

A special reprint for

IMLAC CORP.

PDS Graphic Display Computer

Needham MA 02194

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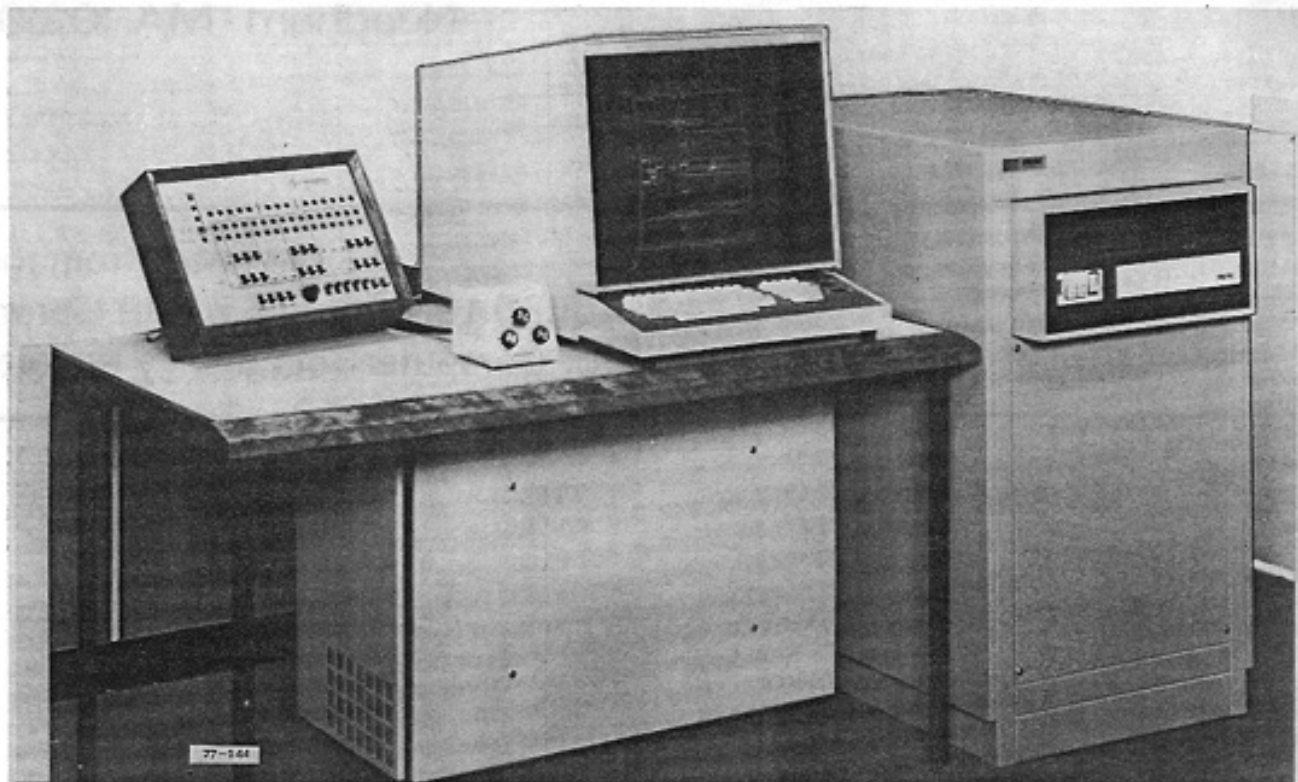


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IMLAC CORP.

PDS Graphic Display Computer



OVERVIEW

Imlac Corporation (founded in 1968) is a manufacturer of interactive intelligent graphic display systems. It has marketed the PDS-1 Graphic Display Computer since 1970 and the PDS-4 system since 1974. The PDS systems are programmable stand-alone or terminal graphics processors. Internally, the systems consist of two independent processors which use system memory in common:

- The main processor (a minicomputer manufactured by Imlac), which performs file I/O, field calculation, and other support functions.
- The display processor, which may be programmed in its own Assembly language to generate the screen displays.

