PDP-10 Simulator Usage
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This memorandum documents the DEC PDP-10 simulator.

1 Simulator Files

To compile the PDP-10, you must define VM_PDP10 and USE_INT64 as part of the compilation command line.

sim/	scp.h sim_console.h sim_defs.h sim_ether.h sim_fio.h sim_rev.h sim_sock.h sim_tape.h sim_timer.h sim_tmxr.h scp.c sim_console.c sim_ether.c sim_fio.c sim_sock.c sim_tape.c sim_timer.c sim_tmxr.c
sim/pdp10/	pdp10_defs.h pdp10_cpu.c pdp10_fe.c pdp10_ksio.c pdp10_lp20.c pdp10_mdfp.c pdp10_pag.c pdp10_rp.c pdp10_sys.c pdp10_tu.c pdp10_xtnd.c
sim/pdp11/	pdp11_dz.c pdp11_pt.c pdp11_ry.c pdp11_xu.c

2 PDP-10 Features

The PDP-10 simulator is configured as follows:

```
      device name(s)    simulates


      CPU               KS10 CPU with 1MW of memory
      PAG               paging unit (translation maps)
```

```
UBA             Unibus adapters (translation maps)
FE              console
TIM             timer
PTR,PTP         PC11 paper tape reader/punch
RY              RX211/RX02 floppy disk and two drives
DZ              DZ11 8-line terminal multiplexor (up to 4)
LP20            LP20 line printer
RP              RH11 controller with eight RP04/RP05/RP06/RP07,
                RM03/RM05/RM80 drives
TU              RH11/TM02 controller with eight TU45 drives
XU              DEUNA/DELUA Ethernet controller
```

The PTR, PTP, and RX211 are initially set DISABLED. The DZ11 and LP20 can also be set DISABLED. Some devices support the `SET <device> ADDRESS` command, which allows the I/O page address of the device to be changed, and the `SET <device> VECTOR` command, which allows the vector of the device to be changed. All devices support the `SHOW <device> ADDRESS` and `SHOW <device> VECTOR` commands, which display the device address and vector, respectively.

The PDP-10 simulator implements several unique stop condition:

- Illegal instruction (000) in kernel mode
- Indirect addressing nesting exceeds limit
- Execute chaining exceeds limit
- Page fail or other error in interrupt sequence
- Illegal instruction in interrupt sequence
- Invalid vector pointer in interrupt sequence
- Invalid Unibus adapter number
- Non-existent exec or user page table address

The `LOAD` command supports RIM10B format paper tapes, SAV binary files, and EXE binary files. `LOAD` switches -r, -s, -e specify RIM10, SAV, EXE format, respectively. If no switch is specified, the `LOAD` command checks the file extension; .RIM, .SAV, .EXE specify RIM10, SAV, EXE format, respectively. If no switch is specified, and no extension matches, the `LOAD` command checks the file format to try to determine the file type.

2.1 CPU

The CPU options allow the user to specify standard microcode, standard microcode with a bug fix for a boostrap problem in TOPS-20 V4.1, or ITS microcode:

```
SET CPU STANDARD            standard microcode
SET CPU TOPS20V41           standard microcode with TOPS-20 V4.1 bug fix
SET CPU ITS                 ITS compatible microcode
```

The CPU implements a SHOW command to display the I/O space address map:

```
SHOW CPU IOSPACE            show I/O space address map
```

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

```
name            size        comments

PC              18          program counter
FLAGS           18          processor flags (<13:17> unused)
```

```
AC0..AC17         36          accumulators
IR                36          instruction register
EBR               18          executive base register
PGON              1           paging enabled flag
T20P              1           TOPS-20 paging
UBR               18          user base register
CURAC             3           current AC block
PRVAC             3           previous AC block
SPT               36          shared pointer table
CST               36          core status table
PUR               36          process update register
CSTM              36          CST mask
HSB               18          halt status block address
DBR1              18          descriptor base register 1 (ITS)
DBR2              18          descriptor base register 2 (ITS)
DBR3              18          descriptor base register 3 (ITS)
DBR4              18          descriptor base register 4 (ITS)
PIENB             7           PI levels enabled
PIACT             7           PI levels active
PIPRQ             7           PI levels with program requests
PIIOQ             7           PI levels with IO requests
PIAPR             7           PI levels with APR requests
APRENB            8           APR flags enabled
APRFLG            8           APR flags active
APRLVL            3           PI level for APR interrupt
IND_MAX           8           indirect address nesting limit
XCT_MAX           8           execute chaining limit
PCQ[0:63]         18          PC prior to last jump or interrupt;
                              most recent PC change first
WRU               8           interrupt character
REG[0:127]        36          fast memory blocks
```

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 Pager

The pager contains the page maps for executive and user mode. The executive page map is the memory space for unit 0, the user page map the memory space for unit 1. A page map entry is 32 bits wide and has the following format:

```
bit               content

31                page is writeable
30                entry is valid
29:19             mbz
18:9              physical page base address
8:0               mbz
```

The pager has no registers.

