Overview of Programmable Logic Controllers (PLCs)

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ECE4951- Design Workshop

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Lecture Objectives

- Expose basic characteristics of PLC.
- Describe the various subparts of a PLC hardware and modules.
- Outline the basic sequence of operation for a PLC.
- Describe the hardware input/output sections available.

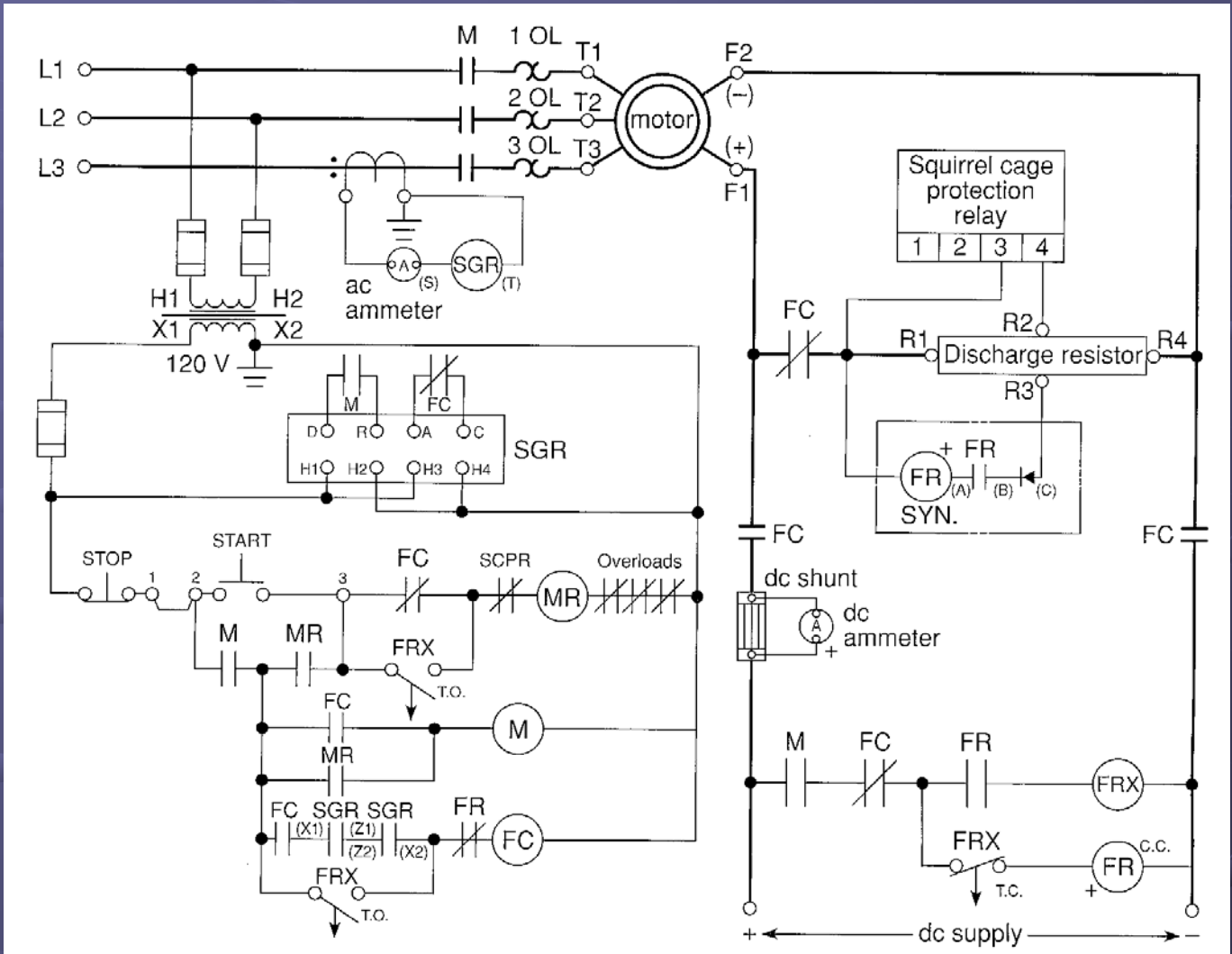
PLC

- A Programmable Logic Controller (PLC) is a specialized computing system used for control of industrial machines and processes.
- A PLC is a computer designed to work in an industrial environment
- PLCs are equipped with special input/output interfaces
- PLCs are programmed using a control programming language.

PLC Applications

- Originally hardwired arrays of relays were used to control the operation of heavy machines that contain motors and other high power devices.
- PLCs were originally used to substitute the switching relay networks used in industrial applications, but now they can also be used implement other tasks such as timing, delaying counting, calculating, comparing and processing of analog signals.