The basic PDS-1, which sells for \$8,300, consists of a 15-inch display screen, an operator keyboard, 4K words of memory, the display and main processors, and an interface for telecommunications. A basic PDS-4, which sells for \$17,300, consists of similar components, with a 17-inch screen, faster main memory, and a more powerful display processor. A full complement of software is supplied with all systems, including a FORTRAN compiler (disk systems only), Assembler,

linking programs, and debugging aids. Also available is a floppy disk system comprising a controller, interface and up to four IBM 3740 compatible disk drives.

For systems sold with cartridge disks, Imlac provides a full disk operating system with file access facilities and support of the programming languages. For systems which use the telecommunication interface, a set of interactive operating software is available, including graphic terminal control programs on the PDS systems and a set of FORTRAN callable support subroutines for the host computer.

To date, some 600 PDS systems have been delivered. Table 1 presents the specifications of the systems.

HEADQUARTERS

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Table 1. PDS System Specifications

CENTRAL PROCESSOR	
Type	16-bit minicomputer
Instructions	43 (PDS-1), 68 (PDS-4)
Main memory size (words)	4K to 32K (PDS-1); 4K to 64K (PDS-4)
Memory cycle time	1 microsecond (PDS-4), 1.8 microsecond (PDS-1)
Memory protection	Optional
Floating point	Optional
Real-time clock	Optional
Interrupt	1 standard, 2 optional
Direct Memory Access (DMA) channel	Optional
Power failure protection	Standard
DISPLAY	
Attachment limits	1 standard, up to 4 independent display processors and screens
Display points	1,024 by 1,024 (PDS-1) 2,048 by 2,048 (PDS-4)
Beam intensities	1 standard, 16 optional (PDS-1) 16 standard (PDS-4)
Hardware blink	optional (PDS-1), standard (PDS-4)
Virtual paging	4 pages (opt: PDS-1), 4 pages (standard: PDS-4)
Character generation	96 characters, upper/lower case
KEYBOARD	
Type	Typewriter with numeric pad
Function keys	16 standard, 36 optional
Light pen	Optional
Joystick	Optional
Trackball	Optional
CARTRIDGE DISC	
Attachment limits	0 to 4
Capacity per unit	10 megabytes
Random access time	35 millisecc, average
Transfer rate	180K bytes/sec
Transfer mechanism	DMA
OTHER OPTIONAL PERIPHERALS	
Printer	30 cps or 70 lpm, 132 columns
Plotter/printer	26 sec/plot, 500 lpm
Floppy disk	Up to 4 units (only for PDS-4). IBM compatible
Magnetic tape	Up to 4 tape transports; 9-track, 800 bpi, 12.5 or 37.5 ips
Cassette	120 cps
Paper tape reader	300 cps
Paper tape punch	75 cps
Graphic hardcopy device	8 by 8 inches
Data tablet	14 by 14 to 72 by 72 inches

COMPATIBILITY

All peripherals of PDS Systems are compatible with all PDS mainframes, allowing upgrade from a PDS-1 to a PDS-4. PDS-1 software is also upward compatible with that of the PDS-4. However, the PDS-4 supports additional display generation commands and its software is not, in general, compatible with PDS-1 software.

For PDS systems which use telecommunications, Imlac provides software to communicate with most timesharing systems. Under local program control, the user may specify transmission speed, character parity, and character echoing. Emulators are also available for Tektronix 4010 and 4014 Graphic Terminals.

As part of its standard peripheral options, Imlac has developed a number of direct connection interfaces to most popular minicomputers and some mainframe computers.

PERFORMANCE AND COMPETITIVE POSITION

Imlac was one of the first companies to produce and market stand-alone intelligent graphic systems. The only product line of the company is and always has been graphic-based systems.

