Introduction to PLC

Chapter 2

1

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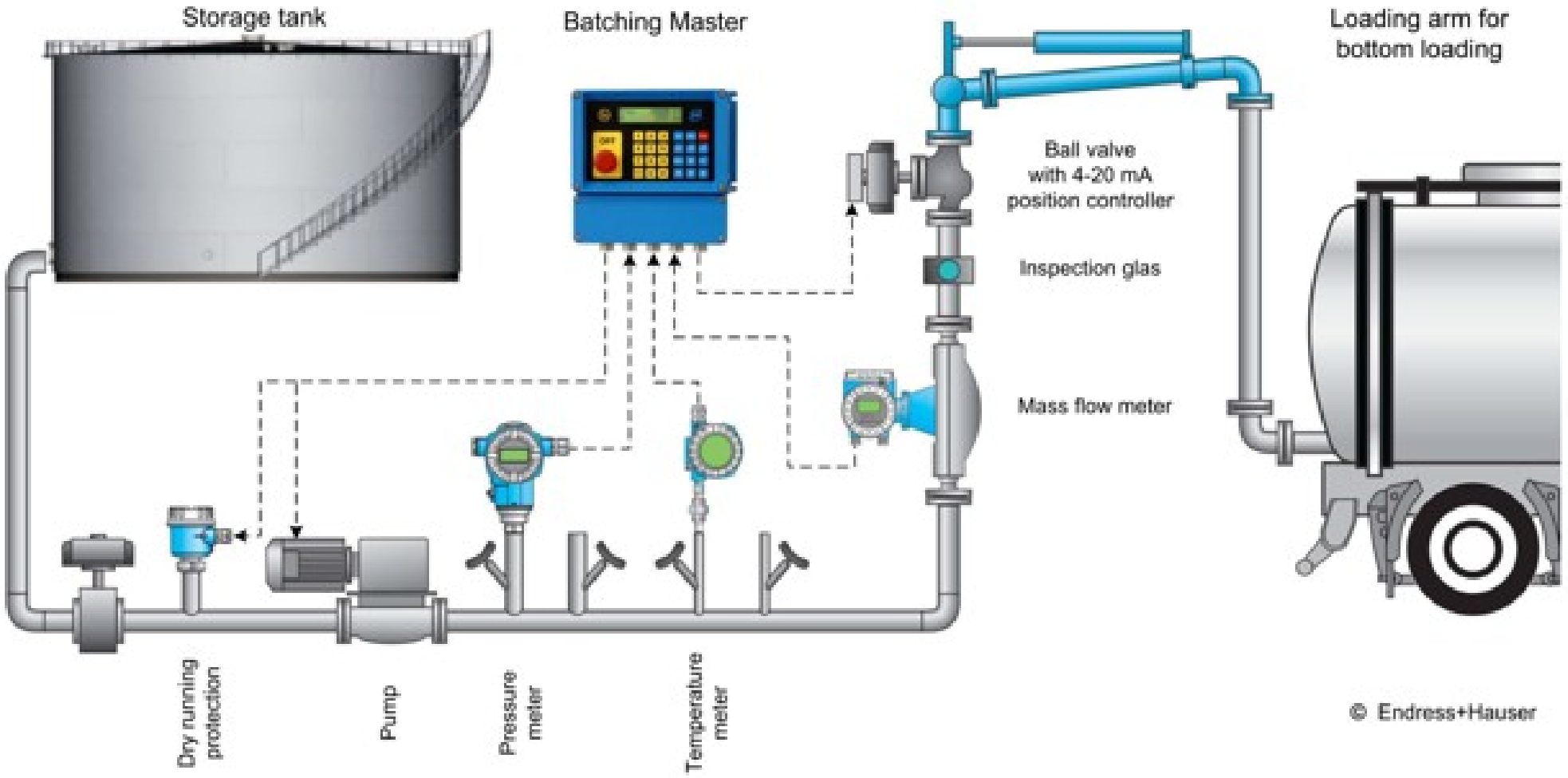
Storage tank
Batching Master
Loading arm for bottom loading
Ball valve with 4-20 mA position controller
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Temperature meter
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Review









A PROGRAMMABLE LOGIC CONTROLLER is a solid state control system that continuously monitors the status of devices connected as inputs. Based upon a user written program, stored in memory, it controls the status of devices connected as outputs.

Definition of PLC

(Definition according to NEMA standard ICS3 1978)

"A digitally operating electronic device which uses a programmable memory for the internal storage of instructions by implementing specific functions such as logic sequencing, timing, counting, and arithmetic to control, through digital or analog input/output modules, various types of machines or processes.

(Definition according to by IEC 61131, Part 1 standard 1992)

" PLC is a digitally operating electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic, to control, through digital or analog inputs and outputs, various types of machines or processes. Both the PC and its associated peripherals are designed so that they can be easily integrated into an industrial control system and easily used' in all their intended functions. "

A programmable logic controller (PLC) is a special purpose computer aimed at implementing control solutions.

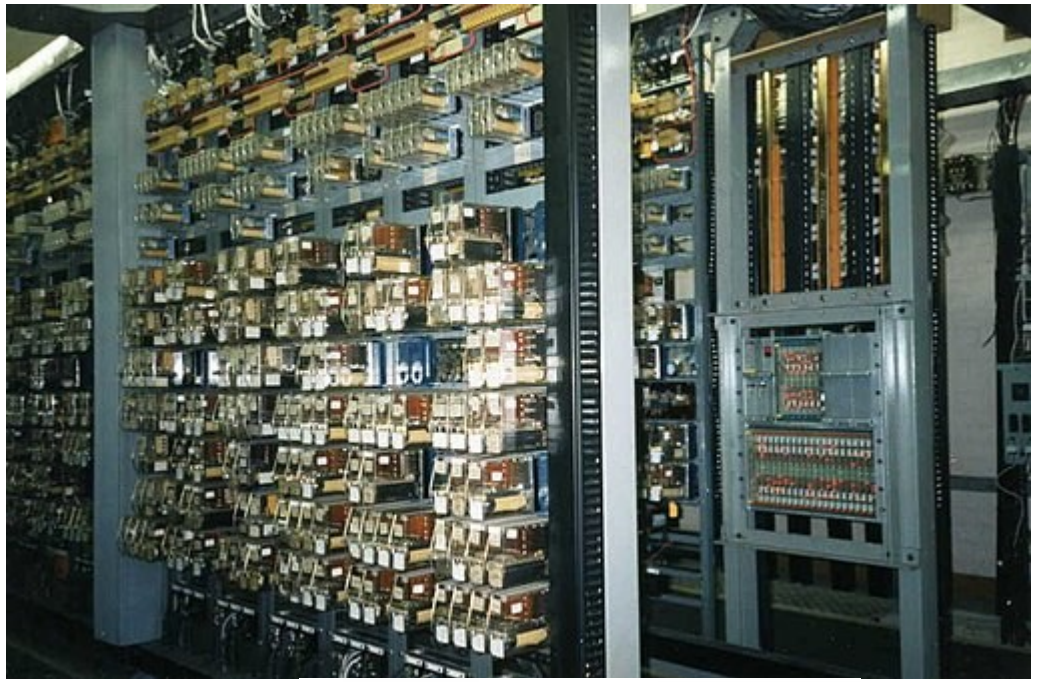
National Electrical Manufacturing Association (NEMA)
International Electrotechnical Commission

History of PLC

The first PLC was developed by a group of engineers at General Motors in 1968, when the company were looking for an alternative to replace complex, high costs and inflexible relay control systems.

