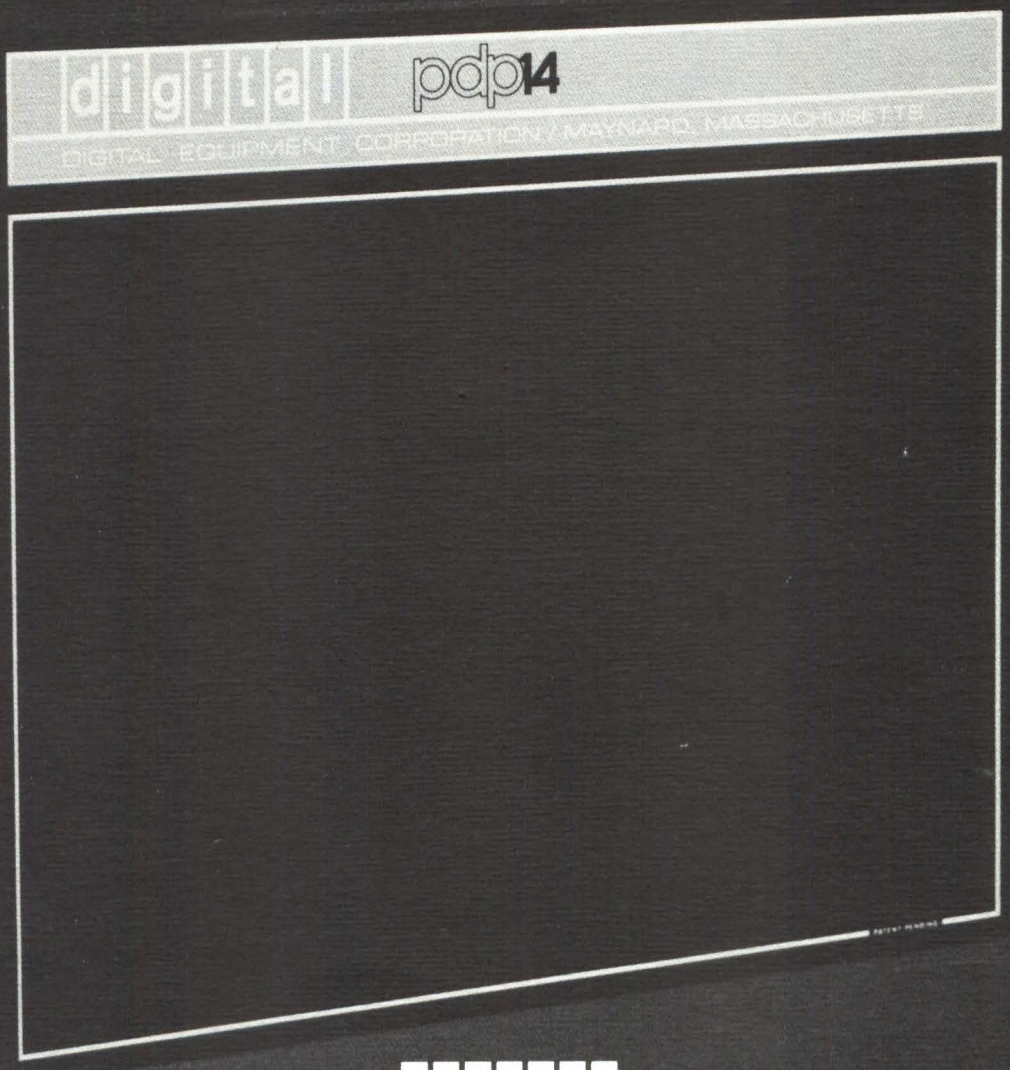
PDP-14 PROGRAMMABLE CONTROLLER PRODUCT SUMMARY



digital

DIGITAL EQUIPMENT CORPORATION Industrial Products Group

WHAT IS THE PDP-14?

The PDP®-14 is a solid-state programmable controller for repetitive manufacturing operations. It accepts inputs from two-state devices such as limit switches, push buttons or pressure switches and, in accordance with input conditions and a predetermined control sequence, turns on or off outputs such as solenoids and motor starters. The control sequence for a particular application is stored in the memory section of the PDP-14.