The principal difference between the PDS-1 and PDS-4 systems is one of throughput, or graphing rate, and graph sophistication. The PDS-4 uses main memory with a cycle time under 1 microsecond, where the PDS-1 uses 1.8-microsecond memory. A larger display screen is provided as a standard element of the PDS-4 than for the PDS-1, and the display processor of the larger system allows for twice the number of addressable points in both the X and Y directions. The PDS-1 has one display intensity value, and the PDS-4 has sixteen (optional on the PDS-1), which may be associated with any figure on the screen under program control. Hardware blink and virtual paging are optional on the PDS-1 and standard on the PDS-4.

A number of display options are available for the PDS-4 only: a special instruction set provides for display processor scaling, rotation, translation and windowing; an automatic increment feature allows rapid display of very compact data lists. Both units offer an arc generation hardware option and may support multiple independent display monitors.

Over the years, a number of competitors have entered the programmable graphic system market, but Imlac has maintained its position of offering programmable graphics systems at a low cost. To date the minicomputer based competitor with the closest price to the Imlac equipment is the Tektronix 4081 Interactive Graphic Computing System, priced at \$27,000. Recently, microprocessor-based programmable graphic systems have also been announced, principally the Tektronix 4051 BASIC Graphic Computer System (priced under \$8,000), but these devices do not have the display power or peripheral capability of the Imlac systems.

Generally, higher priced programmable graphic systems offer faster processors, faster display rates, larger display areas, or specialized functions such as windowing, reflections, circle and ellipse generators, or three dimensional software. To a certain extent, the relatively low price of the Imlac equipment may be attributed to the use of its own minicomputer.

USER REACTION

Users were interviewed from the engineering, electronics, and medical fields. They were unanimous in stating that the PDS systems had met their objectives, and had proven to be a cost-effective solution to the wide range of applications. Typical user configurations were basically of two sorts:

- A small PDS system configured (often by direct connec-

tion to a general-purpose minicomputer) as a smart graphic terminal.

- A stand-alone disk-based configuration, usually with some telecommunication connection to a remote host computer.

Most users programmed PDS systems in Assembly language or by using host facilities provided by Imlac. FORTRAN is usually preferred by users with disk systems; one user has developed a cross assembler for his host minicomputer. Another user found that the program editing software provided by Imlac was very good, and he uses it as a word-processing system for manual documentation.

Equipment reliability was rated good to excellent by the users. A large number of them performed their own hardware maintenance; the rest used standard Imlac service contracts.

Engineering. One user, an engineering consultant, has a PDS-4 system with a disk and line printer. He uses the system to develop a series of power plant control displays for the electric utility market. The Imlac system was chosen over faster screen displays because of the amount of alphanumeric data which could be displayed on the screen, and it was selected over other graphic systems, such as Vector General, IDI, and Evans and Sutherland, on the basis of cost effectiveness.

The power plant displays make heavy use of both alphanumeric and schematic diagram data as control information for the plant operator. The development work done on the first PDS system was sufficiently successful; additional units were built to the firm's own specifications. Recommendations have been made to place the PDS in a number of power plant control rooms around the world.

Research. A large western university has a number of PDS systems installed in various departments; the bulk of the work is done in the field of medicine. The systems, both PDS-1 and PDS-4, are connected to a large central IBM computer, and typically use emulation software for IBM graphic devices such as the 2250. Here, the Imlac equipment was chosen for its cost effectiveness.

A gamut of both experimental and operational application is running on PDS systems: graphical data reduction of EEG recordings for brain function analysis, pulmonary physiology studies for emphysema research, a very large package of statistical programs used in such departments as mental retardation studies, radiation treatment planning, and an "excellent version of Star Trek." These units are mainly small configurations with few peripherals. The host computer is relied upon for application processing with only graph manipulation occurring at the PDS system.

Simulation Applications. A number of other users were employing PDS systems as graphic control terminals in simulation applications. Two users had flight training systems operational where the PDS system was directly connected to a general-purpose minicomputer. In both systems, the PDS was used as the instructor's display and was used to continuously update training history and simulated radar information.

