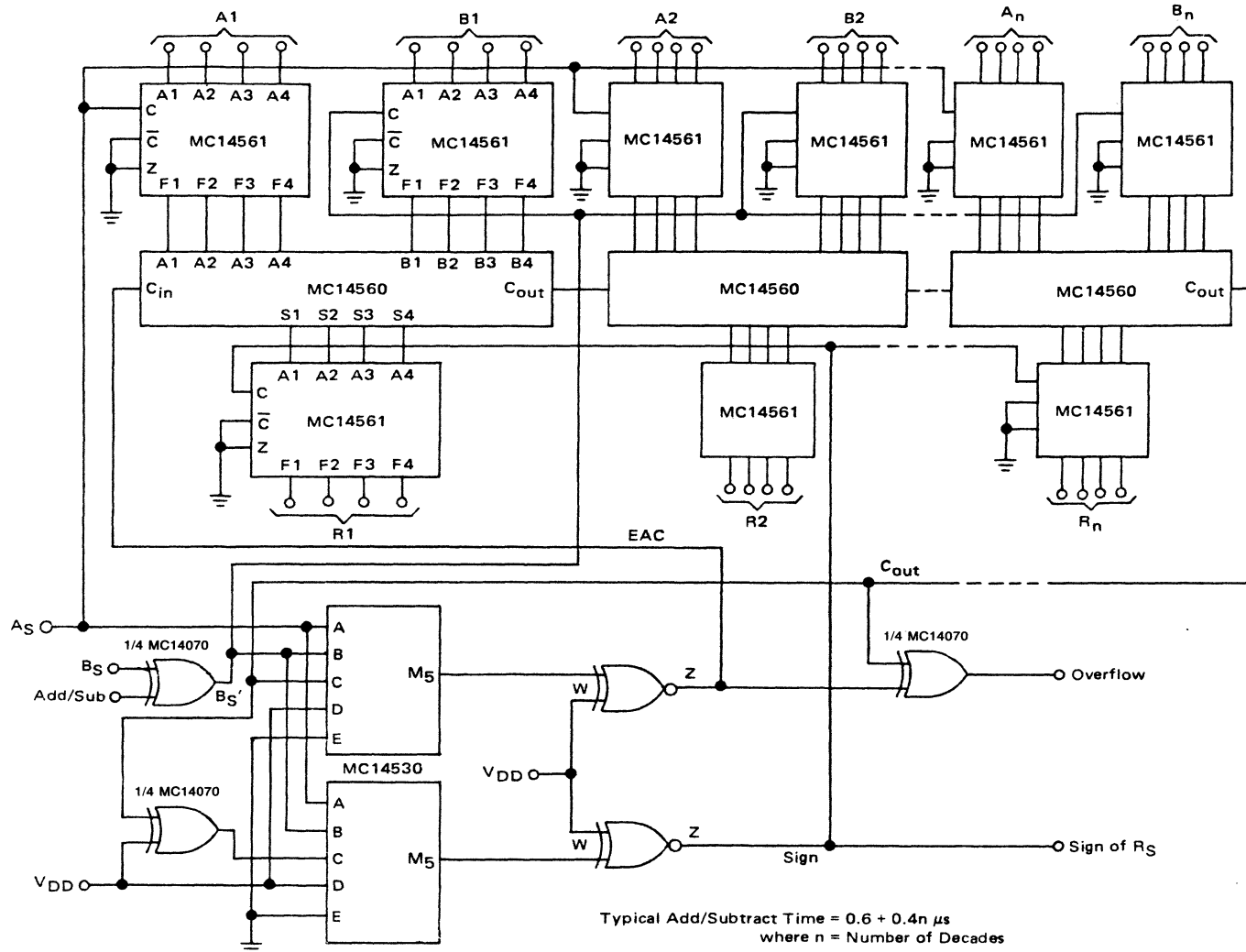
1. Chu, Y.: *Digital Computer Design Fundamentals*, New York, McGraw-Hill, 1962.
2. *McMOS Handbook*, Motorola Inc., 1st Edition.
3. Beuscher, H.: *Electronic Switching Theory and Circuits*, New York, Van Nostrand Reinhold, 1971.
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Typical Add/Subtract Time =  $0.6 + 0.4n \mu\text{s}$   
 where  $n$  = Number of Decades

FIGURE 7 — Adder/Subtractor for Unsigned NBCD Numbers

FIGURE 8 — SIGN AND MAGNITUDE ADDER/SUBTRACTOR WITH OVERFLOW



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MC14560B

INPUTS			Arithmetic Expression for R* (Result)  (N = Number of Digits, $10^N$ = Modulus A, B, R are Positive Magnitudes)	OUTPUTS			
A <sub>S</sub> "1" = Neg	B <sub>S</sub> "1" = Neg	C <sub>out</sub> "1" = Carry		End Around Carry (EAC) "1" = EAC	Sign of R "1" = Negative	Overflow "1" = Overflow	
0	0	0	R = A + B	No EAC ("0") because R is correct result.	Since A and B are positive signed, R is positive signed ("0").	When C <sub>out</sub> = "0", there is no carry ( $R < 10^N$ ) and thus no overflow ("0").	
0	0	1				When C <sub>out</sub> = "1", there is a carry ( $R \geq 10^N$ ) and thus overflow ("1").	
0	1	0	R = A - B = A + (10 <sup>N</sup> - 1 - B) = A - B + 10 <sup>N</sup> - 1	No EAC ("0") because 9's complement expression for R is correct result.	A ≤ B when C <sub>out</sub> = "0"; thus sign of R must be negative ("1").	There is never an overflow when numbers of opposite sign are added	
0	1	1		EAC = "1" because expression for R is in error by 1.	A > B when C <sub>out</sub> = "1"; thus sign of R must be positive ("0").		
1	0	0	R = B - A = B + (10 <sup>N</sup> - 1 - A) = B - A + 10 <sup>N</sup> - 1	No EAC ("0") because 9's complement expression for R is correct result.	B ≤ A when C <sub>out</sub> = "0"; thus sign of R must be negative ("1").		
1	0	1		EAC = "1" because expression for R is in error by 1.	B > A when C <sub>out</sub> = "1"; thus sign of R must be positive ("0").		
1	1	0	R = -A - B = (10 <sup>N</sup> - 1 - A) + (10 <sup>N</sup> - 1 - B) = -(A + B) + 2 × 10 <sup>N</sup> - 2	EAC = "1" because 9's complement expression for R is in error by 1.	Since A and B are negative signed, R is negative signed ("1").		When C <sub>out</sub> = "0", there is no carry ( $R < 10^N$ ) and $(A + B) > 10^N - 1$ indicating overflow ("1").
1	1	1					When C <sub>out</sub> = "1", there is a carry ( $R \geq 10^N$ ) and $(A + B) \leq 10^N - 1$ indicating no overflow ("0").

\*Output of Adders

FIGURE 9 — Truth Table Generation for EAC, Sign, and Overflow Logic

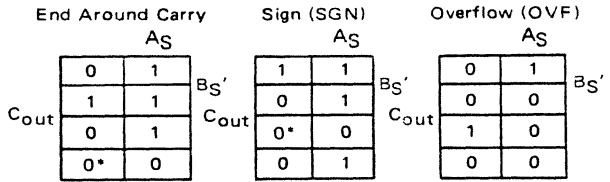
# MC14560B

TRUTH TABLE

INPUTS			OUTPUTS		
A <sub>S</sub>	B <sub>S</sub> '	C <sub>out</sub>	EAC	SGN	OVF
0	0	0	0	0	0
0	1	0	0	1	0
1	0	0	0	1	0
1	1	0	1	1	1
0	0	1	0	0	1
0	1	1	1	0	0
1	0	1	1	0	0
1	1	1	1	1	0

B<sub>S</sub>' = (Add/Sub) ⊕ B<sub>S</sub>  
 A<sub>S</sub> = Sign of A ("1" = Negative)  
 B<sub>S</sub> = Sign of B ("1" = Negative)  
 C<sub>out</sub> = Adder Carry Out

KARNAUGH MAPS



\* = Center of Symmetry

$$\begin{aligned}
 \text{EAC} &= \text{S2} (A_S B_S' C_{out}) + \text{S3} (A_S B_S' C_{out}) \\
 &= \text{M}_3 (A_S B_S' C_{out})
 \end{aligned}$$

$$\begin{aligned}
 \text{SGN} &= \text{S2} (A_S B_S' \bar{C}_{out}) + \text{S3} (A_S B_S' \bar{C}_{out}) \\
 &= \text{M}_3 (A_S B_S' \bar{C}_{out})
 \end{aligned}$$

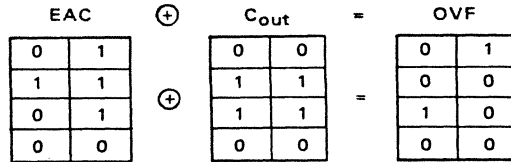


FIGURE 10 — Mapping of EAC, Sign and Overflow Logic



**MOTOROLA**

**MC14561B**

**9's COMPLEMENTER**

The MC14561B 9's complementer is a companion to the MC14560B NBCD adder to allow BCD subtraction. A BCD number (8-4-2-1 code) is applied to the inputs (A1 = 2<sup>0</sup>, A2 = 2<sup>1</sup>, A3 = 2<sup>2</sup>, A4 = 2<sup>3</sup>). If the complement control (Comp) is low, the BCD number appears at the outputs unmodified. The complement disable ( $\overline{\text{Comp}}$ ) allows the complement control to be gated, or an inverted control signal to be used. If the complement input is high and the disable input low, the 9's complement of the number is displayed at the outputs. The zero control (Z), when high, forces the outputs low regardless of the state of the other inputs.

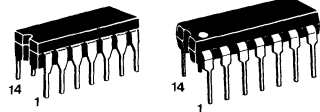
When the MC14561B is used to perform BCD subtraction in conjunction with the MC14560B NBCD adder, the complement control becomes an add/subtract control.

- All Inputs Buffered
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-Power TTL Loads or One Low-Power Schottky TTL Load Over the Rated Temperature Range

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**9's COMPLEMENTER**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

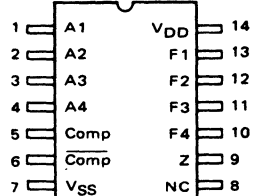
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**PIN ASSIGNMENT**



NC = No Connection

**TRUTH TABLE**

Z	Comp	$\overline{\text{Comp}}$	F1	F2	F3	F4	Mode
0	0	0	A1	A2	A3	A4	Straight-through
0	0	1					
0	1	1					
0	1	0	$\overline{\text{A1}}$	A2	A2 $\overline{\text{A3}}$ + $\overline{\text{A2}}$ A3	$\overline{\text{A2}}$ A3 $\overline{\text{A4}}$	Complement
1	X	X	0	0	0	0	Zero

X = Don't Care.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



# MC14561B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**†† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.5 μA/kHz) f + I <sub>DD</sub>						μAdc	
10	I <sub>T</sub> = (3.0 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (4.5 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.004.

# MC14561B

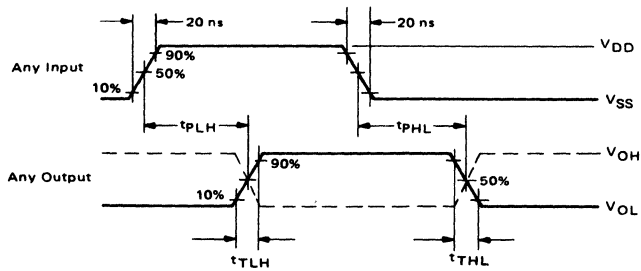
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	$t_{TLH}$ , $t_{THL}$					ns
$t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		5.0	—	100	200	
$t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$					ns
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 315 \text{ ns}$		5.0	—	400	1000	
$t_{PLH}$ , $t_{PHL} = (0.86 \text{ ns/pF}) C_L + 127 \text{ ns}$		10	—	160	400	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 95 \text{ ns}$		15	—	120	300	

\*The formulas given are for the typical characteristics only at 25°C.

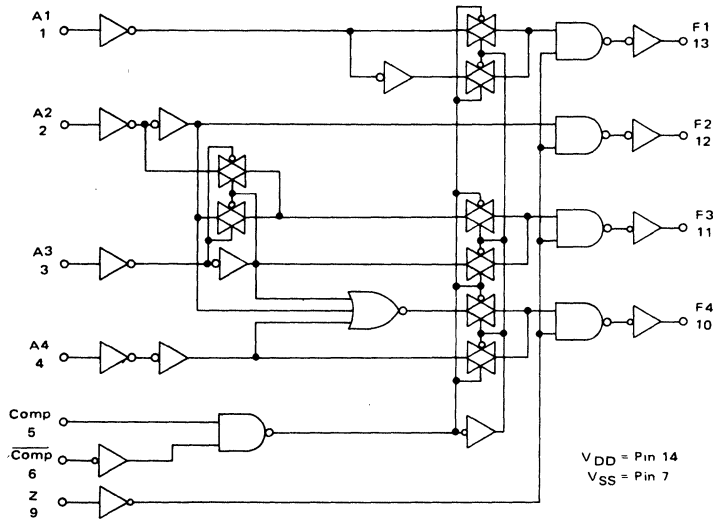
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME WAVEFORMS



# MC14561B

## LOGIC DIAGRAM



### TRUTH TABLE – COMPLEMENT MODE

(Z = 0, Comp = 1, Comp = 0)

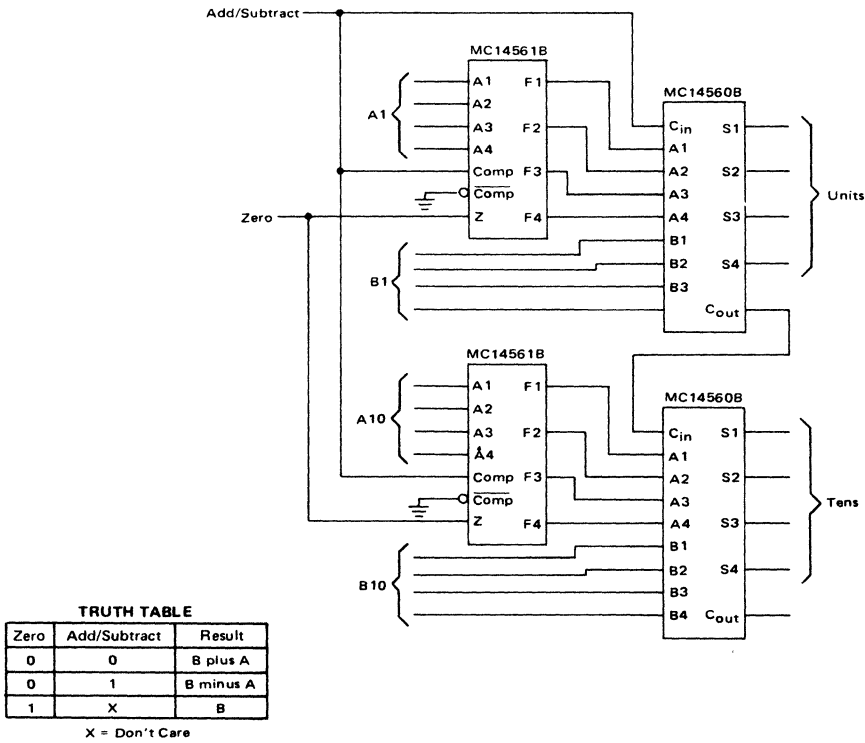
	Decimal Equivalent Input	Inputs				Decimal Equivalent Output	Outputs			
		A4	A3	A2	A1		F4	F3	F2	F1
	0	0	0	0	0	9	1	0	0	1
	1	0	0	0	1	8	1	0	0	0
	2	0	0	1	0	7	0	1	1	1
	3	0	0	1	1	6	0	1	1	0
	4	0	1	0	0	5	0	1	0	1
	5	0	1	0	1	4	0	1	0	0
	6	0	1	1	0	3	0	0	1	1
	7	0	1	1	1	2	0	0	1	0
	8	1	0	0	0	1	0	0	0	1
	9	1	0	0	1	0	0	0	0	0
Illegal	10	1	0	1	0	7	0	1	1	1
BCD	11	1	0	1	1	6	0	1	1	0
Input	12	1	1	0	0	5	0	1	0	1
Codes	13	1	1	0	1	4	0	1	0	0
	14	1	1	1	0	3	0	0	1	1
	15	1	1	1	1	2	0	0	1	0

# MC14561B

## TYPICAL APPLICATIONS

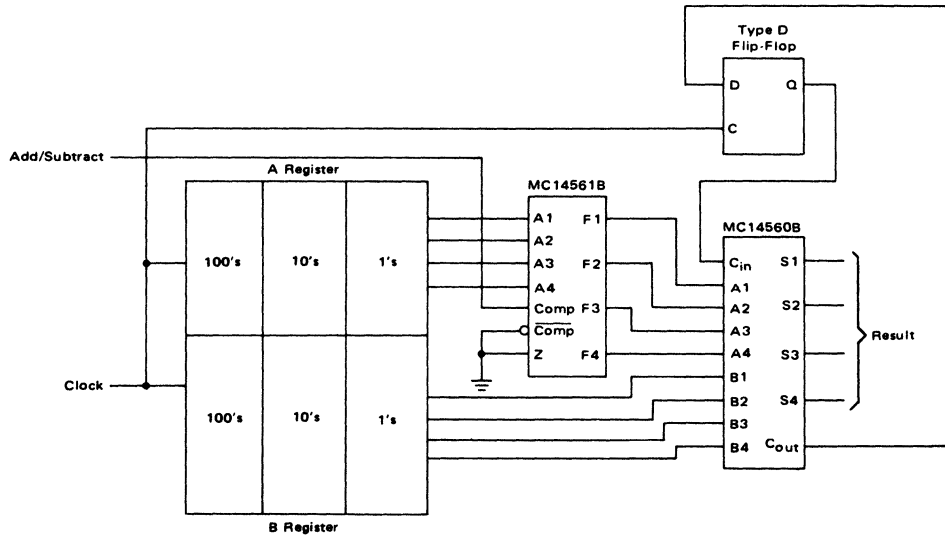
One MC14560B and one MC14561B permit a BCD digit to be added to or subtracted from a second digit, such as in the typical configurations in Figures 2 and 3. A second MC14561B permits either digit to be added to or subtracted from the other, or either word to appear unmodified at the output.

FIGURE 2 – PARALLEL ADD/SUBTRACT CIRCUIT (10's COMPLEMENT)



# MC14561B

FIGURE 3 – SERIAL ADD/SUBTRACT CIRCUIT





# MC14562B

## 128-BIT STATIC SHIFT REGISTER

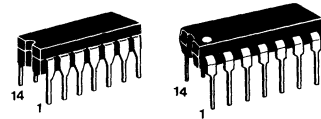
The MC14562B is a 128-bit static shift register constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. Data is clocked in and out of the shift register on the positive edge of the clock input. Data outputs are available every 16 bits, from 16 through bit 128. This complementary MOS shift register is primarily used where low power dissipation and/or high noise immunity is desired.

- Diode Protection on All Inputs
- Fully Static Operation
- Cascadable to Provide Longer Shift Register Lengths
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

## CMOS LSI

(LOW-POWER COMPLEMENTARY MOS)

## 128-BIT STATIC SHIFT REGISTER.



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

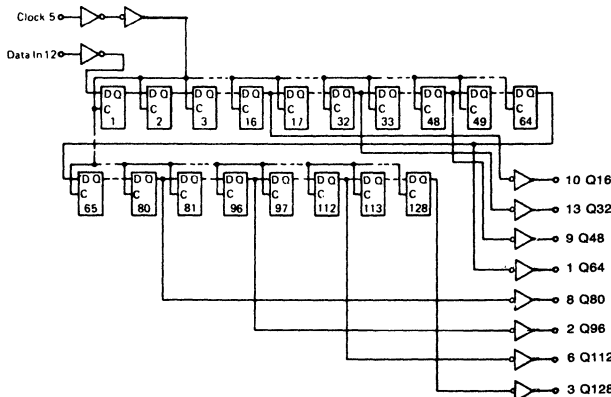
\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

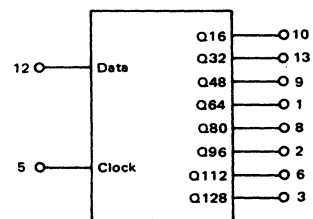
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

6

### LOGIC DIAGRAM



### BLOCK DIAGRAM



Pins 4 and 11  
not used.

V<sub>DD</sub> = Pin 14  
V<sub>SS</sub> = Pin 7

# MC14562B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit		
			Min	Max	Min	Typ #	Max	Min	Max			
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
			10	—	0.05	—	0	0.05	—	0.05		
			15	—	0.05	—	0	0.05	—	0.05		
	V <sub>in</sub> = 0 or V <sub>DD</sub>	"1" Level	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
				10	9.95	—	9.95	10	—	9.95	—	
				15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
			10	—	3.0	—	4.50	3.0	—	3.0		
			15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc	
			10	7.0	—	7.0	5.50	—	7.0	—		
			15	11.0	—	11.0	8.25	—	11.0	—		
Output Drive Current (AL Device)	Source	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
			10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>	
			10	1.6	—	1.3	2.25	—	0.9	—		
			15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device)	Source	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>	
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
			10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>	
			10	1.3	—	1.1	2.25	—	0.9	—		
			15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF		
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μA <sub>dc</sub>		
		10	—	10	—	0.020	10	—	300			
		15	—	20	—	0.030	20	—	600			
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μA <sub>dc</sub>		
		10	—	100	—	0.020	100	—	750			
		15	—	200	—	0.030	200	—	1500			
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.94 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>		
10	I <sub>T</sub> = (3.81 μA/kHz) f + I <sub>DD</sub>											
15	I <sub>T</sub> = (5.52 μA/kHz) f + I <sub>DD</sub>											

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

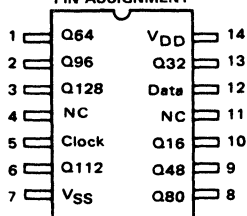
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.004.

### PIN ASSIGNMENT



NC = No Connection

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14562B

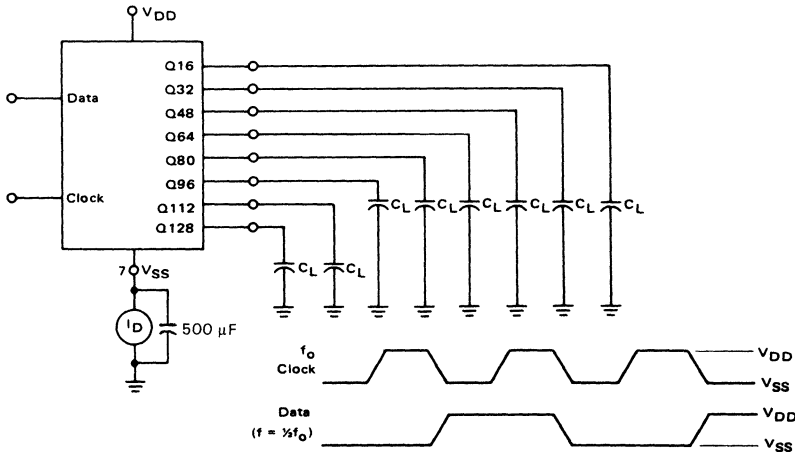
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Q $t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 515 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 217 \text{ ns}$ $t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 145 \text{ ns}$	$t_{PLH}$ , $t_{PHL}$	5.0 10 15	— — —	600 250 170	1200 500 340	ns
Clock Pulse Width (50% Duty Cycle)	$t_{WH}$	5.0 10 15	600 220 150	300 110 75	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	1.9 5.6 8.0	1.1 3.0 4.0	MHz
Data to Clock Setup Time	$t_{su}(1)$	5.0 10 15	-20 -10 0	-170 -64 -60	— — —	ns
	$t_{su}(0)$	5.0 10 15	-20 -10 0	-91 -58 -48	— — —	ns
Data to Clock Hold Time	$t_h(1)$	5.0 10 15	350 165 155	263 109 100	— — —	ns
	$t_h(0)$	5.0 10 15	350 200 140	267 140 93	— — —	ns
Clock Input Rise and Fall Times	$t_{ri}$ , $t_{rf}$	5.0 10 15	— — —	— — —	15 5 4	$\mu\text{s}$

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

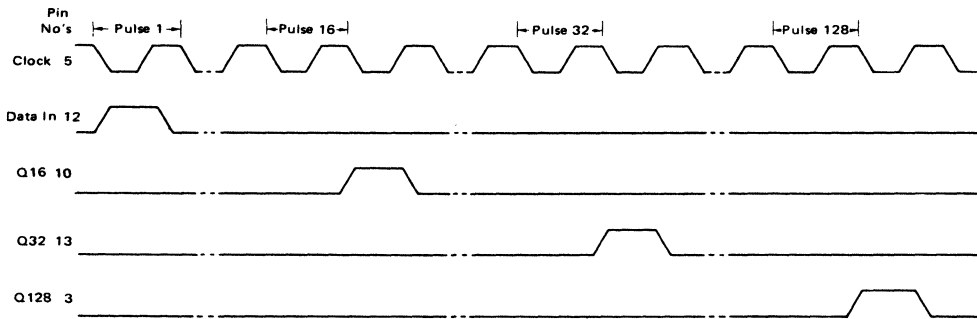
FIGURE 1 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS



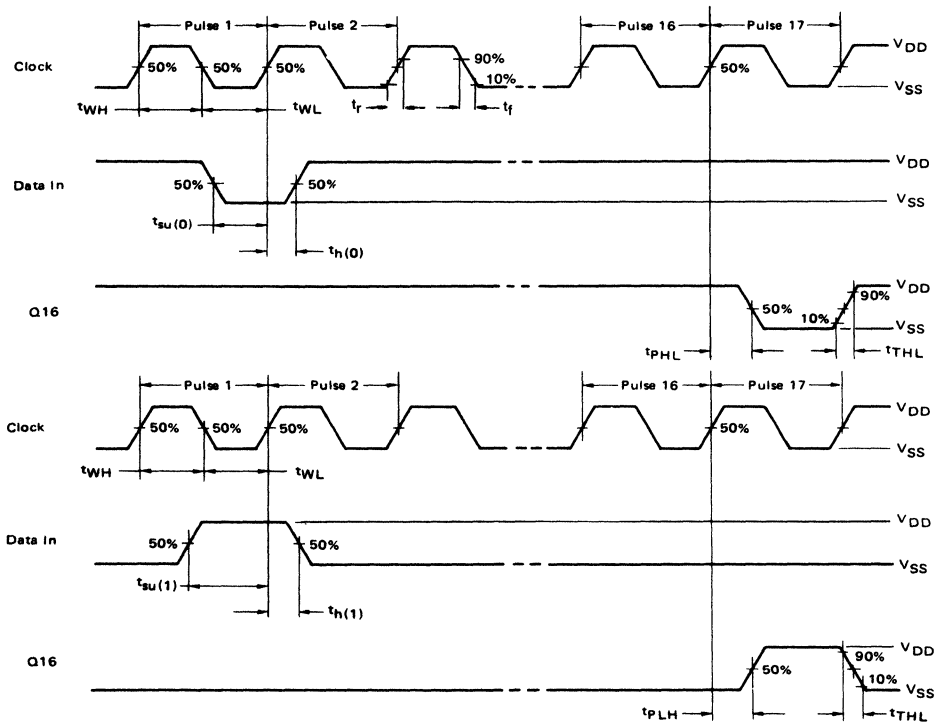


# MC14562B

## TIMING DIAGRAM



## AC TEST WAVEFORMS



Note: The remaining Data-Bit Outputs (Q32, Q48, Q64, Q80, Q96, Q112 and Q128) will occur at Clock Pulse 32, 48, 64, 80, 96, 112, 128 in the same relationship as Q16.

