

digital**pdp11****PROGRAMMING CARD**

FOR FAMILY OF PDP-11 COMPUTERS

WORD FORMAT:BINARY-OCTAL
REPRESENTATION

MODE	R
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Mode	Name	Symbolic	Description
0	register	R	(R) is operand [ex. R2=%2]
1	register deferred	(R)	(R) is address
2	auto-increment	(R)+	(R) is adrs; (R) + (1 or 2)
3	auto-incr deferred	@(R)+	(R) is adrs of adrs; (R) + 2
4	auto-decrement	-(R)	(R) - (1 or 2); (R) is adrs
5	auto-decr deferred	@-(R)	(R) - 2; (R) is adrs of adrs
6	index	X(R)	(R) + X is adrs
7	index deferred	@X(R)	(R) + X is adrs of adrs

PROGRAM COUNTER ADDRESSING: Reg = 7

MODE	7
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2	immediate	#n	operand n follows instr
3	absolute	@#A	address A follows instr
6	relative	A	instr adrs + 4 + X is adrs
7	relative deferred	@A	instr adrs + 4 + X is adrs of adrs

LEGEND:**Op Codes**

- = 0 for word/1 for byte
- SS = source field (6 bits)
- DD = destination field (6 bits)
- R = gen register (3 bits), 0 to 7
- XXX = offset (8 bits), +127 to -128
- N = number (3 bits)
- NN = number (6 bits)

Operations

- () = contents of
- s = contents of source
- d = contents of destination
- r = contents of register
- ← = becomes
- X = relative address
- % = register definition

Boolean

- Λ = AND
- V = inclusive OR
- ∨ = exclusive OR
- ~ = NOT

Condition Codes

- * = conditionally set/cleared
- = not affected
- 0 = cleared
- 1 = set

NOTE:

- ▲ = Applies to the 11/35, 11/40, 11/45 & 11/70 computers
- = Applies to the 11/45 & 11/70 computers

digital equipment corporation

MAYNARD, MASSACHUSETTS

July 1975



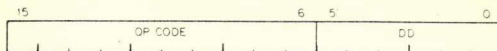
NUMERICAL OP CODE LIST:

OP Code	Mnemonic	OP Code	Mnemonic	OP Code	Mnemonic
00 00 00	HALT	00 60 DD	ROR	10 40 00	EMT
00 00 01	WAIT	00 61 DD	ROL	↓	
00 00 02	RTI	00 62 DD	ASR	10 43 77	TRAP
00 00 03	BPT	00 63 DD	ASL	↓	
00 00 04	IOT	00 64 NN	MARK	10 44 00	EMT
00 00 05	RESET	00 65 SS	MFP1	↓	
00 00 06	RTT	00 66 DD	MTP1	10 47 77	TRAP
00 00 07	(unused)	00 67 DD	SXT	↓	
00 00 77		(unused)	00 70 00	↓	
00 01 DD	JMP		00 77 77		(unused)
00 02 OR	RTS	01 SS DD	MOV	10 50 DD		CLRB
00 02 10	(unused)		02 SS DD	CMP	10 51 DD	COMB
00 02 27		(unused)	03 SS DD	BIT	10 52 DD	INCB
00 02 3N	SPL		04 SS DD	BIC	10 53 DD	DECB
		05 SS DD	BIS	10 54 DD	NEGB
00 02 40	NOP	06 SS DD	ADD	10 55 DD	ADCB
00 02 41	cond codes	07 OR SS	MUL	10 56 DD	SBCB
		07 1R SS	DIV	10 57 DD	TSTB
00 02 77	(unused)	07 2R SS	ASH	10 60 DD	RORB
00 03 DD		SWAB	07 3R SS	ASHC	10 61 DD	ROLB
	07 4R DD		XOR	10 62 DD	ASRB
00 04 XXX	BR	07 50 OR	FADD	10 63 DD	ASLB
		07 50 1R	FSUB	10 64 00	(unused)
00 10 XXX	BNE	07 50 2R	FMUL	10 64 77		(unused)
00 14 XXX	BEQ	07 50 3R	FDIV	10 65 SS	MFPD
00 20 XXX	BGE	07 50 40	(unused)	10 66 DD	MTPD
00 24 XXX	BLT			10 67 00	(unused)
00 30 XXX	BGT	07 67 77	(unused)	10 77 77		(unused)
00 34 XXX	BLE	07 7R NN		SOB	11 SS DD		MOVB
00 4R DD	JSR		12 SS DD		CMPB	13 SS DD	BITB
00 50 DD	CLR	10 00 XXX	BPL	14 SS DD	BICB
00 51 DD	COM	10 04 XXX	BMI	15 SS DD	BISB
00 52 DD	INC	10 10 XXX	BHI	16 SS DD	SUB
00 53 DD	DEC	10 14 XXX	BLOS	17 00 00	floating point
00 54 DD	NEG	10 20 XXX	BVC		
00 55 DD	ADC	10 24 XXX	BVS	17 77 77	floating point
00 56 DD	SBC	10 30 XXX	BCC, BHIS		
00 57 DD	TST	10 34 XXX	BCS, BLO		

