This chapter 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, retract 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](image)

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 microprocessor-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](image)

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.

![The PLC system](image)

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
interfaces are discussed in Chapter 2. Input and output devices can be classified as giving signals which are discrete, digital or analogue (Figure 1.5). Devices giving discrete or digital signals are ones where the signals are either off or on. Thus a switch is a device giving a discrete signal, either no voltage or a voltage. Digital devices can be considered to be essentially discrete devices which give a sequence of on–off signals. Analogue devices give signals whose size is proportional to the size of the variable being monitored. For example, a temperature sensor may give a voltage proportional to the temperature.

Figure 1.5  *Signals: (a) discrete, (b) digital, (c) analogue*

The communications interface is used to receive and transmit data on communication networks from or to other remote PLCs (Figure 1.6). It is concerned with such actions as device verification, data acquisition, synchronisation between user applications and connection management.

![Basic communications model](Image)

**Figure 1.6 Basic communications model**

### 1.3 Internal architecture

Figure 1.7 shows the basic internal architecture of a PLC. It consists of a central processing unit (CPU) containing the system microprocessor, memory, and input/output circuitry. The CPU controls and processes all the operations within the PLC. It is supplied with a clock with a frequency of typically between 1 and 8 MHz. This frequency determines the operating speed of the PLC and provides the timing and synchronisation for all elements in the system. The information within the PLC is carried by means of digital signals. The internal paths along which digital signals flow are called buses. In the physical sense, a bus is just a number of
conductors along which electrical signals can flow. It might be tracks on a printed circuit board or wires in a ribbon cable. The CPU uses the data bus for sending data between the constituent elements, the address bus to send the addresses of locations for accessing stored data and the control bus for signals relating to internal control actions. The system bus is used for communications between the input/output ports and the input/output unit.

![Architecture of a PLC](image)

**Figure 1.7 Architecture of a PLC**

### 1.3.1 The CPU

The internal structure of the CPU depends on the microprocessor concerned. In general they have:

1. An arithmetic and logic unit (ALU) which is responsible for data manipulation and carrying out arithmetic operations of addition and subtraction and logic operations of AND, OR, NOT and EXCLUSIVE-OR.
2. Memory, termed registers, located within the microprocessor and used to store information involved in program execution.
3. A control unit which is used to control the timing of operations.

### 1.3.2 The buses

The buses are the paths used for communication within the PLC. The information is transmitted in binary form, i.e. as a group of *bits* with a bit
being a binary digit of 1 or 0, i.e. on/off states. The term word is used for the group of bits constituting some information. Thus an 8-bit word might be the binary number 00100110. Each of the bits is communicated simultaneously along its own parallel wire. The system has four buses:

1. The data bus carries the data used in the processing carried out by the CPU. A microprocessor termed as being 8-bit has an internal data bus which can handle 8-bit numbers. It can thus perform operations between 8-bit numbers and deliver results as 8-bit values.

2. The address bus is used to carry the addresses of memory locations. So that each word can be located in the memory, every memory location is given a unique address. Just like houses in a town are each given a distinct address so that they can be located, so each word location is given an address so that data stored at a particular location can be accessed by the CPU either to read data located there or put, i.e. write, data there. It is the address bus which carries the information indicating which address is to be accessed. If the address bus consists of 8 lines, the number of 8-bit words, and hence number of distinct addresses, is $2^8 = 256$. With 16 address lines, $65,536$ addresses are possible.

3. The control bus carries the signals used by the CPU for control, e.g. to inform memory devices whether they are to receive data from an input or output data and to carry timing signals used to synchronise actions.

