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Participant Handbook

Sector
Electronics

Sub - Sector
Industrial Automation

Occupation
Engineering-I&A

Reference ID: **ELE/Q7105, Version 1.0**
NSQF Level 5

Mechatronics Maintenance Specialist

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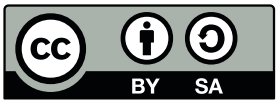

> Skilling is building a better India. If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi
Prime Minister of India

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COMPLIANCE TO
QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

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ELECTRONICS SECTOR SKILL COUNCIL OF INDIA

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/Qualification Pack

"Mechatronics Maintenance Specialist" QP No. **"ELE/Q7105, NSQF Level 5"**

Date of Issuance: February 24th, 2022
Valid up to*: June 2nd, 2025

*Valid up to the next review date of the Qualification Pack or the 'Valid up to' date mentioned above (whichever is earlier)

Authorized Signatory
Electronics Sector Skill Council of India

Acknowledgments

This participant's handbook meant for Mechatronics Maintenance Specialist is a sincere attempt to ensure the availability of all the relevant information to the existing and prospective job holders in this job role. We have compiled the content with inputs from the relevant Subject Matter Experts (SMEs) and industry members to ensure it is the latest and authentic. We express our sincere gratitude to all the SMEs and industry members who have made invaluable contributions to the completion of this participant's handbook. We'd also like to thank all the experts and organizations who have helped us by reviewing the content and providing their feedback to improve its quality.

This handbook will help deliver skill-based training in the field of Mechatronics for Mechatronics Maintenance Specialists. We hope that it will benefit all the stakeholders, such as participants, trainers, and evaluators. We have made all efforts to ensure the publication meets the current quality standards for the successful delivery of QP/NOS-based training programs. We welcome and appreciate any suggestions for future improvements to this handbook.

About this book

This participant handbook has been designed to serve as a guide for participants who aim to obtain the required knowledge and skills to undertake various activities as a Mechatronics Maintenance Specialist. Its content has been aligned with the latest Qualification Pack (QP) prepared for the job role. With a qualified trainer's guidance, the participants will be equipped with the following for working efficiently in the job role:

- **Knowledge and Understanding:** The relevant operational knowledge and understanding to perform the required tasks.
- **Performance Criteria:** The essential skills through hands-on training to perform the required operations to the applicable quality standards.
- **Professional Skills:** The Ability to make appropriate operational decisions about the field of work.

The handbook details the relevant activities to be carried out by a Mechatronics Maintenance Specialist. After studying this handbook, job holders will be adequately skilled to carry out their duties efficiently according to the applicable quality standards, with minimum supervision.

The content in this handbook is aligned with the following National Occupational Standards (NOSs) as given in the latest version of the Mechatronics Maintenance Specialist Qualification Pack (QP):

- ELE/N7109: Set up circuits and electrical components in the mechatronics system
- ELE/N7110: Install, test and use the sensors and actuators in the mechatronics system
- ELE/N7111: Install, test and use microcontroller in the mechatronics system
- ELE/N9905: Work effectively at the workplace
- ELE/N1002: Apply health and safety practices at the workplace

The handbook has been divided into an appropriate number of units and sub-units based on the content of the relevant QP. We hope it will facilitate easy and structured learning for the participants. We sincerely hope that participants will obtain enhanced knowledge and skills after studying this handbook and make career progress in the relevant and senior job roles.

Symbols Used


Key Learning Outcomes


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Steps


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1. Introduction

Key Learning Outcomes

By the end of this module, participants will be able to:

1. Describe the size and scope of the Electronics industry and its sub-sectors.
2. Define Mechatronics.
3. Describe the evolution level of mechatronics.
4. State uses of mechatronics.
5. State importance of mechatronics.
6. Discuss the role and responsibilities of a Mechatronics Maintenance Specialist.
7. Discuss various employment opportunities for a Mechatronics Maintenance Specialist in the Electronics industry.
8. State the organizational policies on incentives, personnel management reporting structure, etc.

