PCS Product Guide

The Microcomputer's Promise

Much has been written about the advantages of the microcomputer. About its power, adaptability, reliability. And certainly about its astonishingly low cost.

Today, companies all around the world are replacing conventional control logic with PCS microcomputers. Many others have introduced revolutionary new product features thanks to the incorporation of PCS micros into their designs.

PCS OEM CUSTOMERS are using MicroPacs to make all kinds of machines smarter. Gas pumps, lumber sorters, boiler cleaners, carburetor test stands and many others. Many of these OEM customers first come to PCS because MicroPac systems cost less than hard wired or mechanical control systems. But, more often than not, the flexibility offered by the MicroPac leads them to add significant features to their products, giving them advantages over their competition.

Because, amazingly, OEM's can make the MicroPac do just about anything they want it to do, just by programming it and selecting a few hardware modules.

In some cases, the OEM has *wanted* to innovate. In others, he has found that his competition is forcing him into this new technology out of necessity. In both cases, he finds that the PCS system gives him a short development time and a *reliable* system. A system that allows him the flexibility to change as the market requires without constant retooling.

PCS END-USER CUSTOMERS are using MicroPacs to improve efficiency of their plants and processes, to provide better management data and to reduce down time.

PCS MicroPacs currently monitor or control processes in nearly every major industry in the world, from automobile manufacturing to the production of steel, chemicals and petroleum.

The micros are replacing control systems with entirely different (and now outmoded) technologies, because the micros are costing less while doing more.

In many cases, the micros are operating as "stand alone" systems, improving control of individual process or assembly functions. In many other instances, the micros report to central computers. Either way, PCS micros are helping production managers win a few battles in the war to maintain and improve productivity levels.

Why is the PCS MicroPac so popular? Because it takes more than a micro CPU to make a micro system you can *use.* It takes process I/O modules and software and service facilities.

The PCS MicroPacs are a complete package including everything you need to get the micro on line. It is this that makes PCS microcomputers more than a promise, but rather a practical working *solution* to your control needs.

The MicroPac Solution

PCS MicroPac microcomputers are actually computers you configure for your own needs, from standard off-the-shelf modules, most of which are described in this booklet.

The patented PCS *flexibus* is what makes this "building block" flexibility possible. The *flexibus* system includes a printed circuit multi-purpose backplane, and modules that are capable of telling the CPU module their addresses within the busing system.

Thus, you the user can mix or match up to 256 memory and input/output modules in any combination *without rewiring,* as is necessary with all other systems available on the market today.

Every PCS module is fully documented and tested. Thousands are in actual use by PCS customers throughout the world. Also, PCS uses the MicroPac BASIC to test every circuit of every module before it is shipped.

Another feature of the MicroPac series is the PCS power supply. These computers use a semi-regulated ferroresonant device, the most reliable low cost power supply available. Regulation begins at the power supply, and precise regulation is accomplished by individual solid state 3-terminal voltage regulators built into each of the modules plugged into the *flexibus* backplane.

There are two principal models in the MicroPac line, a production system and a development system. All parts for both are interchangeable.

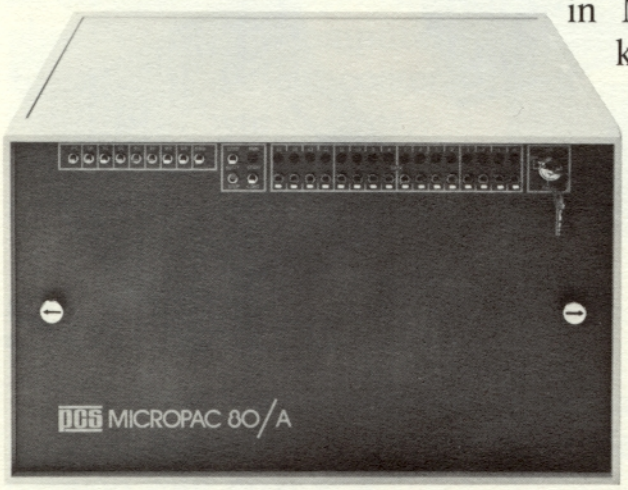
MicroPac 80/A

This is the PCS development system, a microcomputer that includes all the hardware, software and peripherals you need to develop your microcomputer programming.

You may order your MicroPac 80/A either in the attractive desk-top enclosure or standard rack-mount chassis. Either way, it comes with an operator's control panel which allows manual control of the system via start, stop, load, register, alter and display switches and 16 data switches.