4. The system bus is used for communications between the input/output ports and the input/output unit.

1.3.3 Memory

There are several memory elements in a PLC system:

1. System read-only-memory (ROM) to give permanent storage for the operating system and fixed data used by the CPU.
2. Random-access memory (RAM) for the user’s program.
3. Random-access memory (RAM) for data. This is where information is stored on the status of input and output devices and the values of timers and counters and other internal devices. The data RAM is sometimes referred to as a data table or register table. Part of this memory, i.e. a block of addresses, will be set aside for input and output addresses and the states of those inputs and outputs. Part will be set aside for preset data and part for storing counter values, timer values, etc.
4. Possibly, as a bolt-on extra module, erasable and programmable read-only-memory (EPROM) for ROMs that can be programmed and then the program made permanent.

The programs and data in RAM can be changed by the user. All PLCs will have some amount of RAM to store programs that have been developed by the user and program data. However, to prevent the loss of programs when the power supply is switched off, a battery is used in the PLC to maintain the RAM contents for a period of time. After a program
has been developed in RAM it may be loaded into an EPROM memory chip, often a bolt-on module to the PLC, and so made permanent. In addition there are temporary buffer stores for the input/output channels.

The storage capacity of a memory unit is determined by the number of binary words that it can store. Thus, if a memory size is 256 words then it can store $256 \times 8 = 2048$ bits if 8-bit words are used and $256 \times 16 = 4096$ bits if 16-bit words are used. Memory sizes are often specified in terms of the number of storage locations available with 1K representing the number $2^{10}$, i.e. 1024. Manufacturers supply memory chips with the storage locations grouped in groups of 1, 4 and 8 bits. A 4K × 1 memory has $4 \times 1 \times 1024$ bit locations. A 4K × 8 memory has $4 \times 8 \times 1024$ bit locations. The term byte is used for a word of length 8 bits. Thus the 4K × 8 memory can store 4096 bytes. With a 16-bit address bus we can have $2^{16}$ different addresses and so, with 8-bit words stored at each address, we can have $2^{16} \times 8$ storage locations and so use a memory of size $2^{16} \times 8/2^{10} = 64$K × 8 which we might be as four 16K × 8 bit memory chips.

1.3.4 Input/output unit

The input/output unit provides the interface between the system and the outside world, allowing for connections to be made through input/output channels to input devices such as sensors and output devices such as motors and solenoids. It is also through the input/output unit that programs are entered from a program panel. Every input/output point has a unique address which can be used by the CPU. It is like a row of houses along a road, number 10 might be the ‘house’ to be used for an input from a particular sensor while number ‘45’ might be the ‘house’ to be used for the output to a particular motor.

The input/output channels provide isolation and signal conditioning functions so that sensors and actuators can often be directly connected to them without the need for other circuitry. Electrical isolation from the external world is usually by means of optoisolators (the term optocoupler is also often used). Figure 1.8 shows the principle of an optoisolator. When a digital pulse passes through the light-emitting diode, a pulse of infrared radiation is produced. This pulse is detected by the phototransistor and gives rise to a voltage in that circuit. The gap between the light-emitting diode and the phototransistor gives electrical isolation but the arrangement still allows for a digital pulse in one circuit to give rise to a digital pulse in another circuit.

![Optoisolator](image)

Figure 1.8 Optoisolator

The digital signal that is generally compatible with the microprocessor in the PLC is 5 V d.c. However, signal conditioning in the input channel,
with isolation, enables a wide range of input signals to be supplied to it (see Chapter 3 for more details). A range of inputs might be available with a larger PLC, e.g. 5 V, 24 V, 110 V and 240 V digital/discrete, i.e. on–off, signals (Figure 1.9). A small PLC is likely to have just one form of input, e.g. 24 V.

![Input levels diagram]

Figure 1.9 Input levels

The output from the input/output unit will be digital with a level of 5 V. However, after signal conditioning with relays, transistors or triacs, the output from the output channel might be a 24 V, 100 mA switching signal, a d.c. voltage of 110 V, 1 A or perhaps 240 V, 1 A a.c., or 240 V, 2 A a.c., from a triac output channel (Figure 1.10). With a small PLC, all the outputs might be of one type, e.g. 240 V a.c., 1 A. With modular PLCs, however, a range of outputs can be accommodated by selection of the modules to be used.

