

# **PDP-4/7/9/15 Simulator Usage**

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This memorandum documents the DEC PDP-4, PDP-7, PDP-9, and PDP-15 simulators.

## 1 Simulator Files

To compile a particular model in the 18b family, you must include the appropriate switch in the compilation command line:

```
PDP-4/      PDP4
PDP-7/      PDP7
PDP-9/      PDP9
PDP-15/     PDP15
```

If no model is specified, the default is the PDP-15.

		PDP-4	PDP-7	PDP-9	PDP-15
sim/	sim_defs.h	x	x	x	x
	sim_rev.h	x	x	x	x
	sim_sock.h	x	x	x	x
	sim_tape.h			x	x
	sim_tmxr.h	x	x	x	x
	scp.c	x	x	x	x
	scp_tty.c	x	x	x	x
	sim_sock.c	x	x	x	x
	sim_tape.c			x	x
	sim_tmxr.c	x	x	x	x
sim/pdp18b/	pdp18b_defs.h	x	x	x	x
	pdp18b_cpu.c	x	x	x	x
	pdp18b_drm.c	x	x		
	pdp18b_dt.c	x	x	x	x
	pdp18b_fpp.c				x
	pdp18b_lp.c	x	x	x	x
	pdp18b_mt.c			x	x
	pdp18b_rb.c			x	
	pdp18b_rf.c			x	x
	pdp18b_rp.c				x
	pdp18b_stddev.c	x	x	x	x
	pdp18b_sys.c	x	x	x	x
	pdp18b_tt1.c			x	x

## 2 18b PDP Features

The four 18b PDP's (PDP-4, PDP-7, PDP-9, PDP-15) are very similar and are configured as follows:

system	device name(s)	simulates
PDP-4	CPU	PDP-4 CPU with 8KW of memory
	-	Type 18 extended arithmetic element (EAE)
	PTR, PTP	integral paper tape/Type 75 punch
	TTI, TTO	KSR28 console terminal (Baudot code)
	LPT	Type 62 line printer (Hollerith code)
	CLK	integral real-time clock

	DT	Type 550/555 DECTape
	DRM	Type 24 serial drum
PDP-7	CPU	PDP-7 CPU with 32KW of memory
	-	Type 177 extended arithmetic element (EAE)
	-	Type 148 memory extension
	PTR, PTP	Type 444 paper tape reader/Type 75 punch
	TTI, TTO	KSR 33 console terminal
	LPT	Type 647 line printer
	CLK	integral real-time clock
	DT	Type 550/555 DECTape
	DRM	Type 24 serial drum
PDP-9	CPU	PDP-9 CPU with 32KW of memory
	-	KE09A extended arithmetic element (EAE)
	-	KF09A automatic priority interrupt (API)
	-	KG09B memory extension
	-	KP09A power detection
	-	KX09A memory protection
	PTR, PTP	PC09A paper tape reader/punch
	TTI, TTO	KSR 33 console terminal
	TTIX, TTOX	1-4 LT09A additional terminals
	LP9	LP09 line printer
	LPT	Type 647E line printer
	CLK	integral real-time clock
	RB	RB09 fixed-head disk
	RF	RF09/RS09 fixed-head disk
	DT	TC02/TU55 DECTape
	MT	TC59/TU10 magnetic tape
PDP-15	CPU	PDP-15 CPU with 32KW of memory
	-	KE15 extended arithmetic element (EAE)
	-	KA15 automatic priority interrupt (API)
	-	KF15 power detection
	-	KM15 memory protection
	-	KT15 memory relocation and protection
	-	XVM memory relocation and protection
	FPP	FP15 floating point processor
	PTR, PTP	PC15 paper tape reader/punch
	TTI, TTO	KSR 35 console terminal
	TTIX, TTOX	1-16 LT15/LT19 additional terminals
	LP9	LP09 line printer
	LPT	LP15 line printer
	CLK	integral real-time clock
	RP	RP15/RP02 disk pack
	RF	RF15/RS09 fixed-head disk
	DT	TC15/TU56 DECTape
	MT	TC59/TU10 magnetic tape

Most devices can be disabled or enabled, by the commands:

```
SET <dev> DISABLED
SET <dev> ENABLED
```

The simulator allows most device numbers to be changed, by the command:

```
SET <dev> DEV=<number>
```

However, devices can only be booted with their default device numbers.