Relay Networks



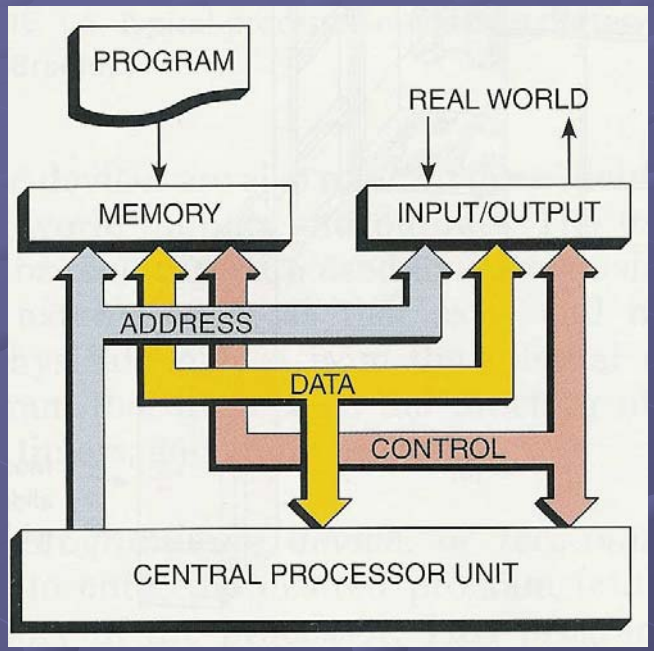
PLC Advantages

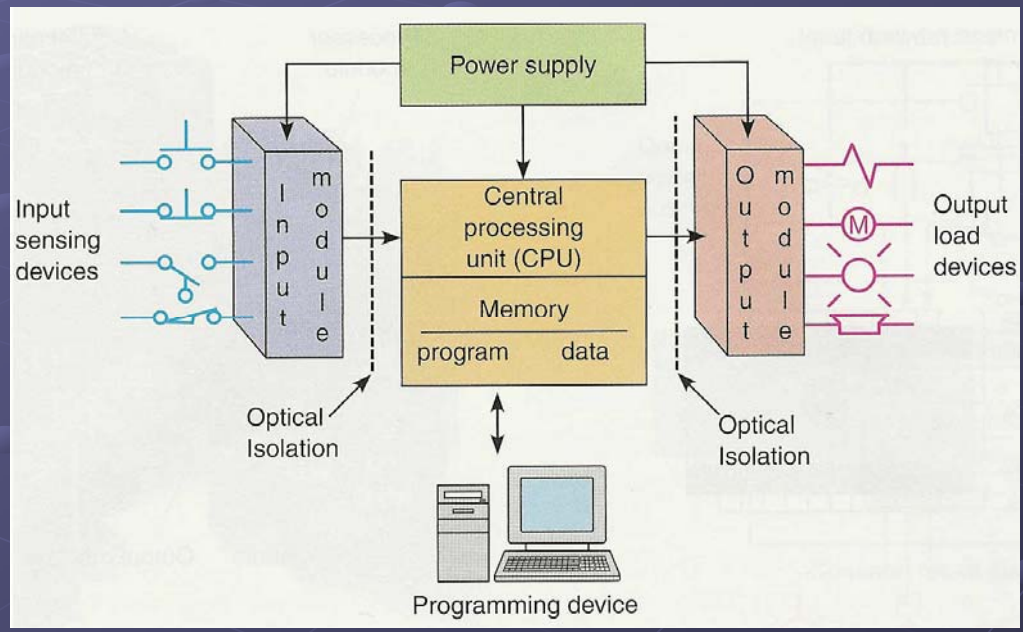
- Increased Reliability
- More Flexibility
- Lower Cost
- Faster Response
- Easier to troubleshoot
- Remote control capability
- Communication Capability

PLC Disadvantages

- In contrast to microcontroller systems that have what is called an *open architecture,* most PLCs manufacturers offer only *closed architectures* for their products
- PLC devices are *proprietary,* which means that parts and software from one manufacturer can't easily be used in combination with parts of another manufacturer, which limits the design and cost options