Another PDS-4 is directly connected to a Data General NOVA minicomputer. It is used by the U.S. Navy to verify operational communications links and protocols. The screen is used in a fashion similar to the standard tactical display screens for exercising, emulating, and verifying communication traffic.

CONFIGURATION GUIDE

The standard PDS system consists of a display screen with display processor that shares memory with the minicomputer, a main processor (16-bit minicomputer), a keyboard, and an RS-232 interface.

The basic PDS-1G includes the graphic display processor, a 15-inch display screen (17- or 21-inch screens are optional), a minicomputer with 4,096 words of memory, an alphanumeric keyboard with programmable function keys, ROM bootstrap for program loading and an RS-232 interface for modems or asynchronous devices (75-600,000 baud). The PDS-1G-8 includes all the above plus an additional 4,096 words of memory.

The basic PDS-4 includes a graphic display processor, a 17-inch display screen (15- or 21-inch screens are optional), a minicomputer with 4,096 words of memory, an alphanumeric keyboard with programmable function keys, a ROM bootstrap for program loading, and an RS-232 interface for modems or asynchronous devices (75-600,000 baud). The PDS-4-8 includes all the above plus an additional 4,096 words of memory.

The basic systems may have the following added to them: memory up to a total of 32K words, three independent display monitors and keyboards, a number of specialized display options, and a variety of peripheral devices (a cartridge disc, a floppy disk unit (PDS-4), paper tape equipment, magnetic or cassette tape drive, a hard copy unit, printers or printer/plotters and a graphical digitizing tablet).

Mainframe

The central, or main, processor is a 16-bit minicomputer with a .99-microsecond (PDS-4) or 1.8-microsecond (PDS-1) cycle time. It includes 4,096 words as standard, and a maximum of 32K words (PDS-1G) or 64K words (PDS-4). The processor has one interrupt level; another interrupt level is added if a direct memory access (DMA) option is used.

The display processor operates on a cycle-stealing basis using the system main memory; its speed is governed by main memory speed on each model. Operationally, the main processor loads or constructs a display program for the display processor and instructs it to execute the display program. The display processor draws the graphic display, based on the contents of its current display program. The display generation occurs simultaneously with other operations by the main processor.

Optional features may be selected for memory protection, floating point arithmetic, a real-time clock, a DMA channel (with additional interrupt), display arc generation hardware,

scaling, rotation and windowing hardware (PDS-4 only), parallel or serial I/O channels, a programmer console, and special direct interfaces to a number of other computers.

PERIPHERALS

A variety of peripherals are available for the PDS graphic systems; Table 1 lists auxiliary storage limitations.

Cartridge Disk. The disk file system consists of a single disk drive of two platters, one fixed and one removable, with a total subsystem storage capacity of 10 megabytes. Data transfer is at the rate of 180K bytes per second, with a random access time of 35 milliseconds. Disk transfers occur through the system DMA channel. Systems with disks are provided with the Imlac Disk Operating System.

Magnetic Tape. Units are available to support both 1200- and 2400-foot reels, using 9-track tape recording at 800 bpi. Transport speed is 12.5 or 37.5 ips.

Floppy Disk. Dual floppy disk drives may be attached to the PDS-4. The units operate across the DMA channel. This floppy disk system comprises a controller, interface, and up to four IBM 3740-compatible disk drives. Minimum system requirements for use with the system is 16K bytes of core memory.

Cassette. A read/write cassette drive is available for recording at 120 cps.

Paper Tape Equipment. A photoelectric paper tape reader, operating at 300 cps, and a paper tape punch, operating at 75 cps, are available.

Graphic Hardcopy Device. This optional unit creates a permanent exact copy of the display screen on an 8-inch-square sheet. It may be connected directly to the system display or driven as an independent display.

