INDUSTRIAL ELECTRONICS

For Polytechnics Student

HASPIRUDIN BIN BASIRON
MUHAMMAD BIN AHMAD KAMAL
CHE AZLINA BINTI CHE NOROHOSENI

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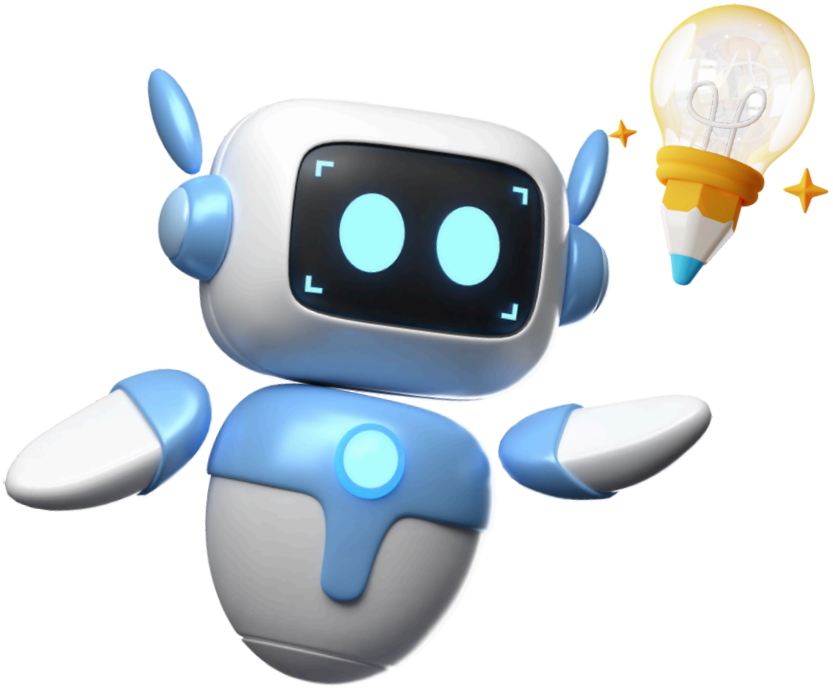

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PREFACE

The goal of this e-book's creation and development was Industrial Electronics course's Continuous Quality Improvement (CQI). According to the conclusions of the Course Outcome Review Report (CORR), instructional materials and course notes need to be updated and upgraded with appropriate and successful teaching strategies. This book helps students pursuing a Diploma in Mechatronic Engineering by improving their understanding and helping them get better results. It is connected with the DJM30062 curriculum. The writers' years of expertise delivering this course concluded in this book. Furthermore, it serves as a forum for the writers to impart their knowledge to other instructors. With the hope that this e-book will help you understand the idea and practical applications of mechatronics.

ACKNOWLEDGEMENT

We are extremely grateful to Allah S.W.T. for providing us with the inspiration and resolve need to finish this book. We are grateful to Allah S.W.T. for his plenty for allowing us to finish our book after devoting all of our time and work to it.

Firstly, our family deserves special thanks for all of their help and time spent with us while we wrote this book. We greatly value your mutual support.

We would also want to thank the entire administration of the Mechanical Engineering Department for their dedication, counsel, and support during the writing of this book.

We express our gratitude to all of our coworkers, faculty, and students at Politeknik for their unwavering collaboration, particularly for their direct and indirect ideas contributions. In particular, we appreciate the staff and students in the Mechanical Engineering Department. We pray that Allah will bless and reward everyone who helped us finish this book.

Lastly, we would like to thank Politeknik management from the bottom of our hearts for the emotional support they provided throughout the book's preparation. Your input has been really helpful in making this book thorough and educational. Thank you.

ABSTRACT

One of the key elements of mechatronics is industrial electronics. The electronics used in mechatronics are discussed in this e-book. This book serves as a convenient resource for students to quickly understand the fundamental concepts and uses of mechatronic devices. Three chapters and easy example questions are included in this eBook edition to demonstrate comprehension of the material. Additionally, it can help students practice and improve what they already know.

CHAPTER ONE

INTRODUCTION TO MECHATRONIC DEVICES

Course Learning Outcome(CLO)

1. Apply the mechatronic devices, switches, relays, solenoid, electronic control devices, sensor and telemetry system in industrial application.(C3)

2. Construct the circuit of relays and sensors accordingto operational principle.(P4)

3. Demonstrate the understanding of mechatronic devices.(A3)

Lourse Learning Outcome(LLO)

After completing lesson, the student will be able to :

- Explain to mechatronics devices

WHAT IS MECHATRONICS?

Integration of Mechanical Engineering:

with Electronics and Intelligent control

for design and manufacturing of industrial products & processes.

Yasakawa Electric Company

YASKAWA

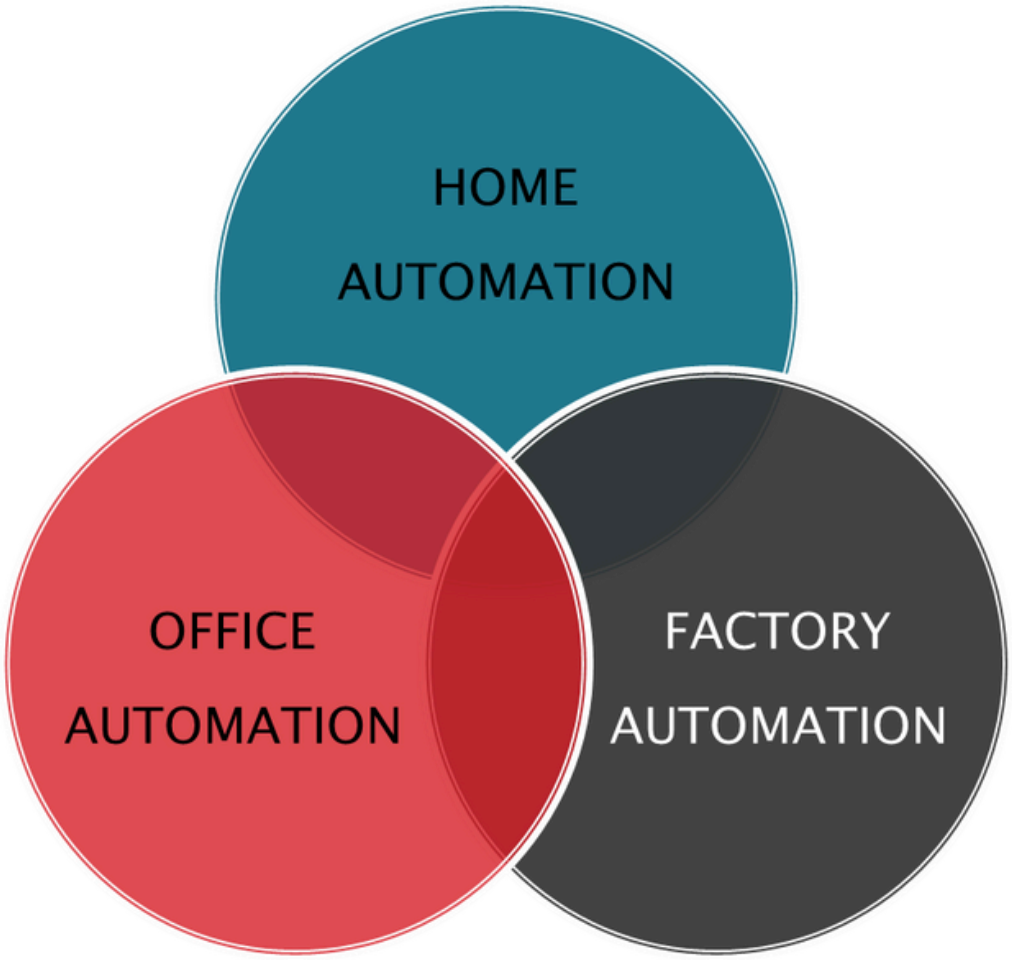
Mechatronics, is composed of

"mecha" from mechanism

"tronics" from electronics.