UNIT 1.1: Overview of the Electronic Industry

Unit Objectives

By the end of this unit, participants will be able to:

1. Describe the size and scope of the Electronic industry and its sub-sectors.

1.1.1 Definition of Electronics

Electronics is a branch of physics that studies the electrons' flow, control, and behaviour and their effects on vacuums, gases, semiconductors, and devices using such electrons.

The electrons are controlled by devices (electronic components) that resist, carry, select, steer, switch, store, manipulate, and exploit them.

1.1.2 Electronic Industry

The electronics industry comprises companies that manufacture, design, manufacture, assemble, and electronic service products. To perform their primary functions, electronic products rely on electronic principles. It consists of materials, parts, components, subassemblies, and equipment that use electronics principles.

1.1.3 Profile of Electronic Sector of India

- Globally, electronics is one of the fastest-growing industries.
- The Indian market is predicted to be second only to China's, followed by Vietnam, South Korea and Taiwan.
- The Indian government focuses on manufacturing electronics hardware at the domestic level, which appears to be the conceptual foundation of the Make in India and Digital India programmes. These initiatives seek to attain a market size of US$ 251 billion by 2023 by encouraging local production and exports across the electronics system design and manufacturing (ESDM) value chain.
- The seven key segments of the Indian electronics industry are industrial electronics, consumer electronics, communications and broadcasting electronics, strategic electronics, electronic components, computer hardware, and LED products.
- The Electronics Development Fund (EDF), the Phased Manufacturing Program (PMP), the Modified Special Incentive Package Scheme (MSIPS), Preferential Market Access (PMA), and a reduction in tariff structure have all been used by the Indian government to support the sector.

1.1.4 Size of Electronic Sector in India

- The electronics sector of India contributes around 3.4% of the country's Gross Domestic Product (GDP).
- The IT sector in India is one of the most significant contributors, with a 9% contribution to Gross Domestic Product (GDP).
- The industry size is around US$ 194 billion and is expected to cross US$ 300-350 billion by 2025.

1.1.5 Key Drivers

The following are some of the electronic industry's most important growth drivers:

- **Economic growth:** India has one of the world's fastest-growing economies, with GDP forecast to rise consistently. Demand in the industry and strategic electronics domains has been positively driven by rising economic activity and implementation of the newest automation technology across many industries.
- **Rapid urbanization and income growth:** Rapid urbanization, combined with rising incomes, has made items more affordable, resulting in increased demand for mobile phones, tablets, and other household gadgets.
- **Government initiatives:** The GST, Make in India, and other policies like Preferential Market Access have improved the business climate for domestic manufacturing. Demand for electronic items is also boosted by government flagship programmes such as Smart Cities and Digital India. The government announced three further plans in April 2020, which were notified by the Ministry of Electronics and Information Technology (MeitY), giving a total of 500 billion (US$ 7.2 billion) in incentives under the schemes. These incentives will boost domestic electronics output and encourage anchor firms in India's key electronics clusters.

  Production Linked Incentives (PLI), Modified Electronics Manufacturing Clusters (EMC 2.0), and Scheme for the promotion of manufacturing of components and semiconductors (SPECS) are the three essential schemes.
- **Evolving technology and innovation:** Rapid technological advancements and newer items with enhanced technologies have resulted in shorter product life cycles for electrical products. Customers may also replace their old electronic equipment with newer items thanks to shifting customer attitudes and consumer-to-consumer websites like Olx and Quikr.

  Demand for high-speed Internet has also fueled the growth of high-end smartphone sales. Consumer electronics has seen tremendous innovation due to this increased demand for high technological items. New technologies such as artificial intelligence (AI), the Internet of Things (IoT), and robots and analytics in the industrial and strategic electronics segment have contributed to various electronic products' overall growth, boosting local demand.

