MANIPAL INSTITUTE OF TECHNOLOGY
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Industrial Automation (ICE 3252)

Programmable Logic Controller

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Understanding the Title

Industry

Systematic Economic Activity that could be related to Manufacture / Service / Trade.

Understanding the Title

Automation

"Auto"(self) and "Matos"(moving)

"move by itself"

Automation is a set of technologies that results in operation of machines and systems without significant human intervention and achieves performance superior to manual operation

Control System..

- Control is a set of technologies that achieves desired patterns of variations of operational parameters and sequences for machines and systems by providing the input signals necessary.
- Automation Systems may include Control Systems but the reverse is not true.
- Control Systems may be parts of Automation Systems.
- The main function of control systems is to ensure that outputs follow the set points.
- Automation Systems may have much more functionality, such as computing set points for control systems, monitoring system performance, plant startup or shutdown, job and equipment scheduling etc.

Role of automation in industry

- Manufacturing processes, basically, produce finished product from raw/unfinished material using energy, manpower and equipment and infrastructure.
- Since an industry is essentially a "systematic economic activity", the fundamental objective of any industry is to make profit.
- Roughly speaking, Profit = (Price/unit – Cost/unit) x Production Volume
- So profit can be maximized by producing good quality products, which may sell at higher price, in larger volumes with less production cost and time.

A Historical Background

- Manual Control
  - Pneumatic Control
    - Hard wired logic control
      - Electronic control using logic gates
        - Programmable logic controller

Manual Control

All the actions related to process control are taken by the operators.

Drawbacks

- Likely human errors and consequently its effect on quality of final product.
- The production, safety, energy consumption and usage of raw material are all subject to the correctness and accuracy of human action.

Pneumatic Control

Industrial automation, with its machine and process control, had its origin in the 1920s with the advent of "*Pneumatic Controllers*".

Actions were controlled by a simple manipulation of pneumatic valves, which in turn were controlled by relays and switches.

Drawbacks

- Bulky and Complex System
- Involves lot of rework to implement control logic
- Longer project time.

Hard wired logic control

The contactor and Relays together with hardware timers and counters were used in achieving the desired level of automation.

Drawbacks

- Bulky panels
- Complex wiring
- Longer project time
- Difficult maintenance and troubleshooting

Electronic Control using Logic Gates

In 1960s with the advent of electronics, the logic gates started replacing the relays and auxiliary contactors in the control circuits.

The hardware timers & counters were replaced by electronic Timers.

Advantages

- Reduced space requirements
- Energy savings
- Less maintenance & greater reliability .

Drawbacks

- Changes in control logic not possible
- More project time

Programmable Logic Controllers

In 1970s with the coming of microprocessors and associated peripheral chips, the whole process of control and automation underwent a radical change.

Instead of achieving the desired control or automation through physical wiring of control devices, in PLC it is achieved through a program or say software.

The programmable controllers have in recent years experienced an unprecedented growth as universal element in Industrial Automation.

It can be effectively used in applications ranging from simple control like replacing small number of relays to complex automation problems .

Introduction of PLC

- Microprocessor: It is a digital integrated circuit which carries out necessary digital functions to process the information obtained from measurement system.

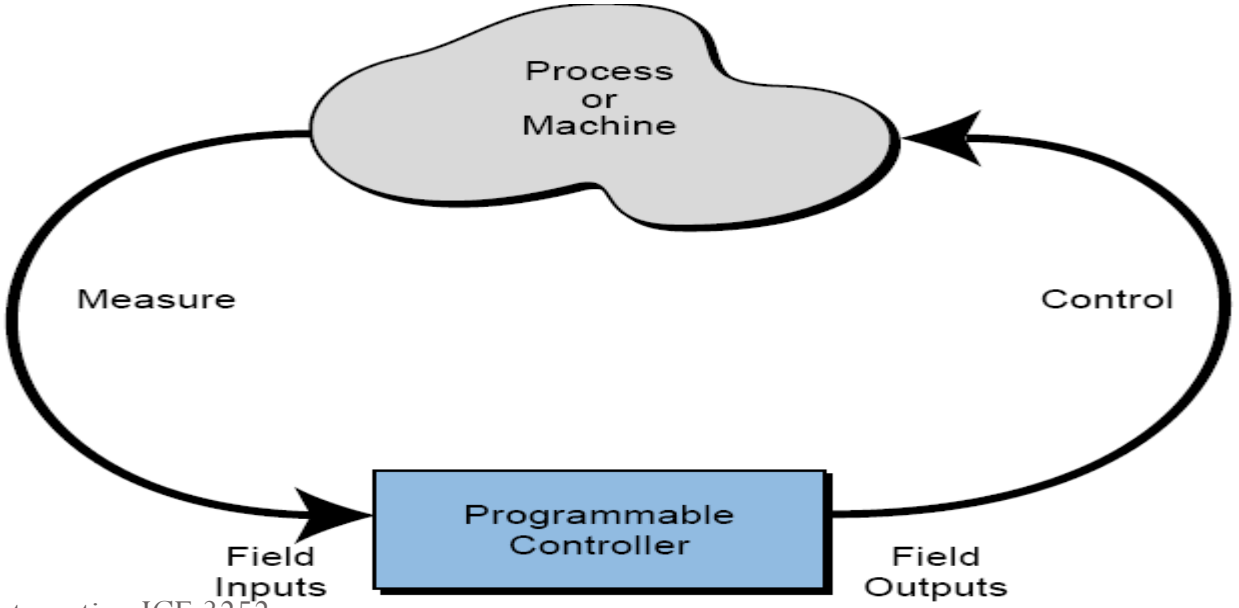
- Microcomputer: It uses microprocessor as its central processing unit and contains all functions of a computer.

- Programmable Logic Controller (PLC): It is used to control the operations of electro-mechanical devices especially in tough and hazardous industrial environments.

Cont..

"The programmable logic controller is defined as a digital electronic device that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic words to control machines and processes.

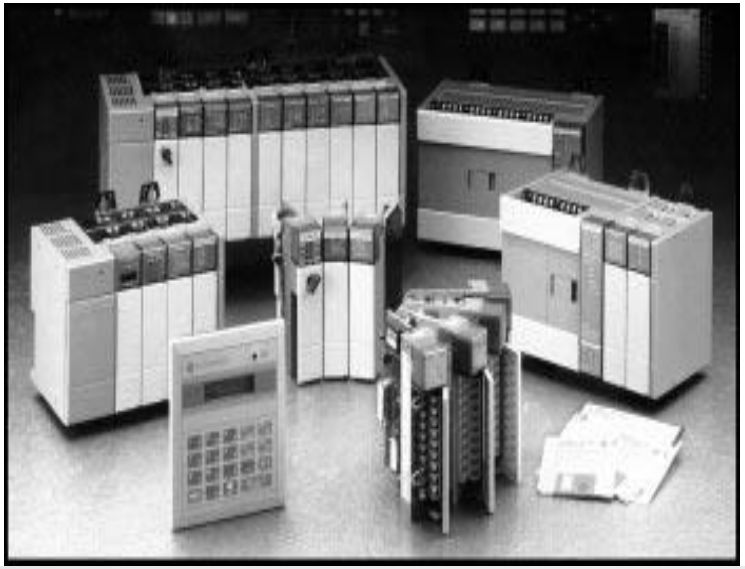
Definition : It is a solid state device ,which can performs a sequential and a discrete logic for industrial or factory Environment.



Programmable Logic Controllers

Sequential logic solver
PID Calculations.
Advanced Subroutines
BIT Operations.
Data Transfer.
Text Handling.