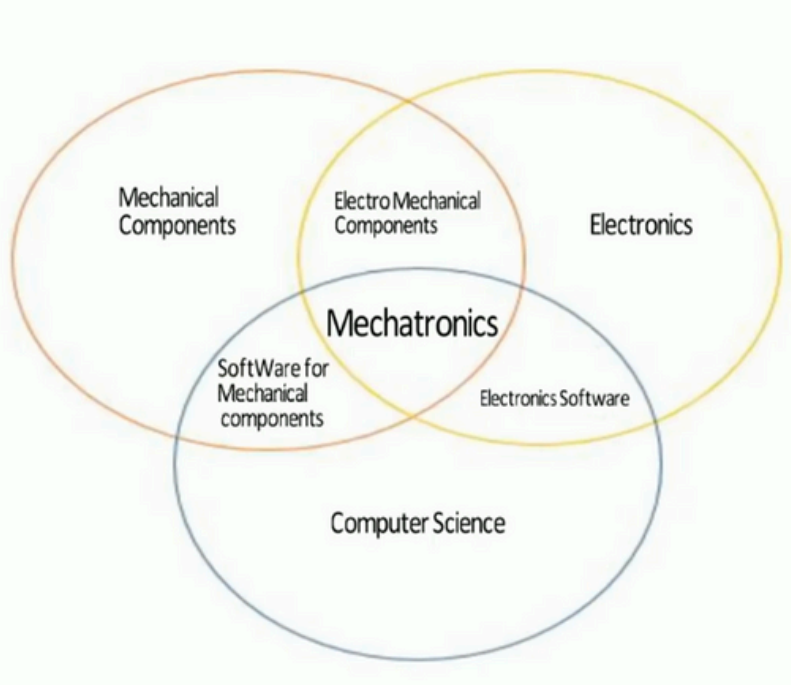
DOMAINS OF MECHATRONICS?

MECHATRONICS can be divided into 3 main context area of applications such as Home Automation, Office Automation And Factory Automation.



CONCEPT OF MECHATRONICS?

Mechatronics is a multidisciplinary knowledge system which involve Mechanical Engineering, Electronics Engineering And Software Engineering.



https://youtu.be/Ro_tFv1iH6g?si=wiymdQKOoD4K7R-C

WATCH NOW

1.1 INTRODUCTION OF MECHATRONIC DEVICES

Key Elements of Mechatronics:

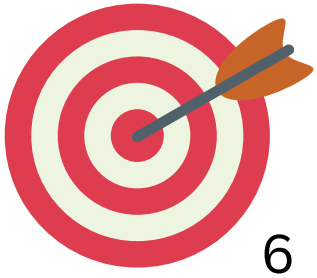
PHYSICAL SYSTEMS MODELING

SENSORS AND ACTUATORS

SIGNALS AND SYSTEMS

COMPUTERS AND LOGIC SYSTEMS

SOFTWARE AND DATA ACQUISITION

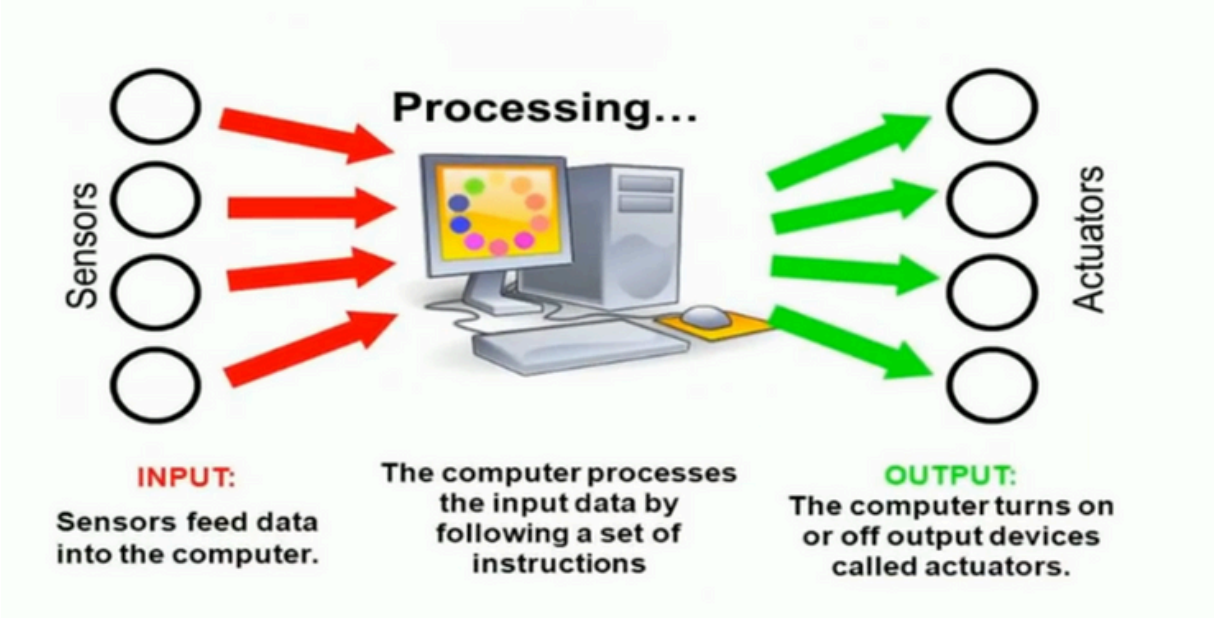


Electronics

- Semiconductor devices such as diodes and transistors is formed by ‘joining’ a p-type and n-type semiconductor together as a p-n junction.
- Transistors are active circuit elements and are typically made from silicon or germanium and come in two types
- Electronics component mainly use in Signals and System , Sensor and Data acquisition.

Digital Control

- Digital Control is use in most type of signalling for the accuaracy and efficiency.
- Computer control and controller system such as Programmable Logic controller and embedded system is used in modern Mechatronic applications.

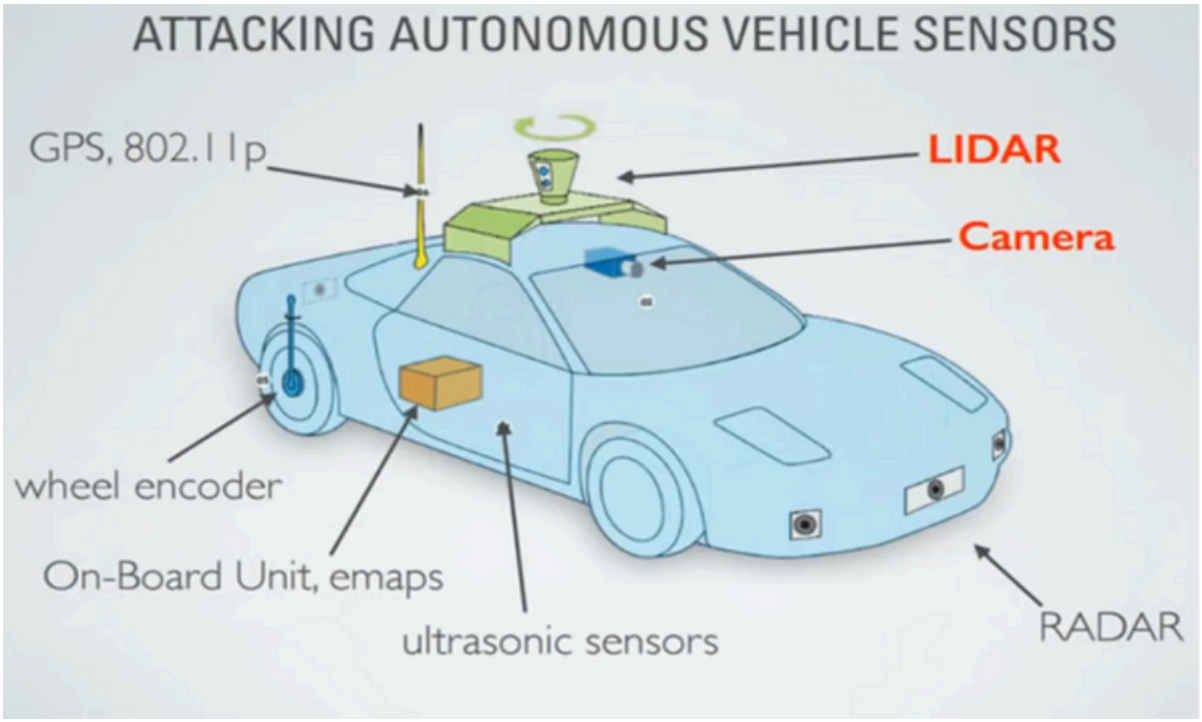


Sensors and Actuators

- Sensors are elements for monitoring the performance of machines and process. Actuators is a device that can convert electrical to mechanical energy. All actuators are tranducers.
- There are 3 types of actuators used such as Electrical drive eg. electrical motor and solenoid, Pneumatic for fast and clean applications and Hidraulic for handle bigger load.