![Output levels diagram]

Figure 1.10 Output levels

Outputs are specified as being of relay type, transistor type or triac type (see Chapter 3 for more details):

1. With the relay type, the signal from the PLC output is used to operate a relay and is able to switch currents of the order of a few amperes in an external circuit. The relay not only allows small currents to switch much larger currents but also isolates the PLC from the external circuit. Relays are, however, relatively slow to operate. Relay outputs are suitable for a.c. and d.c. switching. They can withstand high surge currents and voltage transients.

2. The transistor type of output uses a transistor to switch current through the external circuit. This gives a considerably faster switching action. It is, however, strictly for d.c. switching and is destroyed by overcurrent and high reverse voltage. As a protection, either a fuse or built-in electronic protection are used. Optoisolators are used to provide isolation.
Triac outputs, with optoisolators for isolation, can be used to control external loads which are connected to the a.c. power supply. It is strictly for a.c. operation and is very easily destroyed by overcurrent. Fuses are virtually always included to protect such outputs.

### 1.3.5 Sourcing and sinking

The terms *sourcing* and *sinking* are used to describe the way in which d.c. devices are connected to a PLC. With sourcing, using the conventional current flow direction as from positive to negative, an input device receives current from the input module, i.e. the input module is the source of the current (Figure 1.11(a)). If the current flows from the output module to an output load then the output module is referred to as sourcing (Figure 1.11(b)). With sinking, using the conventional current flow direction as from positive to negative, an input device supplies current to the input module, i.e. the input module is the sink for the current (Figure 1.12(a)). If the current flows to the output module from an output load then the output module is referred to as sinking (Figure 1.12(b)).

![Figure 1.11 Sourcing](image1.png)

![Figure 1.12 Sinking](image2.png)

### 1.4 PLC systems

There are two common types of mechanical design for PLC systems; a *single box*, and the *modular/rack types*. The single box type (or, as sometimes termed, brick) is commonly used for small programmable controllers and is supplied as an integral compact package complete with power supply, processor, memory, and input/output units. Typically such a PLC might have 6, 8, 12 or 24 inputs and 4, 8 or 16 outputs and a memory which can store some 300 to 1000 instructions. Figure 1.13 shows the Mitsubishi MELSEC FX3U compact, i.e. brick, PLC and Table 1.1 gives details of models in that Mitsubishi range.
Table 1.1  Mitsubishi Compact PLC – MELSEC FX3U Product range (By permission of Mitsubishi Electric Europe)

<table>
<thead>
<tr>
<th>Type</th>
<th>FX3U-16 MR</th>
<th>FX3U-32 MR</th>
<th>FX3U-48 MR</th>
<th>FX3U-64 MR</th>
<th>FX3U-80 MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>100-240 V AC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inputs</td>
<td>8</td>
<td>16</td>
<td>24</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Outputs</td>
<td>8</td>
<td>16</td>
<td>24</td>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>Digital outputs</td>
<td>Relay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program cycle period per logical instruction</td>
<td>0.065 µs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User memory</td>
<td>FLROM cassettes (optional)</td>
<td>64k steps (standard)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions in mm (W × H × D)</td>
<td>130 × 90 × 86</td>
<td>150 × 140 × 86</td>
<td>182 × 90 × 86</td>
<td>220 × 90 × 86</td>
<td>285 × 90 × 86</td>
</tr>
</tbody>
</table>