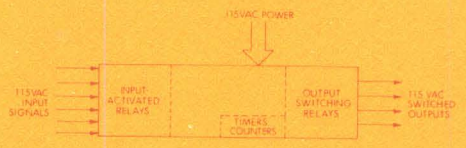
The PDP-14 can control any operation or process that can be broken into a number of discrete steps or logical expressions, each with just two states; i.e., status inputs are either on or off, and the control operation selects outputs and turns them on or off. This type of control sequence is used in most mass production equipment and materials handling systems. It is also used in such diverse industries as automobiles, textiles, food processing, chemicals and utilities.

To direct specific control operations, the PDP-14 system uses an easily alterable memory. Convenient programming techniques allow each user to design a memory to suit his unique control needs. The entire control process can be redefined by changing the memory.

The PDP-14 system is designed to operate independently or with computer monitoring or control. Since the PDP-14 can access all control inputs and outputs, the added monitoring components are simply a general-purpose computer and a simple interface device (available from DIGITAL). A group of PDP-14 systems can be monitored by a single computer using a serial line interface to provide status and malfunction reports for a large control complex.

THE PDP-14 SYSTEM

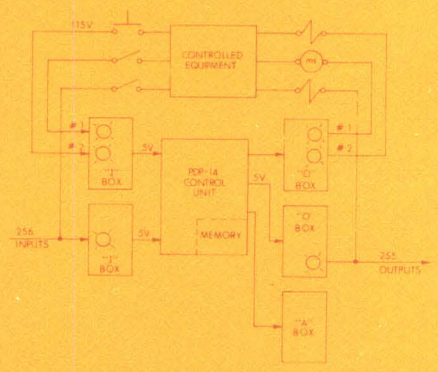
The PDP-14 control system is designed to directly replace conventional systems with a minimum of special considerations. The equipment uses standard 115 VAC (or standard DC levels) input and output signals. To allow for easy repair or replacement of parts, the functional units are divided into plug-in modules containing solid state devices and other components.



The PDP-14 is a direct replacement for this typical control system.

As in ordinary control systems, the PDP-14 accepts low power AC signals at its inputs, determines which signals are necessary for a given machine function, and then turns on and off the required outputs.

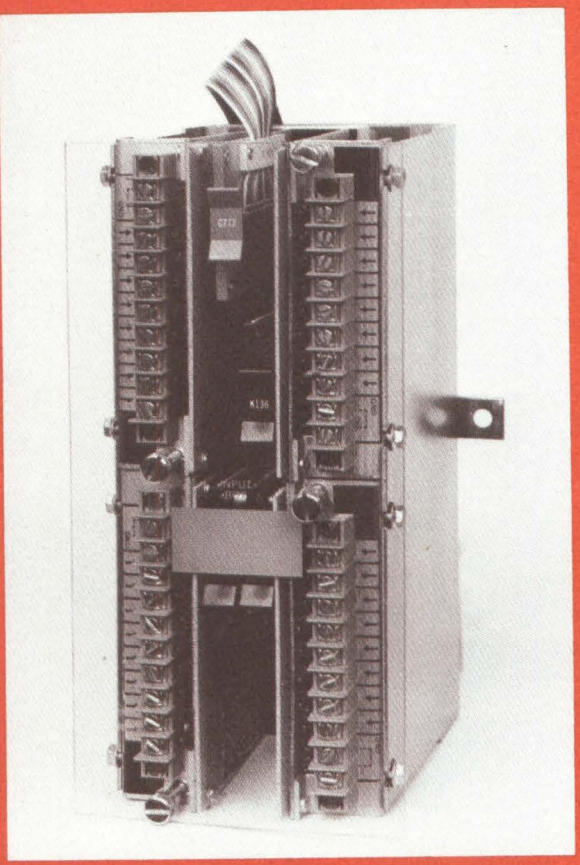
The PDP-14 system is a unified assembly of four basic units: input boxes; output boxes; control unit; and accessory boxes (timers, retentive memories, etc.).



The input (I) boxes and output (O) boxes provide an interface or buffer between the 115 VAC control signals (or DC level) from the controlled device and the PDP-14 control unit.

In the PDP-14 control system, the low-voltage solid-state circuits of the unit test and direct the 115 VAC circuits of the controlled device through control cables. The I and O-boxes provide complete isolation of the PDP-14 internal circuits from the AC power supply. Each I or O-box handles a small number of AC circuits and has its own control cable to the control unit.