Information Technology

- Signals to and from a computer and its peripheral devices are often communicated through the computer's serial and parallel ports.
- Nowadays the computer science play bigger role in controlling and handle big data for various activities including business, factory control, telemetry and others. Many software and platform are commonly used such as Java, PhP and Laravel.



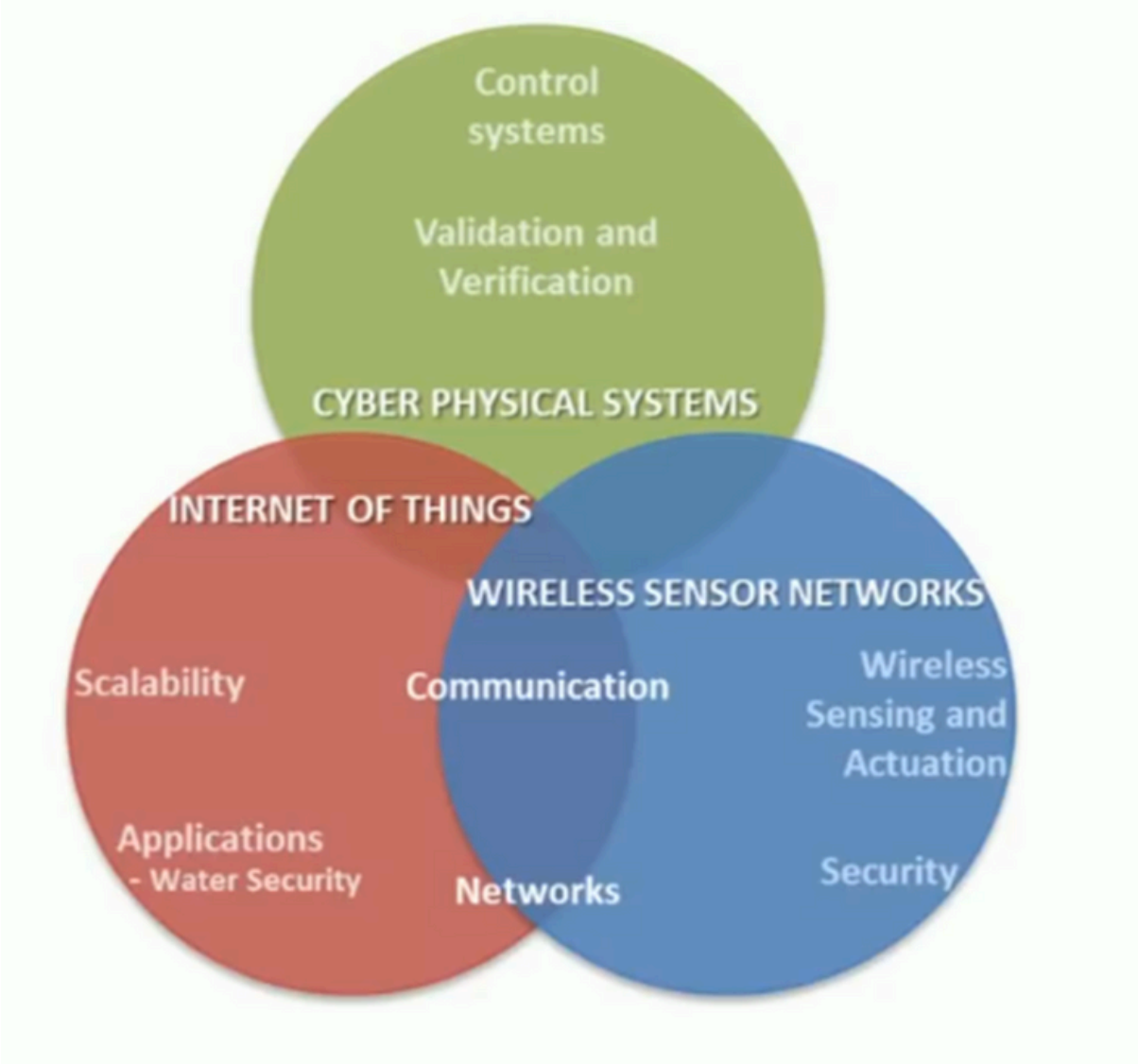
ADVANTAGES OF MECHATRONICS?

Electronics **enhancing** mechanics (to provide high levels of precision & reliability)

- eg. CNC machines, Automatic Teller Machines, Industrial robots.
-

Electronics **replacing** mechanics (to provide new functions and capabilities)

- eg. Digital watches, calculator



Examples of Mechatronics Devices

1. Switch
2. Relay
3. Solenoid
4. Sensor and Transducer
5. Telemetry and Data Acquisition

QUESTIONS AND ANSWER

Q1. What is mechatronics?

Ans: Mechatronics is an interdisciplinary field that combines mechanical engineering, electronics, computer science, and control engineering to design and create intelligent systems and products.

Q2. What are the key components of a mechatronic system?

Ans: The key components include sensors, actuators, control systems, and software that work together to perform specific functions.

Q3. How does mechatronics enhance automation in industries?

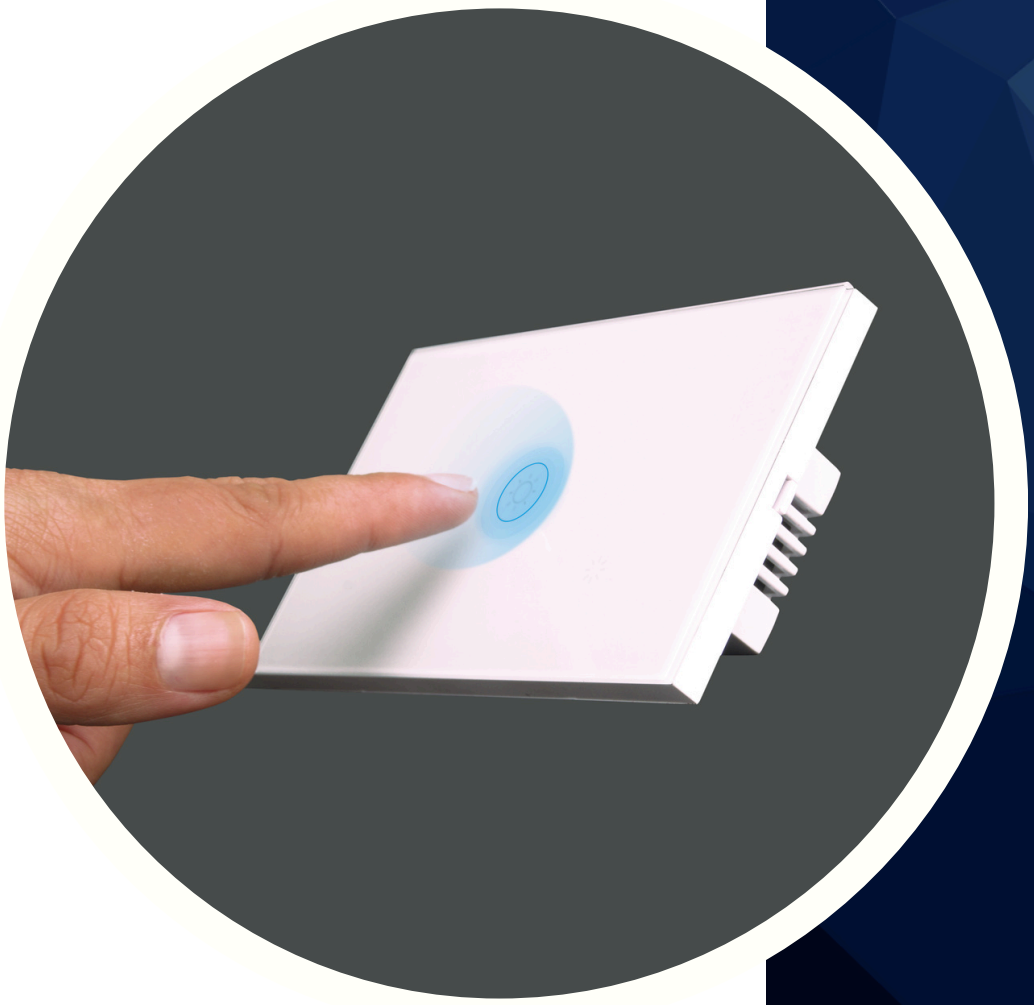
Ans: Mechatronics enhances automation by integrating various technologies to improve efficiency, precision, and reliability in manufacturing processes.

Q4. What are some applications of mechatronic devices?

Ans: Applications include robotics, automated manufacturing systems, smart appliances, and automotive systems.

