PROGRAMMABLE LOGIC CONTROLLERS

What do the names Cutler-Hammer, AEG, Allen-Bradley and Texas Instruments have in common? Certainly more than the letter "e"! These manufacturers are just a few of a large number who produce Programmable Controllers (P.C.s) for industrial use. In this article we'll examine what a P.C. is, why they are used and how they evolved. Note however that the world of industrial control and sequential circuit synthesis is quite large and involved. In these few pages we will barely scratch the surface.

by Peter Ihnat and Lew Pogson,
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Electrical Engineering,
Wollongong College of TAFE

SINCE THE successful development of the digital computer there has been a steady increase in the application of digital principles and devices in industrial electronics. The reason for this is that digital implementation is efficient, reliable, flexible and, in many cases, cheaper than existing analogue equipment. Couple this with the ability to interconnect digital equipment in the plant with the central computer back at the office and you have a factory which is efficient and economical to run — all stages of production can be easily monitored, and new orders or changes to existing orders can be rapidly passed on to the plant.

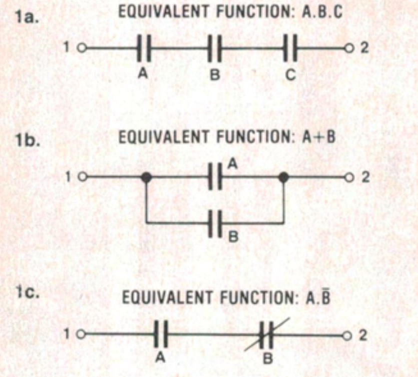


Figure 1. Equivalent logic functions for some simple relay contact connections.

Industrial control

Most industrial processes require several operations to produce the required output. Some or all of the following could be involved — manufacturing, machining, assembling, packaging, finishing and transporting. But on closer examination it becomes obvious that each of these operations is composed of other operations.

For example, to machine a particular metal piece may involve loading it into a lathe, machining into shape, drilling appropriate holes and then putting it onto a conveyor to travel to the anodising area. This is where the industrial control system comes into the picture — it must provide precise co-ordination of the individual tasks for the overall system to function.

Controllers can be divided into two general categories — *sequential* and *combinatorial*. Sequential controllers are for processes which require that certain operations be performed in a specific order. Combinatorial controllers, on the other hand, perform operations without regard to the order. The machining of a metal piece as described above is an example of a sequential process needing sequential control — a bit like filling a bottle and then putting the cap on, it has to be done in that order.

An example of a combinatorial process is the placing of labels on the front and back of a cardboard carton — it doesn't matter in which order this is done. In industry, the

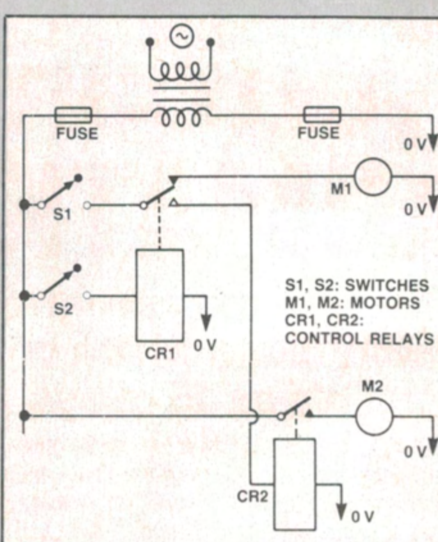


Figure 2a. Example of a simple controller

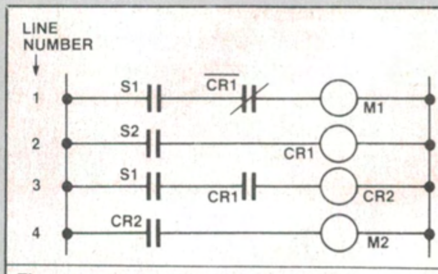
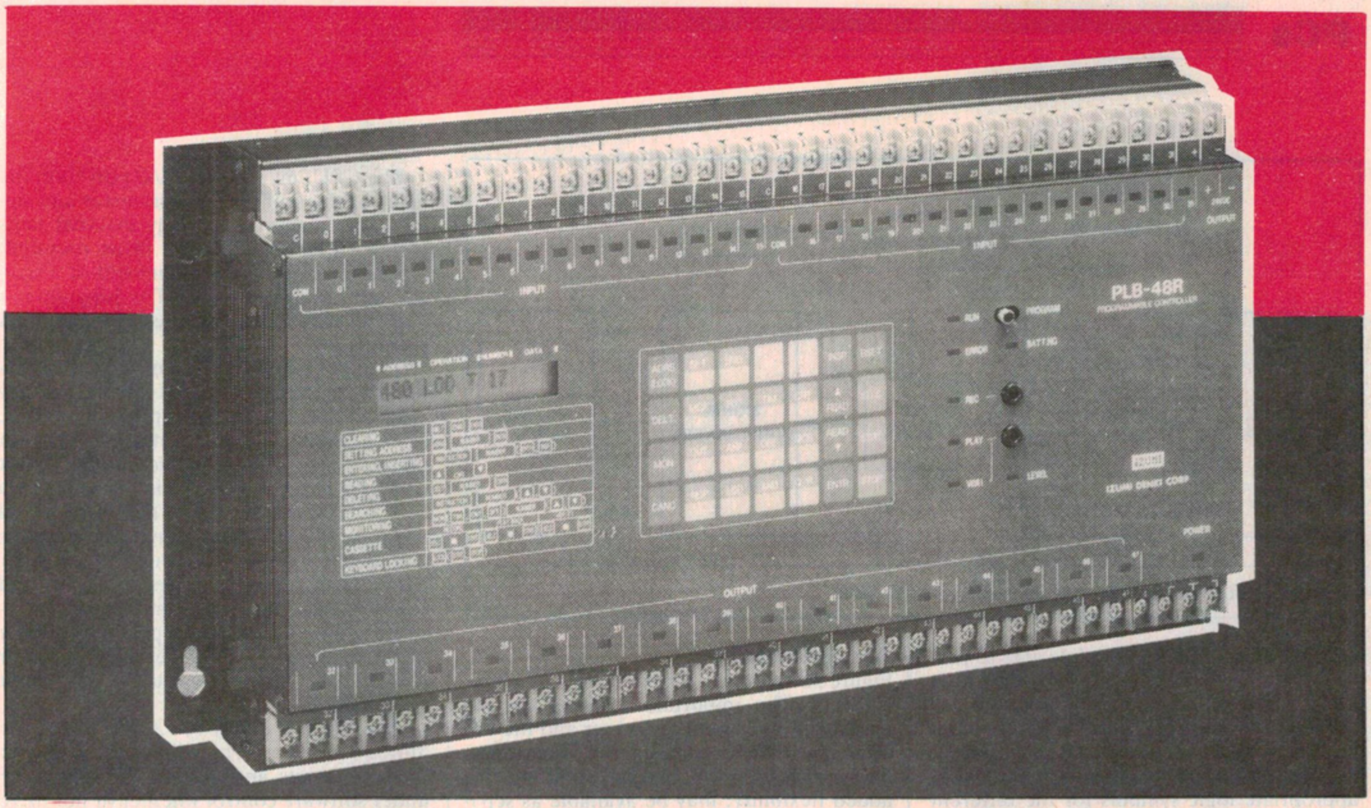


