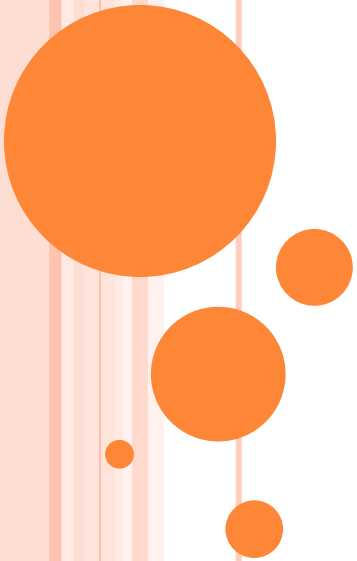


Programmable Logic Controllers

Chapter one

Introduction

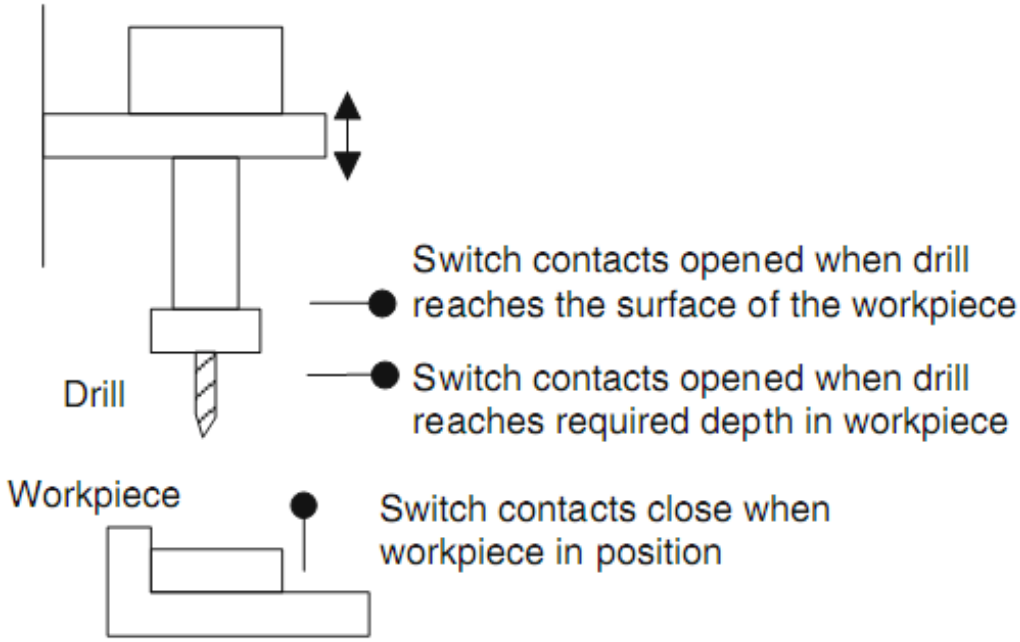
This chapter is an introduction to the programmable logic controller (PLC) and its general function, hardware forms, and internal architecture. This overview is followed by more detailed discussion in the following chapters.

Controllers

What type of task might a control system handle?

It might be required to control a **sequence of events**, **maintain some variable constant**, or **follow some prescribed change**.

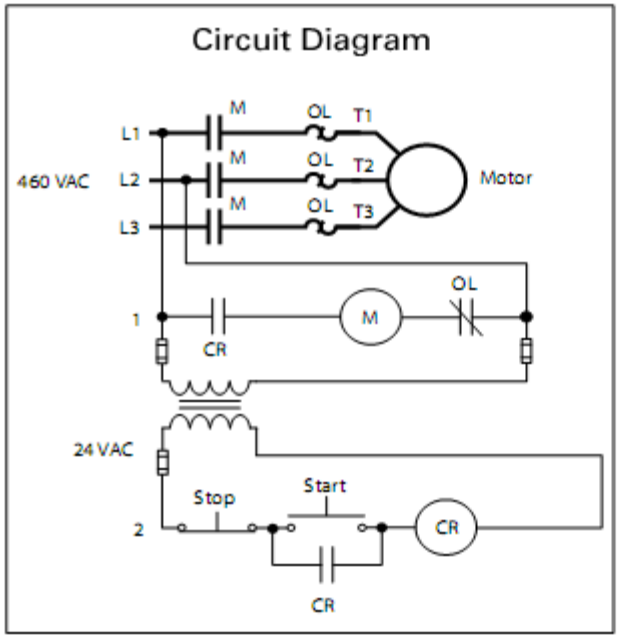
- For example, the control system for an **automatic drilling machine** might be required to
- start lowering the drill when the workpiece is in position,
- start drilling when the drill reaches the workpiece,
- stop drilling when the drill has produced the required depth of hole,
- retract the drill, and then switch off and wait for the next workpiece to be put in position before repeating the operation.