CHAPTER TWO

SWITCH



2.1 Switch

- A mechanical, electrical, or electronic switch is **used to open or close circuits**.
- Refer to the act of **closing a switch** as **"making the circuit"**.
- Breaking the circuit refers to flipping on the switch.
- Another term for switching is "making or breaking the circuit".
- Switch types differ according on the material and mechanism employed.
- Switch example as displayed in Figure 2.1.1 below:

Figure 2.1.1

2.1 INTRODUCTION TO SWITCH

- A common way to describe switches is by how many throws and poles they have, like this:

  i. Single pole, single throw, or SPST
  ii. Single pole, double throw, or SPDT
  iii. Double pole, double throw, or DPDT
  iv. Triple Pole Double Throw (3PDT)
  v. Double-throw, 4-quadruple pole (4PDT)

- The number of **independent connecting circuits** that the switch regulates is expressed in switch terminology as the **number of poles**.
- The total number of **output connections** that are feasible is represented by the **number of throws**.

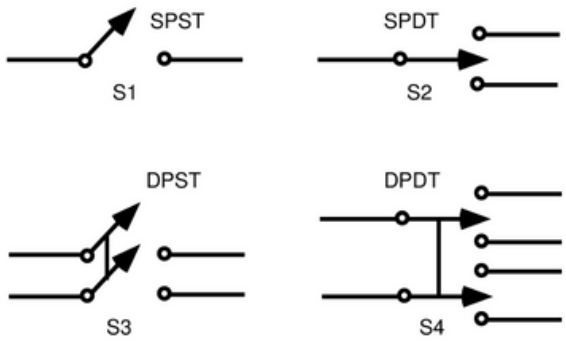


Figure 2.1.2

https://youtu.be/GlHMOK1AnsQ?si=SK8YS97NQsY6lWLM

WATCH NOW

2.2 Types of Switch

2.2.1 Push Buttons Switch

- A pushbutton is a switch activated by finger pressure.
- Two or more contacts open or close when the button is depressed.
- Pushbuttons are usually spring loaded so as to return to their normal position when pressure is removed.
- Figure 2.2.1 show that the mechanical-interlocked pushbutton with NO (normally open) and NC (normally close) contacts, rated to interrupt an ac current of 6A one million times.

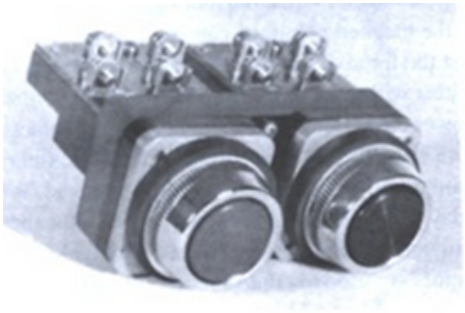


Figure 2.2.1

2.2.2 Limit Switch

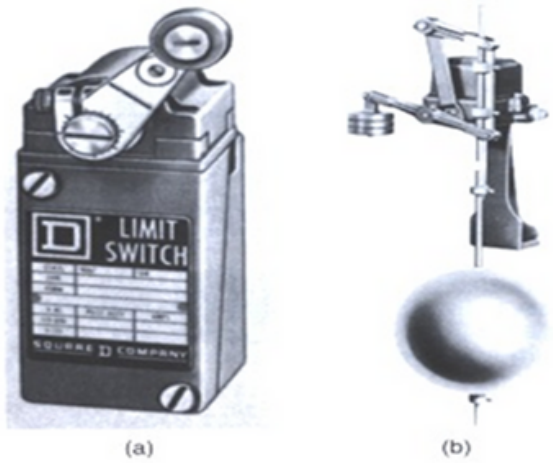


Figure 2.2.2

- A limit switch is a low-power snap-action device that opens or closes a contact, depending upon the position of mechanical part.
- Other limit switches are sensitive to pressure, temperature, liquid level, direction of rotation and so on.
- Figure 2.2.2 show that the limit switch with one NC contact, rated for ten million operations, position accuracy is 0.5 mm.

2.2 Types of Switch

2.2.3 Slide Switch

- A slide switch is a switch activated by sliding of two or more contacts open or close when the button is depressed.
- Figure 2.2.3 show that the mechanical-interlocked sliding plate/rod with NO (normally open) and NC (Normally close) contacts.

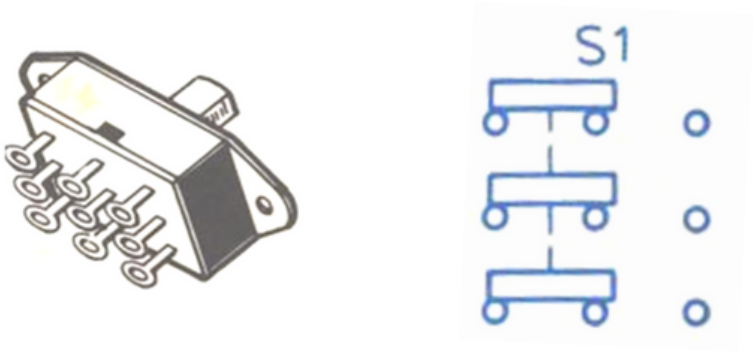


Figure 2.2.3

2.2.4 Rocker Switch

- A rocker switch is a switch activated by 3 finger which includes 2 finger push button for opening and closing of 2 circuits.
- Two contacts open or close for 2 circuits when the button are pressed and depressed.
- Figure 2.2.4 show that the mechanical-interlocked pushbutton with NO (normally open) and NC (Normally close) contacts through 2 circuit involved.

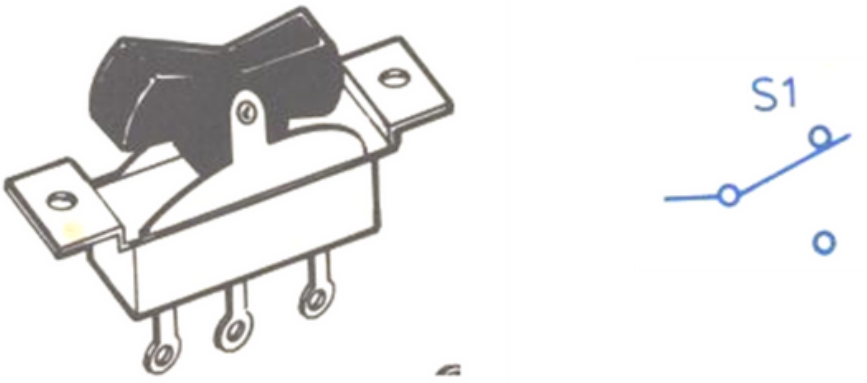


Figure 2.2.4

2.2 Types of Switch

2.2.5 Precision Switch

- A precision switch is a switch activated by roller loaded on the top of pushbutton to open or close a circuit.
- Only one contact open or close when the button is depressed by load moving on top ofthe roller. Pushbutton are usually spring loaded so as to return to their normal position when load on top of roller is removed.
- Figure 2.2.5 show that the mechanical-interlocked pushbutton with ON (normally open) and NC (Normally close) contacts, rated to interrupt an ac current of mechanical effect to the top of roller device.

Figure 2.2.5

2.2.6 Toggle Switch

- A toggle switch is a switch activated by ball bearing moving for open or close a circuit.
- The movement of roller makes a contact to open or close a circuit when the toggle is depressed.
- A toggle usually parallel with the force loaded so as to open or close.
- Figure 2.2.6 show that the mechanical-interlocked toggle pushbutton with NO (normally open) and NC (Normally close) contacts.

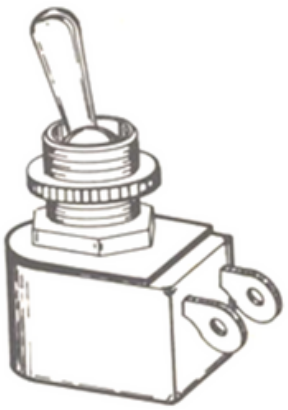


Figure 2.2.6

QUESTIONS AND ANSWER

Q1. What is the primary function of a switch?

Ans: A switch is used to open or close an electrical circuit, controlling the flow of electricity.

Q2. Describe the difference between SPST and DPDT switches.

Ans: An SPST (Single Pole Single Throw) switch controls one circuit with two positions (on/off), while a DPDT (Double Pole Double Throw) switch can control two circuits with two positions.

Q3. What types of switches are commonly used in industrial applications?

Ans: Common types include toggle switches, pushbutton switches, limit switches, and slide switches.

Q4. How does a limit switch operate?

