

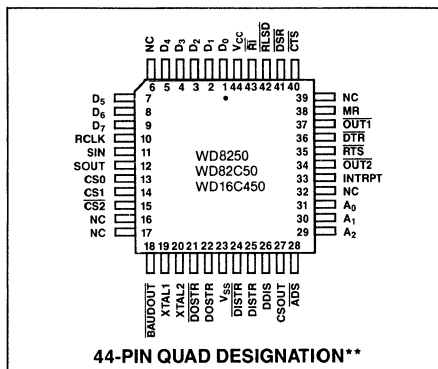
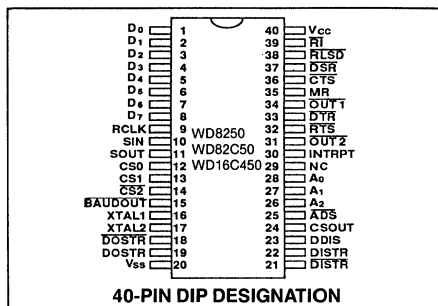
# WD8250/82C50/16C450

## Asynchronous Communications Elements (ACE)

### FEATURES

- Designed to be Easily Interfaced to Most Microprocessors (Z-80, 8080A, 8088, 68000, etc.)
- Generating and Stripping of Serial Asynchronous Data Control Bits (Start, Stop, Parity)
- Full Double Buffering Allows Imprecise Synchronization
- Independently Controlled Transmit, Receive, Line Status, and Data Set Interrupts
- Programmable Baud Rate Generator Allows Division of Any Input Clock by 1 to ( $2^{16} - 1$ ) and Generates the Internal 16X Clock
- Independent Receiver Clock Input
- MODEM Interface Capabilities
- Fully Programmable Serial-Interface Characteristics
  - 5-, 6-, 7-, or 8-Bit Characters
  - Even, Odd, or No-Parity Bit Generation and Detection
  - 1-, 1 1/2-, or 2-Stop Bit Generation
  - Baud Rate Generation (dc to 56K Baud)\*
- False Start Bit Detector
- Complete Status Reporting Capabilities
- THREE-STATE TTL Drive Capabilities for Bi-directional Data Bus and Control Bus
- Line Break Generation and Detection
- Internal Diagnostic Capabilities
  - Loopback Controls for Communications Link Fault Isolation
- Break, Parity, Overrun, Framing Error Simulation
- Full Prioritized Interrupt System Controls
- Single +5 Volt Power Supply

- Low CMOS Power Dissipation (WD82C50, WD16C450)
- Available in 40-pin DIP and 44-Pin QUAD Packages



### DESCRIPTION

The WD8250/82C50/16C450 is a programmable Asynchronous Communication Element (ACE). The device is fabricated in NMOS (WD8250) and CMOS (WD82C50 and WD16C450) silicon gate technology.

The ACE is a software-oriented device using a three-state, 8-bit, bi-directional data bus.

The ACE is used to convert parallel data to a serial format on the transmit side, and convert serial data to parallel on the receiver side. The serial format, in order of transmission and reception, is a start bit, followed by 5 to 8 data bits, a parity bit (if programmed) and 1-, 1 1/2- (5-bit format only) or 2-stop bits. The maximum recommended data rate is 56K baud.\*

Internal registers enable the user to program various types of interrupts, MODEM controls, and character formats. The user can read the status of the ACE at any time monitoring word conditions, interrupts and MODEM status.

An additional feature of the ACE is a programmable baud rate generator capable of dividing an internal XTAL or TTL signal clock by a division of 1 to ( $2^{16} - 1$ ).

The ACE is designed to work in either a polling or interrupt driven system, which is programmable by user's software controlling an internal register.

\* Contact Western Digital Sales Office for information regarding exceeding this recommendation maximum baud rate.

\*\* Consult Western Digital Sales Office for other pinouts.

**PIN DESIGNATIONS**

PIN NUMBERS		MNEMONIC	SIGNAL NAME	FUNCTION
DIP	QUAD			
1 thru 8	1thru5 and 7thru9	D0 thru D7	DATA BUS	3-state, bi-directional communication lines between the ACE and Data Bus. All prepared TX and assembled REC data, Control characters, and Status information are transferred via the data bus (D0-D7).
— 9	6 10	NC RCLK	NO CONNECT RECEIVE CLK	No Connect. This input is the 16X baud rate clock for the receiver section of the chip, may be tied to BAUDOUT (pin 15 for DIP package and/or pin 18 for QUAD package).
10	11	SIN	SERIAL INPUT	Received Serial Data In from the communications link (Peripheral device, MODEM or data set).
11	12	SOUT	SERIAL OUTPUT	Transmitted Serial Data Out to the communication link. The SOUT signal is set to a (logic1) marking condition upon a MASTER RESET.
12	13	CS0	CHIP SELECT	When CS0 and CS1 are high, and CS2 is low, chip is selected. Selection is complete when the address strobe ADS latches the chip select signals. No Connect. No Connect.
13	14	CS1	CHIP SELECT	
14	15	CS2	CHIP SELECT	
—	16	NC	NO CONNECT	
—	17	NC	NO CONNECT	
15	18	BAUDOUT	BAUDOUT	16X clock signal for the transmitter section of the ACE. The clock rate is equal to the oscillator frequency divided by the divisor loaded into the divisor latches. The BAUDOUT signal may be used to clock the receiver by tying to RCLK (pin 9 for DIP package and/or pin 10 for QUAD package).
16	19	XTAL 1	EXTERNAL CLOCK IN	These pins connect the crystal or signal clock to the ACE baud rate divisor circuit. See Fig. 5 and 6 for circuit connection diagrams.
17	20	XTAL 2	EXTERNAL CLOCK OUT	
18	21	DOSTR	DATA OUT STROBE	When the chip has been selected, a low DOSTR or high DOSTR will latch data into the selected WD8250/82C50/16C450 register (a CPU write). Only one of these lines need be used. Tie unused line to its inactive state, DOSTR-high or DOSTR-low.
19	22	DOSTR	DATA OUT STROBE	
20	23	V <sub>SS</sub>	GROUND	System signal ground.
21	24	DISTR	DATA IN STROBE	When chip has been selected, a low DISTR or high DISTR will allow a read of the selected WD8250/82C50/16C450 register (a CPU read). Only one of these lines need be used. Tie unused line to its inactive state, DISTR-high or DISTR-low.
22	25	DISTR	DATA IN STROBE	
23	26	DDIS	DRIVER DISABLE	Output goes low whenever data is being read from the ACE. Can be used to reverse data direction of external transceiver.
24	27	CSOUT	CHIP SELECT OUT	Output goes high when chip is selected. No data transfer can be initiated until CSOUT is high.
25	28	ADS	ADDRESS STROBE	When low, provides latching for Register Select (A0, A1, A2) and Chip Select (CS0, CS1, CS2). NOTE: The rising edge (1) of the ADS signal is required when the Register Select (A0, A1, A2) and the Chip Select (CS0, CS1, CS2) signals are not stable for the duration of a read or write operation. If not required, the ADS input can be tied permanently low.
26	29	A2	REGISTER SELECT A2	These three inputs are used to select an internal register of the ACE during a read or a write. See Table 1.
27	30	A1	REGISTER SELECT A1	
28	31	A0	REGISTER SELECT A0	

PIN NUMBERS		MNEMONIC	SIGNAL NAME	FUNCTION
DIP	QUAD			
29	32	NC	NO CONNECT	No Connect.
30	33	INTRPT	INTERRUPT	Output goes high whenever an enabled interrupt is pending.
31	34	OUT2	OUTPUT 2	User-designated output that can be programmed by Bit 3 of the MODEM Control Register (OUT2 goes low when Bit 3 = 1).
32	35	RTS	REQUEST TO SEND	Output when low informs the MODEM or data set that the ACE is ready to transmit data. See MODEM Control Register.
33	36	DTR	DATA TERMINAL READY	Output when low informs the MODEM or data set that the ACE is ready to receive.
34	37	OUT1	OUTPUT 1	User-designated output that can be programmed by Bit 2 of MODEM Control Register (OUT1 goes low when Bit 2 = 1).
35	38	MR	MASTER RESET	When high clears the registers to the states as indicated in Table 2.
—	39	NC	NO CONNECT	No Connect.
36	40	CTS	CLEAR TO SEND	Input from DCE indicating remote device is ready to transmit. See MODEM Status Register.
37	41	DSR	DATA SET READY	Input from DCE used to indicate the status of the local data set. See MODEM Status Register.
38	42	RLSD	RECEIVER LINE SIGNAL DETECT	Input from DCE indicating that it is receiving a signal which meets its signal quality conditions. See MODEM Status Register.
39	43	RI	RING INDICATOR	Input when low indicates that a ringing signal is being received by the MODEM or data set. See MODEM Status Register.
40	44	Vcc	+5V	+5 Volt Supply.