2.3 Unibus Adapters

The Unibus adapters link the system I/O devices to the CPU. Unibus adapter 1 (UBA1) is unit 0, and Unibus adapter 3 is unit 1. The adapter's Unibus map is the memory space of the corresponding unit.

The Unibus adapter has the following registers:

```
name              size        comments

INTREQ            32          interrupt requests
UB1CS             16          Unibus adapter 1 control/status
UB3CS             16          Unibus adapter 3 control/status
```

2.4 Front End (FE)

The front end is the system console. The keyboard input is unit 0, the console output is unit 1. It supports one option:

```
SET FE STOP                   halt the PDP-10 operating system
```

The front end has the following registers:

```
name              size        comments

IBUF              8           input buffer
ICOUNT            32          count of input characters
ITIME             24          keyboard polling interval
OBUF              8           output buffer
OCOUNT            32          count of output characters
OTIME             24          console output response time
```

2.5 Timer (TIM)

The timer (TIM) implements the system timer, the interval timer, and the time of day clock used to get the date and time at system startup. Because most PDP-10 software is not Y2K compliant, the timer implements one option:

```
SET TIM NOY2K                 software not Y2K compliant, limit time
                              of day clock to 1999 (default)
SET TIM Y2K                   software is Y2K compliant
```

The timer has the following registers:

```
name              size        comments

TIMBASE           59          time base (double precision)
TTG               36          time to go (remaining time) for interval
PERIOD            36          reset value for interval
QUANT             36          quantum timer (ITS only)
TIME              24          tick delay
DIAG              1           use fixed tick delay instead of
```

```
                                    autocalibration
```

Unless the DIAG flag is set, the timer autocalibrates; the tick delay is adjusted up or down so that the time base tracks actual elapsed time. This may cause time-dependent diagnostics to report errors.

2.6 PC11 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 requires an unsupported driver under TOPS-10 and is not supported under TOPS-20 or ITS.

The paper tape reader implements these registers:

```
name            size        comments

BUF             8           last data item processed
CSR             16          control/status register
INT             1           interrupt pending flag
ERR             1           error flag (CSR<15>)
BUSY            1           busy flag (CSR<11>)
DONE            1           device done flag (CSR<7>)
IE              1           interrupt enable flag (CSR<6>)
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         STOP_IOE      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
```

2.7 PC11 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 paper tape punch requires an unsupported driver under TOPS-10 and is not supported under TOPS-20 or ITS.

The paper tape punch implements these registers:

```
name            size        comments

BUF             8           last data item processed
CSR             16          control/status register
INT             1           interrupt pending flag
```

```
ERR             1          error flag (CSR<15>)
DONE            1          device done flag (CSR<7>)
IE              1          interrupt enable flag (CSR<6>)
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
```

2.8 DZ11 Terminal Multiplexer (DZ)

The DZ11 is an 8-line terminal multiplexer. Up to 4 DZ11's (32 lines) are supported. The number of lines can be changed with the command

```
SET DZ LINES=n              set line count to n
```

The line count must be a multiple of 8, with a maximum of 32.

The DZ11 supports three character processing modes, 7P, 7B, and 8B:

```
mode  input characters      output characters

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 is 7B, for compatibility with TOPS-20.

The DZ11 supports logging on a per-line basis. The command

```
SET DZ LOG=line=filename
```

enables logging for the specified line to the indicated file. The command

```
SET DZ NOLOG=line
```

disables logging for the specified line and closes any open log file. Finally, the command

```
SHOW DZ LOG
```

displays logging information for all DZ lines.

The terminal lines perform input and output through Telnet sessions connected to a user-specified port. The ATTACH command specifies the port to be used:

```
ATTACH {-am} DZ <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 optional switch -m turns on the DZ11's modem controls; the optional switch -a turns on active disconnects (disconnect session if computer clears Data Terminal Ready). Without modem control, the DZ behaves as though terminals were directly connected; disconnecting the Telnet session does not cause any operating system-visible change in line status.