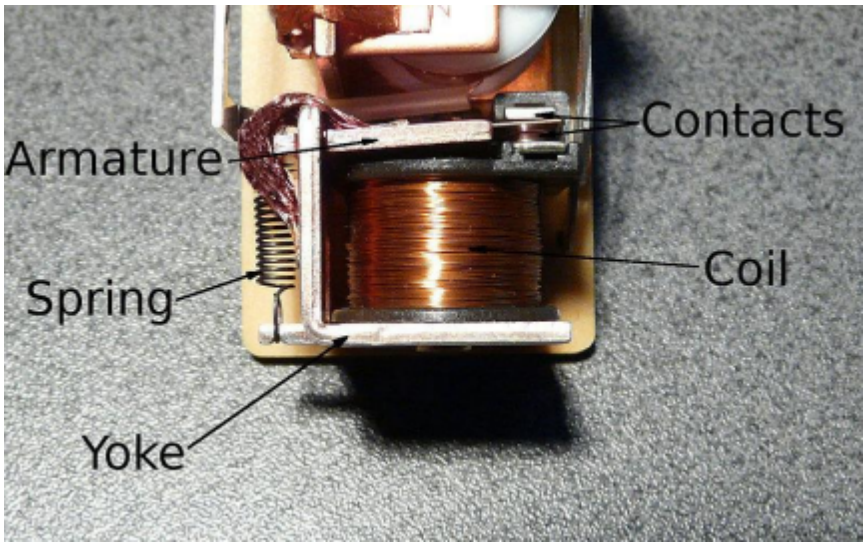
Ans: A limit switch is activated by the position of a mechanical part; it opens or closes contacts based on this position to control machinery or processes.

CHAPTER THREE

RELAY

3.1 Relay

- Relay is an electromechanical device.
- A relay responds to a control signal and performs basic ON/OFF switching.
- Relays are primarily made up of coils and contacts.
- A **magnetic field** is created when a current passes through a wire coil, activating the relay.
- An armature is pulled by the magnetic field, forcing the contact to open or close the circuit.



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WATCH NOW

3.2 Relay- Switch the higher signal Circuits

- The electrical relay offers a simple ON/OFF switching action in response to a control signal (low level signal).
- Figure 1.3 illustrates the principle. When a current flows through the coil of wire a magnetic field is produced. This pulls a movable arm that forces the contact to open or close.
- The contact is used to supply a current to a motor or other high voltage output components such as electric heater in a temperature control system (Higher signal circuits).

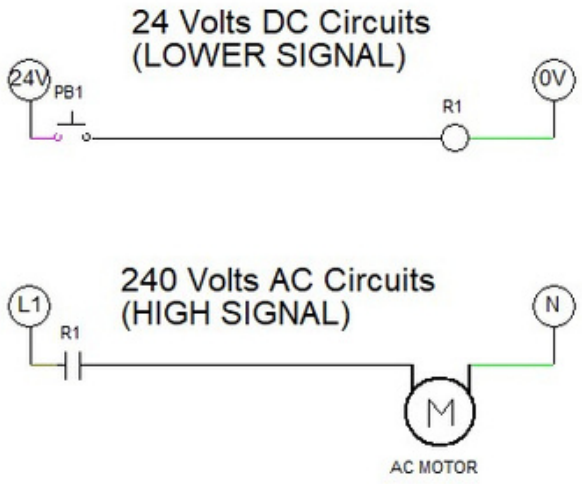


Figure 1.3 Before the push button is pressed

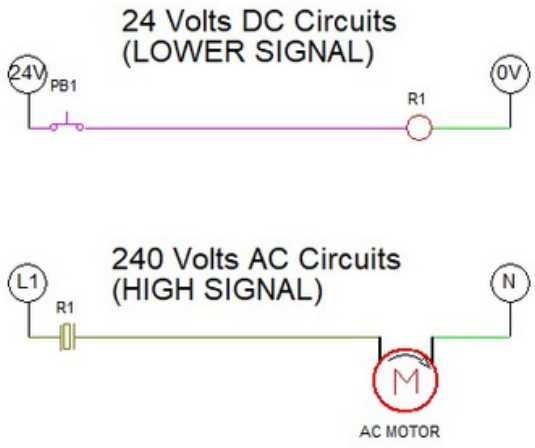
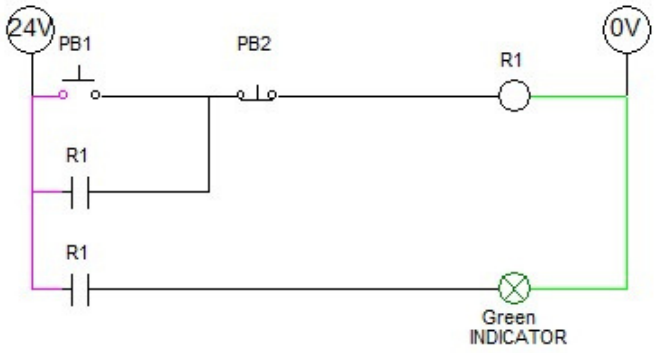


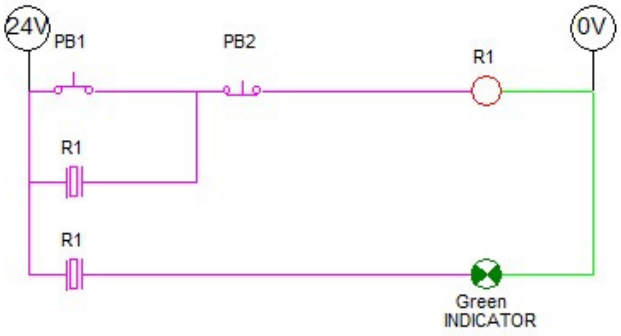
Figure 1.4 After the push button is pressed

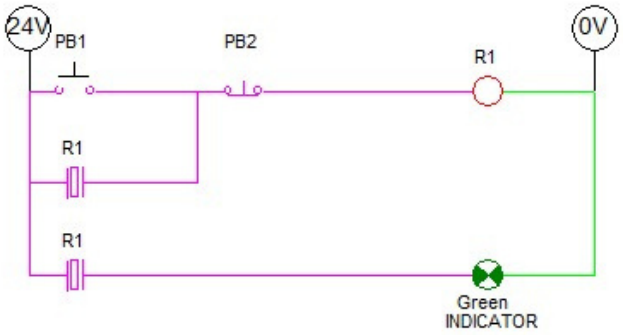
3.3 Latching Application



- In this case the relay is use as holding circuits.
- The contact of the relay will turn ON its coil once the coil energized.

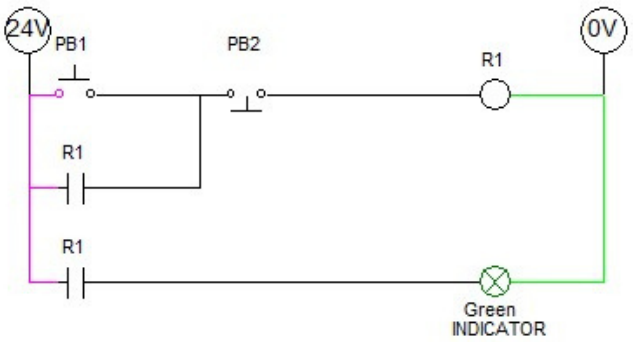
- When the PB1 is pressed, the coil R1 will be energized.
- At the same time the contact which is parallel connected to PB1 will supply the voltage to coil.





- Even though the PB1 is released but the coil still energized
- The green indicator will continue ‘ON’.

- The circuits can be deenergized using PB2 which is initially Normally Closed.
- This type of circuits is normally used to start and stop the machines.



QUESTIONS AND ANSWER

Q1. What is a relay and its purpose in a circuit?

Ans: A relay is an electrically operated switch that uses an electromagnet to mechanically operate a switching mechanism to control larger currents or voltages.

Q2. Explain the difference between a mechanical relay and a solid-state relay.

Ans: A mechanical relay uses physical moving parts to open or close contacts, while a solid-state relay uses semiconductor devices to perform the same function without moving parts.

Q3. What are latching relays and their applications?

Ans: Latching relays maintain their position after being actuated until they receive another signal to change state; they are used in applications requiring memory functions.

Q4. How do relays contribute to safety in electrical systems?

Ans: Relays can isolate different parts of a circuit, preventing overloads and protecting sensitive components from damage due to high currents or faults.

