

## UNIT 1 : INTRODUCTION TO AUTOMATION SYSTEM

### General Objectives

1. Understand and learn about automation control systems and types of automation control systems.
2. Learn about the types of control system pneumatic control systems, hydraulic control systems and electrical control system.

### Specific Objectives;

At the end of this chapter, student should be able to:

1. Define the Automation Control System
2. States the need of Automation Control System in the industry
3. States of the Fixed Automation / Hard-Wire Control System
4. Differentiate between Fixed Automation with Programmable Automation.
5. State the basic concepts of pneumatic control systems, hydraulic control systems and electrical control systems
6. Classification of pneumatic control systems, hydraulic control systems and electrical control systems.
7. Distinguish between the pneumatic control system, hydraulic control system and electrical control systems

### 1.0 Introduction:

In today's fast-moving, highly competitive industrial world, a company must be flexible, cost effective and efficient if it wishes to survive. In the process and manufacturing industries, this has resulted in a great demand for industrial control systems/ automation in order to streamline operations in terms of speed, reliability and product output. Automation plays an increasingly important role in the world economy and in daily experience.

**Automation** is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well.

### What is Automation Control System?

Automation Control System - system that is able to control a process with minimal human assistance or without manual and have the ability to initiate , adjust, action show or measures the variables in the process and stop the process in order to obtain the desired output.

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# INTRODUCTION TO AUTOMATION SYSTEM

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The main objective of Automation Control System used in the industry are:

1. to increase productivity
2. to improve quality of the product
3. Control production cost

## 1.1.1 Types Of Automation In The Industry

### 1.1.1 Classification of automation

#### a) Permanent/Fixed Automation

- This control system is designed to perform a specific task
- Functions of control circuit is fixed and permanent.
- It will be complicated if we want to do other task apart from the existing task

#### b) Programmable /Flexible Automation

- Programmable automation or flexible automation is a complex control system that can perform several tasks
- Functions of control circuit programmed by the user and can be modified.
- When the task to be performed by machines changed, changes only need to be done by making modifications to the machine control program.

### 1.1.2 Comparison Between Fixed And Flexible Automation System

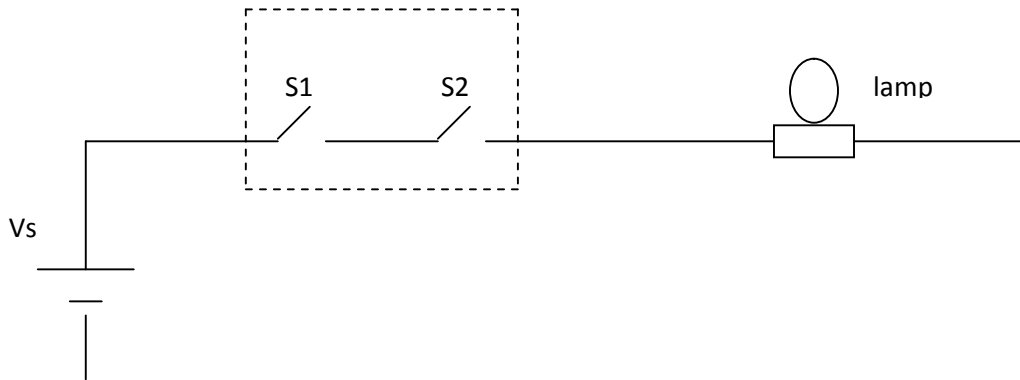
	<b>FIXED AUTOMATION</b>	<b>FLEXIBLE AUTOMATION</b>
Purpose	Specific	Variety
Ease of making changes / upgrade	Difficult	Easy
Maintenance	Hard	Easy
Capability	Depends on manufacturing and design	Very high
Speed	Slow	Fast
Economy efficiency	Suitable for small system	Suitable for all types of systems

# INTRODUCTION TO AUTOMATION SYSTEM

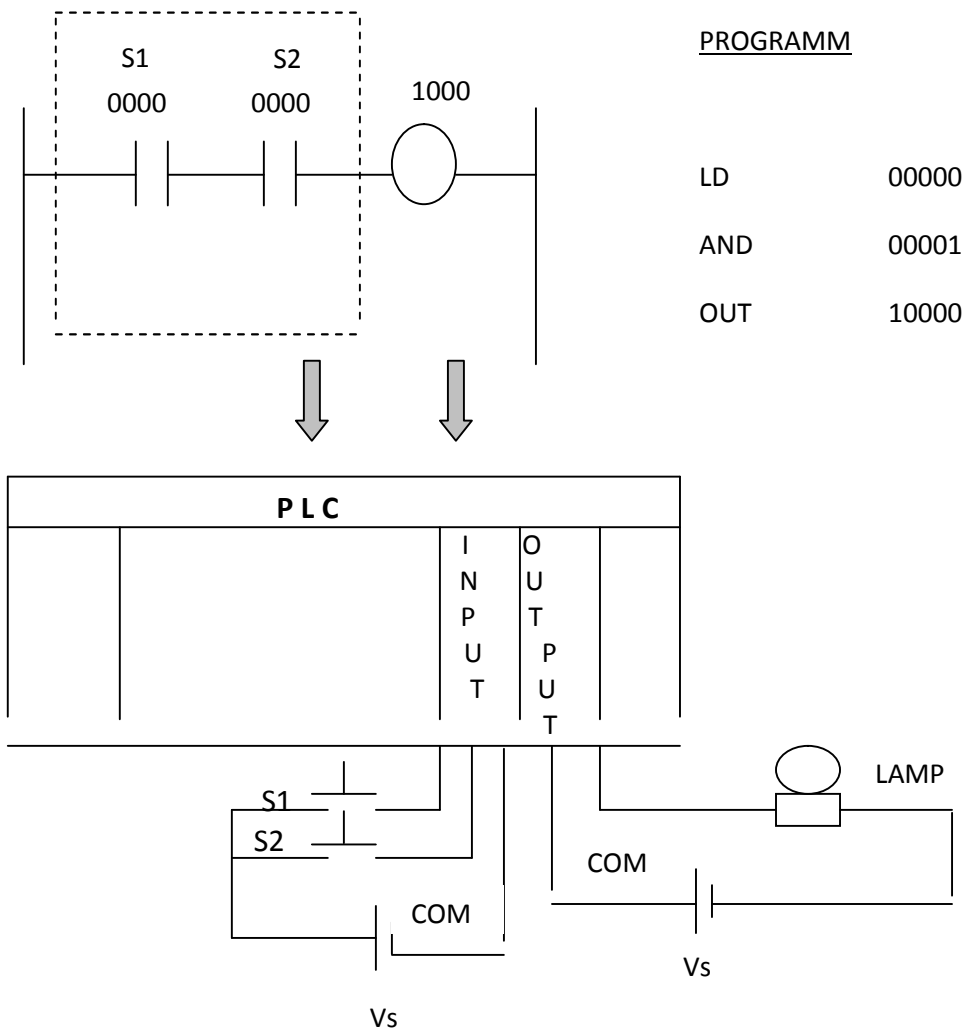
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Example :

## Fixed Automation



## Programmed Automation:

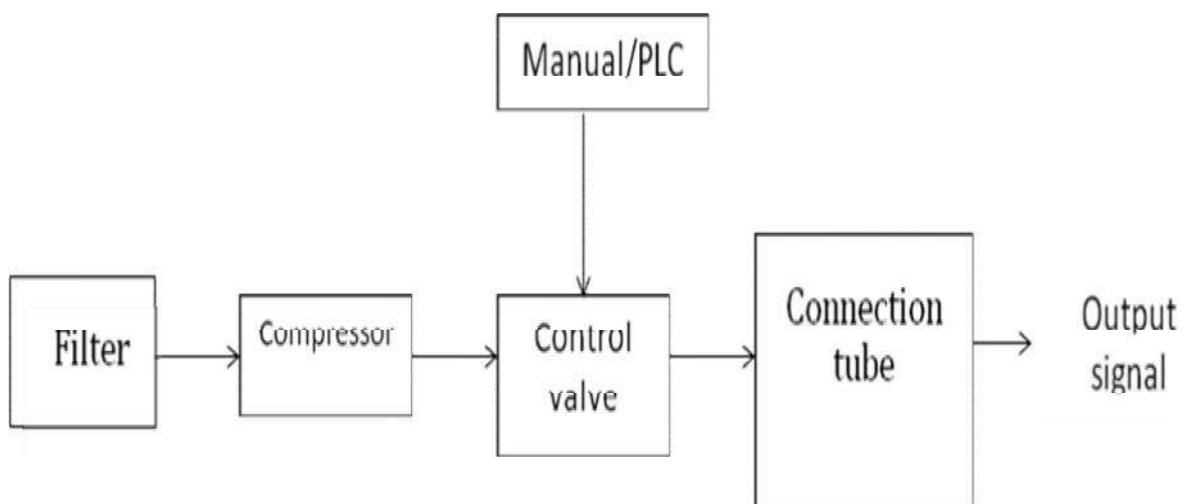


## 1.1.3 There Are Three (3) Types Of The Control System Based On Supply :

- a) Pneumatic Control Systems
- b) Hydraulic Control System
- c) Electrical Control System

### a) Pneumatic Control System

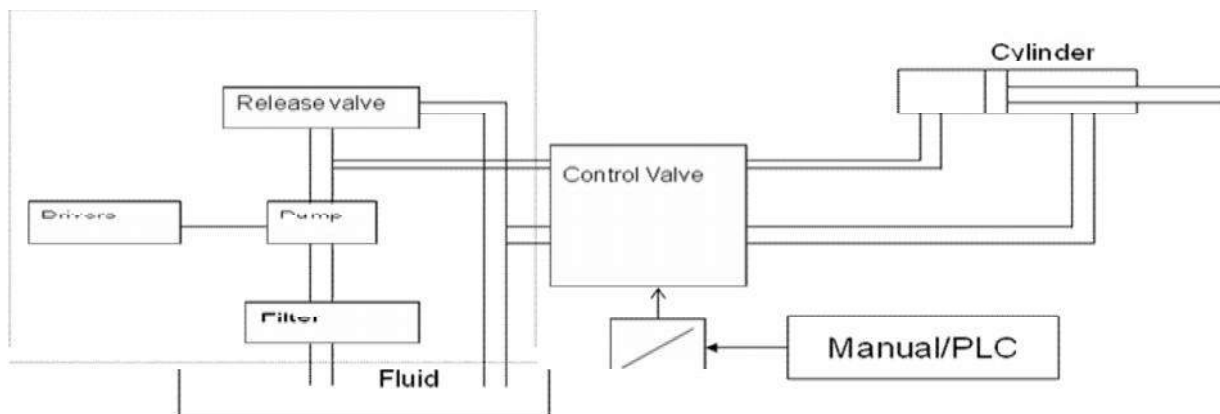
- Pneumatic control system is a system that uses compressed air to produce power / energy to perform any task
- Pneumatic systems found in many industrial systems such as food industry, petrochemical and industrial involves robotics.
  