Figure 2b. Relay ladder diagram for Figure 2a.
NOTES: (1) A CR input is actually one of the relay's contacts. A CR output is the relay's coil.
(2) Note how the SPDT contacts of CR1 are implemented (lines 1 and 3).



majority of control problems are sequential but in practice all processes, whether inherently sequential or not, are performed sequentially. This generally reduces setup costs and results in a well-ordered system.

Early controllers used multicontact relays which were interconnected to perform various functions. Control switches such as start, stop, over-ride, etc operated the relay coils. The contacts they switched operated indicator lamps, motors, solenoids and other relay coils. With the introduction of digital logic to industry, design and implemention of these controllers were greatly simplified. Let's examine some simple ideas in the development of digital controllers.

A closed relay contact represents the TRUE or logic 1 state and the open contact FALSE or logic 0. Figure 1 shows some basic relay contact connections and their equivalent logic functions.

Figure 1a shows the AND function — there will be continuity between points 1 and 2 only if contacts A AND B AND C are closed. This will occur if the coils which operate contacts A, B and C are all energised.

The OR function is shown in Figure 1b and results in continuity if contact A OR B (OR both) are closed. Once again this implies that any of the coils which operates contacts A or B is energised (or both are).

Figure 1c is basically the same as 1b except that continuity is realised if contact A's coil is energised and B's coil is not (in other words, B is a normally closed contact which opens when its coil is energised).

To give a more practical example, refer to Figure 2. Figure 2a shows twomotors, M1 and M2, connected to switches S1, S2 and control relays CR1 and CR2. Operation is as follows: Motor M1 is energised if S1 is ON and S2 is OFF. Motor M2 is energised via relays CR1 and CR2 only if S1 AND S2 are both ON.

Figure 2b shows the equivalent "circuit diagram" which is more commonly known as the RELAY LADDER DIAGRAM. The supply transformer usually has fuses in each secondary lead which then extend vertically to form boundary lines for the diagram. The following conventions are used:

- the supply transformer and its fuses are usually not shown.
- switches, relay contacts and other input devices are placed on the left of the diagram.
- relay coils, lights, motors and other output devices are placed on the right of the diagram.
- output devices are shown in the order they are energised during normal sequence of operations. This enables the operation sequence to be easily listed by traversing the ladder diagram line by line.

The actual controller is hard wired by interconnecting banks of relays in accordance with the ladder diagram and then connecting switches, motors, lamps etc to it.

There are several techniques for designing the sequential controller, given a request in the form of word statements, specifications or manufacturing statements. Most are rather involved and require state diagrams, transition tables and minimization techniques and, as mentioned previously, are outside the scope of this article. For very simple cases the "commonsense" approach usually works and basically is a way of producing a relay ladder diagram line by line as one goes through a machine cycle. This is the method we'll use later when showing examples of P.C. programming.

Meet the P.C. A typical programmable controller unit. Note the two banks of 16 inputs along the top and the row of outputs along the bottom, all with screw terminals. This unit can be programmed via the front panel keyboard using simple mnemonic type instructions. This unit is made by Idec Izumi, distributed here by Email (See Supplier's Index at end of article).

Application of solid-state logic

Originally, the relay ladder diagrams were implemented as implied — racks of relays hard wired to each other, to switches, indicator lights, motors and whatever else needed controlling. You can probably see the major disadvantage of such a system. Any changes required to the control system meant physically changing relays and rewiring the new section — a costly and time-consuming operation.

So it seems quite logical ('scuse the pun) that the next step in the evolution of controllers was to use solid-state digital logic to replace many conventional relay panels. The advantages were higher reliability, lower cost, smaller size, higher speed, *increased flexibility* and compatibility with computers.