Digitizers. A data tablet with a 14- or 72-inch square surface is available, as well as a graphic mouse for the digitizing of input. Both a joystick and lightpen are available.

Printers. Printers (132 column) operating at 30 cps or 70 lpm are available. A 500 lpm printer plotter is also offered.

DATA COMMUNICATIONS

Communications on the PDS systems are performed using a standard serial asynchronous I/O port. Standard asynchronous protocols are supported — as well as transmission speeds from 110 to 4800 baud. Transmission speed, parity selection, echoing and termination character selection may all be specified by the operator. On the PDS-4, a high-speed serial communication feature is available which buffers transmission of a word, rather than a byte, between the main processor and the modem.

A number of software utilities are provided for operation in a communication environment. LINDI (line to disk) is a timesharing line/disk program which operates under the Disk Operating System and allows interaction between the PDS system and any timesharing host computer. LINDI provides for transmission from or to either the display screen or a specified disk file with selection of destination under the control of the operator. Thus the user may perform a normal CRT terminal screen interaction with a timesharing system and, at appropriate times, receive a stream of data onto a disk file for further analysis or graphic display.

The Terminal Interface System (TIS) is a software program which was developed in conjunction with the Graphic Compatibility System (GCS) of the U.S. Military Academy. It provides support on the PDS system for functions generated by a set of FORTRAN callable subroutines of the GCS system. Under TIS, the PDS system can emulate a timesharing interactive terminal, can execute GCS graphic output commands, and can construct graphic displays either when connected to GCS or in stand-alone mode.

SOFTWARE

Imlac offers a complete series of standard utility and support software packages. Software modules are designed to support all system configurations. In addition, Imlac provides a set of interactive software, on both the PDS and host systems.

For local processing, Imlac offers a resident, disk-based FORTRAN compiler, which may operate in as little as 16K words of memory. A number of important extensions have been provided within the language to allow for the construction of graphic displays; display variable declarations; point, line, and character display orders, and other display management functions are provided to the user through verb extensions. The compiler runs by generating assembler language output, which may then be run through the native assembler to generate an object program.

In addition to supporting minicomputer codes, the native assembler includes a special set of codes to specify display processor programs. Output may be either in absolute or relocatable format, and a relocatable loader is provided. Cross assemblers are also available for host machines. Other standard software components include an editor, debugging programs, and peripheral utilities.

For PDS systems equipped with disks, a Disk Operating System is standard. The disk operating system consists of a monitor, which is used to invoke system or user programs, and a set of disk access functions to operate with the local database. The system also supports a 'run control file' in which a series of operator commands may be automatically invoked in sequence. A full set of utility programs are available, including file and volume copying, disk to printer, file packing and unpacking, and storage allocation maintenance.

MAINTENANCE

Imlac offers standard maintenance contracts directly nationwide, on an 8-hour, 5-day-week basis. System maintenance is priced at the rate of 0.9% per month of system purchase price.

PRICE DATA

Imlac Corp. supplies only purchase prices; monthly maintenance prices can be calculated by multiplying purchase price by .009 and monthly rental prices can be calculated by multiplying purchase price by .044 (one year lease rate).