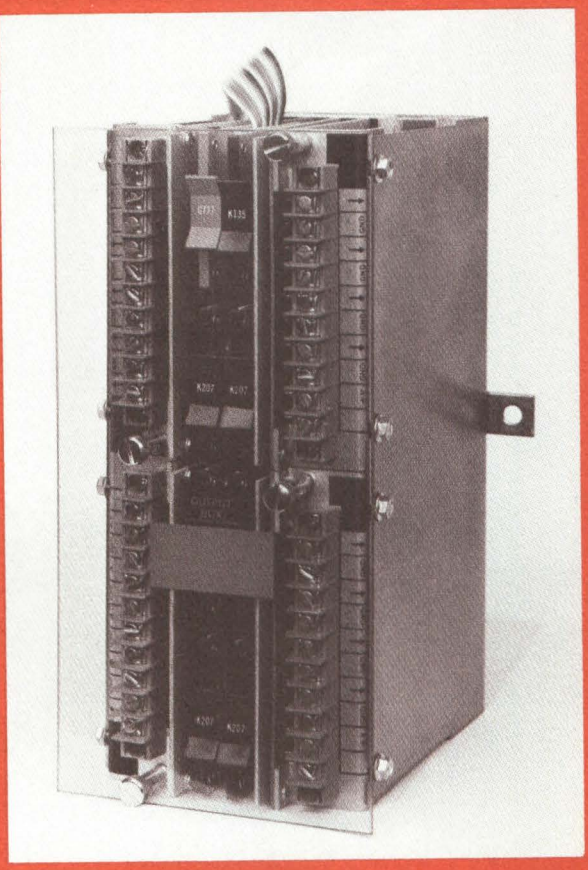
INPUT BOX



Functionally, the I-box contains signal-conditioning devices which accept 115 VAC or 10 to 55 VDC inputs from two-state sensing devices such as limit switches, pushbuttons, proximity switches, pressure switches and photocells. These inputs are converted into signals suitable for the solid state circuits (0 and 5 VDC). The signals are then sent along control cables to the PDP-14 control unit. Each I-box contains 32 independent input circuits. A lamp on each input circuit is lit to signal that voltage is being supplied to the box terminal. AC I-boxes are readily identified by a red terminal strip and DC I-boxes by a blue terminal strip.

The control unit accepts control cables from as many as eight I-boxes (256 inputs per system). Additional input boxes can be used by replacing 32 outputs (two O-boxes) for each input box required beyond the normal limit of eight. In this way a total of 512 inputs (but no outputs) can be connected to a single PDP-14.

OUTPUT BOX



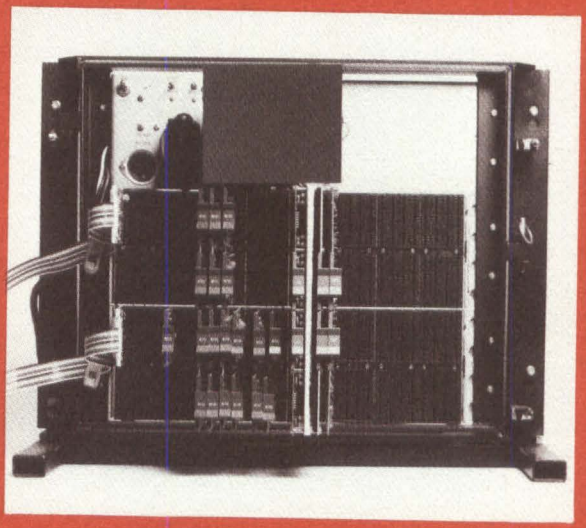
The O-box shell is identical to the I-box shell. Where they differ is in the wiring of the rear module sockets and in the modules used. The front of each box is covered with a plastic safety shield.

There are two versions of the O-box that provide switching of 115 VAC or up to 250 VDC as directed by the control unit. The AC output boxes are also readily identified by a red terminal strip and the DC output boxes by a blue terminal strip. These outputs drive devices such as indicators, motor starters, solenoids, or any other devices that do not exceed 500 VA on the AC outputs or one ampere on the DC outputs. A light emitting diode (LED) on each output shows when voltage is switched to the external device.

Command signals pass from the control unit along control cables to each O-box. The control unit accepts as many as 16 output box cables or a total of 255 outputs per system (the last output is a special purpose output and is not normally used).

Is this per output or per card total? We may not need the relay driver card!