PLC Basic Architecture

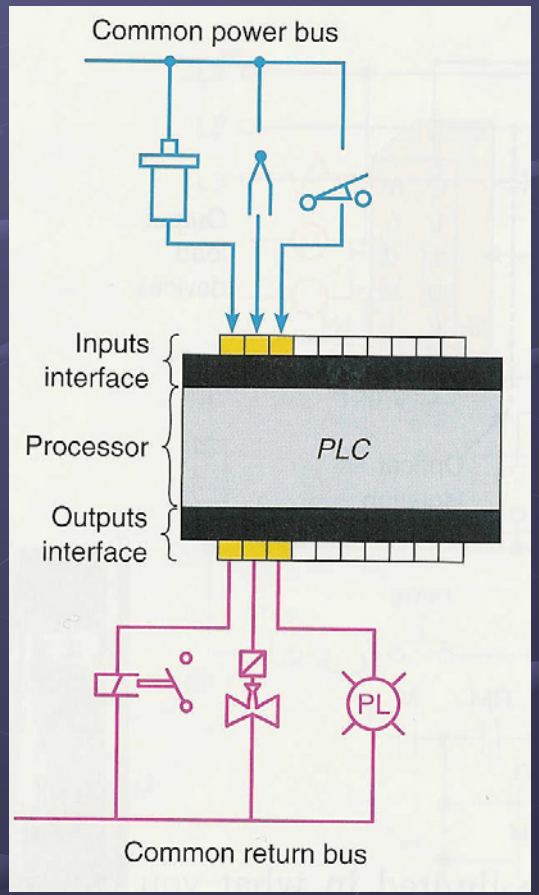




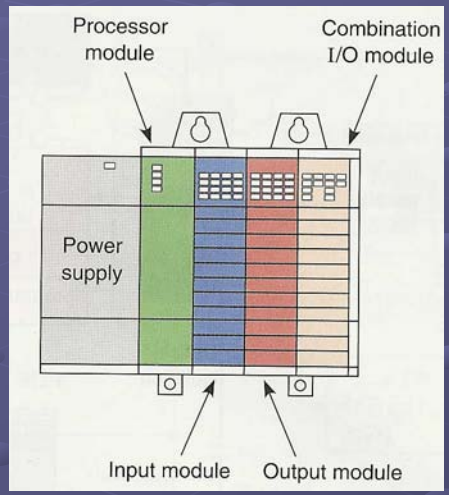
PLC Configurations

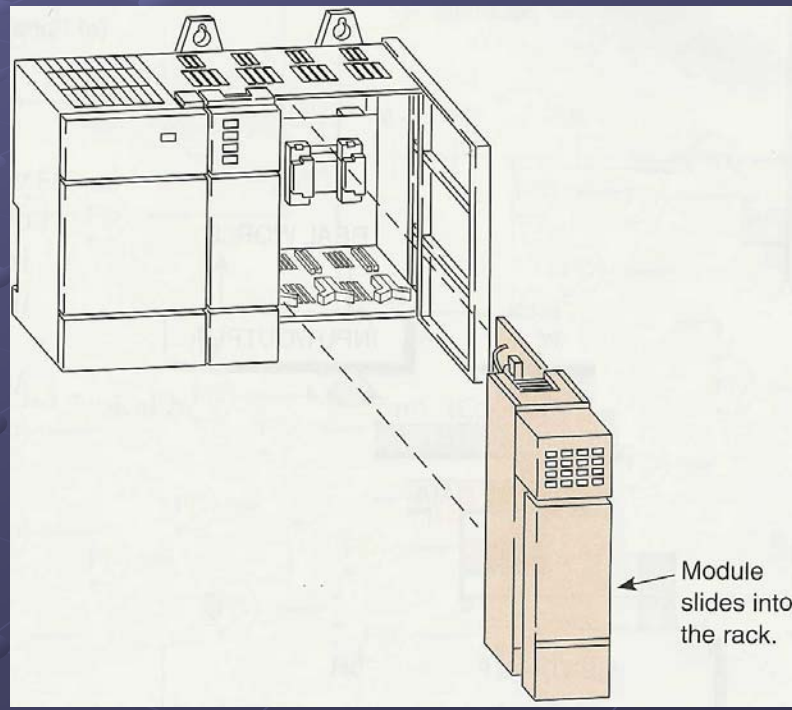
- There are two PLC basic configurations that commercial manufacturers offer.
  - Fixed Configuration
  - Modular Configuration