CHAPTER FOUR

SOLENOID

4.1 Solenoid

- A **solenoid** is an **electromechanical device** that uses electrical energy and magnetism to produce mechanical movement.
- A moving iron plunger and a coil with an iron core make up a solenoid.
- When the coil is activated, the plunger is drawn to it.
- Another mechanism can be triggered by the plunger's motion.
- Numerous electrically operated equipment, including locks, punches, marking machines, and valves, use solenoids.
- The solenoid example that is displayed below:

Solenoid Valve

Solenoid Door Lock

https://youtu.be/-MLGr1_Fw0c?si=u7tq_DBuaB7vmpOJ

WATCH NOW

QUESTIONS AND ANSWER

Q1. What is a solenoid and how does it work?

Ans: A solenoid is a coil of wire that generates a magnetic field when an electric current passes through it, converting electrical energy into linear motion.

Q2. List two common applications of solenoids in industry.

Ans: Solenoids are commonly used in locking mechanisms (like door locks) and as actuators in automated machinery (such as valves).

Q3. What factors should be considered when selecting a solenoid for an application?

Ans: Factors include voltage rating, pull force, stroke length, duty cycle, and environmental conditions.

Q4. How does the design of a solenoid affect its performance?

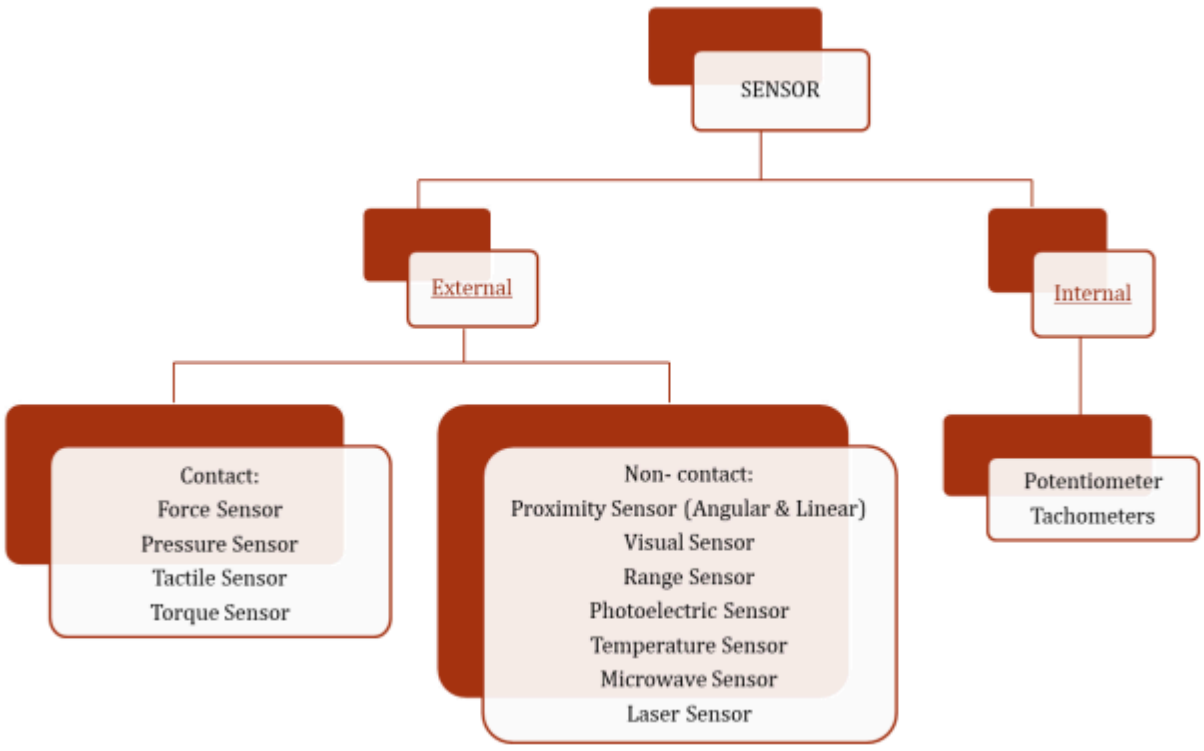
Ans: The design affects its efficiency, speed of actuation, force output, and heat dissipation capabilities during operation.

CHAPTER FIVE

SENSOR AND TRANSDUCER

5.1 Sensor and Transducer

- A **transducer** is an apparatus that converts one quantity into another.
- Its components, such as the displacement to the electrical movement force and others, can convert one signal quantity to another.
- To put it another way, a transducer is an apparatus that connects electrical and non-electrical sources.
- Physical parameters are transformed by a transducer into electrical signals that the acquisition system can understand.
- Temperature, pressure, acceleration, weight displacement, and velocity are a few typical characteristics.
- A **transducer's component** is a **sensor**.
- A sensor is an apparatus that reacts to a modification in a physical phenomena.
- The sensor classification is shown in the picture below:

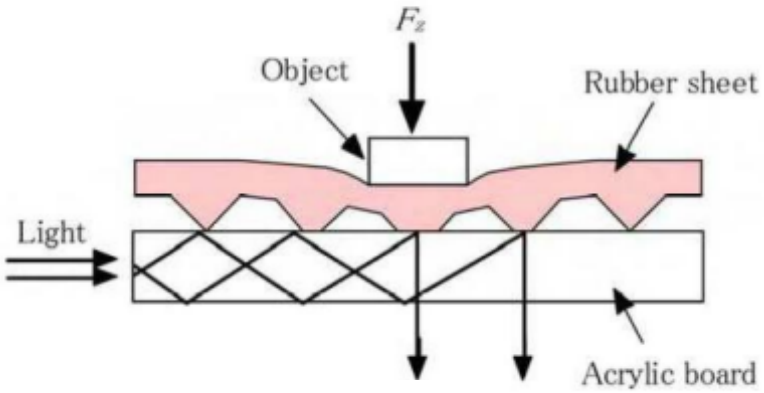


5.1 Sensor and Transducer

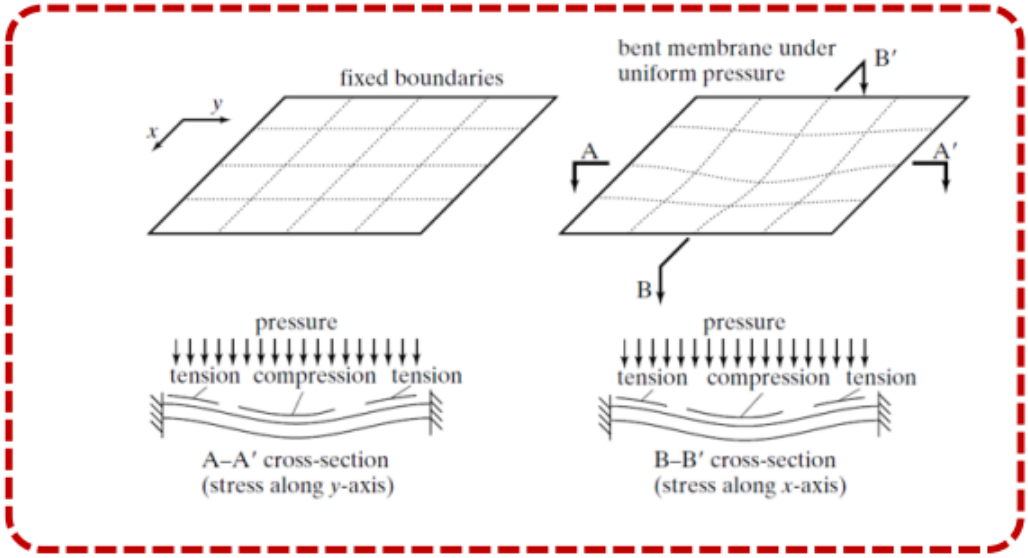
cont..

- The manipulator's external sensor is outside of it.
- This sensor is used in the workplace to control a manipulator and other equipment function together.
- Both touch and non-contact sensors fall under this category.
- **Non-contact sensors** detect the presence of an object by changes in pressure, temperature, or electromagnetic field without making physical contact.
- **Contact sensors** detect through touching.
- **A tactile mechanism** serves as the touch sensor's primary component.
- There are numerous sources of tactile information, including force, torque, and pressure.

i. Force Tactile Sensor

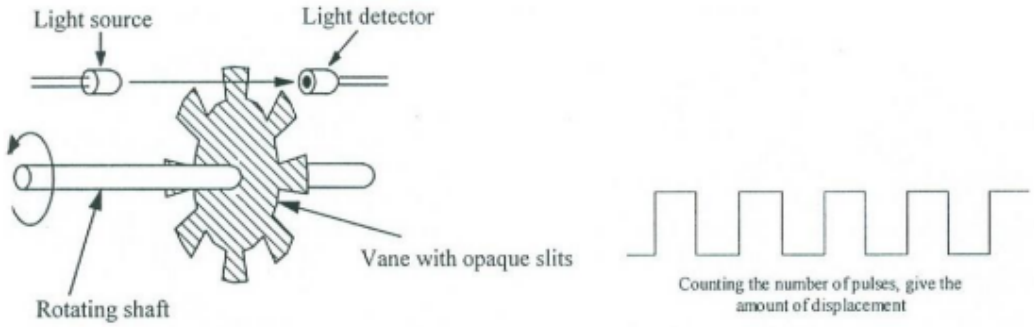


ii. Pressure Tactile Sensor



5.1 Sensor and Transducer

i. Optical Angular and Linear Sensor



cont..