EXAMPLE S OF PLC MODULES



Why PLCs

Reduced space

Energy saving

Ease of maintenance

Economical

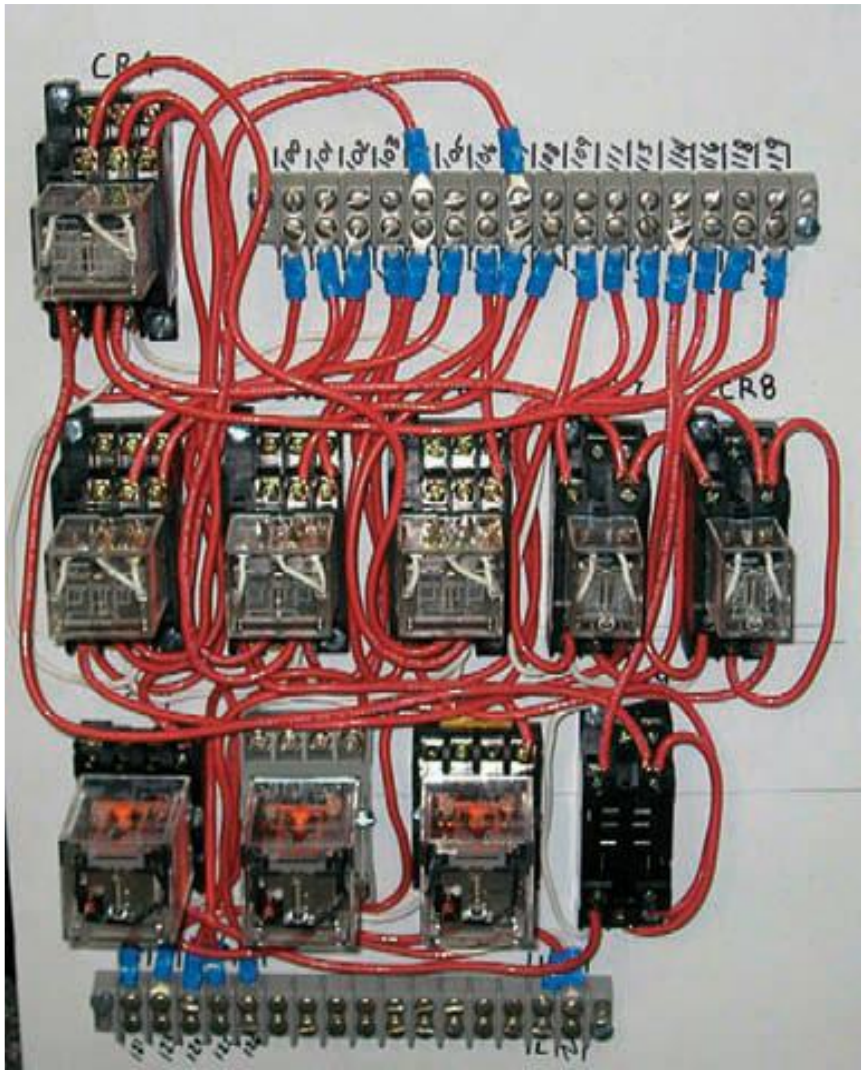
Greater life & reliability

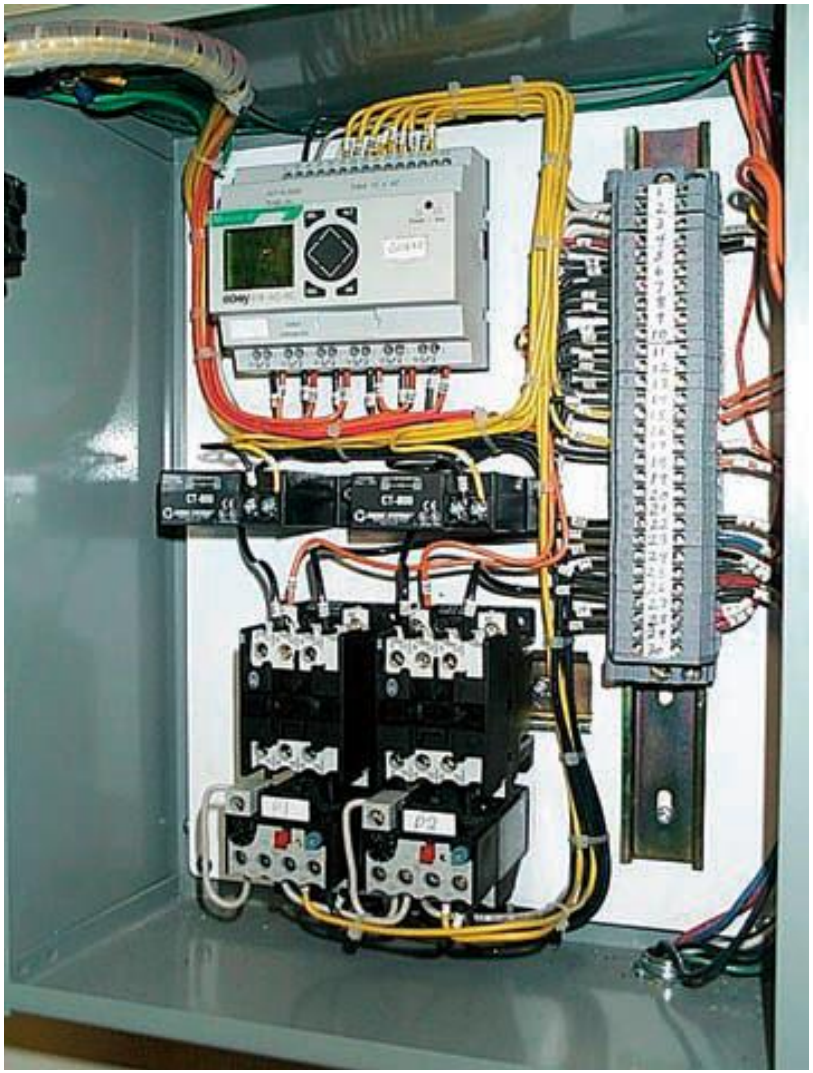
Tremendous flexibility

Faster Response Time.

Shorter project time

Easier storage, archiving and documentation


CR8



Parts of PLC (Basic Components of a PLC System)

There are **five basic components** in a PLC system :

- The PLC processor, or controller. (CPU)
- I/O (Input /Output) modules.
- Chassis or backplane.
- Power supply.
- Programming software that runs in a PC and A network interface(communication).

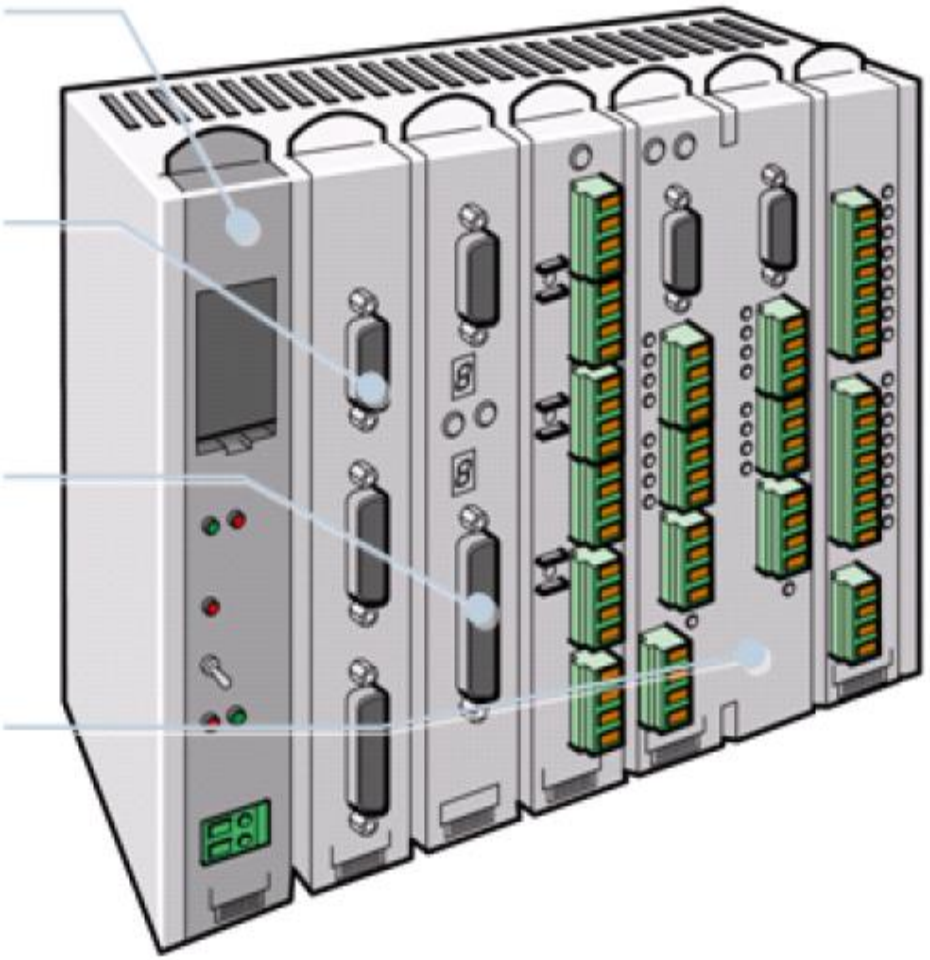
In General PLC contains following parts

Power supply
Internal power supply,
Buffering of remanent data via battery

CPU unit
CPU, System-Software (Firmware),
Program memory
(User program)