CONTROL UNIT



The circuits of the control unit and its memory perform the 3 basic operations of any control system:

1. TEST inputs or outputs for state (ON or OFF)
2. DECIDE what control function is required
3. SET outputs ON or OFF (execute the control decision)

MEMORY

Is this a retentive memory?

The memory in the PDP-14 system is either a "Read Only Memory" (ROM) or a "Read/Write Memory."

The Read Only Memory cannot be altered electrically (that is, written on). It contains a pattern or "braid" of wires woven together. This pattern is actually a list of permanently wired electrical instructions which are read by the control unit to determine system operation.

The control is a sequential operation similar to scanning a relay ladder diagram rung by rung. Each rung of the ladder represents a specific group of sensed input conditions which must be satisfied to cause a change in the condition of the output. The ROM contains instructions in small groups, each corresponding to a single rung in the ladder. It directs the control to select each input specified in a group and test whether it is on or off. Based on the test results, the specified output is selected and set on or off. The control then continues to the next group of inputs and outputs and repeats the process. This action occurs one instruction at a time but at a speed in thousandths of a second.

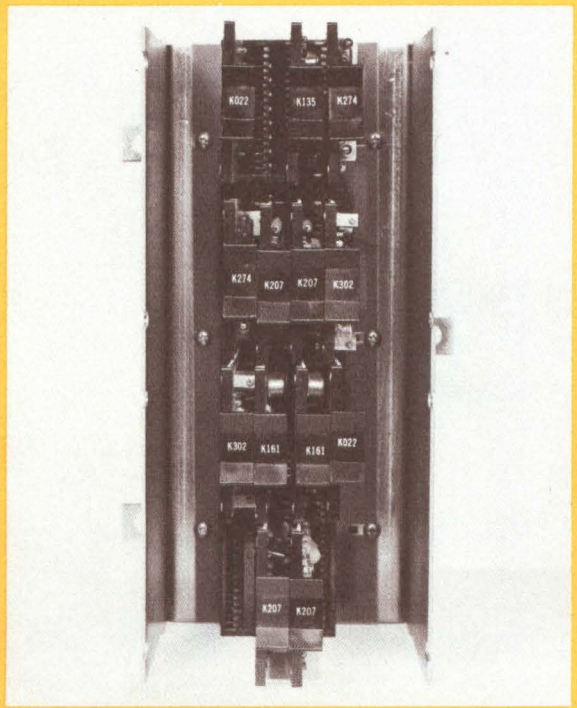
Many applications for the PDP-14 require maximum flexibility during the transient start-up periods or where environmental noise and temperature are not severe. These conditions gave rise to the Read/Write Memory MM14-A.

The Read/Write Memory for the PDP-14 is one 4,000 word memory, industrially packaged in its own mounting box. The MM14-A can only be used with the PDP-14, not the PDP-14L. It can be easily altered, which allows the user to change the control sequence whenever he chooses. The user can load or change the contents of the memory with the same equipment he used to develop his control. What this means is that the memory can now be loaded as soon as the control program is completed. In addition, the memory contents can be altered as soon as the new control program has been developed. This significantly reduces the amount of time required to change the contents of the memory.

ACCESSORY FUNCTIONS

A control system may require a group of preset status signals which cannot be generated by direct machine operation. For example, timers can provide duration and sequencing control for a controlled device. These functions are performed in the PDP-14 system by accessory boxes.

The A-box shell is mechanically identical to the I or O-box and is mounted in the same way. It is enclosed by a metal cover. An A-box has 8 slots, each of which accepts any one card to provide the following functions: timers, retentive memories or storage cards. Each implements two identical functions for a total of 16 functions per A-box. The K302 timer provides timing in the range of 0.01 to 30 seconds as supplied. With a simple modification the range can be extended to 4 minutes, 45 seconds. The K274 retentive memory permits storing critical information which must be retained even if the control unit loses power. The K022 storage card provides temporary storage, which is cleared whenever power is lost.



COMPUTER MONITORING

The PDP-14 system design enables the user to add optional computer monitoring at any time. A small, general-purpose computer can be connected through control cables to the control unit, and certain monitoring modules also installed. The computer can then either monitor any control operation of the PDP-14 system or it can monitor the status of any input or output and convert this information into a printed record if desired. The computer can also assume command of any control function, either on a standard or emergency basis. Some of the most suitable computers for monitoring the PDP-14 are the DIGITAL PDP-8 or PDP-11 family computers. They are inexpensive and convenient to use and install. The monitoring modules to adapt these computers to the PDP-14 are available.