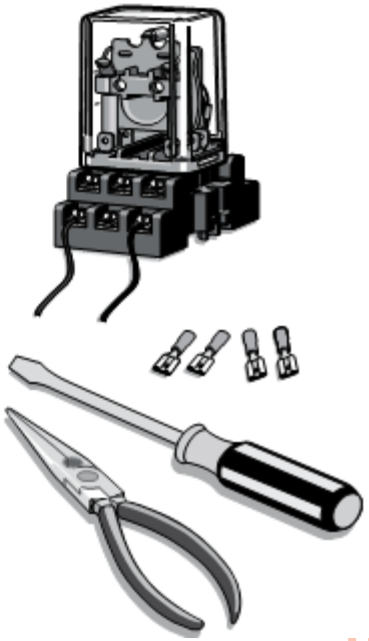


What form might a controller have?

1. Hard-wired control

- The automatic drilling machine task can be performed by contactors, control relays, and other electromechanical devices. This is often referred to as **hard-wired control**.
- Circuit diagrams had to be designed, electrical components specified and installed.

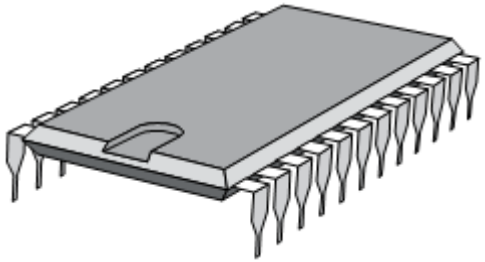




- Electricians would then wire the components necessary to perform a specific task. If an error was made, the wires had to be reconnected correctly . Such electrical circuits would have to be specific to the automatic drilling machine.
- **A change in function or system expansion requires extensive component changes and rewiring.**

2. Microprocessor-Controlled Systems

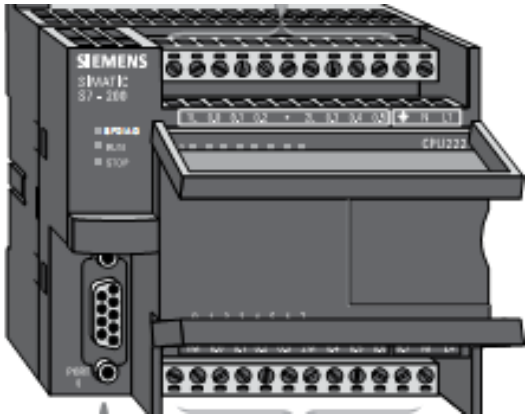
- Instead of hardwiring each control circuit for each control situation, **we can use the same basic system for all situations (different tasks) if we use a microprocessor-based system and write a program to instruct the microprocessor** how to react to each input signal from, say, switches and give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



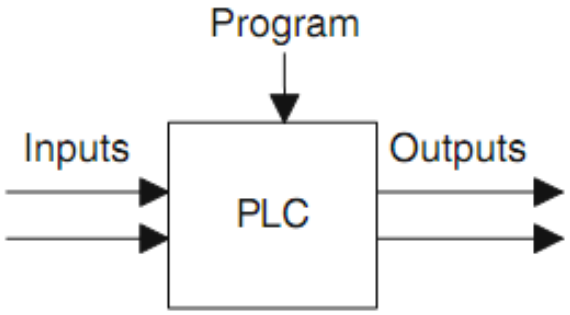
- As an illustration, the modern **domestic washing machine** uses a microprocessor system. Inputs to it arise from the dials used to select the required wash cycle, a switch to determine that the machine door is closed, a temperature sensor to determine the temperature of the water, and a switch to detect the level of the water. On the basis of these inputs the microprocessor is programmed to give outputs that 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.
- **Microcontrollers are not user friendly. It requires well trained engineers to deal with.**

3 The Programmable Logic Controller

- A programmable logic controller (PLC) is a **special form of microprocessor-based controller** that uses programmable memory to store instructions and to implement functions such as **logic**, **sequencing**, **timing**, **counting**, and **arithmetic** in order to control machines and processes.