Communication unit
Field bus interface,
Connection of HMIs,
Cross communication with other controllers

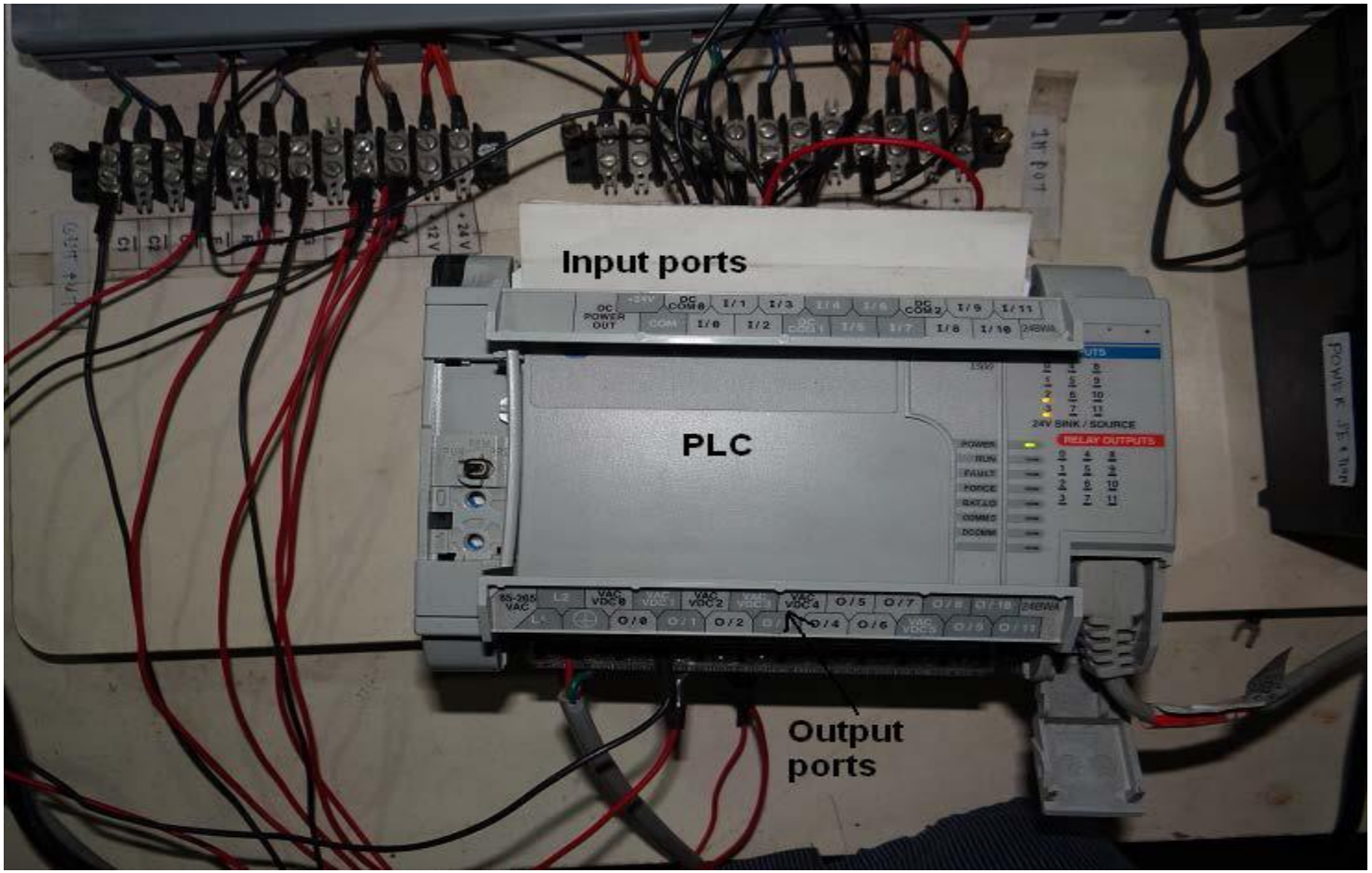
Unit for In- and Outputs
Sensor connection
(switches, initiators, light curtains,
temperature sensors, ...)
Actuator connection
(valves, lamps, motors, contactors ...)