The 18b PDP simulators implement several unique stop conditions:

- An unimplemented instruction is decoded, and register STOP\_INST is set
- More than XCT\_MAX nested executes are detected during instruction execution
- An FP15 instruction is decoded, the FP15 is disabled, and register STOP\_FPP is set
- A simulated DECtape runs off the end of its reel, and register STOP\_OFFR is set

The LOAD command supports three different file formats:

- PDP-7/9/15 hardware read-in RIM format files (data only loaded into sequential addresses)
- PDP-4/7 "second stage" RIM format files (alternating DAC address instructions and data)
- PDP-9/15 binary loader format files

The load file format can be specified by switches:

- -R: hardware read-in RIM format
- -S: second stage RIM format
- -B: binary loader format

If no switch is specified, the load file format is determined from the file extension. Files ending in .RIM are assumed to be RIM format (hardware versus second stage is determined from the data); files ending in any other extension are assumed to be binary loader format. Examples:

```
LOAD -R file address      load PDP-9/PDP-15 RIM format file
                           starting at address
LOAD -S file              load PDP-4/PDP-7 RIM format file
LOAD file.RIM address    assume file is RIM, determine type from data
LOAD -B file              load PDP-9/PDP-15 BIN format file
LOAD file.BIN            assume file is PDP-9/PDP-15 BIN format
```

If no address is given for a RIM format load, a starting address of 200 (octal) is assumed.

The DUMP command is not supported.

## 2.1 CPU

The CPU options are the presence of the EAE, the presence of the API and memory protection (for the PDP-9 and PDP-15), the presence of relocation or XVM (PDP-15 only), and the size of main memory.

system	option	comment
all	SET CPU EAE	enable EAE
all	SET CPU NOEAE	disable EAE
9,15	SET CPU API	enable API
9,15	SET CPU NOAPI	disable API
9,15	SET CPU PROT	enable memory protection
15	SET CPU RELOC	enable memory relocation
15	SET CPU XVM	enable XVM relocation
9,15	SET CPU NOPROT	disable protection, relocation, XVM
4	SET CPU 4K	set memory size = 4K
all	SET CPU 8K	set memory size = 8K
all	SET CPU 12K	set memory size = 12K

all	SET CPU 16K	set memory size = 16K
all	SET CPU 20K	set memory size = 20K
all	SET CPU 24K	set memory size = 24K
all	SET CPU 28K	set memory size = 28K
all	SET CPU 32K	set memory size = 32K
15	SET CPU 48K	set memory size = 48K
15	SET CPU 64K	set memory size = 64K
15	SET CPU 80K	set memory size = 80K
15	SET CPU 96K	set memory size = 96K
15	SET CPU 112K	set memory size = 112K
15	SET CPU 128K	set memory size = 128K

Memory sizes greater than 8K are only available on the PDP-7, PDP-9, and PDP-15; memory sizes greater than 32KW are only available on the PDP-15. If memory size is being reduced, and the memory being truncated contains non-zero data, the simulator asks for confirmation. Data in the truncated portion of memory is lost. Initial memory size is 8K for the PDP-4, 32K for the PDP-7 and PDP-9, and 128K for the PDP-15.

The PROT option corresponds to the KX09A on the PDP-9 and the KM15 for the PDP-15. The PROT option is required to run the Foreground/Background Monitor. The RELOC option corresponds to the KT15 on the PDP-15, and the XVM option corresponds to the XM15 on the PDP-15. ADSS-15, ADSS-15 Foreground/Background, and standard DOS-15 will <not> run if these options are enabled.