The standard MicroPac 80/A contains a terminal interface module, 8K bytes of RAM and 2K bytes of pROM (containing the basic operating system including debug), and the customer may order as much as 64K bytes of RAM, pROM or any combination of both, directly addressable by the CPU.

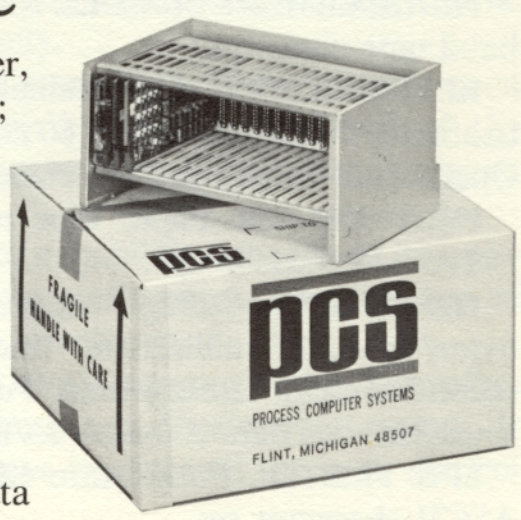
MicroPac 80/A modules and busing system are identical to those in MicroPac BASIC, so you know the hardware configurations and software you develop will meet your highest expectations in actual use. Optional memory and communication modules, peripheral devices and software are described in other parts of this booklet.

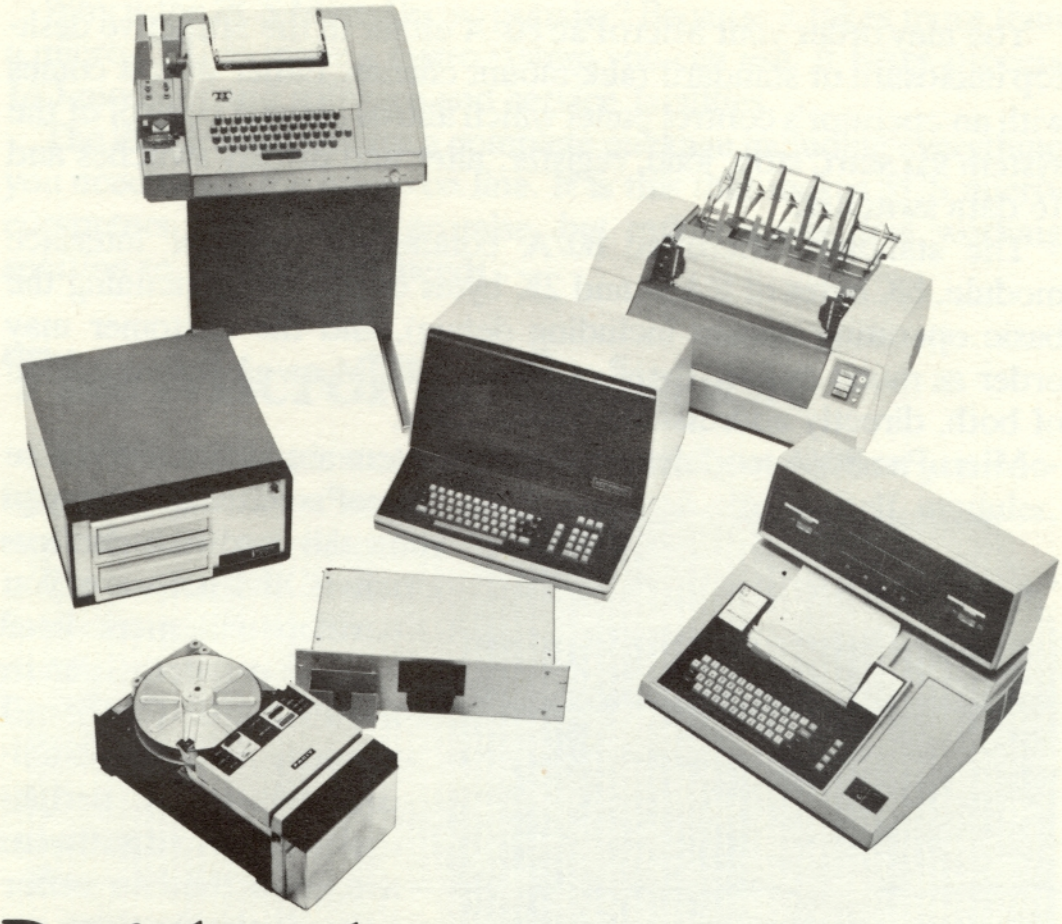


MicroPac Basic

This is the production computer, and it comes in any configuration; you need only select the modules and enclosure you need. 30 days later, it's there, ready for you to load its program and put it to work.