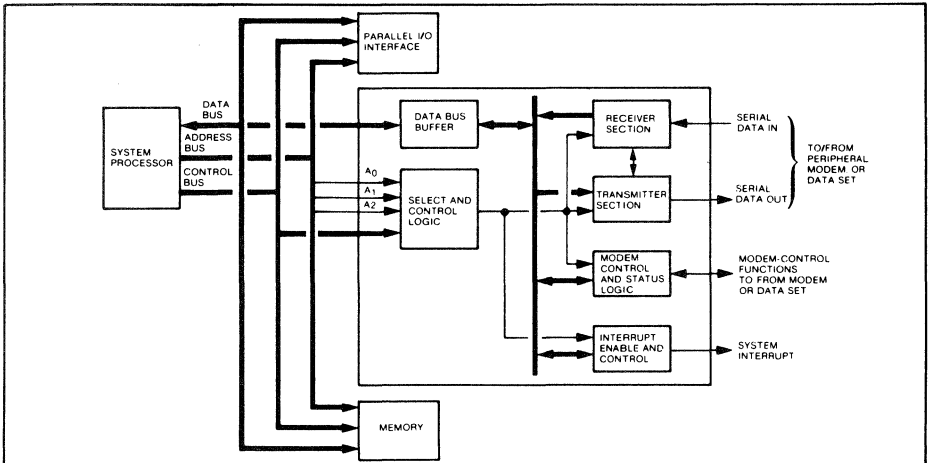


FIGURE 1. WD8250/82C50/16C450 GENERAL SYSTEM CONFIGURATION

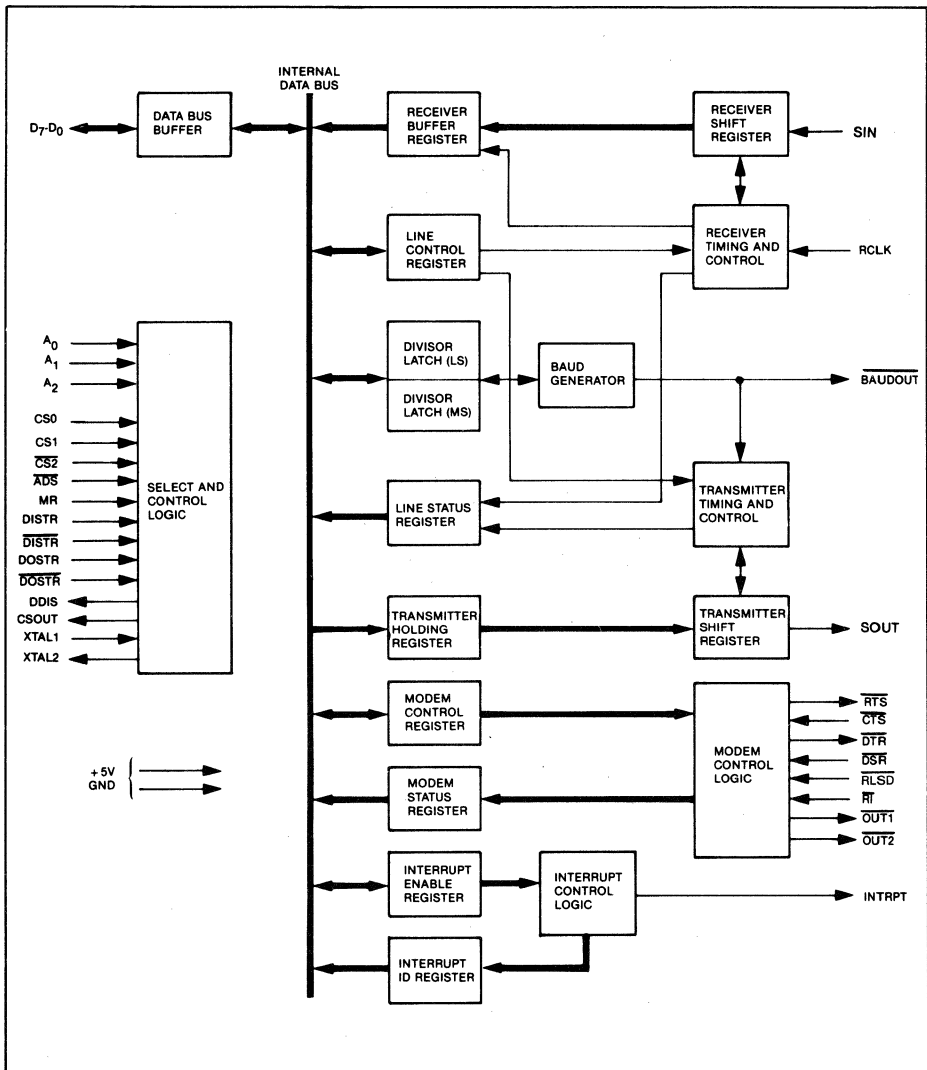


FIGURE 2. WD8250/82C50/16C450 BLOCK DIAGRAM

## CHIP SELECTION AND REGISTER ADDRESSING

**Address Strobe (ADS):** When low, provides latching for register select (A0, A1, A2) and chip select (CS0, CS1, CS2).

**NOTE:** The rising edge (↑) of the  $\overline{\text{ADS}}$  input is required when Register Select (A0, A1, A2) and Chip Select (CS0, CS1, CS2) signals are not stable for the duration of a read or write operation. If  $\overline{\text{ADS}}$  is not required for latching, this input can be tied permanently low.

**Chip Select (CS0, CS1, CS2):** The definition of a chip selected is CS0, CS1 both high and CS2 low. Chip selection is complete when latched by ADS or ADS is tied low.

**Register Select (A0, A1, A2):** To select a register for read or write operation, see Table 1.

**NOTE:** Divisor Latch Access Bit (DLAB) is the MSB of the Line Control Register. DLAB must be programmed high (logic 1) by the system software to access the Baud Rate Generator Divisor Latches.

**TABLE 1. REGISTER ADDRESSING**

DLAB	A2	A1	A0	Register
0	0	0	0	Receiver Buffer (read), Transmitter Holding Register (write)
0	0	0	1	Interrupt Enable
X	0	1	0	Interrupt Identification (read only)
X	0	1	1	Line Control
X	1	0	0	MODEM Control
X	1	0	1	Line Status
X	1	1	0	MODEM Status
X	1	1	1	See Note
1	0	0	0	Divisor Latch (least significant byte)
1	0	0	1	Divisor Latch (most significant byte)

**NOTE:** For this address, WD8250/82C50 = NOT ACCESSIBLE  
WD16C450 = SCRATCH PAD

## ACE OPERATIONAL DESCRIPTION

**Master Reset** A high-level input on this pin causes the ACE to reset to the condition listed in Table 2.

**ACE Accessible Registers** The system programmer has access to any of the registers as summarized in Table 3. For individual register descriptions, refer to the following pages under register heading.