- The non-contact sensor is typically employed in linear or angular movement proximity detection.
- A variety of sources, including optical, photoelectric, microwave, and laser sensors, are used for proximity sensing.
- The sensor's proximity data can then be used to alter the acceleration and velocity data.
- Temperature sensors take a direct reading of the ambient temperature.

https://youtu.be/PJfzQw4bovc?si=YnciO9pdr-DZIwzl

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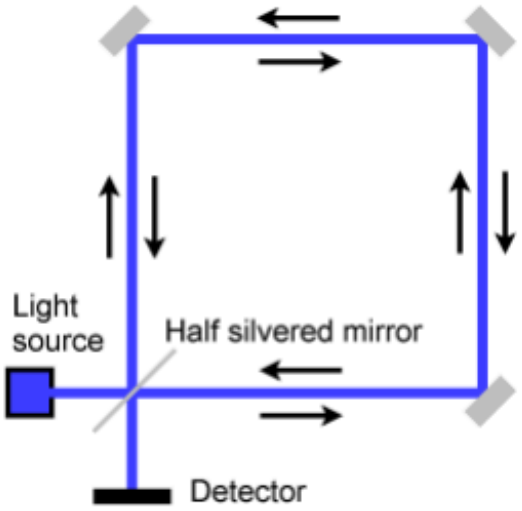
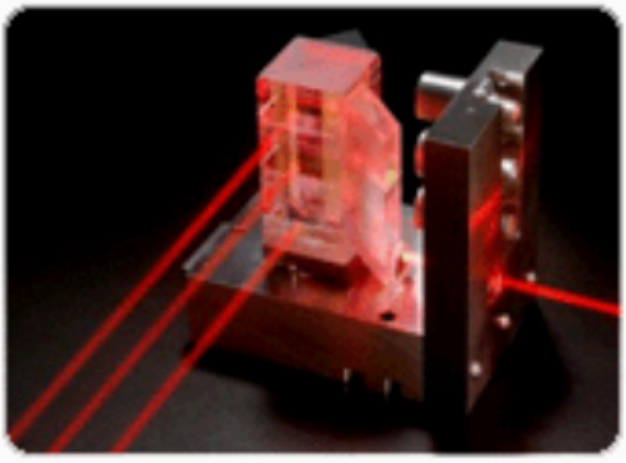
5.1 Sensor and Transducer

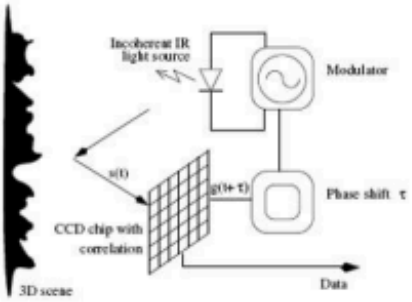
ii. Sagnac Interferometer Velocity Sensor



iii. Laser Distance Sensor



iv. Time of Flight Distance Sensor (Photoelectric)

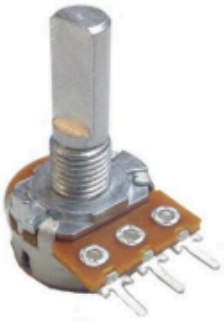


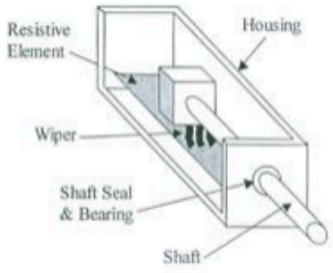
5.1 Sensor and Transducer

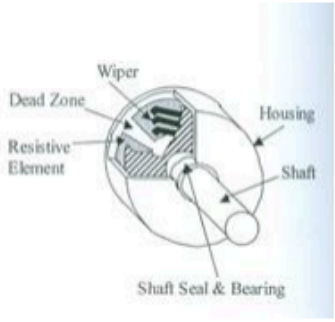
cont..

- Every joint on the robot has an **internal sensor**, which is typically **used to regulate the speed and location** of the **"tool-center point"**.
- The control system was closed-loop, including feedback between the manipulator and control unit.
- The sensor will detect the manipulator's position and speed, sending the information to the controller for processing.

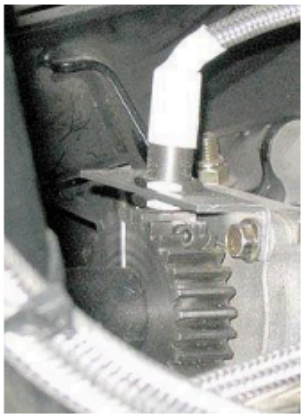
i. Potentiometer







ii. Tachometer



QUESTIONS AND ANSWER

Q1. Define the role of sensors in mechatronic systems.

Ans: Sensors detect physical phenomena (like temperature, pressure, or motion) and convert them into signals that can be interpreted by control systems.

Q2. What is the difference between a sensor and a transducer?

Ans: A sensor detects changes in physical quantities and provides output signals; a transducer converts one form of energy into another (e.g., mechanical to electrical).

Q3. Give examples of different types of sensors used in industrial applications.

Ans: Examples include temperature sensors (thermocouples), pressure sensors (piezoelectric), proximity sensors (inductive), and flow sensors (turbine).

Q4. How do sensors contribute to automation in industrial processes?

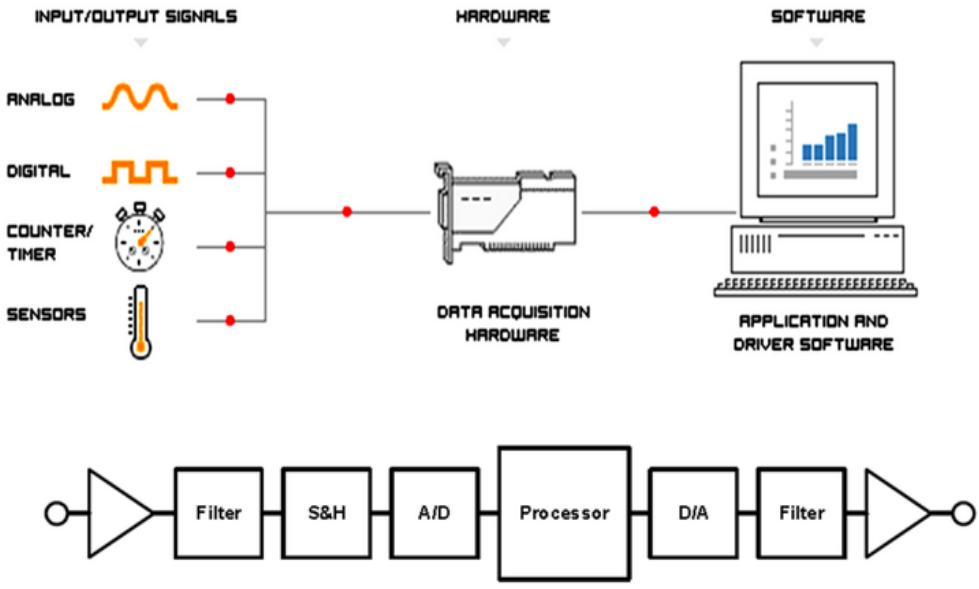
Ans: Sensors provide real-time data about system conditions, allowing for automated adjustments and controls that enhance efficiency and safety.

CHAPTER SIX

TELEMETRY AND DATA ACQUISITION

6.1 Telemetry and Data Acquisition

- **Telemetry** is the **long-distance data transfer** used for control and monitoring.
- Up to a few meters, data can be delivered immediately as a DC voltage or current.
- Long distances drastically restrict speed and make noise a major issue.
- When telemetry first began in the 19th century, it was communicated using DC at a rate of less than one word per minute via the first Morse trans Atlantic cables.
- DC voltage or current was transformed to audio tones and conveyed across wire over extended distances.
- A modem carried out this procedure, which was referred to as **modulation and demodulation** and vice versa.
- Sensors in telemetry systems in industrial electronics produce electrical signals that alter in some way in response to variations in physical properties.