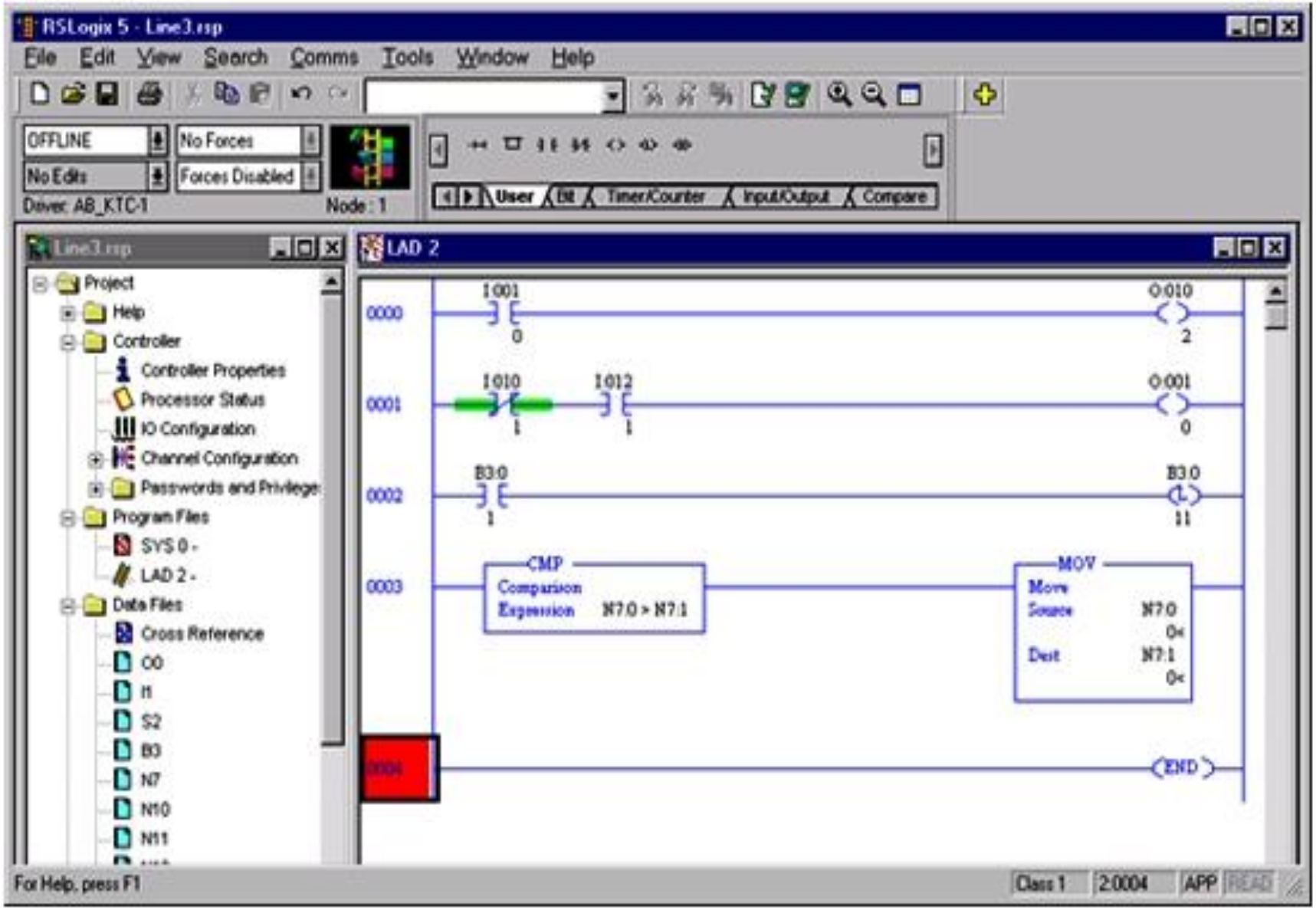
PLC Size

- The criteria used in categorizing PLCs include functionality, number of inputs and outputs, cost, and physical size of these, the *I/O count* is the most important factor.
- The *nano* is the smallest size with less than 15 I/O points.
- The micro types (15 to 128 I/O points),
- Medium types (128 to 512 I/Opoints), and
- Large types (over 512 I/O points).

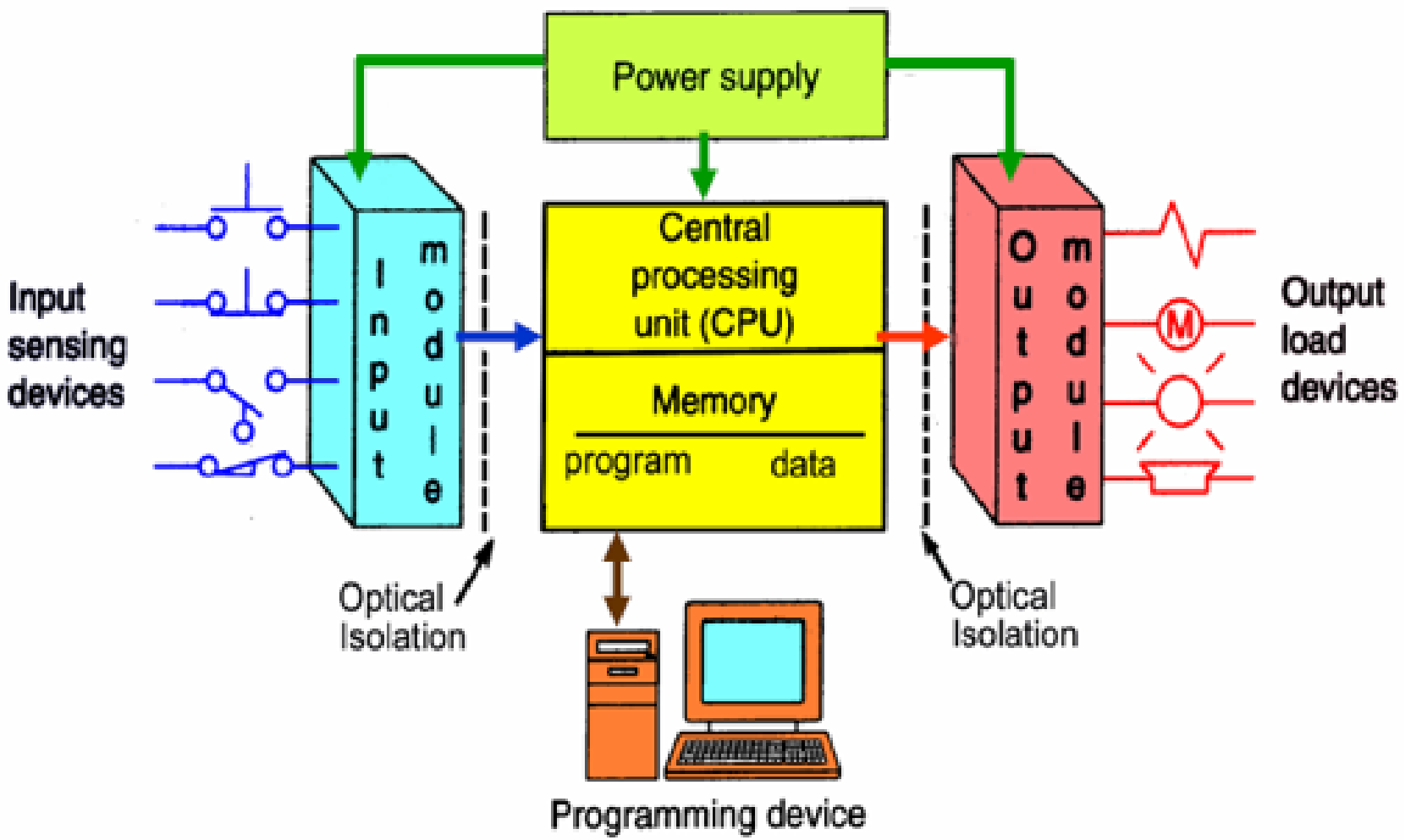
Cont…



An Industrial PLC


RSLogix 5 - Line3.rsp
File Edit View Search Comms Tools Window Help
OFFLINE
No Forces
No Edits
Forces Disabled
Driver: AB_KTC-1
Node: 1
User Bit Timer/Counter Input/Output Compare
Line3.rsp
Project
Help
Controller
Controller Properties
Processor Status
IO Configuration
Channel Configuration
Passwords and Privilege
Program Files
SYS 0 -
LAD 2 -
Data Files
Cross Reference
O0
I1
S2
B3
N7
N10
N11
LAD 2
0000
I:001
0
O:010
2
0001
I:010
1
I:012
1
O:001
0
0002
B3:0
1
B3:0
11
0003
CMP
Comparison
Expression
N7:0 > N7:1
MOV
Move
Source
N7:0
0<
Dest
N7:1
0<
END
For Help, press F1
Class 1
2:0004
APP