1.1.6 Scope of Electronic Industry

The electronic industry has scope in the following sector:

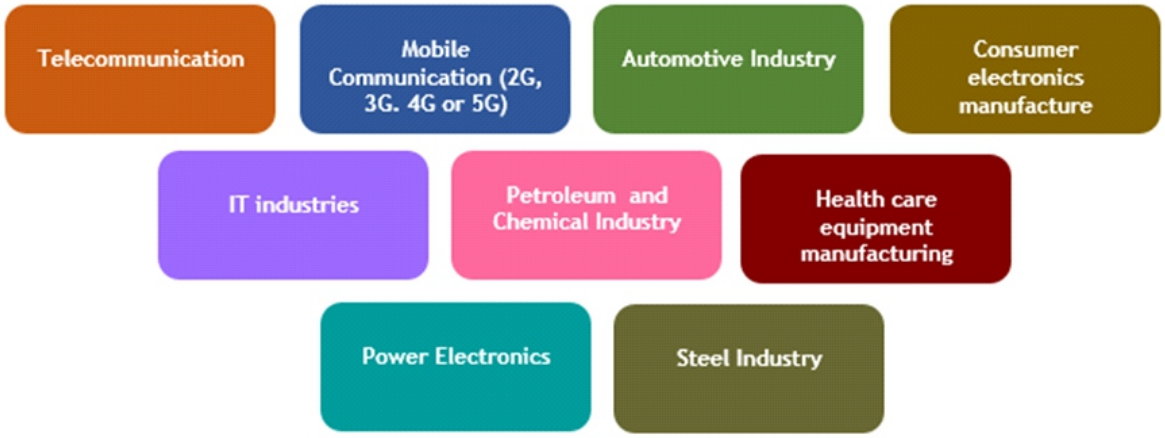

Fig. 1.1.1 Scope of the electronic industry

Notes

Scan the QR Code to watch the related videos

https://www.youtube.com/watch?v=JgLu40JBa-c

Scope of Electronic Industry

UNIT 1.2: Introduction to Mechatronics

Unit Objectives

By the end of this unit, participants will be able to:

1. Define Mechatronics
2. Describe the evolution level of mechatronics
3. State uses of mechatronics
4. State importance of mechatronics

1.2.1 Mechatronics

Mechatronics is made from the words "mecha" (mechanics) and "tronics" (electronics).

In other words, technologies and produced items will increasingly incorporate electronics into mechanics, intimately and organically, making it hard to distinguish between them.

Mechatronics is a multidisciplinary field that describes the skills required in today's modern automated manufacturing industry. Mechatronics engineers produce simpler, smarter systems at the crossroads of mechanics, electronics, and computation.