Some brick systems have the capacity to be extended to cope with more inputs and outputs by linking input/output boxes to them. Figure 1.14 shows such an arrangement with the OMRON CPM1A PLC. The base input/output brick, depending on the model concerned, has 10, 20, 30 or 40 inputs/outputs (I/O). The 10 I/O brick has 6 d.c. input points and four outputs, the 20 I/O brick has 12 d.c. input points and 8 outputs, the 30 I/O brick has 18 d.c. input points and 12 outputs and the 40 I/O brick has 24 d.c. input points and 16 outputs. However, the 30 and 40 I/O models can be extended to a maximum of 100 inputs/outputs by linking expansion units to the original brick. For example a 20 I/O expansion module might be added, it having 12 inputs and 8 outputs, the outputs being relays, sinking transistors or sourcing transistors. Up to three expansion modules can be added. The outputs can be relay or transistor outputs.
Systems with larger numbers of inputs and outputs are likely to be modular and designed to fit in racks. The modular type consists of separate modules for power supply, processor, etc., which are often mounted on rails within a metal cabinet. The rack type can be used for all sizes of programmable controllers and has the various functional units packaged in individual modules which can be plugged into sockets in a base rack. The mix of modules required for a particular purpose is decided by the user and the appropriate ones then plugged into the rack. Thus it is comparatively easy to expand the number of input/output (I/O) connections by just adding more input/output modules or to expand the memory by adding more memory units.

An example of such a modular system is provided by the Allen-Bradley PLC-5 PLC of Rockwell Automation (Figure 1.15). PLC-5 processors are available in a range of I/O capacity and memory size, and can be configured for a variety of communication networks. They are single-slot modules that are placed in the left-most slot of a 1771 I/O chassis. Some 1771 I/O chassis are built for back-panel mounting and some are built for rack mounting and are available in sizes of 4, 8, 12, or 16 I/O module slots. The 1771 I/O modules are available in densities of 8, 16, or 32 I/O per module. A PLC-5 processor can communicate with I/O across a DeviceNet or Universal Remote I/O link.

A large selection of 1771 input/output modules, both digital and analogue, are available for use in the local chassis, and an even larger selection available for use at locations remote from the processor. Digital I/O modules have digital I/O circuits that interface to on/off sensors such as pushbutton and limit switches; and on/off actuators such as motor starters, pilot lights, and annunciators. Analogue I/O modules perform the required A/D and D/A conversions using up to 16-bit resolution. Analogue I/O can be user-configured for the desired fault-response state in the event that I/O communication is disrupted. This feature provides a safe reaction/response in case of a fault, limits the extent of faults, and provides a predictable fault response. 1771 I/O modules include optical coupling and filter circuitry for signal noise reduction.
The basic form of a rack into which components of a PLC system can be slotted.

Possible elements to slot into the rack system:
- Power supply
- Processor module
- Communication module for communication to computers and other PLC processors
- I/O adapter module for connecting the backplane to a processor at another location
- I/O modules to provide the means to convert input signals to backplane levels and backplane signals to output circuit levels

A possible assembled system:

Figure 1.15 *A possible arrangement of a rack system, e.g. the Rockwell Automation Allen-Bradley PLC-5*

Digital I/O modules cover electrical ranges from 5…276V a.c. or d.c. and relay contact output modules are available for ranges from 0…276 V ac or 0…175 V dc. A range of analogue signal levels can be accommodated, including standard analogue inputs and outputs and direct thermocouple and RTD temperature inputs.
1.4.1 Programming PLCs

Programming devices can be a hand-held device, a desktop console or a computer. Only when the program has been designed on the programming device and is ready is it transferred to the memory unit of the PLC.

1. **Hand-held programming devices** will normally contain enough memory to allow the unit to retain programs while being carried from one place to another.

2. **Desktop consoles** are likely to have a visual display unit with a full keyboard and screen display.

3. **Personal computers** are widely configured as program development work-stations. Some PLCs only require the computer to have appropriate software; others require special communication cards to interface with the PLC. A major advantage of using a computer is that the program can be stored on the hard disk or a CD and copies easily made.