Fixed Configuration

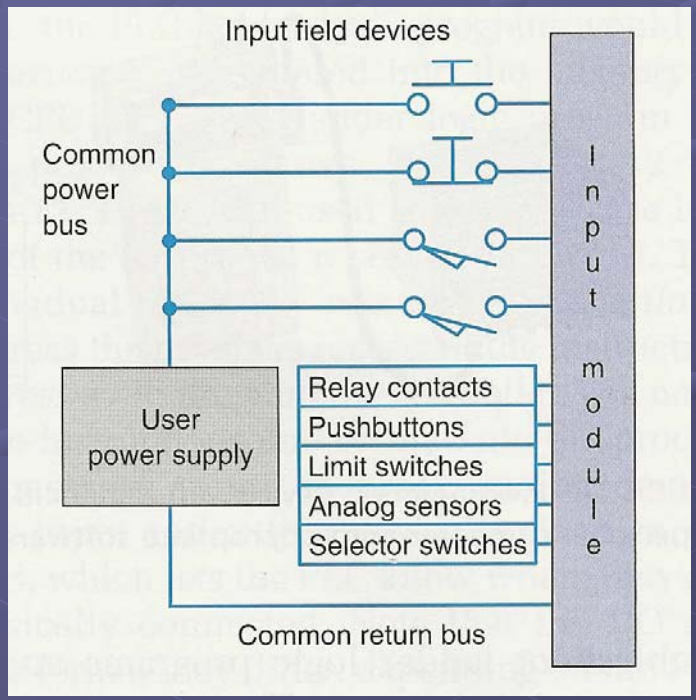


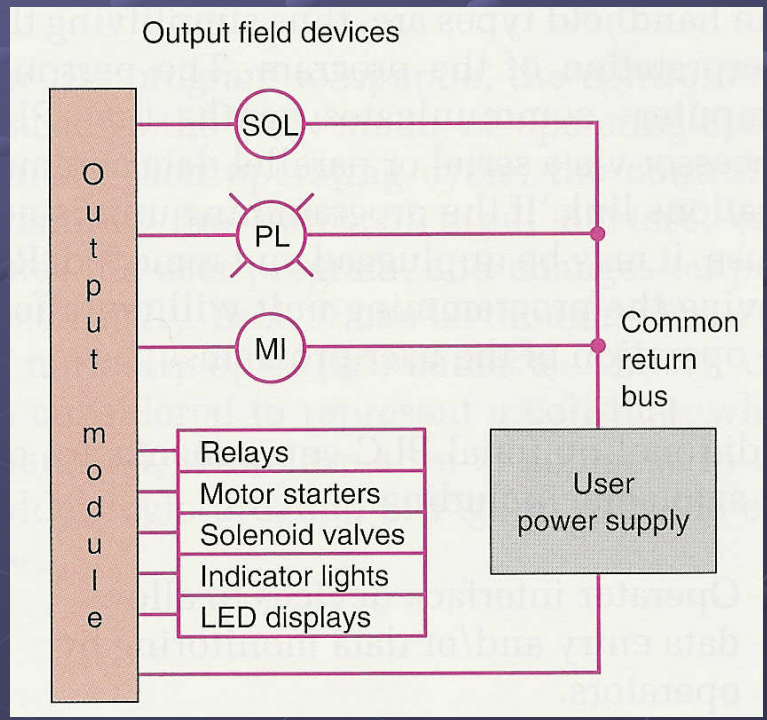
Modular Configuration



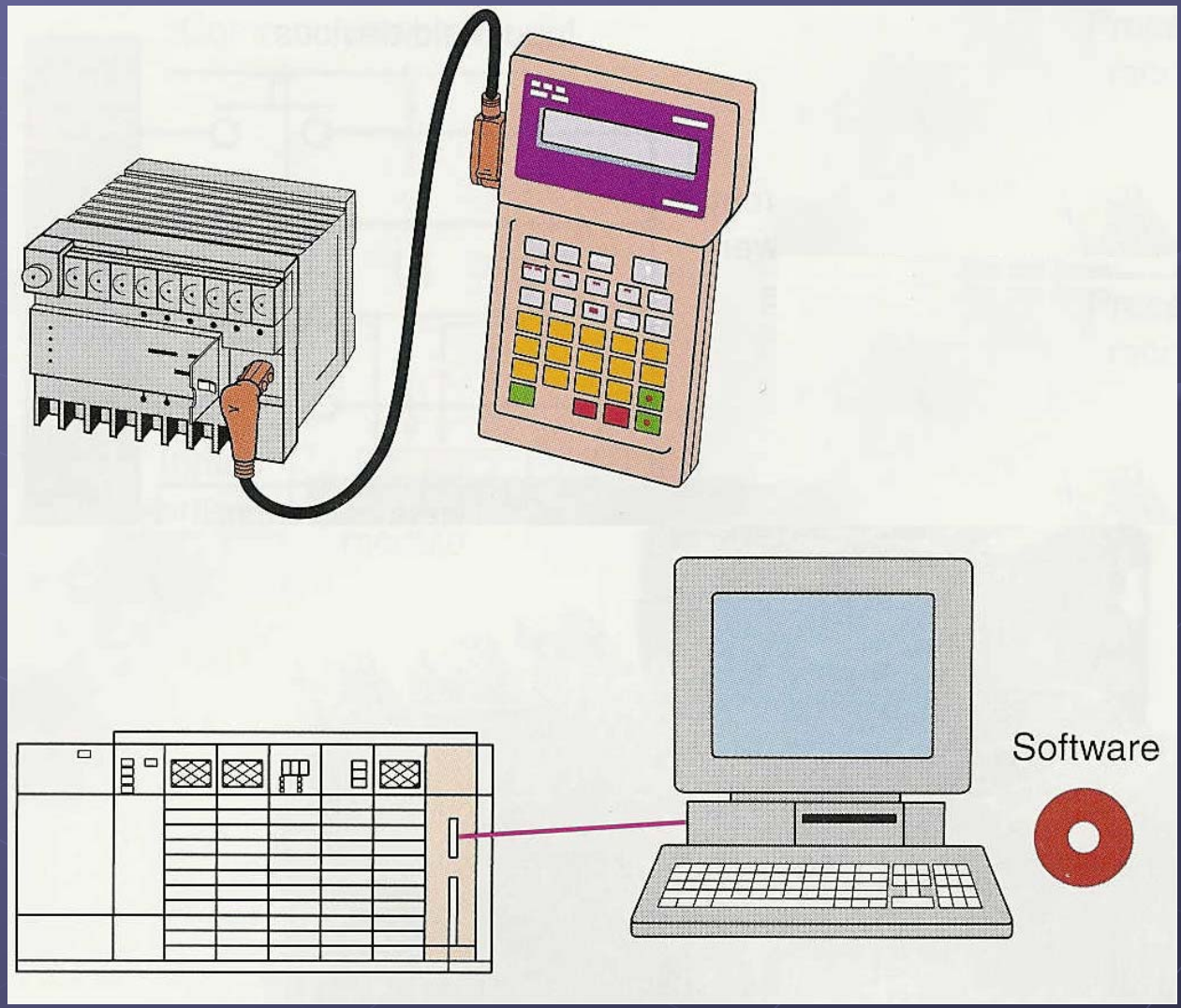