PLC Hardware



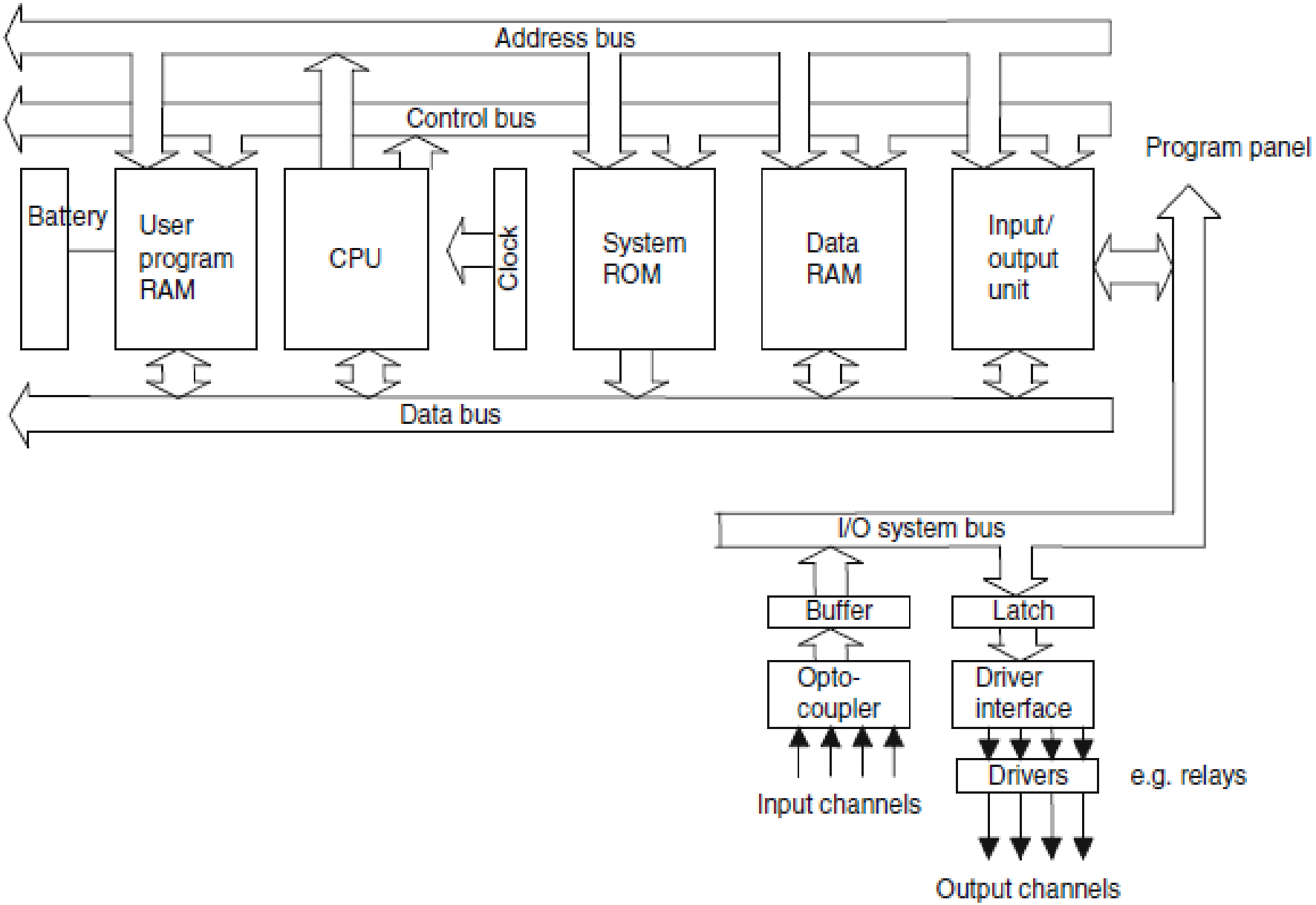
PLC Architecture

- An *open architecture* design allows the system to be connected easily to devices and programs made by other manufacturers.

- A *closed architecture* or *proprietary* system, is one whose design makes it more difficult to connect devices and programs made by other manufacturers.

NOTE: When working with PLC systems that are proprietary in nature you must be sure that any generic hardware or software you use is compatible with your particular PLC.

Internal architecture of PLC



The Buses

The system has four buses:

- Data bus
- Address bus
- Control bus
- System bus

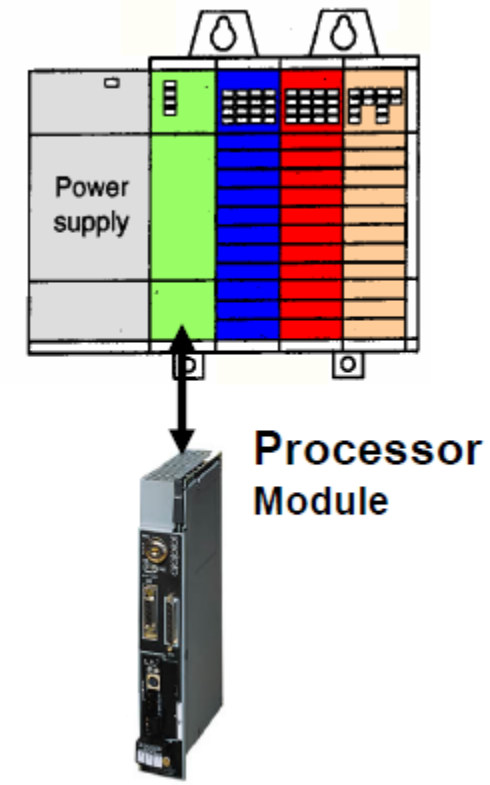
- The buses are the paths used for communication within the PLC.
- The information is transmitted in binary form, i.e. as a group of *bits, a bit* being a binary digit of 1 or 0, i.e. on/off states.
- The term *word is used for* the group of bits constituting some information. Thus an 8-bit word might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

Cont..

- The data bus carries the data used in the processing done by the CPU
- The address bus is used to carry the addresses of memory locations. So that each word can be located in memory, every memory location is given a unique address
- The control bus carries the signals used by the CPU for control, such as to inform memory devices whether they are to receive data from an input or output data and to carry timing signals used to synchronize actions.
- The system bus is used for communications between the input/output ports and the input/ output unit.

Processor (CPU)

- Is the brain of the PLC
- Consists of microprocessor for logic implementation and for controlling the communications among the modules.
- Stores the control program and data in its memory.
- Reads the status of connected input devices.
- Executes the control program.

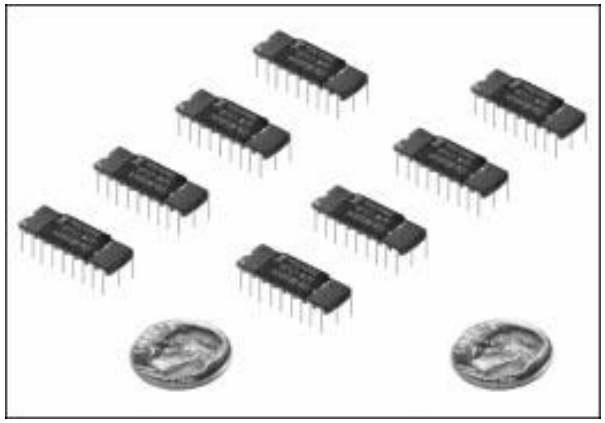


Processor, Controller, or CPU

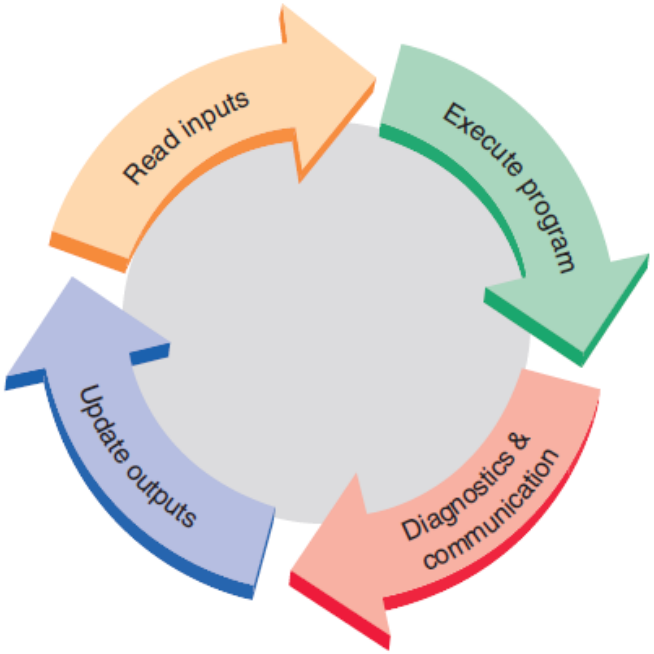
- Commands outputs devices to change state based on program execution.