6



**MOTOROLA**

**MC14566B**

**INDUSTRIAL TIME BASE GENERATOR**

The MC14566B industrial time base generator is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. This device consists of a divide-by-10 ripple counter and a divide-by-5 or divide-by-6 ripple counter to permit stable time generation from a 50 or 60 Hz line. By cascading this device as divide-by-60 counters, seconds and minutes can be counted and are available in BCD format at the circuit outputs. An internal monostable multivibrator is included whose output can be used as a reset or clock pulse providing additional frequency flexibility. Also a pin has been included to allow divide-by-5 counting for generating 1.0 Hz from European 50 Hz line. Pin 11 =  $V_{DD}$  will cause  $\div 5$ .

- Negative Edge Triggered Counters for Ease of Cascading
- Pulse Shapers on Counter Inputs Accept Slow Input Rise Times
- Monostable Multivibrator Positive or Negative Edge Triggered
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

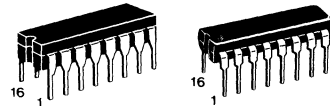
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**INDUSTRIAL TIME BASE GENERATOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

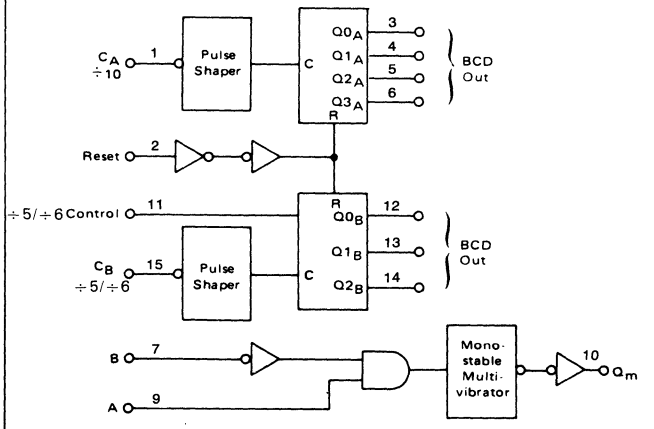
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

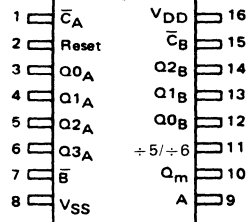
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**6**

**BLOCK DIAGRAM**



**PIN ASSIGNMENT**



# MC14566B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.0 μA/kHz) f + I <sub>DD</sub>						μAdc	
10	I <sub>T</sub> = (2.0 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (3.0 μA/kHz) f + I <sub>DD</sub>									

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*\*The formulas given are for the typical characteristics only at 25°C.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14566B

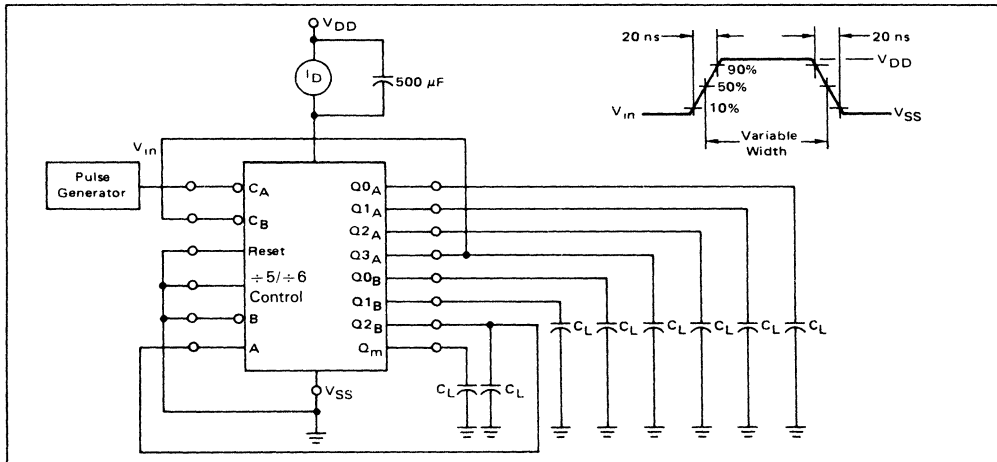
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time, Clock to Q3A $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 1365 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 497 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 295 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	1450 530 320	4500 1500 1000	ns
Propagation Delay Time, Reset to Q3A $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 845 \text{ ns}$ $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 282 \text{ ns}$ $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 185 \text{ ns}$	$t_{PHL}$	5.0 10 15	— — —	930 315 210	3000 1000 750	ns
Clock Pulse Width	$t_{WH(c)}$	5.0 10 15	1200 400 270	400 125 90	— — —	ns
Reset Pulse Width	$t_{WH(R)}$	5.0 10 15	1200 400 270	400 125 90	— — —	ns
Clock Pulse Frequency	$f_{cl}$	5.0 10 15	— — —	1.0 2.5 4.2	0.3 1.0 1.5	MHz
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0 10 15	No Limit			—
Monostable Multivibrator Pulse Width	$t_{WH(Q_m)}$	5.0 10 15	1200 400 300	2800 900 600	— — —	ns

\*The formulas given are for the typical characteristics only at 25°C.

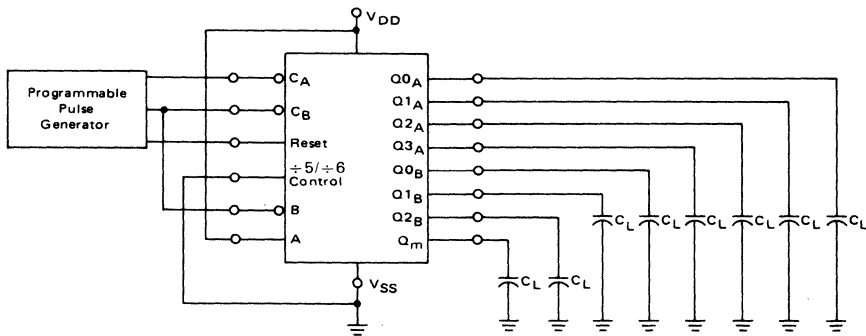
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 — POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

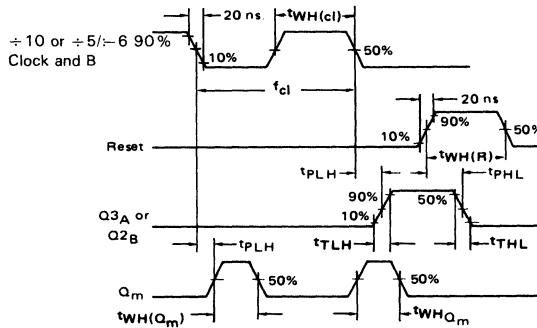


# MC14566B

FIGURE 2 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



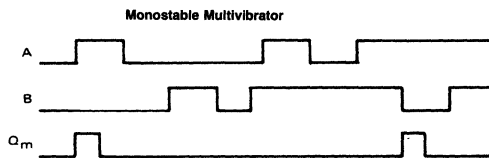
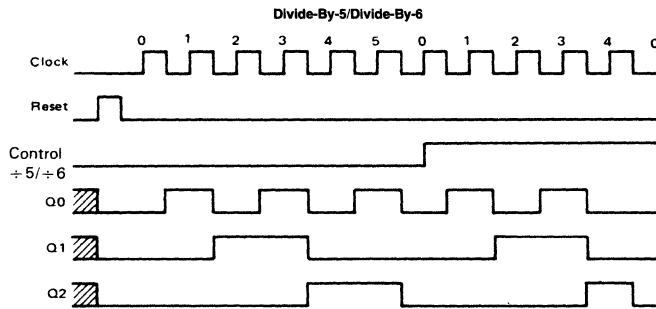
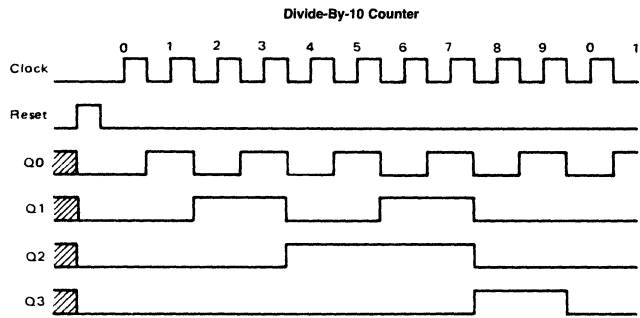
Note: Assume + 10 Counter at "6" and + 5/+ 6 Counter at "2" at beginning of sequence.



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# MC14566B

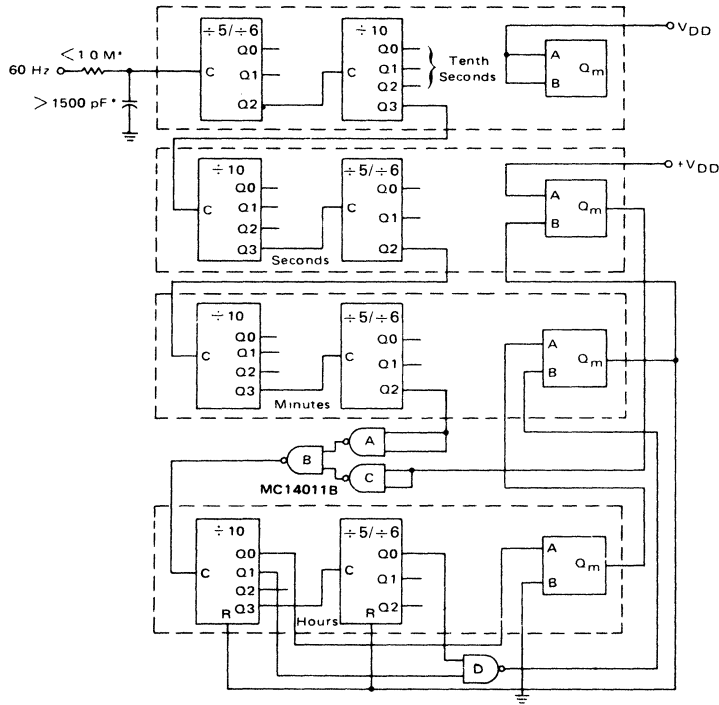
## TIMING DIAGRAM



▨ = Don't Care

# MC14566B

## APPLICATION - 12 HOUR CLOCK



$\div 5/\div 6$  Control not shown =  $V_{SS}$

Reset pins not shown =  $V_{SS}$

\*Care must be taken in the indicated circuit to filter line transients which may cause "false" counting



**MOTOROLA**

# MC14568B

## PHASE COMPARATOR AND PROGRAMMABLE COUNTERS

The MC14568B consists of a phase comparator, a divide-by-4, 16, 64 or 100 counter and a programmable divide-by-N 4-bit binary counter (all positive-edge triggered) constructed with MOS P-channel and N-channel enhancement mode devices (complementary MOS) in a monolithic structure.

The MC14568B has been designed for use in conjunction with a programmable divide-by-N counter for frequency synthesizers and phase-locked loop applications requiring low power dissipation and/or high noise immunity.

This device can be used with both counters cascaded and the output of the second counter connected to the phase comparator (CTL high), or used independently of the programmable divide-by-N counter, for example cascaded with a MC14569B, MC14522B or MC14526B (CTL low).

- Supply Voltage Range = 3.0 to 18 V
- Capable of Driving Two Low-Power TTL Loads, One Low-Power Schottky TTL Load or Two HTL Loads Over the Rated Temperature Range.
- Chip Complexity, 549 FETs or 137 Equivalent Gates

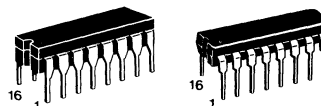
### MAXIMUM RATINGS (Voltages referenced to $V_{SS}$ )

Rating	Symbol	Value	Unit
DC Supply Voltage	$V_{DD}$	-0.5 to +18	V
Input Voltage, All Inputs	$V_{in}$	-0.5 to $V_{DD} + 0.5$	V
DC Input Current, per Pin	$I_{in}$	$\pm 10$	mA
Operating Temperature Range - AL Device	$T_A$	-55 to +125	$^{\circ}C$
CL/CP Device		-40 to +85	
Storage Temperature Range	$T_{stg}$	-65 to +150	$^{\circ}C$

## CMOS MSI

(LOW-POWER COMPLEMENTARY MOS)

## PHASE COMPARATOR AND PROGRAMMABLE COUNTERS



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

### ORDERING INFORMATION

A Series: -55 $^{\circ}C$  to +125 $^{\circ}C$   
MC14568BAL (Ceramic Package Only)

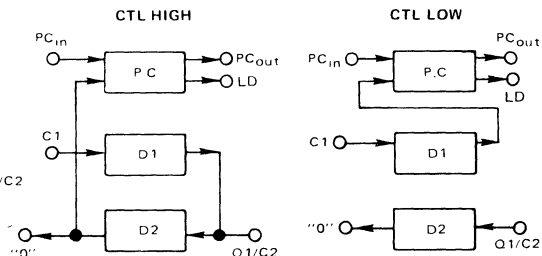
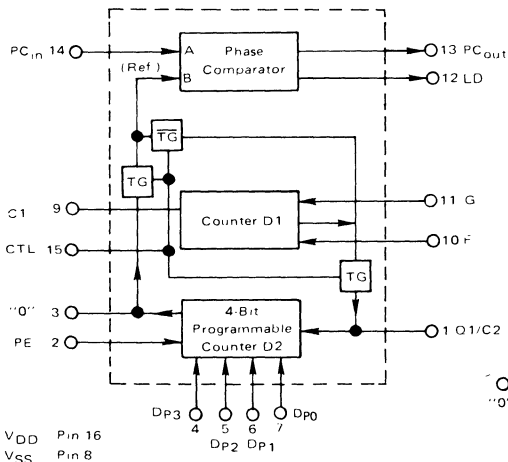
C Series: -40 $^{\circ}C$  to +85 $^{\circ}C$   
MC14568BCP (Plastic Package)  
MC14568BCL (Ceramic Package)

### TRUTH TABLE

F Pin 10	G Pin 11	Division Ratio of Counter D1
0	0	4
0	1	16
1	0	64
1	1	100

The divide-by-zero state on the programmable divide-by-N 4-bit binary counter, D2, is illegal.

### BLOCK DIAGRAM





# MC14568B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ	Max	Min	Max		
Output Voltage V <sub>in</sub> V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
V <sub>in</sub> 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc	
		10	9.95	—	9.95	10	—	9.95	—		
		15	14.95	—	14.95	15	—	14.95	—		
Input Voltage <sup>#†</sup> (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mA <sub>dc</sub>	
		10	-0.25	—	-0.2	-0.36	—	-0.14	—		
		15	-0.62	—	-0.5	-0.9	—	-0.35	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mA <sub>dc</sub>	
		10	-0.2	—	-0.16	-0.36	—	-0.12	—		
		15	-0.5	—	-0.4	-0.9	—	-0.3	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package) V <sub>in</sub> = 0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package) V <sub>in</sub> = 0 or V <sub>DD</sub> , I <sub>out</sub> = 0 μA	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.2 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	
		10	I <sub>T</sub> = (0.4 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (0.9 μA/kHz) f + I <sub>DD</sub>								
Three-State Leakage Current, Pins 1, 13 (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	μA <sub>dc</sub>	
Three-State Leakage Current, Pins 1, 13 (CL/CP Devices)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μA <sub>dc</sub>	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device

T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device

†Noise immunity specified for worst-case input combination

Noise Margin for both "1" and "0" level: 1.0 Vdc min @ V<sub>DD</sub> = 5.0 Vdc

2.0 Vdc min @ V<sub>DD</sub> = 10 Vdc

2.5 Vdc min @ V<sub>DD</sub> = 15 Vdc

†To calculate total supply current at loads other than 50 pF

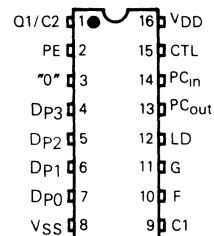
$$I_T(C_L) = I_T(50 \text{ pF}) + 1 \times 10^{-3} (C_L - 50) V_{DD} f$$

where I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V<sub>DD</sub> in Vdc, and f in kHz is input frequency.

\*\*The formulas given are for the typical characteristics only at 25°C.

†Pin 15 is connected to V<sub>SS</sub> or V<sub>DD</sub> for input voltage test.

### PIN ASSIGNMENT



# MC14568B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> V	Min	Typ	Max	Unit
Output Rise Time	t <sub>TLH</sub>	5.0	—	180	360	ns
		10	—	90	180	
		15	—	65	130	
Output Fall Time	t <sub>THL</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Minimum Pulse Width, C <sub>1</sub> , Q <sub>1</sub> /C <sub>2</sub> , or PC <sub>in</sub> Input	t <sub>WH</sub>	5.0	—	125	250	ns
		10	—	60	120	
		15	—	45	90	
Maximum Clock Rise and Fall Time, C <sub>1</sub> , Q <sub>1</sub> /C <sub>2</sub> , or PC <sub>in</sub> Input	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	15	—	—	μs
		10	15	—	—	
		15	15	—	—	

## PHASE COMPARATOR

Input Resistance	R <sub>in</sub>	5.0 to 15	—	10 <sup>6</sup>	—	MΩ
Input Sensitivity, dc Coupled	—	5.0 to 15	See Input Voltage			
Turn-Off Delay Time, PC <sub>out</sub> and LD Outputs	t <sub>PHL</sub>	5.0	—	550	1100	ns
		10	—	195	390	
		15	—	120	240	
Turn-On Delay Time, PC <sub>out</sub> and LD Outputs	t <sub>PLH</sub>	5.0	—	675	1350	ns
		10	—	300	600	
		15	—	190	380	

## DIVIDE-BY-4, 16, 64 OR 100 COUNTER (D1)

Maximum Clock Pulse Frequency Division Ratio = 4, 64 or 100	f <sub>cl</sub>	5.0	3.0	6.0	—	MHz	
		10	8.0	16	—		
		15	10	22	—		
		Division Ratio = 16	5.0	1.0	2.5		—
			10	3.0	6.3		—
			15	5.0	9.7		—
Propagation Delay Time, Q <sub>1</sub> /C <sub>2</sub> Output Division Ratio = 4, 64 or 100	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	450	900	ns	
		10	—	190	380		
		15	—	130	260		
		Division Ratio = 16	5.0	—	720		1440
			10	—	300		600
			15	—	200		400

## PROGRAMMABLE DIVIDE-BY-N 4-BIT COUNTER (D2)

Maximum Clock Pulse Frequency (Figure 3a)	f <sub>cl</sub>	5.0	1.2	1.8	—	MHz
		10	3.0	8.5	—	
		15	4.0	12	—	
Turn-On Delay Time, "0" Output (Figure 3a)	t <sub>PLH</sub>	5.0	—	450	900	ns
		10	—	190	380	
		15	—	130	260	
Turn-Off Delay Time, "0" Output (Figure 3a)	t <sub>PHL</sub>	5.0	—	225	450	ns
		10	—	85	170	
		15	—	60	150	
Minimum Preset Enable Pulse Width	t <sub>WH(PE)</sub>	5.0	—	75	250	ns
		10	—	40	100	
		15	—	30	75	

# MC14568B

## SWITCHING TIME TEST CIRCUITS AND WAVEFORMS

FIGURE 1 – PHASE COMPARATOR

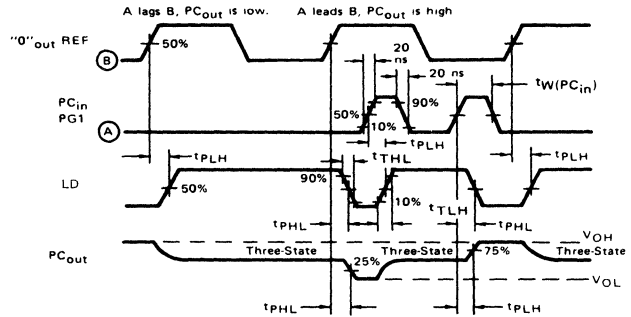
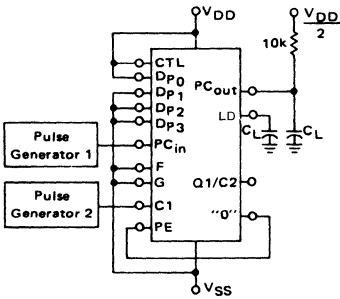


FIGURE 2 – COUNTER D1

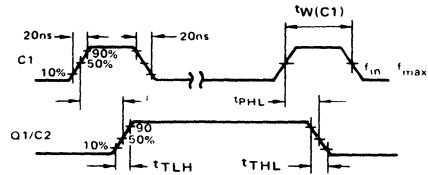
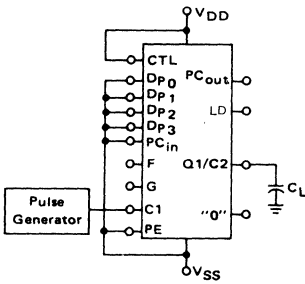
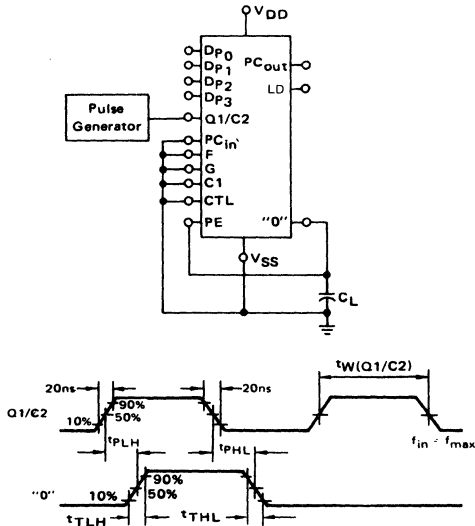
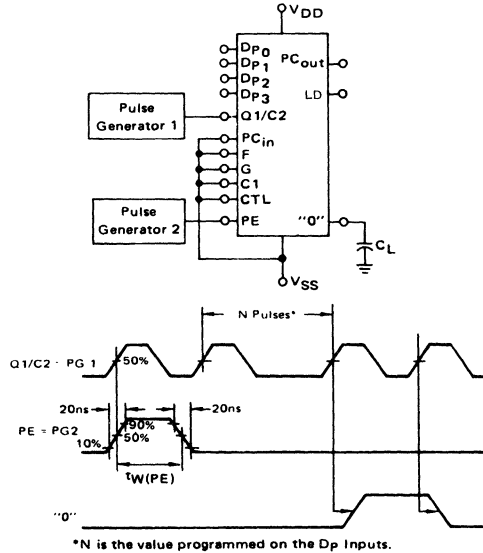


FIGURE 3 – COUNTER D2

a.

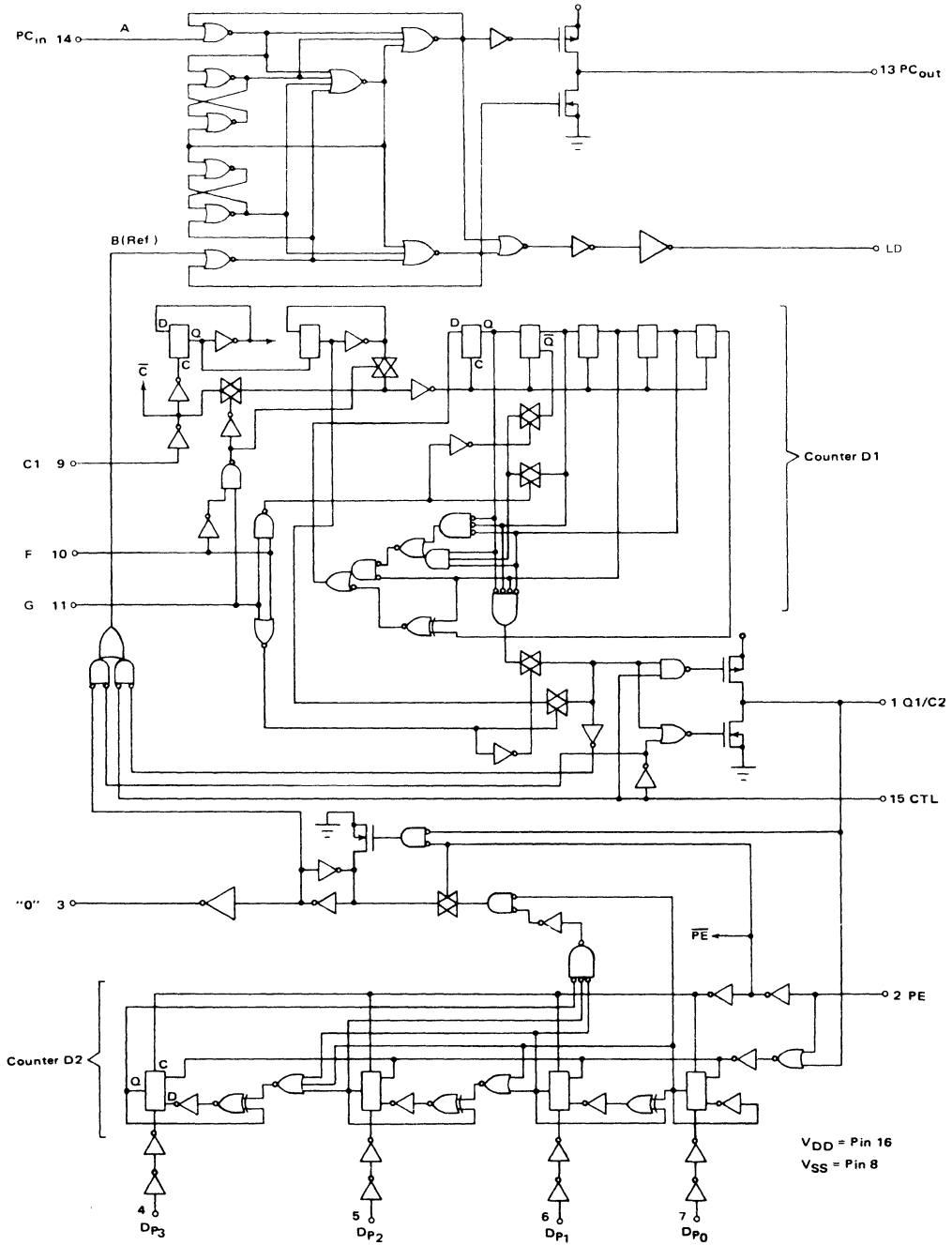


b.



# MC14568B

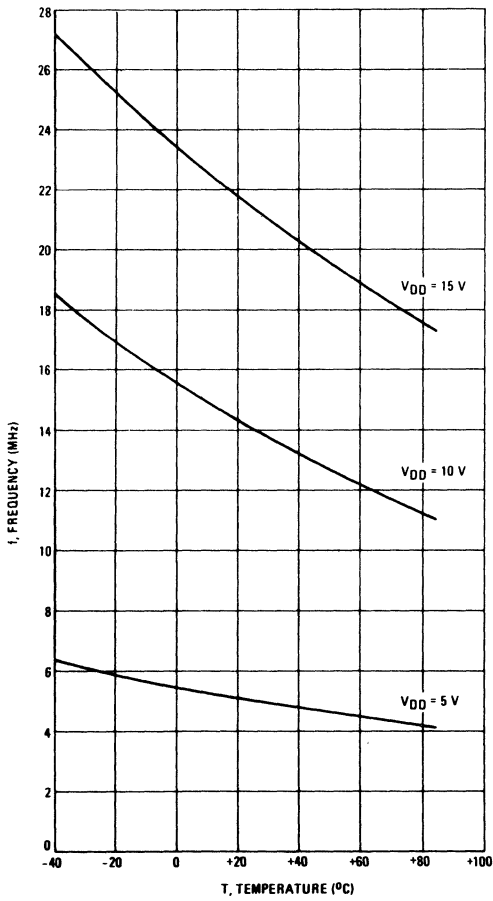
## LOGIC DIAGRAM



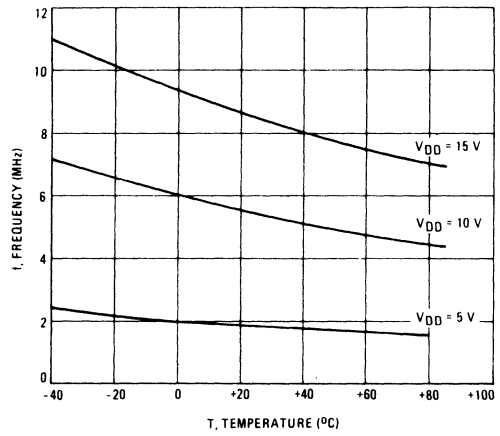
6

# MC14568B

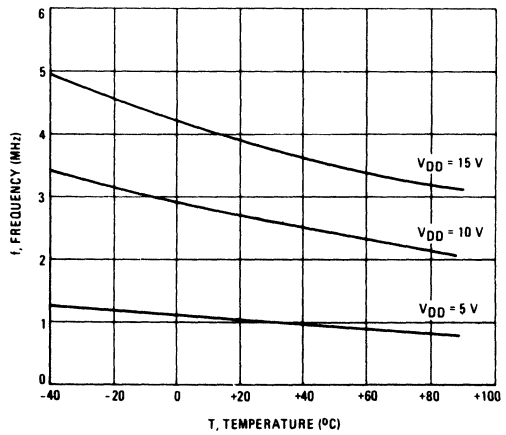
**Typical Maximum Frequency Divider D1**  
 Division ratios: 4, 64 or 100 (CL = 50 pF)



**Typical Maximum Frequency Divider D1**  
 Division ratio: 16 (CL = 50 pF)



**Typical Maximum Frequency Divider D2**  
 Division ratio: 2 (CL = 50 pF)



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# MC14568B

## OPERATING CHARACTERISTICS

The MC14568B contains a phase comparator, a fixed divider ( $\div 4$ ,  $\div 16$ ,  $\div 64$ ,  $\div 100$ ) and a programmable divide-by-N 4-bit counter.