CPU registers include the visible state of the processor as well as the control registers for the interrupt system.

system	name	size	comments
all	PC	addr	program counter
all	AC	18	accumulator
all	L	1	link
all	MQ	18	multiplier-quotient
all	SC	6	shift counter
all	EAE_AC_SIGN	1	EAE AC sign
all	SR	18	front panel switches
all	ASW	addr	address switches for RIM load
all	INT[0:4]	32	interrupt requests, 0:3 = API levels 0-3 4 = PI level
all	IORS	18	IORS register
all	ION	1	interrupt enable
all	ION_DELAY	2	interrupt enable delay
15	ION_INH	1	interrupt inhibit
9,15	APIENB	1	API enable
9,15	APIREQ	8	API requesting levels
9,15	APIACT	8	API active levels
9,15	BR	18	memory protection bounds
15	XR	18	index register
15	LR	18	limit register
9,15	BR	18	memory protection bounds
15	RR	18	memory protection relocation
15	MMR	18	memory protection control
9,15	USMD	1	user mode
9,15	USMDBUF	1	user mode buffer
9,15	USMDDEF	1	user mode load defer
9,15	NEXM	1	non-existent memory violation

9,15	PRVN	1	privilege violation
7,9	EXTM	1	extend mode
7,9	EXTM_INIT	1	extend mode value after reset
15	BANKM	1	bank mode
15	BANKM_INIT	1	bank mode value after reset
7	TRAPM	1	trap mode
7,9,15	TRAPP	1	trap pending
7,9	EMIRP	1	EMIR instruction pending
9,15	RESTP	1	DBR or RES instruction pending
9,15	PWRFL	1	power fail flag
all	PCQ[0:63]	addr	PC prior to last JMP, JMS, CAL, or interrupt; most recent PC change first
all	STOP_INST	1	stop on undefined instruction
all	XCT_MAX	8	max number of chained XCT's allowed
all	WRU	8	interrupt character

"addr" signifies the address width of the system (13b for the PDP-4, 15b for the PDP-7 and PDP-9, 17b for the PDP-15).

The CPU attempts to detect when the simulator is idle. When idle, the simulator does not use any resources on the host system. Idle detection is controlled by the SET IDLE and SET NOIDLE commands:

```
SET CPU IDLE           enable idle detection
SET CPU NOIDLE        disable idle detection
```

Idle detection is disabled by default. At present, the CPU is considered idle if it is executing a KSF/JMP \*-1 loop with interrupts disabled (DECSYS) or a JMP \* loop (XVM/RXS). There is no idle loop detector for ADSS, F/B, or DOS.

The CPU can maintain a history of the most recently executed instructions. This is controlled by the SET CPU HISTORY and SHOW CPU HISTORY commands:

```
SET CPU HISTORY       clear history buffer
SET CPU HISTORY=0    disable history
SET CPU HISTORY=n    enable history, length = n
SHOW CPU HISTORY     print CPU history
SHOW CPU HISTORY=n  print first n entries of CPU history
```

The maximum length for the history is 65536 entries.

## 2.2 Floating Point Processor (FPP)

The PDP-15 features an optional floating point processor, the FP15 (FPP). The FPP can be enabled and disabled; by default it is disabled.

The FPP implements these registers:

name	size	comments
FIR	12	floating instruction register
EPA	18	EPA (A exponent)
FMAS	1	FMA sign
FMAH	17	FMA<1:17>
FMAL	18	FMA<18:35>
EPB	18	EPB (B exponent)

FMBS	1	FMB sign
FMBH	17	FMB<1:17>
FMBL	18	FMB<18:35>
FGUARD	1	guard bit
FMQH	17	FMQ<1:17>
FMQL	18	FMQ<18:35>
JEA	18	exception address register
STOP_FPP	1	stop if FP15 instruction decoded while FP15 is disabled

## 2.3 Programmed I/O Devices

### 2.3.1 Paper Tape Reader (PTR)

The paper tape reader (PTR) reads data from a disk file. The POS register specifies the number of the next data item to be read. Thus, by changing POS, the user can backspace or advance the reader.