PRICE DATA

Model No.	Description	Purchase Price (Maint. not incl) \$	Model No.	Description	Purchase Price (Maint. not incl) \$
			CON-1	Programmer/maintenance control panel	1,500
PDS-1G	GRAPHIC DISPLAY PROCESSOR 15-in. high resolution, high contrast CRT general-purpose mini-computer with 4,096, 16-bit words of 1.8-μsec memory. A/N keyboard with programmable function keys, read-only memory bootstrap program, RS-232 interface for both modem and TTY Devices (speeds from 75-600,000 baud)	8,500	IEI-1	16-bit parallel programmable I/O with external interrupt	580
PDS-1G-8	Includes all of the above features plus an additional 4,096 words of memory	10,500	DSH-3	Switch & electronics to allow either of 2 PDS-1Gs to be master or slave	500
	CRT DISPLAY OPTIONS		PERIPHERAL INTERFACES & DEVICES		
SLM-1	15-in. CRT additional display monitor (addition of MCI-1 makes unit independently addressable)	2,300	ASR-1	Printer, keyboard, paper tape reader and punch unit	5,000
SLM-2	17-in. CRT additional display monitor (addition of MCI-1 makes unit independently addressable)	2,750	CBS-1	Read/write cassette	890
SLM-3	21-in. CRT additional display monitor (addition of MCI-1 makes unit independently addressable)	3,750	PTR-1	IMLAC paper tape reader interface	685
SLM-4	21-in. 4-color CRT display monitor includes interface and 15 feet of cable (in addition to 15-in. CRT supplied)	27,000	TRD-1	High-speed paper tape reader (300 cps)	1,890
MON-1	17-in. CRT instead of standard 15-in. CRT (incremental cost)	890	PTP-1	Facit paper tape punch interface	685
MON-2	21-in. CRT instead of standard 15-in. CRT (incremental cost)	1,600	TPH-1	High-speed paper tape punch (75 cps)	2,400
MON-3	21-in., 4-color CRT display in lieu of the standard 15-in. CRT (incremental cost)	26,000	MTS-1	Magnetic tape controller and one MTU-1 tape transport	10,490
PHO-12	Optional P-12 phosphor instead of standard P-39	260	MTS-2	Magnetic tape controller and one MTU-2 tape transport	9,500
	DISPLAY PROCESSOR OPTIONS		MTS-3	Magnetic tape controller and one MTU-3 tape transport	12,500
GRP-1	Graphic hardware expansion package (includes LVH-1, MDS-1, and SGR-1)	2,550	MTU-1	Magnetic tape transport, 9-track, 10.5-in. reel, 800 bpi, 37-1/2-in. ips recording rate, NRZI	6,100
GRP-2	High-speed graphic hardware package (includes LVH-2, MDS-1, and SGR-1)	3,675	MTU-2	Magnetic tape transport, 9-track, 7-in. reel, 800 bpi, 12-1/2-in. ips recording rate, NRZI	4,725
SRT-1	Programmable two-dimensional scale, rotate, translate, and window module for all graphic entities	5,200	MTU-3	Magnetic tape transport, 9-track, 10.5-in. reel, 1600 bpi, 25-in. ips	7,000
MIC-1	Manual image control for image magnification and positioning	950	DSC-1	Disc file controller controls up to 4 DSF-2 or DSF-3 disk drives	4,400
MDS-1	8-Level display subroutine hardware feature	575	DSF-2	Disk drive, 5M bytes IBM-2315-type removable cartridge plus a non-removable recording surface	8,300
SRG-1	Fast X, Y vector generator (suppressed grid)	550	DSF-3	Disk drive double density, 10M bytes	9,800
ASG-1	Auto incrementing suppressed grid plotting	650	DSF-1C	Disk file cartridge for use with DSF-2 or DSF-3	195
PPM-1	Fast point plot mode	860	HCY-3	Graphic hardcopy device	6,275
CPI-1	Interface only for 4-color CRT display CPS-8001 or equal	2,100	PRT-3	Low-speed serial impact printer, 30 char/sec	4,885
MCI-1	Monitor control interface (for up to four independent display monitors)	800	PRT-4	Low-speed line printer, impact type, 70 lpm	3,675
LVH-1	Long vector generation hardware	2,200	PRT-6	Raster Printer/Plotter, Electrostatic type, print mode; 500 lpm maximum	14,595
LVH-2	High-speed long vector generation hardware	3,050	PRT-7	Raster Printer/Plotter Interface	3,675
	MINI-COMPUTER OPTIONS		GRAPHIC DISPLAY SYSTEM		
MEM-1G	Memory module 4K (factory installed)	2,900	PDS-4	The basic PDS-4 system includes a general-purpose 16-bit minicomputer with 4,096 16-bit words of 990-nanosecond memory (expandable to 32K words); display processor which shares memory with minicomputer; refreshed 17-in. diagonal CRT; alpha-numeric keyboard with 67 keys including 6 user-definable function keys; communications modem interface; and read-only memory (ROM) bootstrap for program loading	17,300
MEM-2G	Memory module 8K (factory installed)	4,500	PDS-4-8	Includes all basic PDS-4 features plus an additional 4,096, 16-bit words of memory	18,900
MEM-3G	Field upgrade of a 4K memory module	3,300	PDS-4/L	Includes all basic PDS-4 features plus 16K of core memory expandable to 64K in 16K increments.	22,700
MEM-5G	Field upgrade of 8K memory module	4,900	PDS-4/SL	A 16K, PDS-4/L configured primarily for stand-alone or application development requirements. Standard features of a PDS-4/SL are an ex-	32,800
ROM	Read-only memory bootstrap	370			