The specifications required are:

- The system had to be capable of sustaining an industrial environment.
- The new control system had to be price competitive with the use of relay systems.
- The system had to be reusable. (Such a control system would reduce machine downtime and provide expandability for the future.)
- The input and output interfaces had to be easily replaceable.
- The controller had to be designed in modular form, so that sub-assemblies could be removed easily for replacement or repair.
- The control system needed the capability to pass data collection to a central system.
- The method used to program the controller had to be simple, so that it could be easily understood by plant personnel



Leading PLC Manufacturers

- Allen Bradley
- Modicon
- Texas Instruments
- General Electric

(US)

- Siemens
- Mouller
- Festo
- Telemechanique

(EU)

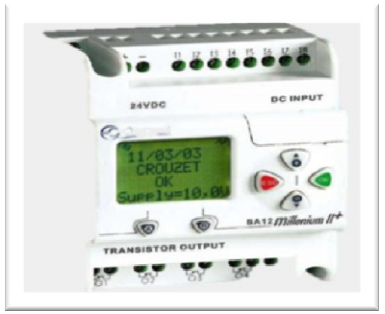
- Toshiba
- Omron
- Fanuc
- Mitsubishi

(JAPAN)

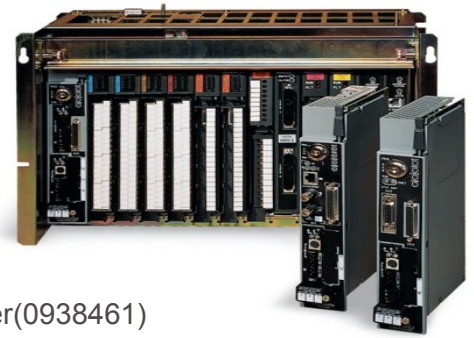
External design of PLC

Depending on how the microprocessor system is connected to the input and output modules, ditferentiation can be made between:

- Compact PLCs: Where input module, central control unit and output module in one housing.



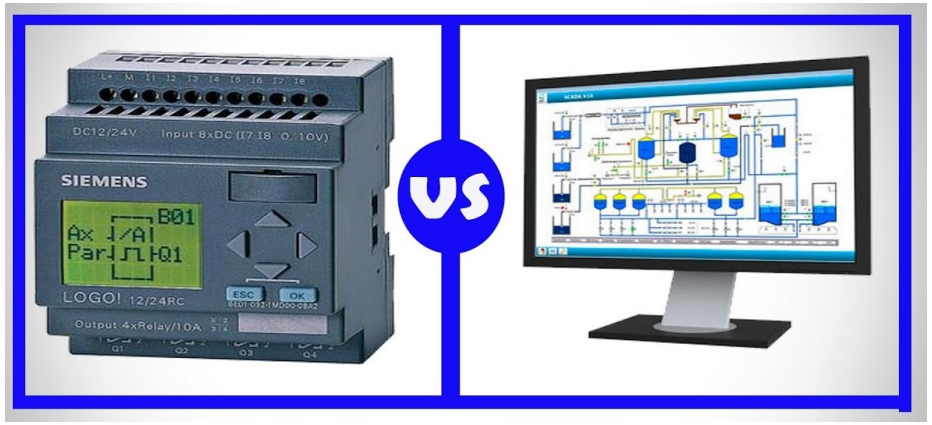
- Modular PLCs: Where the modules required for the practical application (such as: digital input/output modules, analogue modules, positioning and communication modules) are inserted in a rack, where individual modules are linked via a bus system. This type of design is also known as series technology.



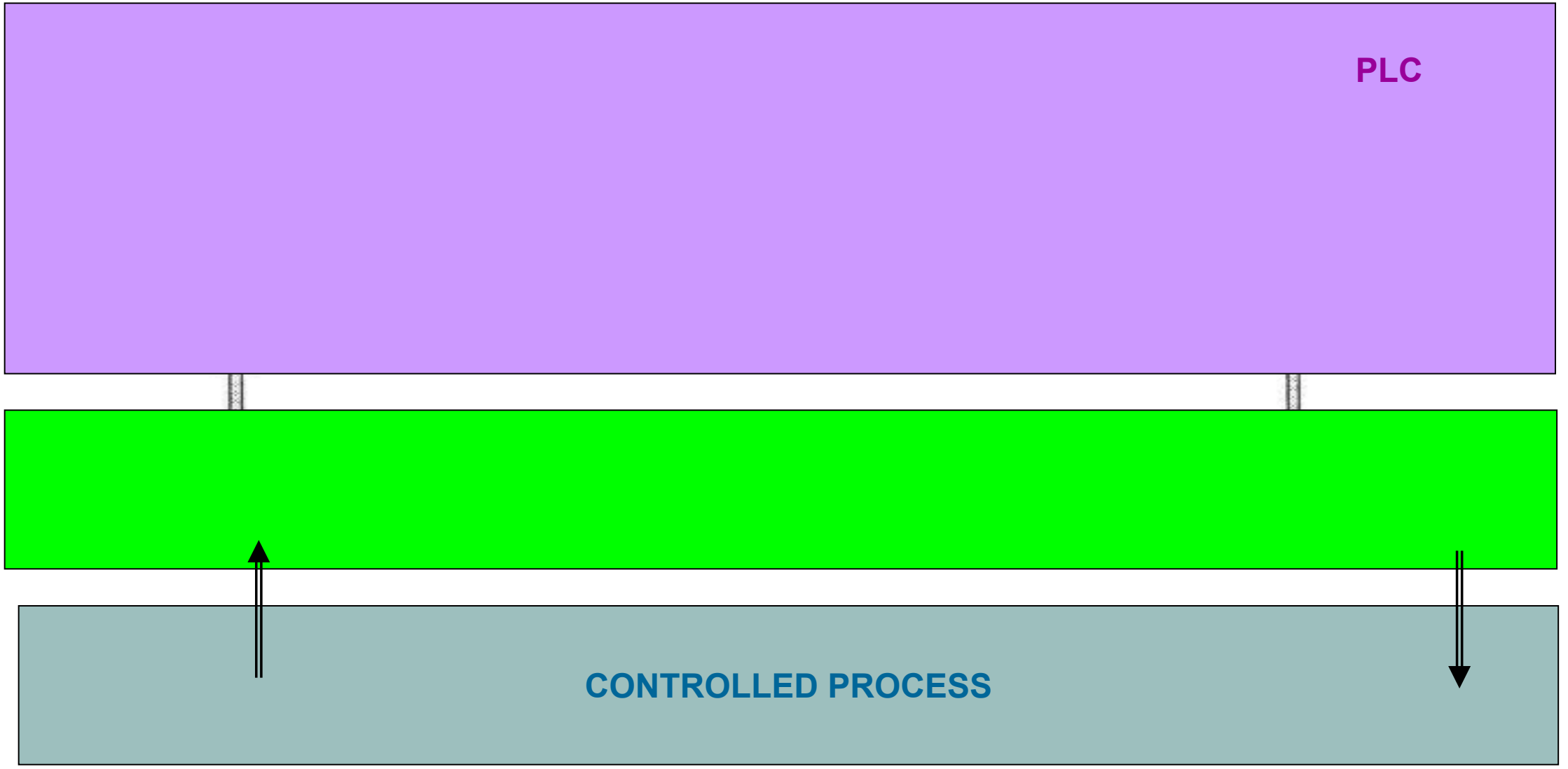
PLC and Computer

The architecture of a PLC's CPU is basically same as that of a general purpose computer; however, some important characteristics set them apart.

- Unlike computer, PLCs are specifically designed to survive the harsh conditions of the industrial environment. A well-designed PLC can be placed in an area with substantial amounts of electrical noise, electromagnetic interference, mechanical vibration, and high humidity.
- Distinction of PLCs is that their hardware and software are designed for easy use by plant electricians and technicians. The hardware interfaces for connecting field devices are actually part of the PLC itself and are easily connected.
- The modular and self-diagnosing interface circuits are able to pin point malfunctions and moreover, are easily removed and replaced.



