Introduction to PLCs

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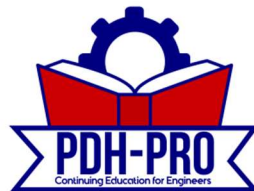
1 Programmable logic controllers

This course is an introduction to the programmable logic controller, its general function, hardware forms and internal architecture. This overview is followed up by more detailed discussion in the following chapters.

1.1 Controllers

What type of task might a control system have? It might be required to control a sequence of events or maintain some variable constant or follow some prescribed change. For example, the control system for an automatic drilling machine (Figure 1.1(a)) might be required to start lowering the drill when the workpiece is in position, start drilling when the drill reaches the workpiece, stop drilling when the drill has produced the required depth of hole, re-tract the drill and then switch off and wait for the next workpiece to be put in position before repeating the operation. Another control system (Figure 1.1(b)) might be used to control the number of items moving along a conveyor belt and direct them into a packing case. The inputs to such control systems might be from switches being closed or opened, e.g., the presence of the workpiece might be indicated by it moving against a switch and closing it, or other sensors such as those used for temperature or flow rates. The controller might be required to run a motor to move an object to some position, or to turn a valve, or perhaps a heater, on or off.
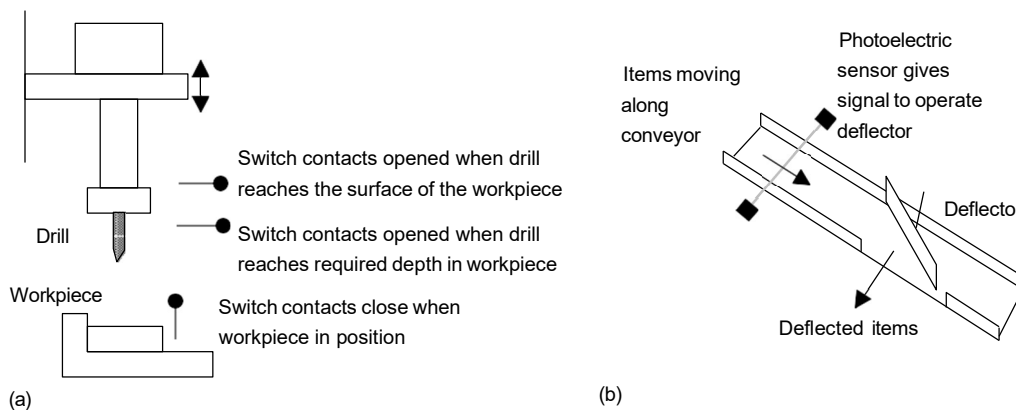

Figure 1.1 *An example of a control task and some input sensors: (a) an automatic drilling machine, (b) a packing system*

What form might a controller have? For the automatic drilling machine, we could wire up electrical circuits in which the closing or opening of switches would result in motors being switched on or valves being actuated. Thus, we might have the closing of a switch activating a relay which, in turn, switches on the current to a motor and causes the drill to rotate (Figure 1.2). Another switch might be used to activate a relay and switch on the current to a pneumatic or hydraulic valve which results in pressure being switched to drive a piston in a cylinder and so results in the workpiece being pushed into the required position. Such electrical circuits would have to be specific to the automatic drilling machine. For controlling the number of items packed into a packing case we could likewise wire up electrical circuits involving sensors and motors. However, the controller circuits we devised for these two situations would be different. In the 'traditional' form of control system, the rules governing the control system and when actions are initiated are determined by the wiring. When the rules used for the control actions are changed, the wiring has to be changed.
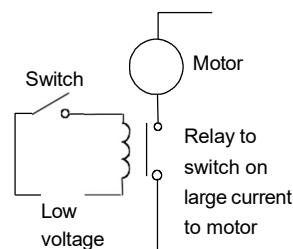

Figure 1.2 *A control circuit*

1.1.1 Microprocessor controlled system

Instead of hardwiring each control circuit for each control situation we can use the same basic system for all situations if we use a microprocessor-based system and write a program to instruct the microprocessor how to react to each input signal from, say, switches and give the required outputs to, say, motors and valves. Thus, we might have a program of the form:

> If switch A closes
> Output to motor circuit
> If switch B closes
> Output to valve circuit

By changing the instructions in the program, we can use the same microprocessor system to control a wide variety of situations.