**TABLE 2. RESET CONTROL OF REGISTERS AND PINOUT SIGNALS**

Register/Signal	Reset Control	Reset State
Receiver Buffer Register	First Word Received	Data
Transmitter Holding Register	Writing into the Transmitter Holding Register	Data
Interrupt Enable Register	Master Reset	All Bits Low (0-3 forced and 4-7 permanent)
Interrupt Identification Register	Master Reset	Bit 0 is High and Bits 1-7 Are Permanently Low
Line Control Register	Master Reset	All Bits Low
MODEM Control Register	Master Reset	All Bits Low
Line Status Register	Master Reset	All Bits Low, Except Bits 5 and 6 Are High
MODEM Status Register	Master Reset MODEM Signal Inputs	Bits 0-3 Low Bits 4-7 — Input Signal
Divisor Latch (low order bits)	Writing into the Latch	Data
Divisor Latch (high order bits)	Writing into the Latch	Data
SOUT	Master Reset	High
BAUDOUT	Writing into either Divisor Latch	Low
CSOUT	ADS Strobe Signal and State of Chip Select Lines	High/Low
DDIS	DDIS = CSOUT • RCLK • DISTR (At Master Reset, the CPU sets RCLK and DISTR low.)	High
INTRPT	Master Reset	Low
OUT 2	Master Reset	High
RTS	Master Reset	High
DTR	Master Reset	High
OUT 1	Master Reset	High
D7-D0 Data Bus Lines	In THREE-STATE Mode, Unless CSOUT • DISTR = High or CSOUT • DOSTR = High	THREE-STATE Data (ACE to CPU) Data (CPU to ACE)

**TABLE 3. ACCESSIBLE WD8250/82C50/16C450 REGISTERS**

Bit No.	Register Address*									
	0DLAB=0	0DLAB=0	1DLAB=0	2	3	4	5	6	0DLAB=1	1DLAB=1
	Receiver Buffer Register (Read Only)	Transmitter Holding Register (Write Only)	Interrupt Enable Register	Interrupt Identification Register	Line Control Register	MODEM Control Register	Line Status Register	MODEM Status Register	Divisor Latch (LS)	Divisor Latch (MS)
0	Data Bit 0	Data Bit 0	Enable Received Data Available Interrupt (ERBFI)	"0" if Interrupt Pending (IP)	Word Length Select Bit 0 (WLS0)	Data Terminal Ready (DTR)	Data Ready (DR)	Delta Clear to Send (DCTS)	Bit 0	Bit 8
1	Data Bit 1	Data Bit 1	Enable Transmitter Holding Register Empty Interrupt (ETBEI)	Interrupt ID Bit (0) (IIDB0)	Word Length Select Bit 1 (WLS1)	Request to Send (RTS)	Overrun Error (OE)	Delta Data Set Ready (DDSR)	Bit 1	Bit 9
2	Data Bit 2	Data Bit 2	Enable Receiver Line Status Interrupt (ELSI)	Interrupt ID Bit (1) (IIDB1)	Number of Stop Bits (STB)	Out 1	Parity Error (PE)	Trailing Edge Ring Indicator (TERI)	Bit 2	Bit 10
3	Data Bit 3	Data Bit 3	Enable MODEM Status Interrupt (EDSSI)	0	Parity Enable (PEN)	Out 2	Framing Error (FE)	Delta Receive Line Signal Detect (DRLSD)	Bit 3	Bit 11
4	Data Bit 4	Data Bit 4	0	0	Even Parity Select (EPS)	Loop	Break Interrupt (BI)	Clear to Send (CTS)	Bit 4	Bit 12
5	Data Bit 5	Data Bit 5	0	0	Stick Parity (STP)	0	Transmitter Holding Register Empty (THRE)	Data Set Ready (DSR)	Bit 5	Bit 13
6	Data Bit 6	Data Bit 6	0	0	Set Break (SBR)	0	Transmitter Shift Register Empty (TSRE)	Ring Indicator (RI)	Bit 6	Bit 14
7	Data Bit 7	Data Bit 7	0	0	Divisor Latch Access Bit (DLAB)	0	0	Received Line Signal Detect (RLSD)	Bit 7	Bit 15

\*Address 7 is a Scratch Pad Register on WD16C450; it is not accessible on WD8250 and WD82C50.

### Line Control Register

**Bits 1 and 0:** These two bits specify the number of bits in each transmitted or received serial character. The encoding of bits 1 and 0 are as follows:

Bit 1	Bit 0	Word Length
0	0	5 bits
0	1	6 bits
1	0	7 bits
1	1	8 bits

**Bit 2:** This bit specifies the number of stop bits in each transmitted or received serial character. If bit 2 is logic 0, 1 Stop bit is generated or checked in the transmit or receive data, respectively. If bit 2 is a logic 1 when a 5-bit word length is selected via bits 0 and 1, 1-1/2 Stop bits are generated or checked. If bit 2 is a logic 1 when either a 6-, 7-, or 8-bit word length is selected, 2 Stop bits are generated or checked.

**Bit 3:** This bit is the Parity Enable bit. When bit 3 is a logic 1, a Parity bit is generated (Transmit data) or checked (Receive data) between the last data word bit and Stop bit of the serial data. (The Parity bit is used to produce an even or odd number of 1s when the data word bits and the Parity bit are summed.)

**Bit 4:** This bit is the Even Parity Select bit. When bit 3 is a logic 1 and bit 4 is a logic 0, an odd number of logic 1s is transmitted or checked in the data word bits and Parity bit. When bit 3 is a logic 1 and bit 4 is a logic 1, an even number of bits is transmitted or checked.

**Bit 5:** This bit is the Stick Parity bit. When bit 3 is a logic 1 and bit 5 is a logic 1, the Parity bit is transmitted and then detected by the receiver in the opposite state indicated by bit 4.

**Bit 6:** This bit is the Set Break Control bit. When bit 6 is a logic 1, the serial output (SOUT) is forced to the

Spacing (logic 0) state and remains there (until reset by a low-level bit 6) regardless of other transmitter activity. The feature enables the CPU to alert a terminal in a computer communications system.

**Bit 7:** This bit is the Divisor Latch Access Bit (DLAB). It must be set high (logic 1) to access the Divisor Latches of the Baud Rate Generator during a Read or Write operation. It must be set low (logic 0) to access the Receiver Buffer, the Transmitter Holding Register, or the Interrupt Enable Register.

### ACE Programmable Baud Rate Generator

The ACE contains a programmable Baud Rate Generator capable of taking any clock input (dc to 3.1 MHz) and dividing it by any divisor from 1 to  $(2^8 - 1)$ . The output frequency of the Baud Generator is 16X the baud rate. Two 8-bit latches store the divisor in a 16-bit binary format. These Divisor Latches must be loaded during initialization in order to insure desired operation of the Baud Rate Generator. Upon loading either of the Divisor Latches, a 16-bit Baud counter is immediately loaded. This prevents long counts on initial load.

Tables 4 and 5 illustrate the use of the Baud Generator with two different driving frequencies. One is referenced to a 1.8432 MHz crystal. The other is a 3.072 MHz crystal.

**NOTE:** The maximum operating frequency of the Baud Generator is 3.1 MHz.

A divisor of 1 is not allowed when using a 1.8432 MHz crystal.

A divisor of 1 or 2 is not allowed when using a 3.072 MHz crystal.

In no case should the data rate be greater than 56K Baud.

See Crystal Specifications on Page 12.

**TABLE 4. BAUD RATES USING 1.8432 MHz CRYSTAL**

Desired Baud Rate	Divisor Used to Generate 16X Clock	Percent Error Difference Between Desired and Actual
50	2304	—
75	1536	—
110	1047	0.026
134.5	857	0.058
150	768	—
300	384	—
600	192	—
1200	96	—
1800	64	—
2000	58	0.69
2400	48	—
3600	32	—
4800	24	—
7200	16	—
9600	12	—
19200	6	—
38400	3	—
56000	2	2.86

**TABLE 5. BAUD RATES USING 3.072 MHz CRYSTAL**

Desired Baud Rate	Divisor Used to Generate 16X Clock	Percent Error Difference Between Desired and Actual
50	3840	—
75	2560	—
110	1745	0.026
134.5	1428	0.034
150	1280	—
300	640	—
600	320	—
1200	160	—
1800	107	—
2000	96	—
2400	80	—
3600	53	0.628
4800	40	—
7200	27	1.23
9600	20	—
19200	10	—
38400	5	—
56000	3	14.285

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### Line Status Register

This 8-bit register provides status information to the CPU concerning the data transfer. Its contents are indicated in Table 3 and are described below.

**Bit 0:** This bit is the Receiver Data Ready (DR) indicator. Bit 0 is set to a logic 1 whenever a complete incoming character has been received and transferred into the Receiver Buffer Register. Bit 0 will be reset to a logic 0 either by the CPU reading the data in the Receiver Buffer Register or by writing a logic 0 into it from the CPU.

**Bit 1:** This bit is the Overrun Error (OE) indicator. Bit 1 indicates that data in the Receiver Buffer Register was not read by the CPU before the next character was transferred into the Receiver Buffer Register, thereby destroying the previous character. The OE indicator is reset whenever the CPU reads the contents of the Line Status Register.

