LECTURE NOTE
DEJ40033

PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION

INTRODUCTION TO AUTOMATION SYSTEM

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LECTURE NOTE
DEJ40033

DEPARTMENT OF ELECTRICAL ENGINEERING
POLITEKNIK SULTAN MIZAN ZAINAL ABIDIN

INTRODUCTION TO AUTOMATION SYSTEM

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FIRST PUBLISHING 2021

Published by:

Department of Electrical Engineering
Politeknik Sultan Mizan Zainal Abidin
Km. 08 Jalan Paka, 23000 Dungun, Terengganu

INTRODUCTION TO AUTOMATION SYSTEM
EDITION 2021

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PREFACE

Thanks to Allah the Lord of the world because of his grace we can complete a book entitled “INTRODUCTION TO AUTOMATION SYSTEM”. We wish to express our deep and sincere gratitude for those who have guided and given full cooperation and commitment in completing this book.

This lecture book is structured to meet the need of topic 1 for PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION. This book can be used as a guidance for all the students and lecturers who are involved in PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION in Sultan Mizan Zainal Abidin Polytechnic (PSMZA).

We realize that this book is far from perfect, therefore constructive criticism and suggestions are welcomed to improve this book.

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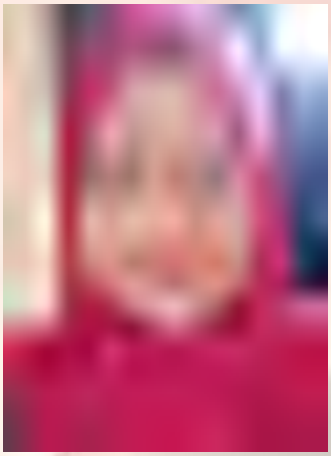

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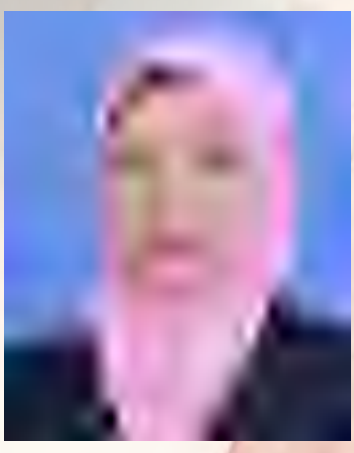

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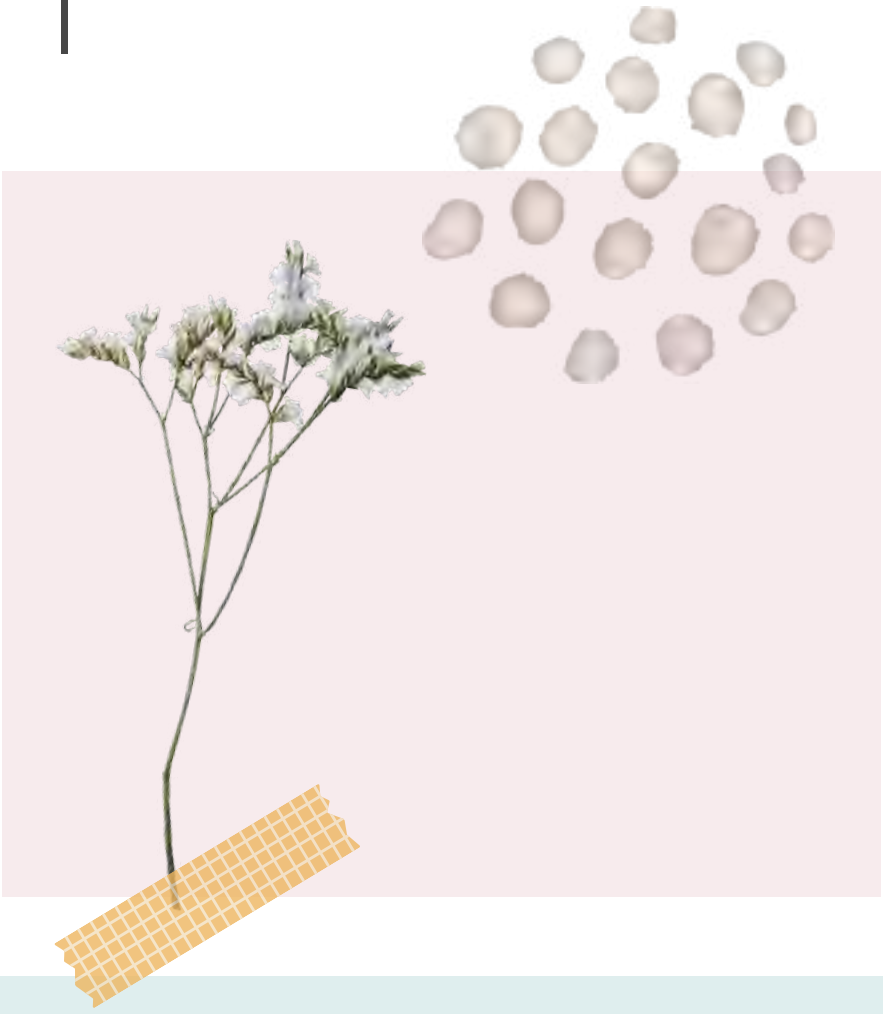
TABLE OF CONTENTS