- It is designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages.
- The designers of the PLC have preprogrammed it so that the control program can be entered using a **simple, rather intuitive form of language**.
- PLCs have the great advantage that the **same controller can be used with a wide range of control systems with no need to rewire**.

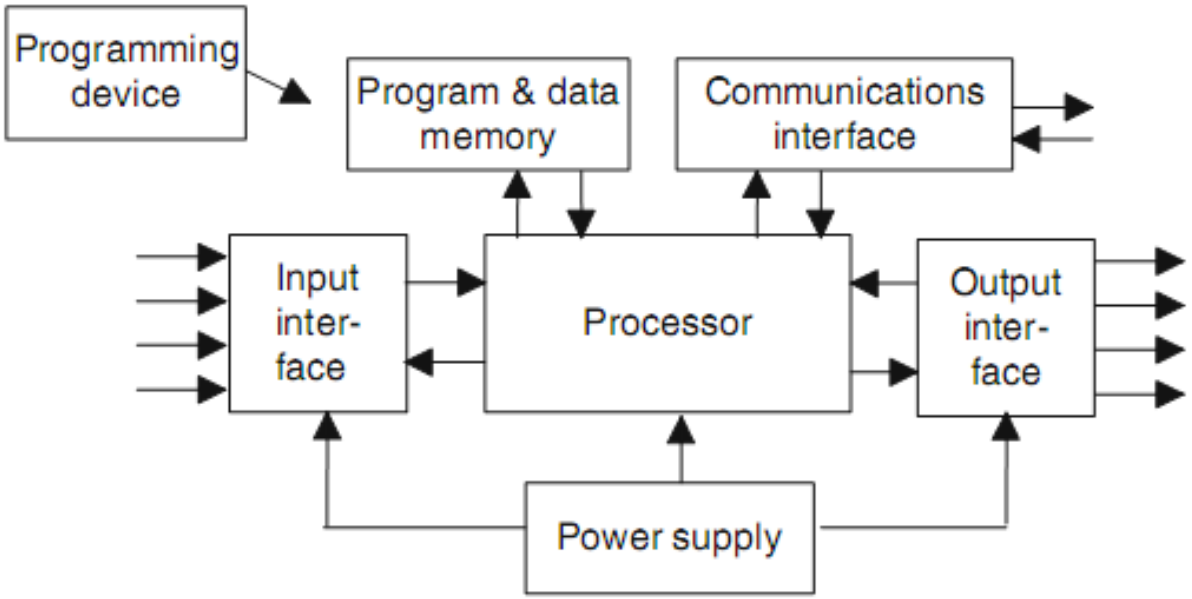


PLCs are similar to computers, but whereas computers are optimized for calculation and display tasks, PLCs are optimized for control tasks and the industrial environment. Thus PLCs:

- Are rugged and designed to withstand vibrations, temperature, humidity, and noise.
- Have interfacing for inputs and outputs already inside the controller.
- Are easily programmed and have an easily understood programming language that is primarily concerned with logic and switching operations.