**Bit 2:** This bit is the Parity Error (PE) indicator. Bit 2 indicates that the received data character does not have the correct even or odd parity, as selected by the Even Parity Select bit. The PE bit is set to a logic 1 upon detection of a parity error and is reset to a logic 0 whenever the CPU reads the contents of the Line Status Register.

**Bit 3:** This bit is the Framing Error (FE) indicator. Bit 3 indicates that the received character did not have a valid Stop bit. Bit 3 is set to a logic 1 whenever the Stop bit following the last data bit or parity bit is detected as a zero bit (Spacing level).

**Bit 4:** This bit is the Break Interrupt (BI) indicator. Bit 4 is set to a logic 1 whenever the received data input is held in the Spacing (Logic 0) state for longer than a full word transmission time (that is, the total time of Start bit + data bits + Parity + Stop bits).

**NOTE:** Bits 1 through 4 are the error conditions that produce a Receiver Line Status interrupt whenever any of the corresponding conditions are detected.

**Bit 5:** This bit is the Transmitter Holding Register Empty (THRE) indicator. Bit 5 indicates that the ACE is ready to accept a new character for transmission. In addition, this bit causes the ACE to issue an interrupt to the CPU when the Transmit Holding Register Empty Interrupt enable is set high. The THRE bit is set to a logic 1 when a character is transferred from the Transmitter Holding Register into the Transmitter Shift Register. The bit is reset to logic 0 concurrently with the loading of the Transmitter Holding Register by the CPU.

**Bit 6:** This bit is the Transmitter Shift Register Empty (TSRE) indicator and is a read-only bit. For WD8250 and WD82C50, bit 6 is set to a logic 1 whenever the Transmitter Shift Register is idle (empty). It is reset to a logic 0 upon a data transfer from the Transmitter Holding Register to the Transmitter Shift Register. It toggles between a logic 0 and a logic 1 during multiple data transfer.

For WD16C450, bit 6 is set to a logic 1 when both transmitter registers (Transmitter Holding Register

and Transmitter Shift Register) are idle (empty). It is reset to a logic 0 upon loading of data into the Transmitter Holding Register. During a multiple data transfer, it remains in a logic 0 state (will not toggle) until the transfer is complete and both transmitter registers are empty.

**Bit 7:** This bit is permanently set to logic 0.

### Interrupt Identification Register

The ACE has an interrupt capability that allows for complete flexibility in interfacing to all popular microprocessors presently available. In order to provide minimum software overhead during data character transfers, the ACE prioritizes interrupts into four levels. The four levels of interrupt conditions are as follows: Receiver Line Status (priority 1); Received Data Ready (priority 2); Transmitter Holding Register Empty (priority 3); and MODEM Status (priority 4).

Information indicating that a prioritized interrupt is pending and source of that interrupt is stored in the Interrupt Identification Register (refer to Table 6). This register (IIR), when addressed during chip-select time, freezes the highest priority interrupt pending and no other interrupts are acknowledged until the particular interrupt is serviced by the CPU. Its contents are indicated in Table 3 and are described below.

**Bit 0:** This bit can be used in either a hardwired prioritized or polled environment to indicate whether an interrupt is pending. When bit 0 is a logic 0, an interrupt is pending and the IIR contents may be used as a pointer to the appropriate interrupt service routine. When bit 0 is a logic 1, no interrupt is pending and polling (if used) continues.

**Bits 1 and 2:** These two bits are used to identify the highest priority interrupt pending (see Table 6).

**Bits 3 through 7:** These five bits are always logic 0.

### Interrupt Enable Register

This 8-bit register enables the four interrupt sources of the ACE to separately activate the chip Interrupt (INTRPT) output signal. Its contents are indicated in Table 3 and are described below. It is possible to totally disable the interrupt system by resetting bits 0 through 3 of the Interrupt Enable Register. Similarly, by setting the appropriate bits of this register to a logic 1, selected interrupts can be enabled. Disabling the interrupt system inhibits the Interrupt Identification Register and the active (high) INTRPT output from the chip. All other system functions operate in their normal manner, including the setting of the Line Status and MODEM Status Registers.

**Bit 0:** This bit enables the Received Data Available Interrupt when set to logic 1.

**Bit 1:** This bit enables the Transmitter Holding Register Empty Interrupt when set to logic 1.

**Bit 2:** This bit enables the Receiver Line Status Interrupt when set to logic 1.

**Bit 3:** This bit enables the MODEM Status Interrupt when set to logic 1.

**Bits 4 through 7:** These four bits are always logic 0.



**TABLE 6. INTERRUPT CONTROL FUNCTIONS**

Interrupt Identification Register			Interrupt Set and Reset Functions			
Bit 2	Bit 1	Bit 0	Priority Level	Interrupt Flag	Interrupt Source	Interrupt Reset Control
0	0	1	—	None	None	—
1	1	0	Highest	Receiver Line Status	Overrun Error or Parity Error or Framing Error or Break Interrupt	Reading the Line Status Register
1	0	0	Second	Received Data Available	Receiver Data Available	Reading the Receiver Buffer Register
0	1	0	Third	Transmitter Holding Register Empty	Transmitter Holding Register Empty	Reading the IIR Register (if source of interrupt) or Writing into the Transmitter Holding Register
0	0	0	Fourth	MODEM Status	Clear to Send or Data Set Ready or Ring Indicator or Received Line Signal Detect	Reading the MODEM Status Register

**MODEM Control Register**

This 8-bit register controls the interface either with the MODEM or data set (or a peripheral device emulating a MODEM). The contents of the MODEM Control Register are indicated in Table 3.

**Bit 0:** This bit controls the Data Terminal Ready ( $\overline{DTR}$ ) output. When bit 0 is set to a logic 1, the  $\overline{DTR}$  output is forced to a logic 0. When bit 0 is reset to a logic 0, the  $\overline{DTR}$  output is forced to a logic 1.

**NOTE:** The  $\overline{DTR}$  output of the ACE may be applied to an EIA inverting line driver (such as the DS1488) to obtain the proper polarity input at the succeeding MODEM or data set.

**Bit 1:** This bit controls the Request to Send ( $\overline{RTS}$ ) output. Bit 1 affects the  $\overline{RTS}$  output in a manner identical to that described above for bit 0.

**Bit 2:** This bit controls the Output 1 ( $\overline{OUT\ 1}$ ) signal, which is an auxiliary user-designated output. Bit 2 affects the  $\overline{OUT\ 1}$  output in a manner identical to that described above for bit 0.

**Bit 3:** This bit controls the Output 2 ( $\overline{OUT\ 2}$ ) signal, which is an auxiliary user-designated output. Bit 3 affects the  $\overline{OUT\ 2}$  output in a manner identical to that described above for bit 0.

**Bit 4:** This bit provides a loopback feature for diagnostic testing of the ACE. When bit 4 is set to logic 1, the following occur: the transmitter Serial Output ( $\overline{SOUT}$ ) is set to a logic 1 (high) state; the receiver Serial Input

( $\overline{SIN}$ ) is disconnected; the output of the Transmitter Shift Register is "looped back" into the Receiver Shift Register input; the four MODEM Control Inputs ( $\overline{CTS}$ ,  $\overline{DSR}$ ,  $\overline{RLSD}$ , and  $\overline{RI}$ ) are disconnected; and the four MODEM Control outputs ( $\overline{RTS}$ ,  $\overline{DTR}$ ,  $\overline{OUT\ 2}$ ,  $\overline{OUT\ 1}$ ) are internally connected to the four MODEM Control inputs. In the diagnostic mode, data that is transmitted is immediately received. This feature allows the processor to verify the transmit- and receive-data paths of the ACE.

In the diagnostic mode, the receiver and transmitter interrupts are fully operational. The MODEM Control Interrupts are also operational but the interrupts' sources are now the lower four bits of the MODEM Control Register instead of the four MODEM Control inputs. The interrupts are still controlled by the Interrupt Enable Register.

The ACE interrupt system can be tested by writing into the lower six bits of the Line Status Register and the lower four bits of the MODEM Status Register. Setting any of these bits to a logic 1 generates the appropriate interrupt (if enabled). The resetting of these interrupts is the same as in normal ACE operation. To return to this operation, the registers must be reprogrammed for normal operation and then bit 4 must be reset to a logic 0.