PRICE DATA (Contd.)

Model No.	Description	Purchase Price (Maint. not incl) \$	Model No.	Description	Purchase Price (Maint. not incl) \$
	panded keyboard, 21" monitor (in place of 17-in.), Joystick and Flexible Diskette. The system is expandable to 64K core memory in 16K increments.		DMA-42	Direct memory access channel for each additional device; includes backplane wiring, control and data buffering logic, and 2 20-foot cables with terminating connectors (up to 3 DMA-42s can be included in a system)	790
PDS-4/DL	Similar to PDS-4/L except that system includes 21-in. monitor, extended keyboard, and 2-D rotational hardware (rack mount version only, includes RCK-41).	31,200	DMA-42-F	Direct memory access channel for each additional device (field up-grade, standard installation charges apply)	1,100
	DISPLAY MONITOR OPTIONS		ROM	Additional or special read-only memory bootstrap program cards	385
SLM-41	Additional slave display monitor, 15-in. CRT/diagonal with 15 feet of cable	2,450	RMX-41	ROM switch to select one of up to 4 total ROMs (extra ROMs not included)	500
SLM-42	Additional slave display monitor, 17-in. CRT/diagonal with 15 feet of cable	2,890	IEI-41	Programmed I/O for 16-bit parallel data transfer, interrupt driven includes backplane wiring, data buffering, logic, and a 20-foot cable with terminating connector; up to 4 IEI-41s may be included in a system including those provided with each DMA channel	580
SLM-43	Additional slave display monitor, 21-in. CRT/diagonal with 15 feet of cable	3,950			
SLM-45	Additional 17-in., 4 color CRT Display Monitor, includes interface and 15 feet of cable	16,900	ACI-41	Real-time clock	890
SLM-46	Additional 21-in., 4 color CRT Display Monitor, includes interface and 15 feet of cable	18,500	PMP-41	Programmable memory protect	1,200
MON-42	21-in. CRT display monitor, in lieu of standard 17-in. monitor	1,680	FPM-42	Floating point arithmetic module	9,500
MON-44	17-in., 4 color CRT Display Monitor, in lieu of standard 17-in. Monitor, includes interface and 15 feet of cable	15,700	DSH-44	Installation of a DSH-44 in a PDS-4 makes it a "main" machine in a Disk Share system. This allows its disk resources to be used by a satellite PDS-4. Only one DSH-44 can be installed in a PDS-4.	2,000
MON-45	21-in., 4 color CRT Display Monitor, in lieu of standard 17-in. Monitor, includes interface and 15 feet of cable	17,300	DSH-45	When installed in a "main" machine DSH-45 allows additional satellite (2nd or 3rd) to use disk resources of "main" machine in a Disk Share system. Each satellite must have DSH-46.	1,260
PHO-41	Optional P-41 Phosphor instead of standard P-39	275	DSH-46	When installed in a PDS-4, allows it to become a satellite in a Disk Share system and use the disk resources of the "main" machine. DSH-46 allows connection to the DSH-44 or DSH-45 cable.	1,260
	DISPLAY PROCESSOR OPTIONS			PERIPHERAL INTERFACES AND DEVICES	
CRG-41	Circle/arc generator	2,950	ASR-41	Printer, keyboard, paper tape reader and punch unit	5,000
SRT-41	Graphic manipulation module	5,200	CBS-41	Read/write cassette	890
CPI-41	Interface for 4-color CRT display (CPS-8001 or equal)	2,300	PTR-41	Paper tape reader interface	750
KRI-41	Interface for 4 color CRT Display	2,300	TRD-41	High speed paper tape reader	1,890
MCI-41	Monitor control interface	850	PTP-41	Paper tape punch interface	750
MIC-41	Manual image control	950	TPH-41	High-speed paper tape punch, 75 char/sec, tabletop unit	2,850
MIC-42	Repeater for slave display	400	MTS-41	Magnetic tape controller and one MTU-41 tape transport	10,890
PPM-41	Fast point plot mode	900	MTS-42	Magnetic tape controller and one MTU-42 tape transport	9,900
	MINICOMPUTER OPTIONS		MTS-43	Magnetic tape controller and one MTU-43 tape transport	12,900
MEM-41	Memory module 4K, 16-bit words (factory installed)	2,900	MTU-41	Magnetic tape transport, 9-track, 10.5-in. reel, 800 bpi, 37-1/2-in. ips recording rate, NRZI	6,500
MEM-42	Memory module 8K, 16-bit words (factory installed)	4,500	MTU-42	Magnetic tape transport, 9-track, 7-in. reel, 800 bpi, 12-1/2-in. ips recording rate, NRZI	5,125
MEM-43	Field upgrade of 4K, 16-bit word memory module to 8K module or field upgrade of 4K module (includes installation)	3,300	MTU-43	Magnetic tape transport, 9-track, 10.5-in. reel, 1600 bpi, 25-in. ips recording rate, phase encoded	7,400
MEM-45	Field upgrade of 8K memory module, includes installation	4,900	DSC-41	Disk file controller, can accept up to 4 DSF-42s or DSF-43s disk drives	4,400
MEM-46	Memory Module 16K, 16-bit words (factory installed)	6,500			
CON-41	Programmer/maintenance control panel (utility and diagnostic software are supplied only when this unit is ordered)	1,500			
DMA-41	Direct memory access channel (first device)	1,000			
DMA-41-F	Direct memory access channel (field upgrade, standard installation charges apply)	1,300			