- Pneumatic systems requires:
  - i. Compressed air supply
  - ii. Control valve
  - iii. Connecting tube
  - iv. Transducer
- Pneumatic control system can be controlled manually and automatically.



**Basic Block Diagram of Pneumatic Control System using manual/PLC**

## b) Hydraulic Control System

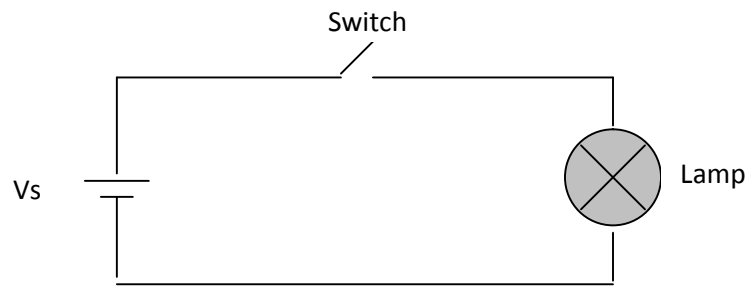
- Hydraulic control system is a system that uses fluid to generate power/energy.
- The hydraulic system used in the automobile industry such as power systems, braking systems, cranes, car jack, satellite and others.
- The fluid used is oil.
- The hydraulic system requires:
  - a) Hydraulic fluid supply
  - b) Control Valve
  - c) Cylinder
- Hydraulic control system can be controlled manually and automatically



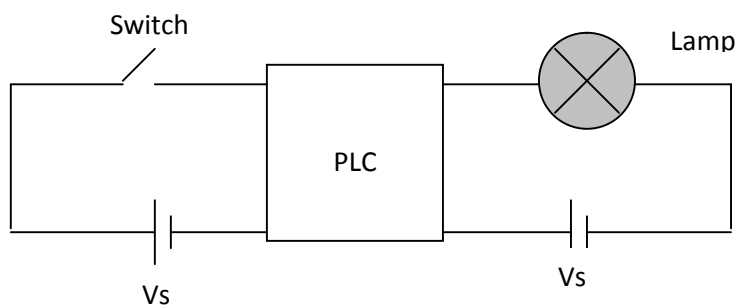
## Basic block diagram of an automatic hydraulic control system by Manual /PLC

### c) Electrical Control System

- A control system that uses an electric current; either direct current (DC) or current shuttle (AC) as a source of supply.
- Electrical Control Systems Generally requires:
  - a) Electricity (DC) or (AC)
  - b) Input elements (switches, sensors, transducer, valves, electronic components, etc.)
  - c) Output elements (motor, lights, etc.)
  - d) Extension cable



**Basic block diagram of a manual electric control system**



**Basic block diagrams of electrical control system using PLC**

## COMPARISON BETWEEN PNEUMATIC CONTROL SYSTEMS ,HYDRAULIC CONTROL SYSTEM AND ELECTRIC CONTROL SYSTEM

- i. **PNEUMATIC CONTROL SYSTEM**
  - a) Easy installation
  - b) Simple design
  - c) Use compressed air as a supply source to perform task.
  
- ii. **HYDRAULIC CONTROL SYSTEM**
  - a) Complex to assemble
  - b) Use fluid like oil as a supply source to perform task.
  - c) Potential leakage will lead to pollution.
  
- iii. **ELECTRIC CONTROL SYSTEM**
  - a) Simple system
  - b) Use electricity as a supply source to perform task.
  - c) Widely use either for home user or in industrial.

## 1.1.4 Advantages And Disadvantages Of Automation Control In Industry

### The main advantages of automation are:

- Replacing human operators in tasks that involve hard physical work
- Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)
- Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.
- Economy improvement: Automation may improve in economy of enterprises, society or most of humanity. For example, when an enterprise invests in automation, technology recovers its investment; or when a state or country increases its income due to automation like Germany or Japan in the 20th Century.
- Reduces operation time and work handling time significantly.

### The main disadvantages of automation are:

- Unemployment rate increases due to machines replacing humans and putting those humans out of their jobs.
- Technical Limitation: Current technology is unable to automate all the desired tasks.
- Security Threats/Vulnerability: An automated system may have limited level of intelligence, hence it is most likely susceptible to commit error.
- Unpredictable development costs: The research and development cost of automating a process may exceed the cost saved by the automation itself.
- High initial cost: The automation of a new product or plant requires a huge initial investment in comparison with the unit cost of the product, although the cost of automation is spread in many product batches of things

### **TUTORIAL QUESTION:**

- Give definition of Automation Control System? [3m]
- Make a comparison between Fixed Automation and Flexible Automation Control System.[12m]
- State three (3) types of control system which based on supply source and states the differences between them.[12m]
- Sketch an automatic control system diagram for:
  - a) Hydraulic Control System
  - b) Electric Control System
  - c) Pneumatic Control System

## 1.2 Explanation Of Relays And Contactors

The representation of relays and contactors in the electrical circuit diagram is identical, as their operating principle.

- i. Relays are used to switch relatively small output and current.
- ii. Contactor to switch relatively large output and currents.

### 1.2.1 Relays

#### a) Definition Relay

A **relay** is an electrically operated switch/electromagnetically actuated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be ON or OFF so relays have two switch positions and most have **double throw (changeover)** switch contacts .

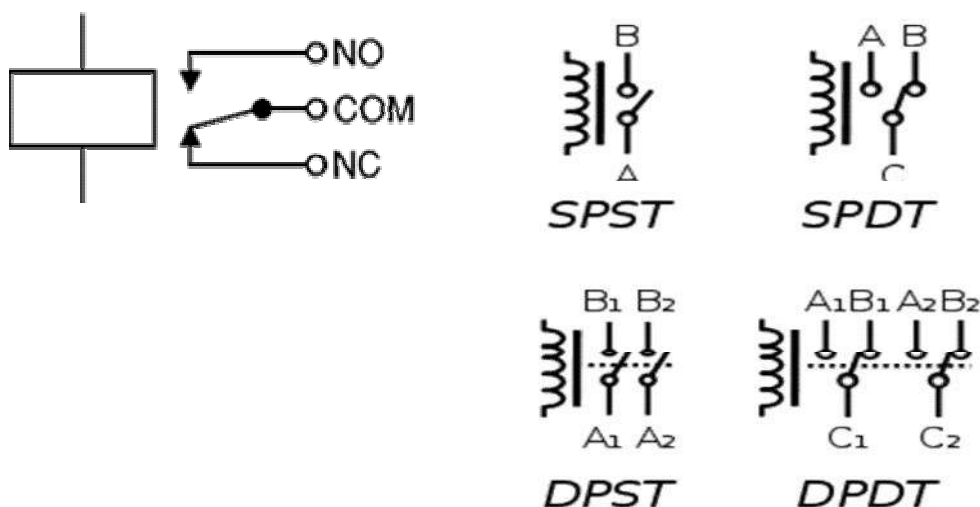
#### b) Types of Relays

Relays are usually SPDT (Single Pole Double Throw) or DPDT (Double Pole Double Throw) but they can have many more sets of switch contacts.