TRAP VECTORS:

000	(reserved)	114	Memory Parity
004	Time Out & other errors	240	PIRQ, prog int req
010	illegal & reserved instr	244	Floating Point
014	BPT instruction	250	Memory Management
020	IOT instruction		
024	Power Fail		
030	EMT instruction		
034	TRAP instruction		

SINGLE OPERAND: OPR dst



Mnemonic Op Code Instruction dst Result N Z V C

General

CLR(B)	050DD	clear	0	0 1 0 0
COM(B)	051DD	complement (1's)	~d	* * 0 1
INC(B)	052DD	increment	d + 1	* * * -
DEC(B)	053DD	decrement	d - 1	* * * -
NEG(B)	054DD	negate (2's compl)	-d	* * * *
TST(B)	057DD	test	d	* * 0 0

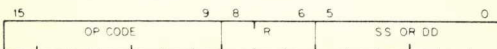
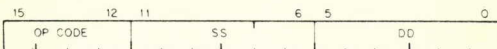
Rotate & Shift

ROR(B)	060DD	rotate right	→ C, d	* * * *
ROL(B)	061DD	rotate left	C, d ←	* * * *
ASR(B)	062DD	arith shift right	d/2	* * * *
ASL(B)	063DD	arith shift left	2d	* * * *
SWAB	0003DD	swap bytes		* * * 0

Multiple Precision

ADC(B)	055DD	add carry	d + C	* * * *
SBC(B)	056DD	subtract carry	d - C	* * * *
▲SXT	0067DD	sign extend	0 or -1	- * 0 -

DOUBLE OPERAND: OPR src, dst OPR src, R or OPR R, dst



Mnemonic Op Code Instruction Operation N Z V C

General

MOV(B)	1SSDD	move	d ← s	* * 0 -
CMP(B)	2SSDD	compare	s - d	* * * *
ADD	06SSDD	add	d ← s + d	* * * *
SUB	16SSDD	subtract	d ← d - s	* * * *

Logical

BIT(B)	3SSDD	bit test (AND)	s ∧ d	* * 0 -
BIC(B)	4SSDD	bit clear	d ← (~s) ∧ d	* * 0 -
BIS(B)	5SSDD	bit set (OR)	d ← s v d	* * 0 -

Register

MUL	070RSS	multiply	r ← r x s	* * 0 *
DIV	071RSS	divide	r ← r/s	* * * *
ASH	072RSS	shift arithmetically		* * * *
ASHC	073RSS	arith shift combined		* * * *
XOR	074RDD	exclusive OR	d ← r ^ d	* * 0 -

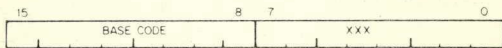
BRANCH: B -- location

If condition is satisfied:

Branch to location,

New PC ← Updated PC + (2 x offset).

adrs of br instr + 2



Op Code = Base Code + XXX

Mnemonic Base Code Instruction Branch Condition

Branches

BR	000400	branch (unconditional)	(always)
BNE	001000	br if not equal (to 0)	$\neq 0$ Z = 0
BEQ	001400	br if equal (to 0)	$= 0$ Z = 1
BPL	100000	branch if plus	$+$ N = 0
BMI	100400	branch if minus	$-$ N = 1
BVC	102000	br if overflow is clear	V = 0
BVS	102400	br if overflow is set	V = 1
BCC	103000	br if carry is clear	C = 0
BCS	103400	br if carry is set	C = 1