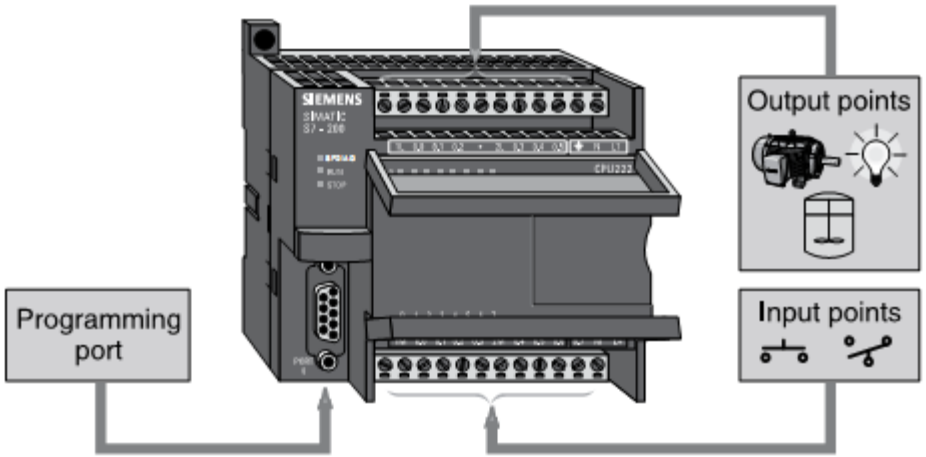
Hardware

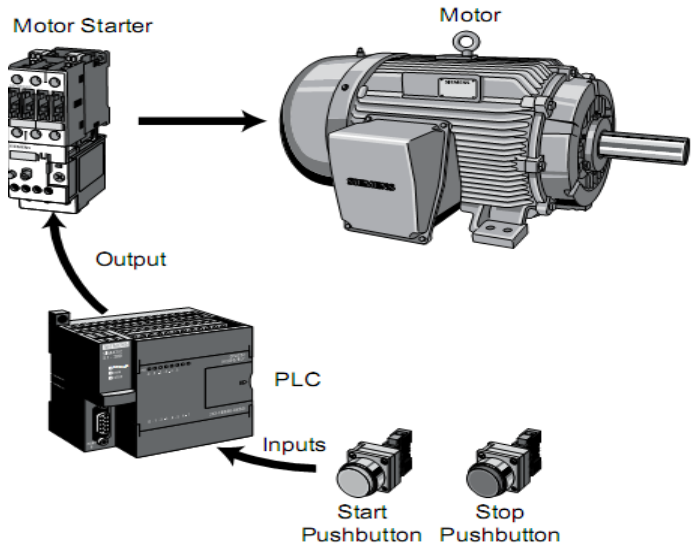
Typically a PLC system has the basic components of **processor** unit, **memory**, **power supply** unit, **input/output interface** section, **communications interface**, and the **programming device**.



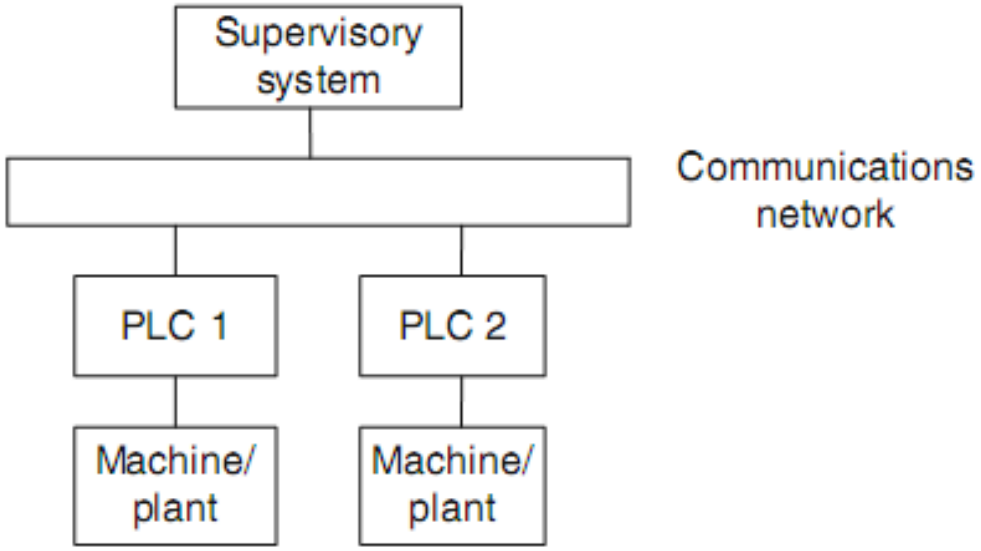
- The ***processor unit*** or ***central processing unit*** (CPU) is the unit containing the microprocessor. This unit interprets the input signals and carries out the control actions according to the program stored in its memory, communicating the decisions as action signals to the outputs.

- The ***power supply unit*** is needed to convert the mains AC voltage to the low DC voltage (5 V) necessary for the processor and the circuits in the input and output interface modules.
- 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.
- 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 or other sensors. The outputs might be to motor starter coils, solenoid valves, or similar things.





- The ***memory unit*** is where the program containing the control actions to be exercised by the microprocessor is stored and where the data is stored from the input for processing and for the output.
- The ***communications interface*** is used to receive and transmit data on communication networks from or to other remote PLCs.



The CPU

- The central processing unit contains the system microprocessor. It controls and processes all the operations within the PLC.
- It is supplied with a clock that has a frequency of typically between 1 and 8 MHz. This frequency determines the operating speed of the PLC and provides the timing and synchronization for all elements in the system.