As an illustration, the modern domestic washing machine uses a microprocessor system. Inputs to it arise from the dials used to select the required wash cycle, a switch to determine that the machine door is closed, a temperature sensor to determine the temperature of the water and

a switch to detect the level of the water. On the basis of these inputs the microprocessor is programmed to give outputs which switch on the drum motor and control its speed, open or close cold and hot water valves, switch on the drain pump, control the water heater and control the door lock so that the machine cannot be opened until the washing cycle is completed.

1.1.2 The programmable logic controller

A *programmable logic controller* (PLC) is a special form of micro-processor-based controller that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes (Figure 1.3) and are designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages. They are not designed so that only computer programmers can set up or change the programs. Thus, the designers of the PLC have pre-programmed it so that the control program can be entered using a simple, rather intuitive, form of language, see Chapter 4. The term *logic* is used because programming is primarily concerned with implementing logic and switching operations, e.g., if A or B occurs switch on C, if A and B occurs switch on D. Input devices, e.g. sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e., a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program and carries out the control rules for which it has been programmed.
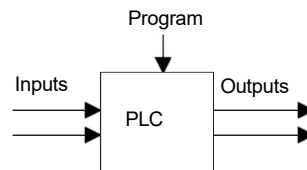

Figure 1.3 *A programmable logic controller*

PLCs have the great advantage that the same basic controller can be used with a wide range of control systems. To modify a control system and the rules that are to be used, all that is necessary is for an operator to key in a different set of instructions. There is no need to rewire. The result is a flexible, cost effective, system which can be used with control systems which vary quite widely in their nature and complexity.

PLCs are similar to computers but whereas computers are optimised for calculation and display tasks, PLCs are optimised for control tasks and the industrial environment. Thus, PLCs are:

1   Rugged and designed to withstand vibrations, temperature, humidity and noise.
2   Have interfacing for inputs and outputs already inside the controller.

3   Are easily programmed and have an easily understood programming language which is primarily concerned with logic and switching operations.

The first PLC was developed in 1969. They are now widely used and extend from small self-contained units for use with perhaps 20 digital inputs/outputs to modular systems which can be used for large numbers of inputs/outputs, handle digital or analogue inputs/outputs, and also carry out proportional-integral-derivative control modes.

1.2 Hardware

Typically a PLC system has the basic functional components of processor unit, memory, power supply unit, input/output interface section, communications interface and the programming device. Figure 1.4 shows the basic arrangement.
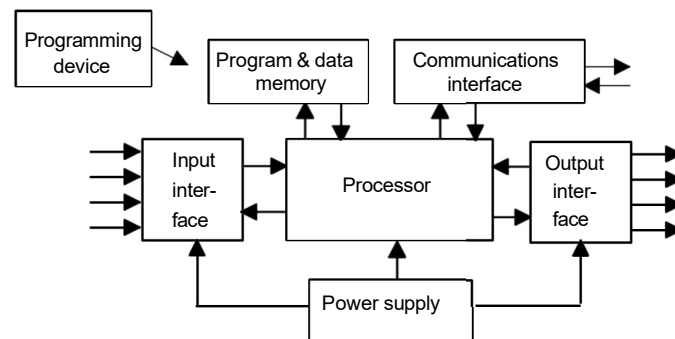

Figure 1.4 *The PLC system*

1   The *processor unit* or *central processing unit (CPU)* is the unit containing the microprocessor and this interprets the input signals and carries out the control actions, according to the program stored in its memory, communicating the decisions as action signals to the outputs.
2   The *power supply unit* is needed to convert the mains a.c. voltage to the low d.c. voltage (5 V) necessary for the processor and the circuits in the input and output interface modules.
3   The *programming device* is used to enter the required program into the memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.
4   The *memory unit* is where the program is stored that is to be used for the control actions to be exercised by the microprocessor and data stored from the input for processing and for the output for outputting.
5   The *input and output sections* are where the processor receives information from external devices and communicates information to external devices. The inputs might thus be from switches, as illustrated in Figure 1.1(a) with the automatic drill, or other sensors such as photo-electric cells, as in the counter mechanism in Figure 1.1(b), temperature sensors, or flow sensors, etc. The outputs might be to motor starter coils, solenoid valves, etc. Input and output