### PHASE COMPARATOR

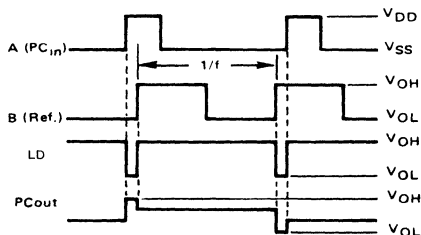
The phase comparator is a positive edge controlled logic circuit. It essentially consists of four flip-flops and an output pair of MOS transistors. Only one of its inputs ( $PC_{in}$ , pin 14) is accessible externally. The second is connected to the output of one of the two counters D1 or D2 (see block diagram).

Duty cycles of both input signals (at A and B) need not be taken into consideration since the comparator responds to leading edges only.

If both input signals have identical frequencies but different phases, with signal A (pin 14) leading signal B (Ref.), the comparator output will be high for the time equal to the phase difference.

If signal A lags signal B, the output will be low for the same time. In between, the output will be in a three-state condition and the voltage on the capacitor of an RC filter normally connected at this point will have some intermediate value (see Figure 4). When used in a phase locked loop, this value will adjust the Voltage Controlled Oscillator frequency by reducing the phase difference between the reference signal and the divided VCO frequency to zero.

FIGURE 4 - PHASE COMPARATOR WAVEFORMS



If the input signals have different frequencies, the output signal will be high when signal B has a lower frequency than signal A, and low otherwise.

Under the same conditions of frequency difference, the output will vary between  $V_{OH}$  (or  $V_{OL}$ ) and some intermediate value until the frequencies of both signals are equal and their phase difference equal to zero, i.e. until locked condition is obtained.

Capture and lock range will be determined by the VCO frequency range. The comparator is provided with a lock indicator output, which will stay at logic 1 in locked conditions.

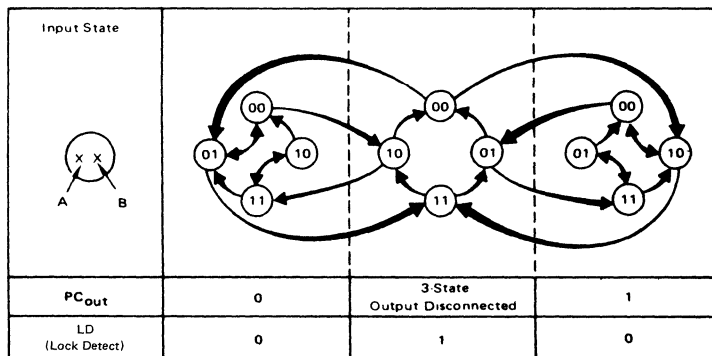
The state diagram (Figure 5) depicts the internal state transitions. It assumes that only one transition on either signal occurs at any time. It shows that a change of the output state is always associated with a positive transition of either signal. For a negative transition, the output does not change state. A positive transition may not cause the output to change; this happens when the signals have different frequencies.

### DIVIDE BY 4, 16, 64 OR 100 COUNTER (D1)

This counter is able to work at an input frequency of 5 MHz for a  $V_{DD}$  value of 10 volts over the standard temperature range when dividing by 4, 64 and 100. Programming is accomplished by use of inputs F and G (pins 10 and 11) according to the truth table shown. Connecting the Control input (CTL, pin 15) to  $V_{DD}$  allows cascading this counter with the programmable divide-by-N counter provided in the same package. Independent operation is obtained when the Control input is connected to  $V_{SS}$ .

The different division ratios have been chosen to generate the reference frequencies corresponding to the channel spacings normally required in frequency synthesizer applications. For example, with the division ratio 100 and a 5 MHz crystal stabilized source a reference frequency of 50 kHz is supplied to the comparator. The lower division ratios permit operation with low frequency crystals.

FIGURE 5 - PHASE COMPARATOR STATE DIAGRAM



# MC14568B

If used in cascade with the programmable divide-by-N counter, practically all usual reference frequencies, or channel spacings of 25, 20, 12.5, 10, 6.25 kHz, etc. are easily achievable.

## PROGRAMMABLE DIVIDE-BY-N 4-BIT COUNTER (D2)

This counter is programmable by using inputs  $Dp_0 \dots$

$Dp_3$  (pins 7 ... 4). The Preset Enable input enables the parallel preset inputs  $Dp_0 \dots Dp_3$ . The "0" output must be externally connected to the PE input for single stage applications. Since there is not a cascade feedback input, this counter, when cascaded, must be used as the most significant digit. Because of this, it can be cascaded with binary counters as well as with BCD counters (MC14569B, MC14522B, MC14526B).

## TYPICAL APPLICATIONS

FIGURE 6 – CASCADING MC14568B AND MC14522B OR MC14526B WITH MC14569B

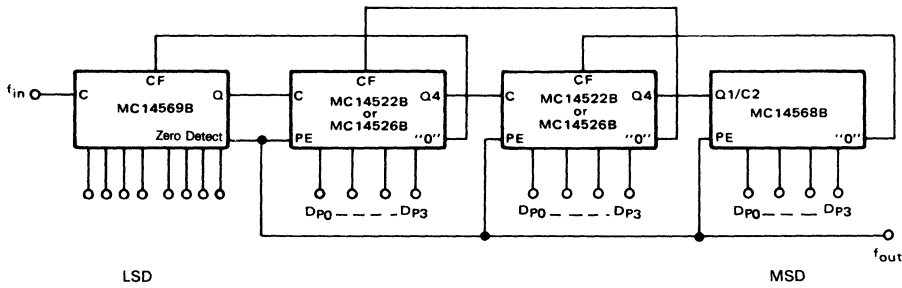
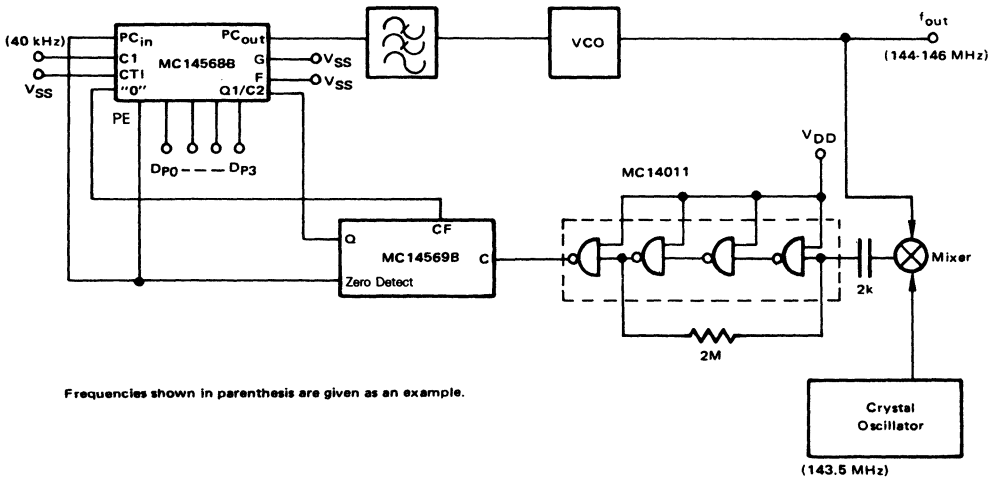


FIGURE 7 – FREQUENCY SYNTHESIZER WITH MC14568B and MC14569B USING A MIXER  
(Channel Spacing 10 kHz)

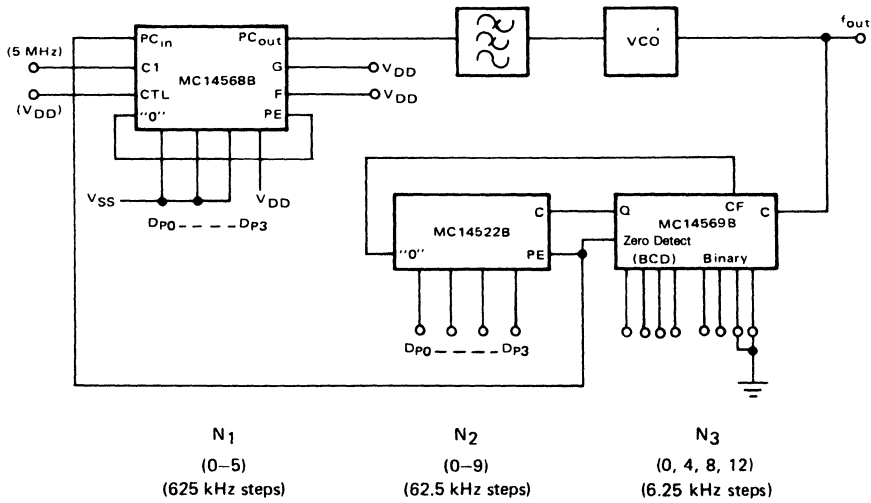


Frequencies shown in parenthesis are given as an example.

6

# MC14568B

FIGURE 8 – FREQUENCY SYNTHESIZER USING MC14568B, MC14569B AND MC14522B  
(Without Mixer)



$$\text{Divide ratio} = 160N_1 + 16N_2 + N_3$$

Example:

$$f_{\text{out}} = N_1 \text{ (MHz)} + N_2 \text{ (x100 kHz)} + N_3 \text{ (x25 kHz)}$$

Frequency range = 5 MHz

Channel spacing = 25 kHz

Reference frequency = 6.25 kHz

Figures shown in parenthesis refer to example.

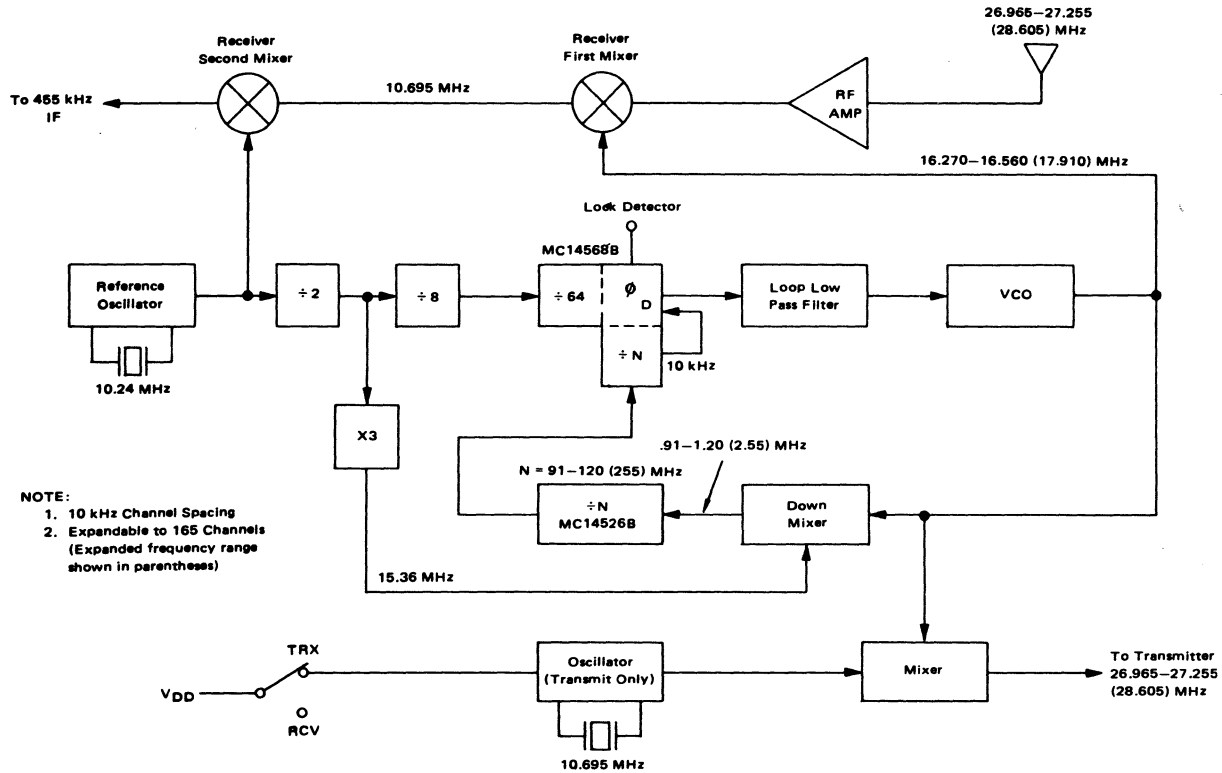
Recommended reading:

- (1) AN535: "Phase-Lock Techniques"
- (2) AR254: "Phase-Locked Loop Design Articles"





FIGURE 9 – TYPICAL 23-CHANNEL CB FREQUENCY SYNTHESIZER FOR DOUBLE CONVERSION TRANSCEIVERS



6-466

MC14568B



**MOTOROLA**

**MC14569B**

**PROGRAMMABLE DIVIDE-BY-N DUAL 4-BIT BINARY/BCD DOWN COUNTER**

The MC14569B is a programmable divide-by-N dual 4-bit binary or BCD down counter constructed with MOS P-channel and N-channel enhancement mode devices (complementary MOS) in a monolithic structure.

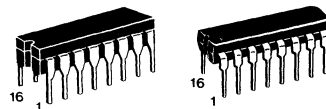
This device has been designed for use with the MC14568B phase comparator/counter in frequency synthesizers, phase-locked loops, and other frequency division applications requiring low power dissipation and/or high noise immunity.

- Speed-up Circuitry for Zero Detection
- Each 4-Bit Counter Can Divide Independently in BCD or Binary Mode
- Can be Cascaded With MC14568B, MC14522B or MC14526B for Frequency Synthesizer Applications
- All Outputs are Buffered
- Schmitt Triggered Clock Conditioning

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**PROGRAMMABLE DIVIDE-BY-N DUAL 4-BIT BINARY/BCD DOWN COUNTER**



**L SUFFIX CERAMIC PACKAGE**  
CASE 620

**P SUFFIX PLASTIC PACKAGE**  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

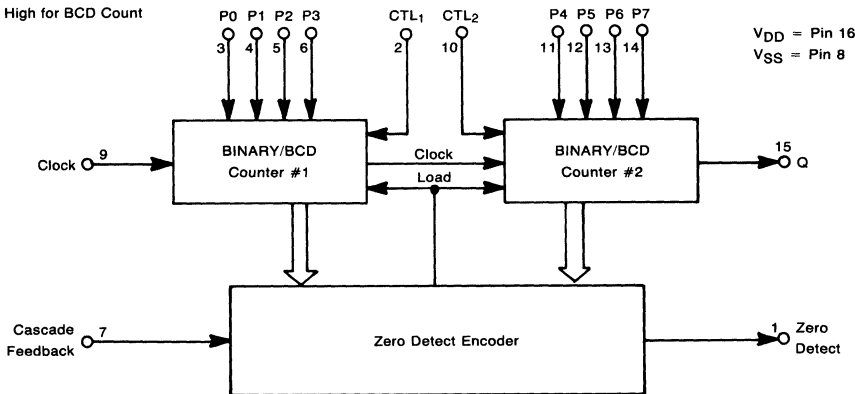
**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**BLOCK DIAGRAM**

CTL = Low for Binary Count  
CTL = High for BCD Count



**6**

# MC14569B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
			5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
			10	-1.6	—	-1.3	-2.25	—	-0.9	—	
			15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device)	Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
			5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
			10	-1.3	—	-1.1	-2.25	—	-0.9	—	
			15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
		15	—	±0.3	—	±0.00001	±0.3	—	±1.0		
		15	—	±0.3	—	±0.00001	±0.3	—	±1.0		
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.005	50	—	150	μAdc	
		10	—	100	—	0.010	100	—	300		
		15	—	200	—	0.015	200	—	600		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.58 μA/kHz) f + I <sub>DD</sub>						μAdc		
		10	I <sub>T</sub> = (1.20 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (1.95 μA/kHz) f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

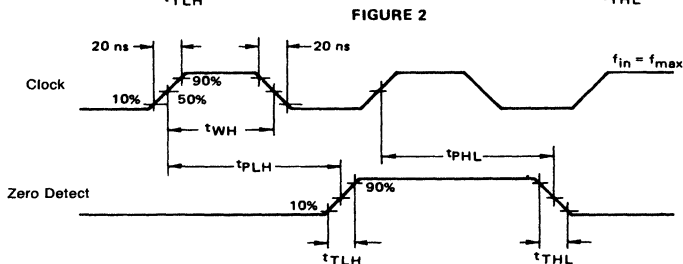
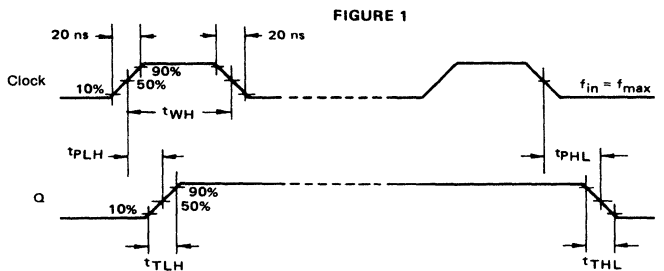
# MC14569B

SWITCHING CHARACTERISTICS\* ( $C_L = 50$  pF,  $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	VDD Vdc	All Types			Unit
			Min	Typ #	Max	
Output Rise Time	$t_{TLH}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time	$t_{THL}$	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Turn-On Delay Time Zero Detect Output	$t_{PLH}$	5.0	—	420	700	ns
		10	—	175	300	
		15	—	125	250	
Q Output		5.0	—	675	1200	ns
		10	—	285	500	
		15	—	200	400	
Turn-Off Delay Time Zero Detect Output	$t_{PHL}$	5.0	—	380	600	ns
		10	—	150	300	
		15	—	100	200	
Q Output		5.0	—	530	1000	ns
		10	—	225	400	
		15	—	155	300	
Clock Pulse Width	$t_{WH}$	5.0	300	100	—	ns
		10	150	45	—	
		15	115	30	—	
Clock Pulse Frequency	$f_{cl}$	5.0	—	3.5	2.1	MHz
		10	—	9.5	5.7	
		15	—	13.0	7.8	
Clock Pulse Rise and Fall Time	$t_{TLH}, t_{THL}$	5.0	NO LIMIT			$\mu\text{s}$
		10				
		15				

\*Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

## SWITCHING WAVEFORMS



# MC14569B

## PIN DESCRIPTIONS

### INPUTS

**P0, P1, P2, P3 (Pins 3, 4, 5, 6)** — Preset Inputs. Programmable inputs for the least significant counter. May be binary or BCD depending on the control input.

**P4, P5, P6, P7 (Pins 11, 12, 13, 14)** — Preset Inputs. Programmable inputs for the most significant counter. May be binary or BCD depending on the control input.

**Clock (Pin 9)** — Preset data is decremented by one on each positive transition of this signal.

### OUTPUTS

**Zero Detect (Pin 1)** — This output is normally low and goes high for one clock cycle when the counter has decremented to zero.

**Q (Pin 15)** — Output of the last stage of the most significant counter. This output will be inactive unless the preset input P7 has been set high.

### CONTROLS

**Cascade Feedback (Pin 7)** — This pin is normally set high. When low, loading of the preset inputs (P0 through P7) is inhibited, i.e., P0 through P7 are "don't cares." Refer to Table 1 for output characteristics.

**CTL<sub>1</sub> (Pin 2)** — This pin controls the counting mode of the least significant counter. When set high, counting mode is BCD. When set low, counting mode is binary.

**CTL<sub>2</sub> (Pin 10)** — This pin controls the counting mode of the most significant counter. When set high, counting mode is BCD. When set low, counting mode is binary.

### SUPPLY PINS

**V<sub>SS</sub> (Pin 18)** — Negative Supply Voltage. This pin is usually connected to ground.

**V<sub>DD</sub> (Pin 16)** — Positive Supply Voltage. This pin is connected to a positive supply voltage ranging from 3.0 volts to 18.0 volts.

## OPERATING CHARACTERISTICS

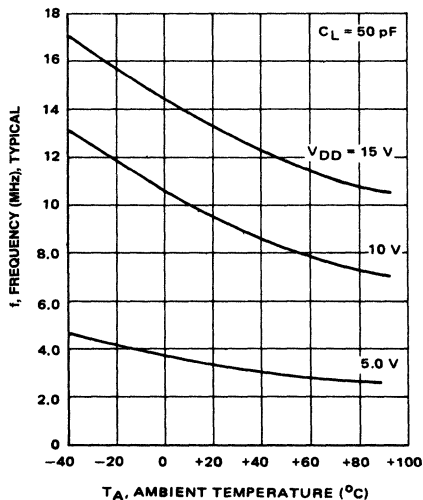
The MC14569B is a programmable divide-by-N dual 4-bit down counter. This counter may be programmed (i.e., preset) in BCD or binary code through inputs P0 to P7. For each counter, the counting sequence may be chosen independently by applying a high (for BCD count) or a low (for binary count) to the control inputs CTL<sub>1</sub> and CTL<sub>2</sub>.

The divide ratio N (N being the value programmed on the preset inputs P0 to P7) is automatically loaded into the counter as soon as the count 1 is detected. Therefore, a division ratio of one is not possible. After N clock

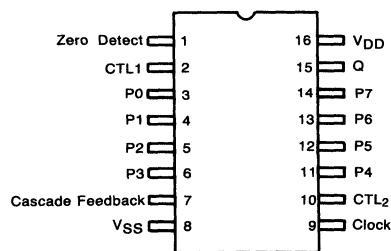
cycles, one pulse appears on the Zero Detect output. (See Timing Diagram.) The Q output is the output of the last stage of the most significant counter (See Tables 1 through 5, Mode Controls.)

When cascading the MC14569B to the MC14568B, MC14522B or the MC14526B, the Cascade Feedback input, Q, and Zero Detect outputs must be respectively connected to "0", Clock, and Load of the following counter. If the MC14569B is used alone, Cascade Feedback must be connected to V<sub>DD</sub>.

6



### PIN ASSIGNMENT



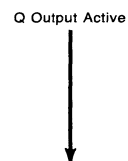




# MC14569B

**TABLE 4 — MODE CONTROLS** (CTL<sub>1</sub> = Low, CTL<sub>2</sub> = High, Cascade Feedback = High)

Preset Values								Divide Ratio		Comments	
P7	P6	P5	P4	P3	P2	P1	P0	Zero Detect	Q		
0	0	0	0	0	0	0	0	160	160	Max Count Illegal State Min Count	
0	0	0	0	0	0	0	1	X	X		
0	0	0	0	0	0	1	0	2	X		
0	0	0	0	0	0	1	1	3	X		
.	.	.	.	.	.	.	.	.	X		
.	.	.	.	.	.	.	.	.	X		
0	0	0	0	1	1	1	1	15	X		
0	0	0	1	0	0	0	0	16	X		
.	.	.	.	.	.	.	.	.	X		
.	.	.	.	.	.	.	.	.	X		
0	0	0	1	1	1	1	1	31	X		
0	0	1	0	0	0	0	0	32	X		
.	.	.	.	.	.	.	.	.	X		
.	.	.	.	.	.	.	.	.	X		
0	0	1	1	0	0	0	0	48	X		
.	.	.	.	.	.	.	.	.	.		
0	1	0	0	0	0	0	0	64	X		
.	.	.	.	.	.	.	.	.	.		
0	1	0	1	0	0	0	0	80	X		
.	.	.	.	.	.	.	.	.	.		
0	1	1	1	0	0	0	0	112	X		
.	.	.	.	.	.	.	.	.	.		
1	0	0	0	0	0	0	0	128	128		
.	.	.	.	.	.	.	.	.	.		
1	0	0	1	0	0	0	0	144	144		
.	.	.	.	.	.	.	.	.	.		
1	0	0	1	1	1	1	1	159	159		
2 <sup>7</sup>	2 <sup>6</sup>	2 <sup>5</sup>	2 <sup>4</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>			Bit Value	
128	64	32	16	8	4	2	1				
Counter #2 BCD				Counter #1 Binary							Counting Sequence



X = No Output (Always Low)