The transition to digital logic was straightforward since, as we saw in Figure 1, the various lines in a ladder diagram can be written as Boolean equations. The design process involves converting the control requirements to Boolean form, performing any simplifications, choosing the components to perform the logic decision-making and selecting the proper interfacing devices to match the circuitry to the outside world.

Solid-state logic components are classified into four categories — input interfacing, logic gates, output interfacing and accessory components. Each component is ▶

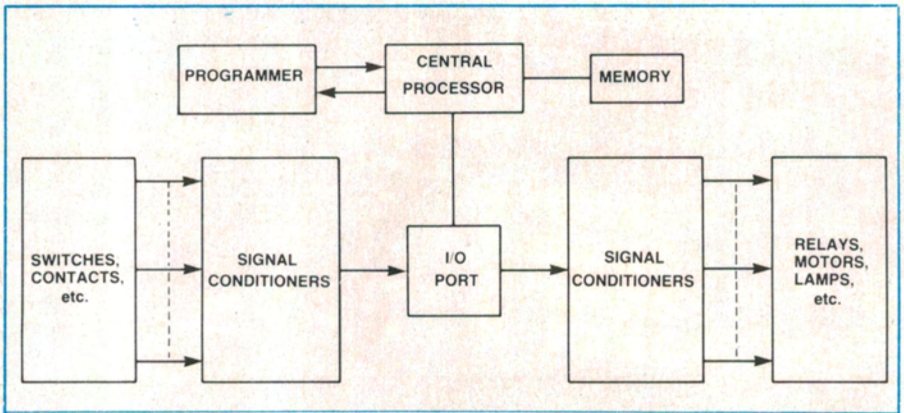


Figure 3a. Block diagram of a programmable controller setup.

a transistorised, plug-in module able to perform one function. Groups of these plug into a base which allows interconnections to be made between the modules. Diagrammatically, the relay ladder diagram is replaced by a logic diagram which uses appropriate logic symbols for the different functions.

Programmable controllers

Even though solid-state logic controllers were simpler to construct than an equivalent relay panel, they were still designed and built for a specific operation or process. The cost of making changes to the circuit was still quite high. In the late 1960s a new type of controller emerged from the automotive industry's need for more flexible control on the factory floor. The programmable controller revolutionised industrial control by being able to have its operation specified by a program.

The transition to using the new controllers was aided by using a programming language already understood by the plant electrician and engineer (relay ladder diagrams).

These days, controllers can replace everything from simple relay circuits to sophisticated process control equipment and, in addition, have new capabilities such as being able to accept analogue inputs, provide analogue outputs and carry out closed loop control. Other invaluable features include the ability to communicate with other P.C.s and with computers over long distances and under adverse conditions with or without separate intelligent data handling equipment.

It's probably not hard to guess that the introduction of P.C.s had something to do with the microprocessor revolution. Basically, a P.C. is a robust microprocessor-based unit which uses memory to store instructions specified in a simple ladder logic programming language. When running, it monitors the conditions of its inputs to provide outputs by implementing logic, sequencing, timing, counting and arithmetic functions.

Architecture

Figure 3a shows the block diagram of a typical P.C. The important sections are the CPU/memory, the programmer and the I/O modules (signal conditioners). These may all be contained in the one unit or, for added flexibility, may be available as separate units. In the latter case, the CPU/memory unit usually includes panels of sockets for the I/O modules to be plugged in. This allows any combination of inputs and outputs to be set up (only limited by maximum number possible for that particular P.C.). Let's look at each section in turn to better appreciate the operation of a P.C.

a) CPU

The CPU is actually the "brains" behind the controller. In many P.C.s it is a standard microprocessor such as the Z80A, 6502 or 6800 (some manufacturers, though, use chips specially designed for logic decision making). With only a few exceptions, all the CPUs are either 8- or 16-bit devices.

The CPU, memory and I/O port form the heart of the unit. The programmer and signal conditioners are usually external units which are simply plugged in as required. Figure 3b shows the arrangement of a typical unit used in practice. The programmer and I/O modules are discussed in the next two sections.

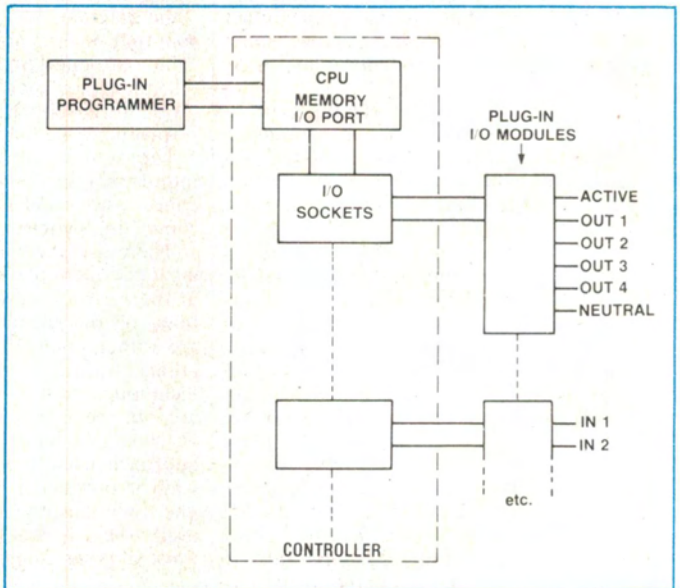
The controller has two modes of operation — PROGRAM and RUN, usually selected by a slide switch or, in some cases, a key-operated switch, making the unit tamper-proof. Programs are entered whilst in PROGRAM mode, which also offers a complete range of editing facilities (we all make mistakes). These include inserting and deleting entries, finding a particular entry, changing parameters of timers and counters etc. Once programmed, it's possible to test the operation by plugging in a test panel made up of switches and indicator lights and going through all input combinations.