Once the DZ is attached and the simulator is running, the DZ will listen for connections on the specified port. It assumes that the incoming connections are Telnet connections. The connection remains open until disconnected by the simulated program, the Telnet client, a `SET DZ DISCONNECT` command, or a `DETACH DZ` command.

Other special DZ commands:

```
SHOW DZ CONNECTIONS           show current connections
SHOW DZ STATISTICS            show statistics for active connections
SET DZ DISCONNECT=linenumber  disconnects the specified line.
```

The DZ11 implements these registers:

```
name              size        comments

CSR[0:3]          16          control/status register, boards 0..3
RBUF[0:3]         16          receive buffer, boards 0..3
LPR[0:3]          16          line parameter register, boards 0..3
TCR[0:3]          16          transmission control register, boards 0..3
MSR[0:3]          16          modem status register, boards 0..3
TDR[0:3]          16          transmit data register, boards 0..3
SAENB[0:3]        1           silo alarm enabled, boards 0..3
RXINT             4           receive interrupts, boards 3..0
TXINT             4           transmit interrupts, boards 3..0
MDMTCL            1           modem control enabled
AUTODS            1           autodisconnect enabled
```

The DZ11 does not support save and restore. All open connections are lost when the simulator shuts down or the DZ is detached.

2.9 RH11 Adapter, RP04/05/06/07, RM02/03/05/80 drives (RP)

The RP controller implements the Massbus 18b (RH11) direct interface for large disk drives. RP options include the ability to set units write enabled or write locked, to set the drive type to one of six disk types, or autosize:

```
SET RPn LOCKED                set unit n write locked
SET RPn WRITEENABLED          set unit n write enabled
SET RPn RM03                  set type to RM03 (same as RM02)
SET RPn RM05                  set type to RM05
SET RPn RM80                  set type to RM80
SET RPn RP04                  set type to RP04 (same as RP05)
SET RPn RP06                  set type to RP06
SET RPn RP07                  set type to RP07
SET RPn AUTOSIZE              set type based on file size at attach
SET RPn BADBLOCK              write bad block table on last track
```

The type options can be used only when a unit is not attached to a file. Note that TOPS-10 V7.03 supported only the RP06 and RM03; V7.04 added support for the RP07. TOPS-20 V4.1 also supported only the RP06 and RM03. Units can be set ENABLED or DISABLED. The RP controller supports the BOOT command.

The RP controller implements these registers:

name	size	comments
RPCS1	16	control/status 1
RPWC	16	word count
RPBA	16	bus address
RPCS2	16	control/status 2
RPDB	16	data buffer
RPDA[0:7]	16	desired surface, sector
RPDS[0:7]	16	drive status, drives 0-7
RPER1[0:7]	16	drive errors, drives 0-7
RPHR[0:7]	16	holding register, drives 0-7
RPOF[0:7]	16	offset, drives 0-7
RPDC[0:7]	8	desired cylinder, drives 0-7
RPER2[0:7]	16	error status 2, drives 0-7
RPER3[0:7]	16	error status 3, drives 0-7
RPEC1[0:7]	16	ECC syndrome 1, drives 0-7
RPEC2[0:7]	16	ECC syndrome 2, drives 0-7
RPMR[0:7]	16	maintenance register, drives 0-7
RPMR2[0:7]	16	maintenance register 2, drives 0-7
IFF	1	transfer complete interrupt request flop
INT	1	interrupt pending flag
SC	1	special condition (CSR1<15>)
DONE	1	device done flag (CSR1<7>)
IE	1	interrupt enable flag (CSR1<6>)
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

2.10 RH11 Adapter, TM02 Formatter, TU45 Magnetic Tape (TU)

The magnetic tape simulator simulates an RH11 Massbus adapter with one TM02 formatter and up to eight TU45 drives. Magnetic tape options include the ability to make units write enabled or locked.

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

Units can also be set ENABLED or DISABLED. The TU controller supports the BOOT command.