SYNOPSIS

PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION provides knowledge regarding the concept and principle of automation system. This course emphasizes the relationship between conventional/hardwired/relay ladder logic (RLL) and PLC system, application of various industrial input and output devices of PLC, designing process, programming, constructing and PLC maintenance method. This course also provides knowledge and skills in designing environmentally friendly of automation control system based on conventional/hardwired/relay ladder logic (RLL) and PLC

COURSE LEARNING OUTCOMES (CLO)

1. Evaluate environmentally-friendly automation control system using electromechanical devicesand PLC (C5)

2. Display the ability to construct, troubleshoot and do maintenance of hardwired and PLC systemsusing appropriate equipment. (P4)

3. Demonstrate an understanding of PLC environmentally-friendly a automation systemnorm by following PLC IEC standard during practical work session (A3)

Types of automation in industry

INTRODUCTION TO AUTOMATION SYSTEM

PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION

AUTOMATION SYSTEM

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, reliablity 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.

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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.

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

PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION

ELECTRONIC

MECHANICAL

Automation can be defined as a technology concerned with the application of :

COMPUTER BASED SYSTEMS

THEREFORE, AN AUTOMATED MACHINE IS COMPOSED OF:

- **A MECHANICAL PART INCLUDING THE ACTUATORS/DRIVES AND SENSORS.**
- **AN ELECTRONIC CIRCUIT I.E THE HARDWARE.**
- **A CONTROL SYSTEM THAT REPRESENTS THE INTELLIGENCE OF THE SYSTEM.**

TYPES OF AUTOMATION IN THE INDUSTRY

CLASSIFICATION OF AUTOMATION

a) Fixed/Hardwired/conventional automation

- This control system is designed to perform a specific task
- Functions of control circuit is fixed and permanent.
- Fixed automation is a system in which the sequence of processing (assembly) operations is fixed by the equipment configuration.
- This is also called hard automation.
- Used when the volume of production is very high, therefore, appropriate to design specialized equipment to process products at high rates and low cost.

b) Programmable Automation

- In programmable automation, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configuration.
- The operation sequence is controlled by a program. New programs can be prepared and entered into the equipment to produce new products.

c) Flexible Automation

- Flexible automation is most suitable for mid-volume production range.
- Flexible automation possesses some of the features of both fixed and programmable automation. Also know as an extension of programmable automation
- It is also called soft-automation.
- Flexible automation typically consists of a series of workstations that are interconnected by material handling and storage equipment to process different product configurations at the same time on the same manufacturing system.

Type of Automation system

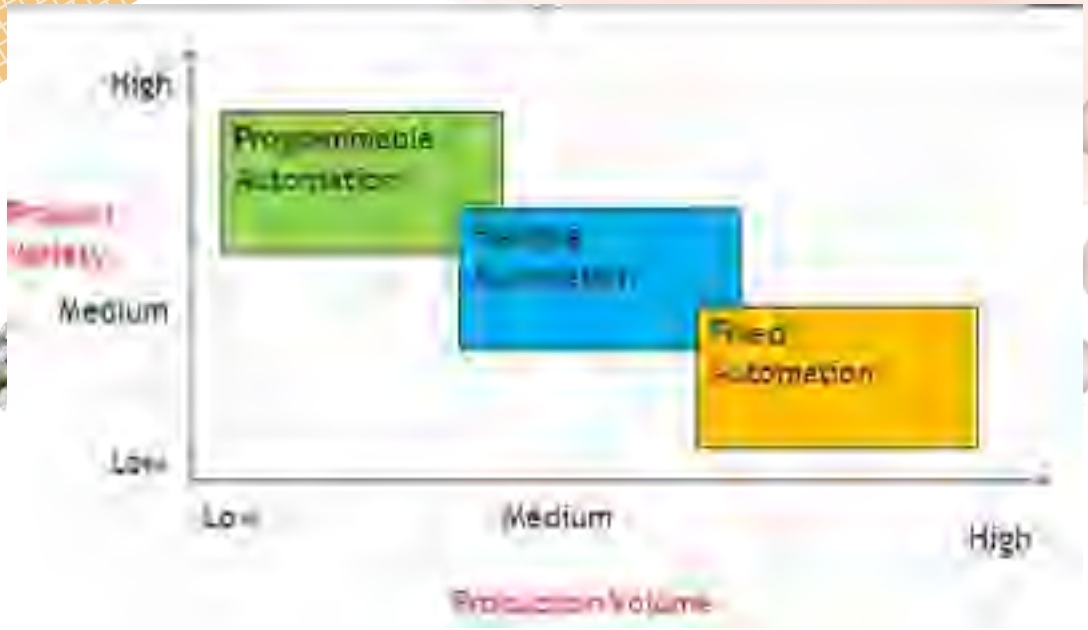

Figure 1.1 type of automation system

Comparison Types of Automation

Automation	When to consider	Advantages	Disadvantages
Fixed			
Programmable			
Flexible			