Alternatively, most P.C.s implement the "force" function. This allows the operator to force inputs and outputs ON and OFF under software control whether or not there are any inputs or outputs actually connected. Its main use, though, is to aid in troubleshooting.

Once programmed and checked, the unit is simply left in RUN mode to control the equipment it becomes part of. Obviously, there will be times when power failures will occur and, as every computer buff knows, static RAM loses all its information if this happens.

The problem is overcome in P.C.s by three methods. Firstly, internal static RAM always has battery backup. This, however, is not usually a permanent arrangement. It is used when the program is first loaded and de-bugged. If all is well, the program is then ▶

Figure 3b. A typical P.C. used in practise.



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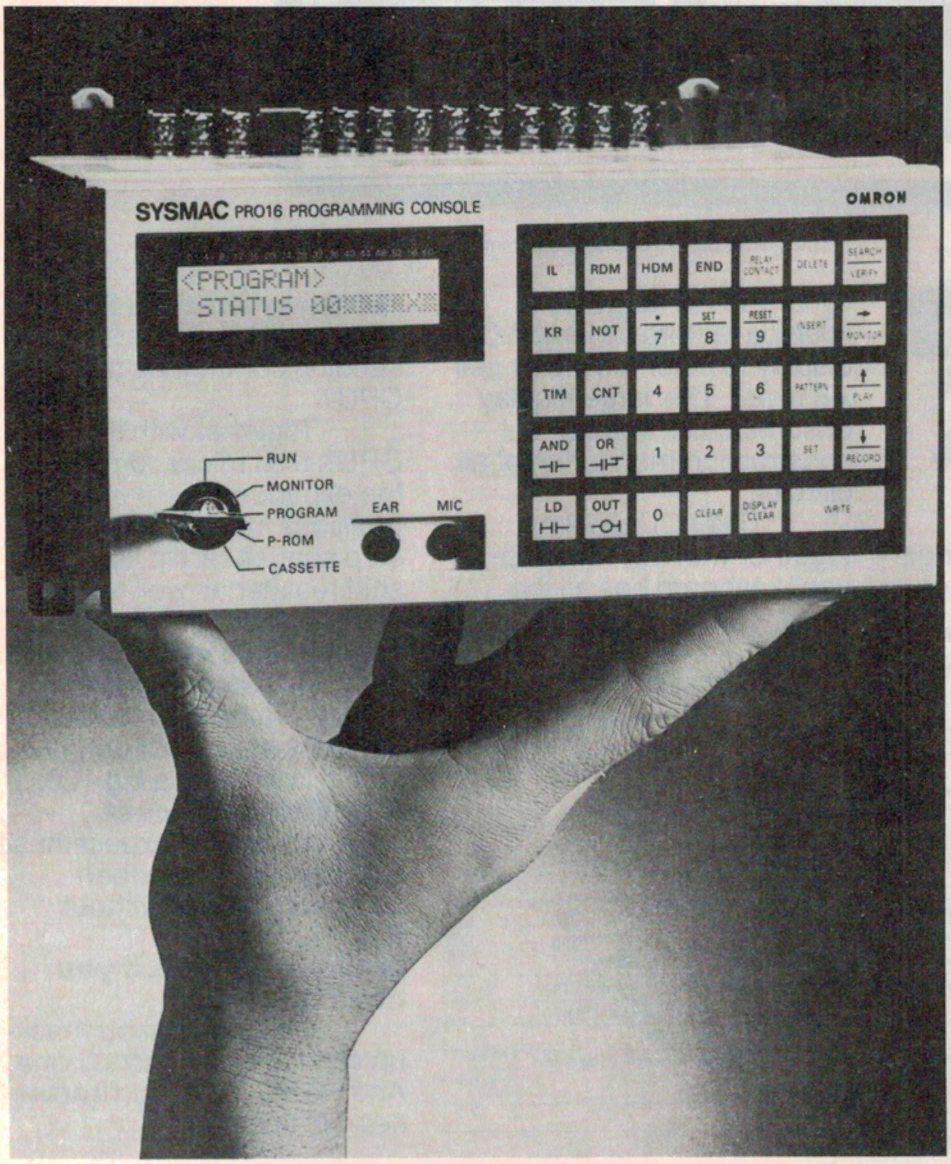

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Category.	Item.	EX20.	EX40.	EX40H.	Remarks.
Program memory	Program size	0.5 kW	1 kW	1 kW	
	Memory elements	CMOS RAM (Battery backup)/PROM			
	Execution time	60μs/step		3μs/step	
Instructions	Logic	—| |— —|/|— —|↑|—*			* EX40/ 40H
	Output	—( )— —[ ]—*	—(MS)— —(MR)—	—(JS)—* —(JR)—*	
	Functions	Step sequence shift-register Timer (0.1-second units), Counter, Flip-flop*, shift-register*			
I/O	Basic points	12(I)/8(O)	24(I)/16(O)	24(I)/16(O)	
	Maximum points	24(I)/16(O)	48(I)/32(O)	72(I)/48(O)	
	Input method		Junction input		
	Output method	Ry(110/240 V AC; 24 V DC, 2 A), Triac(110 V AC, 1 A), Tr(24 V DC, 1 A)			
Storage	Internal output	64 points	128 points	128 points	
	Latch output	64 points	128 points	128 points	
	Timer	8(0.1 to 999.9 seconds)	16(0.1 to 999.9 seconds)	64(0.1 to 999.9 seconds)	
	Counter	8(1 to 9999)	16(1 to 9999)	64(1 to 9999)	
Self-diagnosis	Display	POWER, RUN, ERROR, ALARM, (PROM)			
	Item	WD timer check, memory check, execution time check, battery voltage check			LCD programmer memo code display
Peripheral devices	–	LCD programmer			

TMPC

Process Controls

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A Division of Tubemakers of Australia Limited copied into EPROMs, which plug into the CPU unit. This provides the permanency required by the controller. If any changes are required, these are made in RAM and copied into the EPROMs after erasing the original program.