Computer interfaced operations of the PDP-14 are more fully described in "The PDP-14 in Computer Control."

MEMORY DEVELOPMENT

The PDP-14 is designed for control engineers, not computer programmers. There are two alternative memory development aids: (1) CRT-14 or (2) SET-14, BOOL-14 and SIM-14. To program control systems using relay symbology, the control engineer can use CRT-14. If the control engineer prefers to program using Boolean equations, BOOL-14 and SIM-14 are available. They are program tapes written for the control engineer and are provided with every PDP-14 system. These operate on a PDP-8 family computer and Teletype and enable the control engineer to convert his sequence of operations into the PDP-14 memory without using computer programming techniques.

Do we need the video portion
if we use Book-14.
If not, can we buy without video.

CRT-14

Control Relay Translator-14 enables the control engineer to develop his PDP-14 program directly from a relay ladder diagram and debug this program on-line with a PDP-14 controller and his equipment. After the PDP-14 program has been fully debugged, CRT-14 can output a binary tape from which a read only memory can be woven or the CRT-14 program can be directly entered into the PDP-14 read/write memory. CRT-14's binary output tape can also be input to SIM-14 for editing and both off-line and on-line simulation.

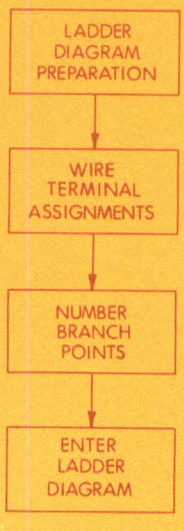
The CRT-14 program runs on an 8K PDP-8 computer with an ASR33 Teletype. An LA30 Teleprinter or VT05 Alphanumeric Display can also be used as console or printer devices.

The control engineer, who must be familiar with ladder diagram schematics, develops his PDP-14 program by entering one ladder diagram at a time via the console keyboard. He keys in each normally open or closed input contact, normally open or closed output contact, branch point, and driven output coil.

Once the drawing of the input circuit is the same as his schematic drawing, he may then store this circuit in the PDP-14 program storage. A series of these circuit diagrams, entered and stored in this way, constitute a PDP-14 program. All stored circuits may be recalled, deleted, listed, and edited at any time. As the control engineer is storing these circuits and building his PDP-14 program, he may run this program on-line, actually running his equipment and interrogating inputs and outputs and setting outputs on or off.

PROGRAMMING WITH CRT-14

In order to develop a PDP-14 program using CRT-14, the control engineer must first prepare his ladder diagram, make wire terminal assignments and number branch points. He may then enter and store the diagrams one at a time.



The following are the ladder diagram design rules for CRT-14:

1. One output circuit may contain up to ten parallel lines. Each line may contain a combination of eleven input contacts, output contacts, and branch points.
2. The same contact may be used in as many circuits as necessary.
3. All branch paths must return to L1 (AC line or DC supply).
4. All inputs and outputs can be numbered using the X and Y symbology or straight number method with inputs from 0-377 octal and outputs from 400-776 octal.

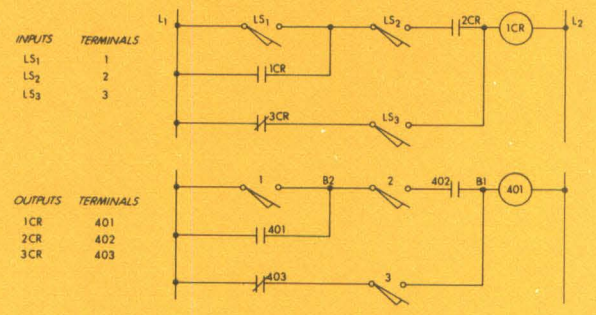
ENTERING THE LADDER DIAGRAM

When the circuit conforms to the CRT-14 design rules, and all wire terminals and branch points in that circuit have been assigned, the control engineer is ready to enter his circuit into CRT-14 using the following keyboard symbols:

CRT-14 KEYBOARD SYMBOLS

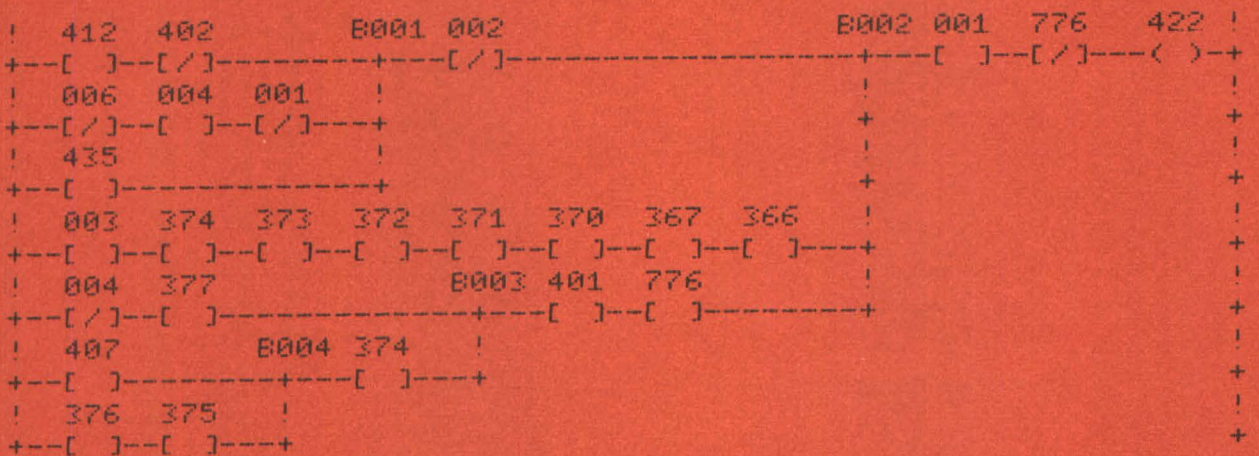
SYMBOL	
L1	Line 1 (AC line or DC supply)
B	Branch Point
⊣⊢	Normally open contact
⊣/⊢	Normally closed contact
–( )–	Output driver (end of circuit)