figure 1.2 Comparison Types of Automation

EXAMPLE

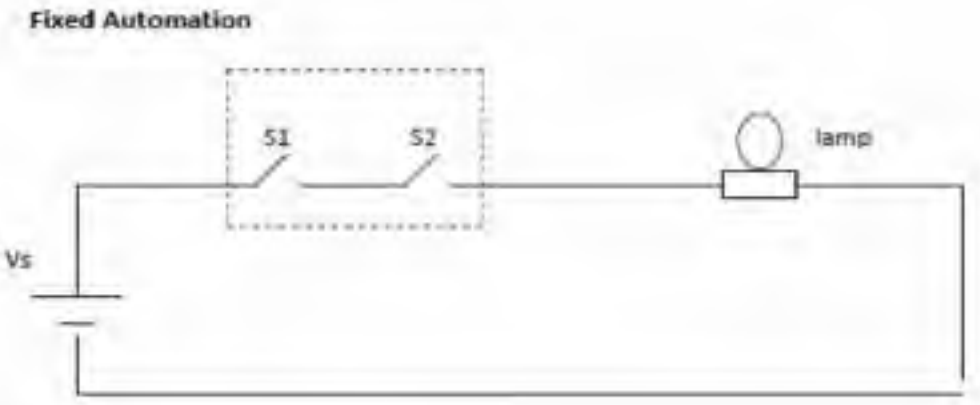

Figure 1.3 Fixed Automation

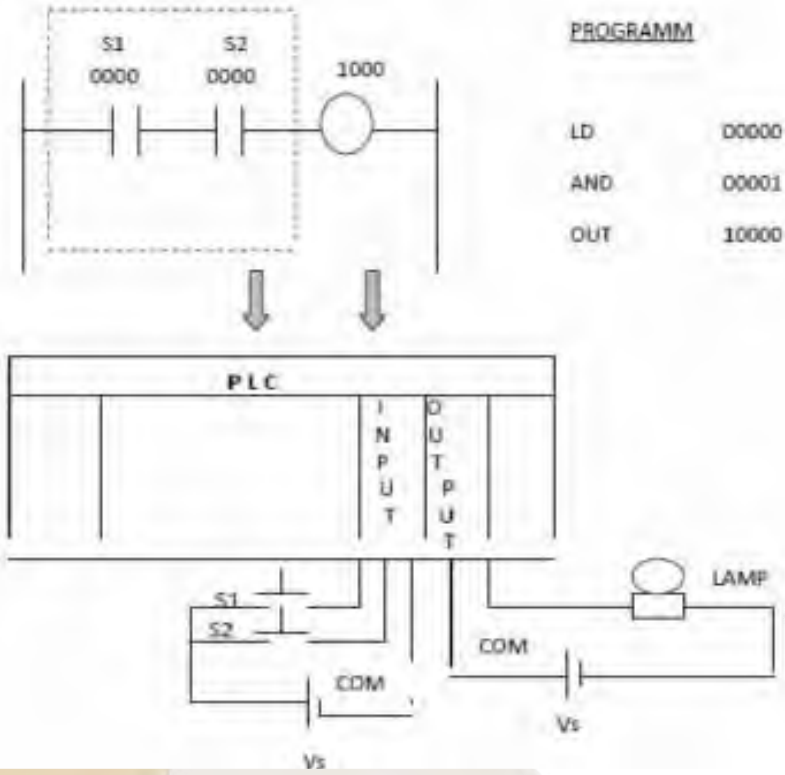

Figure 1.4 Programmable Automation

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.

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

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

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
:

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

TYPES OF AUTOMATION IN INDUSTRY

1. Give definition of Automation Control System

2. List down TWO(2) types of automation system

3. Explain TWO (2) advantages of an automation system.

4. Define automation control system

5. What do you understand about automation system? Discuss and give 3 example.

6. Automation system can be classified into two parts. Fixed Automation and flexible programmable automation. List THREE(3) characteristic of flexible programmable automation

ELECTROMECHANICAL RELAYS

INTRODUCTION TO AUTOMATION SYSTEM

PROGRAMMABLE LOGIC CONTROLLER (PLC) AND AUTOMATION

ELECTROMECHANICAL RELAYS

DEFINE

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 .

*SYMBOL

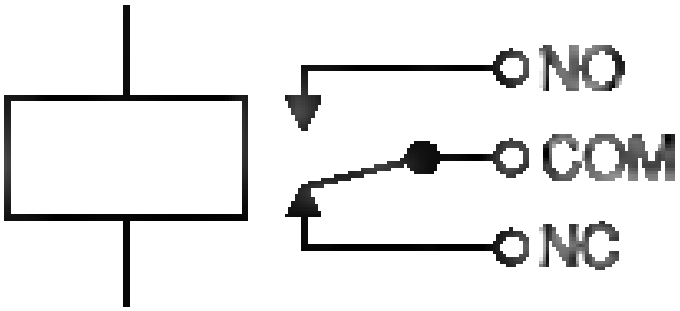

Figure 2.1 symbol of Electromechanical Relays

Figure 2.2 example of Electromechanical Relays

Type of Relay / Application Examples

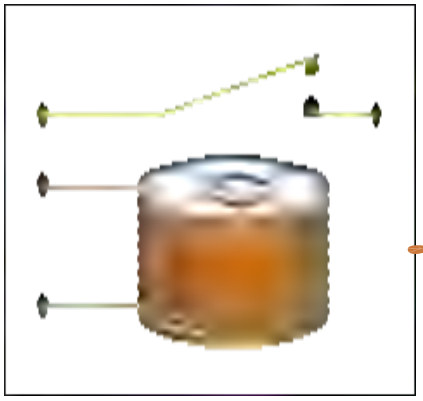

Figure 2.3 SPST

•This is a **Single Pole Single Throw (SPST)** relay.
•Current will only flow through the contacts when the relay coil is energized.