The paper tape reader supports the `BOOT` command. The specific forms recognized vary from system to system:

system	command	comments
4, 7	<code>BOOT PTR</code>	load RIM loader and start it running
4, 7	<code>BOOT -F PTR</code>	load funny format loader and start it running
7	<code>BOOT -H PTR</code>	start hardware RIM load at address given by address switches (ASW)
9, 15	<code>BOOT {-H} PTR</code>	start hardware RIM load at address given by address switches (ASW)

The PDP-4 does not have a hardware read-in mode load capability.

The `ATTACH PTR` command recognizes two switches, `-A` for ASCII mode and `-K` for KSR mode. In ASCII mode, data returned by the read alphabetic command has even parity. This allows normal text files to be used as input to the paper tape reader on the PDP-9 and PDP-15. In KSR mode, data returned by the read alphabetic command has forced ones parity. This allows normal text files to be used as input to the paper tape reader on the PDP-7.

The paper tape reader implements these registers:

name	size	comments
BUF	8	last data item processed
INT	1	interrupt pending flag
DONE	1	device done flag
ERR	1	error flag (PDP-9, PDP-15 only)
POS	32	position in the input file
TIME	24	time from I/O initiation to interrupt
STOP_IOE	1	stop on I/O error

Error handling is as follows:

error	<code>STOP_IOE</code>	processed as
not attached	1	report error and stop

	0	out of tape
end of file	1	report error and stop
	0	out of tape
OS I/O error	x	report error and stop

### 2.3.2 Paper Tape Punch (PTP)

The paper tape punch (PTP) writes data to a disk file. The POS register specifies the number of the next data item to be written. Thus, by changing POS, the user can backspace or advance the punch.

The `ATTACH PTP` command recognizes one switch, `-A` for ASCII mode. In ASCII mode, data is punched with the high order bit clear, and NULL and DEL characters are suppressed. This allows punch output to be processed with normal text editing utilities.

The paper tape punch implements these registers:

name	size	comments
BUF	8	last data item processed
INT	1	interrupt pending flag
DONE	1	device done flag
ERR	1	error flag (PDP-9, PDP-15 only)
POS	32	position in the output file
TIME	24	time from I/O initiation to interrupt
STOP_IOE	1	stop on I/O error

Error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	out of tape
OS I/O error	x	report error and stop

### 2.3.3 Terminal Input (TTI)

On the PDP-7, PDP-9, and PDP-15, the terminal interfaces (TTI, TTO) can be set to one of four modes, KSR, 7P, 7B, or 8B:

mode	input characters	output characters
KSR	lower case converted to upper case, high-order bit set	lower case converted to upper case, high-order bit cleared, non-printing characters suppressed
7P	high-order bit cleared	high-order bit cleared, non-printing characters suppressed
7B	high-order bit cleared	high-order bit cleared
8B	no changes	no changes

The default mode is KSR.

## 2.3.4 Terminal Output (TTO)

The console terminal operates, by default, with local echo. The terminal input can be set to FDX (full duplex), which suppresses local echo.

The terminal input (TTI) polls the console keyboard for input. It implements these registers:

name	size	comments
BUF	8	last data item processed
BUF2ND	5	(PDP-4 only) saved character
INT	1	interrupt pending flag
DONE	1	device done flag
POS	32	number of characters input
TIME	24	input polling interval (if 0, the keyboard is polled synchronously with the line clock)

The terminal output (TTO) writes to the simulator console window. It implements these registers:

name	size	comments
BUF	8	last data item processed
SHIFT	5	(PDP-4 only) letters/figures flag
INT	1	interrupt pending flag
DONE	1	device done flag
POS	32	number of characters output
TIME	24	time from I/O initiation to interrupt

## 2.3.5 Line Printers (LPT, LP9)

The line printers (LPT, LP9) write data to a disk file. The POS register specifies the number of the next data item to be written. Thus, by changing POS, the user can backspace or advance the printer.

LPT is the "default" line printer for a CPU: Type 62 for the PDP-4, Type 647 for the PDP-7 and PDP-9, and LP15 for the PDP-15. LP9 is the LP09 line printer controller for the PDP-9. It may be needed on the PDP-15 to run certain software packages. LP9 is disabled by default.