**Poles** : the number of sets of contacts

**Throw** : The number of positions or combinations (open or close) the contacts have.

Several types of relays shown in the diagram below:



Circuit symbol for a relay

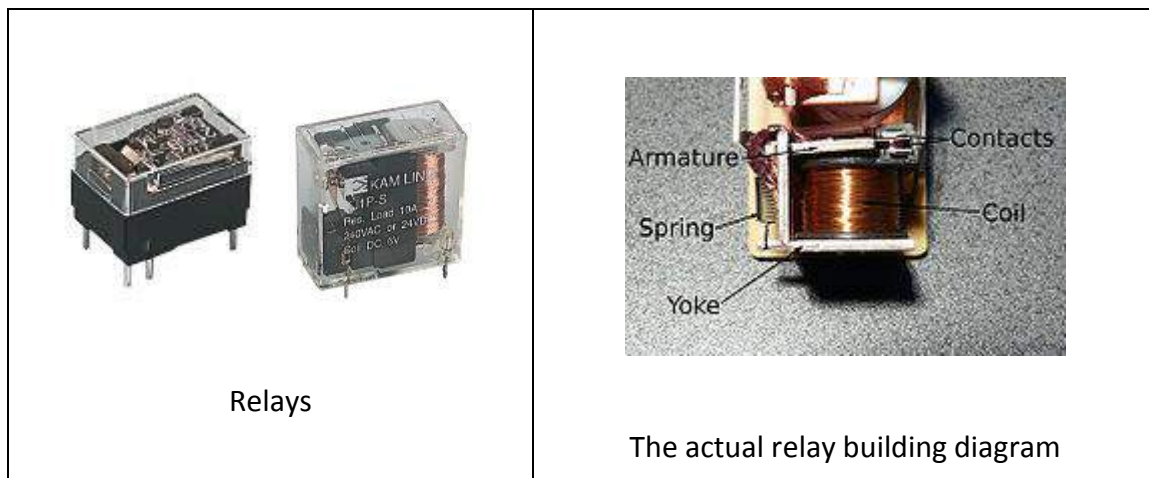


# INTRODUCTION TO AUTOMATION SYSTEM

The relay's switch connections are usually labelled COM, NC and NO:

- **COM** = Common, always connect to this, it is the moving part of the switch.
- **NC** = Normally Closed, COM is connected to this when the relay coil is **off**.
- **NO** = Normally Open, COM is connected to this when the relay coil is **on**.
- **Connect to COM and NO if you want the switched circuit to be on when the relay coil is on.**
- **Connect to COM and NC if you want the switched circuit to be on when the relay coil is off.**

## c) Relay Building Diagram



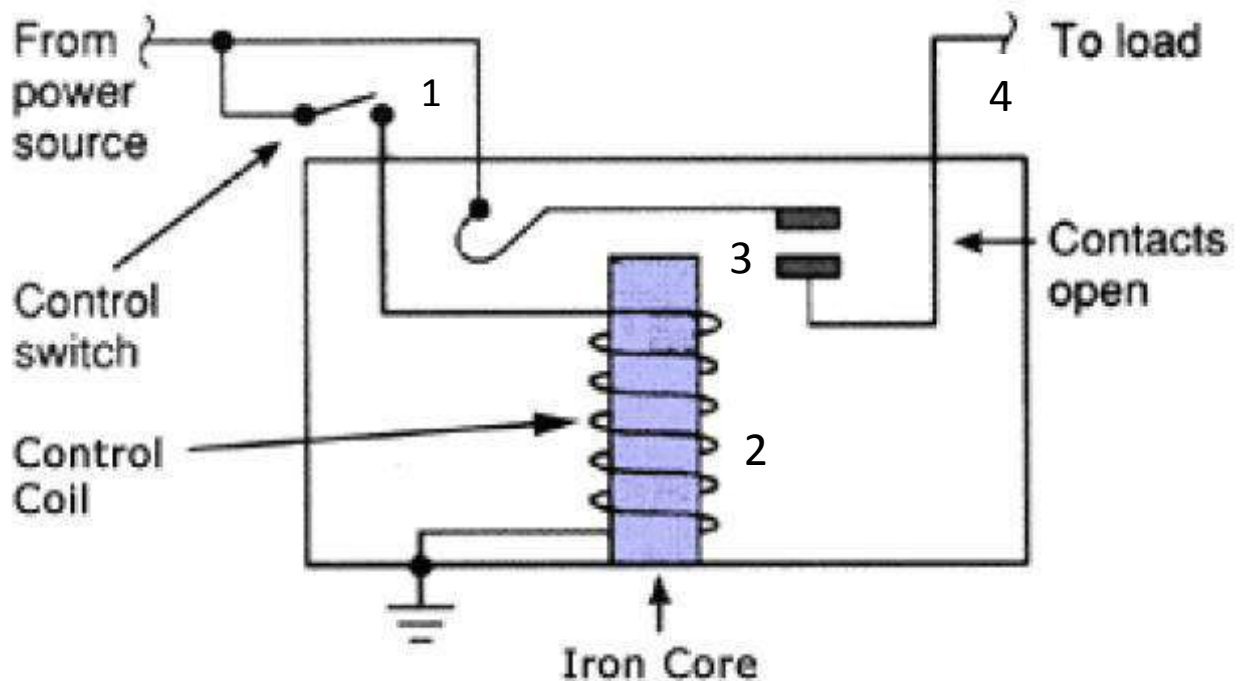
A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts. The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit.

When an electric current is passed through the coil it generates a magnetic field that activates the armature, and the consequent movement of the movable contact(s) either makes or breaks (depending upon construction) a connection with a fixed contact.

If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open.

When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

Relay Building Diagram



## How Relays Work

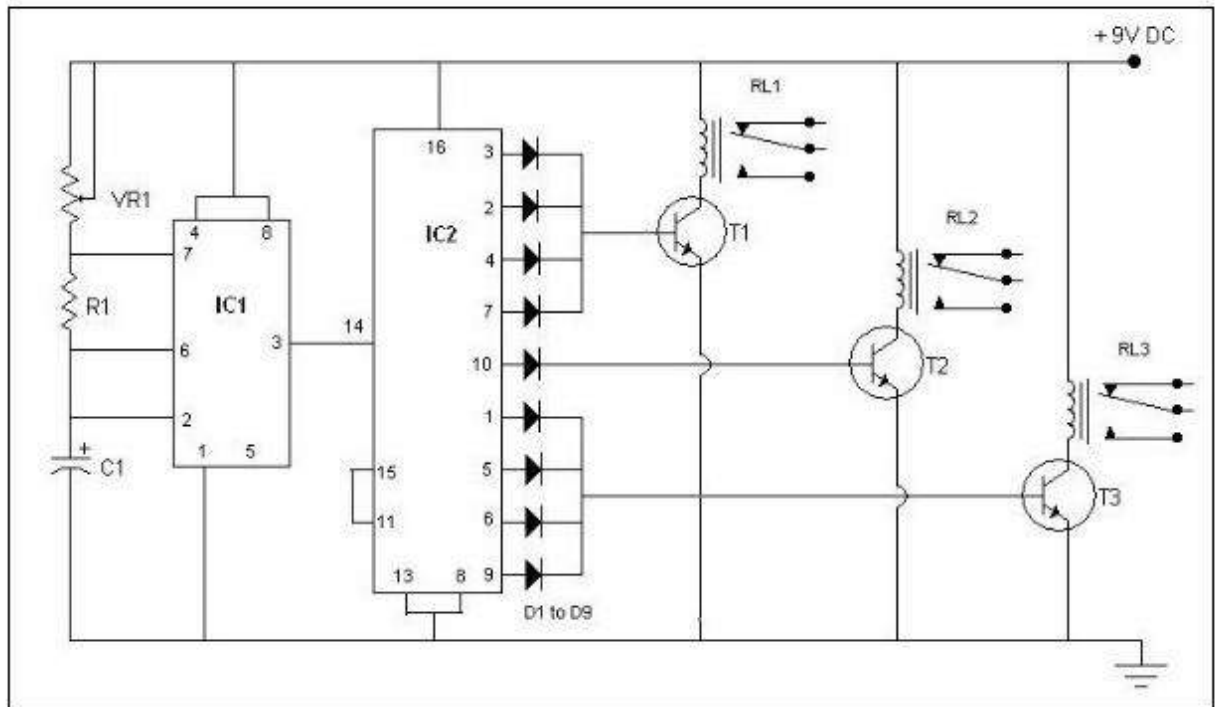
1. When switch is ON/press, the current will flow through it
2. It will energize the electromagnet
3. Then the coil (electromagnet) will attract the lever
4. After the lever touch each other, the electricity will flow to the load

Relay can be used for various regulating, control and monitoring functions:

- i. As interfaces between control circuits and load circuits
- ii. For signal multiplication
- iii. For separation of direct current and alternating current circuits
- iv. For delaying, generating and converting signals and
- v. For linking information.

## d) Example Of Relay Use In The Traffic Light System

### *Circuit Diagram*



#### Operating Principle:

- This circuit can be used to control traffic in public places, or to demonstrate traffic rules in traffic-parks.
- IC2, which is heart of the circuit, is a decade counter. In this counter for every pulse fed to pin-14, potential keeps shifting from D1 to D9 in cyclic order.
- IC1 is used as a pulse generator and generates pulses in regular configurable intervals. These intervals can be changed by varying VR1.
- The circuit is designed in such a way that out of nine pulses, relay RL1 remains triggered for 4 pulses, relay RL2 for 1 pulse and relay RL3 for remaining 4 pulses. Since D1-D4 provide current to T1, T1 is on whenever there is potential on any diode D1 to D4, which keeps relay RL1 triggered. Similarly other diodes are responsible for RL2 and RL3 triggering.
- Red, Yellow and Green lamps can be connected to the relays RL1, RL2 and RL3 respectively to complete your mini traffic light controller.

## 1.2.2 Contactors

### d) Definition Contactor

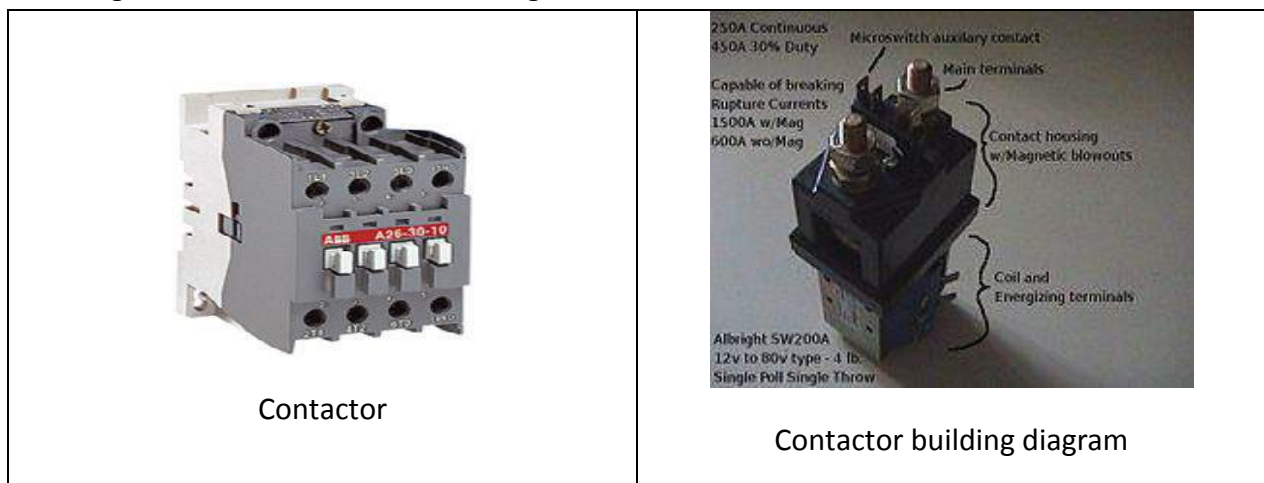
A **relay** that can handle the high power required (higher current rating) to directly control an electric motor or other loads is called a contactor.