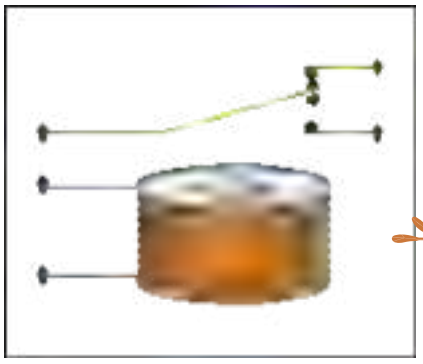

Figure 2.4 SPDT

•This is a **Single Pole Double Throw (SPDT)** relay.
•Current will flow between the movable contact and one fixed contact when the coil is DEenergized and between the movable contact and the alternate fixed contact when the relay coil is energized.
•The most commonly used relay in car audio, the Bosch relay, is a SPDT relay.

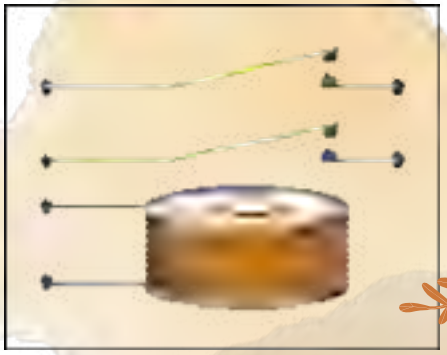

Figure 2.5 DPST

•This is a **Double Pole Single Throw (DPST)** relay.
• When the relay coil is energized, two separate and electrically isolated sets of contacts are pulled down to make contact with their stationary counterparts.
•There is no complete circuit path when the relay is DEenergized.

Type of Relay / Application Examples

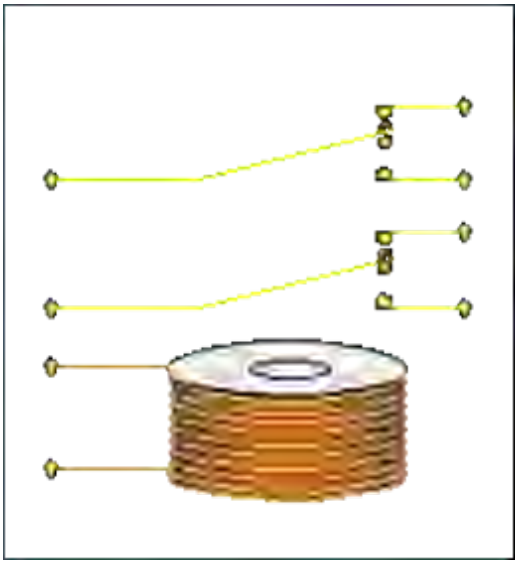

Figure 2.6 DPDT

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

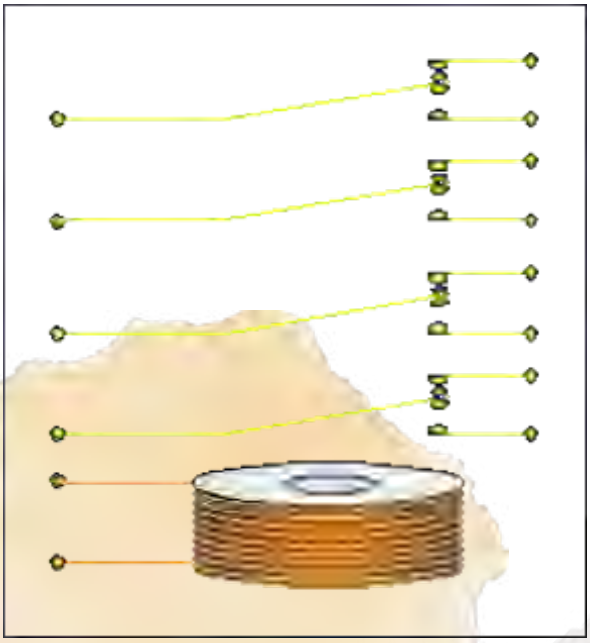

Figure 2.7 4PDT

••This is a **4 Pole Double Throw (4PDT)** relay.
•It operates like the SPDT relay but it has 4 sets of isolated contacts.

RELAY TERMINOLOGY

NO

*__Normally-open__ contacts connect the circuit when the relay is activated,the circuit is disconnected when the relay is inactive

NC

__Normally-closed__ contacts disconnect the circuit when the relay is activated,the circuit is connected when the relay is inactive

DT

*__Double-throw__ contacts control two circuit: one normally-open contacts and one normally-closed contacts with common terminal

COIL

*__Coil__ generates a magnetic field that attract the armature when an electric current is passed through it

Relay Building Diagram

Relays

The actual 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.