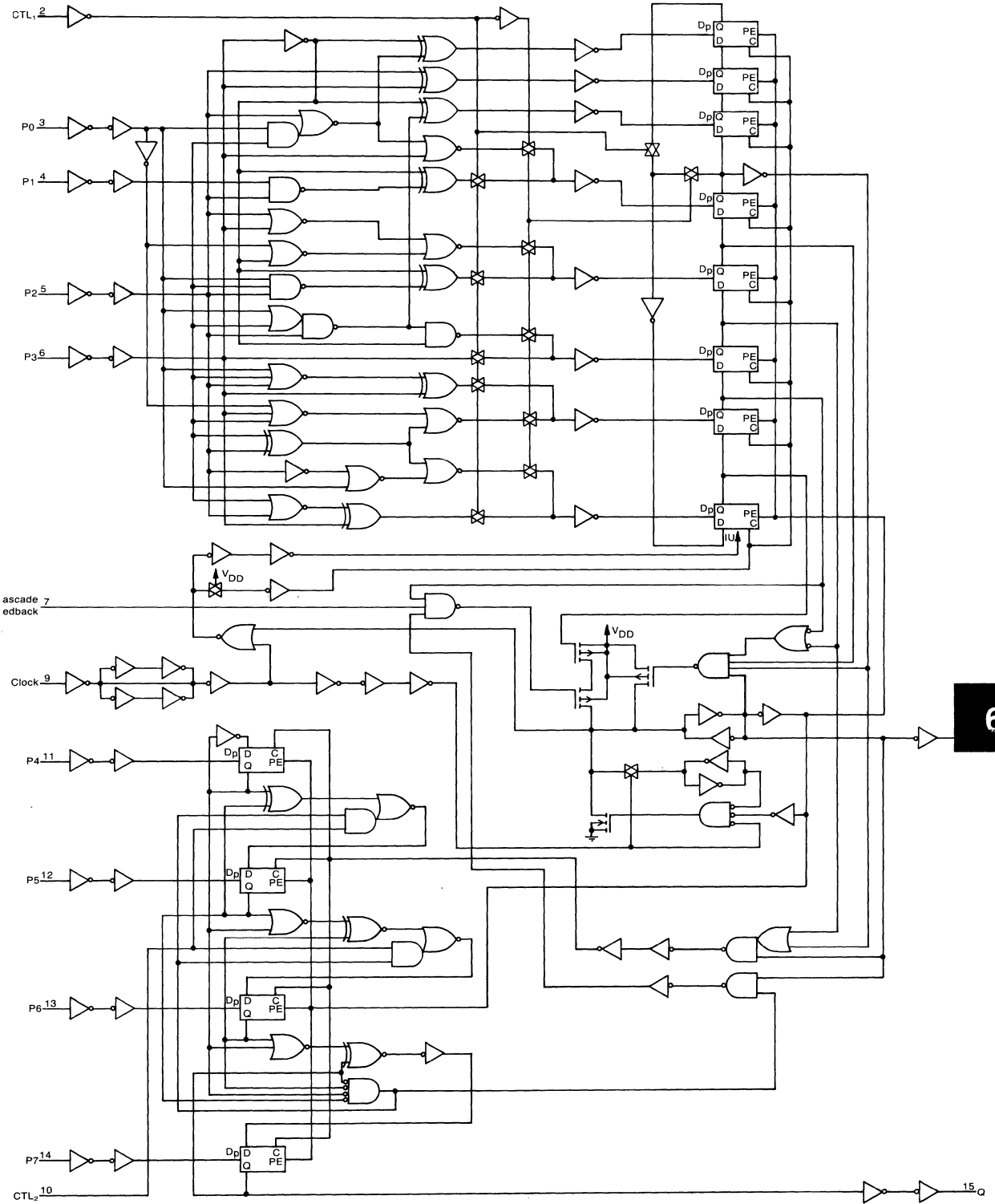






# MC14569B

## LOGIC DIAGRAM



# MC14569B

## TYPICAL APPLICATIONS

FIGURE 6 — CASCADING MC14568B AND MC14522B OR MC14526B WITH MC14569B

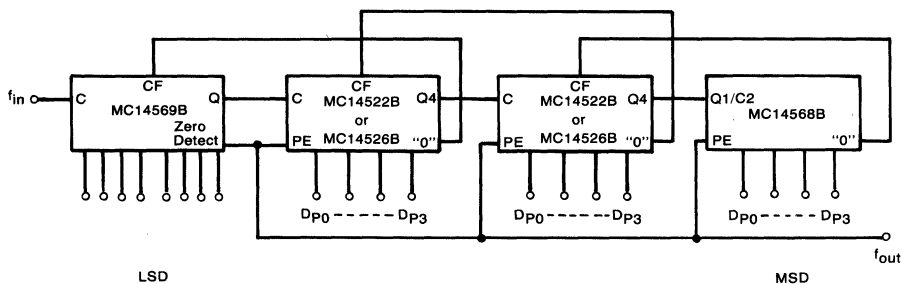
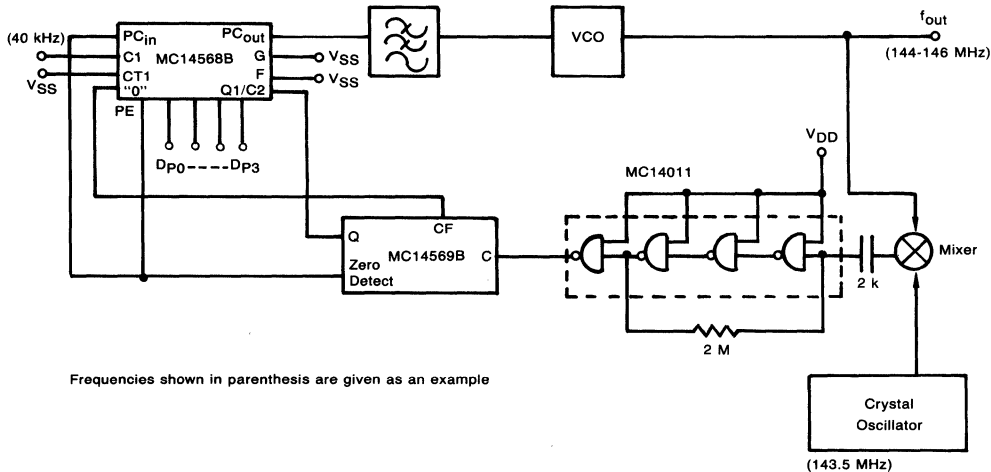


FIGURE 7 — FREQUENCY SYNTHESIZER WITH MC14568B and MC14569B USING A MIXER  
(Channel Spacing 10 kHz)



Frequencies shown in parenthesis are given as an example



**MOTOROLA**

**MC14572UB**

**HEX GATE**

The MC14572UB hex functional gate is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These complementary MOS logic gates find primary use where low power dissipation and/or high noise immunity is desired. The chip contains four inverters, one NOR gate and one NAND gate.

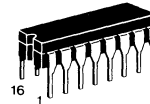
- Diode Protection on All Inputs
- Single Supply Operation
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- NOR Input Pin Adjacent to V<sub>SS</sub> Pin to Simplify Use As An Inverter
- NAND Input Pin Adjacent to V<sub>DD</sub> Pin to Simplify Use As An Inverter
- NOR Output Pin Adjacent to Inverter Input Pin For OR Application
- NAND Output Pin Adjacent to Inverter Input Pin For AND Application
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load over the Rated Temperature Range

**CMOS SSI**

(LOW-POWER COMPLEMENTARY MOS)

**HEX GATE**

**4 INVERTERS PLUS  
2-INPUT NOR GATE PLUS  
2-INPUT NAND GATE**



**L SUFFIX  
CERAMIC PACKAGE  
CASE 620**



**P SUFFIX  
PLASTIC PACKAGE  
CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXUBAL (Ceramic Package Only)

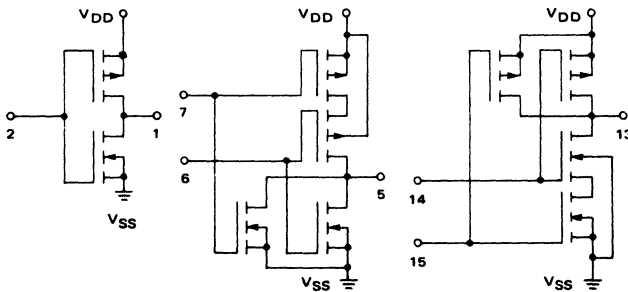
C Series: -40°C to +85°C  
MC14XXXUBCP (Plastic Package)  
MC14XXXUBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

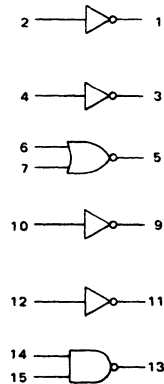
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating Plastic "P" Package - 12mW/°C from 65°C to 85°C  
Ceramic "L" Package - 12mW/°C from 100°C to 125°C

**CIRCUIT SCHEMATIC**



**LOGIC DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

# MC14572UB

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.0	—	2.25	1.0	—	1.0	Vdc	
		10	—	2.0	—	4.50	2.0	—	2.0		
		15	—	2.5	—	6.75	2.5	—	2.5		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	4.0	—	4.0	2.75	—	4.0	—	Vdc
			10	8.0	—	8.0	5.50	—	8.0	—	
			15	12.5	—	12.5	8.25	—	12.5	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mAdc	
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—		
		10	-0.62	—	-0.5	-0.9	—	-0.35	—		
	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc	
		10	1.6	—	1.3	2.25	—	0.9	—		
		15	4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mAdc	
		5.0	-0.2	—	-0.16	-0.36	—	-0.12	—		
		10	-0.5	—	-0.4	-0.9	—	-0.3	—		
	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc	
		10	1.3	—	1.1	2.25	—	0.9	—		
		15	3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μAdc	
		10	—	0.50	—	0.0010	0.50	—	15.0		
		15	—	1.00	—	0.0015	1.00	—	30.0		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μAdc	
		10	—	2.0	—	0.0010	2.0	—	15.0		
		15	—	4.0	—	0.0015	4.0	—	30.0		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.89 μA/kHz) f + I <sub>DD</sub>							μAdc	
10	I <sub>T</sub> = (3.80 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (5.68 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

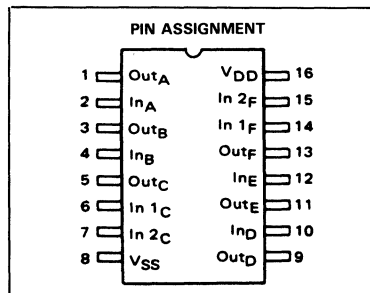
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.006.



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14572UB

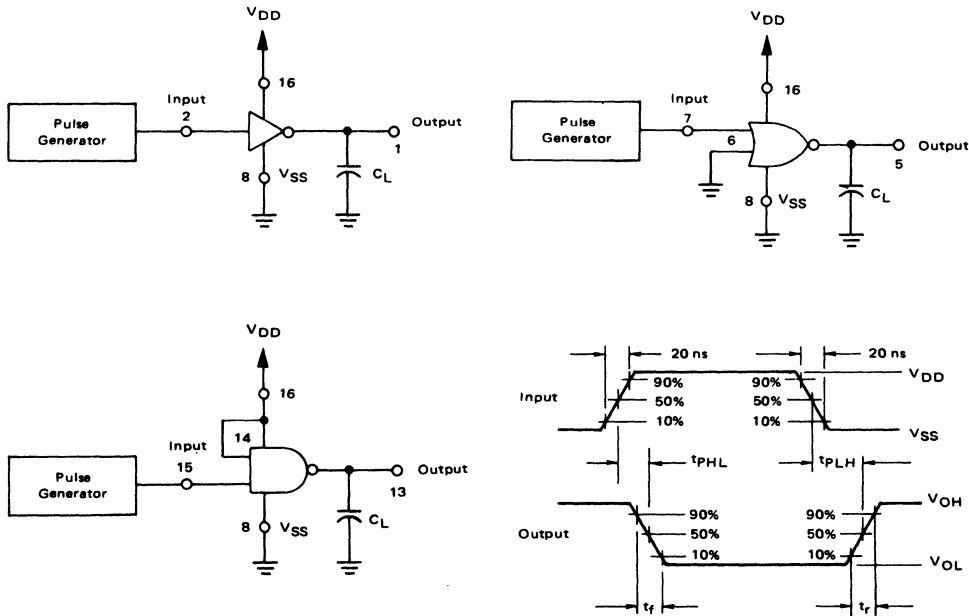
## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise Time	$t_{TLH}$	5.0	—	180	360	ns
$t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$		10	—	90	180	
$t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$		15	—	65	130	
$t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$						
Output Fall Time	$t_{THL}$	5.0	—	100	200	ns
$t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$		10	—	50	100	
$t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		15	—	40	80	
$t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$						
Propagation Delay Time	$t_{PLH}$ , $t_{PHL}$	5.0	—	90	180	ns
$t_{PLH}$ , $t_{PHL} = (1.7 \text{ ns/pF}) C_L + 5 \text{ ns}$		10	—	50	100	
$t_{PLH}$ , $t_{PHL} = (0.66 \text{ ns/pF}) C_L + 17 \text{ ns}$		15	—	40	80	
$t_{PLH}$ , $t_{PHL} = (0.5 \text{ ns/pF}) C_L + 15 \text{ ns}$						

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME TEST CIRCUITS AND WAVEFORMS





**MOTOROLA**

**MC14580B**

**4 x 4 MULTIPOINT REGISTER**

The MC14580B is a 4 by 4 multipoint register useful in small scratch pad memories, arithmetic operations when coupled with an adder, and other data storage applications. It allows independent reading of any two words (or the same word at both outputs) while writing into any one of four words.

Address changing and data entry occur on the rising edge of the clock. When the write enable input is low, the contents of any word may be accessed but not altered.

- No Restrictions on Clock Input Rise or Fall Times
- 3-State Outputs
- Single Phase Clocking
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or one Low-power Schottky TTL Load Over the Rated Temperature Range
- Pin Compatible with CD40108

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

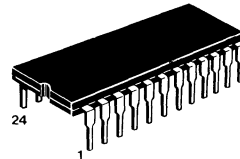
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	± 10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

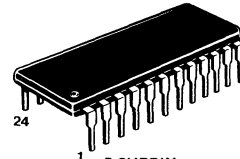
**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)

**4 x 4 MULTIPOINT REGISTER**



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 623



**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 709

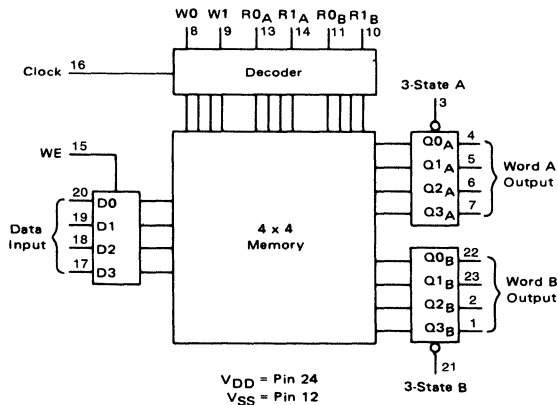
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

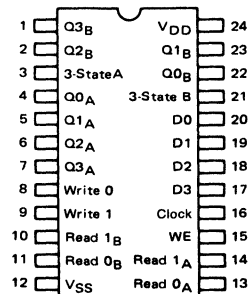
C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

6

**BLOCK DIAGRAM**



**PIN ASSIGNMENT**



# MC14580B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	+0.00001	±0.1	—	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	+0.00001	±0.3	—	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.010	5.0	—	150	μAdc	
		10	—	10	—	0.020	10	—	300		
		15	—	20	—	0.030	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	50	—	0.010	50	—	375	μAdc	
		10	—	100	—	0.020	100	—	750		
		15	—	200	—	0.030	200	—	1500		
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0 10 15	I <sub>T</sub> = (1.18 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (1.91 μA/kHz) f + I <sub>DD</sub> I <sub>T</sub> = (2.67 μA/kHz) f + I <sub>DD</sub>							μAdc	
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	0.00001	±0.1	—	±3.0	μAdc	
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	0.00001	±1.0	—	±7.5	μAdc	

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.004.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.



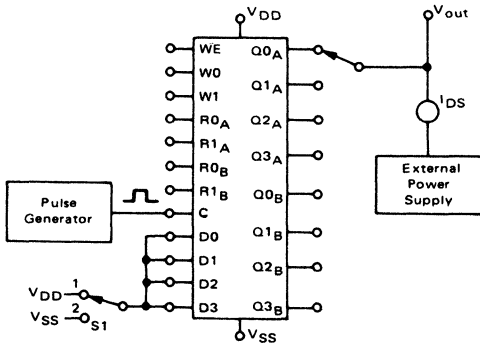
# MC14580B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}$ , $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}$ , $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}$ , $t_{THL}$ (Figures 3 and 6)	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time Clock to Output	$t_{PLH}$ , $t_{PHL}$ (Figures 3 and 6)	5.0 10 15	— — —	650 250 170	1300 500 340	ns
Write Enable Setup Time (Enabling a Write or Read)	$t_{su}$ (Figure 5)	5.0 10 15	800 300 200	400 150 100	— — —	ns
Write Enable Removal Time (Disabling a Write or Read)	$t_{rem}$ (Figure 5)	5.0 10 15	0 0 0	-100 -50 -35	— — —	ns
Setup Time** Address, Data to Clock	$t_{su}$ (Figure 3)	5.0 10 15	50 30 25	20 0 0	— — —	ns
Hold Time** Clock to Address, Data	$t_h$ (Figure 3)	5.0 10 15	480 195 150	160 65 50	— — —	ns
3-State Enable/Disable Delay Time	$t_{PHZ}$ , $t_{PLZ}$ $t_{PZH}$ , $t_{PZL}$ (Figures 4 and 7)	5.0 10 15	— — —	130 60 45	260 120 90	ns
Clock Pulse Width	$t_w$ (Figure 3)	5.0 10 15	820 330 220	410 165 110	— — —	ns

\*\*When loading repetitive highs, the output may glitch low momentarily after the rising edge of Clock. However, data integrity remains unaffected and data is valid after the propagation delays listed in the Switching Characteristics Table.

FIGURE 1 – OUTPUT DRIVE CURRENT TEST CIRCUIT



	Sink Current	Source Current
Position of S1	2	1
V <sub>GS</sub> =	V <sub>DD</sub>	-V <sub>DD</sub>
V <sub>DS</sub> =	V <sub>out</sub>	V <sub>out</sub> - V <sub>DD</sub>

# MC14580B

FIGURE 2 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS (3-State Inputs are High)

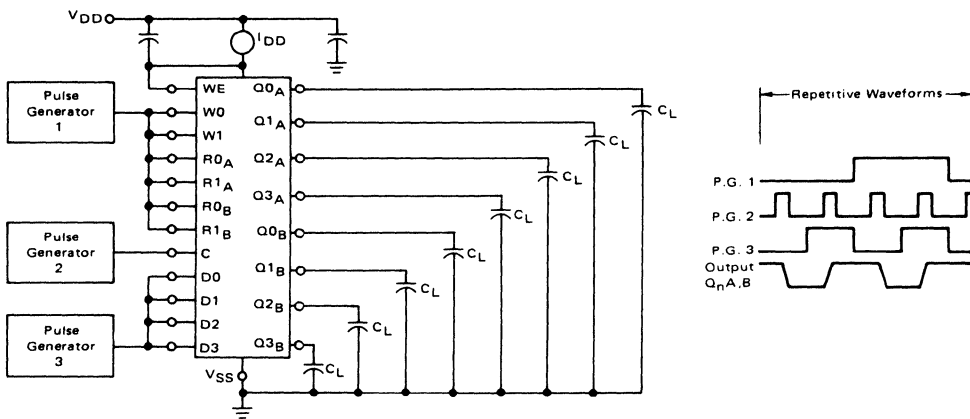


FIGURE 3

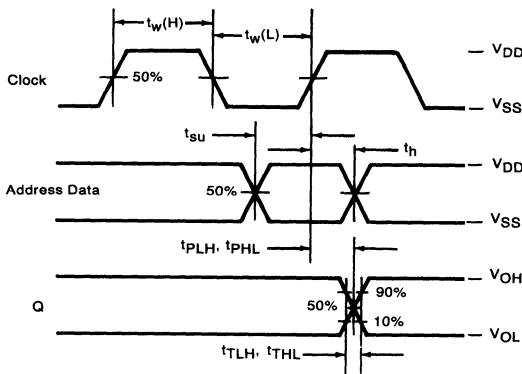


FIGURE 4

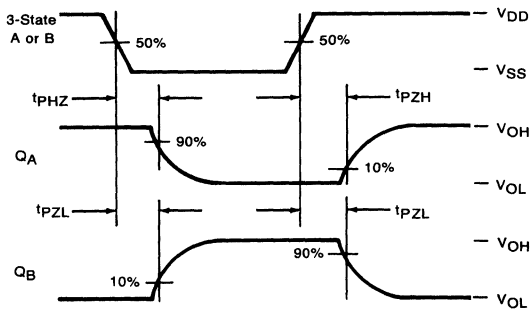


FIGURE 5

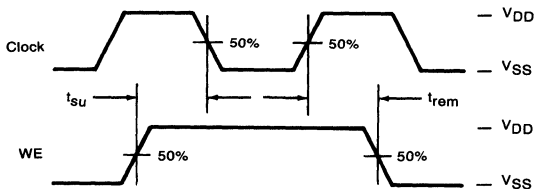


FIGURE 6 – TEST CIRCUIT

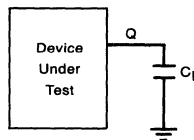
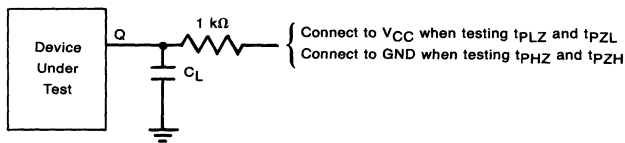
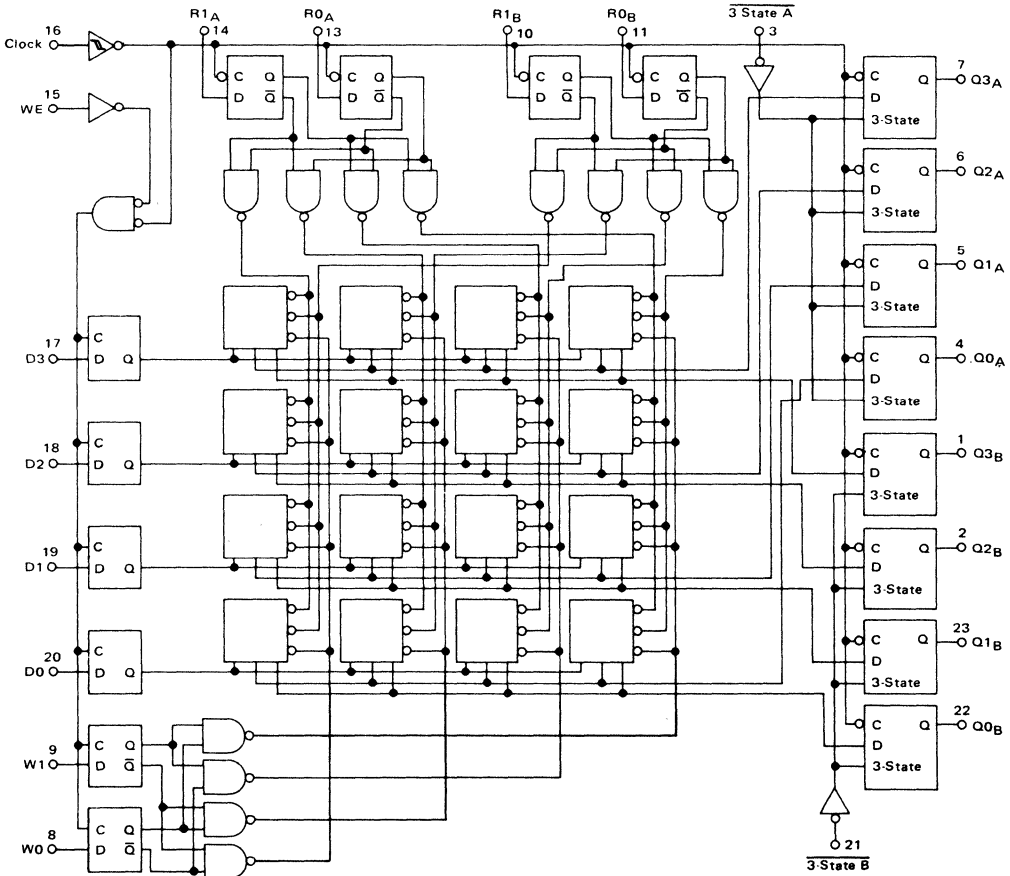


FIGURE 7 – TEST CIRCUIT



# MC14580B

LOGIC DIAGRAM



6

TRUTH TABLE

Clock	WE	Write 1	Write 0	Read 1 <sub>A</sub>	Read 0 <sub>A</sub>	Read 1 <sub>B</sub>	Read 0 <sub>B</sub>	3-State A	3-State B	D <sub>n</sub>	Q <sub>nA</sub>	Q <sub>nB</sub>
	1	0	1	0	1	0	1	1	1	1	1	1
	1	0	1	0	1	0	1	1	1	0	0	0
	X	X	X	X	X	X	X	1	1	X	No Change	No Change
	X	X	X	X	X	X	X	0	0	X	Z	Z
	0	X	X	X	X	X	X	1	1	X	No Change	No Change
	1	X	X	X	X	X	X	1	1	X	No Change	No Change
	1	0	0	0	1	1	0	1	1	D <sub>n</sub> to word 0	Contents of word 1 displayed	Contents of word 2 displayed
	0	0	0	0	1	1	0	1	1	Word 0 not altered	Contents of word 1 displayed	Contents of word 2 displayed

Z = High Impedance  
X = Don't care



**MOTOROLA**

**MC14581B**

**4-BIT ARITHMETIC LOGIC UNIT**

The MC14581B is a CMOS 4-bit ALU capable of providing 16 functions of two Boolean variables and 16 binary arithmetic operations on two 14-bit words. The level of the mode control input determines whether the output function is logic or arithmetic. The desired logic function is selected by applying the appropriate binary word to the select inputs (S0 thru S3) with the mode control input high, while the desired arithmetic operation is selected by applying a low voltage to the mode control input, the required level to carry in, and the appropriate word to the select inputs. The word inputs and function outputs can be operated with either active high or active low data.

Carry propagate ( $\overline{P}$ ) and carry generate ( $\overline{G}$ ) outputs are provided to allow a full look-ahead carry scheme for fast simultaneous carry generation for the four bits in the package. Fast arithmetic operations on long words are obtainable by using the MC14582B as a second order look ahead block. An inverted ripple carry input ( $C_n$ ) and a ripple carry output ( $C_{n+4}$ ) are included for ripple through operation.