The third and latest development is to use EEPROMs (Electrically Erasable PROMs) to hold the program. These don't need a UV source for erasing old information and allow changes to be made relatively quickly.

In RUN mode, the CPU performs a number of functions. Firstly, it scans the inputs and loads their status (1 for ON, 0 for OFF) into a temporary store. Also in this store are the outputs — the results of the Boolean, arithmetic and other operations. These are output to their appropriate output modules. Next, the CPU traverses the stored program line by line and logically or arithmetically combines inputs and outputs as specified by the program to produce new outputs, which are placed in the temporary store. The cycle then repeats.

Other functions which the P.C. implements are timers, counters, master control relays, drum controllers etc. These are all implemented in software and, as mentioned before, will not be treated here in any depth.

b) The programmer

There are basically two types of programmers available with P.C.s — *handheld* programmers and *video* programmers. The cheapest is the handheld programmer and is most often used with small P.C.s. Its appearance is similar to that of a calculator and has a display (LED or more recently, LCD) and a sealed keyboard to stand harsh industrial conditions (see Figure 4a). It is plugged into the controller either directly (that is, it physically mounts into a recessed area on the controller) or via a cable of some sort.

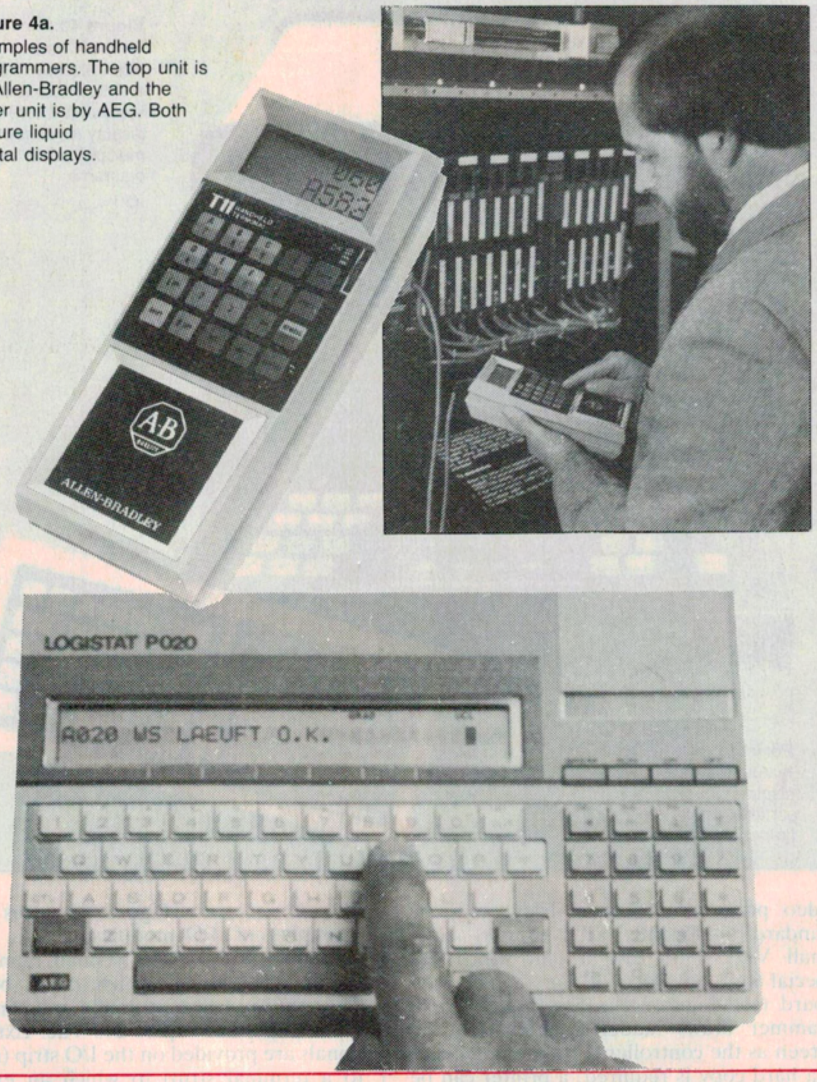


Figure 4a. Examples of handheld programmers. The top unit is by Allen-Bradley and the lower unit is by AEG. Both feature liquid crystal displays.

Simple. The AEG Logistat A020 P.C. is probably one of the simplest, low-cost units around. It's distributed here by Nilsen Rowe.

Some controllers have built-in programmers but in many cases this is not required. The reason is that once the controller is programmed and fitted beside the equipment it controls, the programmer is of no further direct use. It can, however, be carried by the plant engineer and plugged into a controller to modify the program, monitor inputs, outputs, internal timers, counters or even change variables or conditions of inputs and outputs *while the controller is running*.