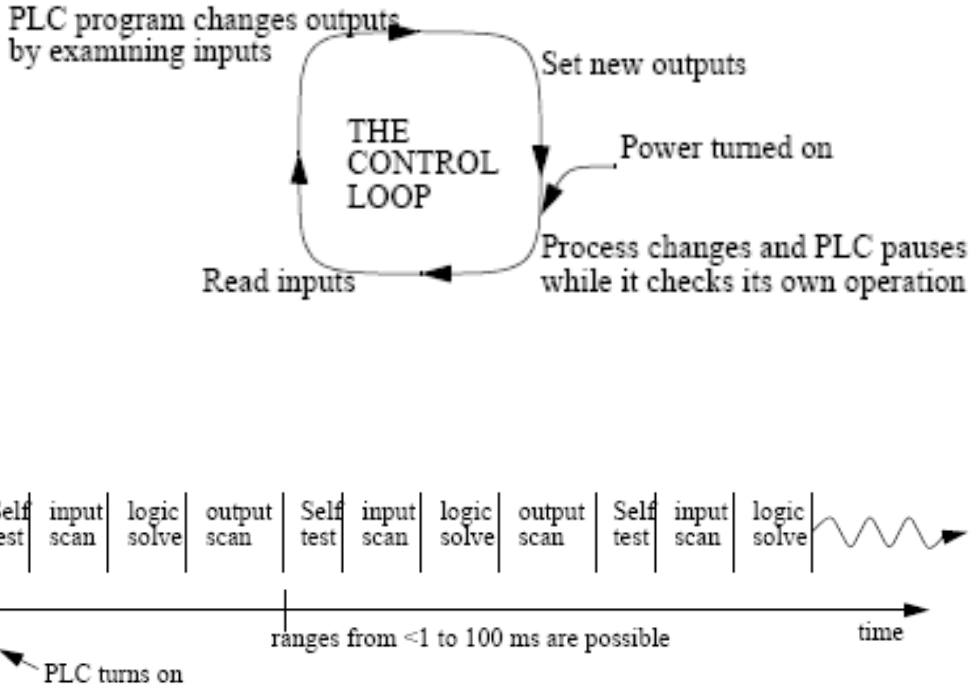
  - For example : Turn a light on, start a fan, adjust a speed, or temperature.

- Comes in various physical forms.

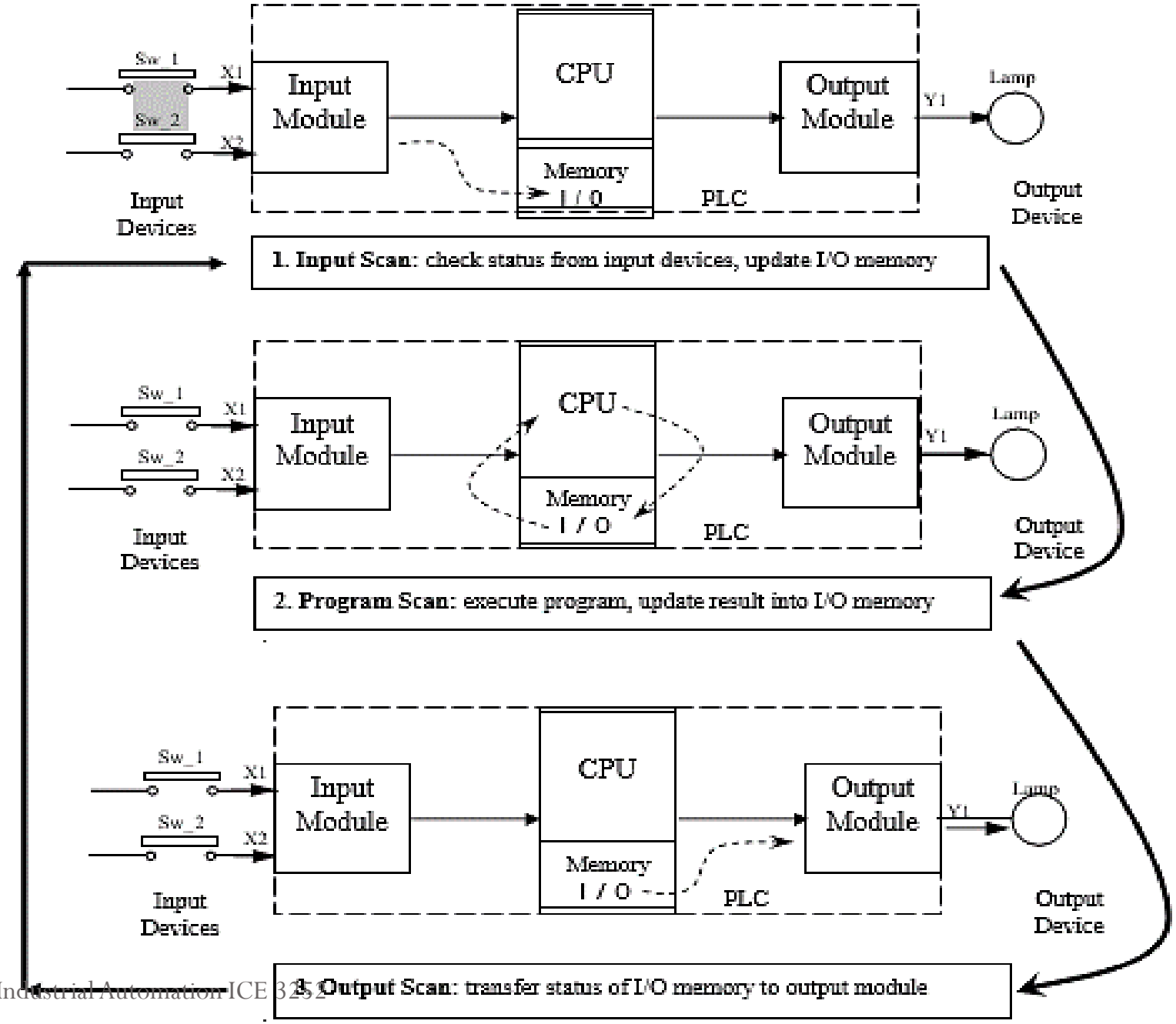


Typical PLC scan cycle





- When the inputs to the PLC are scanned the physical input values are copied into memory.
- When the outputs to a PLC are scanned they are copied from memory to the physical outputs.
- When the ladder logic is scanned it uses the values in memory, not the actual input or output values.


Sw_1
Sw_2
X1
X2
Input Module
CPU
Memory
I / O
Output Module
Y1
Lamp
Input Devices
PLC
Output Device
1. Input Scan: check status from input devices, update I/O memory
2. Program Scan: execute program, update result into I/O memory
3. Output Scan: transfer status of I/O memory to output module

Memory Types

ROM (Read Only Memory): is designed to permanently store a fixed program that is not alterable under ordinary circumstances

RAM (Random Access Memory):is designed so that information can be written into or read from the memory storage area. Random-access memory does not retain its contents if power is lost; therefore, it is a volatile type of memory.

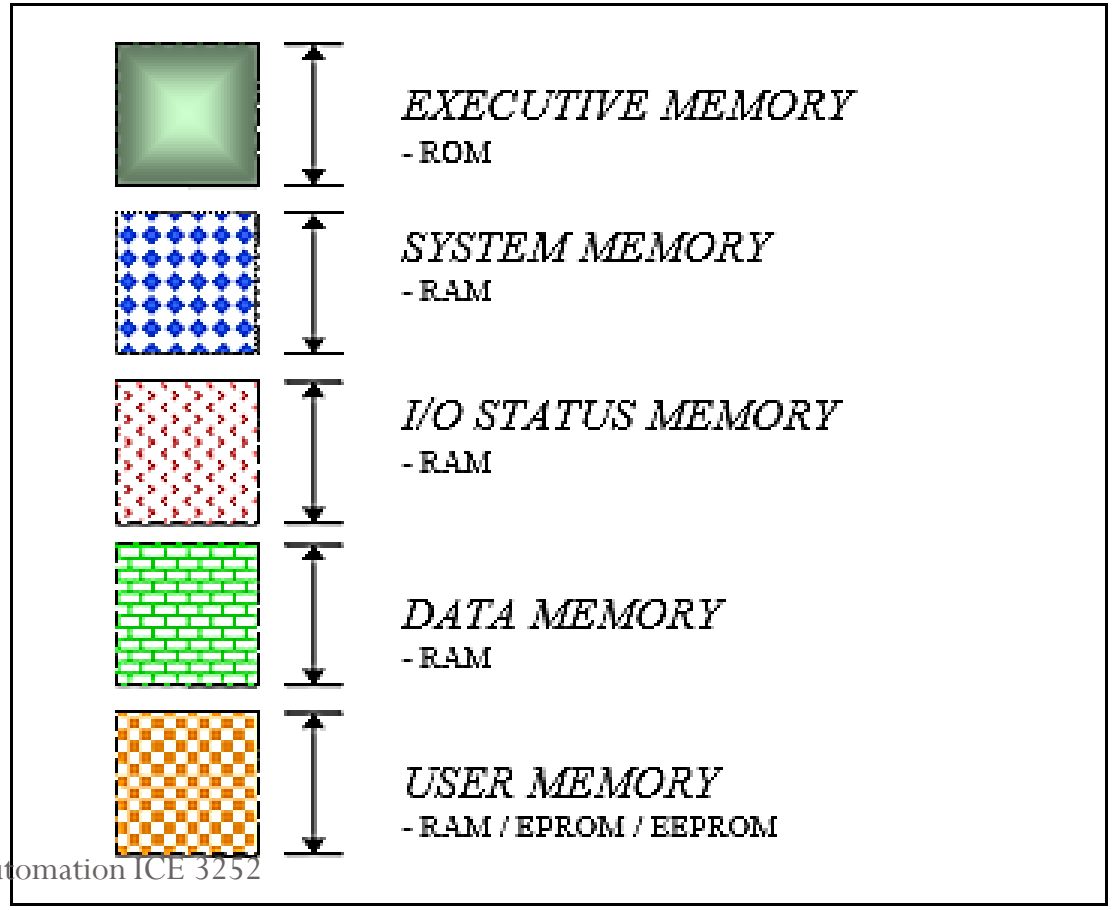
PROM (Programmable ROM): is a special type of ROM because it can be programmed.