**Bits 5 through 7:** These bits are permanently set to a logic 0.

### MODEM Status Register

This 8-bit register provides the current state of the control lines from the MODEM (or peripheral device) to the CPU. In addition to this current-state information, four bits of the MODEM Status Register provide change information. These bits are set to a logic 1 whenever a control input from the MODEM changes state. They are reset to logic 0 whenever the CPU reads the MODEM Status Register.

The contents of the MODEM Status Register are indicated in Table 3 and are described below.

**Bit 0:** This bit is the Delta Clear to Send (DCTS) indicator. Bit 0 indicates that the CTS input to the chip has changed state since the last time it was read by the CPU.

**Bit 1:** This bit is the Delta Data Set Ready (DDSR) indicator. Bit 1 indicates that the DSR input to the chip has changed state since the last time it was read by the CPU.

**Bit 2:** This bit is the Trailing Edge of Ring Indicator (TERI) detector. Bit 2 indicates that the RI input to the chip has changed from an On (logic 1) to an Off (logic 0) condition.

**Bit 3:** This bit is the Delta Received Line Signal Detector (DRLSD) indicator. Bit 3 indicates that the RLSD input to the chip has changed state.

NOTE: Whenever bit 0, 1, 2, or 3 is set to logic 1, a MODEM Status Interrupt is generated.

**Bit 4:** This bit is the complement of the Clear to Send (CTS) input. This bit becomes equivalent to RTS of the

MODEM Control Register, if Bit 4 of the MODEM Control Register is set to 1.

**Bit 5:** This bit is the complement of the Data Set Ready (DSR) input. This bit becomes equivalent to DTR of the MODEM Control Register, if Bit 4 of the MODEM Control Register is set to 1.

**Bit 6:** This bit is the complement of the Ring Indicator (RI) input. This bit becomes equivalent to OUT1 of the MODEM Control Register, if Bit 4 of the MODEM Control Register is set to 1.

**Bit 7:** This bit is the complement of the Received Line Signal Detect (RLSD) input. This bit becomes equivalent to OUT2 of the MODEM Control Register, if Bit 4 of the MODEM Control Register is set to 1.

### Typical Applications

Figures 3 and 4 show how to use the ACE chip in an 8080A system and in a microcomputer system with a high-capacity data bus.

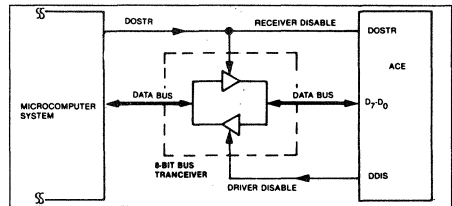


FIGURE 3. TYPICAL INTERFACE FOR A HIGH-CAPACITY DATA BUS

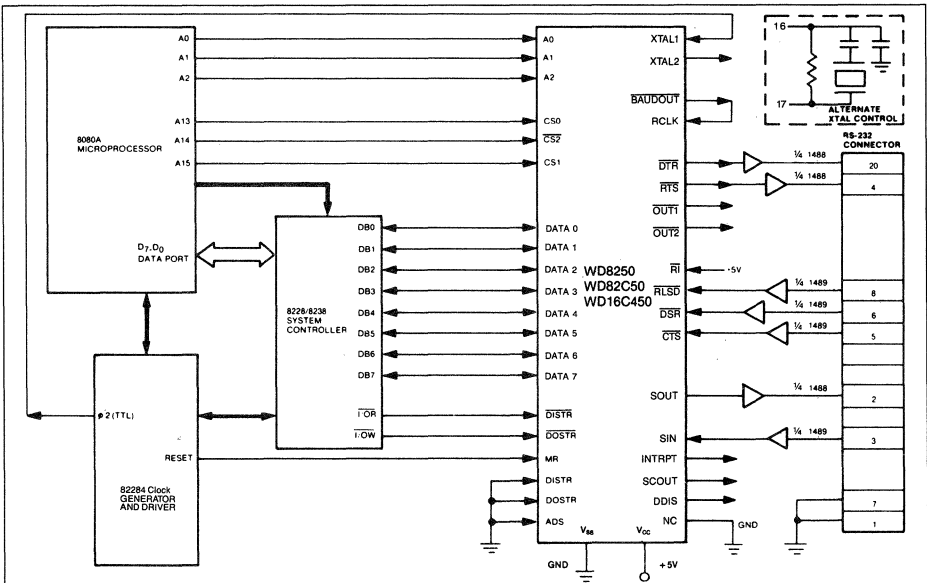


FIGURE 4. TYPICAL 8-BIT MICROPROCESSOR/RS-232 TERMINAL INTERFACE USING THE ACE

### ABSOLUTE MAXIMUM RATINGS

Temperature  
 Under Bias ..... 0°C (32°F) to 70°C (158°F)  
 Storage Temperature  
 Ceramic .... -65°C (-85°F) to +150°C (302°F)  
 Plastic ..... -50°C (-58°F) to +125°C (257°F)  
 All Input or Output Voltages  
 with respect to V<sub>SS</sub> ..... -0.5V to +7.0V

Power Dissipation WD8250 ..... 750 mW  
 WD82C50 ..... 110 mW  
 WD16C450 ..... 110 mW  
*Absolute maximum ratings indicate limits beyond which permanent damage may occur. Continuous operation at these limits is not intended; operation should be limited to those conditions specified under DC Operating Characteristics.*

**TABLE 7. DC OPERATING CHARACTERISTICS**

T<sub>A</sub> = 0°C (32°F) to +70°C (158°F), V<sub>CC</sub> = +5V ±5%, V<sub>SS</sub> = 0V, unless otherwise specified

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
V <sub>ILX</sub>	Clock Input Low Voltage	-0.5	0.8	-0.5	0.8	-0.5	0.8	V	I <sub>OL</sub> = 1.6mA on all outputs I <sub>OH</sub> = -100µA V <sub>CC</sub> = 5.25V. No loads on SIN, DSR, RLSD, CTS. R <sub>I</sub> = 2.0V. All other in- puts = 0.8V. Baud rate gen- erator at 4 MHz. Baud rate at 56K. V <sub>CC</sub> = 5.25V. V <sub>SS</sub> = 0V. All other pins floating. V <sub>IN</sub> = 0V, 5.25V. V <sub>OUT</sub> = 0.4V V <sub>OUT</sub> = 4.6V Data Bus is at High- Impedance State
V <sub>IHX</sub>	Clock Input High Voltage	2.4	V <sub>CC</sub>	2.0	V <sub>CC</sub>	2.0	V <sub>CC</sub>	V	
V <sub>IL</sub>	Input Low Voltage	-0.5	0.8	-0.5	0.8	-0.5	0.8	V	
V <sub>IH</sub>	Input High Voltage	2.2	V <sub>CC</sub>	2.0	V <sub>CC</sub>	2.0	V <sub>CC</sub>	V	
V <sub>OL</sub>	Output Low Voltage		0.45		0.4		0.4	V	
V <sub>OH</sub>	Output High Voltage	2.4		2.4		2.4		V	
I <sub>CC</sub>	(AV) Average Power Supply Current (V <sub>CC</sub> )		150		20		20	mA	
I <sub>IL</sub>	Input Leakage		± 10		± 10		± 10	µA	
I <sub>CL</sub>	Clock Leakage		± 10		± 10		± 10	µA	
I <sub>DL</sub>	Data Bus Leakage		± 10		± 10		± 10	µA	
V <sub>ILMR</sub>	MR Schmitt V <sub>IL</sub>	N/A	N/A	N/A	N/A	2.0	0.8	V	
V <sub>IHMR</sub>	MR Schmitt V <sub>IH</sub>							V	

**TABLE 8. CAPACITANCE**

T<sub>A</sub> = 25°C (77°F), f = 1.0 MHz, V<sub>CC</sub> = V<sub>SS</sub> = 0V

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		UNITS	TEST CONDITIONS
		TYP	MAX	TYP	MAX		
C <sub>XIN</sub>	Clock Input Capacitance	10	15	15	20	pF	fc = 1 MHz
C <sub>XOUT</sub>	Clock Output Capacitance	20	30	20	30	pF	
C <sub>IN</sub>	Input Capacitance	6	10	6	10	pF	Unmeasured pins returned to V <sub>SS</sub>
C <sub>OUT</sub>	Output Capacitance	10	20	10	20	pF	

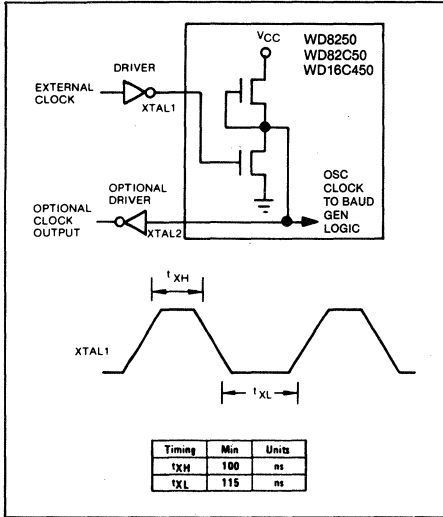


FIGURE 5. EXTERNAL CLOCK INPUT (3.1 MHz MAX.)