Signed Conditional Branches

BGE	002000	br if greater or eq (to 0)	≥ 0 N + V = 0
BLT	002400	br if less than (0)	< 0 N + V = 1
BGT	003000	br if greater than (0)	> 0 Z v (N + V) = 0
BLE	003400	br if less or equal (to 0)	≤ 0 Z v (N + V) = 1

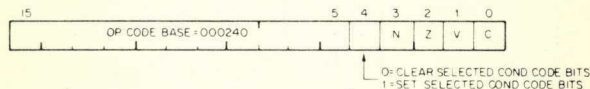
Unsigned Conditional Branches

BHI	101000	branch if higher	$>>>$ C v Z = 0
BLOS	101400	branch if lower or same	$>>>$ C v Z = 1
BHIS	103000	branch if higher or same	C = 0
BLO	103400	branch if lower	C = 1

MISCELLANEOUS:

Mnemonic	Op Code	Instruction
HALT	000000	halt
WAIT	000001	wait for interrupt
RESET	000005	reset external bus (no operation)
NOP	000240	
● SPL	00023N	set priority level (to N)
▲ MFPI	00655S	move from previous instr space
▲ MTPI	0066DD	move to previous instr space
● MFDP	10655S	move from previous data space
● MTPD	1066DD	move to previous data space

CONDITION CODE OPERATORS:



Mnemonic	Op Code	Instruction	N	Z	V	C
CLC	000241	clear C	-	-	-	0
CLV	000242	clear V	-	-	0	-
CLZ	000244	clear Z	-	0	-	-
CLN	000250	clear N	0	-	-	-
CCC	000257	clear all cc bits	0	0	0	0
SEC	000261	set C	-	-	-	1
SEV	000262	set V	-	-	1	-
SEZ	000264	set Z	-	1	-	-
SEN	000270	set N	1	-	-	-
SCC	000277	set all cc bits	1	1	1	1

JUMP & SUBROUTINE:

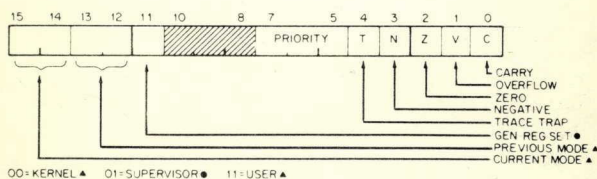
Mnemonic	Op Code	Instruction	Notes
JMP	0001DD	jump	PC ← dst
JSR	004RDD	jump to subroutine	} use same R
RTS	00020R	return from subroutine	
▲ MARK	0064NN	mark		aid in subr return
▲ SOB	077RNN	subtract 1 & br (if ≠ 0)	(R) - 1, then if (R) ≠ 0: PC ← Updated PC - (2 x NN)

TRAP & INTERRUPT:

Mnemonic	Op Code	Instruction	Notes
EMT	104000 to 104377	emulator trap (not for general use)	PC at 30, PS at 32
TRAP	104400 to 104777	trap	PC at 34, PS at 36
BPT	000003	breakpoint trap	PC at 14, PS at 16
IOT	000004	input/output trap	PC at 20, PS at 22
RTI	000002	return from interrupt	
▲ RTT	000006	return from interrupt	inhibit T bit trap

PROCESSOR REGISTER ADDRESSES:

Processor Status Word PS - 777 776



▲ Stack Limit Register — 777 774

● Program Interrupt Request — 777 772

General Registers	R0 — 777 700	R4 — 777 704
(console use only)	R1 — 777 701	R5 — 777 705
	R2 — 777 702	R6 — 777 706
(not for 11/45)	R3 — 777 703	R7 — 777 707

Console Switches & Display Register — 777 570

DEVICE REGISTER ADDRESSES:

Device	Registers	Address	Int Vec-tor	Prior-ity	NPR	Device	Registers	Address	Int Vec-tor	Prior-ity	NPR		
CD11	Card Reader, high speed status & control	(CDST) 777 160	230	BR4	X	RJP04/ Disk RWP04/ control & status #1 RP04 word count	(RPCS1) 776 700	254*	BR5**	X			
	column count	(CDBC) 777 162					(RPWC) 776 702						
	current address	(CDBA) 777 164					(RPBA) 776 704						
	data	(CDDB) 777 166					(RPDA) 776 706						
CR11	Card Reader status	(CRS) 777 160	230	BR6		RH11 control & status	(RPCS2) 776 710						
	buffer, 12-bit char	(CRB1) 777 162					(RPDS) 776 712						
	buffer, 8-bit char	(CRB2) 777 164					(RPER1) 776 714						
KW11-L	Line Clock	(LKS) 777 546	100	BR6		error register #1	(RPER1) 776 714						
	Programmable Clock control & status	772 540	104	BR6		attention summary	(RPAS) 776 716						
KW11-P	count set buffer	772 542				look ahead	(RPLA) 776 720						
	counter	772 544				data buffer	(RPDB) 776 722						
						maintenance register	(RPMR) 776 724						
						drive type	(RPDT) 776 726						
LA30, LA36, LT33, VT05, VT50	Console Terminal keyboard/reader status	777 560	60	BR4		serial number	(RPSN) 776 730						
	keyboard/reader buffer	777 562	64	BR4	offset	(RPOF) 776 732							
	printer/punch status	777 564			desired cylinder	(RPDC) 776 734							
	printer/punch buffer	777 566	current cylinder	(RPCC) 776 736									
			error #2	(RPER2) 776 740									
			error #3	(RPER3) 776 740									
			ECC position	(RPEC1) 776 744									
LP11, LS11, LV11	Line Printer printer status	777 514	200	BR4		ECC pattern	(RPEC2) 776 746						
	printer data	777 516				bus address ext control & status #3	(RPBAE) 776 750†						
PC11	Paper Tape reader status	(PRS) 777 550	70	BR4		RJS04/ Disk control & status #1	(RSCS1) 772 040	204*	BR5**	X			
	reader buffer	(PRB) 777 552	74	BR4	RS04, word count	(RSWC) 772 042							
	punch status	(PPS) 777 554			RJS03, UNIBUS address	(RSBA) 772 044							
	punch buffer	(PPB) 777 556	desired disk adrs	(RSBA) 772 046									
RK11/ RK05	Disk Cartridge drive status	(RKDS) 777 400	220	BR5	X	RH11 control & status	(RSCS2) 772 050						
	error	(RKER) 777 402				drive status	(RSDS) 772 052						
	control & status	(RKCS) 777 404				error	(RSER) 772 054						
	word count	(RKWC) 777 406				attention summary	(RSAS) 772 056						
	current bus adrs	(RKBA) 777 410				look ahead	(RSLA) 772 060						
	disk address	(RKDA) 777 412				data buffer	(RSDB) 772 062						
	data buffer	(RKDB) 777 416				maintenance	(RSMR) 772 064						
						drive type	(RSDT) 772 066						
						bus address ext	(RSBAE) 772 070†						
						control & status #3	(RSCS3) 772 072†						
RF11/ RS11	Disk disk control status	(DCS) 777 460	204	BR5	X	TJU16/ Tape control & status #1	(MTSC1) 772 440	224*	BR5**	X			
	word count	(WC) 777 462				TWU16/ word count	(MTWC) 772 442						
	current mem adrs	(CMA) 777 464				TU16 UNIBUS address	(MTBA) 772 444						
	disk address	(DAR) 777 466				frame count	(MTFC) 772 446						
	disk adrs ext & error	(DAE) 777 470				RH11 control & status	(MTCS2) 772 450						
	disk data buffer	(DBR) 777 472				drive status	(MTDS) 772 452						
	maintenance	(MA) 777 474				error	(MTER) 772 454						
	adrs of disk segment	(ADS) 777 476				attention summary	(MTAS) 772 456						
RP11-C/Disk RP03, RPR11/ RPR02	device status	(RPDS) 776 710	254	BR5	X	check character	(MTCK) 772 460						
	error	(RPER) 776 712				data buffer	(MTDB) 772 462						
	control status	(RPCS) 776 714				maintenance	(MTMR) 772 464						
	word count	(RPWC) 776 716				drive type	(MTDT) 772 466						
	bus address	(RPBA) 776 720				serial number	(MTSN) 772 470						
	cylinder address	(RPCA) 776 722				tape control	(MTTC) 772 472						
	disk address	(RPDA) 776 724				bus address ext	(MTBAE) 772 474†						
	maintenance 1	(RPM1) 776 726				control & status #3	(MTCS3) 772 476†						
	maintenance 2	(RPM2) 776 730				TMA11/ Magnetic Tape status	(MTS) 772 520				224	BR5	X
	maintenance 3	(RPM3) 776 732				TU10, command	(MTC) 772 522						
	selected unit	(SUCA) 776 734				byte record cntr	(MTBRC) 772 524						
	cy adrs					current mem adrs	(MTCMA) 772 526						
silos memory	(SILO) 776 736	data buffer	(MTD) 772 530										
		read lines	(MTRD) 772 532										
RX11/ RX01	Floppy Disk command & status	(RXCS) 777 170	264	BR5		*Jumper Selectable							
	data buffer	(RXDB) 777 172				**Plug Selectable							