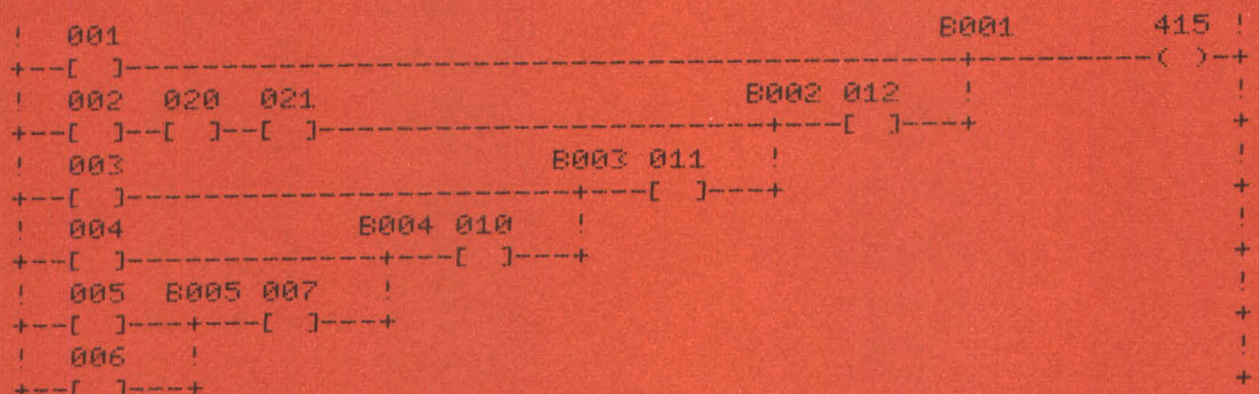
SAMPLE ENTRY OF LADDER DIAGRAM

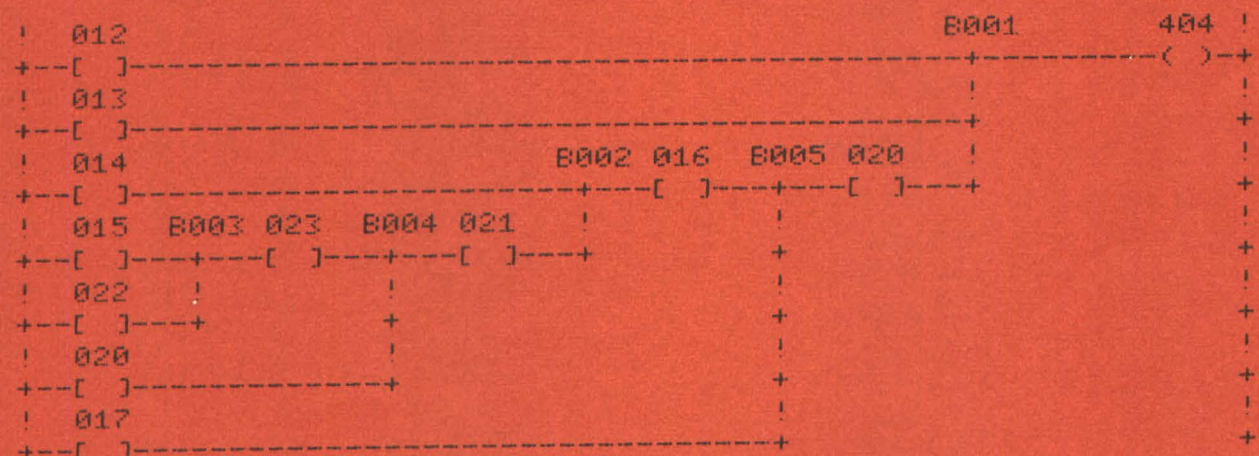


You Type:	Description of Item
L1	(Reference AC line or DC supply)
⊣⊢ 1	(N/O input #1)
B2	(Branch point 2)
L1	(Reference AC line or DC supply)
⊣⊢ 401	(N/O contact #401)
B2	(Branch point 2)
⊣⊢ 2	(N/O input #2)
⊣⊢ 402	(N/O output #402)
B1	(Branch point 1)
L1	(Reference AC line or DC supply)
⊣/⊢ 403	(N/C output #403)
⊣⊢ 3	(N/O input #3)
B1	(Branch point 1)
–( )– 401	(Output driver 401—end of circuit)

SAMPLE CRT-14 PRINTOUT OF THREE CIRCUITS







SET-14 AND BOOL-14

SET-14 and BOOL-14 translate English statements into PDP-14 control statements and automatically write all the necessary instructions. System documentation and hard copy used in debugging the control sequence are also generated. SET-14 allows the control engineer to write equations using his own names for inputs and outputs. It then translates these symbolic equations into "X and Y" equations required for BOOL-14 and generates a listing which includes both the symbolic equation and the corresponding X and Y equation.

BOOL-14 translates control equations which are written with symbols similar to Boolean notation into the PDP-14 machine code instructions. A series of these equations constitute a PDP-14 program.

SIM-14: PDP-14 PROGRAM DEBUGGING AID

SIM-14 is the PDP-8 based simulator for the PDP-14 system. Its primary use is to assist the PDP-14 user in debugging programs compiled by BOOL-14 or developed with CRT-14. It can also be used to compose programs directly by typing PDP-14 instructions under control of SIM-14.

SIM-14 has two basic modes of operation, local and on-line. It offers the user several approaches to locating and correcting program bugs. SIM-14 also protects the user from making mistakes that could damage valuable machinery.

The local mode of operation enables the user to check his program for errors off-line. The program check is performed entirely within the PDP-8 family computer. All inputs and outputs are simulated by the PDP-8 computer. The program can be checked without concern for damage to equipment since operations in the local mode have no effect on the PDP-14 or the controlled machinery. In fact, it is unnecessary to have the machinery connected to the PDP-14 or to have the PDP-14 connected to the PDP-8 computer. Local mode debugging offers three features for testing programs:

1. The user supplies input states for a given equation and SIM-14 reports the resultant state of the output. This proceeds equation by equation.
2. The computer generates a complete truth table which totally defines the state of an output for all possible input states. This is also done for each equation.
3. The user tests the complete program using simulated execution. He tests the complete program in sequence by specifying input states. Changing output states are reported by SIM-14. The user continues to vary input values to test all segments of the program.