**CRYSTAL MANUFACTURERS (Partial List)**

American Time Products Division  
 Frequency Control Products, Inc.  
 Woodside, New York 11377

Bliley Electric Company  
 Erie, Pennsylvania 16508

Erie Frequency Control  
 Carlisle, Pennsylvania 17013

Q-Matic Corporation  
 Costa Mesa, California 92626

**CRYSTAL SPECIFICATIONS**

Frequency: 1.8432 MHz and 3.072 MHz

Type: Microprocessor Crystal

Temperature range: 0°C to +70°C

Series resistance: 200Ω to 500Ω (1.8432 MHz)  
 100Ω to 200Ω (3.072 MHz)

Series resonant

Overall tolerance ± 0.01%

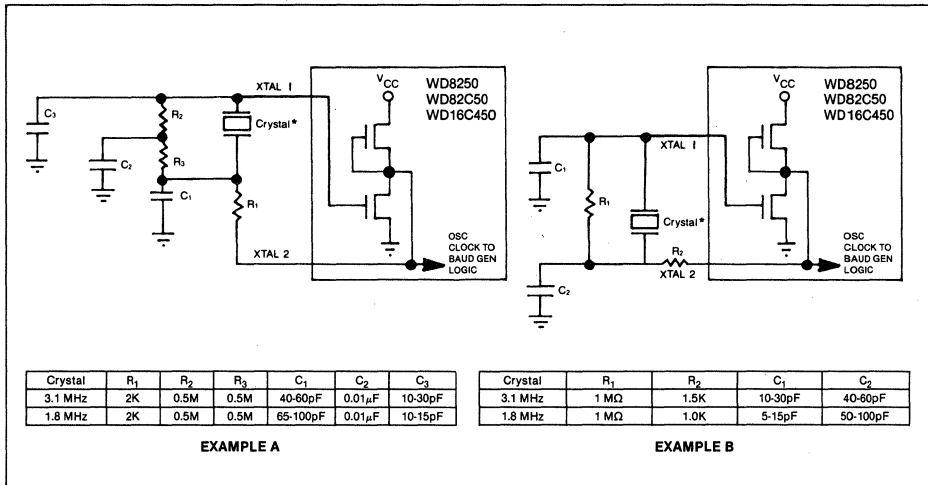
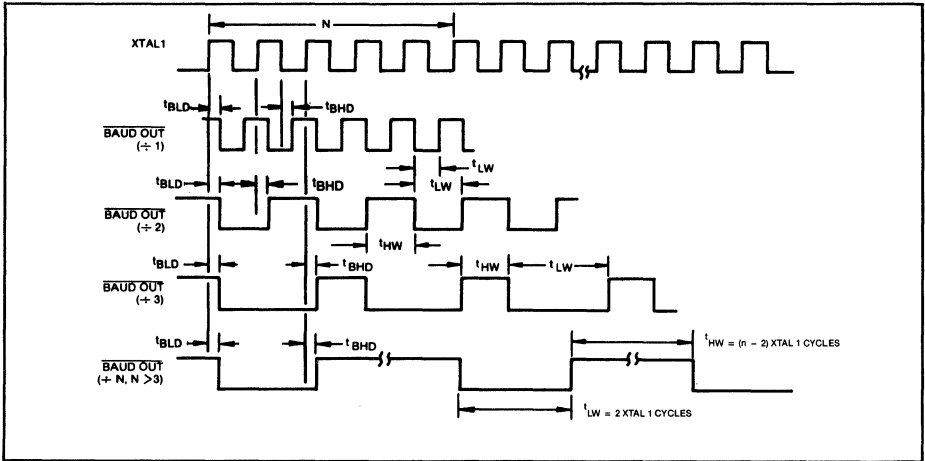


FIGURE 6. TYPICAL CRYSTAL OSCILLATOR NETWORKS

\*See Crystal Specifications

**AC OPERATING CHARACTERISTIC**

$T_A = 0^\circ\text{C} (32^\circ\text{F})$  to  $+70^\circ\text{C} (158^\circ\text{F})$ ,  $V_{SS} = +5\text{V} \pm 5\%$



**FIGURE 7. BAUD RATE GENERATOR TIMING**

**TABLE 9. BAUD RATE GENERATOR**

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	TYP	MIN	MAX		
N	Baud Rate Divisor	1	$(2^{16} - 1)$	1	$(2^{16} - 1)$	1	$(2^{16} - 1)$		
$t_{BLD}$	Baud Output Negative Edge Delay		250		250		125	nsec	100pF Load
$t_{BHD}$	Baud Output Positive Edge Delay		250		250		125	nsec	100pF Load
$t_{LW}$	Baud Output Low Time	450		425		425		nsec	100pF Load
$t_{HW}$	Baud Output High Time	330		330		330		nsec	100pF Load

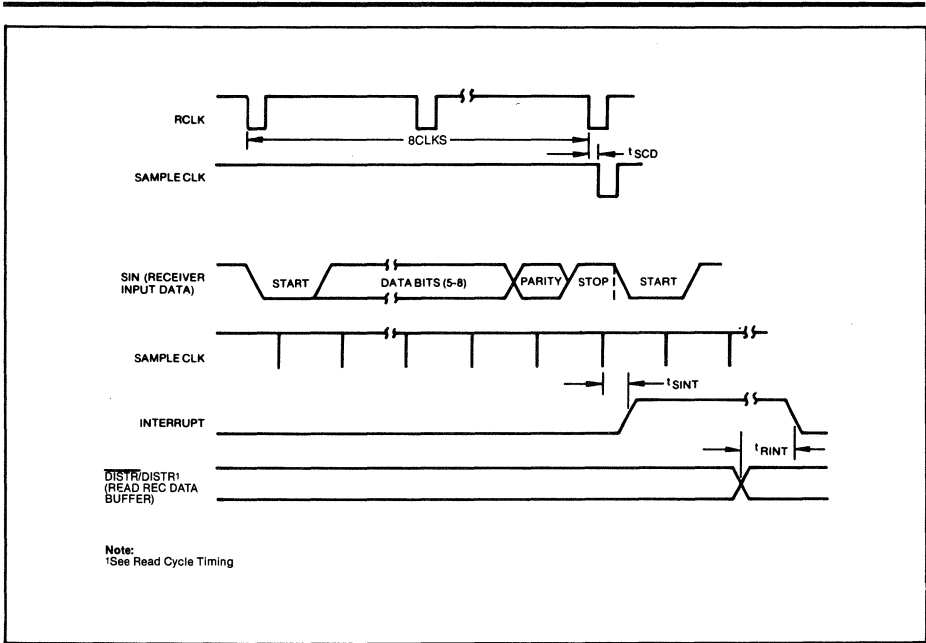


FIGURE 8. RECEIVER TIMING

TABLE 10. RECEIVER TIMING

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
$t_{SCD}$	Delay from RCLK to Sample Time		2		2		2	$\mu\text{sec}$	
$t_{SINT}$	Delay from Sample CLK to Set Interrupt		2		2	1	1	RCLK Cycles	100pF Load
$t_{RINT}$	Delay from DISTR/DISTR (RD RBR) Reset Interrupt	0.250	1	0.250	1	0.250	1	$\mu\text{sec}$	100pF Load