The magnetic tape controller implements these registers:

```
name            size        comments

MTCS1           16          control/status 1
MTBA            16          memory address
MTWC            16          word count
MTFC            16          frame count
MTCS2           16          control/status 2
MTFS            16          formatter status
MTER            16          error status
MTCC            16          check character
MTDB            16          data buffer
MTMR            16          maintenance register
MTTC            16          tape control register
INT             1           interrupt pending flag
DONE            1           device done flag
IE              1           interrupt enable flag
STOP_IOE        1           stop on I/O error
TIME            24          delay
UST[0:7]        16          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     operation incomplete

OS I/O error    parity error; if STOP_IOE, stop
```

2.11 LP20 DMA Line Printer (LP20)

The LP20 is a DMA-based line printer controller. There is one line printer option to clear the vertical forms unit (VFU):

```
SET LP20 VFUCLEAR           clear the vertical forms unit
```

The LP20 implements these registers:

```
name            size        comments

LPCSA           16          control/status register A
LPCSB           16          control/status register B
LPBA            16          bus address register
LPBC            12          byte count register
LPPAGC          12          page count register
LPRDAT          12          RAM data register
LPCBUF          8           character buffer register
LPCOLC          8           column counter register
LPPDAT          8           printer data register
LPCSUM          8           checksum register
DVPTR           7           vertical forms unit pointer
DVLNT           7           vertical forms unit length
INT             1           interrupt request
```

```
ERR             1          error flag
DONE            1          done flag
IE              1          interrupt enable flag
POS             32         position in output file
TIME            24         response time
STOP_IOE        1          stop on I/O error
TXRAM[0:255]    12         translation RAM
DAVFU[0:142]    12         vertical forms unit array
```

Error handling is as follows:

```
error         STOP_IOE      processed as

not attached    1           report error and stop
                0           out of paper

OS I/O error    x           report error and stop
```

2.12 RX211/RX02 Floppy Disk (RY)

RX211 options include the ability to set units write enabled or write locked, single or double density, or autosized:

```
SET RYn LOCKED              set unit n write locked
SET RYn WRITEENABLED        set unit n write enabled
SET RYn SINGLE              set unit n single density
SET RYn DOUBLE              set unit n double density (default)
SET RYn AUTOSIZE            set unit n autosized
```

The floppy disk requires an unsupported driver under TOPS-10 and is not supported under TOPS-20 or ITS.

The RX211 implements these registers:

```
name            size        comments

RYCS            16          status
RYBA            16          buffer address
RYWC            8           word count
RYDB            16          data buffer
RYES            12          error status
RYERR           8           error code
RYTA            8           current track
RYSA            8           current sector
STAPTR          4           controller state
INT             1           interrupt pending flag
ERR             1           error flag (CSR<15>)
TR              1           transfer ready flag (CSR<7>)
IE              1           interrupt enable flag (CSR<6>)
DONE            1           device done flag (CSR<5>)
CTIME           24          command completion time
STIME           24          seek time, per track
XTIME           24          transfer ready delay
STOP_IOE        1           stop on I/O error
SBUF[0:255]     8           sector buffer array
```

Error handling is as follows:

```
error         STOP_IOE        processed as

not attached      1           report error and stop
                  0           disk not ready
```

RX02 data files are buffered in memory; therefore, end of file and OS I/O errors cannot occur.

2.13 DEUNA/DELUA Ethernet Controller (XU)

XU simulates the DEUNA/DELUA Ethernet controller. The current implementation is a stub and is permanently disabled.

3 Symbolic Display and Input

The PDP-10 simulator implements symbolic display and input. Display is controlled by command line switches:

```
-a                display as ASCII character
-c                display as (sixbit) character string
-p                display as packed (seven bit) string
-m                display instruction mnemonics
-v                interpret address as virtual
-e                force executive mode
-u                force user mode
```

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

```
' or -a           ASCII character
" or -c           sixbit string
# or -p           packed seven bit string
alphabetic        instruction mnemonic
numeric           octal number
```

Instruction input uses standard PDP-10 assembler syntax. There are three instruction classes: memory reference, memory reference with AC, and I/O.

Memory reference instructions have the format

```
memref {@}address{(index)}
```

memory reference with AC instructions have the format

```
memac ac,{@}address{(index)}
```

and I/O instructions have the format

```
io device,{@}address{(index)}
```

where @ signifies indirect. The address is a signed octal number in the range 0 - 0777777. The ac and index are unsigned octal numbers in the range 0-17. The device is either a recognized device mnemonic (APR, PI, TIM) or an octal number in the range 0 - 0177.

The simulator recognizes the standard MACRO alternate mnemonics (CLEAR for SETZ, OR for IORI), the individual definitions for JRST and JFCL variants, and the extended instruction mnemonics.