MB Bit	State	Description
6	0	No effect
6	1	Rewind
7 & 8	00	No effect
	01	200 cpi
	10	556 cpi
	11	800 cpi
9, 10, 11	001	Tape Unit 1
	010	Tape Unit 2
	011	Tape Unit 3
	100	Tape Unit 4
	101	Tape Unit 5
	110	Tape Unit 6
	111	Tape Unit 7
	000	Tape Unit 8

Clear Go
cgo Address 0073

This is a maintenance instruction provided to stop the tape transport.

Magnetic Tape Function
mtf Address xx71

Bits 6 through 11 of the Memory Buffer Register busses are transferred to the MTF Register. If the function is illegal the Tape Control Busy flip-flop is cleared and a restart pulse is sent to tthe computer. If not illegal, the Tape Control Busy flip-flop is set to 1 and a restart pulse is sent. The instruction also clears the Tape Indicate On condition in the tape transport.

The xx bits are decoded as follows:

MB Bit	State	Description
6	0	No change of slice level during read
6	1	Change to low slice level during read
7	0	No EOF
7	1	Write EOF
8	0	Backward
8	1	Forward
9	0	Write
9	1	Read
10	0	Odd Parity
10	1	Even Parity
11	0	Normal block transfer
11	1	Proceed to next block transfer

MULTIPLEXED A-D CONVERTER (TYPE 138/139)

The Type 138 A-D Converter transforms an analog voltage to a binary number, selectable between six and eleven bits. Conversion time is variable, depending upon the number of bits desired and the required system accuracy. Different combinations of switching point accuracy and number of bits can be selected on the front panel.

The table below shows the conversion time as a function of switching point accuracy and number of bits. Normally, the choice is made from on of the times in the diagonal row indicated in the table. Settings shown on the top line give a minimum uncertainty in the switching points for applications such as pulse height analysis. Total conversion error is equal to the maximum switching point error ±1/2 LSB (least significant bit).

Max. Switching	Number of Bits					
Point Error	6	7	8	9	10	11
±0.05%	48 µsec	56	64	72	80	88
±0.1%	30	35	40	45	50	-
±0.2%	18	21	24	27	-	-
±0.4%	15	17.5	20	-	-	-
±0.8%	12	14	-	-	-	-
±1.6%	9	-	-	-	-	-

The table shows the actual conversion time. The minimum time between conversions is the conversion time rounded up to the nearest multiple of PDP-1 cycle times, plus the time required to read out the buffer.

The Type 139 Multiplexer Control permits up to 64 channels of analog information to be applied singly to the input of the Type 138 A-D Converter. The multiplexer can be operated in either the Individual Address of Sequential Address mode. Individual Addressing routes any preselected channel to the converter input. In the Sequential Address mode, an indexing command instructs the multiplexer control to advance the multiplexer channel address by one. In this mode, the multiplexer automatically returns to zero when an advance from the last channel is requested. Sequenced operation can be short-cycled when the number of channels used is less than the maximum.

The Type 138 output is a binary number of seven to twelve bits. When the word length selector is set for N-bit conversion, the readout is N + 1 bits in 2's complement notation. The additional bit is always 1. Thus quantization error is always within one-half the Nth bit. A -10 volt analog input corresponds to the largest negative digital output; a 0 volt input results in the largest possible digital output.

The temperature range for the above accuracies is 20 to 30 degrees Centigrade.

The instructions provided for the Type 138/139 Multiplexed A-D Converter are as follows:
Read Converter Buffer
rcb Address 0031

The contents of the A-D converter output buffer are read into the I/O register. The converter buffer and flag are set to zero.

Convert a Voltage
cad Address 0040

A conversion is initiated in the A-D Converter.

Select Multiplexer
scv Address mm47

The bits mm are used to select up to 64 channels.

Index Multiplexer
icv Address 0060

Indexes the multiplexer channel by one.

AUTOMATIC LINE PRINTER (TYPE 64)

The Type 64 Printer is an on-line printing station capable of operating at a maximum speed of 300 lines per minute. A rotating drum contains 64 rows, each containing 120 identical characters. As the drum rotates to a row position, print hammers are activated to strike certain characters in that row, printing them at various places along the line. As the drum rotates to the next row position, the process is repeated. After one full revolution of the drum, all of the characters required on that line have been printed, and the printer spaces the paper to the next line. Printing and spacing are automatically controlled by the computer, which is connected to the printer through a Control Unit containing the following major circuits:

CHARACTER TRANSFER

These circuits strobe 6-bit characters from the computer into the printer, where they are stored until printed. A flag denotes the status of the process for each character so strobed. If requested by the computer, a signal can also be generated to inform the computer of the completion of a character transfer.