A **contactor** is an electrically controlled switch used for switching a power circuit, similar to a relay except with higher current ratings.

Contactors are used to control electric motors, lighting, heating, capacitor banks, and other electrical loads.

### b) Basic Component Of Contactor:

A contactor has three components. The contacts are the current carrying part of the contactor. This includes **power contacts, auxiliary contacts, and contact springs**. The electromagnet provides the driving force to close the contacts. The enclosure is a frame housing the contact and the electromagnet.



Contactor

Contactor building diagram

A basic contactor will have a coil input (which may be driven by either an AC or DC supply depending on the contactor design). The coil may be energized at the same voltage as the motor, or may be separately controlled with a lower coil voltage better suited to control by programmable controllers and lower-voltage pilot devices.

### c) Operating Principle

Unlike general-purpose relays, contactors are designed to be directly connected to high-current load devices. Relays tend to be of lower capacity and are usually designed for both *normally closed* and *normally open* applications. Devices switching more than 15 amperes or in circuits rated more than a few kilowatts are usually called contactors. Apart from optional auxiliary low current contacts, contactors are almost exclusively fitted with

# INTRODUCTION TO AUTOMATION SYSTEM

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normally open contacts. Unlike relays, contactors are designed with features to control and suppress the arc produced when interrupting heavy motor currents.

When current passes through the electromagnet, a magnetic field is produced, which attracts the moving core of the contactor. The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.

## i. Main Contact.

Main contact of the contactor are normally open contact and usually use to connect power load to the main supply.

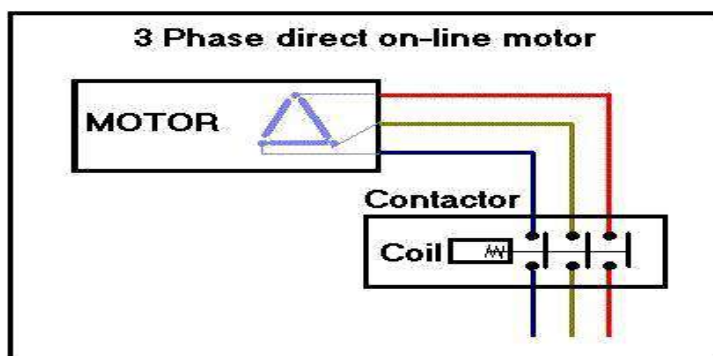
## ii. Auxiliary Contacts

Auxiliary contacts are **secondary switching devices** which **work in conjunction with primary switching equipment** such as circuit breakers, relays, and contactors. These contacts are **physically linked to the main switching mechanism and activate at the same time it does.**

Auxiliary contacts are **commonly used as interlocks or retainers on the primary device's control circuit** and often used to give indication of its state of operation such as **trip function indication, electrical interlocks, and start circuit retainers..** Many contactors and circuit breakers feature sets of auxiliary contacts as integral parts or they may be modular snap on units which **can be added or removed as required.** Auxiliary contacts are available with either **normally open or normally closed contact points or a combination of both.**

## d) Examples Application Of Contactor In Motor Control Sytem.

### 1. DOL Motor Starter



### 2. A STAR DELTA Motor Starter

## 1.2.3 Difference Between Relay And Contactors

### The Difference :

1. Since a contactor is required for a higher load, a relay is always cheaper than a contactor.
2. A relay is normally used in appliances below 5KW, while a contactor is preferred when the appliance is heavier.
3. A relay is used only in control circuit while a contactor can be used in both control and power circuits.
4. In general contactors are little slower than relays
5. Contactor is so designed that it can be repaired while it is not normally done in the case of relays.

### NOTES:

It should be noted that when installing contactors or relays that you always check the coil ratings. They often have not got a default rating of 230volts, and only go bang once if they are connected to the wrong voltage!

# Differences between Pneumatic, Hydraulic and Electrical control system

	<b>Pneumatic</b>	<b>Hydraulic</b>	<b>Electric</b>
1	Using Compress air as supply source	Using oil as supply source	Using electricity as a supply source
2	Easy installation	Complicated Installation	Simple system
3	Simple design	If leak will cause dirty	Widespread use

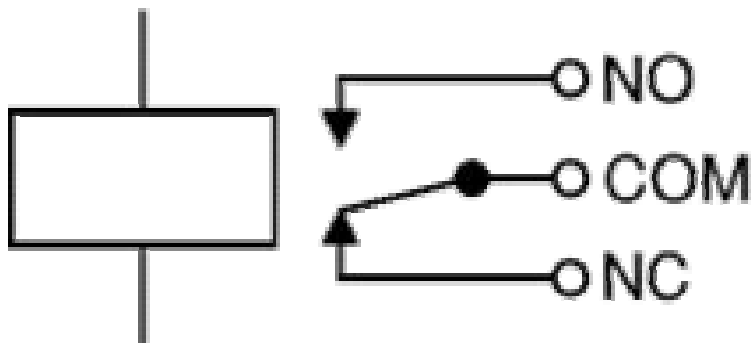
# Unit 1.2

## RELAY AND CONTACTOR



# WHAT IS RELAY...

- A relay is an **electrically operated switch**. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have **double throw (changeover)** switch contacts as shown in the diagram.



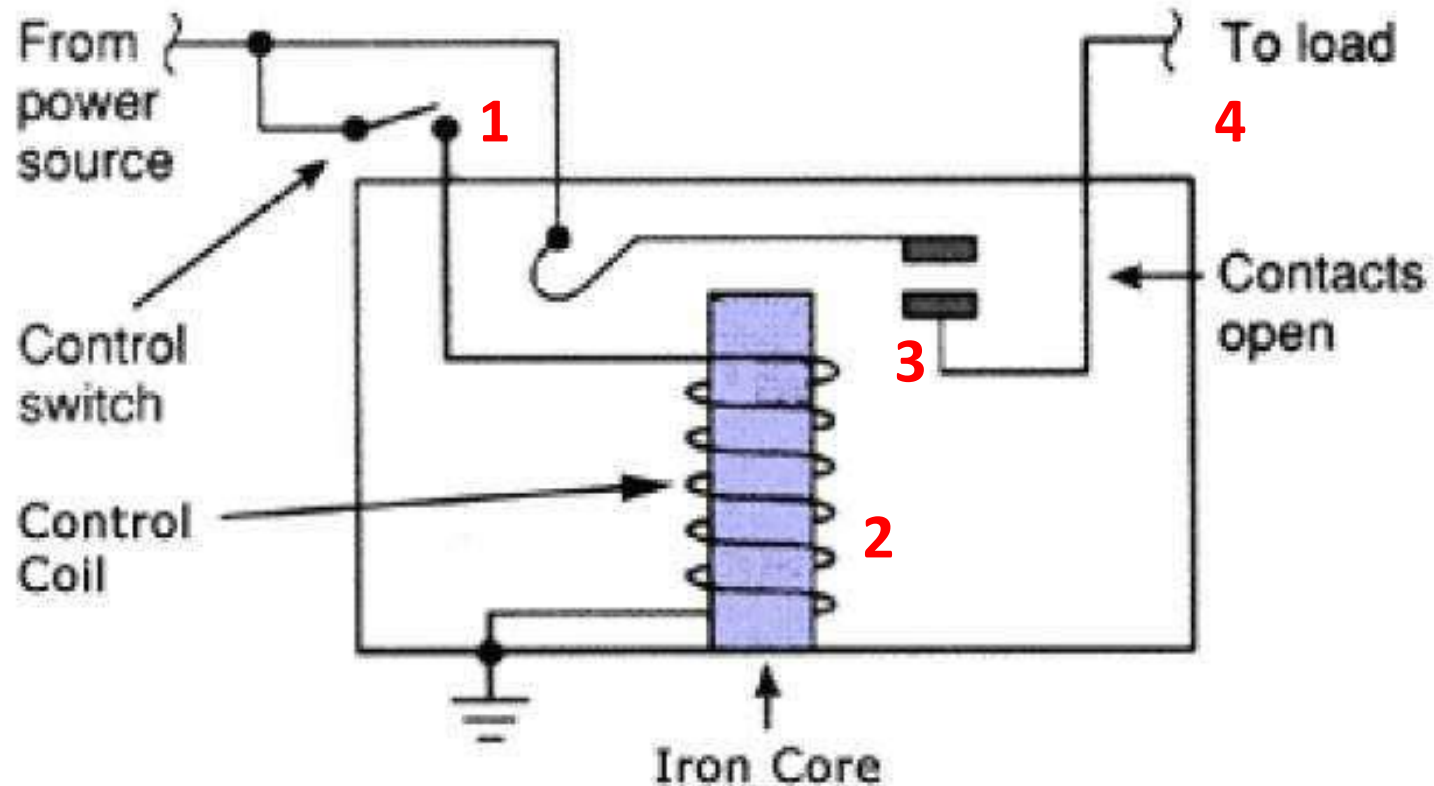
Symbol of relay



Several design of relay are in used today, 3-pin,4-pin,5-pin,6-pin, single switch or dual switches