Use it for sequence control, timing, counting. It can also handle parameter, process and programmable control and data logging.





Peripherals

PCS offers the following peripherals to enhance software development:

BASIC PRINTER. ASR model 33 teletypewriter, 10 cps.

PROGRAMMER'S CONSOLE. Keyboard, 30 cps printer, dual 1,200 baud tape cassettes.

KEYBOARD/CRT. Alphanumeric video display/keyboard. 1,920 character display (24 lines x 80 characters), 64 ASCII character set. Operates at 2,400 baud via current loop interface.

PHOTOREADER. Paper tape reader, rack mountable. 300 cps.

TAPE PUNCH. 75 cps.

FLOPPY DISK. Storage capacity over 1 million bytes. 256,256 bytes/drive. 10 millisecond track-to-track access time, 83 millisecond average latency time. Full sector read/write buffers allow asynchronous data transfers to/from CPU.

LINE PRINTER. Fully buffered. 60-200 l.p.m., 132 columns, 64 ASCII character set.

pROM Programmer

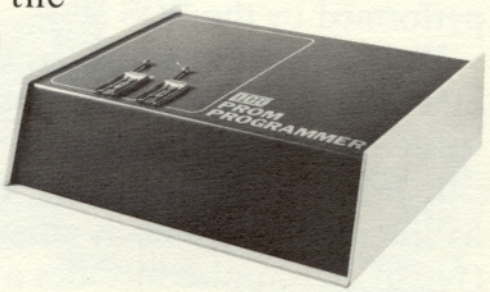
A separate pROM programmer in a desktop enclosure can program or copy one pROM at a time in less than 1 minute via a control program run on the MicroPac 80/A development computer. The control program detects error or non-zero pROM at the start and verifies after each programming cycle.

The PCS pROM programmer offers several unique features:

pROM chips in both sockets (the original pROM and the duplicate) may be examined directly.

The programmer automatically checks each byte of a pROM to be burned. If any byte has already been burned, no burning takes place and the computer prints the address and present contents of the first pROM byte in error.

All errors are accompanied by an explanatory error message.



Software

PCS development software is perhaps the most powerful and useful in the industry, and it'll make life a lot easier for you as you develop your programs.

It allows you to examine all parts of the computer at all times as the CPU executes the program you're developing, so that you can "trouble shoot" quickly and easily. The trace package allows you to interrupt program execution, print certain information and resume program execution, all automatically.

A powerful macro & conditional assembler will shave hours, even *weeks,* off your development time by eliminating much of the time-consuming duplications and repetitive editing that are inevitable in most program writing.

These software packages feature capabilities not found in many other microcomputer (and minicomputer) systems, and they are of significant benefit to the program developer.

BASIC OPERATING SYSTEM (BOS 80/A) programs the MicroPac to operate efficiently and conveniently as a development system. It resides in pROM, so that it is always loaded and ready to control the computer.

The standard BOS 80/A includes the driver routine for teletypewriter and CRT. Optional compatible pROM chips provide drivers for floppy disk, cassette printer, line printer and tape reader and punch.

A debug program is also part of BOS 80/A. This debug program is your basic program development tool, allowing you to examine all registers at any point in the execution of your program. You may instruct the CPU to halt at up to 8 breakpoints during execution and display the contents of all registers and memory.

MACRO ASSEMBLER (MAS 80/A) is a 2 or 3 pass assembler, depending upon which peripherals are used. It produces absolute hexidecimal object and source assembly outputs; input/output is performed by the BOS 80/A.

Written itself in assembly, this macro assembler is smaller than others, and is therefore faster and takes less memory, allowing space for additional features:

It prints the symbol table at the end of the source output. It has room to handle many more symbols than most other assemblers (140 in 8K). And it includes a first pass editor.

The first pass line editor is of particular benefit to the programmer working with the teletypewriter, since it means the programmer need not load the EDIT program for simple edits, then having to reload the assembler.