† Implemented on PDP-11/70 only

Device	Registers	Address	Int Vec- tor	Prior- ity	NPR
TA11	Cassette command & status data buffer	(TACS) (TADB) 777 500 777 502	260	BR6	
TC11/ TU56	DECTape control & status command word count bus address data	(TCST) (TCCM) (TCWC) (TCBA) (TCDT) 777 340 777 342 777 344 777 346 777 350	214	BR6	X

ABSOLUTE LOADER

Starting Address: — 500
Memory Size: —
4K 017
8K 037
12K 057
16K 077
20K 117
24K 137
28K 157
(or larger)

BOOTSTRAP LOADER

Address	Contents	Address	Contents
— 744	016 701	— 764	000 002
— 746	000 026	— 766	— 400
— 750	012 702	— 770	005 267
— 752	000 352	— 772	177 756
— 754	005 211	— 774	000 765
— 756	105 711	— 776	177 560 (TTY)
— 760	100 376		or 177 550 (PC11)
— 762	116 162		
773 000	Paper Tape Bootstrap		
773 100	Disk/DECTape Bootstrap		
773 200	Card Reader Bootstrap		
773 300	Cassette Bootstrap		
773 400	Floppy Disk Bootstrap		

BM873-YA BOOTSTRAP LOADER:

Starting Address	Device
773 000	RF11
773 010	RK11
773 020	Transfer to address contained in Switch Register
773 030	TC11
773 050	TM11
773 100	RP11
773 144	RC11
773 210	ASR paper tape reader
773 230	TA11
773 312	PC11

MR11-DB BOOTSTRAP LOADER:

Starting Address	Device
773 100	RF11
773 110	RK11
773 120	TC11
773 136	TM11
773 154	RP11
773 220	RC11

BM873-YB BOOTSTRAP LOADER:

Starting Address	Device
773 000	RJS03/RJS04 Disk Unit 0
773 002	RJS03/RJS04 Unit specified in console switch register
773 030	RK11 Disk Unit 0
773 032	RK11 Unit specified in console switch register
773 070	TC11
773 110	TM11
773 136	RF11
773 150	TJU16
773 212	RC11
773 320	RJP04 Disk Unit 0
773 322	RJP04 Unit specified in console switch register
773 344	Transfer to address in console switch register
773 350	RP11 Disk Unit 0
773 352	RP11 Unit specified in console switch register
773 510	KL11/DL11 Console TTY Reader
773 524	TA11 Cassette Unit 0
773 526	TA11 Unit specified in console switch register
773 620	PC11

PDP-11/70 BOOTSTRAP LOADER:

Starting Address 17 765 000

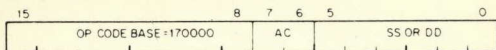
21	8	7	3	2	0
		DEVICE TYPE		UNIT #	

Device Type:	1	TM11	6	TWU16
	2	TC11	7	RWP04
	3	RK11	10	RWS03/4
	4	RP11	11	RX11

7-BIT ASCII CODE:

Octal Code	Char	Octal Code	Char	Octal Code	Char	Octal Code	Char
000	NUL	040	SP	100	@	140	\
001	SOH	041	!	101	A	141	a
002	STX	042	"	102	B	142	b
003	ETX	043	#	103	C	143	c
004	EOT	044	\$	104	D	144	d
005	ENQ	045	%	105	E	145	e
006	ACK	046	&	106	F	146	f
007	BEL	047	'	107	G	147	g
010	BS	050	(	110	H	150	h
011	HT	051	)	111	I	151	i
012	LF	052	*	112	J	152	j
013	VT	053	+	113	K	153	k
014	FF	054	,	114	L	154	l
015	CR	055	-	115	M	155	m
016	SO	056	.	116	N	156	n
017	SI	057	/	117	O	157	o
020	DLE	060	0	120	P	160	p
021	DC1	061	1	121	Q	161	q
022	DC2	062	2	122	R	162	r
023	DC3	063	3	123	S	163	s
024	DC4	064	4	124	T	164	t
025	NAK	065	5	125	U	165	u
026	SYN	066	6	126	V	166	v
027	ETB	067	7	127	W	167	w
030	CAN	070	8	130	X	170	x
031	EM	071	9	131	Y	171	y
032	SUB	072	:	132	Z	172	z
033	ESC	073	;	133	[	173	{
034	FS	074	<	134	\	174	|
035	GS	075	=	135	]	175	}
036	RS	076	>	136	^	176	~
037	US	077	?	137	_	177	DEL

PDP-11/45, 11/70 FLOATING POINT PROCESSOR:



Mnemonic	Op Code	Instruction	Operation
CFCC	170000	copy fl cond codes	
SETF	170001	set floating mode	FD ← 0
SETI	170002	set integer mode	FL ← 0
SETD	170011	set fl dbl mode	FD ← 1
SETL	170012	set long integer mode	FL ← 1
LDFPS	1701 src	load FPP prog status	
STFPS	1702 dst	store FPP prog status	
STST	1703 dst	store (exc codes & adrs)	
CLRF, CLRD	1704 fdst	clear floating/double	fdst ← 0
TSTF, TSTD	1705 fdst	test fl/dbl	
ABSF, ABSD	1706 fdst	make absolute fl/dbl	fdst ← |fdst|
NEGF, NEGD	1707 fdst	negate fl/dbl	fdst ← -fdst
MULF, MULD	171 (AC) fsrc	multiply fl/dbl	AC ← AC x fsrc
MODF, MODD	171 (AC + 4) fsrc	multiply & integerize	
ADDF, ADDD	172 (AC) fsrc	add fl/dbl	AC ← AC + fsrc
LDF, LDD	172 (AC + 4) fsrc	load fl/dbl	AC ← fsrc
SUBF, SUBD	173 (AC) fsrc	subtract fl/dbl	AC ← AC - fsrc
CMPF, CMPD	173 (AC + 4) fsrc	compare fl/dbl (to AC)	
STF, STD	174 (AC) fdst	store fl/dbl	fdst ← AC
DIVF, DIVD	174 (AC + 4) fsrc	divide fl/dbl	AC ← AC / fsrc
STEXP	175 (AC) dst	store exponent	
STCFI, STCFL	175 (AC + 4) dst	{ store & convert fl or dbl to int or long int	
STCDI, STCDL			
STCFD, STCDF	176 (AC) fdst	store & convert (dbl-fl)	
LDEXP	176 (AC + 4) src	load exponent	
LDCIF, LDCID	177 (AC) src	{ load & convert int or long int to fl or dbl	
LDCLF, LDCLD			
LDCDF, LDCFD	177 (AC + 4) fsrc	load & convert (dbl-fl)	

PDP-11/35, 11/40 FLOATING POINT UNIT:

			N	Z	V	C
FADD	07500R	floating add	*	*	0	0
FSUB	07501R	floating subtract	*	*	0	0
FMUL	07502R	floating multiply	*	*	0	0
FDIV	07503R	floating divide	*	*	0	0

POWERS OF 2:

n	2 ⁿ	n	2 ⁿ
0	1	10	1,024
1	2	11	2,048
2	4	12	4,096
3	8	13	8,192
4	16	14	16,384
5	32	15	32,768
6	64	16	65,536
7	128	17	131,072
8	256	18	262,144
9	512	19	524,288