How does a relay work?

All relays contain **a sensing unit**, the electric coil, which is powered by **AC or DC current**. When the applied current or voltage exceeds a threshold value, **the coil activates** the armature, which operates either **to close the open contacts** or **to open the closed contacts**. When a **power is supplied** to the coil, it **generates a magnetic force** that **actuates the switch mechanism**. The magnetic force is, in effect, relaying the action from one circuit to another. The first circuit is called **the control circuit**; the second is **called the load circuit.**

***There are three (3) basic functions of a relay:**

***On/Off Control**

***Logic Operation**

***Limit Control**

OPERATION

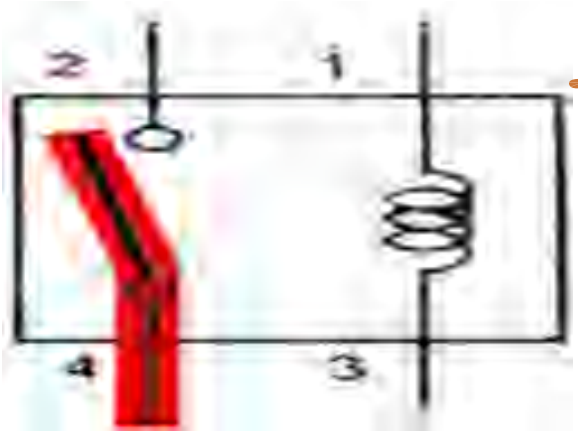

Figure 2.8 NO CIRCUIT

•When **no voltage** is applied to pin 1, there is **no current flow** through the **coil**.
•**No current** means **no magnetic field** is developed, and the switch is open.

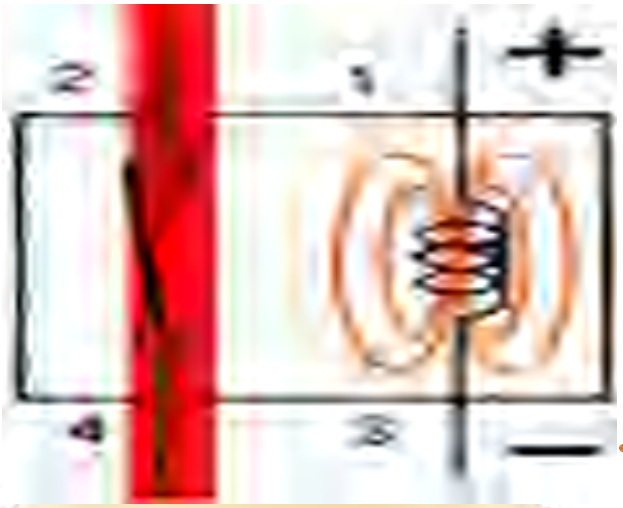

Figure 2.9 NC CIRCUIT

•When **voltage is supplied** to pin 1, **current flow** though the coil creates **the magnetic field** needed to close the switch allowing continuity between pins 2 and 4.