Since it works in the first pass, edits can be made before actual assembly is performed.

This is a MACRO assembler, allowing a symbol (macro name) to represent a group of instructions. Each macro need be defined only once in a program. This saves much time for the programmer, who no longer needs to "long hand" each repetitive set of instructions.

This also reduces the risk of error, and when errors are found it means that the errors have to be changed only once even when they have been repeated throughout the program.

As a *conditional* assembler, the program saves even more programming time. The programmer may write into the source program a number of routines, then custom select which of these routines are to be included in each object tape.

For example, the program writer may include debug instruction at various points in the source program and determine at each

support people whose primary job is to give you any help you need as you use our equipment.

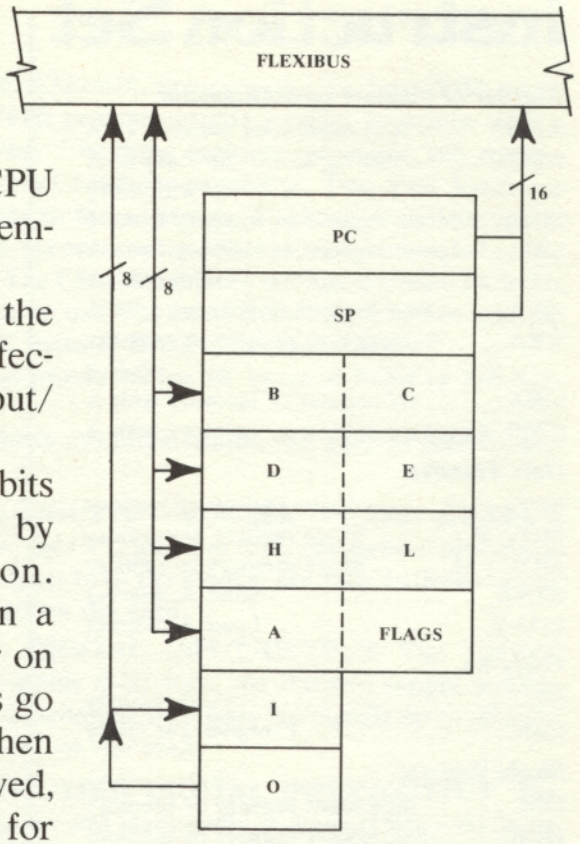
REPAIR SERVICE While no one can promise complete freedom from breakdowns, PCS has done more than anyone to minimize down time, in two ways:

First, your PCS MicroPac computers can diagnose their own circuits. PCS provides you (at no extra charge) with diagnostic software for each module you order. You may write this into the program you develop, so that each MicroPac BASIC contains in its own pROM the ability to detect and report failure in any module. Or you may choose to diagnose your production modules on your 80/A development system.

In either case, once you have learned which module has failed and have called PCS, we'll send you a replacement module *that very day!*

We call this service our "board exchange program", and what it means is that we set aside enough modules to supply spares instantly.

Architecture



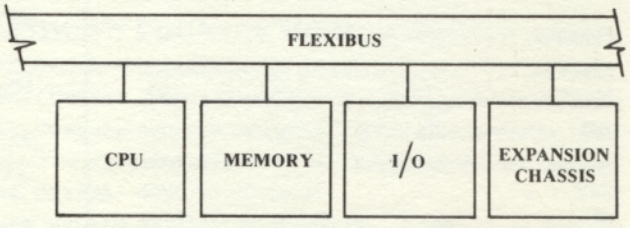
CM4400 CPU MODULE

The *flexibus* treats all input/output slots as memory locations, so that the CPU conducts I/O operations via memory reference instructions.

The unique architecture of the PCS CM4400 CPU module effectively allows 16-bit parallel input/output by an 8-bit processor.

The processor requests 16 bits of data from an I/O module by memory reference instruction. The MSBs of data are held in a special 8 bit input ("I") register on the CPU module and the LSBs go directly to the accumulator. When LSBs in the accumulator are saved, the program makes a request for the MSBs in the "I" register and processes the data.

To output 16 bits of data, the CPU brings the MSBs into the accumulator and then to a special output ("O") register on the module. Then it acquires the LSBs and the contents of the accumulator and the "O" register are sent on the bus simultaneously to the addressed module by a memory reference instruction.



I/O modules have 8-bit addresses, which allow direct parallel communication between the CPU and up to 256 modules.