The Type 62 printer controller implements these registers:

name	size	comments
BUF	8	last data item processed
INT	1	interrupt pending flag
DONE	1	device done flag
SPC	1	spacing done flag
BPTR	6	print buffer pointer
POS	32	position in the output file
TIME	24	time from I/O initiation to interrupt
STOP_IOE	1	stop on I/O error
LBUF[0:119]	8	line buffer

The Type 647 printer controller implements these registers:

name	size	comments
------	------	----------

BUF	8	last data item processed
INT	1	interrupt pending flag
DONE	1	device done flag
ENABLE	1	interrupt enable (PDP-9 only)
ERR	1	error flag
BPTR	7	print buffer pointer
POS	32	position in the output file
TIME	24	time from I/O initiation to interrupt
STOP_IOE	1	stop on I/O error
LBUF[0:119]	8	line buffer

The LP09 printer controller implements these registers:

name	size	comments
BUF	7	output character
INT	1	interrupt pending flag
DONE	1	device done flag
ENABLE	1	interrupt enable
ERR	1	error flag
POS	32	position in the output file
TIME	24	time from I/O initiation to interrupt

The LP15 printer controller implements these registers:

name	size	comments
STA	18	status register
MA	18	DMA memory address
INT	1	interrupt pending flag
ENABLE	1	interrupt enable
LCNT	8	line counter
BPTR	7	print buffer pointer
POS	32	position in the output file
TIME	24	time from I/O initiation to interrupt
STOP_IOE	1	stop on I/O error
LBUF[0:131]	8	line buffer

For all printers, error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	out of tape or paper
OS I/O error	x	report error and stop

### 2.3.6 Real-Time Clock (CLK)

The real-time clock (CLK) frequency can be adjusted as follows:

SET CLK 60HZ	set frequency to 60Hz
SET CLK 50HZ	set frequency to 50Hz

The default is 60Hz.

The clock implements these registers:

name	size	comments
INT	1	interrupt pending flag
DONE	1	device done flag
ENABLE	1	clock enable
TIME	24	clock frequency

The real-time clock autocalibrates; the clock interval is adjusted up or down so that the clock tracks actual elapsed time.

### 2.3.7 Additional Terminals (TTIX, TTOX)

The additional terminals consist of two independent devices, TTIX and TTOX. The entire set is modeled as a terminal multiplexer, with TTIX as the master unit. The additional terminals perform input and output through Telnet sessions connected to a user-specified port. The ATTACH command specifies the port to be used:

```
ATTACH TTIX <port>          set up listening port
```

where port is a decimal number between 1 and 65535 that is not being used for other TCP/IP activities.

The PDP-9 supports 1-4 additional terminals. The PDP-15 supports 1-16 additional terminals. The number of additional terminals can be changed with the command:

```
SET TTIX LINES=n            set number of lines to n
```

The default is one additional terminal.

The additional terminals can be set to one of four modes, KSR, 7P, 7B, or 8B:

mode	input characters	output characters
KSR	lower case converted to upper case, high-order bit set	lower case converted to upper case high-order bit cleared, non-printing characters suppressed
7P	high-order bit cleared	high-order bit cleared, non-printing characters suppressed
7B	high-order bit cleared	high-order bit cleared
8B	no changes	no changes

The default mode is KSR. Finally, each line supports output logging. The SET TTOXn LOG command enables logging on a line:

```
SET TTOXn LOG=filename      log output of line n to filename
```

The SET TTOXn NOLOG command disables logging and closes the open log file, if any.

Once TTIX is attached and the simulator is running, the terminals listen for connections on the specified port. They assume that the incoming connections are Telnet connections. The connections remain open until disconnected either by the Telnet client, a SET TTOXn DISCONNECT command, or a DETACH TTIX command.

Other special commands:

SHOW TTX CONNECTIONS	show current connections
SHOW TTX STATISTICS	show statistics for active connections
SET TTXn DISCONNECT	disconnects the specified line.