*SYMBOL

Example Of Relay Use In The Traffic Light System

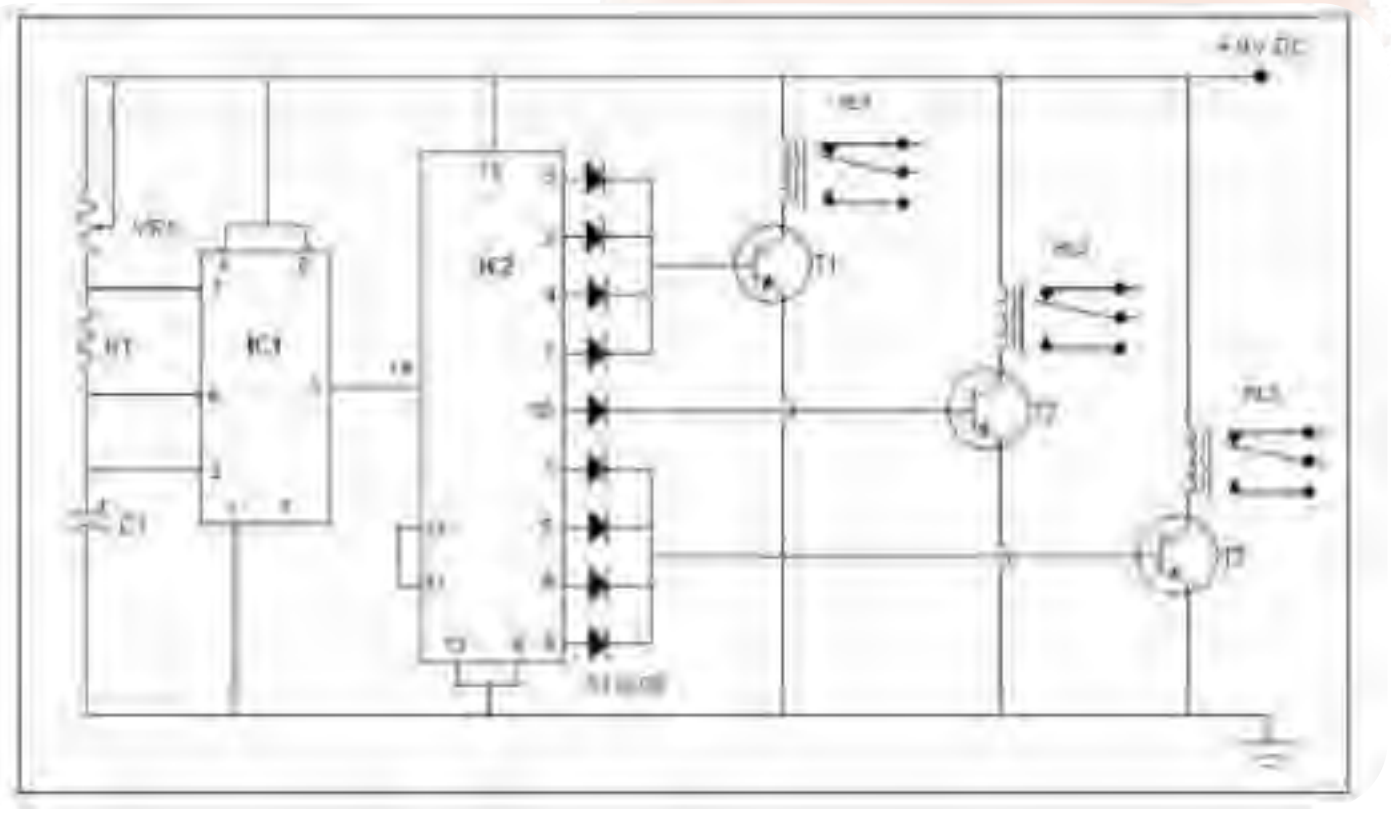

Figure 2.10 Relay Use In The Traffic Light System

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.

TUTORIAL QUESTION

RELAY

1. Relay is operated as a switch. Based on the relay building diagram in Figure B1(a), describe its working operation

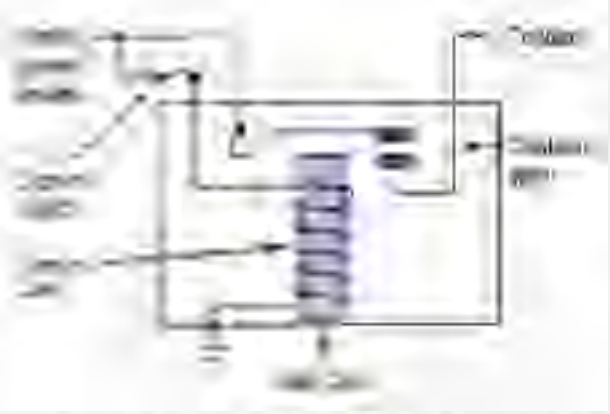

Figure 2.11 bulding diagram

2. Sketch types of relay:
   1. SPST
   2. DPST

3. Explain briefly the operation of relay

CONTACTORS

INTRODUCTION TO AUTOMATION SYSTEM

CONTACTORS

DEFINE

- Contactors are used to indicate an open or closed path of current flow. Contacts are shown as normally open (NO) or normally closed (NC). Contacts shown by this symbol require another device to actuate them.
- 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.

SYMBOL

Figure 3.1 Symbol of Contactors

BASIC Operation

The Contacts

•The contacts operates similarly to the contacts of a simple switch or pushbutton. You should consider the contacts as a pair of metals like the following diagram

Figure 3.2 NO Contactors

Figure 3.3 NC Contactors

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.

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.

Building Diagram

POWER/MAIN CONTACT

•Main contact generally normally open contact
•It is used for open and closed power circuits

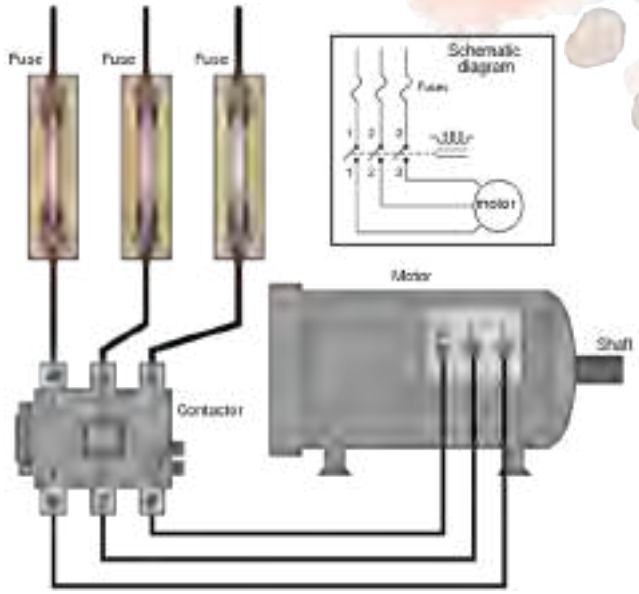

Figure 3.4 Power Main Contact

AUXILIARY CONTACT

••There are two basic auxiliary contact types: those that are closed in the non-activated state or those that are open
•Theseareknownasnormally-open(NO) and normally-closed(NC) contacts