Memory registers have 16-bit addresses, providing the CPU with direct access to as many as 64K memory bytes.

Because I/O modules are treated as memory locations, I/O and memory modules may be interspersed indiscriminately throughout 16 of the 20 slots in each chassis.

You can add up to 16 expansion chassis and address each via its address switch.

Instruction Set

Register or Memory to Accumulator

ADD. . . . . Add register or memory to A
ADC. . . . . Add register or memory to A with carry
SUB. . Subtract register or memory from A
SBB. . Subtract register or memory from A with borrow
ANA. . . . . And register or memory with A
XRA. . . . . Exclusive or register or memory with A
ORA. . . . . Or register or memory with A
CMP. Compare register or memory with A

Data Transfer

MOV r^1,r^2. . . . . Move register to register
MOV M,r. . . . . Move register to memory
MOV r,M. . . . . Move memory to register
STAX. . . . . Store A indirect
LDAX. . . . . Load A indirect

Carry Bit

STC. . . . . Set Carry
CMC. . . . . Complement Carry

Single Register

INR. . . . . Increment register or memory
DCR. . . . . Decrement register or memory
CMA. . . . . Complement A
DAA. . . . . Decimal adjust A

NOP Instruction

NOP. . . . . No operation

Rotate Accumulator

RLC. . . . . Rotate A left
RRC. . . . . Rotate A right
RAL. . . . . Rotate A left through carry
RAR. . . . . Rotate A right through carry

Control

JMP. . . . . Jump unconditional
JC. . . . . Jump on carry
JNC. . . . . Jump on no carry
JZ. . . . . Jump on zero
JNZ. . . . . Jump on no zero
JP. . . . . Jump on positive
JM. . . . . Jump on minus
JPE. . . . . Jump on parity even
JPO. . . . . Jump on parity odd
CALL. . . . . Call unconditional
CC. . . . . Call on carry
CNC. . . . . Call on no carry
CZ. . . . . Call on zero
CNZ. . . . . Call on no zero
CP. . . . . Call on positive
CM. . . . . Call on minus
CPE. . . . . Call on parity even
CPO. . . . . Call on parity odd
RET. . . . . Return
RC. . . . . Return on carry
RNC. . . . . Return on no carry
RZ. . . . . Return on zero
RNZ. . . . . Return on no zero
RP. . . . . Return on positive
RM. . . . . Return on minus
RPE. . . . . Return on parity even
RPO. . . . . Return on parity odd
RST. . . . . Restart
PCHL. . . Jump, H & L to program counter

Immediate

LXI. . . . . Move 16 bit immediate into register pair
MVI. . . . . Move immediate to register or memory
ADI. . . . . Add immediate to A
ACI. . . . . Add immediate to A with carry
SUI. . . . . Subtract immediate from A
SBI. . . . . Subtract immediate from A with borrow
ANI. . . . . And immediate with A
XRI. . . . . Exclusive OR immediate with A
ORI. . . . . Or immediate with A
CPI. . . . . Compare immediate with A

Direct Addressing

STA. . . . . Store A direct
LDA. . . . . Load A direct
SHLD. . . . . Store H & L direct
LHLD. . . . . Load H & L direct

Register Pair

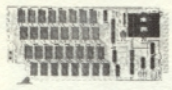
PUSH. . . . . Push register pair on stack
POP. . . . . Pop register pair off stack
DAD . . . Add register pair or stack pointer to 16 bit number in Hand L
INX. . . . . Increment register pair or stack pointer by 1
DCX. . . . . Decrement register pair or stack pointer by 1
XCHG. . Exchange D & E, H & L registers
XTHL. . . . . Exchange top of stack with H and L
SPHL. . . . . Load stack pointer from H & L

Miscellaneous

EI. . . . . Enable the interrupt system
DI. . . . . Disable the interrupt system
IN Ø. . . . . Interrupt acknowledge — load interrupting module address into A
IN 1. . . . . Load holding register into A
OUT Ø. . . Master clear — reset MicroPac system
OUT 1. . . . . Load A into holding register

The Modules

MICRO CPU MODULE (CM4400), incorporating an Intel 8080 micro CPU, is a self contained 8-bit general purpose parallel processor with a repertoire of 74 instructions, 7 working registers, unlimited sub routine nesting and multiple interrupt handling capability. Two 8-bit hardware registers, used as extensions to the accumulator, allow 16-bit I/O operations. The module directly accesses up to 64K bytes of memory.