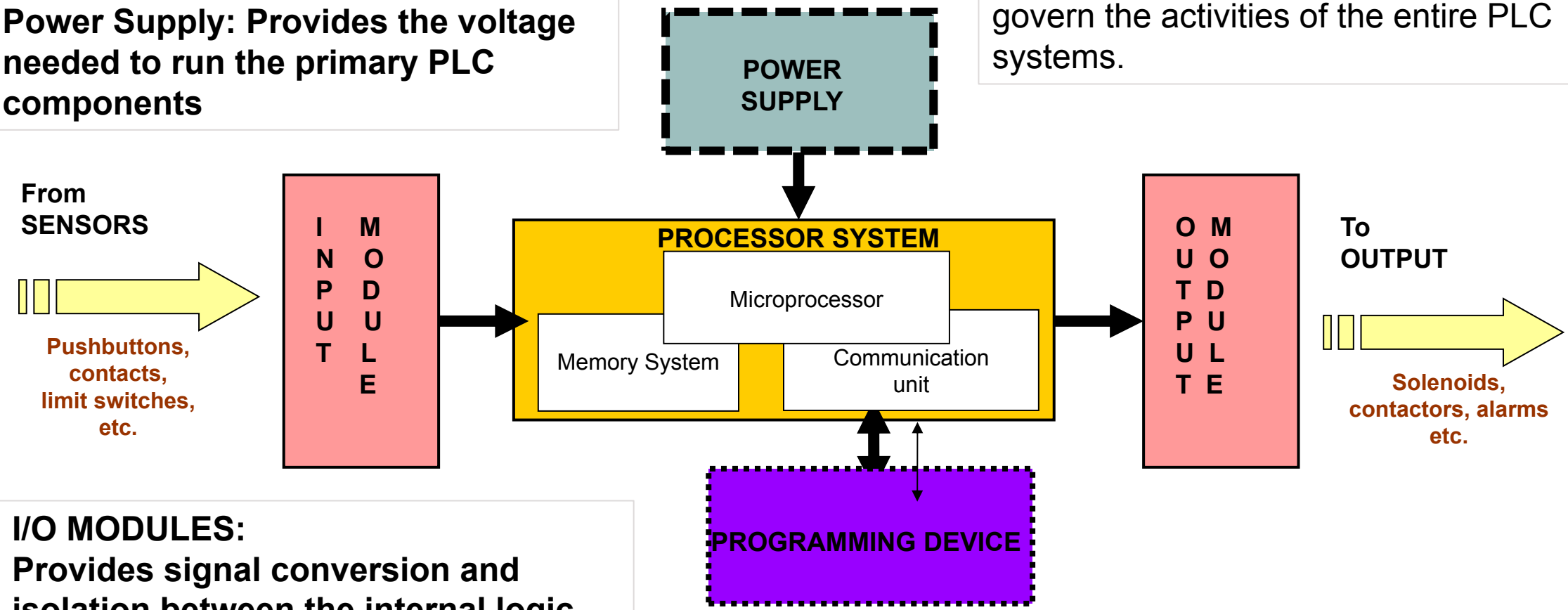
PLC components



PLC Architecture

Power Supply: Provides the voltage needed to run the primary PLC components

PROCESSOR SYSTEM
Provides intelligence to command and govern the activities of the entire PLC systems.



I/O MODULES:
Provides signal conversion and isolation between the internal logic-level signals inside the PLC and the field's high level signal.

PROGRAMMING DEVICE :
used to enter the desired program that will determine the sequence of operation.

PROCESSOR SYSTEM

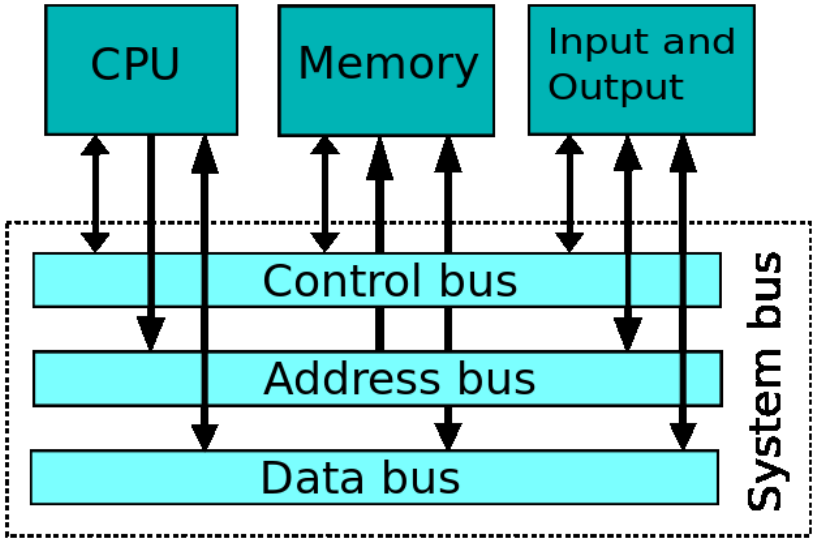
The processor system contains the PLC's microprocessor, memory system and communication unit.

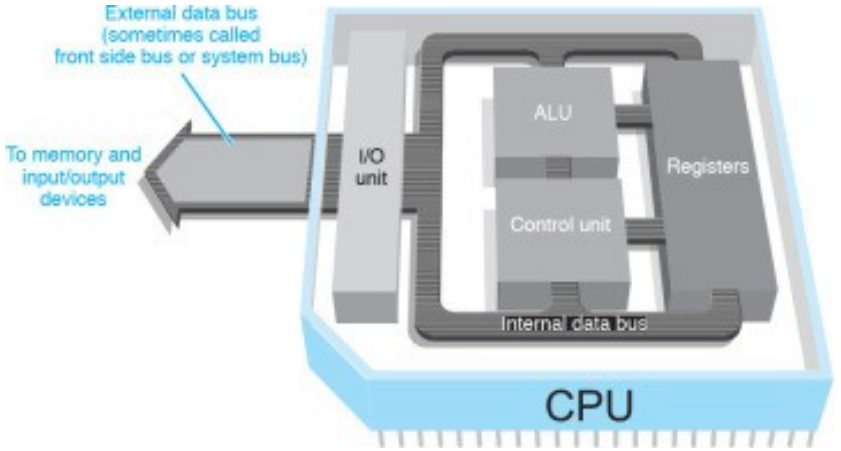
The main function of the microprocessor is to analyze data coming from field sensors through input modules, make decisions based on the user's defined control program and return signal back through output modules to the field devices.

The memory system in the processor module has two parts: a *system memory* and an *application memory.*

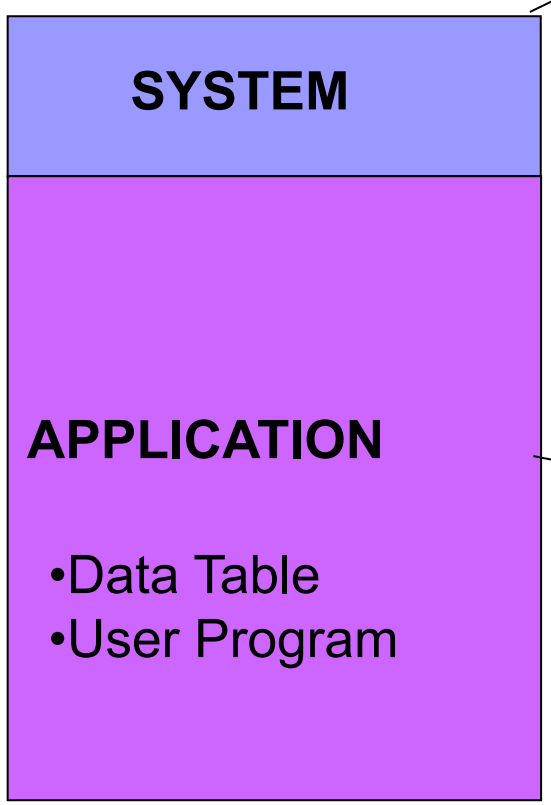
The PLC uses the Communication unit (which has Serial (RS 232, RS 422, RS 485), Ethernet,…) to:

- Changing resident PLC programs - uploading/downloading from a supervisory controller (Laptop or desktop computer).
- Forcing I/O points and memory elements from a remote terminal.
- Linking a PLC into a control hierarchy containing several sizes of PLC and computer.
- Monitoring data and alarms.





Memory Map Organization

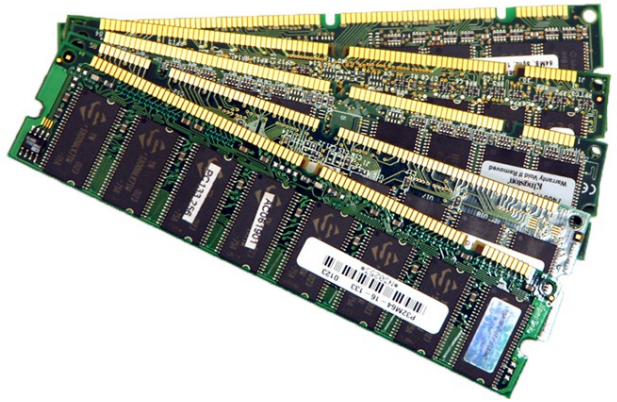


•System memory includes an area called the EXECUTIVE, composed of permanently-stored programs that direct all system activities, such as execution of the users control program, communication with peripheral devices, and other system activities.
•System memory is generally built from read-only memory devices.