When the device is in the subtract mode (LHHL), comparison of two 4-bit words present at the  $\overline{A}$  and  $\overline{B}$  inputs is provided using the  $A = B$  output. It assumes a high-level state when indicating equality. Also, when the ALU is in the subtract mode the  $C_{n+4}$  output can be used to indicate relative magnitude as shown in this table:

Data Level	$C_n$	$C_{n+4}$	Magnitude
Active High	H	H	$A \leq B$
	L	H	$A < B$
	H	L	$A > B$
Active Low	L	L	$A \leq B$
	H	L	$A < B$
	L	H	$A > B$

- Functional and Pinout Equivalent to 74181.
- Diode Protection on All Inputs
- All Outputs Buffered
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range

**MAXIMUM RATINGS\*** (Voltages Referenced to  $V_{SS}$ )

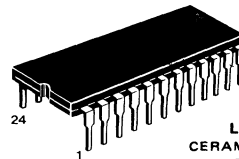
Symbol	Parameter	Value	Unit
$V_{DD}$	DC Supply Voltage	-0.5 to +18.0	V
$V_{in}, V_{out}$	Input or Output Voltage (DC or Transient)	-0.5 to $V_{DD} + 0.5$	V
$I_{in}, I_{out}$	Input or Output Current (DC or Transient), per Pin	$\pm 10$	mA
$P_D$	Power Dissipation, per Package†	500	mW
$T_{stg}$	Storage Temperature	-65 to +150	°C
$T_L$	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

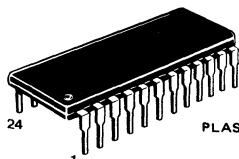
**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**4-BIT ARITHMETIC LOGIC UNIT**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 623



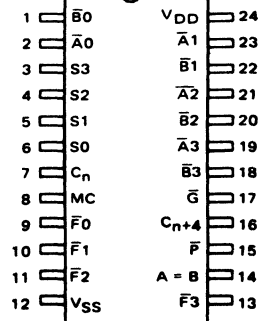
**P SUFFIX**  
PLASTIC PACKAGE  
CASE 709

**ORDERING INFORMATION**

- A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)
- C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

**6**

**PIN ASSIGNMENT**



# MC14581B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	—	0.05	—	0	0.05	—	0.05	Vdc	
		10	—	0.05	—	0	0.05	—	0.05		
		15	—	0.05	—	0	0.05	—	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
			10	9.95	—	9.95	10	—	9.95	—	
			15	14.95	—	14.95	15	—	14.95	—	
Input Voltage "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc	
		10	—	3.0	—	4.50	3.0	—	3.0		
		15	—	4.0	—	6.75	4.0	—	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
			10	7.0	—	7.0	5.50	—	7.0	—	
			15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mA <sub>dc</sub>	
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—		
		10	-1.6	—	-1.3	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.6	—	1.3	2.25	—	0.9	—	
			15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) Source (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mA <sub>dc</sub>	
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—		
		10	-1.3	—	-1.1	-2.25	—	-0.9	—		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
			10	1.3	—	1.1	2.25	—	0.9	—	
			15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>	
		10	—	10	—	0.010	10	—	300		
		15	—	20	—	0.015	20	—	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>	
		10	—	40	—	0.010	40	—	300		
		15	—	80	—	0.015	80	—	600		
Total Supply Current** † (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.8 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>	
10	I <sub>T</sub> = (3.7 μA/kHz) f + I <sub>DD</sub>										
15	I <sub>T</sub> = (5.5 μA/kHz) f + I <sub>DD</sub>										

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.008.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>IN</sub> and V<sub>OUT</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>IN</sub> or V<sub>OUT</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14581B

## SWITCHING CHARACTERISTICS\* (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time	t <sub>TLH</sub> , t <sub>THL</sub>	5.0	—	100	200	ns
t <sub>TLH</sub> , t <sub>THL</sub> = (1.5 ns/pF) C <sub>L</sub> + 25 ns	t <sub>TLH</sub> , t <sub>THL</sub>	10	—	50	100	
t <sub>TLH</sub> , t <sub>THL</sub> = (0.75 ns/pF) C <sub>L</sub> + 12.5 ns	t <sub>TLH</sub> , t <sub>THL</sub>	15	—	40	80	
t <sub>TLH</sub> , t <sub>THL</sub> = (0.55 ns/pF) C <sub>L</sub> + 9.5 ns						
Propagation Delay Time	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	705	1410	ns
Sum in to Sum Out	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	250	500	
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 620 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	180	360	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 217 ns						
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 155 ns						
Sum in to Sum Out (Logic Mode)	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	605	1210	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 520 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	215	430	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 182 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	180	360	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 155 ns						
Sum in to A = B	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	955	1910	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 870 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	330	660	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 297 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	245	490	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 220 ns						
Sum In to P or G	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	485	970	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 400 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	180	360	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 147 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	130	260	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 105 ns						
Sum In to C <sub>n+4</sub>	t <sub>PLH</sub>	5.0	—	615	1230	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 530 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	220	440	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 187 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	160	360	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 135 ns						
Carry In to Sum Out	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	380	760	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 295 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	145	290	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 112 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	105	210	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 80 ns						
Carry in to C <sub>n+4</sub>	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	305	610	ns
t <sub>PLH</sub> , t <sub>PHL</sub> = (1.7 ns/pF) C <sub>L</sub> + 220 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	10	—	120	240	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.66 ns/pF) C <sub>L</sub> + 87 ns	t <sub>PLH</sub> , t <sub>PHL</sub>	15	—	85	170	
t <sub>PLH</sub> , t <sub>PHL</sub> = (0.5 ns/pF) C <sub>L</sub> + 60 ns						

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

### AC TEST SETUP REFERENCE TABLE

TEST	AC PATHS		DC DATA INPUTS		MODE	FIG. 3 WAVEFORM
	INPUTS	OUTPUTS	TO V <sub>SS</sub>	TO V <sub>DD</sub>		
Sum <sub>in</sub> to Sum <sub>out</sub> Delay Time	$\bar{A}0$	Any $\bar{F}$	Remaining $\bar{A}$ 's C <sub>n</sub>	All $\bar{B}$ 's	Add	#1
Sum <sub>in</sub> to $\bar{P}$ Delay Time	$\bar{A}0$	$\bar{P}$	Remaining $\bar{A}$ 's C <sub>n</sub>	All $\bar{B}$ 's	Add	#1
Sum <sub>in</sub> to $\bar{G}$ Delay Time	$\bar{B}0$	$\bar{G}$	All $\bar{A}$ 's C <sub>n</sub>	Remaining $\bar{B}$ 's	Add	#1
Sum <sub>in</sub> to C <sub>n+4</sub> Delay Time	$\bar{B}0$	C <sub>n+y</sub>	All $\bar{A}$ 's C <sub>n</sub>	Remaining $\bar{B}$ 's	Add	#2
C <sub>n</sub> to Sum <sub>out</sub> Delay Time	C <sub>n</sub>	Any $\bar{F}$	All $\bar{A}$ 's	All $\bar{B}$ 's	Add	#1
C <sub>n</sub> to C <sub>n+4</sub> Delay Time	C <sub>n</sub>	C <sub>n+4</sub>	All $\bar{A}$ 's	All $\bar{B}$ 's	Add	#1
Sum <sub>in</sub> to A = B Delay Time	$\bar{A}0$	A = B	All $\bar{B}$ 's Remaining $\bar{A}$ 's	C <sub>n</sub>	Sub	#2
Sum <sub>in</sub> to Sum <sub>out</sub> Delay Time (Logic Mode)	$\bar{B}0$	Any $\bar{F}$	All A's	M	Exclusive OR	#2

# MC14581B

FIGURE 1 – TYPICAL SOURCE CURRENT TEST CIRCUIT

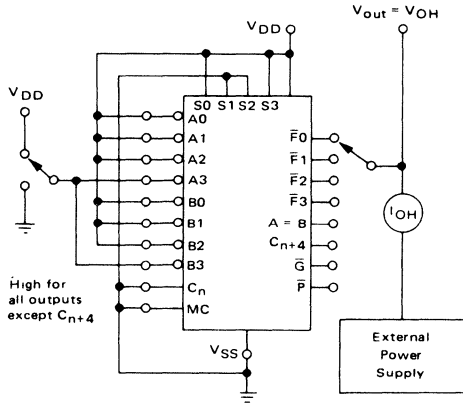


FIGURE 2 – TYPICAL SINK CURRENT TEST CIRCUIT

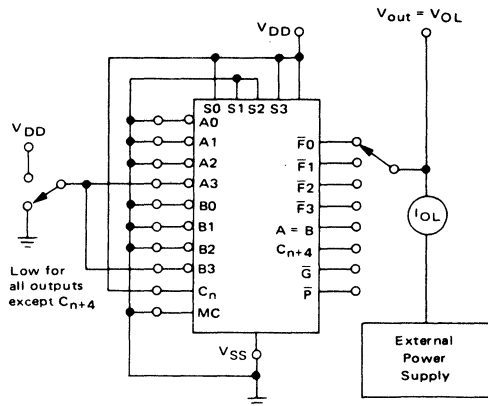


FIGURE 3 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

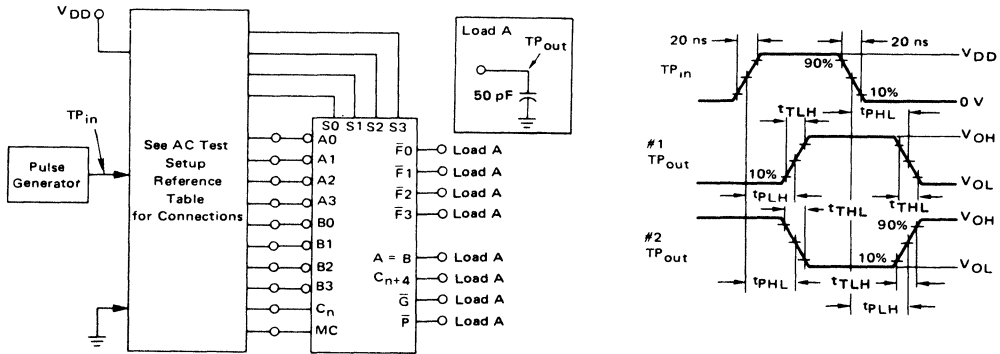
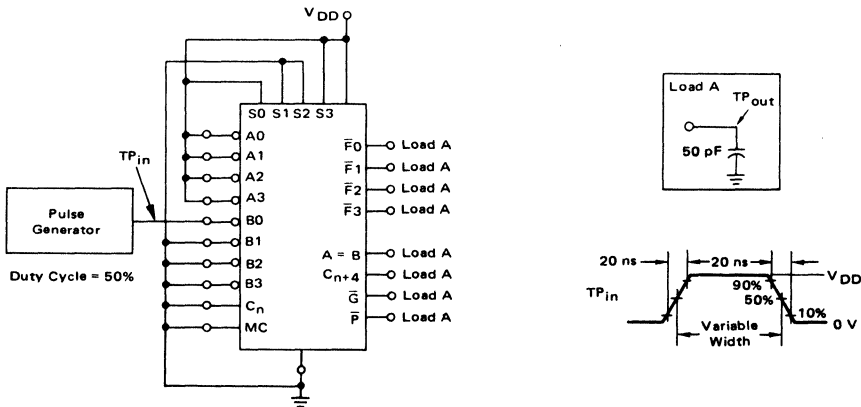
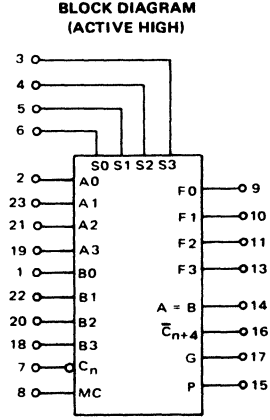
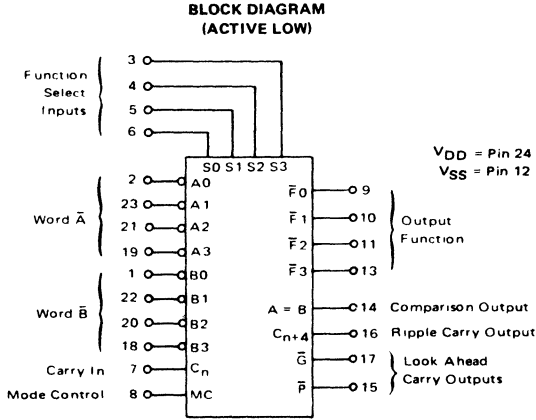


FIGURE 4 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORM



# MC14581B



**TRUTH TABLE**

FUNCTION SELECT	INPUTS/OUTPUTS ACTIVE LOW			INPUTS/OUTPUTS ACTIVE HIGH	
	LOGIC FUNCTION (MC = H)	ARITHMETIC* FUNCTION (MC = L, $C_n = L$ )	LOGIC FUNCTION (MC = H)	ARITHMETIC* FUNCTION (MC = L, $C_n = H$ )	
$S_3 S_2 S_1 S_0$					
L L L L	$\bar{A}$	A minus 1	$\bar{A}$	A	
L L L H	$\bar{A}\bar{B}$	AB minus 1	$\overline{A+B}$	A+B	
L L H L	$\bar{A}+B$	$\bar{A}\bar{B}$ minus 1	$\bar{A}\bar{B}$	$A+\bar{B}$	
L L H H	Logic "1"	minus 1	Logic "0"	minus 1	
L H L L	$\bar{A}+\bar{B}$	A plus (A+B)	$\bar{A}\bar{B}$	A plus $\bar{A}\bar{B}$	
L H L H	$\bar{B}$	AB plus (A+B)	$\bar{B}$	(A+B) plus $\bar{A}\bar{B}$	
L H H L	$A \oplus B$	A minus B minus 1	$A \oplus B$	A minus B minus 1	
L H H H	A+B	A+B	$\bar{A}\bar{B}$	$\bar{A}\bar{B}$ minus 1	
H L L L	$\bar{A}\bar{B}$	A plus (A+B)	$\bar{A}+B$	A plus AB	
H L L H	$A \oplus B$	A plus B	$A \oplus B$	A plus B	
H L H L	B	$\bar{A}\bar{B}$ plus (A+B)	B	(A+B) plus AB	
H L H H	A+B	A+B	AB	AB minus 1	
H H L L	Logic "0"	A plus A	Logic "1"	A plus A	
H H L H	$\bar{A}\bar{B}$	AB plus A	$A+\bar{B}$	(A+B) plus A	
H H H L	AB	$\bar{A}\bar{B}$ plus A	A+B	(A+B) plus A	
H H H H	A	A	A	A minus 1	

\* Expressed as two's complements. For arithmetic function with  $C_n$  in the opposite state, the resulting function is as shown plus 1.





**MOTOROLA**

**MC14582B**

**LOOK-AHEAD CARRY BLOCK**

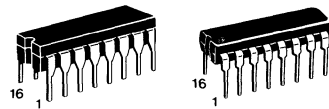
The MC14582B is a CMOS look-ahead carry generator capable of anticipating a carry across four binary adders or groups of adders. The device is cascadable to perform full look-ahead across n-bit adders. Carry, generate-carry, and propagate-carry functions are provided as enumerated in the pin designation table shown below.

- Expandable to any Number of Bits
- All Buffered Outputs
- Low Power Dissipation
- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-Power Schottky TTL Load over the Rated Temperature Range

**CMOS MSI**

(LOW-POWER COMPLEMENTARY MOS)

**LOOK-AHEAD CARRY BLOCK**



**L SUFFIX CERAMIC PACKAGE CASE 620**      **P SUFFIX PLASTIC PACKAGE CASE 648**

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
i <sub>in</sub> , i <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

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**LOGIC EQUATIONS**

$$C_{n+x} = \bar{G}_0 + (P_0 \bullet C_n)$$

$$C_{n+y} = \bar{G}_1 + (P_1 \bullet \bar{G}_0) + (\bar{P}_1 \bullet P_0 \bullet C_n)$$

$$C_{n+z} = \bar{G}_2 + (P_2 \bullet \bar{G}_1) + (\bar{P}_2 \bullet P_1 \bullet \bar{G}_0) + (P_2 \bullet P_1 \bullet P_0 \bullet C_n)$$

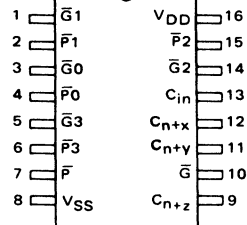
$$\bar{G} = \bar{G}_3 + (P_3 \bullet \bar{G}_2) + (\bar{P}_3 \bullet P_2 \bullet \bar{G}_1) + (\bar{P}_1 \bullet P_2 \bullet P_3 \bullet \bar{G}_0)$$

$$\bar{P} = P_3 \bullet P_2 \bullet P_1 \bullet P_0$$

**PIN DESIGNATIONS**

DESIGNATION	PIN NO's	FUNCTION
$\bar{G}_0, \bar{G}_1, \bar{G}_2, \bar{G}_3$	3, 1, 14, 5	Active-Low Carry-Generate Inputs
$\bar{P}_0, \bar{P}_1, \bar{P}_2, \bar{P}_3$	4, 2, 15, 6	Active-Low Carry-Propagate Inputs
C <sub>n</sub>	13	Carry Input
C <sub>n+x</sub> , C <sub>n+y</sub> , C <sub>n+z</sub>	12, 11, 9	Carry Outputs
$\bar{G}$	10	Active-Low Group Carry-Generate Output
$\bar{P}$	7	Active-Low Group Carry-Propagate Output

**PIN ASSIGNMENT**



# MC14582B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mAdc
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
		15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mAdc
		10	1.6	—	1.3	2.25	—	0.9	—	
Output Drive Current (CL/CP Device)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mAdc
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mAdc
		10	1.3	—	1.1	2.25	—	0.9	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±1.0	μAdc
		15	—	±0.3	—	±0.0001	±0.3	—	±1.0	
		15	—	±0.3	—	±0.0001	±0.3	—	±1.0	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
		—	—	—	—	5.0	7.5	—	—	
		—	—	—	—	5.0	7.5	—	—	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μAdc
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μAdc
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.4 μA/kHz) f + I <sub>DD</sub>							μAdc
		10	I <sub>T</sub> = (2.8 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (4.3 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) \text{ Vfk}$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.005.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14582B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise and Fall Time $t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 260 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 107 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 85 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0 10 15	— — —	345 140 110	690 280 220	ns

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION TEST CIRCUIT AND WAVEFORM

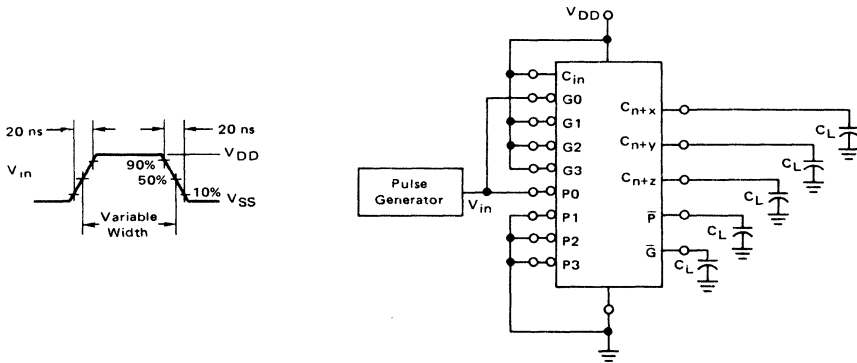


FIGURE 2 – SOURCE CURRENT TEST CIRCUIT

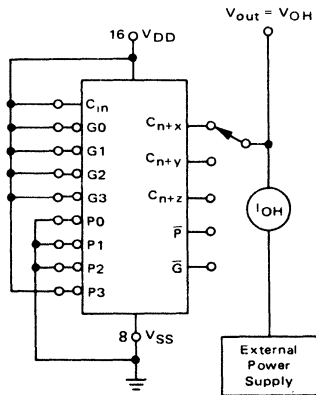
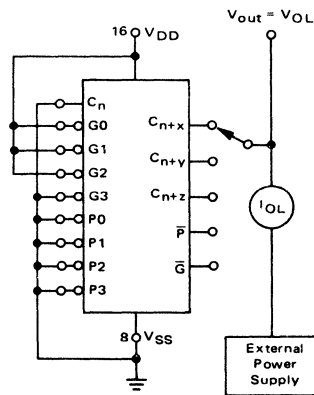
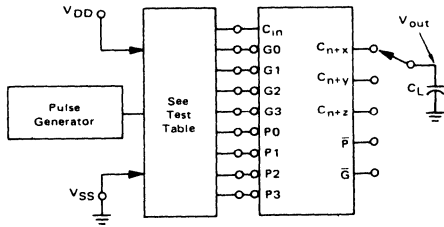


FIGURE 3 – SINK CURRENT TEST CIRCUIT

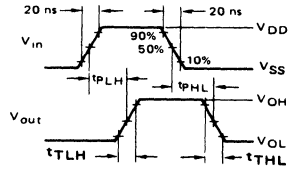


# MC14582B

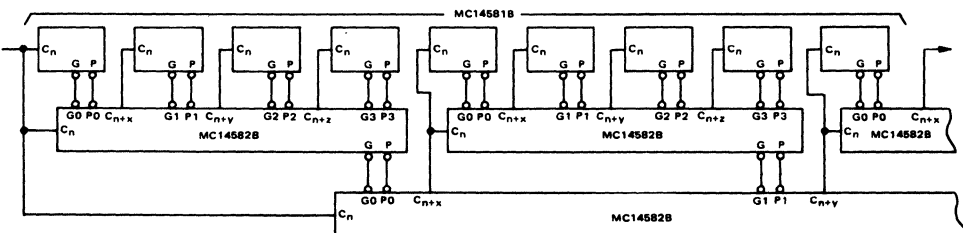
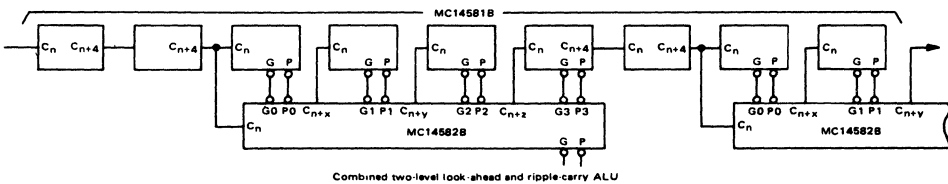
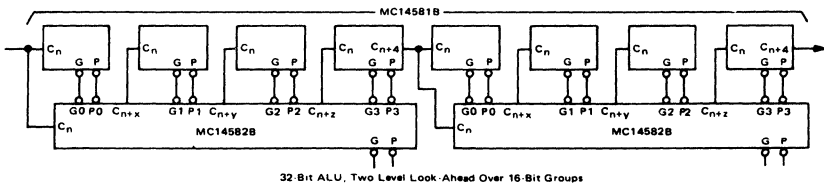
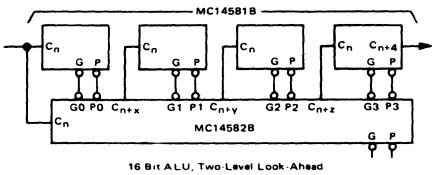
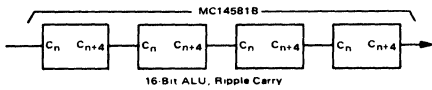
FIGURE 4 - SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



AC PATHS		DC DATA	
INPUT	OUTPUT	To VSS	To VDD
$\bar{P}0$	$\bar{F}$	Remaining $P$ 's, $C_n$	$\bar{G}$ 's
$\bar{G}0$	$\bar{C}$	$\bar{P}$ 's, $C_n$	Remaining $\bar{G}$ 's
$C_n$	$C_{n+x}, C_{n+y}, C_{n+z}$	$\bar{P}$ 's	$\bar{G}$ 's



## TYPICAL APPLICATIONS



A and B inputs and F outputs are not shown (MC14581B).

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# MC14583B

## DUAL SCHMITT TRIGGER

The MC14583B is a dual Schmitt trigger constructed with complementary P-channel and N-channel MOS devices on a monolithic silicon substrate. Each Schmitt trigger is functionally independent except for a common 3-state input and an internally-connected Exclusive OR output for use in line receiver applications. Trigger levels are adjustable through the positive, negative, and common terminals with the use of external resistors. Applications include the speed-up of a slow waveform edge in interface receivers, level detectors, etc.

- Diode Protection on All Inputs
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Single Supply Operation
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load Over the Rated Temperature Range
- Resistor Adjustable Trigger Levels

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

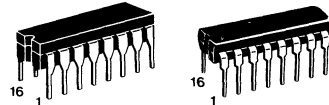
Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.  
 †Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C  
 Ceramic "L" Package: -12mW/°C from 100°C to 125°C

## CMOS SSI

(LOW-POWER COMPLEMENTARY MOS)

## DUAL SCHMITT TRIGGER



**L SUFFIX**  
 CERAMIC PACKAGE  
 CASE 620

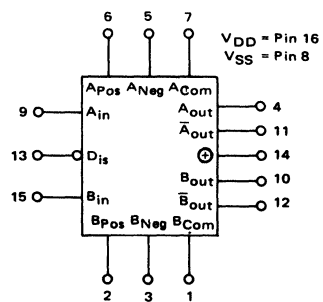
**P SUFFIX**  
 PLASTIC PACKAGE  
 CASE 648

### ORDERING INFORMATION

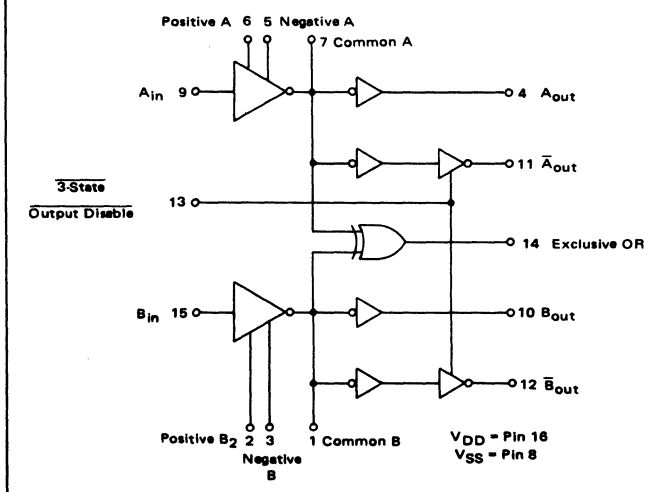
A Series: -55°C to +125°C  
 MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
 MC14XXXBCP (Plastic Package)  
 MC14XXXBCL (Ceramic Package)

### BLOCK DIAGRAM



### LOGIC DIAGRAM



### TRUTH TABLE

INPUTS			OUTPUTS				
A	B	Dis	A <sub>out</sub>	$\bar{A}_{out}$	B <sub>out</sub>	$\bar{B}_{out}$	⊕
0	0	0	0	Z	0	Z	0
0	0	1	0	1	0	1	0
0	1	0	0	Z	1	Z	1
0	1	1	0	1	1	0	1
1	0	0	1	Z	0	Z	1
1	0	1	1	0	0	1	1
1	1	0	1	Z	1	Z	0
1	1	1	1	0	1	0	0

Z = High impedance at output

# MC14583B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage A and B (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.2	—	-1.0	-1.7	—	-0.7	—	mA <sub>dc</sub>
		5.0	-0.25	—	-0.2	-0.36	—	-0.14	—	
		10	-0.62	—	-0.5	-0.9	—	-0.35	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—	
		15	4.2	—	3.4	8.8	—	2.4	—	
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-1.0	—	-0.8	-1.7	—	-0.6	—	mA <sub>dc</sub>
		5.0	-0.2	—	-0.16	-0.36	—	-0.12	—	
		10	-0.5	—	-0.4	-0.9	—	-0.3	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—	
		15	3.6	—	3.0	8.8	—	2.4	—	
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.00001	±0.3	—	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	0.25	—	0.0005	0.25	—	7.5	μA <sub>dc</sub>
		10	—	0.50	—	0.0010	0.50	—	15.0	
		15	—	1.00	—	0.0015	1.00	—	30.0	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	1.0	—	0.0005	1.0	—	7.5	μA <sub>dc</sub>
		10	—	2.0	—	0.0010	2.0	—	15.0	
		15	—	4.0	—	0.0015	4.0	—	30.0	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.33 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>
10	I <sub>T</sub> = (2.65 μA/kHz) f + I <sub>DD</sub>									
15	I <sub>T</sub> = (3.98 μA/kHz) f + I <sub>DD</sub>									
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	—	±0.1	—	±0.00001	±0.1	—	±3.0	A <sub>dc</sub>
Three-State Leakage Current (CL/CP Device)	I <sub>TL</sub>	15	—	±1.0	—	±0.00001	±1.0	—	±7.5	μA <sub>dc</sub>

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

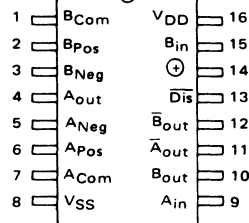
\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts,  
f in kHz is input frequency, and k = 0.005.