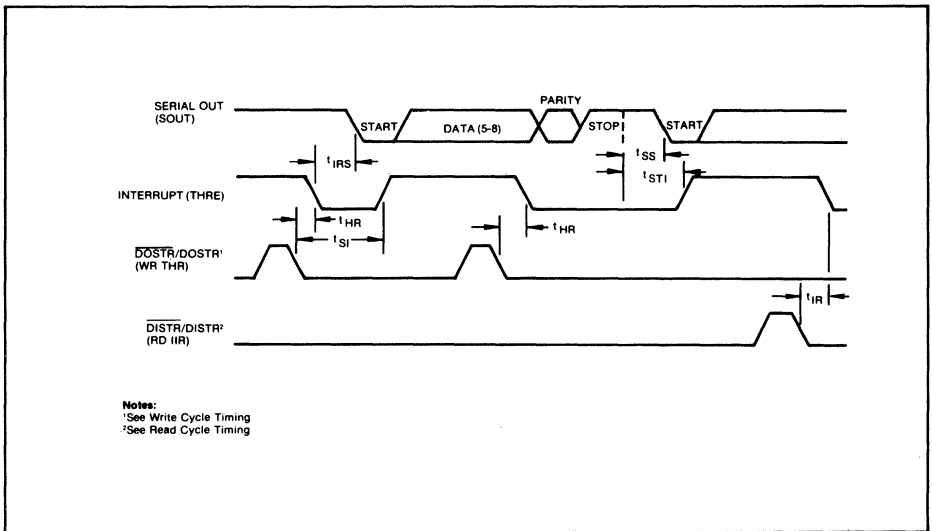


FIGURE 9. TRANSMITTER TIMING

TABLE 11. TRANSMITTER TIMING

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
$t_{HR}$	Delay from DOSTR/DOSTR' (WR THR) to Reset Interrupt	0.250	1.0	0.250	1.0		0.175	$\mu$ sec	100pF Load
$t_{IRS}$	Delay from Initial INTR Reset to Transmit Start		16		16	8	24	BAUDOUT Cycles	
$t_{SI}$	Delay from Initial Write to Interrupt		24		24	16	32	BAUDOUT Cycles	
$t_{SS}$	Delay from Stop to Next Start	0.250	1	0.250	1	0.250	1	$\mu$ sec	
$t_{STI}$	Delay from Stop to Interrupt (THRE)		8		8		8	BAUDOUT Cycles	
$t_{IR}$	Delay from DISTR/DISTR' (RD IIR) to Reset Interrupt (THRE)	0.250	1	0.250	1		0.250	$\mu$ sec	100pF Load

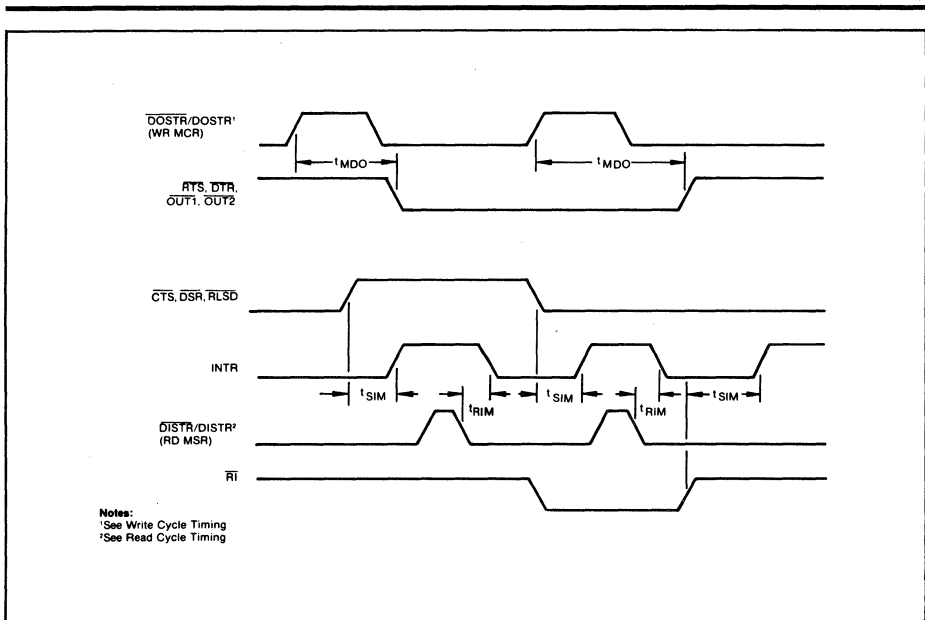


FIGURE 10. MODEM CONTROL TIMING

TABLE 12. MODEM CONTROL TIMING

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
$t_{MDO}$	Delay from DOSTR/DOSTR (WR MCR) to Output	0.250	1	0.250	1	0.200		$\mu\text{sec}$	100 pF Load
$t_{SIM}$	Delay to Set Interrupt from MODEM Input	0.250	1	0.250	1	0.250	1	$\mu\text{sec}$	100 pF Load
$t_{RIM}$	Delay to Reset Interrupt from DISTR/DISTR (RD MSR)	0.250	1	0.250	1		0.250	$\mu\text{sec}$	100 pF Load