Note that if numerous controllers are used on the plant and if all are identical, then only two or three programmers need be purchased. This reduces the overall cost of the system since not all controllers will require programmers simultaneously once commissioned.

The most sophisticated method of programming and fault-finding is by use of a ▶

Figure 4b. This unit from Allen-Bradley features a detachable touchpad keyboard. The 9-inch display can show multiple ladder logic diagrams. ◁

Portable. This Toshiba features a liquid crystal display that gives a portable programmer ladder logic readout. ▷

video programming unit. These may be standard intelligent VDUs or may be a small VDU built into a unit which has special keys in place of the regular keyboard (see Figure 4b). This type of programmer draws ladder diagrams on the screen as the controller is programmed and if a hard copy is required, a printer can be connected to the system.

When troubleshooting or placed in RUN mode, controller operation can easily be monitored since paths and coils which are energised are shown by thicker lines (intensification of light on a VDU or double lines in printouts). Figure 4c gives an example of a typical printout. Of course, this type of programmer is much more expensive than the other.

c) I/O modules

These modules provide the link between the controller and the outside world. The equipment connected to a P.C. will almost certainly require different operating voltages. In fact in practice, most outputs will need to control much higher voltages and currents than the controller will supply. Inputs may also be high voltage ac and/or dc signals. In all cases, isolation from the controller circuitry is required. This is achieved easily by means of opto-couplers, but sometimes in the case of outputs relays are used.

Figure 5a gives some examples of I/O modules.

Smaller P.C.s have a small number of inputs and ouputs which come built-in. These are isolated internally and can operate devices rated up to 240 Vac. Extra terminals are provided on the I/O strip (similar to a terminal strip) to which an external power supply can be connected for powering each particular device (see Figure 5b).

The outputs and inputs are usually grouped in pairs or fours so that different voltages can be applied to each group. Larger P.C.s simply provide panels of sockets into which input and output modules are plugged. Each module provides four inputs or outputs, each with an individual indicator lamp, fuse and opto-isolator. This provides the greatest flexibility since:

- only the number of I/O modules actually required need be purchased (plus spares)
- a blown module can be easily swapped without switching off the entire system
- number of I/Os can be increased up to the limit of the machine by using expansion modules which hold extra I/O modules.

Typical inputs to a P.C. include pushbuttons, limit switches, sensors, flow switches, controllers, thumbwheels, LDRs and other optical devices, vacuum switches. Some outputs are solenoid coils, motor starter coils, indicator lights, alarm circuits, etc.

Overall advantages

1. Size: A P.C. can be housed in an enclosure which is substantially smaller than that required for its relay counterpart.

2. Reliability: The P.C. has no moving mechanical parts to wear out and fail. With electronic systems, most failures occur during manufacture and testing.

3. Flexibility: The P.C. is ideally suited for control systems whose control schemes may be revised later. Changing a hand-wired relay system often requires long downtimes and high labour costs. By contrast, changing the control system in a P.C. most often only requires the changes to be entered with the programmer.

4. Ease of installation: With a P.C., minimal panel wiring is required for installation in the plant.

5. Simple programming: Most P.C.s are designed to be programmed in ladder logic, a language normally understood by the users.

6. Fault-finding: Fault-finding is relatively easy with the use of ladder diagrams and input/output module indicators.

7. Hostile environment: P.C.s are specifically designed to operate in industrial environments; e.g: a typical operating temperature range could be 0-60°C.

8. Cost: Overall costs of P.C. schemes are less than relay schemes.

9. Range of P.C.s available: Nearly 40 manufacturers in the USA alone produce P.C.s. They vary in size from eight I/Os to 4096!

```
       :                                  :
       :                                  :
 1.    :===[ ]----[ ]------( )----:
       :    S1        S2          M1      :
       :                                  :
 2.    :===[ ]====[/]===+==( )====:
       :    S3        S4   "    CR1       :
       :                   "              :
       :                   "              :
       :                   +==( )====:
 3.    :                        CR2       :
       :                                  :
 4.    :===[ ]====[ ]---+--( )----:
       :    CR1       S1   :    M2        :
       :                   :              :
       :                   :              :
 5.    :                   +--( )----:
       :                        M3        :
       :                                  :
       :                                  :

                  etc.
```

Figure 4c. Example of a P.C. printout.

Normally open contacts (NO)	[ ]
Normally closed contacts (NC)	[/]
outputs	( )
active path	====
inactive path	----

Programming example

Just to complete the discussion of P.C.s, let's look at some very, very simple programming examples.

Example 1: Refer to the example given in Figures 2a and 2b. Since the relay ladder diagram is already given, the controller can be programmed without further simplification. Using a typical programming language we obtain —

```
START X1
AND NOT CR1
OUT Y1
START X2
OUT CR1
START X1
AND CR1
OUT CR2
START CR2
OUT Y2
END.
```

Note that START begins each new line of the program. Inputs and outputs can be represented by X and Y and control relays by CR.

When switches S1, S2 and motors M1 and M2 are connected to the P.C. they connect to I/O terminals X1, X2, Y1 and Y2, respectively. Finally, an ENTER button is usually pressed after each line of programming. Simple! Saves interconnecting relays.

Example 2: Refer to fig. 4c.

```
START X1
AND X2
OUT Y1
START X3
AND NOT X4
OUT CR1
OUT CR2
START CR1
AND X1
OUT Y2
OUT Y3
END.
```

Example 3: Assume we have a room with two doors and one light in the middle of the ceiling. Each door has a switch which operate as follows — the light can be switched ON and OFF by either switch. For example, the light can be switched ON when you enter door 1 and switched OFF as you leave door 2. The same applies if you re-enter via door 1 or door 2.