The input device (TTIX) implements these registers:

name	size	comments
BUF[0..3/15]	8	last character received
DONE	16	input ready flags, line 0 on right
INT	1	interrupt pending flag
TIME	24	keyboard polling interval

The output device (TTOX) implements these registers:

name	size	comments
BUF[0..3/15]	8	last character transmitted
DONE	16	output ready flags, line 0 on right
INT	1	interrupt pending flag
TIME[0..3/15]	24	time from I/O initiation to interrupt

## 2.4 RP15/RP02 Disk Pack (RP)

RP15 options include the ability to make units write enabled or write locked:

SET RPn LOCKED	set unit n write locked
SET RPn WRITEENABLED	set unit n write enabled

Units can also be set ENABLED or DISABLED.

The RP15 implements these registers:

name	size	comments
STA	18	status A
STB	18	status B
DA	18	disk address
MA	18	current memory address
WC	18	word count
INT	1	interrupt pending flag
BUSY	1	control busy flag
STIME	24	seek time, per cylinder
RTIME	24	rotational delay
STOP_IOE	1	stop on I/O error

Error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	disk not ready
end of file	x	assume rest of disk is zero

OS I/O error            x            report error and stop

## 2.5 Type 24 Serial Drum (DRM)

The serial drum (DRM) implements these registers:

name	size	comments
DA	9	drum address (sector number)
MA	16	current memory address
INT	1	interrupt pending flag
DONE	1	device done flag
ERR	1	error flag
WLK	32	write lock switches
TIME	24	rotational latency, per word
STOP_IOE	1	stop on I/O error

Error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	disk not ready

Drum data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

## 2.6 RB09 Fixed Head Disk (RB)

The RB09 was an early fixed-head disk for the PDP-9. It was superseded by the RF09/RS09. It is disabled by default.

The RB09 implements these registers:

name	size	comments
STA	18	status
DA	20	current disk address
WC	16	word count
MA	15	memory address
INT	1	interrupt pending flag
WLK	20	write lock switches for track groups, 10 tracks per group
TIME	24	rotational delay, per word
BURST	1	burst flag
STOP_IOE	1	stop on I/O error

The RB09 is a data break device. If BURST = 0, word transfers are scheduled individually; if BURST = 1, the entire transfer occurs in a single data break.

Error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	disk not ready

RB09 data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

## 2.7 RF09/RF15/RS09 Fixed Head Disk (RF)

RF09/RF15 options include the ability to set the number of platters to a fixed value between 1 and 8, or to autosize the number of platters from the attached file:

SET RF 1P	one platter (256K)
SET RF 2P	two platters (512K)
SET RF 3P	three platters (768K)
SET RF 4P	four platters (1024K)
SET RF 5P	five platters (1280K)
SET RF 6P	six platters (1536K)
SET RF 7P	seven platters (1792K)
SET RF 8P	eight platters (2048K)
SET RF AUTOSIZE	autosize on ATTACH

The default is AUTOSIZE.

The RF09/RF15 implements these registers:

name	size	comments
STA	18	status
DA	21	current disk address
WC	18	word count (in memory)
CA	18	memory address (in memory)
BUF	18	data buffer (diagnostic only)
INT	1	interrupt pending flag
WLK[0:7]	16	write lock switches for disks 0-7
TIME	24	rotational delay, per word
BURST	1	burst flag
STOP_IOE	1	stop on I/O error

The RF09/RF15 is a three-cycle data break device. If BURST = 0, word transfers are scheduled individually; if BURST = 1, the entire transfer occurs in a single data break.

Error handling is as follows:

error	STOP_IOE	processed as
not attached	1	report error and stop
	0	disk not ready

RF15/RF09 data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

## 2.8 Type 550/555, TC02/TU55, and TC15/TU56 DECtape (DT)

The PDP-4 and PDP-7 use the Type 550 DECtape, a programmed I/O controller. The PDP-9 uses the TC02, and the PDP-15 uses the TC15. The TC02 and TC15 are DMA controllers and programmatically identical. Except for the first five units of the Type 550, PDP-4/7/9/15 DECtape format has 5 18b words in the block header and trailer, like all other DECtapes.