# Relay building diagram..



# How relay works..

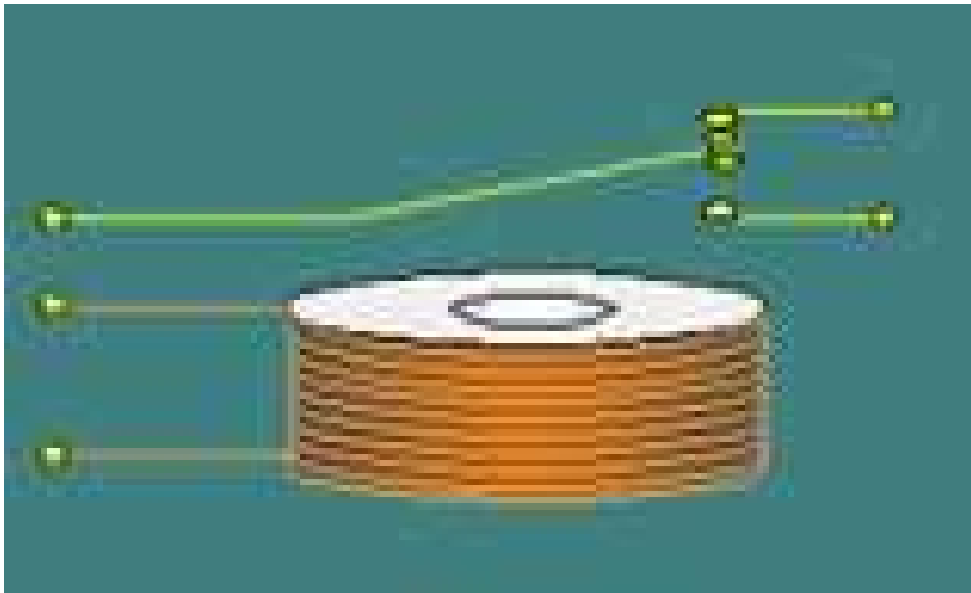
1. When switch is ON/press, the current will flow through the coil.
2. It will energize the electromagnet
3. Then the coil (electromagnet) will attract the lever
4. After the lever touch each other, the electricity will flow to the load

# Types of Relays

- Relays are usually SPDT (Single Pole Double Throw) or DPDT (Double Pole Double Throw) but they can have many more sets of switch contacts.
- **Poles** : the number of sets of contacts
- **Throw** : The number of positions or combinations (open or close) the contacts have.

# Types of relay..

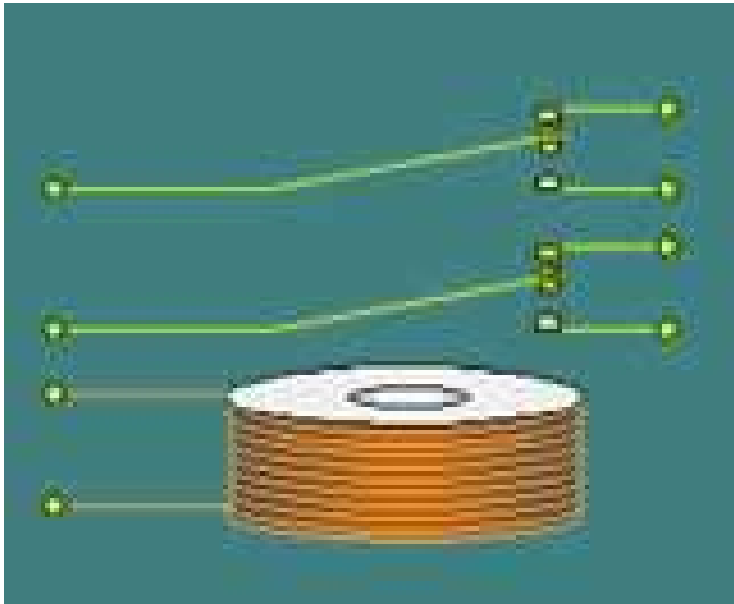
## SPDT-Single Pole Double Throw



This is a Single Pole Double Throw relay. Current will flow between the movable contact and one fixed contact (NC) when the coil is de-energized.

When the relay coil is energized the current will flow between the movable contact and the alternate fixed contact (NO).

## DPDT – Double Pole Double Throw

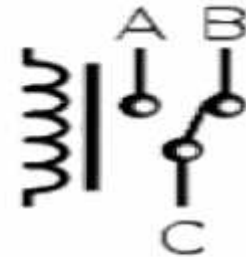


This relay is a Double Pole Double Throw relay. It operates like the SPDT relay but has twice as many contacts. There are two completely isolated sets of contacts.

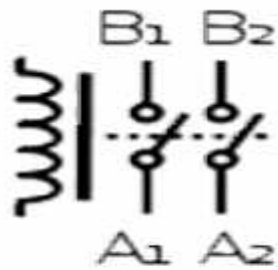
# Types of Relays



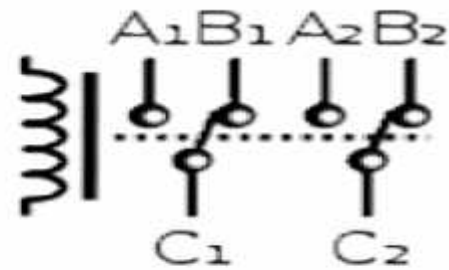
*SPST*



*SPDT*



*DPST*



*DPDT*

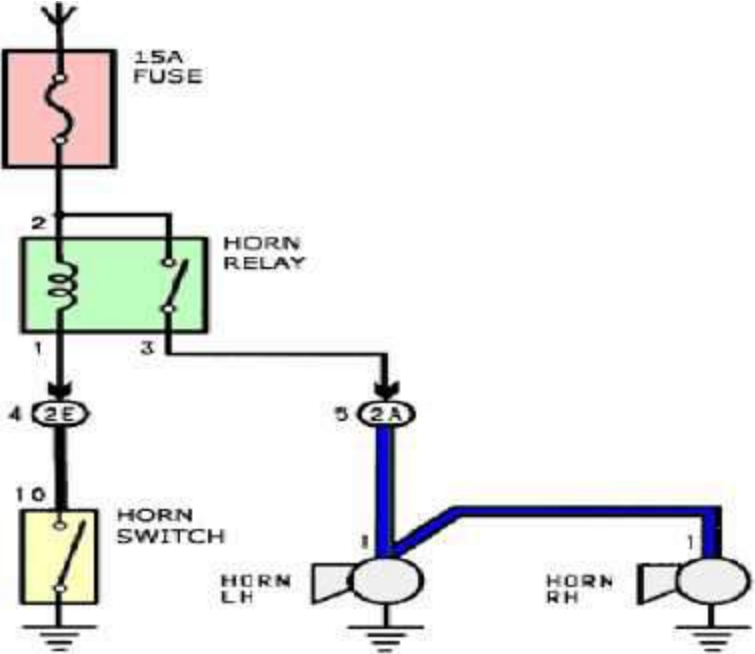


# Relay application

- Relay can be used for various regulating, control and monitoring functions:
  - As interfaces between control circuits and load circuits
  - For signal multiplication
  - For separation of direct current and alternating current circuits
  - For delaying, generating and converting signals and
  - For linking information.

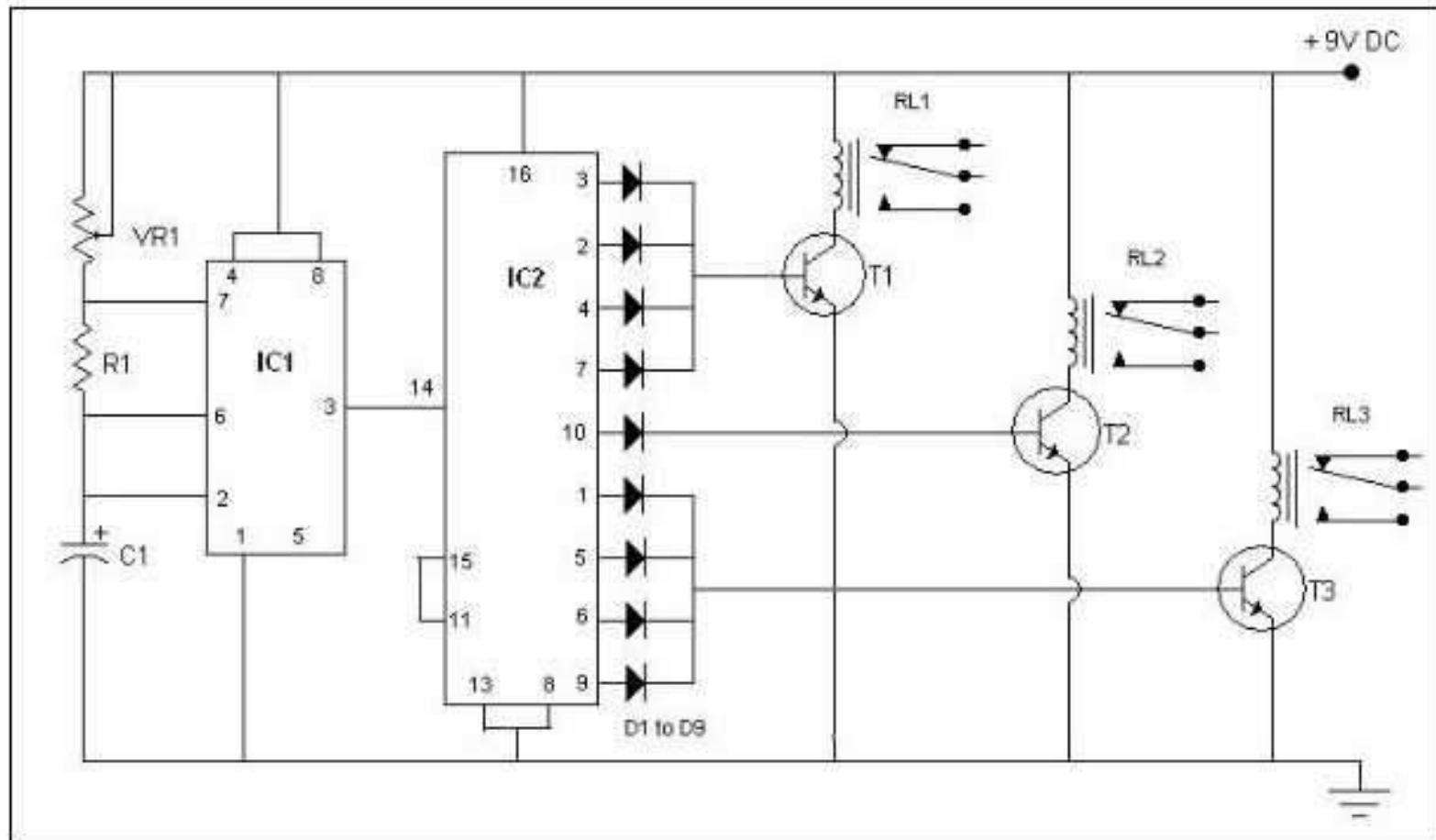
# Example of Relay Application:

## 1. Vehicle horn



# 2. Relay in Traffic Light System

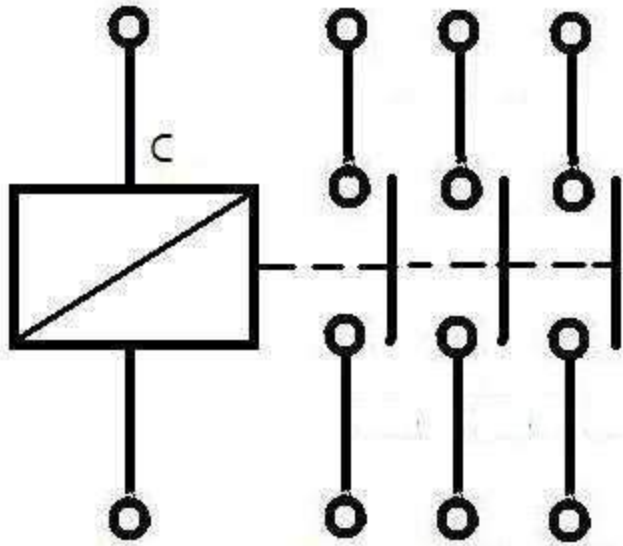
*Circuit Diagram*



## Operating Principle:

- This circuit can be used to control traffic in public places, or to demonstrate traffic rules in traffic-parks.
- IC2, which is heart of the circuit, is a decade counter. In this counter for every pulse fed to pin-14, potential keeps shifting from D1 to D9 in cyclic order.
- IC1 is used as a pulse generator and generates pulses in regular configurable intervals. These intervals can be changed by varying VR1.
- The circuit is designed in such a way that out of nine pulses, relay RL1 remains triggered for 4 pulses, relay RL2 for 1 pulse and relay RL3 for remaining 4 pulses. Since D1-D4 provide current to T1, T1 is on whenever there is potential on any diode D1 to D4, which keeps relay RL1 triggered. Similarly other diodes are responsible for RL2 and RL3 triggering.
- Red, Yellow and Green lamps can be connected to the relays RL1, RL2 and RL3 respectively to complete your mini traffic light controller.

# WHAT IS CONTACTOR



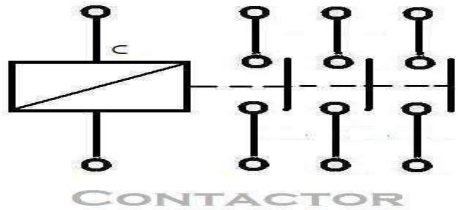
CONTACTOR

A **contactor** is an electrically controlled switch used for switching a power circuit, similar to a relay except with **higher current ratings**.

A contactor is controlled by a circuit which has a much lower power level than the switched circuit.



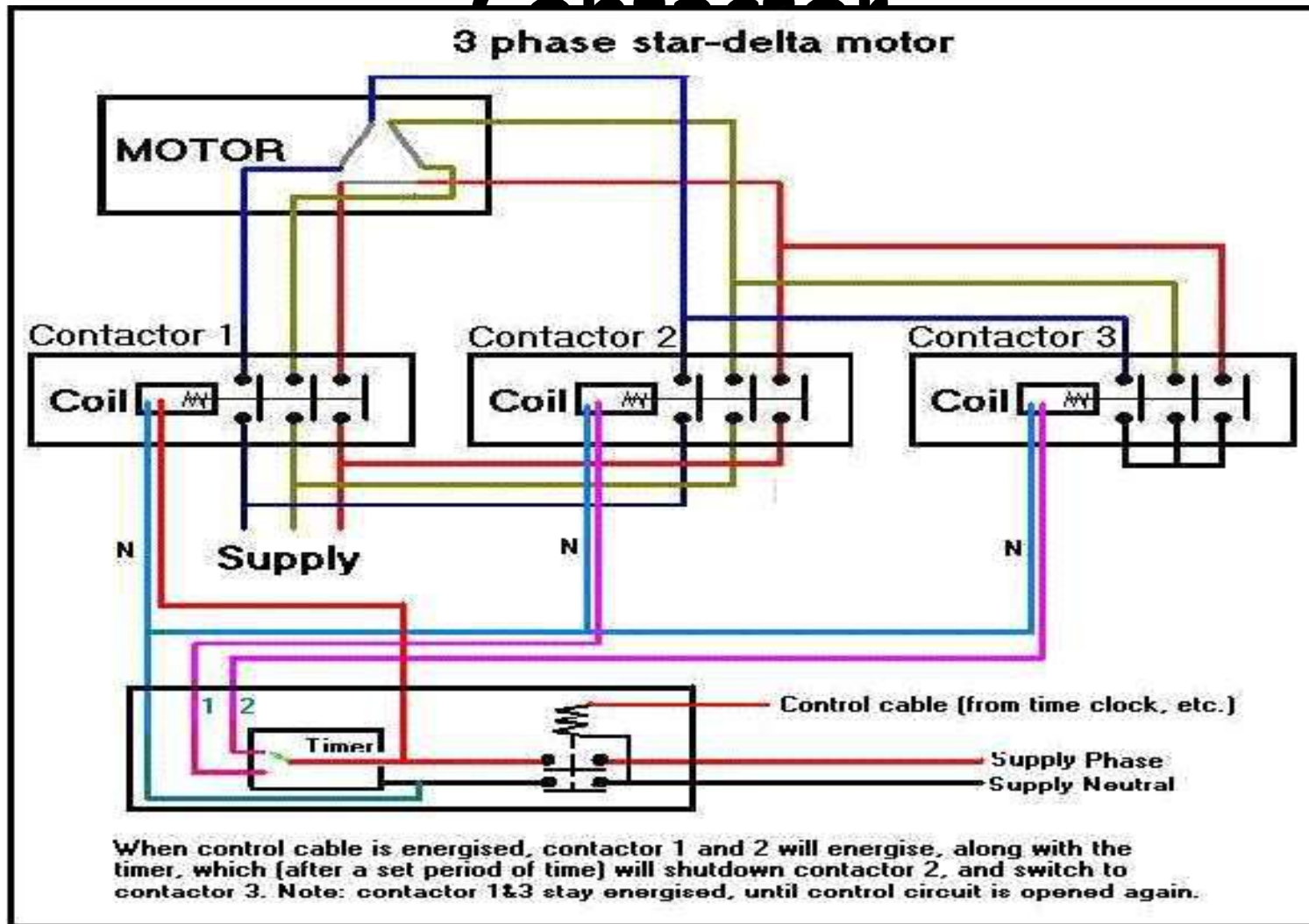
# How the contactor works



- When current passes through the electromagnet, a magnetic field is produced, which attracts the moving core of the contactor.
- The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together.
- When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.

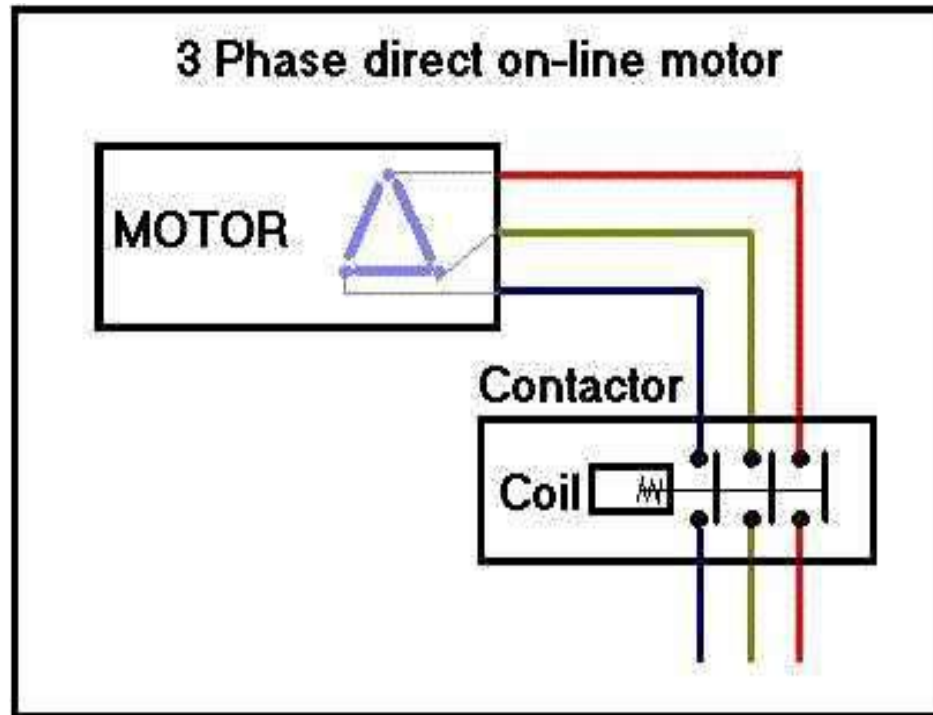
# Examples Application Of

## Contactor



### 1. STAR-DELTA Motor Starter

# Examples Application Of Contactor



2. DOL Motor Starter



# Relay vs Contactor

RELAY	CONTACTOR
Use for lower load, below 5KW Light duty switch	Use for high load Heavy duty switch
controlled device that opens and closes electrical contacts to effect the operation of other devices in the same or another circuit.	for repeatedly establishing and interrupting an electrical power circuit
relay is used in control circuit only	contactor is used in both control and power circuit.
Cheaper	Expensive
Not economically to repair	Designed that it can be repaired