Those of you into logic will recognise this as the EXCLUSIVE-OR function. If we start with both switches in the UP position, the light will be OFF. If the room is entered via either door and the switch operated, the light will come ON.

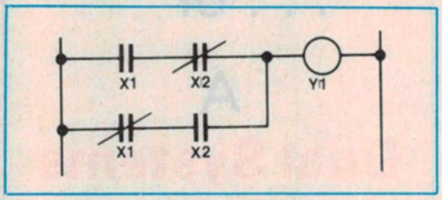
In this condition, one switch will be in the UP position and the other DOWN. When leaving, to put the light OFF, either both switches will be in the DOWN position or both will be UP (depending on which door is used). To put this into digital form, let's call the switches X1 and X2 and the light Y1.

If a switch is put in the UP position then it is represented by $\overline{X1}$ (or $\overline{X2}$). If in the down position, then it becomes X1 (or X2, depending on which switch we're talking about).

For the light to come on, we can deduce from the previous paragraph that one switch must be DOWN and the other UP. If both are UP or DOWN then the light will be OFF. In other words:

$$\text{light ON} = X1.\overline{X2} + \overline{X1}.X2.$$

This is read as "the light will be ON if X1 is DOWN AND X2 is UP OR X1 is UP AND X2 is DOWN". The ladder diagram and program are —




```
START X1
AND NOT X2
START NOT X1
AND X2
OR MEMORY
OUT Y1
END.
```

Note how two lines are started to give the two parallel paths. When the second path is started, the first is stored in memory (like a stack) since it wasn't completed. The OR MEMORY instruction ORs the current line with the stored line. ▶

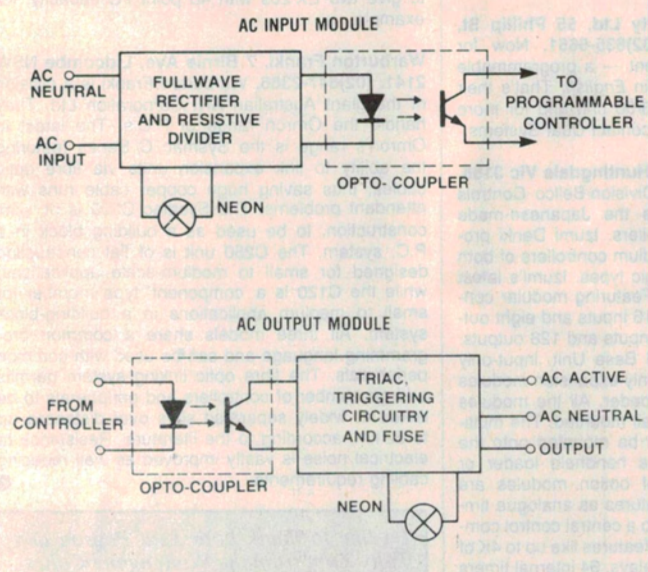


Figure 5a. Block diagrams of typical I/O modules.

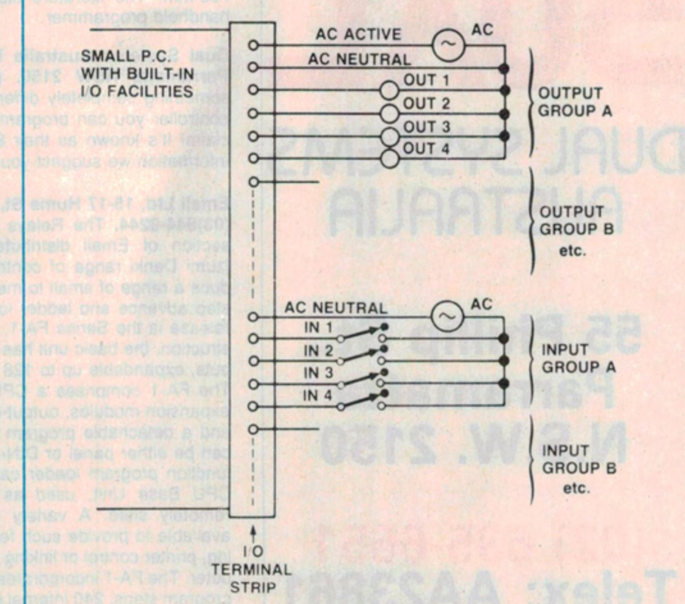


Figure 5b. Example of I/O connections for a small P.C.

SUPPLIERS' INDEX

This index is intended as a guide to suppliers of programmable controllers and is based on information supplied from the companies listed. We make no claims that this is a 'definitive' list. Further details on programmable controllers should be sought from the firms listed, not from Electronics Today.

Allen-Bradley Pty Ltd, 188 Whitehorse Rd, Balwyn Vic 3103. (03)80-6171. Australian branch of the Ohio, USA-based electronics manufacturer. They offer a positively huge variety of controllers, from quite 'tiny' systems with just 32 I/O lines and 640 words of memory to monsters with 4096 inputs and 4096 outputs featuring 96K of memory (core or RAM), report generation, prompted programming and other sophisticated features. A-B controllers can be programmed with terminal type or handheld programmers. Allen-Bradley has offices in Sydney (648-2652), Brisbane (343-7900) and Perth (387-1702).