PRINT AND SPACE

This circuitry assists in controlling the printing and spacing sequence initiated by the computer. Upon command, the control unit issues a signal to the printer to commence printing a line. After the line is printed, the control unit assists in spacing the printer to the line commanded by the computer. The printer spaces in the following way: As the automatic spacing sequence starts, a continuous loop of punched, 8-channel tape moves in synchronism with the paper advance mechanism. Each punched character is optically sensed and read into the Control Unit for comparison with a computer-generated character specifying spacing distance. When identity occurs, spacing stops.

TIMING CIRCUITRY

These circuits keep computer and printer in synchronism. Various signals are issued as various operations in both computer and printer are initiated or completed. It should be noted that this circuitry also assists in storing characters in the printer **at the same time** that the printer is printing and spacing.

Three basic instructions are added to the PDP-1 with the installation of this option:

Clear Buffer
clr buf Address 2045

A Clear Buffer instruction is usually issued to the printer control unit prior to the start of any major printing operation. This instruction emulates an LPB 1 pulse and causes the control unit to issue an LPB SBS COMP pulse, a P SBS COMP pulse, and a P IOT pulse, if requested to the computer. The instruction also causes a CLR LPB Flag pulse to be issued, by clearing the LPB Flag flip-flop. In addition, the clr buf instruction is fed through a 5-millisecond delay network to the printer where it clears all buffers.

Load Printer Buffer
lpb Address 0045

The LPB pulse is regenerated as an LPB1 pulse in the control unit and strobes the character bits from the computer, through the control unit, and into printer storage. It sets the LPB Flag to 0 and causes a CHAR TRANS pulse to be sent to the printer.

Print and Space
pas Address 1x45

The PAS signal causes the printer to print the line stored in its buffers and space to the next line (x is decoded to select on of 8 format channels). It sets the End-of-Line flip-flop to the ONE state, and strobes spacing control bits MB9, MB10, and MB11 into the control unit, where they are compared with information sent back by the printer during spacing. When comparison is made, a STOP FORMS signal is issued to the printer, and the PAS Flag flip-flop is set to the ONE state.

STANDARD DEC PROGRAM LIBRARY FOR PDP-1

The standard library is designed to provide the nucleus of a growing system of programs and subroutines for the PDP-1. It consists of two broad categories of programs: (1) General and (2) Maintenance, all of which operate with the Standard PDP-1.

GENERAL

MACRO ASSEMBLY PROGRAM

MACRO is a two-pass assembly program which produces a self-loading, machine language version of a program written in MACRO Symbolic Language. Important features of MACRO include:

Complete macro-instruction facilities with automatic dummy-argument assignment at call-time.

Automatic “constant” and “variable” assignment. Only unique constants are stored.

Symbol assignment printout in alphabetical or numerical order (at programmer option).

Symbol table punchout acceptable by the DDT Program (see below) to allow symbolic debugging.

Informative error printouts.

Automatic repeated assembly of a specified symbolic statement.

Automatic block storage assignment.

Punched block-letter tape labelling.

The MACRO package includes: (1) the Internal Operations Manual with complete, symbolic program lisiting, (2) the Programming Manual and (3) the necessary symbolic and self-loading machine language tapes.

DDT (DEC DEBUGGING TAPE)

This program is a complete symbolic-octal debugging aid. Its operation is controlled from the typewriter. Its major features are:

Ability to read MACRO generated symbol table tapes to allow completely symbolic debugging.

Examination and modification of the contents of selected memory locations.

Block-search according to specified bits within a specified word.

Printout or punchout of specified areas of memory.

Read and compare tape with memory and printout discrepancies.

EXPENSIVE TYPEWRITER

Under typewriter control, this program is capable of editing symbolic tapes by reading a tape into its “buffer”, accepting addition and corrections, and punching out the amended “buffer” contents. It can perform tape-to-tape, tape-to-typewriter, and typewriter-to-tape translations.

UTILITY PROGRAM GROUP

RANDOM, a random number generation subroutine for 18 bits

SINGLEDEC, a single precision floating point package for arithmetic using an 18-bit fraction and an 18-bit exponent

Master Tape Duplicator, a perforated tape duplicator that verifies tape with character count and checksum

DO, a short “Debug in Octal” routine

PUNCHOUT, a routine that saves all non-zero memory

Octal Typeout, a short routine for octal output to typewriter

MAINTENANCE

A complete set of standard test tapes and their description and use is delivered with each PDP-1.