The Memory

There are several memory elements in a PLC system:

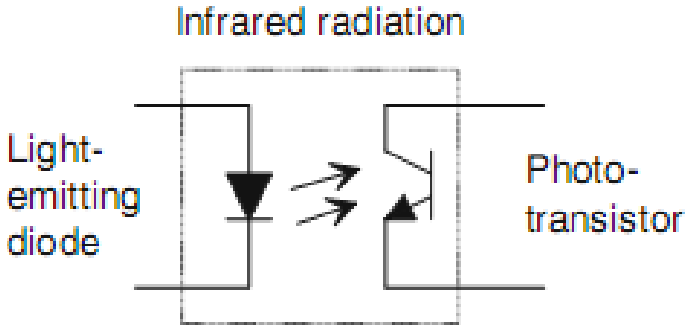
- System ***read-only-memory*** (ROM) gives permanent storage for the operating system and fixed data used by the CPU.
- ***Random-access memory*** (RAM) is used for the user's program.
- ***Random-access memory*** (RAM) is used for data. This is where information is stored on the status of input and 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*.
- ***Erasable and programmable read-only-memory*** (EPROM) is used to store programs permanently.

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, and so made permanent

Input/Output Unit

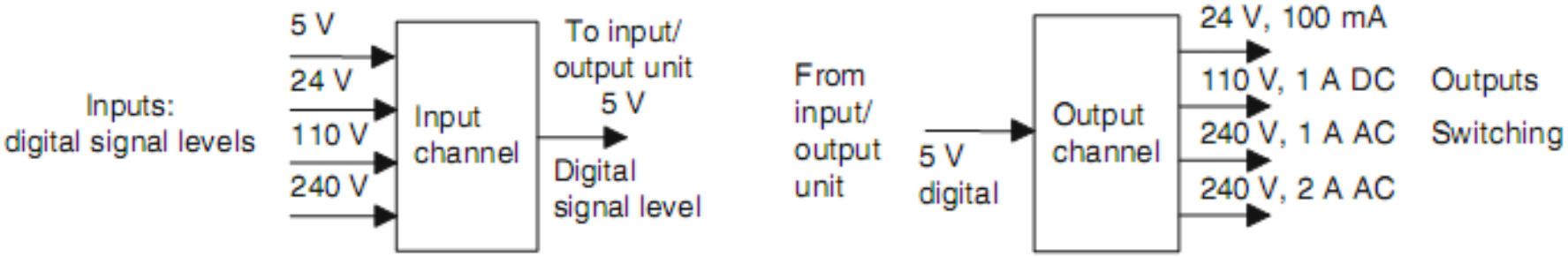
The input/output unit provides the interface between the system and the outside world.

- 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.



Input

- The digital signal that is generally compatible with the microprocessor in the PLC is 5 V DC. However, signal conditioning in the input channel, with isolation, enables a wide range of input signals to be supplied to it. A range of inputs might be available with a larger PLC, such as 5 V, 24 V, 110 V, and 240 V digital/discrete, that is, on/ off, signals. A small PLC is likely to have just one form of input, such as 24 V.



Output

- 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 DC;
- 110 V , 1 A DC;
- 240 V, 1 A AC;
- 240 V, 2 A AC.

PLC Systems

There are two common types of mechanical design for PLC systems:

- single box type (brick)
- modular/rack type

Single box type

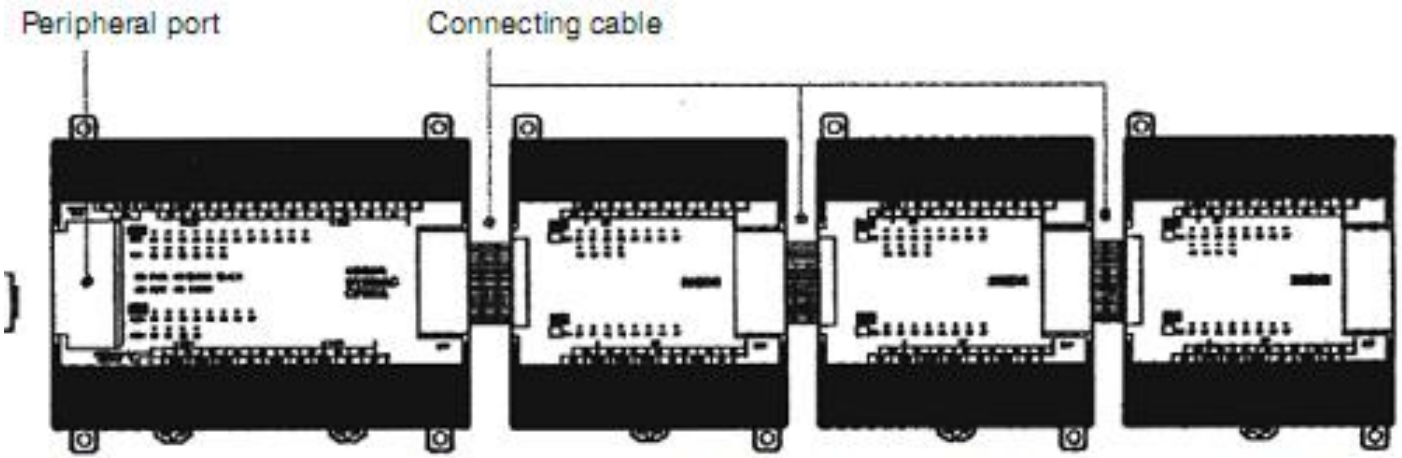
- The ***single-box type*** (or, as it's sometimes called, a ***brick***) is commonly used for small programmable controllers.
- It is supplied as an integral compact package complete with power supply, processor, memory, and input/output units.

- Typically such a PLC might have 6, 8, 12, or 24 inputs and 4, 8, or 16 outputs.
- A memory can store some 300 to 1000 instructions.

Table 1.1: Mitsubishi Compact PLC: MELSEC FX3U Product Range

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

- Some brick systems have the capacity to be extended to cope with more inputs and outputs by linking input/output boxes to them.



Modular type

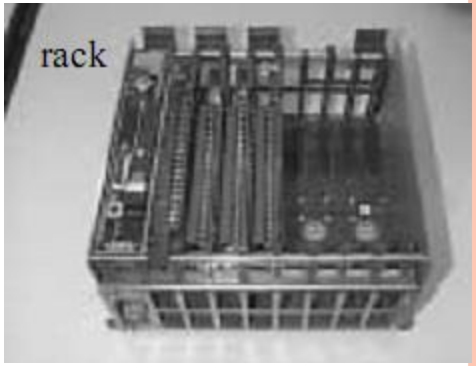
- The ***modular type*** consists of separate modules for power supply, processor, and the like, which are often mounted on rails within a metal cabinet.
- The mix of modules required for a particular purpose is decided by the user and the appropriate ones then plugged into the rack.

Processor module

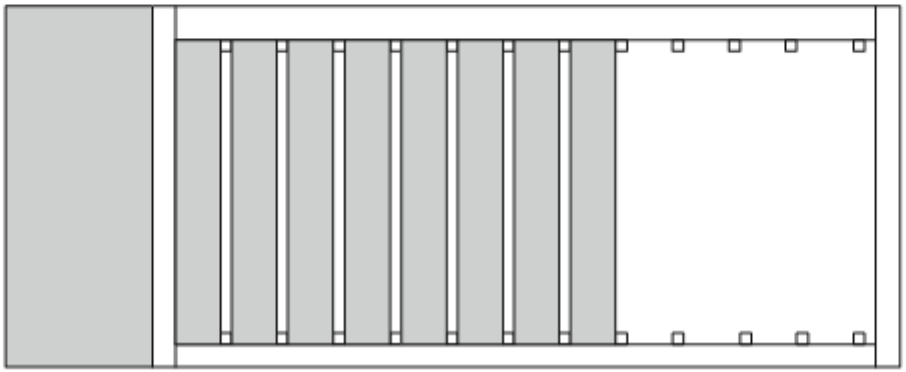
Communication module for communication to computers, I/O adapters and other PLC processors

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



- Thus it is comparatively easy to expand the number of I/O connections by simply adding more input/output modules or to expand the memory by adding more memory units.

Programming PLCs

- Programs for use with PLCs can be written in a number of formats. To make it easier for engineers with no great knowledge of programming to write programs for PLCs, ***ladder programming*** was developed.
- A programming device can be:
- a ***handheld device*** (can be carried from one place to another),
- a ***desktop console*** (are likely to have a visual display unit with a full keyboard and screen display),
- or ***personal computers***.

  Only when the program has been designed on the programming device and is ready is it transferred to the memory unit of the PLC.