•The application memory is divided into the data table area and user program area.
•The data table stores any data associated with the user's control program, such as system input and output status data, and any stored constants, variables, or preset values. The data table is where data is monitored, manipulated, and changed for control purposes.
•The user program area is where the programmed instructions entered by the user are stored as an application control program.

Memory

- System memory (Non-Volatile)
  - ROM (Read Only Memory)
  - PROM (Programmable Read Only Memory)
  - EPROM (Erasable Programmable Read Only Memory)
  - EEPROM (Electric Erasable Programmable ROM)
- Application (Program/Data) memory (Volatile)
  - RAM (Random Access Memory)
  - CMOS (Complementary Metal Oxide Semiconductor)



PLC Communications

Serial ports

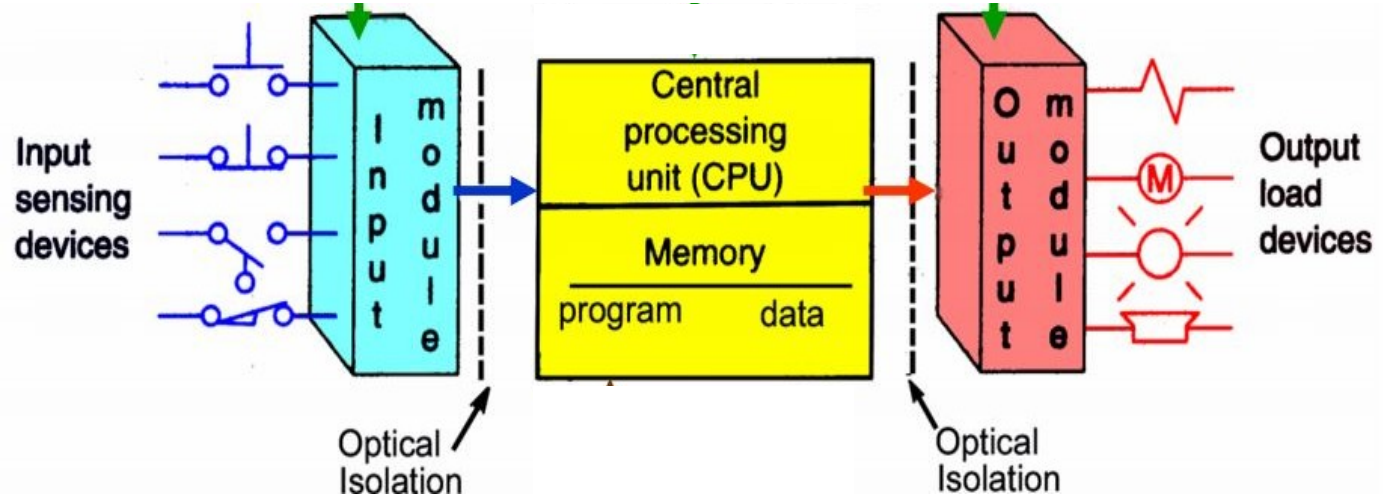
- RS 232
  - Used in short-distance computer communications, with the majority of computer hardware and peripherals.
  - Has a maximum effective distance of approx. 30 m at 9600 baud.
- RS 422 / RS 485
  - Used for longer-distance links, often between several PCs in a distributed system. RS 485 can have a maximum distance of about 1000 meters.

Ethernet: Local Area Network (LAN)

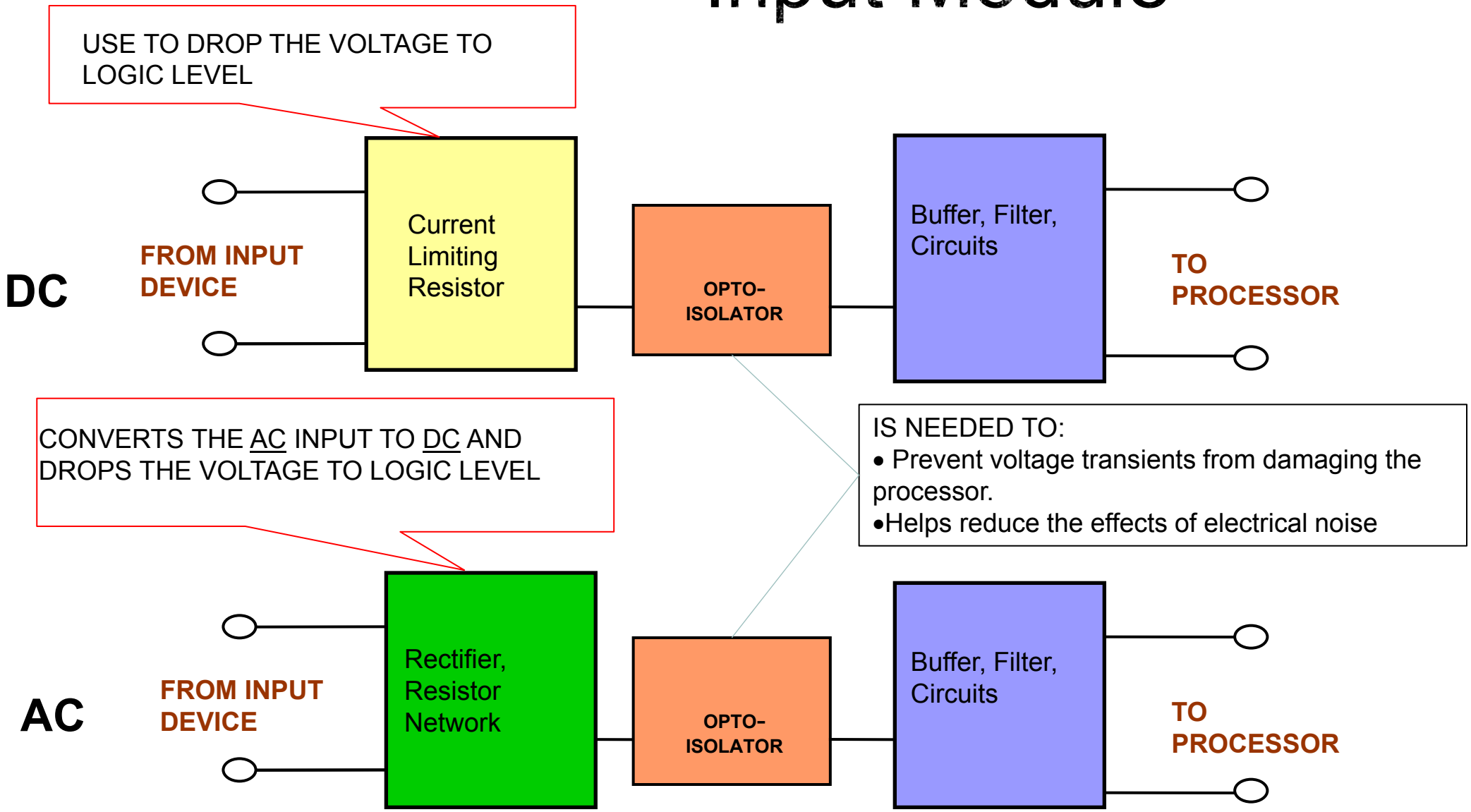
- Local Area Network provides a physical link between all devices plus providing overall data exchange management or protocol, ensuring that each device can “talk” to other machines and understand data received from them.
- LANs provide the common, high-speed data communications bus which interconnects any or all devices within the local area.