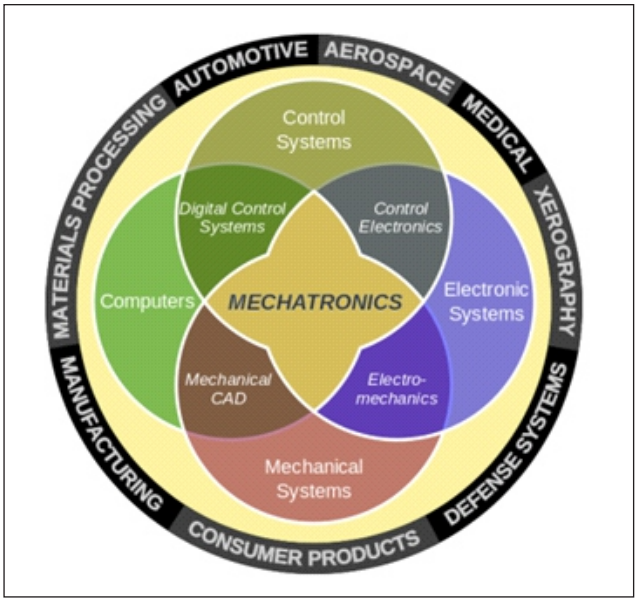

Fig. 1.2.1 Application of Mechatronics

1.2.2 Evolution Level of Mechatronics

- **Primary Level Mechatronics:** At the fundamental control levels, this level includes I/O devices such as sensors and actuators that combine electrical signals with mechanical action. Examples: Fluid valves and relays that are controlled by electricity
- **Secondary Level Mechatronics:** Microelectronics are integrated into electrically controlled devices at this level. Examples: Players for cassette tapes
- **Third Level Mechatronics:** This level combines sophisticated feedback functions into the control strategy, increasing the quality of the smart system in terms of sophistication. Microelectronics, microprocessors, and other 'Application Specific Integrated Circuits' are part of the control approach (ASIC). They control an electrical motor to operate industrial robots, hard disc drives, CD drives, and automated washing machines, for example.
- **Fourth Level Mechatronics:** This level of mechatronics includes intelligent control. It provides technologies for intelligence and failure detection and isolation (FDI).

1.2.3 Utility of Mechatronics

Mechatronics may be used in many industries and for a wide range of applications. While mechatronics is most commonly associated with the manufacturing business (which includes the manufacture of consumer products, industrial goods, automobiles, and electronics, among other things), it is also used in healthcare, transportation, and a variety of other disciplines. These are a few of the most common mechatronics applications to be aware of:

- Robotic automation
- Home and building automation
- Computer-driven machinery
- Medical imaging systems
- Robotic surgery
- Machine vision and inspection
- Various sensing and control systems
- Temperature/humidity control
- Automotive engineering
- Computer-aided design and production (such as CNC)
- Transportation

1.2.4 Importance of Mechatronics

- It has simplified the process of designing products and processes.
- The Mechatronics system aids in the improvement of performance and quality.
- The products are both cost-effective and of good quality.
- Flexibility is increased.

Notes

Scan the QR Code to watch the related videos

https://youtu.be/af9xQznYQAw

Mechatronics

UNIT 1.3: Role and Responsibilities of a Mechatronics Maintenance Specialist

Unit Objectives

By the end of this unit, participants will be able to:

1. Discuss the role and responsibilities of a Mechatronics Maintenance Specialist.
2. Discuss various employment opportunities for a Mechatronics Maintenance Specialist in the Electronics industry.
3. State the organizational policies on incentives, personnel management reporting structure, etc.

1.3.1 Mechatronics Maintenance Specialist

A Mechatronics Maintenance Specialist is responsible for installing, testing, and using the mechatronics system's sensors, actuators, and microcontrollers. The individual is also responsible for carrying out the repair and maintenance of the mechatronics system.

1.3.2 Job Responsibilities of a Mechatronics Maintenance Specialist

The key responsibilities of a Mechatronics Maintenance Specialist are:

- Troubleshoot, repair and install all aspects of CNC equipment
- Relocate, install, maintain and repair electrical, electronic, mechanical, hydraulic and pneumatic machinery and equipment
- Connect wiring & hydraulic lines
- Diagnose machinery and equipment malfunctions through observation and analysis of blueprints, machine parts, sketches or specifications
- Discuss machine operation variations with Team Leaders and maintenance coworkers to diagnose problems and perform proper repairs
- Ensure all routine and scheduled maintenance on equipment is completed on time and documented
- Maintain equipment and facilities
- Maintain accurate records

1.3.3 Career Opportunities

A degree in mechatronics can lead to employment in management, including project management. Laboratories, industrial factories, and engineering design offices are all examples of workplaces.

Cybersecurity, computer science, automotive engineering, robotics, artificial intelligence, telecommunications, consumer products, and packaging are domains where mechatronics professionals operate.

1.3.4 Organizational Policies on incentives, Personnel Management and Reporting Structure

The organizational policies on incentives, personnel management, and reporting structure depend on the organization the individual joins. These vary across organizations.