COIL INPUT

••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 controller and lower-voltage pilot devices
•Coil is used to produce electromagnetic when power is supplied

Basic contactor operation

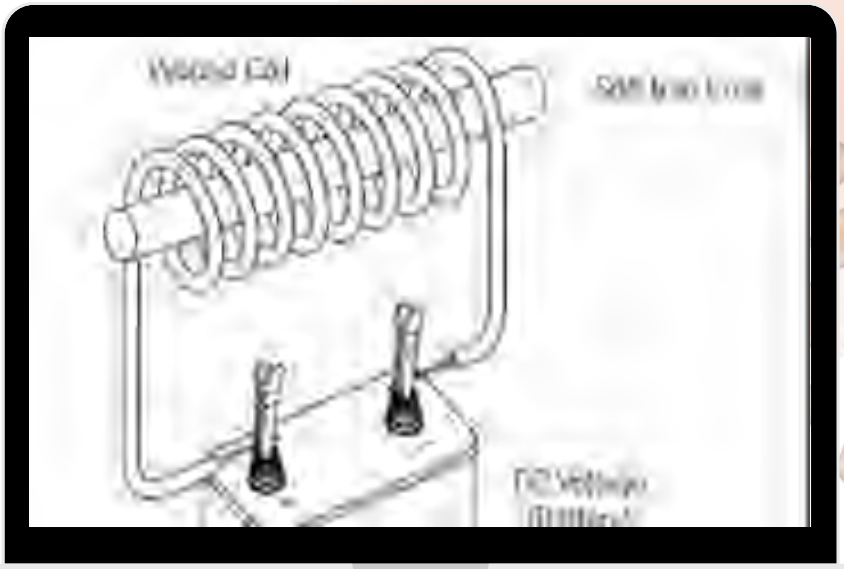

Figure 3.5 Basic operation Contactor

*contactors operate utilizing electromagnetic principles
*When a DC voltage is applied to the wire,the iron becomes magnetic
*When theDCvoltage isremovedfrom wire,the iron returns toitsnonmagnetic state

Normally Open Contact

Figure 3.6 NO Contact

Normally Close Contact

Figure 3.7 NC Contact

In the following illustration the circuit is first shown in the de-energized state. The contacts are shown in their normally open (NO) state. When the relay is energized, the contacts close, completing the path of current and illuminating the light. The contacts have been highlighted to indicate they are now closed.

In the following illustration the contacts are shown as normally closed (NC), meaning the contacts is closed when the relay is de-energized. A complete path of current exists and the light is on. When the relay is energized the contacts open turning the light off.

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!

TUTORIAL QUESTION

CONTACTORS

1. Explain briefly the operation of Contactors NORMALLY OPEN or NORMALLY CLOSED

2. List three different iteam in contacors

3. Explain briefly operation contactors based of picture below

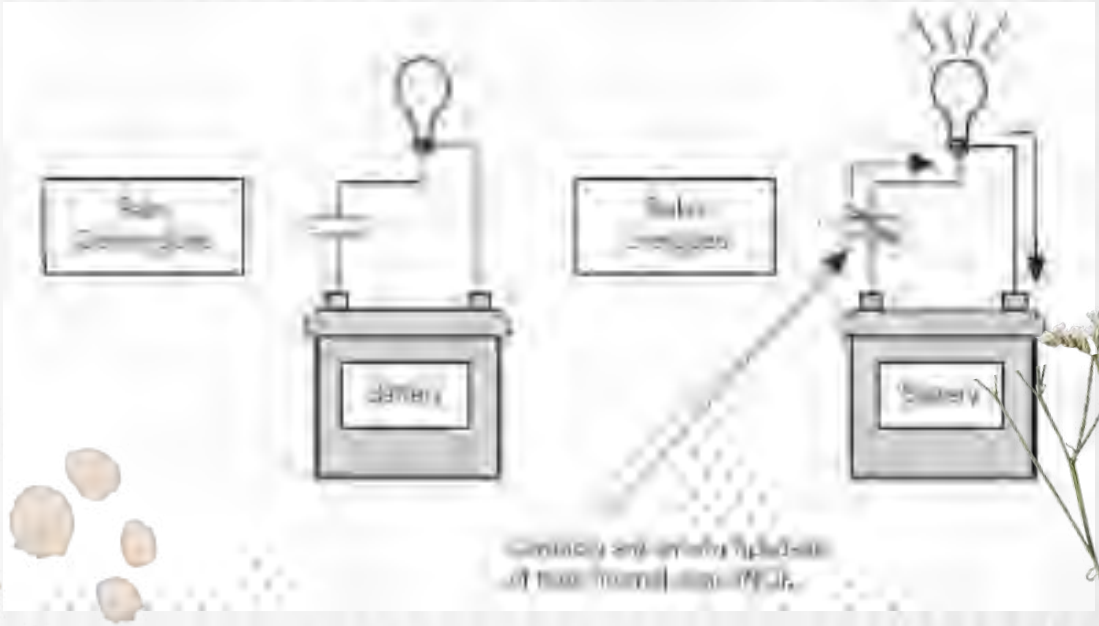

Figure 3.8 NO and NC Contact

ELECTROMECHANICAL TIMER

INTRODUCTION TO AUTOMATION SYSTEMS

ELECTROMECHANICAL TIMER

Define

*•Electromechanical timers are used to start or stop a machine or other device at preset or delayed intervals.
• They consist of both electrical and mechanical components, and often feature an electric motor that drives one or more gears.
•They typically accept electric or electronic inputs to operate a mechanical output such as rotating wheels or knobs.