Typical Example of Data Acquisition Block Diagram

6.1 Telemetry and Data Acquisition

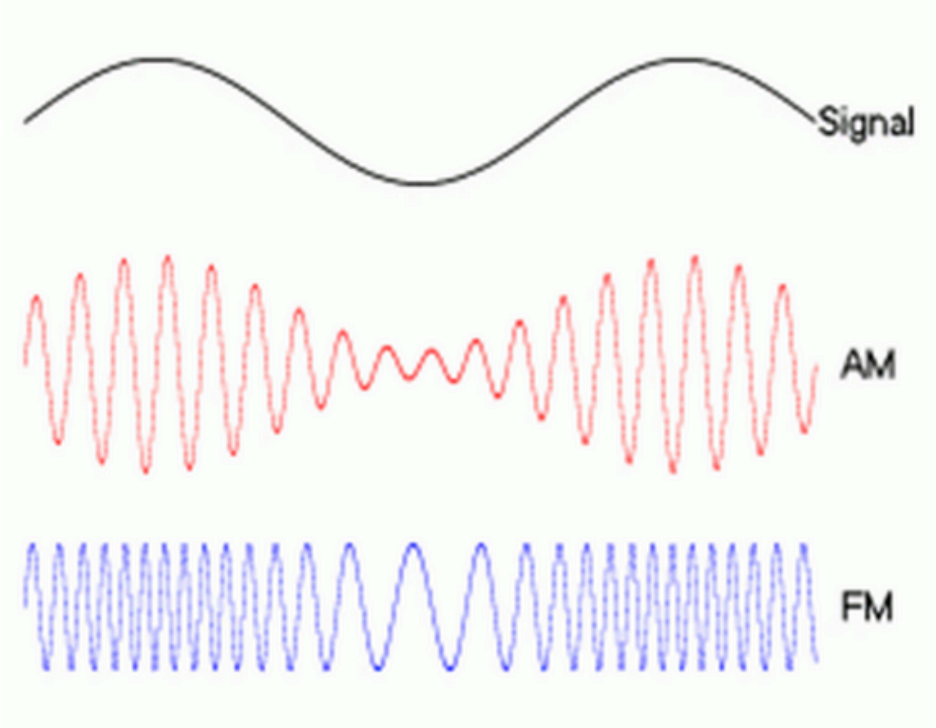
- Signals acquired in essentially two methods are measured and recorded using data capture systems:
  1. Signals derived from the direct measurement of electrical quantities are commonly found in fields like electronic component testing, environmental studies, and quality analysis activities. These signals can include resistance, frequency, and DC and AC voltages.
  2. Signals coming from transducers, including thermocouples and strain gauges.

- Analog and digital data acquisition are the two categories into which data acquisition is separated. The contrast of digital and analog data acquisition is shown below:

Analog Data System	Digital Data System
Wide bandwidth	Narrow bandwidth
Lower accuracy can be tolerated	High accuracy and low per-channel cost is required
Less complex than digital	Range in complexity
Not require converts to change analog voltages into discrete digital quantities or numbers	Require converts to change analog voltages into discrete digital quantities or numbers
Defined as a continuous function	Consist of a number of discrete and discontinuous pulse

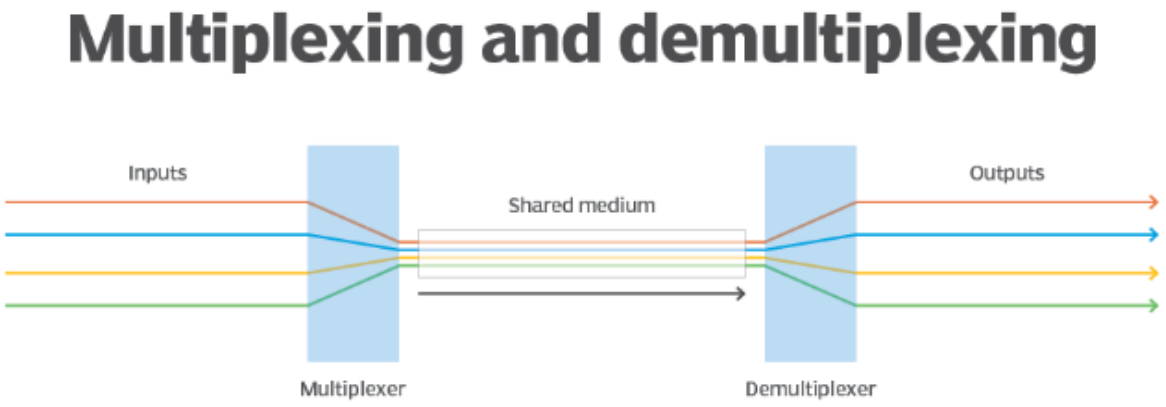
6.1 Telemetry and Data Acquisition

- Signals can be transmitted into remote area using a few methods suc as:
    1. Radio frequency such as Frequency Modulation And Amplitude Modulation
    2. Satelite Communication
    3. Fibre Optic or Internet Communication.



MULTIPLEXING SYSTEM

- The process of simultaneously sending two or more separate signals across a single communication channel is known as **multiplexing**.
- In order to transfer more information, multiplexing has the effect of expanding the number of communication channels.
- Time division multiplexing (TDM) and frequency division multiplexing (FDM) are the two fundamental forms of multiplexing.
- In general, digital information is handled by TDM systems, while analog information is handled by FDM systems.



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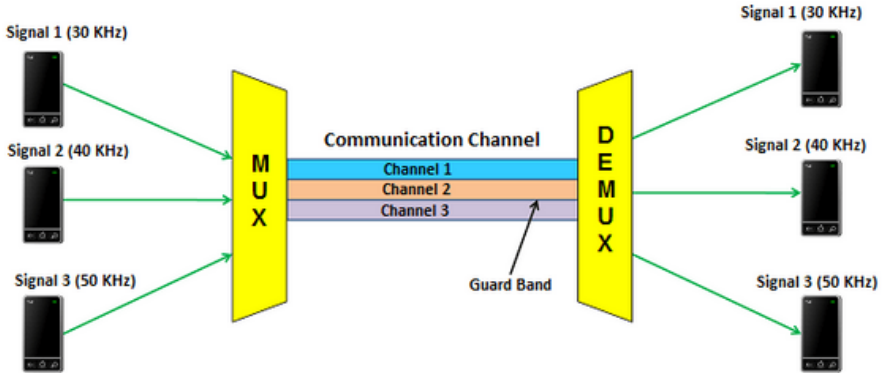
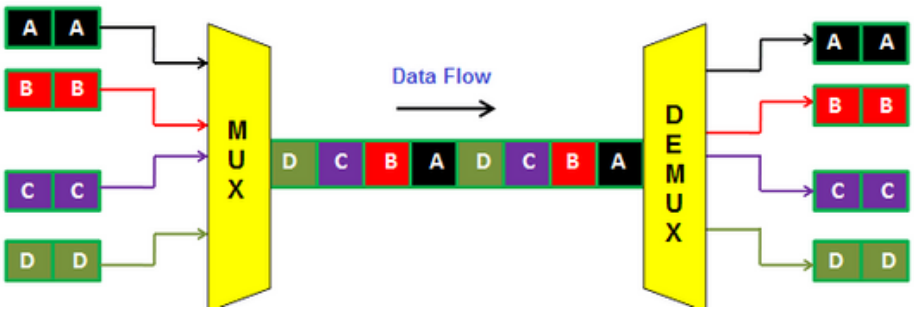


Frequency Devision Multiplexing



Time Devision Multiplexing

QUESTIONS AND ANSWER

Q1. What is telemetry and its significance in industrial applications?

Ans: Telemetry involves collecting data from remote locations for monitoring and analysis; it enables real-time decision-making based on accurate data from various sources.

Q2. Describe the process of data acquisition in mechatronic systems.

Ans: Data acquisition involves capturing signals from sensors, converting them into digital form using analog-to-digital converters (ADCs), and processing them for analysis or control.

Q3. What technologies are commonly used for telemetry systems?

Ans: Common technologies include wireless communication (RFID, Wi-Fi), satellite communication, and cellular networks for transmitting data over long distances.

Q4. How does data acquisition improve system performance?

Ans: By providing continuous feedback on system performance, data acquisition allows for timely adjustments to optimize operations and prevent failures or inefficiencies.

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