For example, a public sector company may offer different incentives for work performance compared to a private company. The same is the case with the reporting structure.

Personnel management policies also tend to differ from organization to organization. The individual should conduct proper research before interviewing for a job at a particular company to ensure that they are satisfied with the company policies on remuneration, human resource management, career progression, etc.

Exercise

1. Identify any two key drivers of the electronic industry.
2. State five job responsibilities of a Mechatronics Maintenance Specialist.
3. Define Electronics.
4. State in brief about Mechatronics.

Notes

Scan the QR Code to watch the related videos

https://youtu.be/4YjLZcQRLds

Job Responsibilities of a Mechatronics Maintenance Specialist

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2. Process of Setting Up Circuits and Electrical Components in the Mechatronics System

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Unit 2.1 - Introduction to Mechatronics Systems

Unit 2.2 - Circuits, Electrical Components and Pneumatic Systems

ELE/N7109

Key Learning Outcomes

By the end of this module, participants will be able to:

1. Explain the mechatronics system and its scope in the automation sector.
2. Explain the traditional vs mechatronics approach.
3. Explain how to interpret the block diagram representation of a general mechatronics system showing various components with suitable examples.
4. Explain relevant control systems such as open and closed-loop systems and basic elements of the closed-loop system.
5. Explain the basic circuit concepts.
6. Explain the semiconductor circuit elements.
7. Explain different types of circuits used in mechatronic devices.
8. Explain how to interpret the pneumatic symbols in pneumatic systems.
9. Describe the function and operation of pneumatic valves.
10. Describe the logic functions used in the pneumatic system.
11. Describe the function of relays and their working in the pneumatic system.
12. Explain the need for the proximity sensor and its application in a pneumatic cylinder.
13. Explain the design of cascade circuits.
14. Describe the process of programming PLCs in the Ladder diagram.
15. Explain the principles of operation, characteristics and applications of power semiconductor devices.
16. Explain the concept of fluid power.

UNIT 2.1: Introduction to Mechatronics Systems

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the mechatronics system and its scope in the automation sector.
2. Explain the traditional vs mechatronics approach.
3. Explain how to interpret the block diagram representation of a general mechatronics system showing various components with suitable examples.
4. Explain relevant control systems such as open and closed-loop systems and basic elements of the closed-loop system.

2.1.1 Mechatronics System

A Mechatronics system combines mechanical, electrical, telecommunications, control and computer science technologies. It is used to integrate microprocessor control systems and electrical and mechanical systems. A mechatronics system is not just a marriage of electrical and mechanical systems and is more than just a control system; it is the complete integration of all of them.

The mechatronic system comprises several systems like measurement system, drive and actuation system, control system, microprocessor system, and computer system.

Traditional vs Mechatronics Approach

Mechanical, hydraulic, and pneumatic components and concepts are used to develop components in conventional design. Mechanical, electrical, computer technology, and control engineering concepts are used in a mechatronics method to build a system.

Comparison of traditional and mechatronics design

S.No	Basis	Traditional Design	Mechatronics Design
1	Basis	Traditional systems such as mechanical, hydraulic and pneumatic systems	Mechanical, electronics, computer technology and control engineering
2	Flexibility	Less flexible	More flexible
3	Accuracy	Less accurate	More accurate
4	Design Mechanism	More complicated mechanism in design	Less complicated mechanism design
5	Components	It involves more components and moving parts	It involves fewer components and moving parts

Table 2.1.1 Comparison of traditional and mechatronics design

2.1.2 Key Elements of Mechatronics System

A system, sensors, actuators, and devices for information processing create a basic structure of the mechatronic system. The surrounding environment in which the mechatronic system operates is also essential.