MEMORY MODULES The CM4500 memory module includes 1K bytes of RAM with provisions for up to 1K bytes of ROM; the CM4501 module has provisions for up to 4K bytes of RAM in 1K increments.

The CM4503 module has provisions for 4K bytes of ROM in 256 byte increments.

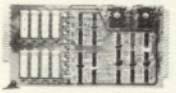
Switches located on these modules enable the user to select base addresses.

16-BIT DIGITAL INPUT/OUTPUT MODULE (PM5001) provides a two way interface between the CPU and any TTL compatible process or peripheral device. Data outputs from the module are fully buffered allowing output data to be stored on the card.

16-BIT HIGH LEVEL DIGITAL INPUT/OUTPUT The PM5004 module accepts high level inputs (5-50 volt); the PM5005 output module provides the open collector switching necessary for signals up to 50 volts at 500mA. Output is buffered on the card.

16-BIT OPTICALLY ISOLATED DIGITAL INPUT/OUTPUT The PM5006 input module accepts and electrically isolates (1500 volt) input data from 3-50 volts. The PM5007 output module provides a data output interface and 1500 volt electrical isolation between the CPU and process or peripheral device. Provides outputs up to 50 volts, buffered on the card.

8-CHANNEL INTERRUPT EXPANDER MODULE (PM5008) provides eight interrupt channels for hardware priority. When an interrupt is detected, a module address and interrupting channel number is supplied to the microcomputer to initiate specific action as programmed in system software.



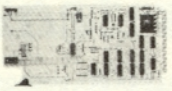
8-CHANNEL RELAY OUTPUT MODULE (PM5009) provides eight 100Va Form C mercury wetted relay contact outputs.

16-BIT DIGITAL UP/DOWN COUNTER MODULE (PM5010) records the number of selected events through the incrementing and decrementing of its 16-bit up/down counter. The computer may load a predetermined count into the counter, may increment and decrement the counter and may clear the counter. The counter also may be incremented or decremented by a peripheral device.

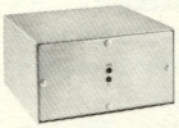
A maskable interrupt detects a counter overflow condition in either direction, sets the appropriate status word flag bit and, when enabled, initiates an interrupt operations. Through jumper connections, the module may either accept TTL compatible inputs or optically isolate voltage inputs between 3 and 50 volts.

REAL TIME CLOCK MODULE (PM5011) provides 13 programmable time bases from one micro-second to one hour. A 1-MHz crystal controlled oscillator generates the module's frequency standard.

When enabled, the module informs the computer at the completion of each time interval.

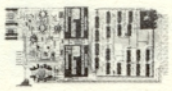


REAL TIME CLOCK & POWER FAIL DETECT MODULE The PM5013 module has been designed to: provide a maskable interrupt or "pollable" flag at 10Hz rate (120, 60, 40, 30, 24, 15, 13.3, and 12 are jumper selectable); provide a power fail interrupt at least 500 microseconds before program execution halts because of a low power condition; provide battery pack status input and reset output; and to provide a switch to allow the manual selection of a cold start upon power up.



BATTERY PACK This unit (PS3014) provides backup power to support RAM. Time of support is dependent upon the amount of RAM to be kept under power; 4K bytes can be supported for 8 hours, which 20K bytes can be supported for 1 hour.

STEPPING MOTOR CONTROLLER MODULE The PM5020 2-channel 12-bit pulsed output module provides the parallel to pulse interface between the CPU and external translator. The computer puts out a 16-bit word, 12 bits for the number of pulses and 4 bits to control the direction and channel. Maximum frequency of the pulse output is set by 2 potentiometers providing a coarse and fine adjust. Frequency can be adjusted from 20Hz to 5KHz to within 1Hz. Includes up/down ramping function.



DIGITAL-ANALOG CONVERTERS (12 BIT) The PM5051 2-channel digital-to-analog converter module converts a 12-bit digital value from the computer into an analog voltage or current output. Voltage ranges: ±10V, ±5V and 0-10V. Current ranges: ±64mA, ±32mA and 0-64mA. Inputs are buffered so that output remains the same until input is changed.

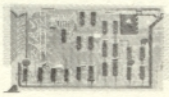
The PM5054 16-channel analog-to-digital converter module is capable of 10K samples/second and has a 100 micro-second conversion time with a preset gain of 1, 2, 5 or 10. Unipolar or bipolar operation. Differential or single ended input. Random or sequential mode.