PRICE DATA (Contd.)

Model No.	Description	Purchase Price (Maint. not incl) \$
DSF-42	Disk drive, 5M bytes; IBM-2315-type removable recording surface	8,500
DSF-43	Disk drive double density; same as DSF-42 except capacity is 10M bytes	9,800
DSF-41C	Disk file cartridge; for use with DSF-42 or DSF-43	195
DSF-42C	Disk File Cartridge for use with DSF-43. Includes verification of cartridge.	195
FDS-41	Floppy disk system (dual drive). Includes controller, interface, and up to four IBM 3740-compatible drives	7,900
FDD-41	Additional floppy disk drive (up to 4 per system)	1,200
HCY-43	Graphic hardcopy device	6,700
HCY-42	Multiplexor for connecting hardcopy unit to additional PDS-4 system	700
HCY-44	Interface & 20-foot cable for connecting each additional PDS-4 to HCY-42.	500
PRT-43	Low-speed, serial impact printer; 30-char/sec, 96-character font standard, 132 print columns with variable character spacing; changeable type face available; includes interface and 20-foot cable	4,885
PRT-44	Low-speed, impact line printer; 70 lpm, 60-character font, 5 x 7 dot matrix, 80 print columns with pen feed; includes interface and 20-foot cable	3,675
PRT-46	Raster printer/plotter with interface print mode; 500 lpm maximum, 96 char/set, 132 print columns (11 in. wide)	15,595