The system usually has a mechanical, electromechanical or hydraulic structure or a combination of these structures. A given physical system can be generally understood as a respective system that a hierarchically structured mechatronic system can represent. The mechatronic system is composed of the following main components:

- **Sensors:** It is a device that monitors and responds to environmental input. Light, heat, motion, moisture, pressure, or any of a variety of other environmental phenomena might constitute the specific input.
- **Actuators:** It is a device that converts a control signal into mechanical motion using a source of electricity. Actuators may be found everywhere, from automotive door locks to aircraft ailerons.
- **MicroControllers:** It is called the "brain" of the mechatronic system, processing user commands and detected inputs to create command signals that are then transmitted to the actuator. Actuators are electronic devices that transform electrical energy into mechanical energy.

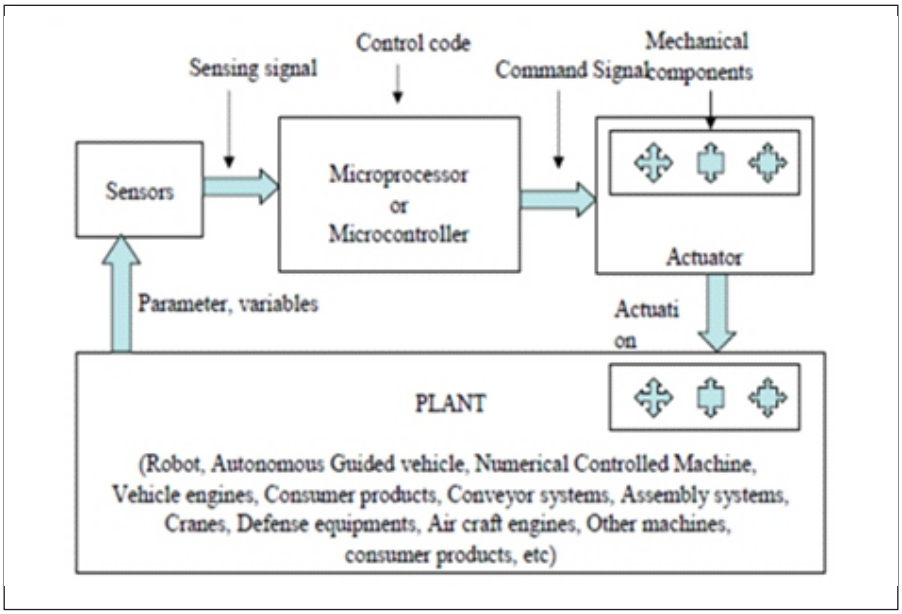


Fig. 2.2.1 Key elements of mechatronics system

2.1.3 Advantages and Disadvantages of Mechatronics System

Advantages

- It is both cost-effective and capable of producing high-quality goods.
- Production of international-standard parts and products results in a superior reputation and return.
- It is ideal for applications requiring great dimensional precision.
- It allows for great flexibility when it comes to changing or redesigning systems.
- It has outstanding performance properties.
- It leads to manufacturing, assembly, and quality control automation.
- In the manufacturing industry, mechatronic systems boost productivity.
- Low-volume production is aided by the reconfiguration feature provided by pre-supplied programmes.
- It has higher adaptability, which is necessary for short product cycles.
- Remote control, as well as centralized monitoring and control, are both possible with it.
- It utilizes machines to a larger extent.
- Proper maintenance and quick diagnosis of the defect are anticipated to extend the life of the machine.

Disadvantages

- The initial investment is substantial.
- Repairs and maintenance can be pricey.
- Design and implementation need multidisciplinary engineering expertise.
- Its operation necessitates the use of highly skilled personnel.
- When choosing a mechatronic system, extensive techno-economic analysis is required.
- It has a high level of difficulty in identifying and correcting system faults.

2.1.4 Scope of Mechatronics in Automation

Mechatronics has revolutionized the design and production process; in recent years, its seen how the use of microelectronics and computers in the manufacturing industry has considerably improved product quality, and integrated embedded technology has become an essential component of automation. In the sphere of automation, Mechatronics has achieved more significant advancements. Automation has been employed in a wide range of applications, including manufacturing, equipment process control, robotics, and home automation, among others. Mechatronics has enabled goods to have a high level of flexibility and dependability. By producing new goods, Mechatronics has transformed our markets. Mechanical engineering, electronics, and computer intelligence are all used to create advanced goods.