DECtapes drives are numbered 1-8; in the simulator, drive 8 is unit 0. DECtape options include the ability to make units write enabled or write locked.

```
SET DTn WRITEENABLED      set unit n write enabled
SET DTn LOCKED            set unit n write locked
```

Units can also be set ENABLED or DISABLED.

The Type 550, TC02, and TC15 support PDP-8 format, PDP-11 format, and 18b format DECtape images. . ATTACH assumes the image is in 18b format; the user can force other choices with switches:

```
-t          PDP-8 format
-s          PDP-11 format
-a          autoselect based on file size
```

The DECtape controller is a data-only simulator; the timing and mark track, and block header and trailer, are not stored. Thus, the WRITE TIMING AND MARK TRACK function is not supported; the READ ALL function always returns the hardware standard block header and trailer; and the WRITE ALL function dumps non-data words into the bit bucket.

The DECtape controller implements these registers:

system	name	size	comments
all	DTSA	12	status register A
all	DTSB	12	status register B
all	DTDB	18	data buffer
all	INT	1	interrupt pending flag
9,15	ENB	1	interrupt enable flag
all	DTF	1	DECtape flag
7	BEF	1	block end flag
all	ERF	1	error flag
9,15	CA	18	current address (memory location 30)
9,15	WC	18	word count (memory location 31)
all	LTIME	31	time between lines
all	DCTIME	31	time to decelerate to a full stop
all	SUBSTATE	2	read/write command substate
all	POS[0:7]	32	position, in lines, units 0-7
all	STATT[0:7]	18	unit state, units 0-7
all	STOP_OFFR	1	stop on off-reel error

It is critically important to maintain certain timing relationships among the DECtape parameters, or the DECtape simulator will fail to operate correctly.

- LTIME must be at least 6
- DCTIME needs to be at least 100 times LTIME

Acceleration time is set to 75% of deceleration time.

## 2.9 TC59/TU10 Magnetic Tape (MT)

Magnetic tape options include the ability to make units write enabled or or write locked.

```
SET MTn LOCKED          set unit n write locked
SET MTn WRITEENABLED   set unit n write enabled
```

Magnetic tape units can be set to a specific reel capacity in MB, or to unlimited capacity:

```
SET MTn CAPAC=m          set unit n capacity to m MB (0 = unlimited)
SHOW MTn CAPAC           show unit n capacity in MB
```

Units can also be set ENABLED or DISABLED.

The magnetic tape controller implements these registers:

name	size	comments
CMD	18	command
STA	18	main status
CA	18	memory address (in memory)
WC	18	word count (in memory)
INT	1	interrupt pending flag
STOP_IOE	1	stop on I/O error
TIME	24	record delay
UST[0:7]	24	unit status, units 0-7
POS[0:7]	32	position, units 0-7

Error handling is as follows:

error	processed as
not attached	tape not ready; if STOP_IOE, stop
end of file	bad tape
OS I/O error	parity error; if STOP_IOE, stop

### 3 Symbolic Display and Input

The 18b PDP simulators implement symbolic display and input. Display is controlled by command line switches:

```
-a          display as ASCII character
-b          display as three DECSys Baudot packed characters
-c          display as three SIXBIT packed characters
-f          display as three FIODEC packed character
-m          display instruction mnemonics
```

The PDP-15 also recognizes an additional switch:

```
-p          display as packed ASCII (five 7b ASCII characters
           in two 18b words)
```

Input parsing is controlled by the first character typed in or by command line switches:

' or -a	ASCII character
" or -c	three packed SIXBIT characters
alphabetic	instruction mnemonic
numeric	octal number

The PDP-15 also recognizes an additional input mode:

```
# or -p          five character packed ASCII string in two 18b words
```

Instruction input uses standard 18b PDP assembler syntax. There are eight instruction classes: memory reference, EAE, index (PDP-15 only), IOT, operate, LAW, FP15 memory reference (PDP-15 only), and FP15 no operand (PDP-15 only).