### PIN ASSIGNMENT



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>. Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

# MC14583B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
Output Rise Time $t_{TLH} = (3.0 \text{ ns/pF}) C_L + 30 \text{ ns}$ $t_{TLH} = (1.5 \text{ ns/pF}) C_L + 15 \text{ ns}$ $t_{TLH} = (1.1 \text{ ns/pF}) C_L + 10 \text{ ns}$	$t_{TLH}$	5.0 10 15	— — —	180 90 65	360 180 130	ns
Output Fall Time $t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$ $t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$ $t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$	$t_{THL}$	5.0 10 15	— — —	100 50 40	200 100 80	ns
Propagation Delay Time $A_{in}, B_{in}$ to $A_{out}, B_{out}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 565 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 197 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 125 \text{ ns}$  $A_{in}, B_{in}$ to $A_{out}, B_{out}$ $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 1015 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 347 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 235 \text{ ns}$  $A_{in}, B_{in}$ to Exclusive OR $t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 665 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 257 \text{ ns}$ $t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 145 \text{ ns}$	$t_{PLH},$ $t_{PHL}$	5.0 10 15	— — —	650 230 150	1300 460 300	ns
3-State Enable, Disable Delay Time (see figure 5) $t_{on}, t_{off} = (1.7 \text{ ns/pF}) C_L + 140 \text{ ns}$ $t_{on}, t_{off} = (0.66 \text{ ns/pF}) C_L + 57 \text{ ns}$ $t_{on}, t_{off} = (0.5 \text{ ns/pF}) C_L + 30 \text{ ns}$	$t_{on},$ $t_{off}$	5.0 10 15	— — —	225 90 55	450 180 110	ns
Positive Threshold Voltage $(R_1, R_2 = 5.0 \text{ k}\Omega)$	$V_{T+}$	5.0 10 15	— — —	3.30 5.70 8.20	— — —	Vdc
Negative Threshold Voltage $(R_1, R_2 = 5.0 \text{ k}\Omega)$	$V_{T-}$	5.0 10 15	— — —	1.70 4.30 6.80	— — —	Vdc
Hysteresis Voltage $(R_1, R_2 = 5.0 \text{ k}\Omega)$	$V_H$	5.0 10 15	0.85 0.70 0.70	1.70 1.40 1.40	3.40 2.80 2.80	Vdc
Threshold Voltage Variation, A to B $(R_1, R_2 = 5.0 \text{ k}\Omega)$	$\Delta V_T$	5.0 10 15	— — —	0.1 0.15 0.20	— — —	Vdc

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14583B

FIGURE 1 – TYPICAL OUTPUT SOURCE AND SINK CHARACTERISTICS TEST CIRCUIT

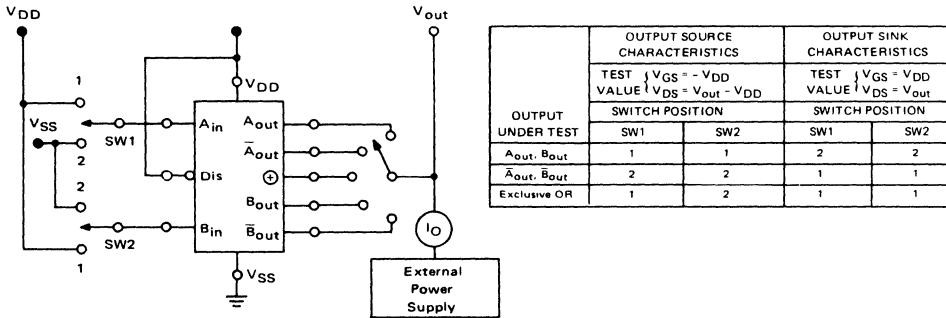


FIGURE 2 – POWER DISSIPATION TEST CIRCUIT AND WAVEFORMS

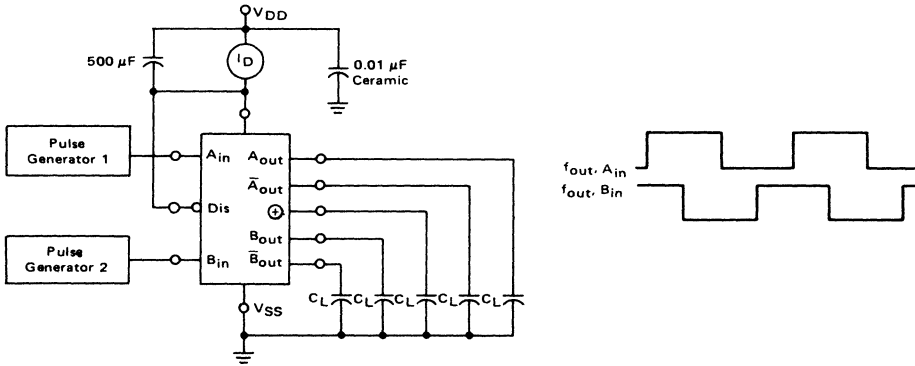
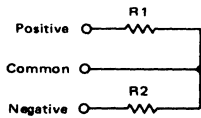
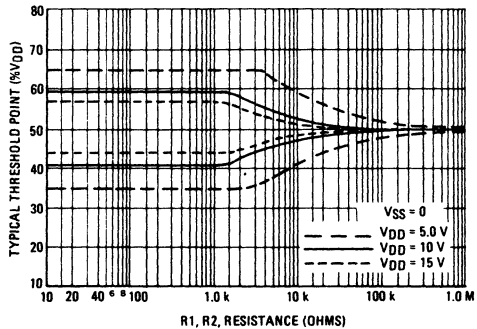
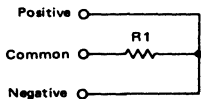


FIGURE 3 – TYPICAL THRESHOLD POINTS

A – Feedback scheme for independent threshold adjustment:



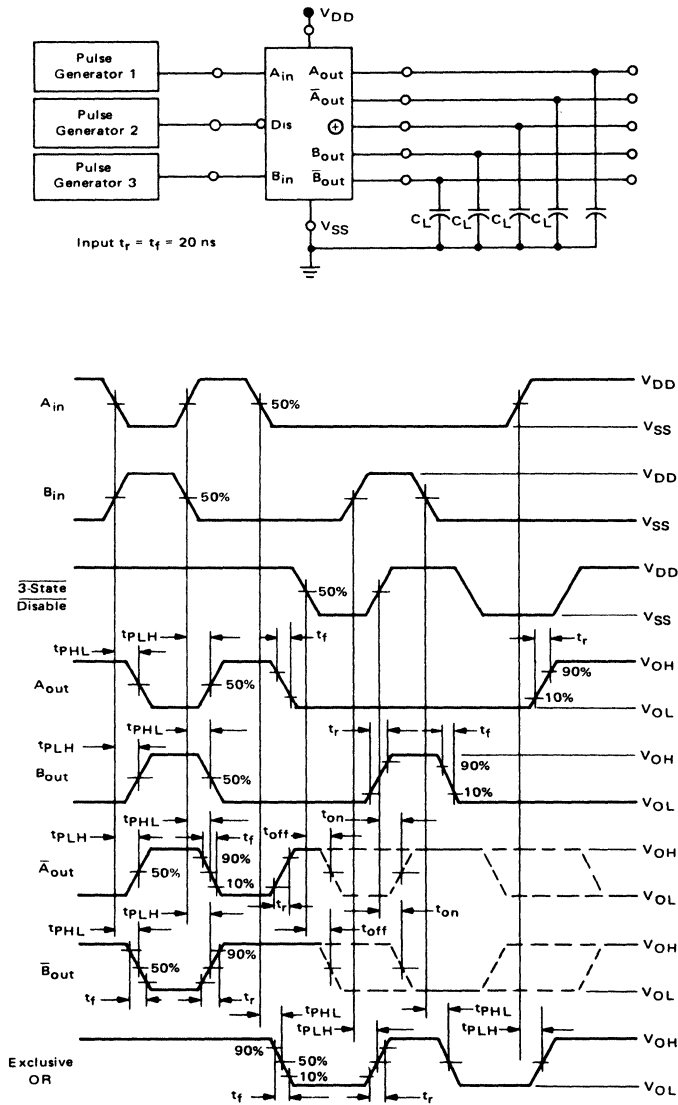
B – Feedback scheme for hysteresis adjustment:





# MC14583B

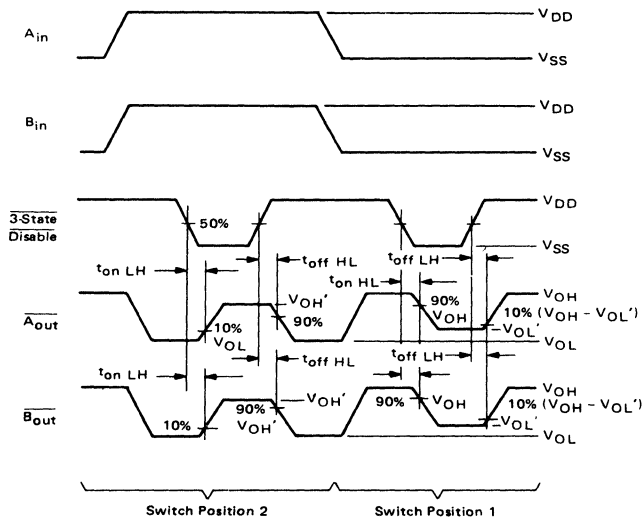
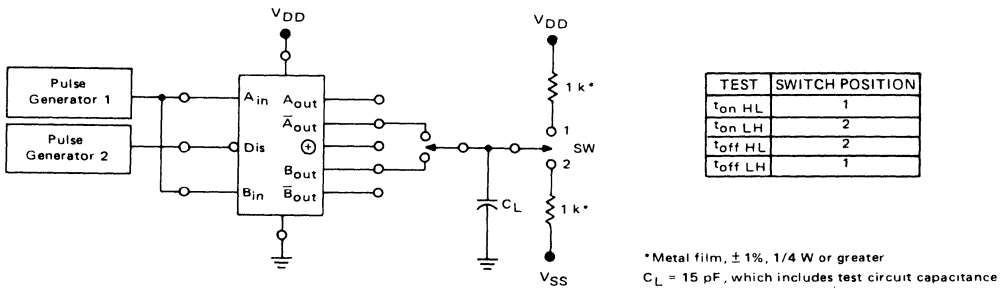
FIGURE 4 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



6

# MC14583B

FIGURE 5 – 3-STATE SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



$V_{OL'}$  and  $V_{OH'}$  refer to the levels present as a result of the 1 k ohm load resistors.



# MOTOROLA

## MC14584B

### HEX SCHMITT TRIGGER

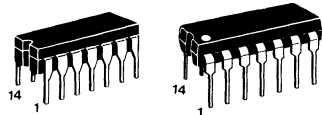
The MC14584B Hex Schmitt Trigger is constructed with MOS P-channel and N-channel enhancement mode devices in a single monolithic structure. These devices find primary use where low power dissipation and/or high noise immunity is desired. The MC14584B may be used in place of the MC14069UB hex inverter for enhanced noise immunity to "square up" slowly changing waveforms.

- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range
- Double Diode Protection on All Inputs
- Can Be Used to Replace MC14069UB
- For Greater Hysteresis, Use MC14106B which is Pin-for-Pin Replacement for CD40106B and MM74C14

### CMOS SSI

(LOW-POWER COMPLEMENTARY MOS)

### HEX SCHMITT TRIGGER



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 632

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 646

### ORDERING INFORMATION

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

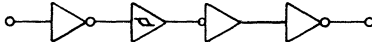
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

### MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

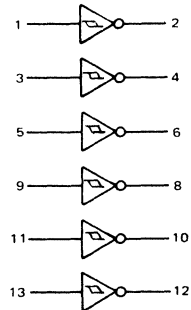
\*Maximum Ratings are those values beyond which damage to the device may occur  
†Temperature Derating. Plastic "P" Package: -12mW/°C from 65°C to 85°C  
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

### EQUIVALENT CIRCUIT SCHEMATIC (1/6 OF CIRCUIT SHOWN)



This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.  
Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

### LOGIC DIAGRAM



V<sub>DD</sub> = Pin 14  
V<sub>SS</sub> = Pin 7

# MC14584B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub>	V <sub>OL</sub>	5.0	–	0.05	–	0	0.05	–	0.05	Vdc	
		10	–	0.05	–	0	0.05	–	0.05		
		15	–	0.05	–	0	0.05	–	0.05		
	"1" Level V <sub>in</sub> = 0	V <sub>OH</sub>	5.0	4.95	–	4.95	5.0	–	4.95	–	Vdc
			10	9.95	–	9.95	10	–	9.95	–	
			15	14.95	–	14.95	15	–	14.95	–	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	–3.0	–	–2.4	–4.2	–	–1.7	–	mAdc	
		5.0	–0.64	–	–0.51	–0.88	–	–0.36	–		
		10	–1.6	–	–1.3	–2.25	–	–0.9	–		
		10	–1.6	–	–1.3	–2.25	–	–0.9	–		
		15	–4.2	–	–3.4	–8.8	–	–2.4	–		
		15	–4.2	–	–3.4	–8.8	–	–2.4	–		
	I <sub>OL</sub>	5.0	0.64	–	0.51	0.88	–	0.36	–	mAdc	
		10	1.6	–	1.3	2.25	–	0.9	–		
		10	1.6	–	1.3	2.25	–	0.9	–		
		15	4.2	–	3.4	8.8	–	2.4	–		
		15	4.2	–	3.4	8.8	–	2.4	–		
		15	4.2	–	3.4	8.8	–	2.4	–		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) Source (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc) (V <sub>OL</sub> = 0.4 Vdc) Sink (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OH</sub>	5.0	–2.5	–	–2.1	–4.2	–	–1.7	–	mAdc	
5.0		–0.52	–	–0.44	–0.88	–	–0.36	–			
10		–1.3	–	–1.1	–2.25	–	–0.9	–			
10		–1.3	–	–1.1	–2.25	–	–0.9	–			
15		–3.6	–	–3.0	–8.8	–	–2.4	–			
15		–3.6	–	–3.0	–8.8	–	–2.4	–			
I <sub>OL</sub>	5.0	0.52	–	0.44	0.88	–	0.36	–	mAdc		
	10	1.3	–	1.1	2.25	–	0.9	–			
	10	1.3	–	1.1	2.25	–	0.9	–			
	15	3.6	–	3.0	8.8	–	2.4	–			
	15	3.6	–	3.0	8.8	–	2.4	–			
	15	3.6	–	3.0	8.8	–	2.4	–			
Input Current (AL Device)	I <sub>in</sub>	15	–	±0.1	–	±0.00001	±0.1	–	±1.0	μAdc	
Input Current (CL/CP Device)	I <sub>in</sub>	15	–	±0.3	–	±0.00001	±0.3	–	±1.0	μAdc	
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	–	–	–	–	5.0	7.5	–	–	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	–	0.25	–	0.0005	0.25	–	7.5	μAdc	
		10	–	0.50	–	0.0010	0.50	–	15		
		15	–	1.00	–	0.0015	1.00	–	30		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	–	1.0	–	0.0005	1.0	–	7.5	μAdc	
		10	–	2.0	–	0.0010	2.0	–	15		
		15	–	4.0	–	0.0015	4.0	–	34		
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (1.8 μA/kHz) f + I <sub>DD</sub>							μAdc	
		10	I <sub>T</sub> = (3.6 μA/kHz) f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (5.4 μA/kHz) f + I <sub>DD</sub>								
Hysteresis Voltage	V <sub>H</sub> †	5.0	0.27	1.0	0.25	0.6	1.0	0.21	1.0	Vdc	
		10	0.36	1.3	0.30	0.70	1.2	0.25	1.2		
		15	0.77	1.7	0.60	1.1	1.5	0.50	1.4		
Threshold Voltage Positive-Going	V <sub>T+</sub>	5.0	1.9	3.5	1.8	2.7	3.4	1.7	3.4	Vdc	
		10	3.4	7.0	3.3	5.3	6.9	3.2	6.9		
		15	5.2	10.6	5.2	8.0	10.5	5.2	10.5		
Negative-Going	V <sub>T–</sub>	5.0	1.6	3.3	1.6	2.1	3.2	1.5	3.2	Vdc	
		10	3.0	6.7	3.0	4.6	6.7	3.0	6.7		
		15	4.5	9.7	4.6	6.9	9.8	4.7	9.9		

\*T<sub>low</sub> = –55°C for AL Device, –40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> – V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.

\*V<sub>H</sub> = V<sub>T+</sub> – V<sub>T–</sub>. (But maximum variation of V<sub>H</sub> is specified as less than V<sub>T+ max</sub> – V<sub>T– min</sub>).

# MC14584B

## SWITCHING CHARACTERISTICS (C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C)

Characteristic	Symbol	V <sub>DD</sub> Vdc	Min	Typ #	Max	Unit
Output Rise Time	t <sub>TLH</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Output Fall Time	t <sub>THL</sub>	5.0	—	100	200	ns
		10	—	50	100	
		15	—	40	80	
Propagation Delay Time	t <sub>PLH</sub> , t <sub>PHL</sub>	5.0	—	125	250	ns
		10	—	50	100	
		15	—	40	80	

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – SWITCHING TIME TEST CIRCUIT AND WAVEFORMS

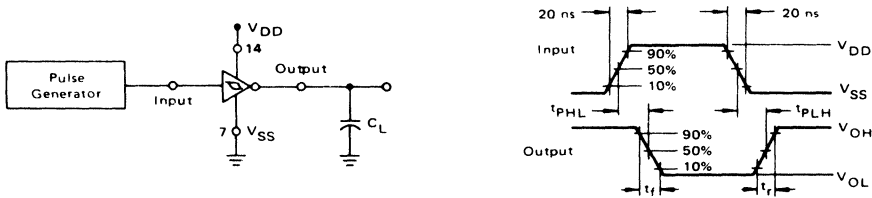


FIGURE 2 – TYPICAL SCHMITT TRIGGER APPLICATIONS

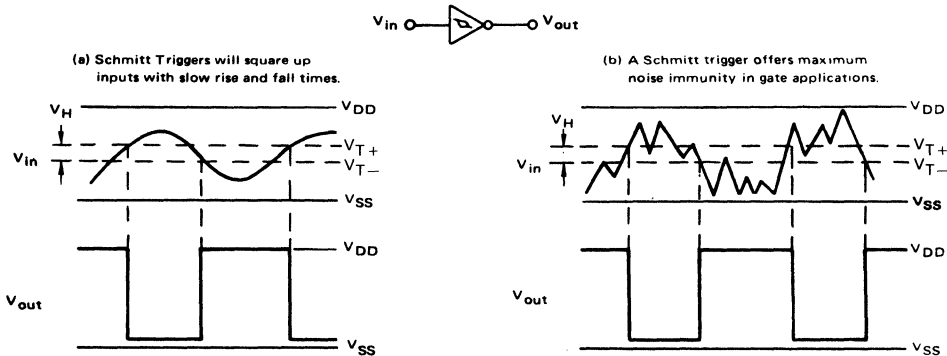
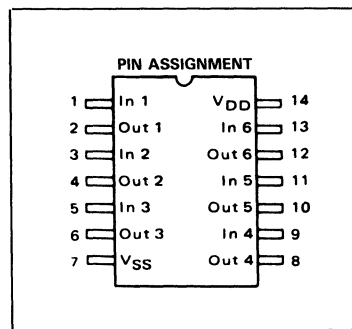
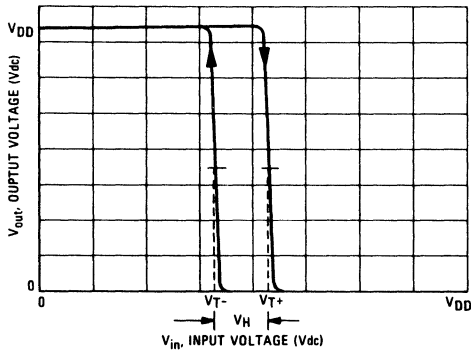


FIGURE 3 – TYPICAL TRANSFER CHARACTERISTICS





**MOTOROLA**

**MC14585B**

**4-BIT MAGNITUDE COMPARATOR**

The MC14585B 4-Bit Magnitude Comparator is constructed with complementary MOS (CMOS) enhancement mode devices. The circuit has eight comparing inputs (A3, B3, A2, B2, A1, B1, A0, B0), three cascading inputs (A < B, A = B, and A > B), and three outputs (A < B, A = B, and A > B). This device compares two 4-bit words (A and B) and determines whether they are "less than", "equal to", or "greater than" by a high level on the appropriate output. For words greater than 4-bits, units can be cascaded by connecting outputs (A > B), (A < B), and (A = B) to the corresponding inputs of the next significant comparator. Inputs (A < B), (A = B), and (A > B) on the least significant (first) comparator are connected to a low, a high, and a low, respectively.

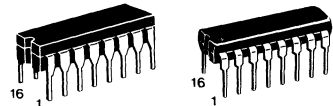
Applications include logic in CPU's, correction and/or detection of instrumentation conditions, comparator in testers, converters, and controls.

- Diode Protection on All Inputs
- Expandable
- Applicable to Binary or 8421-BCD Code
- Supply Voltage Range = 3.0 Vdc to 18 Vdc
- Capable of Driving Two Low-power TTL Loads or One Low-power Schottky TTL Load over the Rated Temperature Range
- Can be Cascaded - See Fig. 3

**CMOS MSI**

(LOW POWER COMPLEMENTARY MOS)

**4-BIT MAGNITUDE COMPARATOR**



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620

**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648

**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)

C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

**MAXIMUM RATINGS\*** (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub> , V <sub>out</sub>	Input or Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> + 0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

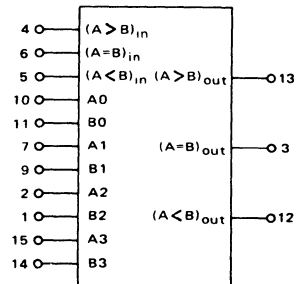
Ceramic "L" Package: -12mW/°C from 100°C to 125°C

**TRUTH TABLE**

COMPARING INPUTS				CASCADING			OUTPUTS		
A3, B3	A2, B2	A1, B1	A0, B0	A < B	A = B	A > B	A < B	A = B	A > B
A3 > B3	x	x	x	x	x	x	0	0	1
A3 = B3	A2 > B2	x	x	x	x	x	0	0	1
A3 = B3	A2 = B2	A1 > B1	x	x	x	x	0	0	1
A3 = B3	A2 = B2	A1 = B1	A0 > B0	x	x	x	0	0	1
A3 = B3	A2 = B2	A1 = B1	A0 = B0	0	0	x	0	0	1
A3 = B3	A2 = B2	A1 = B1	A0 = B0	0	1	x	0	1	0
A3 = B3	A2 = B2	A1 = B1	A0 = B0	1	0	x	1	0	0
A3 = B3	A2 = B2	A1 = B1	A0 = B0	1	1	x	1	1	0
A3 = B3	A2 = B2	A1 = B1	A0 < B0	x	x	x	1	0	0
A3 = B3	A2 = B2	A1 < B1	x	x	x	x	1	0	0
A3 = B3	A2 < B2	x	x	x	x	x	1	0	0
A3 < B3	x	x	x	x	x	x	1	0	0

x = Don't Care

**BLOCK DIAGRAM**



V<sub>DD</sub> = Pin 16  
V<sub>SS</sub> = Pin 8

**6**

# MC14585B

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit
			Min	Max	Min	Typ #	Max	Min	Max	
Output Voltage V <sub>in</sub> = V <sub>DD</sub> or 0  V <sub>in</sub> = 0 or V <sub>DD</sub>	"0" Level VOL	5.0	—	0.05	—	0	0.05	—	0.05	Vdc
		10	—	0.05	—	0	0.05	—	0.05	
		15	—	0.05	—	0	0.05	—	0.05	
	"1" Level VOH	5.0	4.95	—	4.95	5.0	—	4.95	—	Vdc
		10	9.95	—	9.95	10	—	9.95	—	
		15	14.95	—	14.95	15	—	14.95	—	
Input Voltage (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)  (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	"0" Level V <sub>IL</sub>	5.0	—	1.5	—	2.25	1.5	—	1.5	Vdc
		10	—	3.0	—	4.50	3.0	—	3.0	
		15	—	4.0	—	6.75	4.0	—	4.0	
	"1" Level V <sub>IH</sub>	5.0	3.5	—	3.5	2.75	—	3.5	—	Vdc
		10	7.0	—	7.0	5.50	—	7.0	—	
		15	11.0	—	11.0	8.25	—	11.0	—	
Output Drive Current (AL Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-3.0	—	-2.4	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.64	—	-0.51	-0.88	—	-0.36	—	
		10	-1.6	—	-1.3	-2.25	—	-0.9	—	
		15	-4.2	—	-3.4	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.64	—	0.51	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.6	—	1.3	2.25	—	0.9	—	
15		4.2	—	3.4	8.8	—	2.4	—		
Output Drive Current (CL/CP Device) (V <sub>OH</sub> = 2.5 Vdc) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)  (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	Source I <sub>OH</sub>	5.0	-2.5	—	-2.1	-4.2	—	-1.7	—	mA <sub>dc</sub>
		5.0	-0.52	—	-0.44	-0.88	—	-0.36	—	
		10	-1.3	—	-1.1	-2.25	—	-0.9	—	
		15	-3.6	—	-3.0	-8.8	—	-2.4	—	
	Sink I <sub>OL</sub>	5.0	0.52	—	0.44	0.88	—	0.36	—	mA <sub>dc</sub>
		10	1.3	—	1.1	2.25	—	0.9	—	
15		3.6	—	3.0	8.8	—	2.4	—		
Input Current (AL Device)	I <sub>in</sub>	15	—	±0.1	—	±0.0001	±0.1	—	±1.0	μA <sub>dc</sub>
Input Current (CL/CP Device)	I <sub>in</sub>	15	—	±0.3	—	±0.0001	±0.3	—	±1.0	μA <sub>dc</sub>
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	—	—	—	—	5.0	7.5	—	—	pF
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	—	5.0	—	0.005	5.0	—	150	μA <sub>dc</sub>
		10	—	10	—	0.010	10	—	300	
		15	—	20	—	0.015	20	—	600	
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	—	20	—	0.005	20	—	150	μA <sub>dc</sub>
		10	—	40	—	0.010	40	—	300	
		15	—	80	—	0.015	80	—	600	
Total Supply Current**† (Dynamic plus Quiescent, Per Package) (C <sub>L</sub> = 50 pF on all outputs, all buffers switching)	I <sub>T</sub>	5.0	I <sub>T</sub> = (0.6 μA/kHz) f + I <sub>DD</sub>							μA <sub>dc</sub>
		10	I <sub>T</sub> = (1.2 μA/kHz) f + I <sub>DD</sub>							
		15	I <sub>T</sub> = (1.8 μA/kHz) f + I <sub>DD</sub>							

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.  
T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

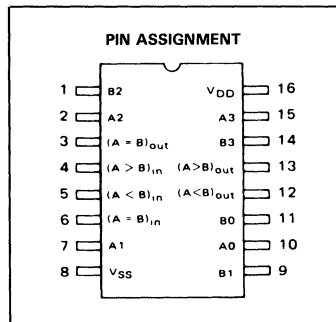
#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

\*\*The formulas given are for the typical characteristics only at 25°C.

†To calculate total supply current at loads other than 50 pF:

$$I_T(C_L) = I_T(50 \text{ pF}) + (C_L - 50) V f k$$

where: I<sub>T</sub> is in μA (per package), C<sub>L</sub> in pF, V = (V<sub>DD</sub> - V<sub>SS</sub>) in volts, f in kHz is input frequency, and k = 0.001.



6

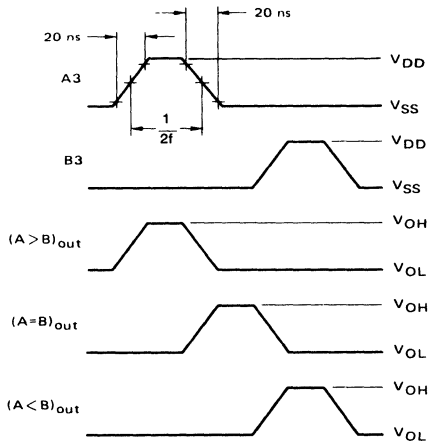
# MC14585B

## SWITCHING CHARACTERISTICS\* ( $C_L = 50 \text{ pF}$ , $T_A = 25^\circ\text{C}$ )

Characteristic	Symbol	V <sub>DD</sub>	Min	Typ #	Max	Unit
<b>Output Rise and Fall Time</b>						
$t_{TLH}, t_{THL} = (1.5 \text{ ns/pF}) C_L + 25 \text{ ns}$	$t_{TLH}, t_{THL}$	5.0	—	100	200	ns
$t_{TLH}, t_{THL} = (0.75 \text{ ns/pF}) C_L + 12.5 \text{ ns}$		10	—	50	100	
$t_{TLH}, t_{THL} = (0.55 \text{ ns/pF}) C_L + 9.5 \text{ ns}$		15	—	40	80	
<b>Turn-On, Turn-Off Delay Time</b>						
$t_{PLH}, t_{PHL} = (1.7 \text{ ns/pF}) C_L + 345 \text{ ns}$	$t_{PLH}, t_{PHL}$	5.0	—	430	860	ns
$t_{PLH}, t_{PHL} = (0.66 \text{ ns/pF}) C_L + 147 \text{ ns}$		10	—	180	360	
$t_{PLH}, t_{PHL} = (0.5 \text{ ns/pF}) C_L + 105 \text{ ns}$		15	—	130	260	

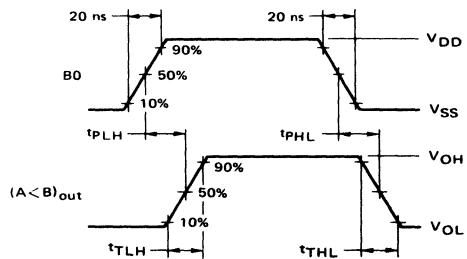
\*The formulas given are for the typical characteristics only at 25°C.  
 #Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

FIGURE 1 – DYNAMIC POWER DISSIPATION SIGNAL WAVEFORMS



Inputs (A > B) and (A = B) high, and inputs B2, A2, B1, A1, B0, A0 and (A < B) low.  
 f in respect to a system clock.