2.1.5 Design Stages of Mechatronics System

The steps of the mechatronics system design process are as follows:

Stage 1: Need for Design: The process of designing a mechatronics system starts with a need. Dissatisfaction with an existing condition is the most common source of needs. Needs can be derived from operational or service personnel and customers via sales or marketing agents. They might be made to cut costs, improve reliability or performance, or simply alter because the public has grown tired of the product.

Stage 2: Problem analysis: The analysis of the problem, or determining the fundamental nature, is perhaps the most crucial phase in the mechatronics system design process. The underlying issue is not always what it appears to be on the surface. Because this step takes up a small portion of the overall time required to construct the final design, its significance is sometimes ignored. It is advisable to broaden the scope of the problem as much as feasible. If the problem is not clearly stated, time will be wasted on designs that will not meet the demand.

Stage 3: Specification preparation: The design must fulfil all performance requirements. As a result, the specification of the requirements must come first. This section will include the issue specification, limits imposed on the solution, and the criteria used to assess the design. All of the design's functions, as well as any desirable characteristics, are listed in the problem statement. Some of the statements on the problem are as follows:

- Mass and dimensions of design.
- Type and range of motion required.
- Accuracy of the element.
- Input and output requirements of elements.
- Power requirements.
- Operating environment.
- Interfaces.
- Relevant standards and code of practice.

Stage 4: Identifying potential solutions: This stage is often referred to as the conceptualization stage. The conceptualization stage identifies the elements, mechanisms, materials, and configuration procedures that, when combined in some way, result in a design that meets the need. This is the most important stage in using ingenuity and imagination.

Synthesis is an essential part of this phase. Synthesis is the process of taking concept pieces, organizing them in the appropriate sequence, and sizing and dimensioning them correctly.

Outline solutions are created for various conceivable models, which are detailed enough to show how to acquire each essential function.

Stage 5: Evaluation or selection of a suitable solution: This step entails a detailed design examination. The assessment step involves a comprehensive computation of the design's performance using an analytical model, generally utilizing a computer. The numerous solutions found in step 4 are analyzed, and the most appropriate one is chosen.

Stage 6: Detailed design creation: The specifics of the chosen design must be worked out. In order to find the best design features, substantial simulated service testing of an experimental model or a full-size prototype may have been necessary.

Stage 7: Production of working drawing: The completed drawing must be correctly communicated to the individual manufacturing it. An oral presentation or a design report may be used to communicate. The design report includes detailed technical drawings of each component and the machine's assembly and a thorough specification for the manufacturing process.

Stage 8: Design implementation: The components are manufactured and assembled as a whole system according to the designs.

2.1.6 Measurement System

A measurement system is a system which is used for making measurements. It has as its input the quantity being measured and its output the value of that quantity. For example, a temperature measurement system, i.e. a thermometer, has an input of temperature and an output of a number on a scale.

- A sensor responds to the quantity being measured by giving as its output a signal related to the quantity. For example, a thermocouple is a temperature sensor.
- A signal conditioner takes the signal from the sensor and manipulates it into a condition suitable for either display or, in the case of a control system, for exercise control.
- A display system where the output from the signal conditioner is displayed.