EPROM (Erasable PROM): : is a specially designed PROM that can be reprogrammed after being entirely erased by an ultraviolet (UV) light source.

EEPROM-Electrically erasable PROM: Several of today's small and medium-size controllers use EEPROM as the only memory within the system. It provides permanent storage for the program and can be easily changed with the use of a programming device (e.g., a PC) or a manual programming unit.

PLC Memory

- All PLC memories can be subdivided into at least five major areas. A typical memory utilization map for a PLC is depicted in the following figure.



Executive Memory

- The operating system or executive memory for the PLC is always in ROM
- Once programmed and developed by the manufacturer, it rarely needs changing.
- It is the one that actually does the scanning in a PLC.
- The operating system is a special machine language program that runs the PLC.
- It instructs the microprocessor to read each user instruction, helps the microprocessor to interpret user programmed symbols and instructions,
- Keeps track of all the I/O status, and is responsible for maintaining/monitoring the current status of the health of the system and all its components.

System memory

- This memory is allotted for system administration.
- Normally this area is allotted for use of the operating system only and is not available to the user for programming.
- It might be assumed of as a scratch pad for the operating system to doodle on as necessary.

I/O Status Memory

- Another portion of RAM is allocated for the storage of current I/O status.
- Every single input/output module has been assigned to it a particular location within the input/output image table.
- The location within the input and output image tables are identified by addresses, each location has its own unique address.
- During the execution, the status of input modules used are read from the input image table (not directly from the input module itself).
- Various output device status generated during the execution of user program are stored in the output image table

Data Memory

- Whenever timers, counters, mathematics and process parameters are required, an area of memory must be set aside for data storage.

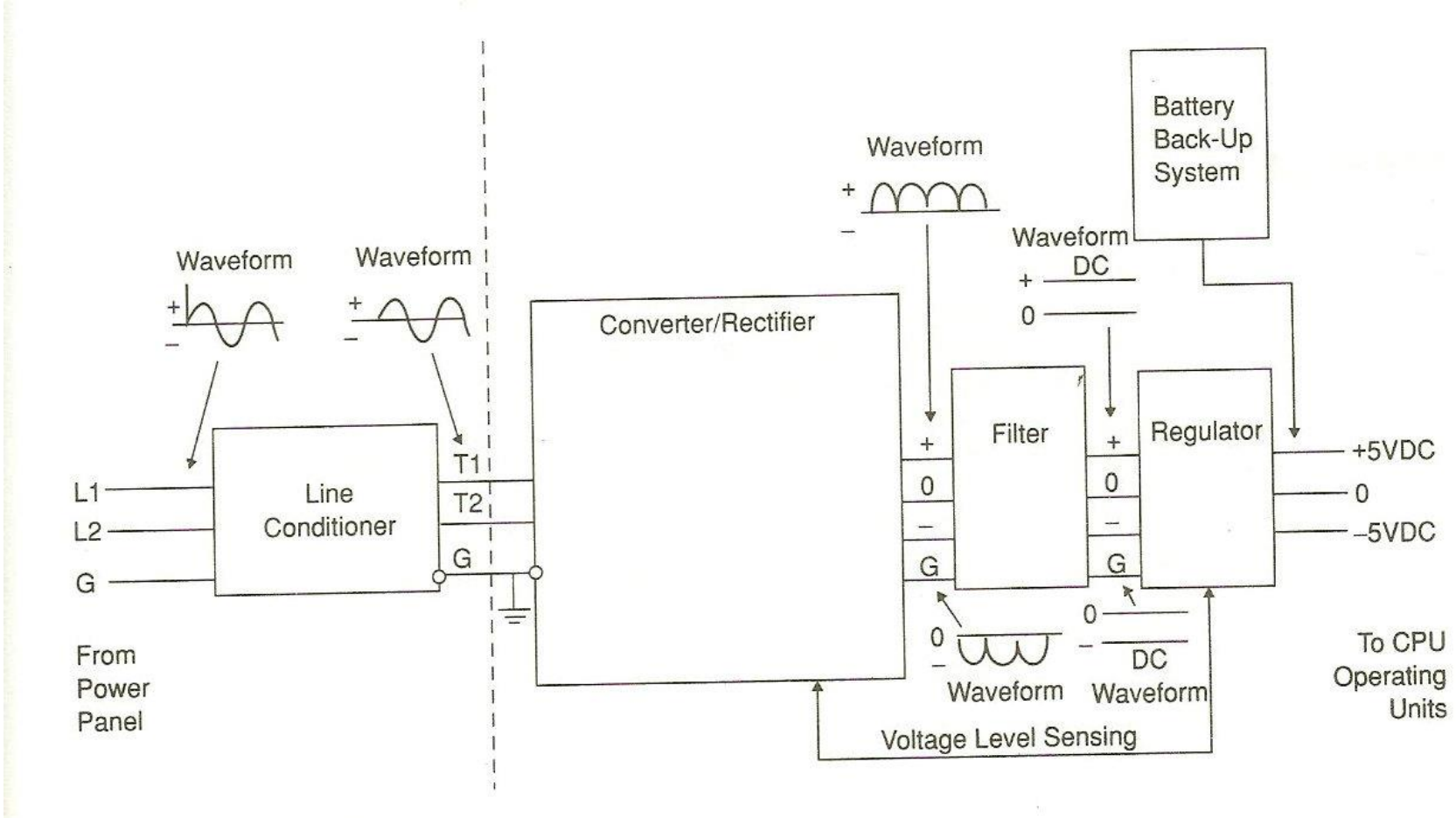
User Program Memory

- The final area of memory in a PLC is allocated to the storage of the user program. It is this memory area that the executive program instructs the microprocessor to examine or 'scan' to find the user instructions.
- In the majority PLCs, the internal data storage and user program areas are located in RAM.