PLC manufacturers have programming software for their PLCs. For example, Mitsubishi have **MELSOFT**. Their GX Developer supports all MELSEC controllers from the compact PLCs of the MELSEC FX series to the modular PLCs including MELSEC System Q and uses a Windows based environment. It supports the programming methods (see Chapter 4) of instruction list (IL), ladder diagram (LD) and sequential function chart (SFC) languages. You can switch back and forth between IL and LD at will while you are working. You can program your own function blocks and a wide range of utilities are available for configuring special function modules for the MELSEC System Q – there is no need to program special function modules, you just configure them. The package includes powerful editors and diagnostics functions for configuring MELSEC networks and hardware, and extensive testing and monitoring functions to help get applications up and running quickly and efficiently. It offers off-line simulation for all PLC types and thus enables simulation of all devices and application responses for realistic testing.

As another illustration, Siemens have **SIMATIC STEP 7**. This fully complies with the international standard IEC 61131-3 for PLC programming languages. With STEP 7, programmers can select between different programming languages. Besides ladder diagram (LAD) and function block diagram (FBD), STEP 7 Basis also includes the Instruction List (STL) programming language. Other additional options are available for IEC 61131-3 programming languages such as Structured Text (ST) called SIMATIC S7-SCL or a Sequential Function Chart (SFC) called SIMATIC S7-Graph which provides an efficient way to describe sequential control systems graphically. Features of the whole engineering system include system diagnostic capabilities, process diagnostic tools, PLC simulation, remote maintenance, and plant documentation. S7-PLCSIM is an optional package for STEP 7 that allows simulation of a SIMATIC S7 control platform and testing of a user program on a PC, enabling testing and refining prior to physical hardware installation. By testing early in a project’s development, overall project quality can be improved. Installation and commissioning can thus be quicker and less
expensive as program faults can be detected and corrected early on during development.

Likewise, Rockell Automation have RSLogix for the Allen-Bradley PLC-5 family of PLCs, OMRON has CX-One and Telemecanique have ProWorx 32 for its Modicon range of PLCs.

Problems

Questions 1 to 6 have four answer options: A, B, C or D. Choose the correct answer from the answer options.

1 The term PLC stands for:
   A  Personal logic computer.
   B  Programmable local computer.
   C  Personal logic controller.
   D  Programmable logic controller.

2 Decide whether each of these statements is True (T) or False (F).
   A transistor output channel from a PLC:
     (i) Is used for only d.c. switching.
     (ii) Is isolated from the output load by an optocoupler.
   Which option BEST describes the two statements?
   A  (i) T  (ii) T
   B  (i) T  (ii) F
   C  (i) F  (ii) T
   D  (i) F  (ii) F

3 Decide whether each of these statements is True (T) or False (F).
   A relay output channel from a PLC:
     (i) Is used for only d.c. switching.
     (ii) Can withstand transient overloads.
   Which option BEST describes the two statements?
   A  (i) T  (ii) T
   B  (i) T  (ii) F
   C  (i) F  (ii) T
   D  (i) F  (ii) F

4 Decide whether each of these statements is True (T) or False (F).
   A triac output channel from a PLC:
     (i) Is used for only a.c. output loads.
     (ii) Is isolated from the output load by an optocoupler.
   Which option BEST describes the two statements?
   A  (i) T  (ii) T
   B  (i) T  (ii) F
   C  (i) F  (ii) T
   D  (i) F  (ii) F
5 Which of the following is most likely to be the voltage level used internally in a PLC, excluding the voltage levels that might occur during conditioning in output/input channels:

A  5 V  
B  24 V  
C  110 V  
D  240 V  

6 Decide whether each of these statements is True (T) or False (F).

The reason for including optocouplers on input/output units is to:
(i)  Provide a fuse mechanism which breaks the circuit if high voltages or currents occur.  
(ii) Isolate the CPU from high voltages or currents. 
Which option BEST describes the two statements?

A  (i) T  (ii) T  
B  (i) T  (ii) F  
C  (i) F  (ii) T  
D  (i) F  (ii) F  

7 Draw a block diagram showing in very general terms the main units in a PLC.

8 Draw a block diagram of a PLC showing the main functional items and how buses link them, explaining the functions of each block.

9 State the characteristics of the relay, transistor and triac types of PLC output channels.

10 How many bits can a 2K memory store?