FIGURE 2 – DYNAMIC SIGNAL WAVEFORMS



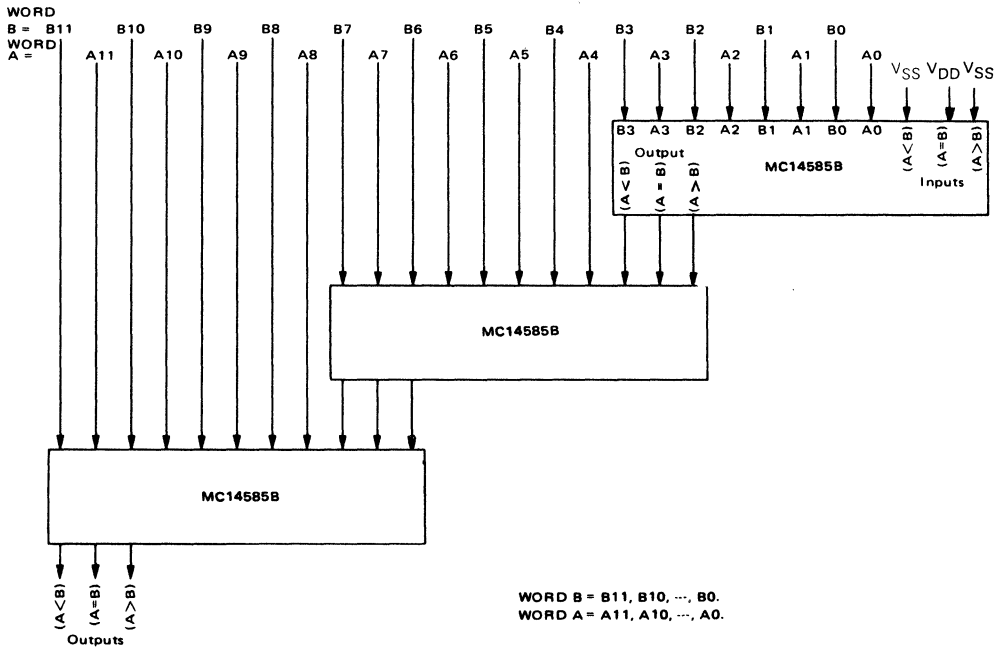
Inputs (A > B) and (A = B) high, and inputs B3, A3, B2, A2, B1, A1, A0, and (A < B) low.

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation,  $V_{in}$  and  $V_{out}$  should be constrained to the range  $V_{SS} \leq (V_{in} \text{ or } V_{out}) \leq V_{DD}$ . Unused inputs must always be tied to an appropriate logic voltage level (e.g., either  $V_{SS}$  or  $V_{DD}$ ). Unused outputs must be left open.

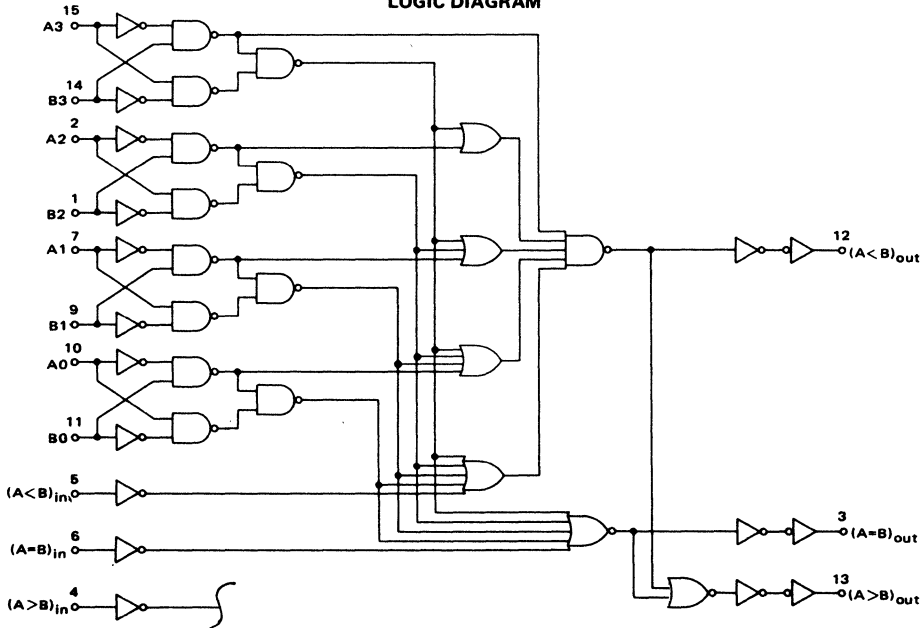


# MC14585B

FIGURE 3 - CASCADING COMPARATORS



## LOGIC DIAGRAM



6



**MOTOROLA**

**MC14599**  
See Page 6-170

**MC14597B**  
**MC14598B**

**8-BIT BUS-COMPATIBLE LATCHES**

The MC14597B and MC14598B are 8-bit latches, one addressed with an internal counter and the other addressed with an external binary address. The 8 latch-outputs are high drive, three-state and bus line compatible. The drive capability allows direct applications with MPU systems such as the Motorola 6800 family.

With MC14597B, a 3-bit address counter (clocked on the falling edge of Increment) selects the appropriate latch. The latches of the MC14598B are accessed via the Address pins, A0, A1, and A2. A Full Flag is provided on the MC14597B to indicate the position of the Address counter.

All 8 outputs from the latches are available in parallel when Enable is in the low state. Data is entered into a selected latch from the Data pin when the Strobe is high. Master reset is available on both parts.

- Serial Data Input
- Three-State Bus Compatible Parallel Outputs
- Three-State Control Pin (Enable) TTL Compatible Input
- Open Drain Full Flag (Multiple Latch Wire-O Ring)
- Master Reset
- Level Shifting Inputs on All Except Enable
- Diode Protection — All Inputs
- Supply Voltage Range — 3.0 Vdc to 18 Vdc
- Capable of Driving TTL Over Rated Temperature Range

With Fanout as Follows:

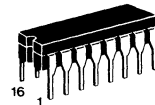
- 1 TTL Load
- 4 LSTTL Loads

**CMOS MSI**

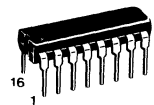
(LOW-POWER COMPLEMENTARY MOS)

**8-BIT, BUS-COMPATIBLE  
THREE-STATE LATCHES**

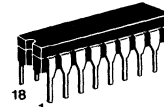
Internal Counter — MC14597B  
Binary Address — MC14598B



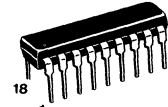
**L SUFFIX**  
CERAMIC PACKAGE  
CASE 620



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 648



**L SUFFIX**  
CERAMIC PACKAGE  
CASE 726

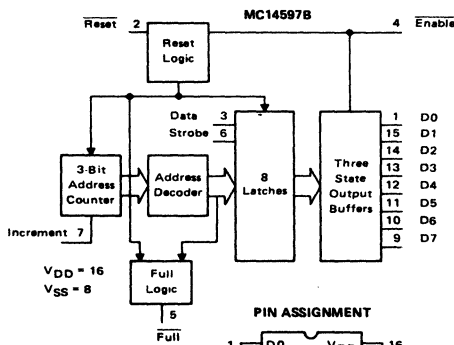


**P SUFFIX**  
PLASTIC PACKAGE  
CASE 707

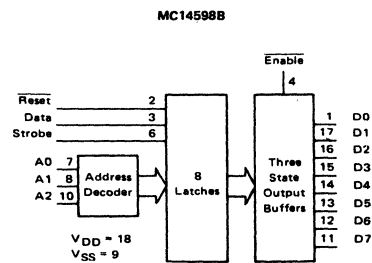
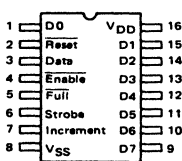
**ORDERING INFORMATION**

A Series: -55°C to +125°C  
MC14XXXBAL (Ceramic Package Only)  
C Series: -40°C to +85°C  
MC14XXXBCP (Plastic Package)  
MC14XXXBCL (Ceramic Package)

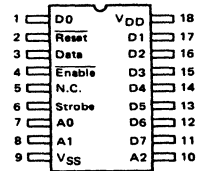
**BLOCK DIAGRAMS**



**PIN ASSIGNMENT**



**PIN ASSIGNMENT**



**OUTPUT TRUTH TABLE**

Enable	Outputs
1	High Impedance
0	D <sub>n</sub>

D<sub>n</sub> = State of nth latch

NC = No Connection

**6**

# MC14597B•MC14598B

## MAXIMUM RATINGS\* (Voltages Referenced to V<sub>SS</sub>)

Symbol	Parameter	Value	Unit
V <sub>DD</sub>	DC Supply Voltage	-0.5 to +18.0	V
V <sub>in</sub>	Input Voltage, Enable (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
V <sub>in</sub>	Input Voltage, All other Inputs (DC or Transient)	-0.5 to V <sub>DD</sub> +12	V
V <sub>out</sub>	Output Voltage (DC or Transient)	-0.5 to V <sub>DD</sub> +0.5	V
I <sub>in</sub> , I <sub>out</sub>	Input or Output Current (DC or Transient), per Pin	±10	mA
P <sub>D</sub>	Power Dissipation, per Package†	500	mW
T <sub>stg</sub>	Storage Temperature	-65 to +150	°C
T <sub>L</sub>	Lead Temperature (8-Second Soldering)	260	°C

This device contains protection circuitry to guard against damage due to high static voltages or electric fields. However, precautions must be taken to avoid applications of any voltage higher than maximum rated voltages to this high-impedance circuit. For proper operation, V<sub>in</sub> and V<sub>out</sub> should be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>). Unused outputs must be left open.

\*Maximum Ratings are those values beyond which damage to the device may occur.

†Temperature Derating: Plastic "P" Package: -12mW/°C from 65°C to 85°C

Ceramic "L" Package: -12mW/°C from 100°C to 125°C

## ELECTRICAL CHARACTERISTICS (Voltages Referenced to V<sub>SS</sub>)

Characteristic	Symbol	V <sub>DD</sub> Vdc	T <sub>low</sub> *		25°C			T <sub>high</sub> *		Unit	
			Min	Max	Min	Typ #	Max	Min	Max		
Output Voltage "0" Level V <sub>in</sub> = V <sub>DD</sub> or 0	V <sub>OL</sub>	5.0	-	0.05	-	0	0.05	-	0.05	Vdc	
		10	-	0.05	-	0	0.05	-	0.05		
		15	-	0.05	-	0	0.05	-	0.05		
	"1" Level V <sub>in</sub> = 0 or V <sub>DD</sub>	V <sub>OH</sub>	5.0	4.95	-	4.95	5.0	-	4.95	-	Vdc
			10	9.95	-	9.95	10	-	9.95	-	
			15	14.95	-	14.95	15	-	14.95	-	
Input Voltage** — Enable "0" Level (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	-	0.8	-	1.1	0.8	-	0.8	Vdc	
		10	-	1.6	-	2.2	1.6	-	1.6		
		15	-	2.4	-	3.4	2.4	-	2.4		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	2.0	-	2.0	1.9	-	2.0	-	Vdc
			10	6.0	-	6.0	3.1	-	6.0	-	
			15	10	-	10	4.3	-	10	-	
Input Voltage "0" Level Other Inputs (V <sub>O</sub> = 4.5 or 0.5 Vdc) (V <sub>O</sub> = 9.0 or 1.0 Vdc) (V <sub>O</sub> = 13.5 or 1.5 Vdc)	V <sub>IL</sub>	5.0	-	1.5	-	2.25	1.5	-	1.5	Vdc	
		10	-	3.0	-	4.50	3.0	-	3.0		
		15	-	4.0	-	6.75	4.0	-	4.0		
	"1" Level (V <sub>O</sub> = 0.5 or 4.5 Vdc) (V <sub>O</sub> = 1.0 or 9.0 Vdc) (V <sub>O</sub> = 1.5 or 13.5 Vdc)	V <sub>IH</sub>	5.0	3.5	-	3.5	2.75	-	3.5	-	Vdc
			10	7.0	-	7.0	5.50	-	7.0	-	
			15	11	-	11	8.25	-	11	-	
Output Drive Current Source (Full-Sink Only) (V <sub>OH</sub> = 4.6 Vdc) (V <sub>OH</sub> = 9.5 Vdc) (V <sub>OH</sub> = 13.5 Vdc)	I <sub>OH</sub>	5.0	-1.0	-	-1.0	-2.0	-	-1.0	-	mA <sub>dc</sub>	
		10	-	-	-	-6.0	-	-	-		
		15	-	-	-	-12	-	-	-		
	Sink (V <sub>OL</sub> = 0.4 Vdc) (V <sub>OL</sub> = 0.5 Vdc) (V <sub>OL</sub> = 1.5 Vdc)	I <sub>OL</sub>	5.0	1.6	-	1.6	3.2	-	1.6	-	mA <sub>dc</sub>
			10	-	-	-	6.0	-	-	-	
			15	-	-	-	12	-	-	-	
Input Current (AL Device)	I <sub>in</sub>	15	-	±0.1	-	±0.00001	±0.1	-	±1.0	μA <sub>dc</sub>	
Input Current (CL/CP Device)	I <sub>in</sub>	15	-	±0.3	-	±0.00001	±0.3	-	±1.0	μA <sub>dc</sub>	
Three-State Leakage Current (AL Device)	I <sub>TL</sub>	15	-	±0.1	-	±0.00001	±0.1	-	±3.0	μA <sub>dc</sub>	
		15	-	±1.0	-	±0.00001	±1.0	-	±7.5		
Input Capacitance (V <sub>in</sub> = 0)	C <sub>in</sub>	-	-	-	-	5.0	7.5	-	-	pF	
Quiescent Current (AL Device) (Per Package)	I <sub>DD</sub>	5.0	-	5.0	-	0.005	5.0	-	150	μA <sub>dc</sub>	
		10	-	10	-	0.010	10	-	300		
		15	-	20	-	0.015	20	-	600		
Quiescent Current (CL/CP Device) (Per Package)	I <sub>DD</sub>	5.0	-	20	-	0.005	20	-	150	μA <sub>dc</sub>	
		10	-	40	-	0.010	40	-	300		
		15	-	80	-	0.015	80	-	600		
**Total Supply Current at an External Load Capacitance of 130 pF	I <sub>T</sub>	5.0	I <sub>T</sub> = (2.0 μA/kHz)f + I <sub>DD</sub>							μA <sub>dc</sub>	
		10	I <sub>T</sub> = (4.0 μA/kHz)f + I <sub>DD</sub>								
		15	I <sub>T</sub> = (6.0 μA/kHz)f + I <sub>DD</sub>								

\*T<sub>low</sub> = -55°C for AL Device, -40°C for CL/CP Device.

\*T<sub>high</sub> = +125°C for AL Device, +85°C for CL/CP Device.

\*\* The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

# MC14597B•MC14598B

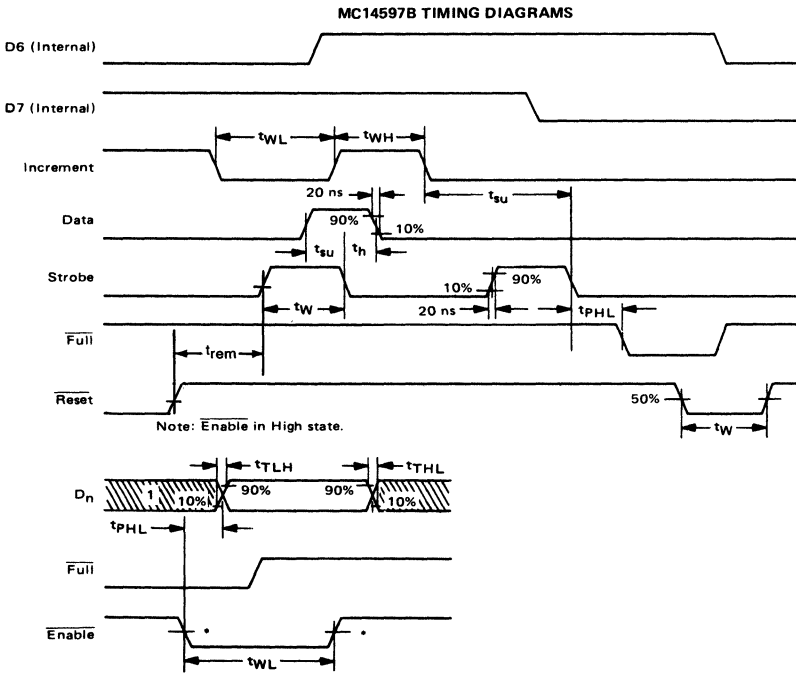
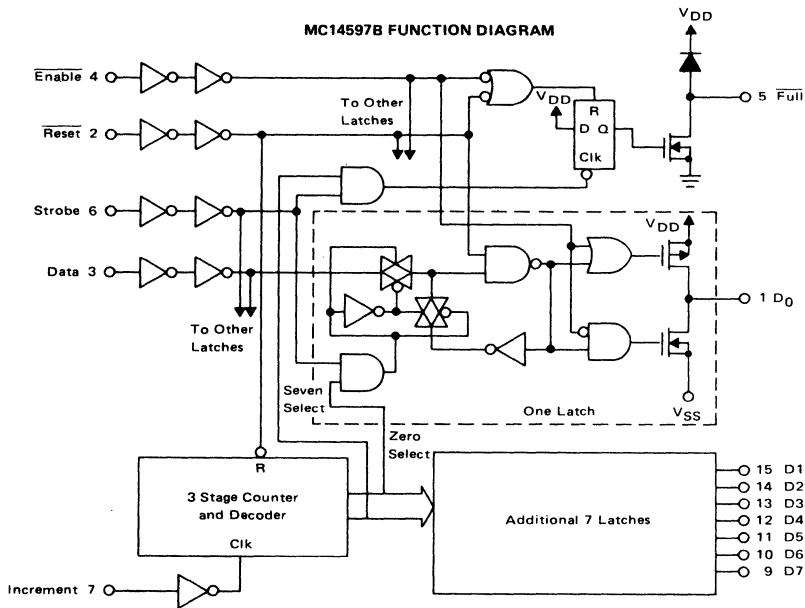
SWITCHING CHARACTERISTICS\* ( $T_A = 25^\circ\text{C}$ ,  $C_L = 130\text{ pF} + 1\text{ TTL Load}$ )

Characteristic	Symbol	V <sub>DD</sub> Vdc	All Types			Unit			
			Min	Typ #	Max				
Output Rise and Fall Time $t_{TLH}, t_{THL} = (0.5\text{ ns/pF})C_L + 35\text{ ns}$ $t_{TLH}, t_{THL} = (0.2\text{ ns/pF})C_L + 25\text{ ns}$ $t_{TLH}, t_{THL} = (0.16\text{ ns/pF})C_L + 20\text{ ns}$	$t_{TLH},$ $t_{THL}$	5.0	—	100	200	ns			
		10	—	50	100				
		15	—	40	80				
Propagation Delay Time Enable to Output  Strobe to Output  Strobe to $\overline{\text{Full}}$ (MC14597B only)  $\overline{\text{Reset}}$ to Output	$t_{PLH},$ $t_{PHL}$	5.0	—	160	320	ns			
		10	—	125	250				
		15	—	100	200				
		5.0	—	200	400				
		10	—	100	200				
		15	—	80	160				
		5.0	—	200	400				
		10	—	100	200				
		15	—	80	160				
		5.0	—	175	350				
		10	—	90	180				
		15	—	70	140				
Pulse Width Enable  Strobe  Increment (MC14597B only)  $\overline{\text{Reset}}$	$t_{WH},$ $t_{WL}$	5.0	320	160	—	ns			
		10	240	120	—				
		15	160	80	—				
		5.0	200	100	—				
		10	100	50	—				
		15	80	40	—				
		5.0	200	100	—				
		10	100	50	—				
		15	80	40	—				
		5.0	300	150	—				
		10	160	80	—				
		15	100	50	—				
Setup Time Data  Address (MC14598B only).  Increment (MC14597B only)	$t_{su}$	5.0	100	50	—	ns			
		10	50	25	—				
		15	35	20	—				
		5.0	200	100	—				
		10	100	50	—				
		15	70	35	—				
		5.0	400	200	—				
		10	200	100	—				
		15	170	85	—				
		Hold Time Data  Address (MC14598B only)	$t_h$	5.0	100		50	—	ns
				10	50		25	—	
				15	35		20	—	
5.0	100			50	—				
10	50			25	—				
15	35			20	—				
Reset Removal Time	$t_{rem}$	5.0	20	-25	—	ns			
		10	20	-15	—				
		15	20	-10	—				

\*The formulas given are for the typical characteristics only at 25°C.

#Data labelled "Typ" is not to be used for design purposes but is intended as an indication of the IC's potential performance.

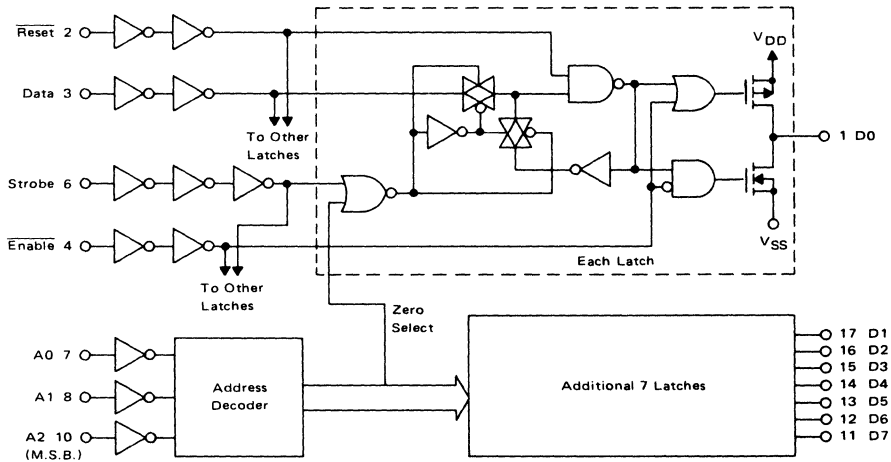
# MC14597B•MC14598B



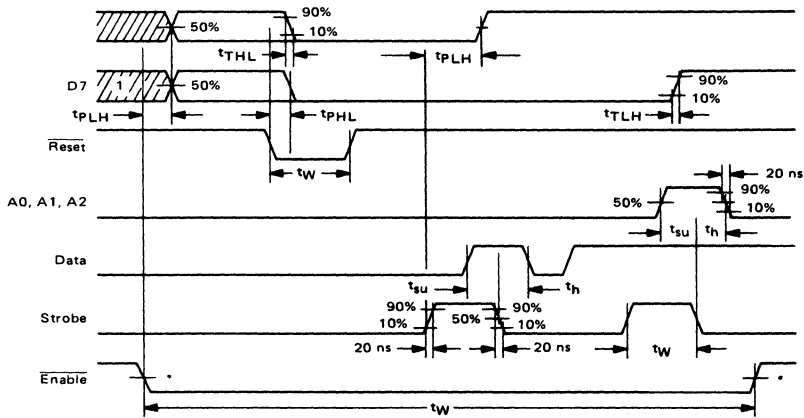
- NOTES: 1. High-impedance output state (another device controls bus).  
2. Reset in High state.

# MC14597B•MC14598B

MC14598B FUNCTION DIAGRAM



MC14598B TIMING DIAGRAM



\* 1.4 V with  $V_{DD} = 5.0$  V.  
 NOTES 1. High-impedance output state (another device controls bus).  
 2. Output Load as for MC14597B.

# MC14597B•MC14598B

LATCH TRUTH TABLE

Strobe	$\overline{\text{Reset}}$	Addressed Latch	Other Latches
0	1	*	*
1	1	Data	*
X	0	0	0

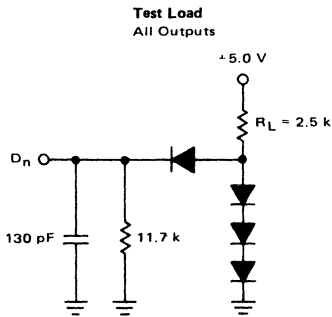
\* = No change in state of latch

X = Don't care

TRUTH TABLE FOR MC14597B

Increment	$\overline{\text{Enable}}$	$\overline{\text{Reset}}$	Address Counter	$\overline{\text{Full}}$
	X	1	Count Up	—
	X	1	No Change	—
X	1	0	Reset to Zero	Set to One
X	0	1	No Change	Set to One
X	1	1	If at ADDRESS 7	To Zero on Falling Edge of STROBE

X = Don't care



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Circuit diagrams external to or containing Motorola products are included as a means of illustration only. Complete information sufficient for construction purposes may not be fully illustrated. Although the information herein has been carefully checked and is believed to be reliable, Motorola assumes no responsibility for inaccuracies. Information herein does not convey to the purchaser

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# CMOS Reliability

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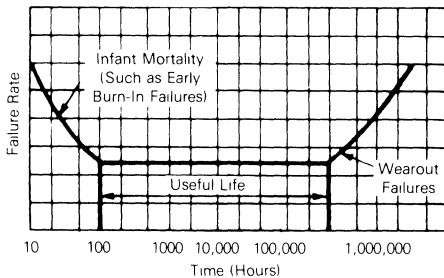
## RELIABILITY

Paramount in the mind of every semiconductor user is the question of device performance versus time. After the applicability of a particular device has been established, its effectiveness depends on the length of troublefree service it can offer. The reliability of a device is exactly that — an expression of how well it will serve the customer. The following discussion will attempt to present an overview of Motorola's reliability efforts.

## BASIC CONCEPTS

It is essential to begin with an explanation of the various parameters of Reliability. These are probably summarized best in the Bathtub Curve (Figure 1). The reliability performance of a device is characterized by three phases: infant mortality, useful life, and wearout. When a device is produced, there is often a small distribution of failure mechanisms which will exhibit themselves under relatively moderate stress levels and therefore appear early. This period of early failures, termed infant mortality is reduced significantly through proper manufacturing controls and screening techniques. The most effective period is that in which only occasional random failure mechanisms appear. The useful life typically spans a long period of time with a very low failure rate. The final period is that in which the devices literally wear out due to continuous phenomena which existed at the time of manufacture. Using strictly controlled design techniques and selectivity in applications, this period is shifted well beyond the lifetime required by the user.

FIGURE 1



Both the infant mortality and random failure rate regions can be described through the same types of calculations. During this time the probability of having no failures to a specific point in time can be expressed by the equation:

$$P_0 = e^{-\lambda t}$$

where  $\lambda$  is the failure rate and  $t$  is time. Since  $\lambda$  is changing rapidly during infant mortality, the expression does not become useful until the random period, where  $\lambda$  is relatively constant. In this equation  $\lambda$  is failures per unit of time. It is usually expressed in percent failures per thousand hours. Other forms include FIT (Failures in Time =  $(\%/10^3 \text{ hrs}) \times 10^{-4} = 10^{-9}$  failures per hour) and MTTF (Mean Time To Failure) or MTBF (Mean Time Between Failures), both being equal to  $1/\lambda$  and having units of hours.

Since reliability evaluations usually involve only samples of an entire population of devices, the concepts of the Central Limit Theorem apply and  $\lambda$  is calculated using  $\chi^2$  distribution through the equation:

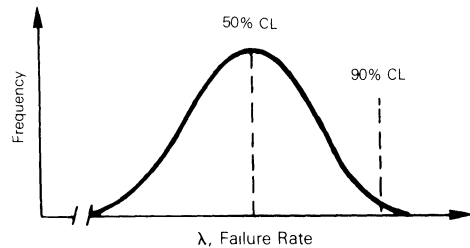
$$\lambda \leq \frac{\chi^2(x, 2r + 2)}{2nt}$$

where  $x = \frac{100 - CL}{100}$

- CL = Confidence Limit in percent
- r = Number of rejects
- n = Number of devices
- t = Duration of test

The confidence limit is the degree of conservatism desired in the calculation. The Central Limit Theorem states that the values of any sample of units out of a large population will produce a normal distribution. A 50% confidence limit is termed the best estimate and is the mean of this distribution. A 90% confidence limit is a very conservative value and results in a higher  $\lambda$  which represents the point at which 90% of the area of the distribution is to the left of that value (Figure 2). The term  $(2r + 2)$  is called the degrees of freedom and is an expression of the number of rejects in a form suitable to  $\chi^2$  tables.