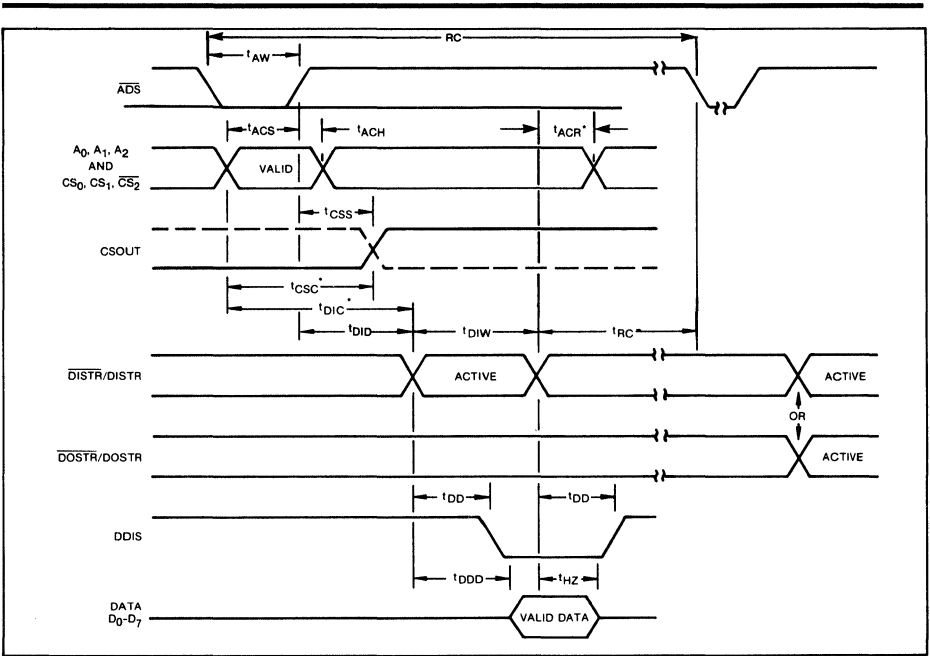


FIGURE 11. READ CYCLE TIMING

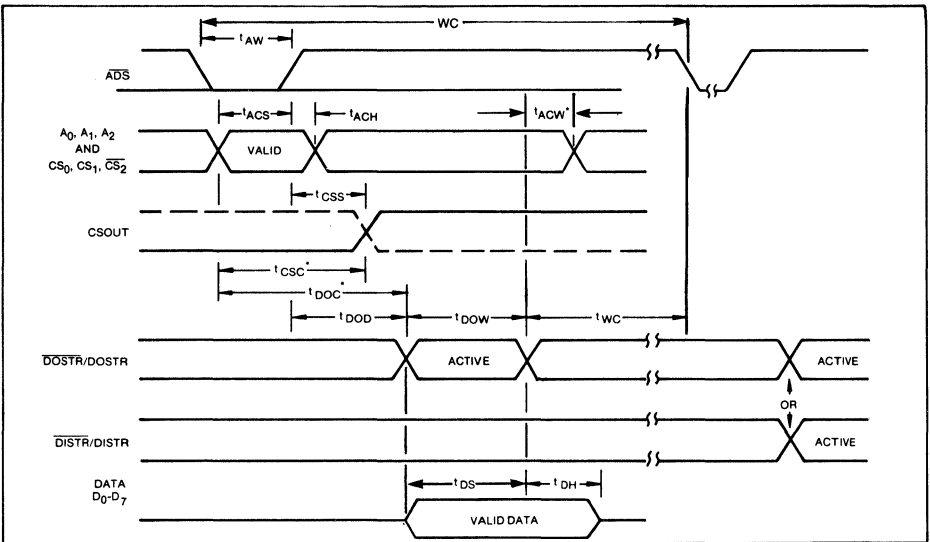


FIGURE 12. WRITE CYCLE TIMING

**TABLE 13. READ/WRITE CYCLE TIMING**

SYMBOL	CHARACTERISTIC	WD8250		WD82C50		WD16C450		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
t <sub>AW</sub>	Address Strobe Width	120		90		60		nsec	1TTL Load
t <sub>ACS</sub>	Address and Chip Select Setup Time	100		110		60		nsec	1TTL Load
t <sub>ACH</sub>	Address and Chip Select Hold Time	10		0		0		nsec	1TTL Load
t <sub>CSS</sub>	CSOUT Delay from Latch		160		90			nsec	1TTL Load
t <sub>DD</sub>	DISTR/DISTR Delay from Latch	50		0				nsec	1TTL Load
t <sub>DIW</sub>	DISTR/DISTR Strobe Width	300		175		125		nsec	1TTL Load
t <sub>RC</sub>	Read Cycle Delay	655		1735		175		nsec	1TTL Load
RC	Read Cycle = t <sub>ACS</sub> + t <sub>DD</sub> + t <sub>DIW</sub> + t <sub>RC</sub> + 20 ns	1125		2050		360		nsec	1TTL Load
t <sub>DD</sub>	DISTR/DISTR to Driver Disable Delay		200		150		60	nsec	1TTL Load
t <sub>DDD</sub>	Delay from DISTR/DISTR to Data		300		250		125	nsec	1TTL Load
t <sub>HZ</sub>	DISTR/DISTR to Floating Data Delay	60		100		0	100	nsec	1TTL Load
t <sub>DOD</sub>	DOSTR/DOSTR Delay from Latch	20		50				nsec	1TTL Load
t <sub>DOW</sub>	DOSTR/DOSTR Strobe Width	175		175		100		nsec	1TTL Load
t <sub>WC</sub>	Write Cycle Delay	685		1785		200		nsec	1TTL Load
WC	Write Cycle = t <sub>ACS</sub> + t <sub>DOD</sub> + t <sub>DOW</sub> + t <sub>WC</sub> + 20 ns	1000		2150		360		nsec	1TTL Load
t <sub>DS</sub>	Data Setup Time		t <sub>DOW</sub>		t <sub>DOW</sub>	40		nsec	1TTL Load
t <sub>DH</sub>	Data Hold Time	60		60		40		nsec	1TTL Load
t <sub>CSC*</sub>	CSOUT Delay from Select		260		200		100	nsec	1TTL Load
t <sub>DIC*</sub>	DISTR/DISTR Delay from Select or Address	70		70		50		nsec	1TTL Load
t <sub>DOC*</sub>	DOSTR/DOSTR Delay from Select or Address	70		70		50		nsec	1TTL Load
t <sub>ACR*</sub>	Address and Chip Select Hold Time from DISTR/DISTR	10		50		20		nsec	1TTL Load
t <sub>ACW*</sub>	Address and Chip Select Hold Time from DOSTR/DOSTR	10		50		20		nsec	1TTL Load
t <sub>MR</sub>	Master Reset Pulse Width	1.0		25		5.0		μsec	1TTL Load
t <sub>XH</sub>	Duration of Clock HIGH Pulse			140		140		nsec	
t <sub>XL</sub>	Duration of Clock LOW Pulse			140		140		nsec	External Clock (3.1 MHz Max.)

\*Only applicable when  $\overline{ADS}$  is permanently low.

## APPENDIX A

### A.0 PACKAGE DIAGRAMS

Figures A-1, A-2, and A-3 illustrate the 40-pin DIP packages and 44-pin QUAD package showing dimensions in inches.

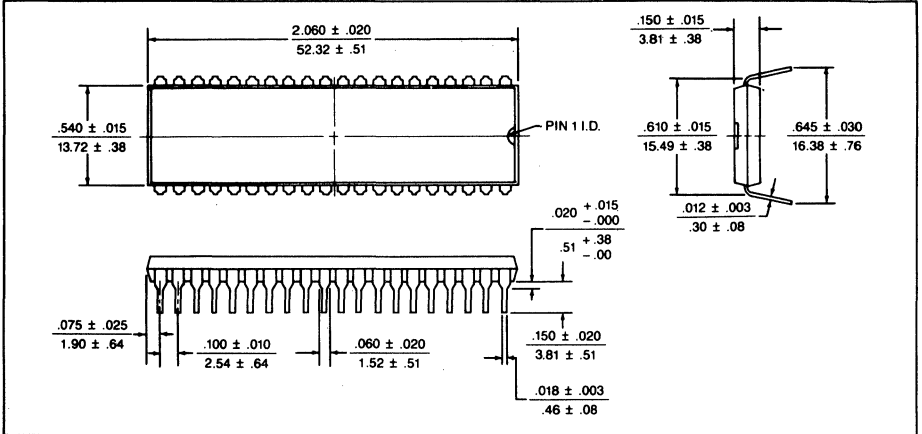


FIGURE A-1. 40 LEAD PLASTIC "PL"

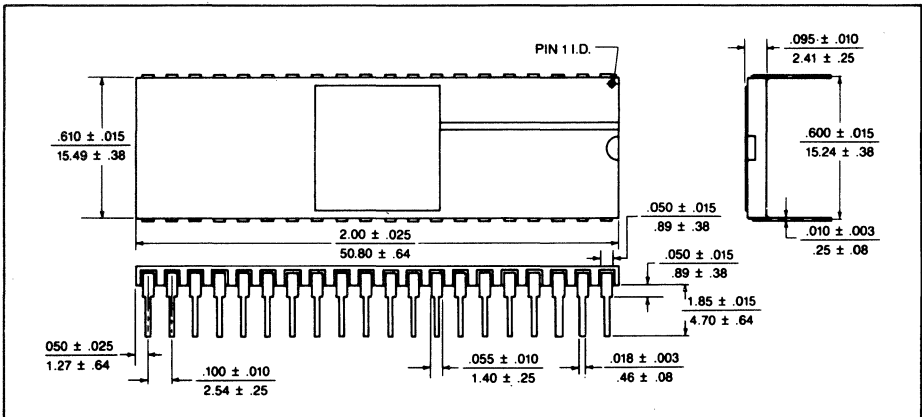


FIGURE A-2. 40 LEAD CERAMIC "AL"

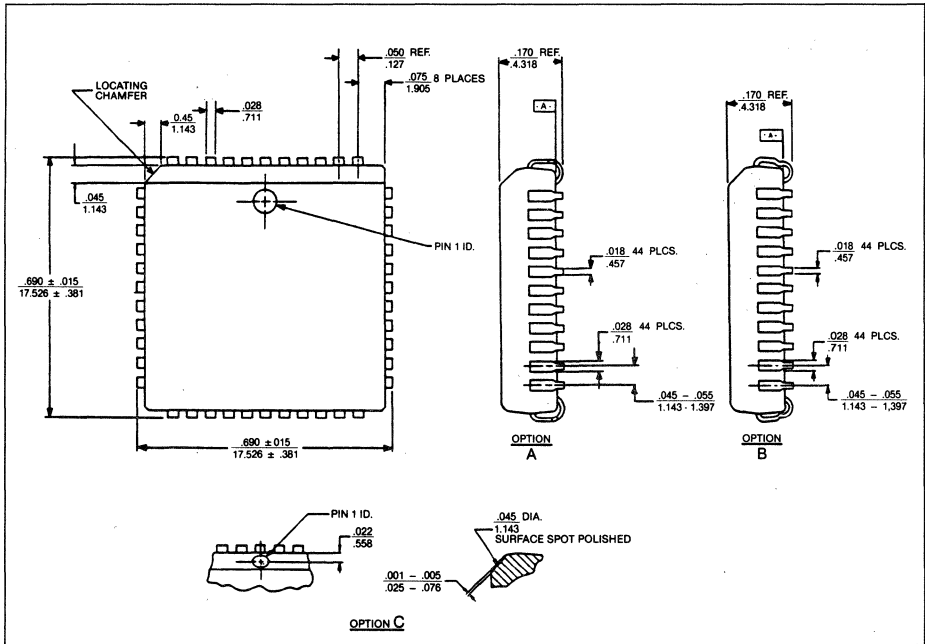


FIGURE A-3. 44 LEAD PLASTIC "JM"

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