AVH Electrical Engineering Pty Ltd, 86-88 Greville St, Prahran Vic 3181. (03)51-6844. AVH distribute and service the German-made Dold 'Minimaster BT 3200' programmable controller system. This compact unit can be programmed with a personal computer, such as a Commodore 8000 system or the Epson HX-20 portable. They can be supplied with I/O combinations ranging from 32 to 128. It comes with 2K of memory and features 16 internal software timers. Remote potentiometers are available for external and internal timers. Programs can be filed on tape or printer.

Cutler-Hammer Australia Pty Ltd, 27 Leeds St, Rhodes NSW 2138. (02)736-1666. A firm well known in the PLC trade for their PL20-64 range of controllers, Cutler-Hammer has recently introduced the Model PL256 P.C. This is a modular design controller expandable to 256 I/O units and based on an Intel 8085 CPU. Features include 2K of 16-bit word memory, 32 timers (providing 100 ms to 2047 seconds timing delays), 16 counters, 256 internal relays, 32 master control relays and 32 jump commands. The programming language is relay ladder based. The unit uses 16-point I/O modules and the panel space requirements for a 128 I/O system is only 460 x 336 mm while a 256 I/O scheme takes up just 460 x 700 mm. The literature illustrates the unit with a handheld programmer.

Dual Systems Australia Pty Ltd, 55 Phillip St, Parramatta NSW 2150. (02)635-6651. Now for something completely different — a programmable controller you can program in *English*. That's their claim! It's known as their 83/00 unit and for more information we suggest you contact Dual Systems.

Email Ltd, 15-17 Hume St, Huntingdale Vic 3166. (03)544-8244. The Relays Division/Bellco Controls section of Email distributes the Japanese-made Izumi Denki range of controllers. Izumi Denki produce a range of small to medium controllers of both step advance and ladder logic types. Izumi's latest release is the Series FA-1. Featuring modular construction, the basic unit has 16 inputs and eight outputs, expandable up to 128 inputs and 128 outputs. The FA-1 comprises a CPU Base Unit, input-only expansion modules, output-only expansion modules and a detachable program loader. All the modules can be either panel or DIN-rail mounted. The multi-function program loader can be mounted onto the CPU Base Unit, used as a handheld loader or remotely sited. A variety of option modules are available to provide such features as analogue timing, printer control or linking to a central control computer. The FA-1 incorporates features like up to 4K of program steps, 240 internal relays, 64 internal timers ranging from 10 ms to 999.9 seconds and 45 internal counters providing a capacity of 9999 count rates to 1 kHz and add/subtract capabilities.

Nilsen Rowe Australia Pty Ltd, 200 Berkeley St, Carlton Vic 3053. (03)347-9166. Nilsen Rowe import and distribute the German-made AEG-Telefunken Logistat A020 programmable controller. This compact unit features 24 inputs and 16 outputs. It features LED displays to indicate the state of the outputs plus programming via either a portable, LCD readout unit or a terminal using the DOLOG 80 A language. Up to 896 instructions can be handled by the A020. In addition, it can handle up to 16 timer and counter functions, three of which can be set from external decade switches (optional).

Siemens Industries, 544 Church St, Richmond Vic 3121. (03)429-7111. The 'Simatic' S5-101U mini P.C. is new to the Siemens range and features 240 V operation. It has 16 inputs and eight triac outputs, expandable to double that number. It can be combined with other units for 24 V supplies with 20 or 10 inputs and six or 12 relay outputs so that various supply and signal requirements can be mixed. The Simatic S5-101U is programmed in the STEP 5 language which is also used with the larger S5 series P.C.s in world-wide use. The S5-101U rounds off the Siemens S5 range and costs around $600. The Siemens 670 or 675 programmers can be used with it in the 'control systems flowchart', 'ladder diagram' or 'statement list' methods, or with the 605U handheld unit in the 'statement list' form.

TMPC Process Controls, Cnr Victoria & Elizabeth Sts, Wetherill Park NSW 2164. (02)609-6666. TMPC Process Controls (formerly Shankel Controls) is a division of Tubemakers of Australia Ltd, a BHP subsidiary. TMPC markets a comprehensive range of Japanese-made Toshiba programmable controllers. These include the EX Series, suited to small-scale control systems. The Series comprises three models: the EX 20, EX 40 and EX 40H. A consistent concept applies through the three models with the same architectures, common peripherals and expanders. The EX Series are expandable from 20 to 120 I/O points. All units employ ladder network programming, the programming unit featuring an LCD ladder pattern display. The units are lightweight and can be DIN-rail mounted. Three types of output device are available — relay, triac and transistor. The basic EX 20 incorporates eight timers and eight counters. Units can be linked together with an expansion unit to give two EX 20s with 40 point I/O capacity, for example.

Warburton Franki, 7 Birnie Ave, Lidcombe NSW 2141. (02)647-2366. Warburton Franki is a division of the giant Australian ANI Corporation Ltd. They handle the Omron range of P.C.s. The latest in Omron's range is the Sysmac C Series featuring the ability to link expansion units via fibre optic cables, thus saving huge copper cable runs with attendant problems. The Sysmac C500 is of 'slim' construction, to be used as a building block in a P.C. system. The C250 unit is of flat construction designed for small to medium-scale applications, while the C120 is a 'component' type member for small to medium applications in a building-block system. All three models share a common programming language and can be used with common peripherals. The fibre optic linking system permits a large number of controllers and peripherals to be linked at widely separated sites over distances up to 52 km, according to the literature. Resistance to electrical noise is vastly improved as well reducing cabling requirements. ●

I'd like to thank both Lew Pogson and Tony Zom from the Wollongong College of TAFE for their invaluable assistance with this article. **Peter Ihnat**

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