## CHAPTER 2: INTRODUCTION TO PLC

### Objectives:

At the end of this lecture the students should be able to:

1. Describe a PLC and its functions
2. Explain the history of PLC development
3. Identify the main parts of PLC and describe the functions.
4. List the types and advantages of PLC

### 2.0 INTRODUCTION

In this chapter, we will discuss about PLC in detail:

- 2.1 Definition of PLC
- 2.2 Define PLC Terminologies
- 2.3 Background PLC
- 2.3 The function of PLC and Types of Construction
- 2.4 Advantages of PLCs

### 2.1 Definition of PLC

#### Definition according to NEMA standard ICS3-1978

A digitally operating electronic apparatus which uses a programming memory for the internal storage of instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic to control through digital or analog modules, various types of machines or process.

OR

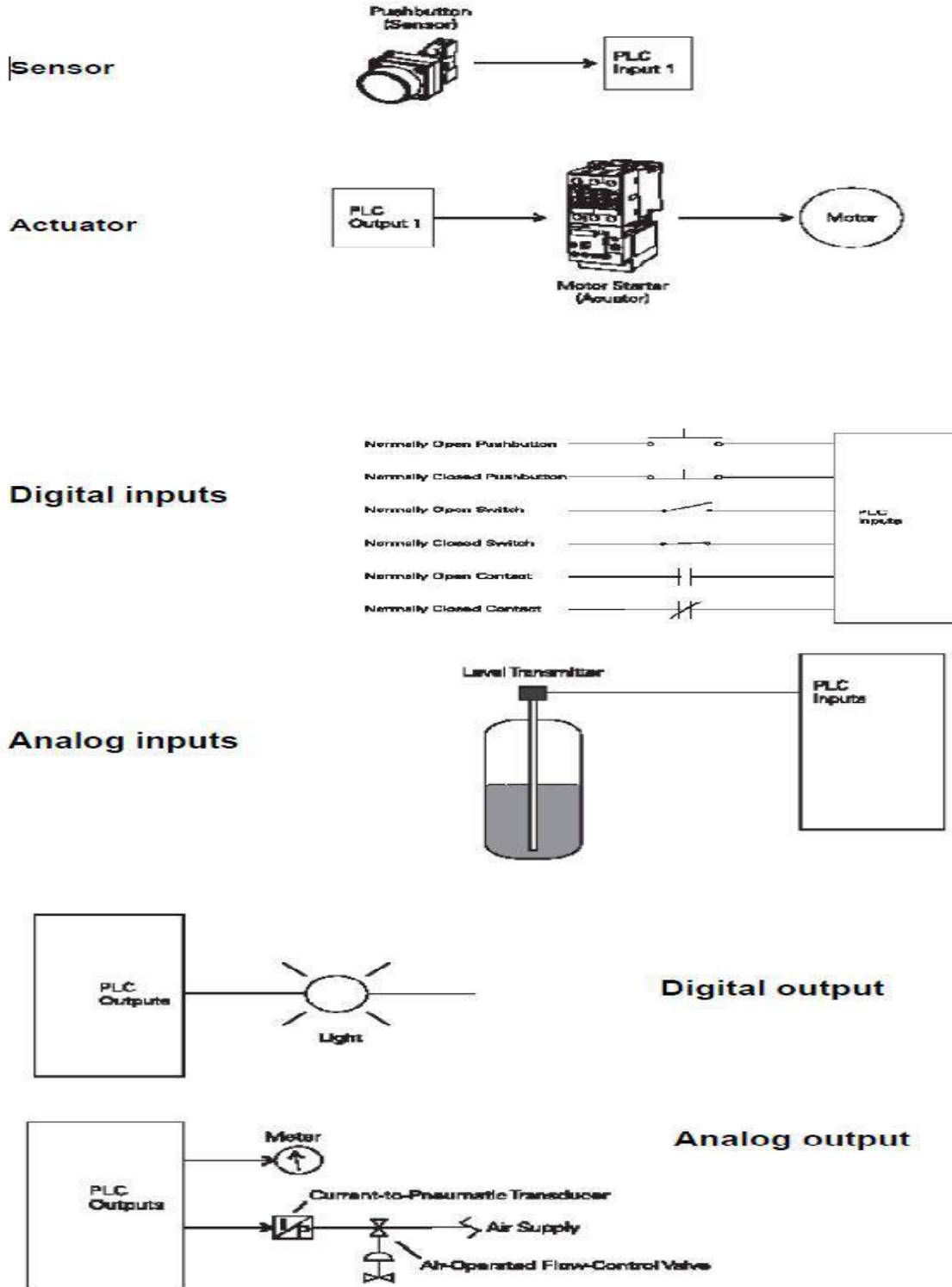
A device that is pre-programmed to accept relay ladder logic instructions and perform these instructions to control the equipment operation.

# INTRODUCTION TO PLC

## 2.2 PLC Terminologies

**sensors:** switches, flow, level, pressure, temp. transmitters, etc.

**output devices/actuators:** motors, valves, solenoids, lamps, or audible devices



## **CPU - Central Processing Unit.**

The CPU is a microprocessor that co-ordinates the activities of the PLC system. It executes the program, processes I/O signals & communicates with external devices

## **Ladder Diagram -**

Ladder diagrams are specialized schematics commonly used to document industrial control logic systems. They are called "ladder" diagrams because they resemble a ladder, with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent built from relays, is being simulated

## **2.2 Background of PLC**

Among the factors that create the initial design and development of control systems that can be controlled are as follows:

- i. Requirements of a low cost
- ii. Intelligent system
- iii. The Controller that is easy to control

The first PLC was designed by a team of engineers at the company General Motors (GM), the United States in 1968 when the company is looking for other methods to replace the complex system of relays. They also set the specifications of the new control system must meet the following requirements:

- i. Easily programmed
- ii. There is no need for rewiring if there are changes on the program
- iii. Smaller, cheaper and higher reliability.
- iv. Simple building construction and the maintenance cost is cheap.
- v. Cost competitive

# INTRODUCTION TO PLC

## 2.3 FUNCTIONS AND TYPE OF CONSTRUCTION

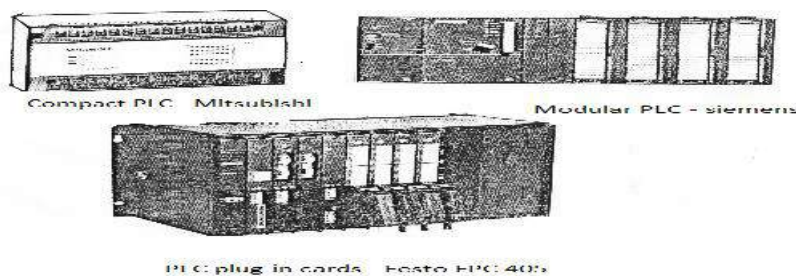
### 2.3.1 Function of PLC

PLC can perform various functions, such as follows :

Type of control	Function
Sequence Control	<ol style="list-style-type: none"> <li>1. Successor Control Relay - conventional logic</li> <li>2. Timer/counter</li> <li>3. Substitute PCB Control card</li> <li>4. Machine and Process Controller for Automatic, Semi-auto and manual</li> </ol>
Advanced Control	<ol style="list-style-type: none"> <li>1. Solve Mathematics of Operations (+, -, ÷, x)</li> <li>2. Managing Information</li> <li>3. Analog control (temperature, pressure, etc..)</li> <li>4. Servo Motor Control</li> <li>5. Stepper motor control</li> <li>6. control P.I.D (Propotional - Integral - derivation)</li> </ol>
Supervision control	<ol style="list-style-type: none"> <li>1. Process Display and Alarm</li> <li>2. Diagnosis and Display Fault</li> <li>3. Interface with Computer (RS 232C / RS 422)</li> <li>4. Interface Printer / ASCII</li> <li>5. Factory Automation Network</li> <li>6. Local Area Network (LAN)</li> <li>7. Widespread Area Network (WAN)</li> <li>8. Factory Automation (FA),Flexible Manufacturing System (FMS), Computer Integrated Manufacturing (CIM) etc..</li> </ol>

### 2.3.2 Type of PLC Construction

Figure 2.3.2 shows the types of PLC construction in the market today.



**Types of PLC construction.**

## 2.4. Advantages of PLC are as follows:

- The implementation of a short control projects.
- Program can be change easily.
- Accurate calculation of the cost project.
- Requires a short training time.
- Flexible control system design using the software.
- A wide range of control applications.
- Easy maintenance.
- High reliability
- A standard Hardware controller
- Resistance to the problems of the environment (temperature, moisture, voltage instability and noise) is good.