Input/Output Modules



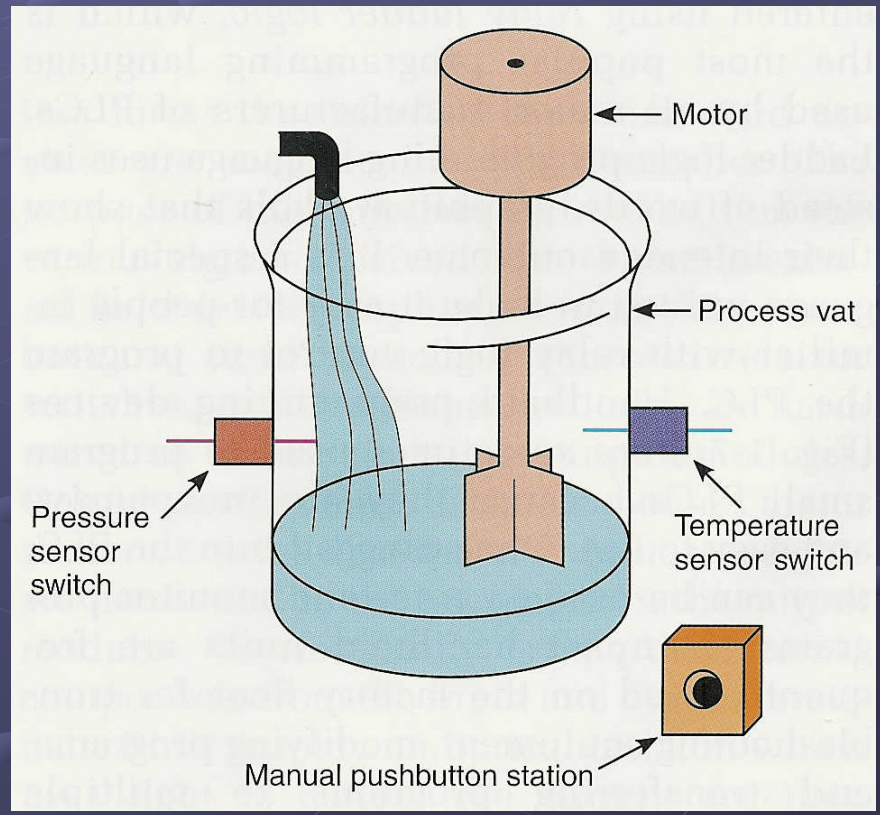


Programming the PLC

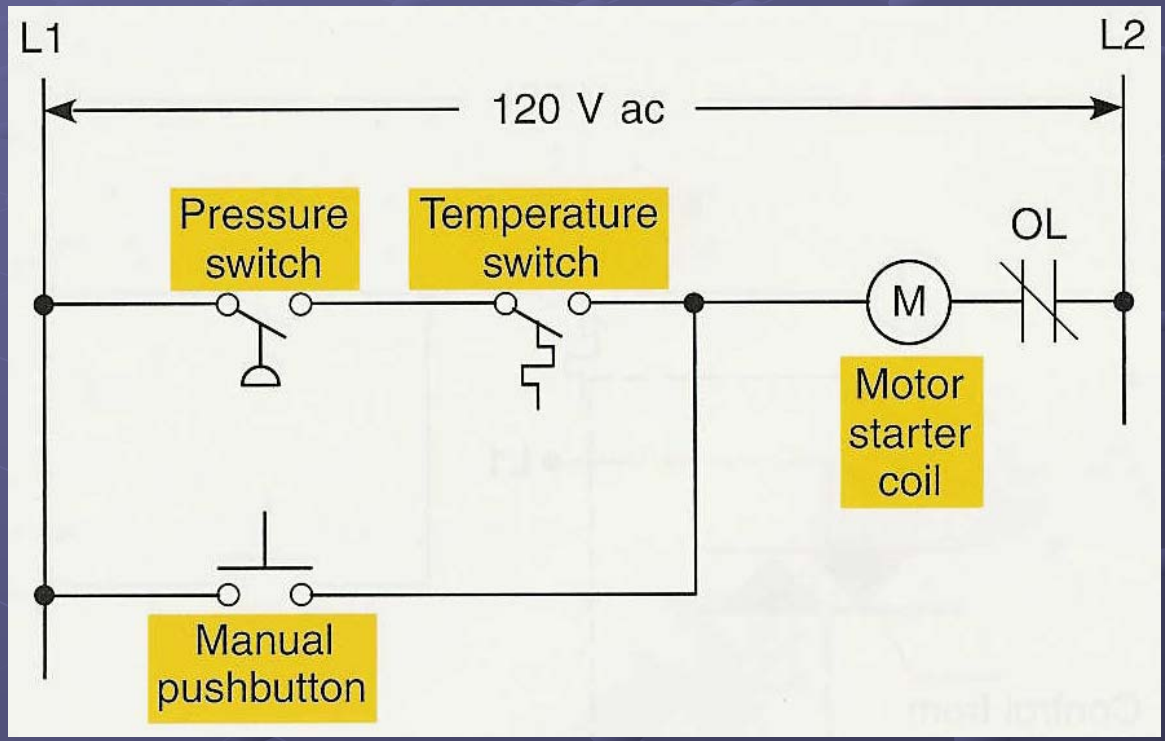