FIGURE 2



The number of rejects is a critical factor since the definition of rejects often differs between manufacturers. While Motorola uses data sheet limits to determine failures, sometimes rejects are counted only if they are catastrophic. Due to the increasing chance of a test not being representative of the entire population, as sample size and test time are decreased, the  $\chi^2$  calculation produces surprisingly high values of  $\lambda$  for short test durations even though the true long term failure rate may be quite low. For this reason relatively large amounts of data must be gathered to demonstrate the real long term failure rate.

Since this would require years of testing on thousands of devices, methods of accelerated testing have been developed.

Years of semiconductor device testing has shown that temperature will accelerate failures and that this behavior fits the form of the Arrhenius equation:

$$R(t) = R_0(t)e^{-\Theta/kT}$$

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where  $R(t)$  = Reaction rate as a function of time and temperature

- $R_0$  = A constant
- $t$  = Time
- $\Theta$  = Activation energy in electron volts
- $k$  = Boltzman's constant
- $T$  = Temperature in degrees Kelvin

To provide time-temperature equivalents this equation is applied to failure rate calculations in the form:

$$t = t_0 e^{\Theta/kT}$$

where  $t$  = time

$t_0$  = A constant

The Arrhenius equation essentially states that reaction rate increases exponentially with temperature. This produces a straight line when plotted in log-linear paper with a slope expressed by  $\Theta$ .  $\Theta$  may be physically interpreted as the energy threshold of a particular reaction or failure mechanism. The activation energy exhibited by semiconductors varies from about 0.3 eV. Although the relationships do not prohibit devices from having poor failure rates and high activation energies, good performance usually does not imply a high  $\Theta$ . Studies by Bell Telephone Laboratories have indicated that an overall  $\Theta$  for semiconductors is 1.0 eV. This value has been accepted by the Rome Air Development Command for time-temperature acceleration in powered burn-in. Data taken by Motorola on Integrated Circuits have verified this number and it is therefore applied as our standard time-temperature regression for extrapolation of high temperature failure rates to temperatures at which the devices will be used (Figure 3). For Discrete products, 0.7 eV is generally applied.

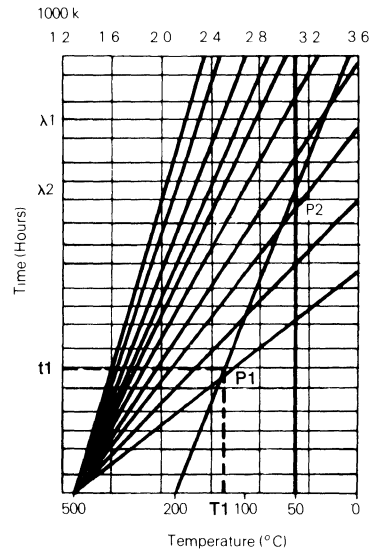
To accomplish this, the time in device hours ( $t_1$ ) and temperature ( $T_1$ ) of the test are plotted as point P1. A vertical line is drawn at the temperature of interest ( $T_2$ ) and a line with a 1.0 eV slope is drawn through point P1.

Its intersection with the vertical line defines point P2, and determines the number of equivalent device hours ( $t_2$ ). This number may then be used with the  $x^2$  formula to determine the failure rate at the temperature of interest. Assuming  $T_1$  of 125°C at  $t_1$  of 10,000 hours, a  $t_2$  of 7.8 million hours results at a  $T_2$  of 50°C. If one reject results in the 10,000 device hours of testing at 125°C, the failure rate at that temperature will be 20%/1,000 hours using a 60% confidence level. One reject at the equivalent 7.8 million device hours at 50°C will result in a 0.026%/1,000 hour failure rate, as illustrated in Figure 4.

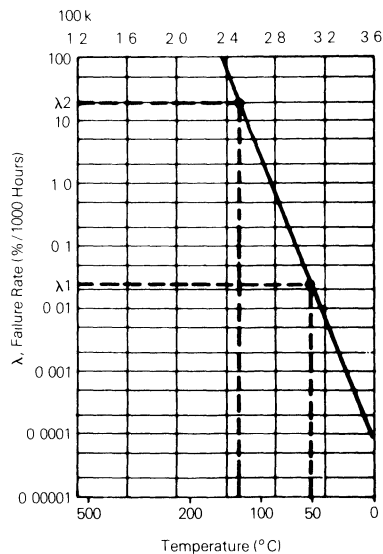
Three parameters determine the failure rate quoted by the manufacturer: the failure rate at the test temperature, the activation energy employed, and the difference between the test temperature and the temperature of the quoted  $\lambda$ . A term often used in this manipulation is the "acceleration factor" which is simply the equivalent device hours at the lower temperature divided by the actual test device hours.

Every device will eventually fail, but with the present techniques in Semiconductor design and applications, the wearout phase is extended far beyond the lifetime required. During wearout, as in infant mortality, the failure rate is changing rapidly and therefore loses its value. The parameter used to describe performance in this area is "Median Life" and is the point at which 50% of the devices have failed. There are currently only few significant wearout mechanisms: electromigration of circuit metallization, electrolytic corrosion in plastic devices and metal fatigue for Power devices.

**FIGURE 3  
NORMALIZED TIME-TEMPERATURE  
REGRESSIONS FOR VARIOUS ACTIVATION  
ENERGY VALUES**



**FIGURE 4  
FAILURE RATE**



For increased flexibility in working with a broad range of device hours, the time-temperature regression lines have been normalized to 500°C and the time scale omitted, permitting the user to define the scale based on his own requirements.

## “RAP” RELIABILITY AUDIT PROGRAM FOR LOGIC INTEGRATED CIRCUITS

### INTRODUCTION

In January, 1977, Motorola Bipolar Digital Reliability Engineering implemented “RAP” (Rapid Reliability Assessment Program) to provide rapid assessment of the reliability of newly introduced TTL Low-Power Schottky (LS) devices. This RAP concept permits rapid feedback of information on any reliability problems to the Product Engineering group so that corrective action can be quickly implemented. The RAP program is performed by the Reliability Engineering Department on samples submitted by Product, Process, or Package Engineering for obtaining a rapid look at the reliability of new products, processes, or packages. This program has been extended to standard 74F (FAST), TTL, TTL Memories, MDTL, MHTL, MECL III, MECL 10K and 10KH, MECL Memories, Macrocell Arrays, Phase Lock Loop (PLL) and CMOS Logic product families.

### RELIABILITY AUDIT PROGRAM (RAP) (per Motorola specification 12MRM15301A)

**PTHB** — 15 psig/121°C/100% RH at rated  $V_{CC}$  for 16 hours — performed on a weekly basis. (To be performed on plastic encapsulated devices only.) Final readout at 48 hrs.

**Temp Cycling** — MIL-STD-833, Method 1010, 1000 cycles, Condition C, -65°C/+150°C. Interim readout at 100 cycles (plastic and hermetic packages). Sample pulled on weekly basis — final readout at 1000 cycles.

**Op. Life Test** — MIL-STD-883, Method 1005, Condition A (Reverse Bias) or C (Power plus Reverse Bias),  $T_A = 145^\circ\text{C}$ ; readouts at 40 hrs and 250 hrs (plastic and hermetic packages). Sample pulled on weekly basis.

**Report** — Monthly Reliability Engineering computer printout summarizing test results.

### NOTES:

1. All standard 25°C dc and functional parameters will be measured Go/No/Go at each readout.
2. Any indicated failure is first verified and then submitted to the Product Analysis Lab for detailed analysis.
3. Device types sampled will be by generic type within each digital I/C product family and will include all major package assembly options (U/S bond, TC bond, ball bond, T.A.B., etc.) and all assembly locations (Korea, Malaysia, etc.).
4. 16 hrs PTHB is equivalent to approximately 800 hrs of 85°C/85% RH THB for  $V_{CC} \leq 15\text{ V}$ .
5. Only moisture related failures (like corrosion) are criteria for failure on PTHB test.
6. 40 hr/145°C Op Life is equivalent to 160 hr/125°C using 1.0 eV in Arrhenius equation.
7. 250 hrs/145°C Op Life is equivalent to 1000 hrs/125°C using 1.0 eV in Arrhenius equation.
8. Special device specifications (48A's) for logic products will reference 12MRM15301A as source of generic data for any customer required monthly audit reports.

## Equivalent Gate Count

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## EQUIVALENT GATE COUNT

The following is a list of equivalent gate counts for some of Motorola's CMOS devices. In general for CMOS, the number of equivalent gates is equal to the total number of transistors on chip divided by four. This list includes only those devices with equivalent gate counts known at the time of this printing.

DEVICE	EQUIVALENT GATE COUNT	DEVICE	EQUIVALENT GATE COUNT
MC1400UB	3.5	MC14099B	70
MC14001B	8	MC14161B	72.5
MC14001UB	4	MC14163B	72.5
MC14002B	7	MC14174B	43.5
MC14002UB	4	MC14014B	74
MC14006B	61.5	MC14018B	38.25
MC14007UB	1.5	MC14021B	74
MC14008B	40	MC14067B	65
MC14011B	8	MC14097B	65
MC14011UB	4	MC14500B	206
MC14012B	7	MC14534B	192
MC14012UB	4	MC14175B	39.5
MC14013B	16	MC14490	136.5
MC14014B	74	MC14500B	192
MC14016B	8	MC14503B	17
MC14017B	62.5	MC14504B	37.5
MC14018B	38.25	MC14508B	42
MC14020B	84	MC14510B	74
MC14021B	74	MC14511B	54
MC14023B	9	MC14512B	17
MC14023UB	4.5	MC14514B	59
MC14024B	59	MC14515B	67
MC14025B	9	MC14516B	61
MC14025UB	4.5	MC14517B	119
MC14028B	26	MC14518B	43.5
MC14029B	65.5	MC14520B	43.5
MC14034B	145	MC14522B	86
MC14035B	38.5	MC14526B	86
MC14040B	73	MC14527B	46
MC14042B	17.5	MC14528B	24
MC14046B	35	MC14532B	38.5
MC14049UB	3	MC14534B	206
MC14050B	6	MC14536B	103
MC14051B	48.5	MC14538B	38
MC14052B	38.5	MC14539B	20
MC14053B	38	MC14541B	93
MC14066B	13	MC14543B	52
MC14067B	65	MC14549B	122
MC14068B	8	MC14551B	35
MC14069UB	3	MC14553B	147.5
MC14071B	10	MC14555B	21
MC14072B	8	MC14556B	25
MC14073B	10.5	MC14557B	232.5
MC14075B	10.5	MC14559B	122
MC14078B	7.5	MC14568B	137.25
MC14081B	10	MC14569B	156
MC14082B	8	MC14572UB	4
MC14093B	16	MC14573	7
MC14094B	79	MC14574	9
MC14097B	65	MC14575	11

# **Packaging Information Including Surface Mounts**

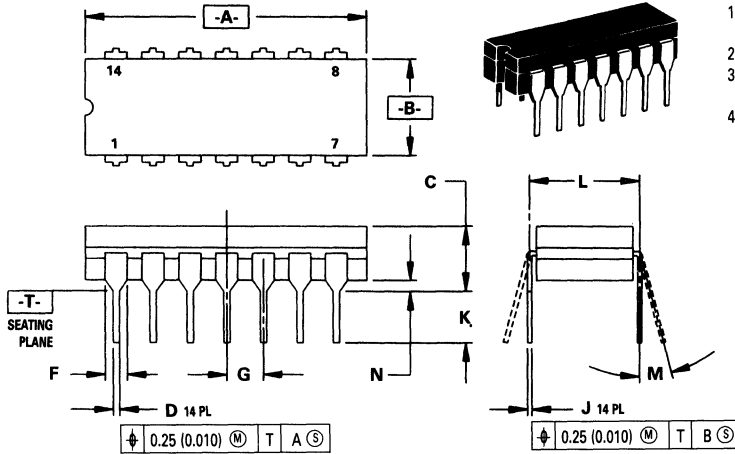
**9**

# PACKAGE DIMENSIONS

The standard package availability for each device is indicated on the front page of the individual data sheets. Dimensions for the packages are given in this chapter. Surface mount packages may be special ordered by specifying the following suffixes: "D" (narrow SOIC), "DW" (wide SOIC), or "FN" (PLCC). For example, to order a quad NOR gate, use MC14001BD.

## 14-PIN PACKAGE

### CERAMIC PACKAGE CASE 632-08

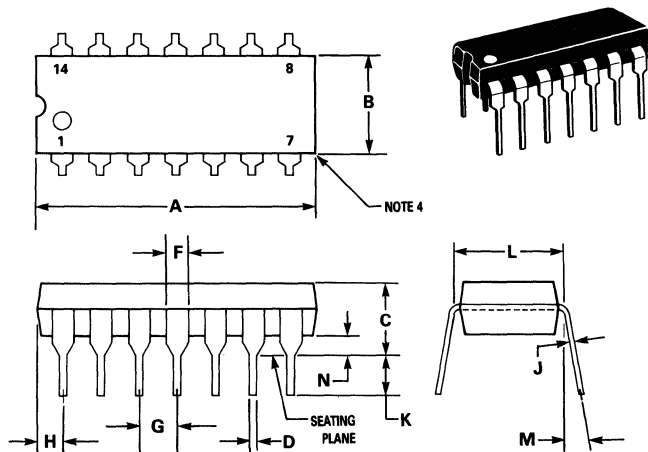


NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIM F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.05	19.94	0.750	0.785
B	6.23	7.11	0.245	0.280
C	3.94	5.08	0.155	0.200
D	0.39	0.50	0.015	0.020
F	1.40	1.65	0.055	0.065
G	2.54 BSC		0.100 BSC	
J	0.21	0.38	0.008	0.015
K	3.18	4.31	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.01	0.020	0.040

### PLASTIC PACKAGE CASE 646-06



NOTES:

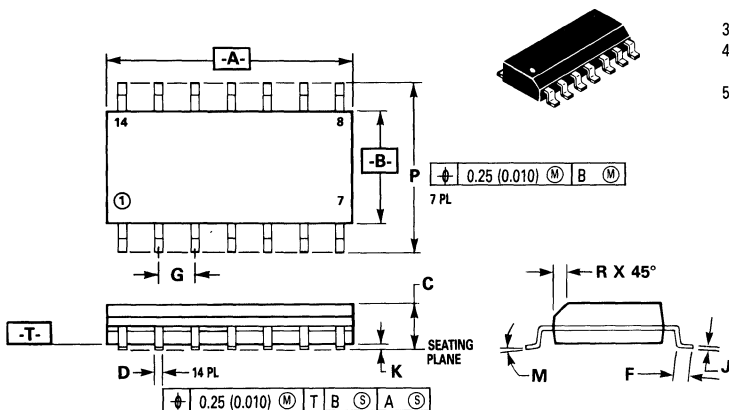
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.39	1.01	0.015	0.039

# PACKAGE DIMENSIONS (Continued)

## 14-PIN PACKAGE

### SOIC PACKAGE CASE 751A-02 D SUFFIX



**NOTES:**

1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

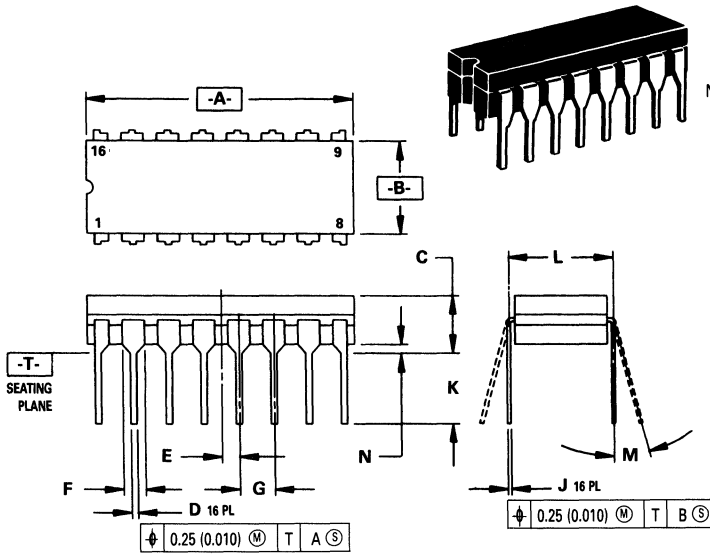
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0° - 7°		0° - 7°	
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019



# PACKAGE DIMENSIONS (Continued)

## 16-PIN PACKAGE

### CERAMIC PACKAGE CASE 620-09

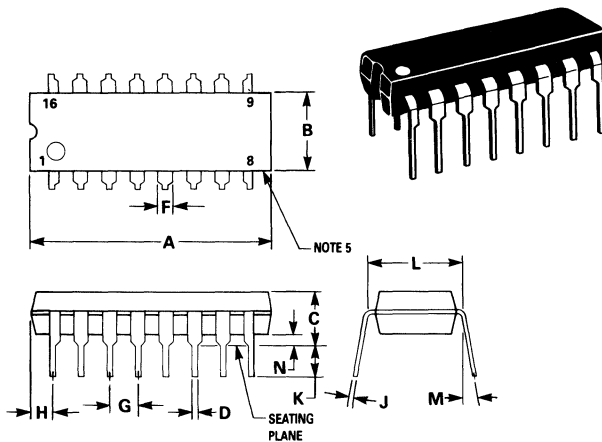


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
4. DIM F MAY NARROW TO 0.76 (0.030) WHERE THE LEAD ENTERS THE CERAMIC BODY.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.05	19.55	0.750	0.770
B	6.10	7.36	0.240	0.290
C	—	4.19	—	0.165
D	0.39	0.53	0.015	0.021
E	1.27 BSC		0.050 BSC	
F	1.40	1.77	0.055	0.070
G	2.54 BSC		0.100 BSC	
J	0.23	0.27	0.009	0.011
K	—	5.08	—	0.200
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.39	0.88	0.015	0.035

### PLASTIC PACKAGE CASE 648-06



**NOTES:**

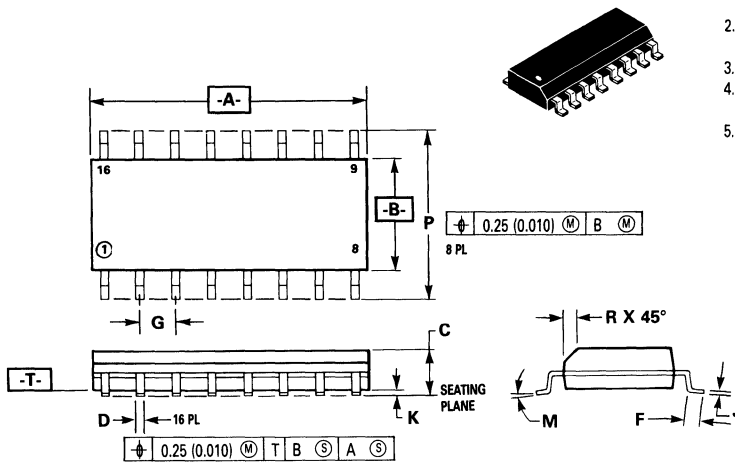
1. LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
4. "F" DIMENSION IS FOR FULL LEADS.
5. ROUNDED CORNERS OPTIONAL.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.80	21.34	0.740	0.840
B	6.10	6.60	0.240	0.260
C	3.69	4.69	0.145	0.185
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.38	2.41	0.015	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.39	1.01	0.015	0.040

# PACKAGE DIMENSIONS (Continued)

## 16-PIN PACKAGE

### SOIC PACKAGE CASE 751B-03 D SUFFIX

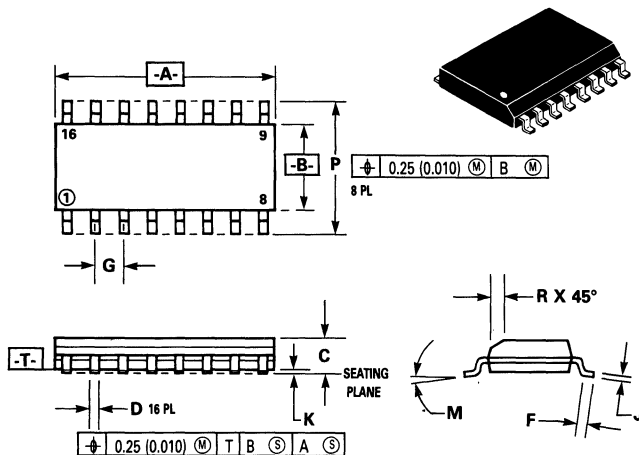


NOTES:

1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.80	10.00	0.386	0.393
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019

### SOIC PACKAGE CASE 751G-01 DW SUFFIX



NOTES:

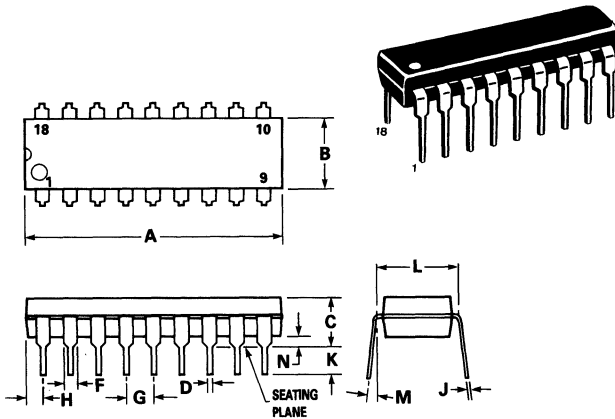
1. DIMENSIONS A AND B ARE DATUMS AND T IS A DATUM SURFACE.
2. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
3. CONTROLLING DIMENSION: MILLIMETER.
4. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.15	10.45	0.400	0.411
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.50	0.90	0.020	0.035
G	1.27 BSC		0.050 BSC	
J	0.25	0.32	0.010	0.012
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	10.05	10.55	0.395	0.415
	0.25	0.75	0.010	0.029

# PACKAGE DIMENSIONS (Continued)

## 18-PIN PACKAGE

### PLASTIC PACKAGE CASE 707-02

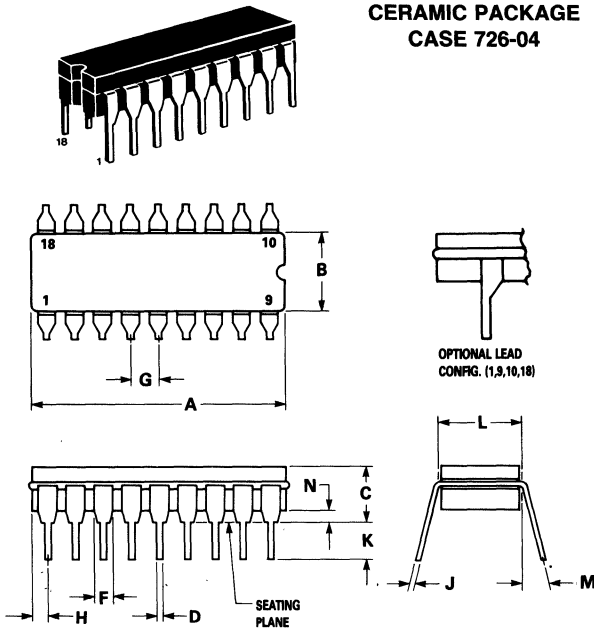


NOTES:

1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25mm(0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.22	23.24	0.875	0.915
B	6.10	6.60	0.240	0.260
C	3.56	4.57	0.140	0.180
D	0.36	0.56	0.014	0.022
F	1.27	1.78	0.050	0.070
G	2.54 BSC		0.100 BSC	
H	1.02	1.52	0.040	0.060
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

### CERAMIC PACKAGE CASE 726-04



NOTES:

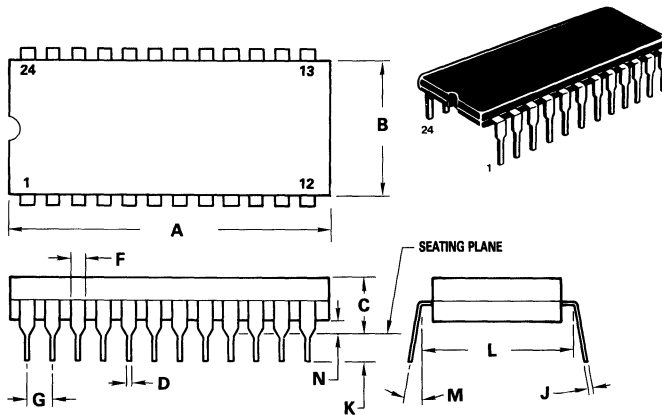
1. LEADS, TRUE POSITIONED WITHIN 0.25 mm (0.010) DIA. AT SEATING PLANE, AT MAXIMUM MATERIAL CONDITION.
2. DIM "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIM "A" & "B" INCLUDES MENISCUS.
4. "F" DIMENSION IS FOR FULL LEADS. "HALF" LEADS ARE OPTIONAL AT LEAD POSITIONS 1, 9, 10, AND 18.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	22.35	23.11	0.880	0.910
B	6.10	7.49	0.240	0.295
C	—	5.08	—	0.200
D	0.38	0.53	0.015	0.021
F	1.40	1.78	0.055	0.070
G	2.54 BSC		0.100 BSC	
H	0.51	1.14	0.020	0.045
J	0.20	0.30	0.008	0.012
K	3.18	4.32	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

# PACKAGE DIMENSIONS (Continued)

## 24-PIN PACKAGE

### CERAMIC PACKAGE CASE 623-05

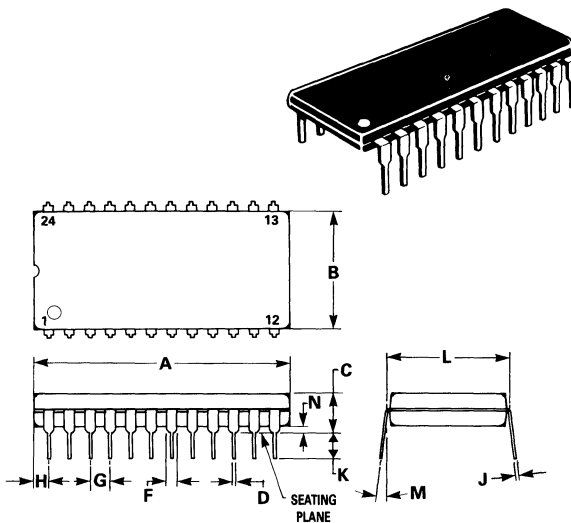


**NOTES:**

- DIM "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
- LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION. (WHEN FORMED PARALLEL).

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	31.24	32.77	1.230	1.290
B	12.70	15.49	0.500	0.610
C	4.06	5.59	0.160	0.220
D	0.41	0.51	0.016	0.020
F	1.27	1.52	0.050	0.060
G	2.54 BSC		0.100 BSC	
J	0.20	0.30	0.008	0.012
K	3.18	4.06	0.125	0.160
L	15.24 BSC		0.600 BSC	
M	0°	15°	0°	15°
N	0.51	1.27	0.020	0.050

### PLASTIC PACKAGE CASE 709-02



**NOTES:**

- POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25 mm (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
- DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
- DIMENSION B DOES NOT INCLUDE MOLD FLASH.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	31.37	32.13	1.235	1.265
B	13.72	14.22	0.540	0.560
C	3.94	5.08	0.155	0.200
D	0.36	0.56	0.014	0.022
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.65	2.03	0.065	0.080
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	15.24 BSC		0.600 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040





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**5 CMOS Handling and Design Guidelines**

**6 Data Sheets**

**7 CMOS Reliability**

**8 Equivalent Gate Count**

**9 Packaging Information  
Including Surface Mounts**



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