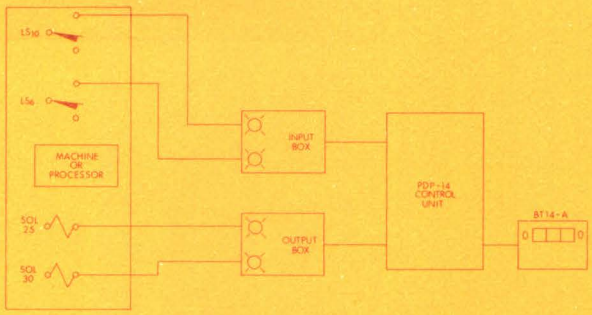
After a program has been fully debugged in the local mode, the on-line mode can be used to guarantee the program operates the actual equipment when placed in a PDP-14 memory. The PDP-14 is used in the on-line mode to execute the program contained within the PDP-8 computer before a Read Only Memory is made. Using on-line mode, wiring of inputs can be checked by "interrogating" each input to determine whether the input contact is wired to the proper terminal. Output wiring can be checked by directly setting non-critical outputs (i.e., signal lights, conveyor motors, etc.) on and off. Once the program has been fully debugged SIM-14 can output a binary tape from which a Read Only Memory is made or the SIM-14 program may be entered directly into the PDP-14 read/write memory.

MAINTENANCE

The PDP-14 is designed to be maintained by the user. Although computer-based diagnostics and DIGITAL field service are available, they are generally not necessary for the maintenance of the equipment. The first step in servicing the PDP-14 and the controlled equipment is to distinguish equipment failures in the controlled device from those in the control system. With the PDP-14 Programmable Controller, a systematic maintenance procedure is presented.

The PDP-14 is equipped with indicator lamps on each input and output. Used in conjunction with these lights is an interrogator box (BT14-A) which allows maintenance personnel to differentiate between failures in the PDP-14 and failures to a specific I/O field device or a specific component on the PDP-14.

Let's use the inputs and outputs in the diagram to describe a maintenance procedure. First, let's say that to activate Solenoid 25, both Limit Switch 10 and Limit Switch 16 must be on. However, Solenoid 25 was not activated. What do we do?



STEP 1. If the indicator lamp for Solenoid 25 on the O-Box is *off*, look at the indicator lamps on the input box for LS_{10} and LS_{16}.

A. If either LS_{10} or LS_{16} indicator lamps are *off*, the limit switch is not operating and should be replaced.

B. If both LS_{10} and LS_{16} indicator lamps are *on*, use the interrogator box.

This step has told us that the malfunction is not in the field device, but in the controller itself.

STEP 2. Use Interrogator Box to test the output to Solenoid 25.

A. If the test light on the BT14-A is *on*, the trouble is either a bad triac driver or a blown fuse on the output module (K614), possibly caused by a shorted solenoid. Replace the faulty component.

B. If the test light on BT14-A is *off*, use the BT14-A to test inputs LS_{10} and LS_{16}.

STEP 3. Use Interrogator Box to test inputs LS_{10} and LS_{16}.

A. If the test light on the BT14-A for either LS_{10} or LS_{16} is *off*, replace the input *converter* module (K578 or K579).

B. If the test light on the BT14-A is *on*, for both inputs, replace the output enabling module (K207).

If timers or storage elements are part of the sequence, treat them as outputs and perform the same maintenance procedures. For more detailed information, consult the PDP-14 Maintenance Manual.

SUMMARY OF PDP-14 HARDWARE

INPUTS	Eight I-boxes of 32 inputs each, total of 256 inputs. All inputs 115 VAC, 1.5 VA, or 10-55 VDC.
OUTPUTS	16 O-boxes with 16 outputs each, total of 255 outputs. All outputs 115 VAC, 500 VA max., or total distributed load of 250 VA each. DC: 10-250 VDC (one amp per output switched to ground).
CONTROL UNIT	Accepts memory containing over 4,000 separate instructions. Requires 115 VAC, less than 160 VA. The control program is scanned at approximately 15 milliseconds per 1K or PDP-14 memory.

Dimensions:	PDP-14 Control Unit: 24" w x 17-5/8" h x 8" d Interface Boxes (I,O,A): 4-3/8" w x 10-7/16" h x 7-1/8" d
Ambient Temperature:	0° to 70° C.
Electrical:	Meets J.I.C. Electrical Standards for mass production equipment (EMP-1-1967).
Line Voltage:	105-125, 210-240 VAC single phase
Line Frequency:	47-500 Hz
Input Box:	AC: Reactive load, nominal 1.5 VA per input DC: 10-55 VDC (above with external resistor)
Output Box:	AC: 4000 VA to its combined 120 VAC loads (individual output circuits can supply up to 500 VA). DC: 10-250 VDC (1 amp per output switched to ground).

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