Principles of Operation

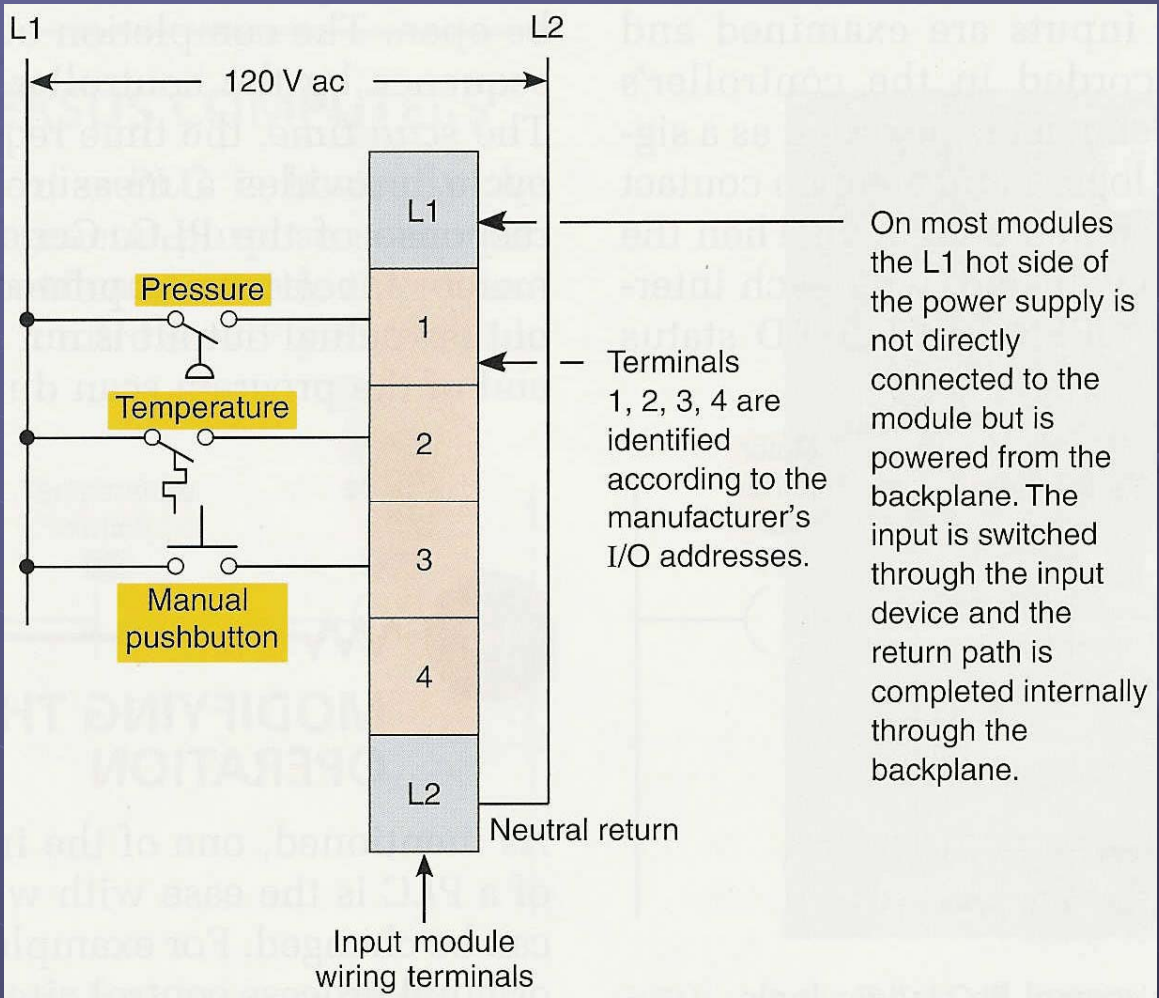
- To get an idea on how PLC operates lets consider the following simple process control problem.