4.1 typical mechanical timer

4.2 A simple digital timer. The internal components

*Symbol Electromechanical Timer

Contact symbols determine the time of timer action:-
On-delay action - TR energized, contacts change state after set time interval
Off-delay action - TR de-energized, contacts change state after set time interval

Figure 4.3 sysmbol of Electromechanical timer

How do electromechanical timer work?

An electromechanical cam timer uses a small synchronous AC motor turning a cam against a comb of switch contacts. The AC motor is turned at an accurate rate by the alternating current, which power companies carefully regulate. Gears drive a shaft at the desired rate, and turn the cam

What are the different types of timers?

The two main types of light timers are mechanical and electronic, and come as hardwired or plug-in modules. The other two timers—astronomic and photocell—are really types of electronic timers, but we have separated them since they are so different

What is PLC timer type?

There are three types of PLC timers:

- ON delay timer (TON)
- OFF delay timer (TOFF)
- Retentive Timer (RTO)

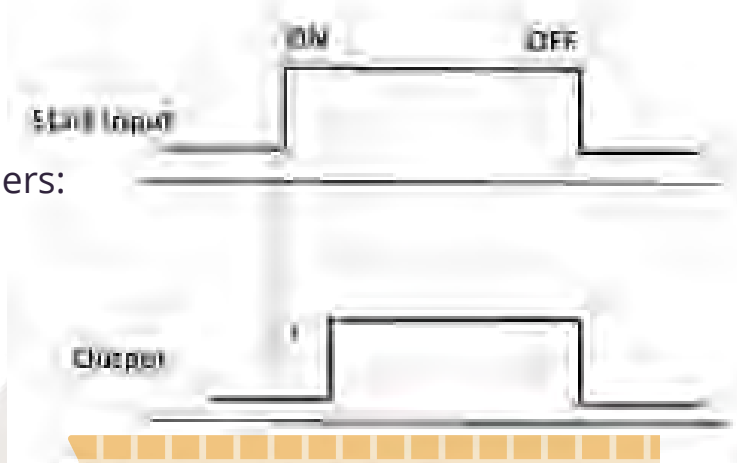

Figure 4.4 types of timer

TUTORIAL QUESTION

ELECTROMECHANICAL TIMER

DEFINE ELECTROMECHANICAL TIMER

ELECTROMECHANICAL COUNTER

INTRODUCTION TO AUTOMATION SYSTEM

ELECTROMECHANICAL COUNTER

Define

*•Electromechanical counters are used to detect, totalize, and indicate a sequence of events.
•They typically accept electric or electronic inputs to operate mechanical outputs such as rotating wheels or knobs.
•These devices may count UP and/or DOWN, support multiple functions, and provide reset capabilities.

**Symbol Electromechanical Counter

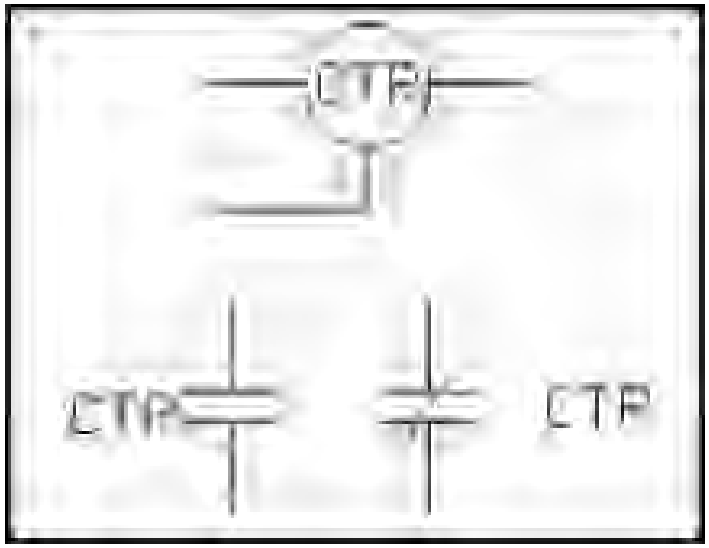

Figure 5.1 sysmbol of Electromechanical Counter

*SYMBOL

What is electromechanical counter?

Electromechanical counters are used to detect, totalize, and indicate a sequence of events. They typically accept electric or electronic inputs to operate mechanical outputs such as rotating wheels or knobs. These devices may count UP and/or DOWN, support multiple functions, and provide reset capabilities.

How do electromechanical counters work?

Electro-mechanical counters detect, totalize, and indicate a sequence of events, popular along production lines. ... Electro-mechanical counters typically accept electric or electronic inputs to operate mechanical outputs such as rotating wheels or knobs.

*SYMBOL

TUTORIAL QUESTION

ELECTROMECHANICAL COUNTER

1. **What is electromechanical counter**

e ISBN 978-967-2099-75-8