Input/Output Modules

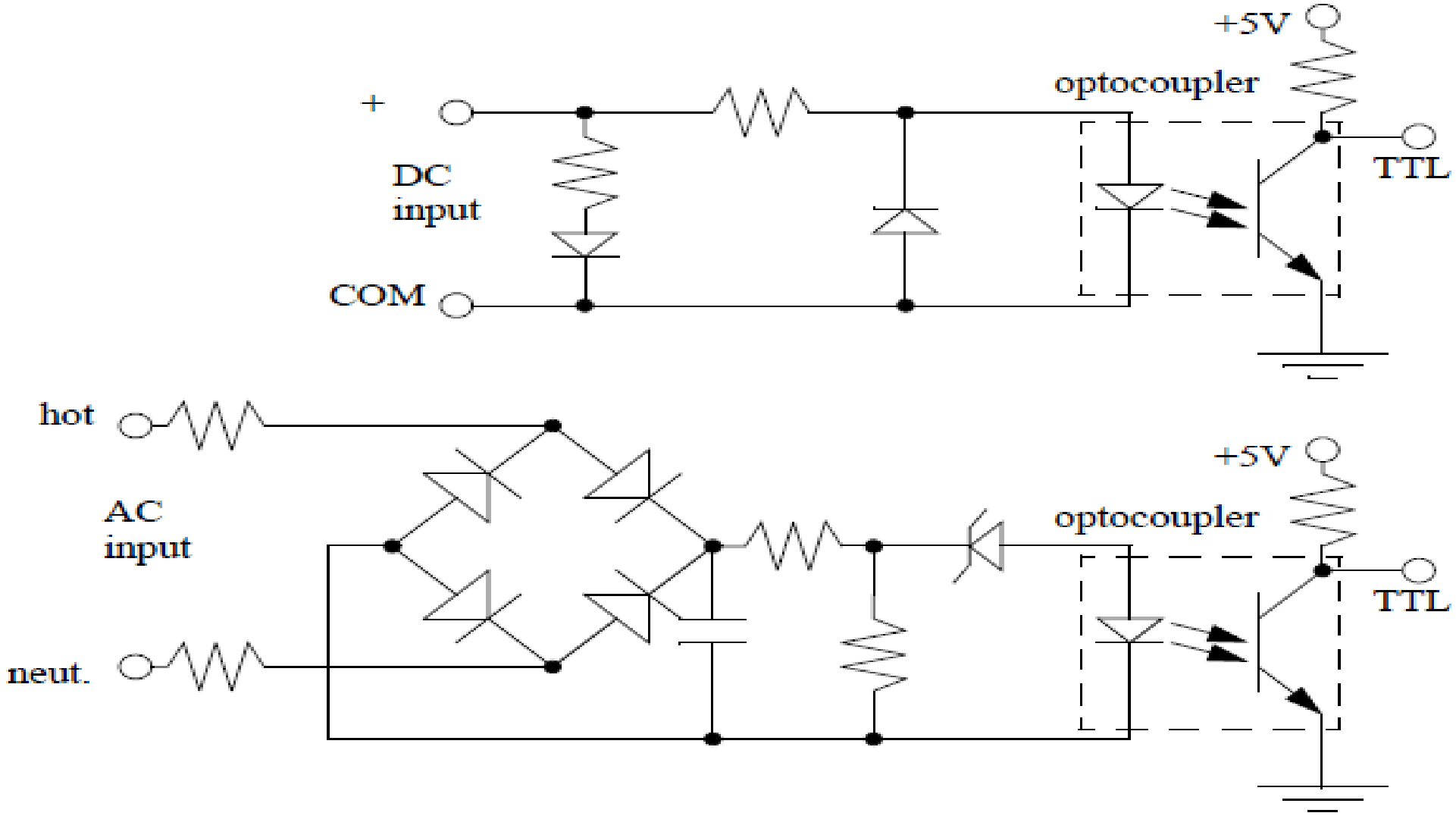
- The I/O interface section of a PLC connects it to external field devices.
- The main purpose of the I/O interface is to condition the various signals received from or sent to the external input and output devices.
- Input modules converts signals from discrete or analog input devices to logic levels acceptable to PLC's processor.
- Output modules converts signal from the processor to levels capable of driving the connected discrete or analog output devices.



Input Module



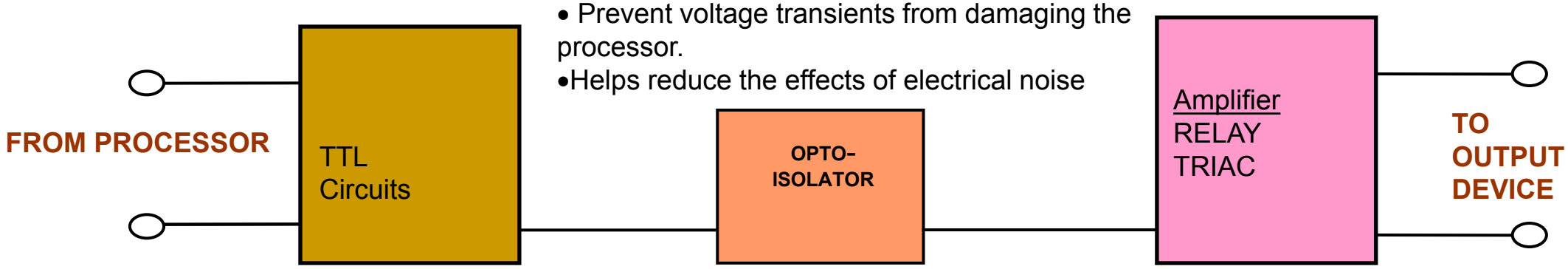
Input Module

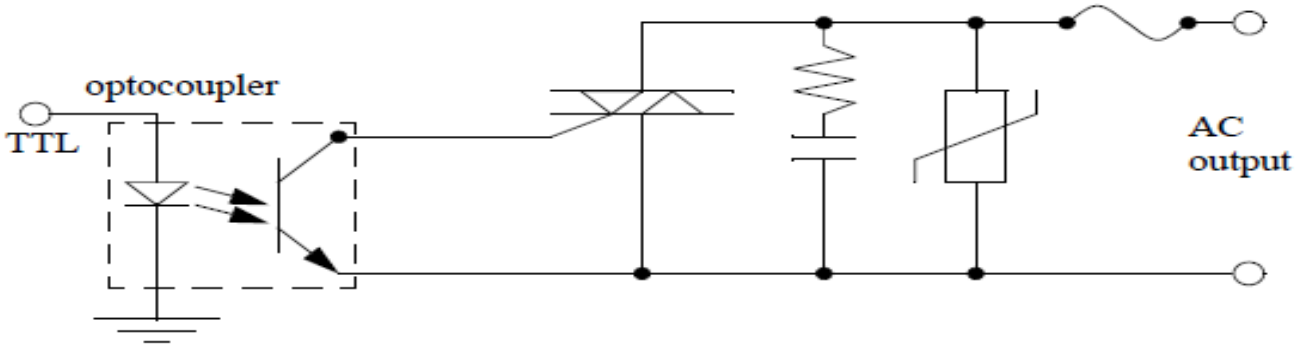


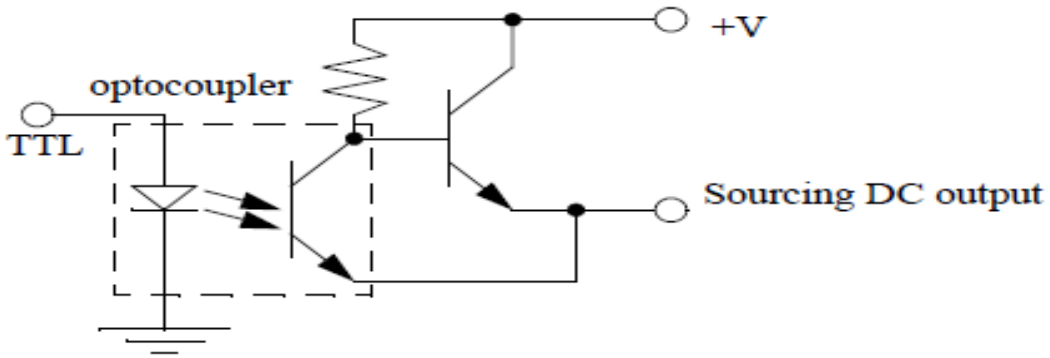
Output Module

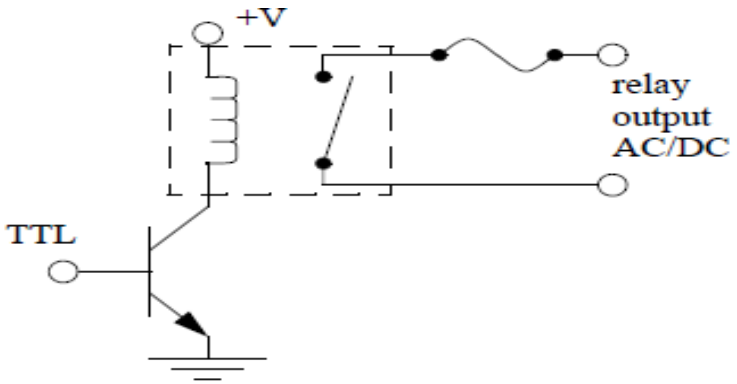
IS NEEDED TO:

- Prevent voltage transients from damaging the processor.
- Helps reduce the effects of electrical noise

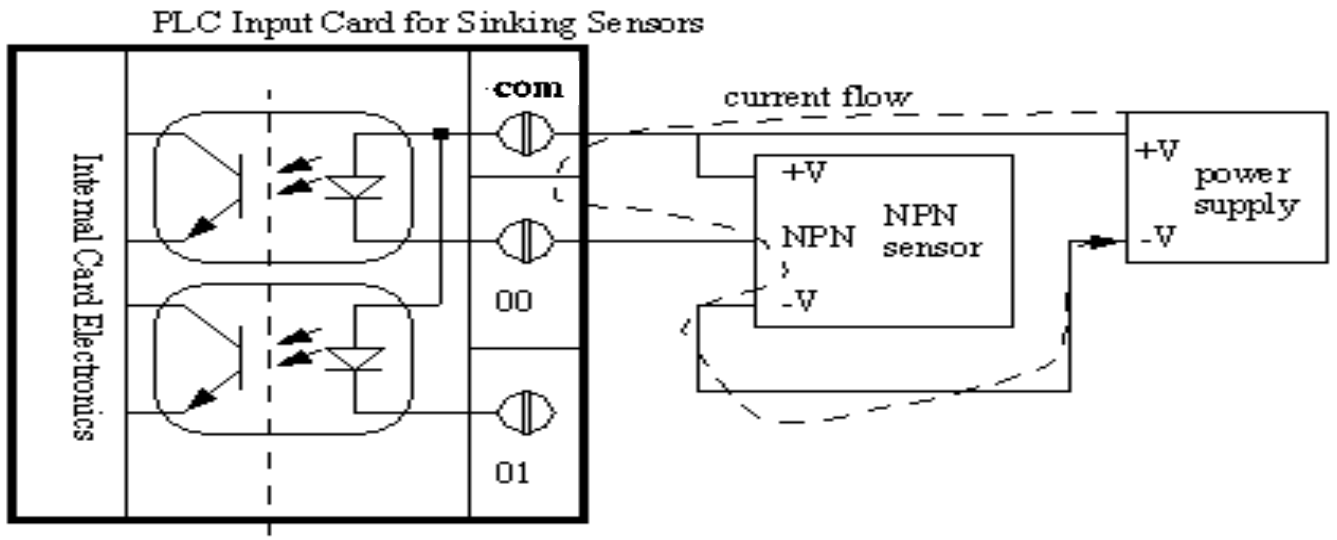


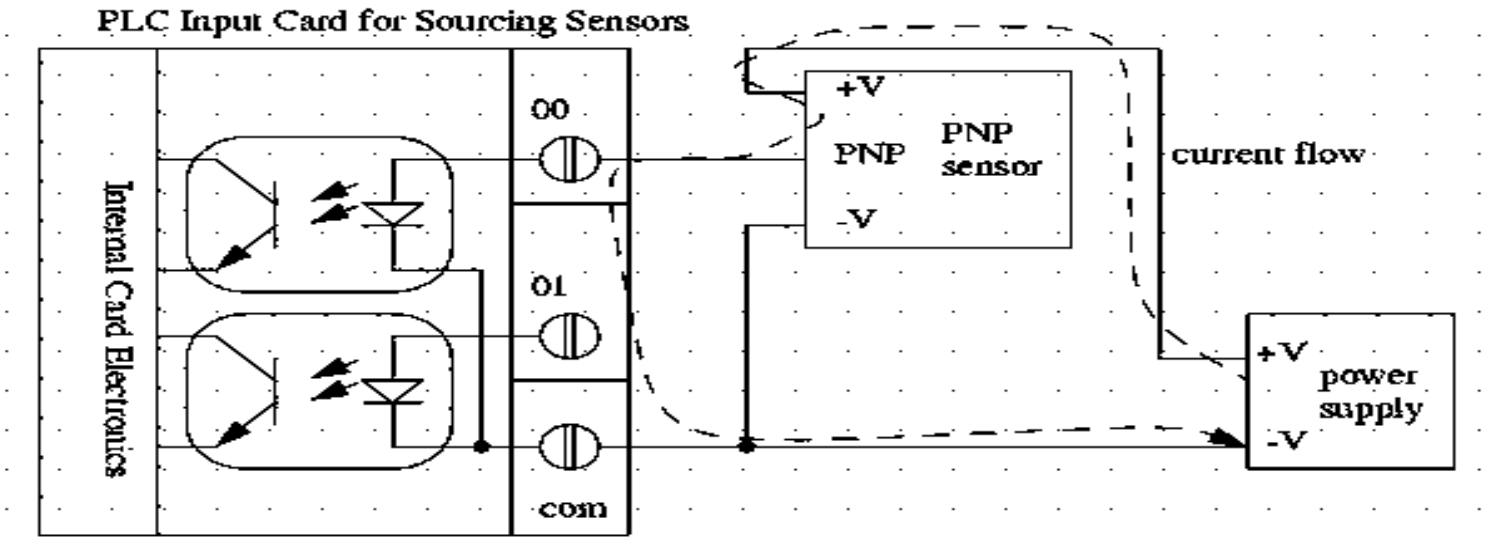




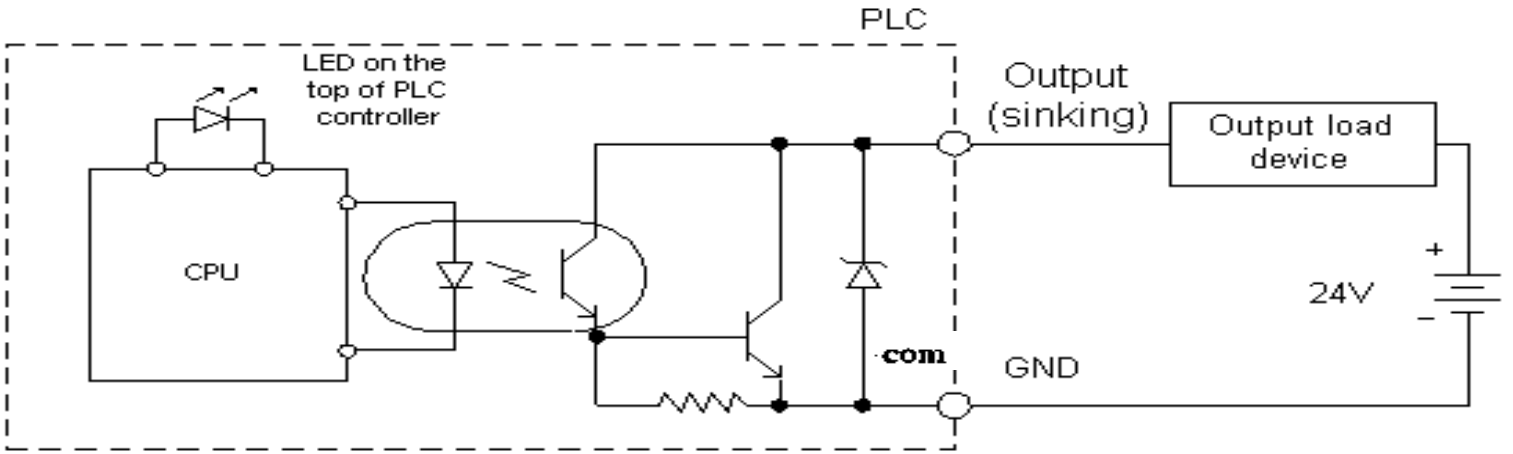


External Inputs

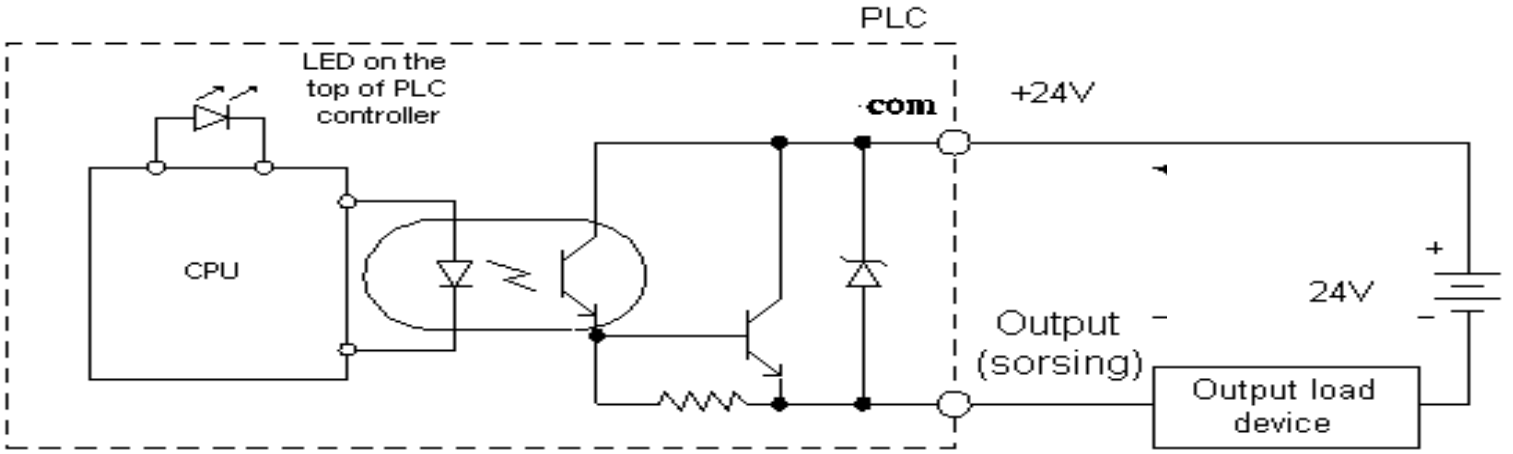




External Output



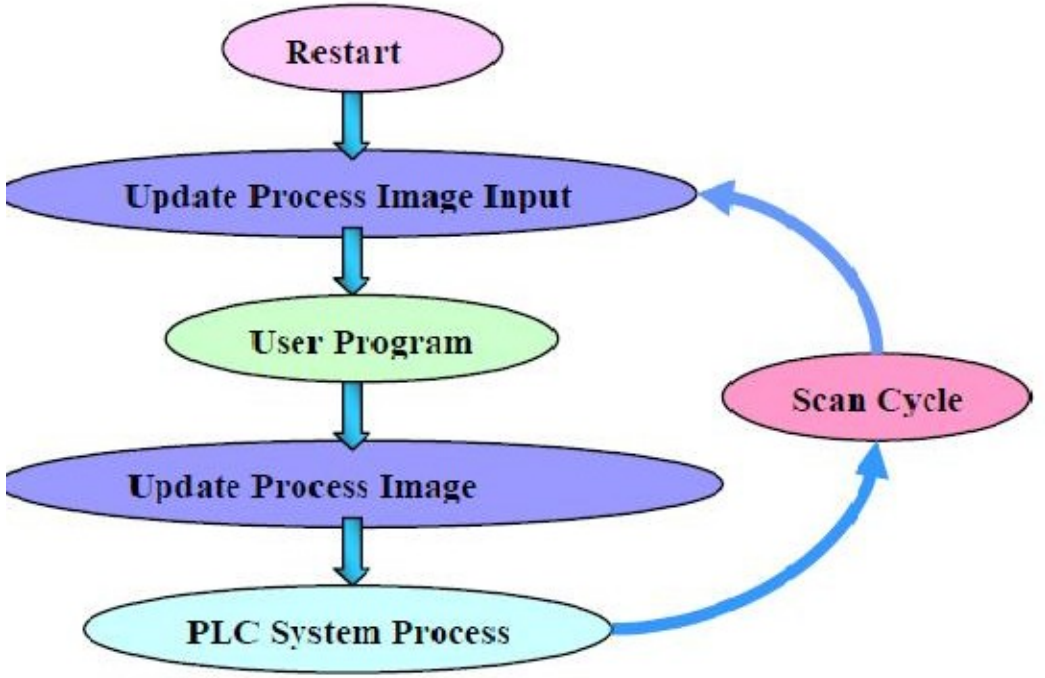
Connecting output load device to a sinking PLC controller output



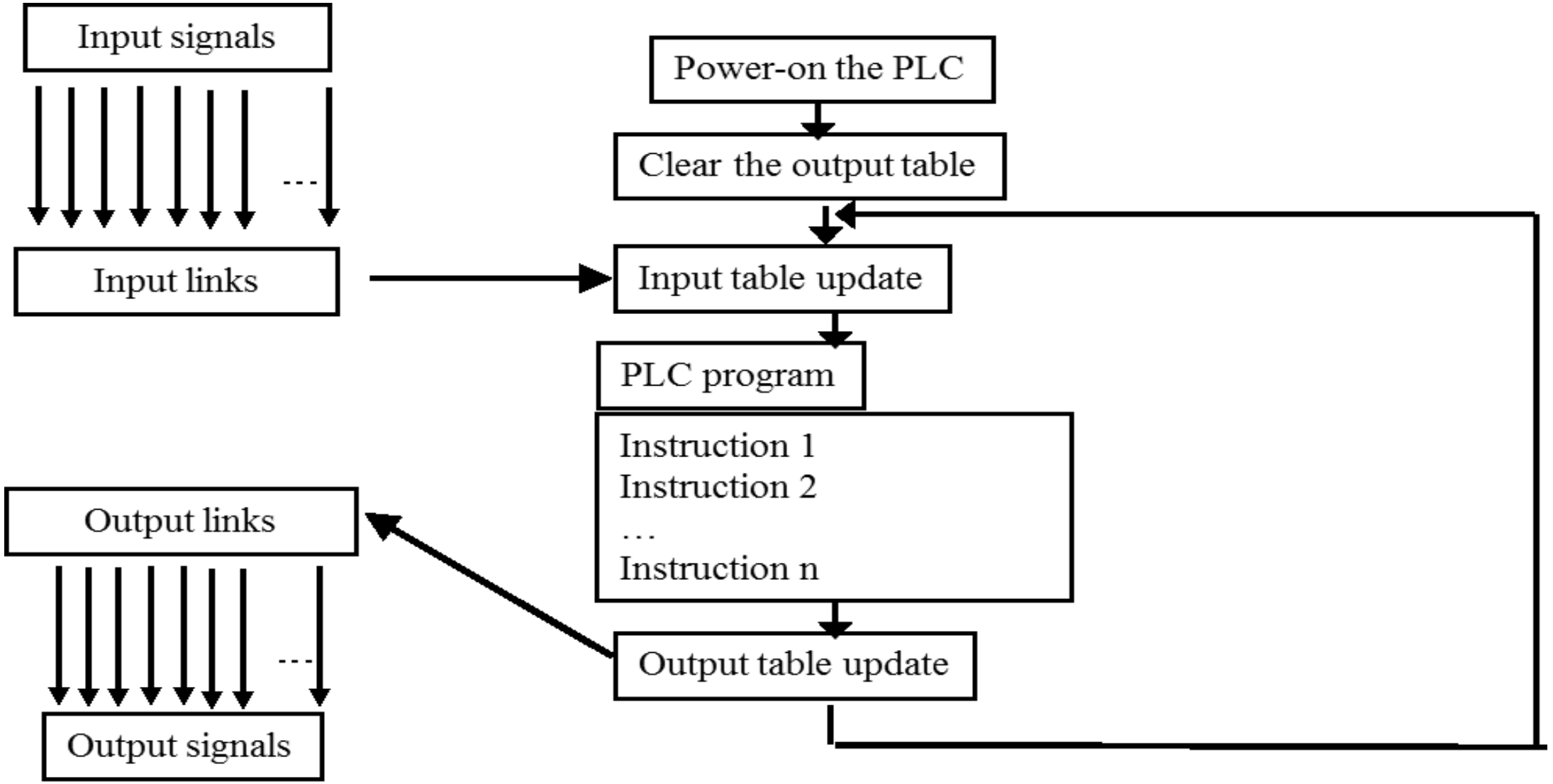
Connecting output load device to a sourcing PLC controller output

PLC Operation

- Read all field input devices via the input interfaces. Execute the user program stored in application memory, then, based on whatever control scheme has been programmed by the user. Turn the field output devices on or off, or perform whatever control is necessary for the process application.
- This process of sequentially reading the inputs, executing the program in memory, and updating the outputs is known as scanning.