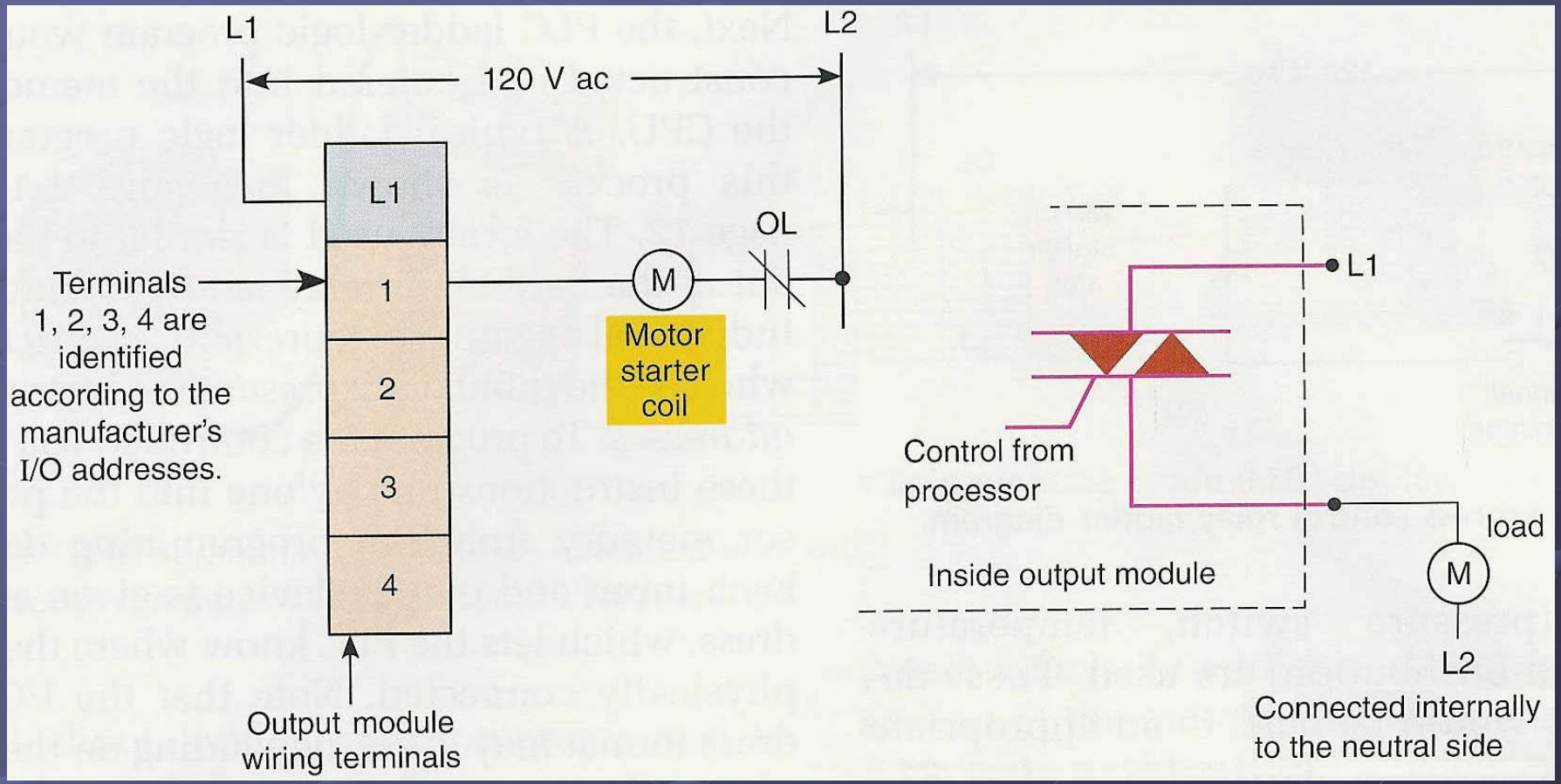
Process Control Description



PLC Inputs Connection



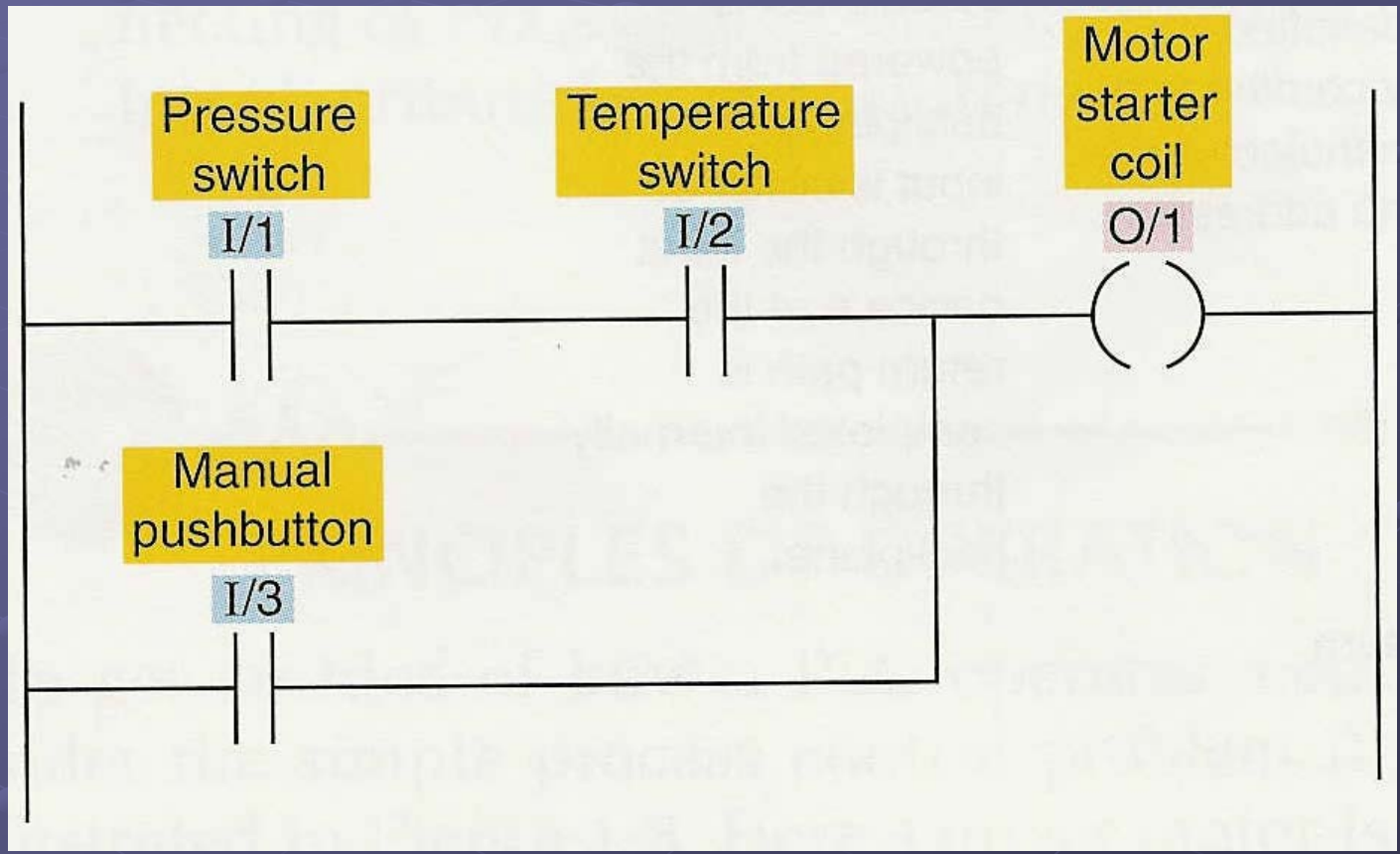
PLC Output Connections



Programming the PLC

- To implement the described system using the PLC, a description in ladder logic should be provided.
- Next the ladder logic is complied and translated to basic instructions and down loaded to the internal memory.
- During programming the PLC should be in the *Terminal or Programming* mode.