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# PLC HARDWARE DESIGN

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## CHAPTER 3 – PLC HARDWARE DESIGN

### Objectives:

After completed this chapter, the student will know the major components of a PLC and the functions of these components.

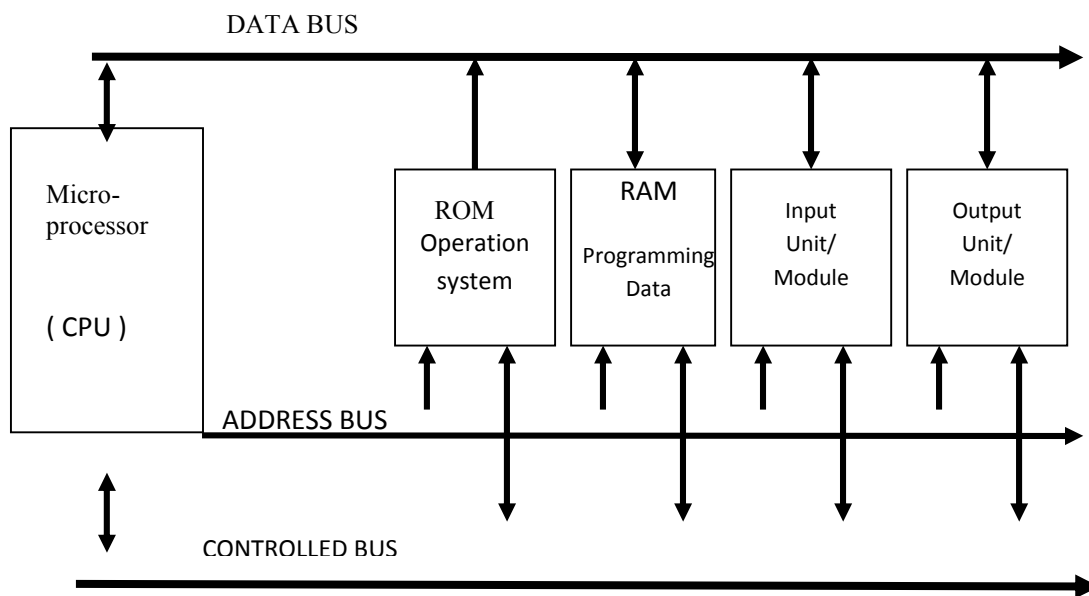
### Introduction:

The PLC, being a microprocessor based device, has a similar internal structure to many embedded controllers and computers. A PLC consist of the following components:

- i. CPU,
- ii. Memory
- iii. Input modules
- iv. Output modules
- v. Power supply.

These components are integral to the PLC controller. Additionally the PLC has a connection for the Programming and Monitoring Unit, Printer and Program Recorder.

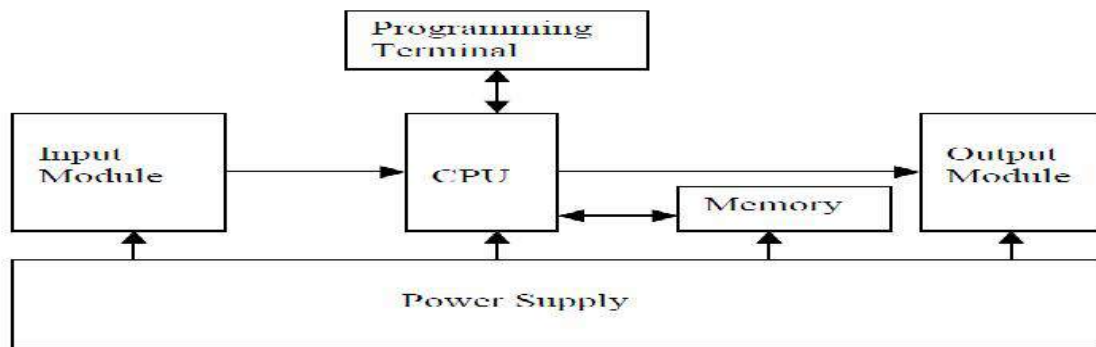
### 3.1 Hardware Design of PLC



a) Design Of A Basic Microcomputer

# PLC HARDWARE DESIGN

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**b) PLC Hardware Block Diagram**

## 3.1.1 Explanation of the PLC Block Diagram

The programming terminal in the diagram (b) is not part of the PLC, but it is essential to have a terminal for programming or monitoring a PLC. In the diagram, the arrows between blocks indicate the information and power flowing directions.

### a) Central Processing Unit - CPU

This unit is the most important unit in the building of a PLC, which is the “**brain**” of a PLC. In this unit lies a chip of microprocessor - integrated circuit chips which controls the overall operation of the PLC control system. Microprocessors contain **arithmetic unit, control unit and a number of memory units, known as registrars.**

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 output devices.

In detail, the CPU of a PLC does the following operation:

- Updating inputs and outputs. This function allows a PLC to read the status of its input terminals and energize or deenergize its output terminals.
- Performing logic and arithmetic operations. A CPU conducts all the mathematic and logic operations involved in a PLC.
- Communicating with memory. The PLC programs and data are stored in memory. When a PLC operating, its CPU may read or change the contents of memory locations.
- Scanning application programs. An application program, which is called *a ladder logic program*, is a set of instructions written by a PLC programmer. The scanning function allows the PLC to execute the application program as specified by the programmer.



- Communicating with a programming terminal. The CPU transfers program and data between itself and the programming terminal.

### b) **Memory Unit**

Memory is the component that stores information, programs and data in a PLC. The process of putting new information into a memory location is called **writing**. The process of retrieving information from a memory location is called **reading**.

Above figure shows the memory unit in the internal design of PLCs. This unit contains two (2) types of memory:

#### i. **RAM (Random Access Memory)**

RAM is the memory type of **read / write** and easy to program and repaired. All users program are stored in this memory. **Read** indicates that the information stored in the memory can be retrieved or read, while **write** indicates that the user can program or write information into the memory. The data in the RAM would normally be lost if the power source is removed. This problem is solved by backing up the RAM with the battery

#### ii. **ROM (Read Only Memory)**

ROM is read-only memory types. **Read Only** indicates that the information stored in memory can be read only and cannot be changed. Information in ROM is placed there by the manufacturer for the internal use and operation of the PLC. The system program is stored in this memory. This program will not be lost when the power is disconnected. Special equipment is used to delete the program from this memory

The memory capacities of PLCs vary.

### c) **Display and Indicators Unit**

Display and the indicator unit refers to the internal relay PLC status display. This can be seen in the Console programming if the user using the mnemonic code and programming computer screen if the user using software programming methods.

### d) **Input And Output Unit /Module**

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# PLC HARDWARE DESIGN

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Referring to above figure, the input and output units are the units available in the internal design of PLCs.

The Input/Output units are the interfaces between the internal PLC systems and the external processes/ field devices to be monitored and controlled. Input Unit is the unit which input devices (switches, sensors) are connected to it. While the output unit is a unit which output devices (Lights, motors) are connected to it.

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.

Since the PLC is a logic based device with a typical operating voltage of 5 volts and the **external processes usually demand higher powers and currents, the I/O modules are optically or otherwise isolated**. The typical I/O operating voltages are 5V - 240 V dc (or ac) and currents from 0.1A up to several amperes. The I/O modules are designed in this way to minimize or eliminate the need for any intermediate circuitry between the PLC and the process to be controlled.

Small PLC units would have around 40 I/O connections with larger ones having more than 128 with either local or remote connections and extensive upgrade capabilities.

## 3.2 Function And Operation Of The Following Hardware Units

### 3.2.1 Housing Unit

This unit provides protection to the circuits and components - the internal components of a PLC.

### 3.2.2 Programming Unit

Programming units are essential components of the PLC systems. Since they are used only in the development/testing stage of a PLC program, they are not permanently attached to the PLC. The program in a ladder diagram or other form can be designed and usually tested before downloading to the PLC. The Programming unit can be a dedicated device or a personal computer. It allows the graphical display of the program (ladder diagram). The unit, once connected to the PLC can download the program and allows for the real time monitoring of its operation to assist debugging. Once the program is found to operate as required the Programming Unit is disconnected from the PLC which continues the operation

### **3.2.3 Program Loader Unit**

Is used to enter the desired program into the memory of the processor. Program is entered using relay ladder logic (most popular programming language used by all major manufacturers of PLCs). Program loader can be a computer or a console (handheld type). All leading brands of PLCs have software available so that a PC can be used as the programming device.

### **3.2.4 Secondary Storage Unit**

This unit is related to the Central Processing Unit where all the programs and information stored

### **3.2.5 VDU (Video Display Unit)**

Information processing unit operations and the system status will be displayed by the PLC

### **3.2.6 Power Supply Unit**

This unit provides power to the Central Processing Unit, Input Unit and Output Unit. PLCs are powered by standard commercial Ac power lines. However , many PLC components such as CPU and memory, utilize 5 volts or another level of DC power. The PLC power supply converts Ac power into Dc power to support those components of the PLC.

### **3.2.7 Printers**

This unit is used to print the program a system controlled by a PLC control either graphics or text.

Tutorial :

ANSWER ALL THESE QUESTIONS

- 1.1 State THREE (3) units available in the microprocessor.
- 1.2 Explain the difference between RAM and ROM memory.
- 1.3 What do you understand about the Input Unit and Output Unit
- 1.4 Explain the functions of the printer unit.

## PLC HARDWARE DESIGN

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### QUESTION

- a. State TWO (2) information contained in the definition of PLC by NEMA.
- b. List Five (5) tasks can be done by the PLC in the control of advanced types.
- c. List Five (5) the reason why the factory used the PLC as a controller process automation control system.
- d. Briefly explain any three (3) the units of the PLC hardware