Memory reference instructions have the format

```
PDP-4, PDP-7:      memref {I} address
PDP-9:             memref{*} address
PDP-15:            memref{*} address{,X}
```

where I (PDP-4, PDP-7) /\* (PDP-9, PDP-15) signifies indirect reference, and X signifies indexing (PDP-15 in page mode only). The address is an octal number in the range 0 - 017777 (PDP-4, PDP-7, PDP-9, and PDP-15 in bank mode) or 0 - 07777 (PDP-15 in page mode).

IOT instructions consist of single mnemonics, eg, KRB, TLS. IOT instructions may be or'd together

```
iot iot iot...
```

IOT's may also include the number 10, signifying clear the accumulator

```
iot 10
```

The simulator does not check the legality of IOT combinations. IOT's for which there is no opcode may be specified as IOT n, where n is an octal number in the range 0 - 07777.

EAE instructions have the format

```
eae {+/- shift count}
```

EAE instructions may be or'd together

```
eae eae eae...
```

The simulator does not check the legality of EAE combinations. EAE's for which there is no opcode may be specified as EAE n, where n is an octal number in the range 0 - 03777.

Index instructions (PDP-15 only) have the format

```
index {immediate}
```

The immediate, if allowed, must be in the range of -0400 to +0377.

Operate instructions have the format

```
opr opr opr...
```

The simulator does not check the legality of the proposed combination. The operands for MUY and DVI must be deposited explicitly.

The LAW instruction has the format

LAW immediate

where immediate is in the range of 0 to 017777.

FP15 memory reference instructions occupy two successive words and have the format

fpmem{\*} address

where \* signifies indirect addressing. The address is a number in the range 0 - 0377777.

FP15 no operand instructions occupy two successive words and have the format

fpop

The second word is ignored on output and set to 0 on input.

## 4 Character Sets

The PDP-4's console was an ASR-28 Teletype; its character encoding was Baudot. The PDP-4's line printer used a modified Hollerith character set. The PDP-7's and PDP-9's consoles were KSR-33 Teletypes; their character sets were basically ASCII. The PDP-7's and PDP-9's line printers used sixbit encoding (ASCII codes 040 - 0137 masked to six bits). The PDP-15's I/O devices were all ASCII. The following table provides equivalences between ASCII characters and the PDP-4's I/O devices. In the console table, FG stands for figures (upper case).

ASCII	PDP-4 console	PDP-4 line printer
000 - 006	none	none
bell	FG+024	none
010 - 011	none	none
lf	010	none
013 - 014	none	none
cr	002	none
016 - 037	none	none
space	004	000
!	FG+026	none
"	FG+021	none
#	FG+005	none
\$	FG+062	none
%	none	none
&	FG+013	none
'	FG+032	none
(	FG+036	057
)	FG+011	055
*	none	072
+	none	074
,	FG+006	033
-	FG+030	054
.	FG+007	073
/	FG+027	021
0	FG+015	020
1	FG+035	001
2	FG+031	002

3	FG+020	003
4	FG+012	004
5	FG+001	005
6	FG+025	006
7	FG+034	007
8	FG+014	010
9	FG+003	011
:	FG+016	none
;	FG+017	none
<	none	034
=	none	053
>	none	034
?	FG+023	037
@	none	{MID DOT} 040
A	030	061
B	023	062
C	016	063
D	022	064
E	020	065
F	026	066
G	013	067
H	005	070
I	014	071
J	032	041
K	036	042
L	011	043
M	007	044
N	006	045
O	003	046
P	015	047
Q	035	050
R	012	051
S	024	022
T	001	023
U	034	024
V	017	025
W	031	026
X	027	027
Y	025	030
Z	021	031
[	none	none
\	none	{OVERLINE} 056
]	none	none
^	none	{UP ARROW} 035
_	none	UC+040
0140 - 0177	none	none

DECsys Baudot packs the five bit character code, and the figure/letters flag, into six bits as follows:

bits<0:4>            Baudot 5b character code  
bit<5>                0 = letters, 1 = figures