Power Supply :

A power supply is needed to provide power to the PLC and any other modules. Power supplies come in various forms :

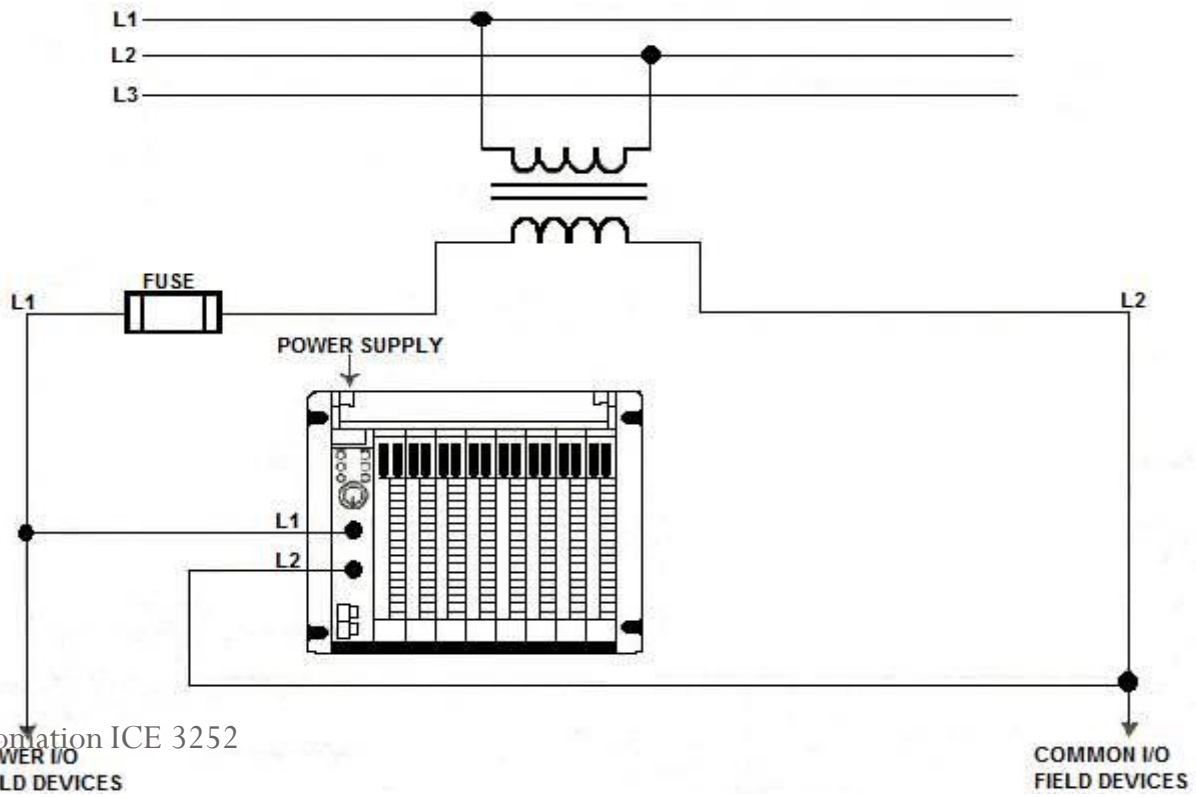
- Power supply modules that fit into one of the slots in a chassis.
- External power supplies that mount to the outside of a chassis.
- Stand alone power supplies that connect to the PLC or I/O through a power cable.
- Embedded power supplies that come as part of the PLC block.


Waveform
Waveform
Waveform
Battery
Back-Up
System
Waveform
DC
Converter/Rectifier
L1
L2
G
Line
Conditioner
T1
T2
G
Filter
Regulator
+5VDC
0
–5VDC
From
Power
Panel
Waveform
DC
Waveform
To CPU
Operating
Units
Voltage Level Sensing

The function of the power supply is to provide the DC power to operate the PLC. It is supplied by single-phase 120 or 240 VAC line power that powers the PLC system.

The Power Supply is a module located in the PLC system module rack. The DC power (voltage and current) it provides power to the other modules in the rack, such as the CPU, Co-processor Modules, and I/O Modules.

The line power provided to the PLC system also powers the I/O Field Devices in micro PLCs. The PLC system is protected against PLC module or field device malfunctions. The Fuse in Figure provides this protection. In large PLC systems, it does not power the field devices.



Chassis/Backplane /Rack:

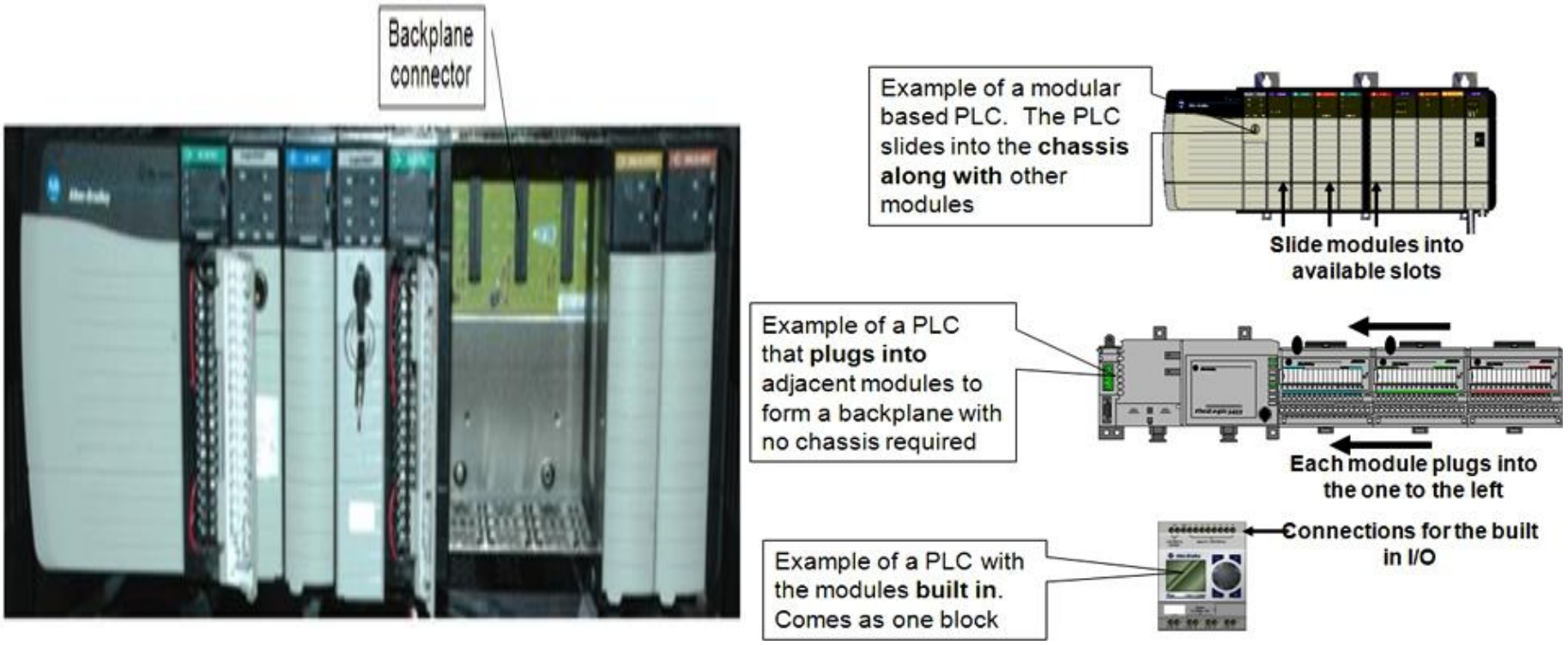
All PLCs need some method of communicating between the controller, I/O and communications modules. Here are three ways used to accomplish this communications between the various components that make up the PLC system.

Modules are installed in the **same chassis** as the PLC and communicate over the chassis backplane.

Modules are designed to **"plug" into** each other. The interconnecting plugs form a backplane there is no chassis.

Modules are **built into** the PLC and modules come together in one physical block. The backplane in this case is transparent to the user.

A backplane chassis based system. You can see the backplane in the area where the modules are not inserted. The modules have connectors that plug into the black connectors on the backplane. All of the connectors on the backplane are connected together electrically.




PLC Rack or Chassis
R08PCPU
READY
ERROR
PROGRAM RUN
USER
BATTERY
CARD READY
CARD ACCESS
FUNCTION
▼PULL
▲PULL
USB
10BASE-T/100BASE-TX
SPEED

References

- John. W. Webb Ronald A Reis, *Programmable Logic Controllers - Principles and Applications*, PHI, (4e). 1998.
- Frank D. Petruzella, *Programmable Logic Controllers,* MGH, (2e), 1997.