TTY CONTROLLER MODULE (PM5080) provides 20mA control loop data transfer and control between the CPU and such low and medium speed serial devices as teletypewriters and CRT's. The module also has RS-232 transmit and receive capability (110-2400 baud).

RS-232C COMPATIBLE CONTROLLER This module (PM5081) is a serial-to-parallel/parallel-to-serial converter with control lines designed to interface the PCS MicroPac system to most asynchronous modems (especially those which are Bell 103 or 202 equivalent). Six different baud rates are available: 110, 300, 1200, 2400, 4800 and 9600. Data word length is selectable from 5 to 8 bits inclusive. One or two stop bit capability is selectable. If parity is selected, it may be further selected to be either odd or even.

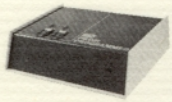
SERIAL/PARALLEL CONVERTER MODULE The PM5082 8-bit transmitter/receiver serial/parallel module makes possible asynchronous full-duplex operation between a computer and a remote application. The modules are used in pairs, one with the computer and the other in the remote location. They transfer data at rates from 1.25K to 80K baud up to 10,000 feet on twisted pair cable.

BUS EXTENDER The PM5061 module is used to extend the bus for the purpose of scoping or signal tracing, *not* for expansion.

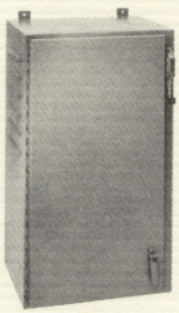


BUS BUFFER The CM4402 module provides for multiple chassis.

BREAD BOARDS are available with 5V (BB8004) and 5 & 15V (BB8001) regulators.



pROM PROGRAMMER The PB1000 programmer consists of a self-contained desk top enclosure to be used as a pROM programmer for the MicroPac 80/A. The unit has the capability to program or copy pROMS under MicroPac 80/A control.



ENCLOSURE The EN1001 is a NEMA 12-like ventilated enclosure, including air blower, air filter, power disconnect, card chassis, PS3012 power supply, PM5000 bus terminator and termination panel with 16 terminal strips. Space is provided for 2 battery packs and a PM5100 control panel.

MicroPac 80/A General Specifications

Physical Characteristics
Supplied as a table-top unit complete with power supply and control panel. Rack-mountable units are also available.

Rack mounted chassis (19″)
8.50″ (21.59 cm) x 18.94″ (48.10 cm) x 18″ (45.72 cm) weight 34 lbs. 2 oz. (15.47 kgm) with power supply

Rack mounted front panel (19″)
1.75″ (4.45 cm) x 18.94″ (48.11 cm) x 2.13″ (5.41 cm)

Table top configuration
11.25″ (28.57 cm) x 19.75″ (50.16 cm) x 21.68″ (55.06 cm) weight 90 lbs. (40.77 kgm) with power supply

Computer:
CPU: n-channel single chip 8-bit parallel microprocessor, the 8080

Instruction cycle: 2 microseconds

Instruction set: 74 instructions
Decimal and binary arithmetic
Direct load and store of accumulator
PUSH and POP stack instructions
Double length operations (16 bits)
Increment and decrement memory

Registers: six 8-bit data registers
8-bit accumulator
four 8-bit temporary registers
four testable flag bits

Maximum number of addressable I/O devices: 256

Interrupts: multi-level vectored interrupts

Bus: Printed circuit backplane with 20 slots (16 addressable slots), 8 address lines, 16 data lines, Interrupt & control line, 8 command lines, 3 power buses, (one spare power bus, user defined)

Clock: 2-phase non-overlapping 2-MHz clock

Memory:
10k bytes (8kB RAM, 2kB pROM) expandable to 64k bytes

Word Size:
8 bit word length
16 bit I/O word length

Electrical Requirements:
Ferroresonant power supply provides the backplane with +7 volts, 20 amperes and ±20 volts, 2 amperes preregulated power
115 - 230 VAC, 60 Hz
230 VAC, 50 Hz (optional)
110 VAC, 50 Hz (optional)

Environmental Requirements:
Operating −0° to 60° C (140° F) 90% R.H. maximum, non-condensing
Storage −0° to 85° C (185° F) 90% R.H. maximum, non-condensing

Printed in U.S.A.