APPENDIX

Abbreviated Instruction List

BASIC INSTRUCTIONS

INSTRUCTION	CODE #	EXPLANATION	OPER. TIME (µsec)
add Y	40	Add C(Y) to C(AC)	10
and Y	02	Logical AND C(Y) with C(AC)	10
cal Y	16	Equals jda 100	10
dac Y	24	Deposit C(AC) in Y	10
dap Y	26	Deposit contents of address part of AC in Y	10
dio Y	32	Deposit C(IO) in Y	10
dip Y	30	Deposit contents of instruction part of AC in Y	10
div Y	56	Divide	40 max
dzm Y	34	Deposit zero in Y	10
idx Y	44	Index (add one) C(Y), leave in Y & AC	10
ior Y	04	Inclusive OR C(Y) with C(AC)	10
iot Y	72	In-out transfer, see below	
isp Y	46	Index and skip if result is positive	10
jda Y	17	Equals dac Y and jsp Y+1	10
jmp Y	60	Take next instruction from Y	5
jsp Y	62	Jump to Y and save program counter in AC	5
lac Y	20	Load the AC with C(Y)	10
law N	70	Load the AC with the number N	5
law-N	71	Load the AC with the number -N	5
lio Y	22	Load IO with C(Y)	10
mul Y	54	Multiply	25 max
opr	76	Operate, see below	5
sad Y	50	Skip next instruction if C(AC) <> C(Y)	10
sas Y	52	Skip next instruction if C(AC) = C(Y)	10
sft	66	Shift, see below	5
skp	64	Skip, see below	5
sub Y	42	Subtract C(Y) from C(AC)	10
xct Y	10	Execute instruction in Y	5+
xor Y	06	Exclusive OR C(Y) with C(AC)	10

OPERATE GROUP

cla	760200	Clear AC	5
clf	76000f	Clear selected Program Flag (f = flag #)	5
cli	764000	Clear IO	5
cma	761000	Complement AC	5
hlt	760400	Halt	5
lap	760100	Load AC with Program Counter	5
lat	762200	Load AC from Test Word switches	5
nop	760000	No operation	5
stf	76001f	Set selected Program Flag	5

IN-OUT TRANSFER GROUP

PERFORATED TAPE READER

rpa	720001	Read Perforated Tape Alphanumeric
rpb	720002	Read Perforated Tape Binary
rrb	720030	Read Reader Buffer

PERFORATED TAPE PUNCH

ppa	720005	Punch Perforated Tape Alphanumeric
ppb	720006	Punch Perforated Tape Binary

ALPHANUMERIC ON-LINE TYPEWRITER

tyo	720003	Type Out
tyi	720004	Type In

SEQUENCE BREAK SYSTEM TYPE 120

esm	720055	Enter Sequence Break Mode
lsm	720054	Leave Sequence Break Mode
cbs	720056	Clear Sequence Break System
dsc	72kn50	Deactivate Sequence Break Channel
asc	72kn51	Activate Sequence Break Channel
isb	72kn52	Initiate Sequence Break
cac	720053	Clear All Channels

HIGH SPEED DATA CONTROL TYPE 131

swc	72x046	Set Word Counter
sia	720346	Set Location Counter
sdf	720146	Stop Data Flow
rlc	720366	Read Location Counter
shr	720446	Set High Speed Channel Request

PRECISION CRT DISPLAY TYPE 30

dpy	720007	Display One Point

SYMBOL GENERATOR TYPE 33

gpl	722027	Generator Plot Left
gpr	720027	Generator Plot Right
glf	722026	Load Format
gsp	720026	Space
sdb	722007	Load Buffer, No Intensity

ULTRA-PRECISION CRT DISPLAY TYPE 31

dpp	720407	Display One Point on Ultra Precision CRT

CARD PUNCH CONTROL TYPE 40-1

lag	720044	Load a Group
pac	720043	Punch a Card

CARD READER TYPE 421

rac	720041	Read Card Alpha
rbc	720042	Read Card Binary
rcc	720032	Read Card Column

PROGRAMMED MAGNETIC TAPE CONTROL TYPE 51

msm	720073	Select Mode
mcs	720034	Check Status
mcb	720070	Clear Buffer
mwc	720071	Write a Character
mrc	720072	Read Character

AUTOMATIC MAGNETIC TAPE CONTROL TYPE 52

muf	72ue76	Tape Unit and FinalT
mic	72ue75	Initial and Command
mrf	72u067	Reset Final
mri	72ug66	Reset Initial
mes	72u035	Examine States
mel	72u036	Examine Location
inr	72ur67	Initiate a High Speed Channel Request
ccr	72s067	Clear Command Register