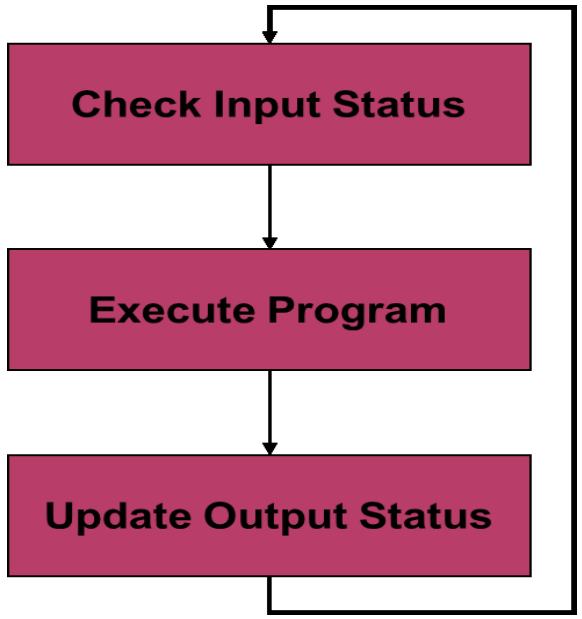


PLC Operation



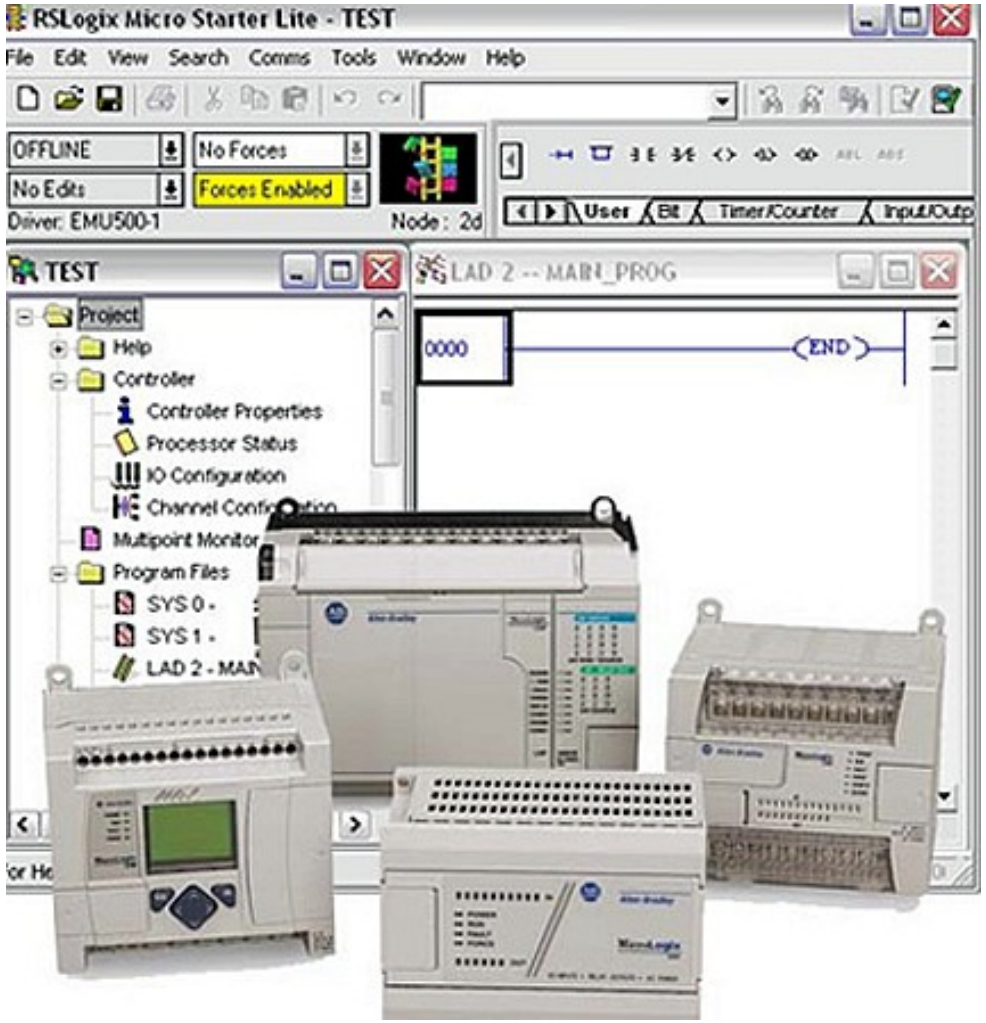
Scan cycle and scan time

- Input table update is also called input scan.
- Output table update is output scan.
- The process from input scan to output scan is a scan cycle.
- The time it takes to implement a scan cycle is called scan time. The scan time composed of the program scan time, which is the time required for solving the control program, and the I/O update time, or time required to read inputs and update outputs. The program scan time generally depends on the amount of memory taken by the control program and type of instructions used in the program. The time to make a single scan can vary from 1 ms to 100 ms.

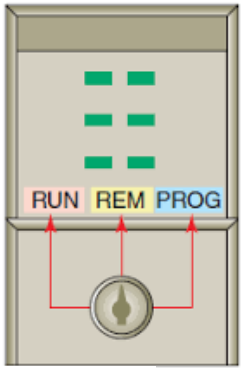


Criteria for PLC Selection

- Number of logical inputs and outputs.
- Memory
- Number of special I/O modules
- Scan Time
- Communications
- Software
- New or Existing System



Other PLC Terminology



- **Run Mode:** The PLC actively scanning the code and driving outputs.
- **Program Mode:** The PLC is not being scanned (All outputs disabled)
- **Remote Mode:** programming computer can change the PLC between Run and Program.
- **Note:** There is a physical key on the front of each PLC processor module, which allows the PLC to be switched between Run, Remote and Program Mode.

Previously PLC standards

- Previously valid PLC standards focus mainly on PLC programming were generally derived by current state of the art technology in Europe at the end of the seventies.
- This took into account non-networked PLC systems, which primarily execute logic operations on binary signals.
- DIN 19 239, for example, specifies programming languages which possess the corresponding language commands for these applications.
- No equivalent, standardised language elements existed for the PLC developments and system expansions made in the eighties such as
  - Processing of analogue signals
  - Interconnection of intelligent modules
  - Networked PLC systems etc.
- Consequently, PLC systems by different manufacturers required entirely different programming.

IEC 61131 Standard

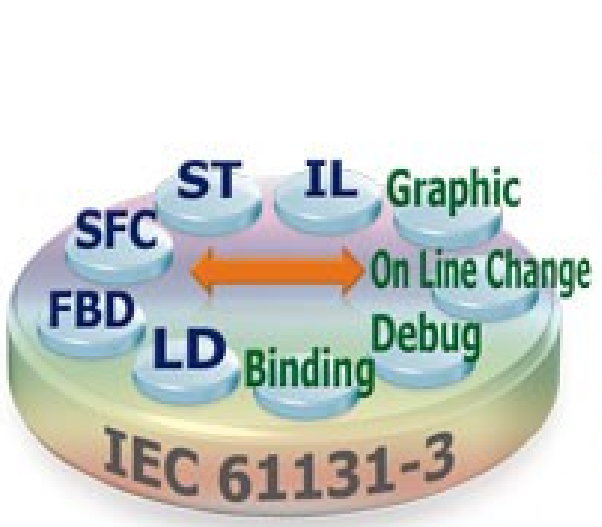
Since 1992, an international standard now exists for programmable logic controllers and associated peripheral devices. (PLC system)

- Part 1: General information
- Part 2: Equipment requirements and tests
- Part 3: Programming languages
- Part 4: User guidelines
- Part 5: Communication
- Part 6: Functional safety
- Part 7: Fuzzy control programming
- Part 8: Guidelines for the application and implementation of programming languages
- Part 9: Single-drop digital communication interface for small sensors and actuators

PLC programming languages

Part 3 of *IEC 61131* deals with programming languages and defines the following PLC programming language standards:

- Ladder diagram (LD)
- Function block diagram (FBD)
- Instruction list (IL)
- Structured text (ST)
- Sequential function chart (SFC)



PLC Programming Languages