Ladder Logic Program



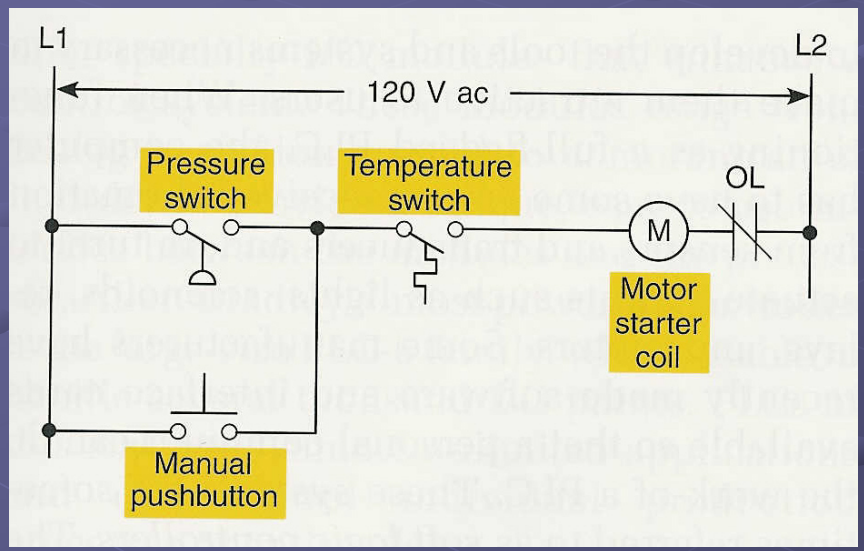
Running the Program

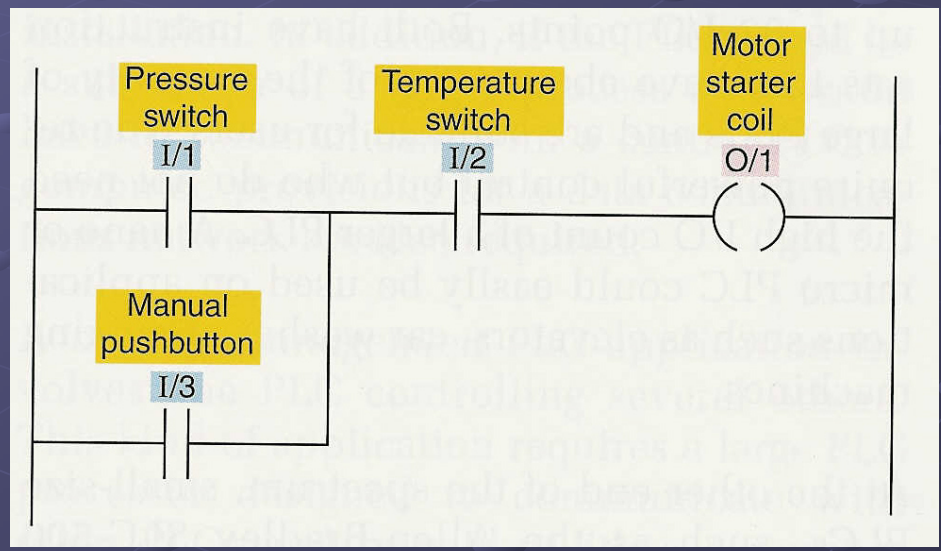
- For the program to operate the PLC should be put on the Run mode or Operating cycle.
- In the operating cycle first the controller examines the inputs and their status is recorded in the PLC memory, then the ladder diagram is evaluated, and changes are send to the outputs accordingly.

Scan Time

- The completion of a cycle of the controller is called a *Scan.*
- The *scan time* needed to complete a full cycle by the controller gives the measure of the speed of execution for the PLC.
- Generally outputs are updated in memory during the scan but the actual output is updated until the end of the program during the I/O scan.

Process Modification





PLC vs Computer

- PLC
  - Designed for extreme industrial environments
  - Can operation in high temperature and humidity
  - High immunity to noise
  - Integrated command interpreter (proprietary)
  - No secondary memory available (in the PLC)
  - Optimized for Single task
- Computer
  - Designed mainly for data processing and calculation
  - Optimized for speed
  - Can’t operate in extreme environments
  - Can be programmed in different languages
  - Lost of secondary memory available
  - Multitasking capability

PLC Size

- Manufacturers offer five sizes of PLCs:
  - Nano (up to 16 I/O points)
  - Micro (more than16 I/O points, up to 64 I/O points)
  - Small (up to 960 I/O points)
  - Medium (multitasking - control of several processes)
  - Large (control management of several PLCs)

PLC Instruction Set

- The instruction set for a particular PLC could range from 15 instructions for small units up to 100 instructions for larger units

TYPICAL PLC INSTRUCTIONS

Instruction	Operation
XIC (Examine ON)	Examine a bit for an ON condition
XIO (Examine OFF)	Examine a bit for an OFF condition
OTE (Output Energize)	Turn ON a bit (nonretentive)
OTL (Output Latch)	Latch a bit (retentive)
OTU (Output Unlatch)	Unlatch a bit (retentive)
TOF (Timer Off-Delay)	Turn an output ON or OFF after its rung has been OFF for a preset time interval
TON (Timer On-Delay)	Turn an output ON or OFF after its rung has been ON for a preset time interval
CTD (Count Down)	Use a software counter to count down from a specified value
CTU (Count Up)	Use a software counter to count up to a specified value