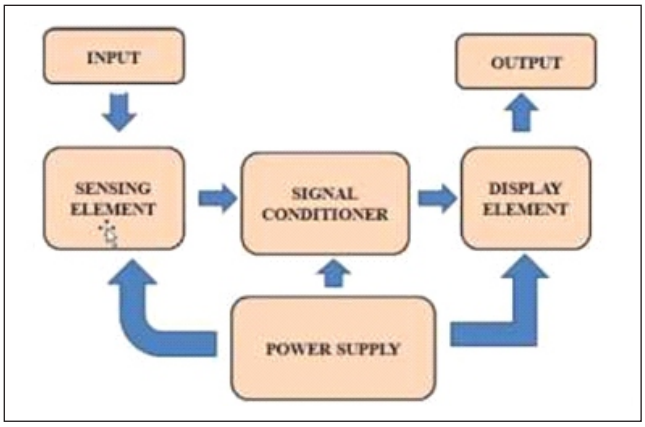


Fig. 2.2.2 Measurement System

2.1.7 Control System

A control system can is a system which is used to control its output to some particular value or a particular sequence of values. So, for example, an air conditioner can set a particular temperature, and it works based on sensing the atmospheric temperature.

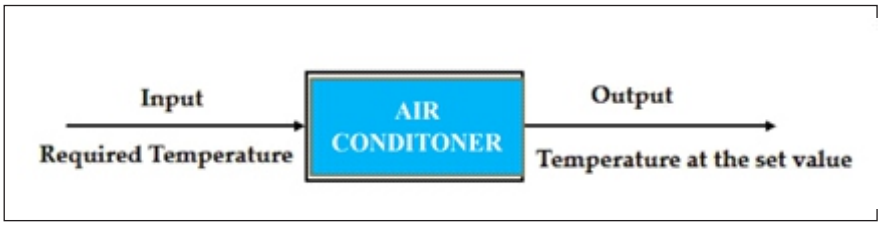


Fig. 2.2.3 Example of Control System

The Control system can be classified as follows:

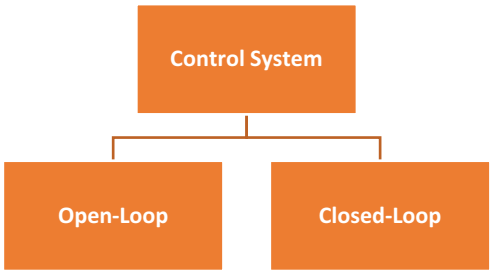


Fig. 2.2.4 Classification of Control System

2.1.8 Open-Loop System

In an open-loop system, the shaft's rotation speed may be exclusively governed by the initial setting of a knob that influences the voltage provided to the motor. Any changes in the supply voltage, the motor's characteristics as a consequence of temperature changes, or the shaft load will cause the shaft speed to fluctuate. However, this will not be compensated. There is not any feedback loop.

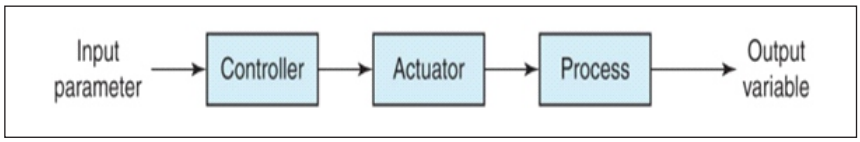


Fig. 2.2.5 Open-Loop System

Advantages

- **Simplicity and stability:** Being simpler in their layout, they are economical and stable too due to their simplicity.
- **Construction:** Due to their simple layout so are easier to construct.

Disadvantages

- **Accuracy and Reliability:** Due to the absence of a feedback mechanism, they are very inaccurate in terms of result output and unreliable.
- **Noise Reduction:** Due to the absence of a feedback mechanism, they are unable to remove the disturbances occurring from external sources.

2.1.9 Closed-Loop System

Use the control system's output to alter the input signal on occasion. This is referred to as feedback. "A closed-loop control system has a special characteristic called feedback." The output of a closed-loop control system is compared to the intended outcome, and then necessary control actions are taken to change the input signal. As a result, a closed-loop system must always include a sensor to monitor the output and compare it to the intended outcome.

The elements of the closed-loop control system are the Comparison Unit, Control Unit, Correction Unit, Process Unit, and Measurement Device.

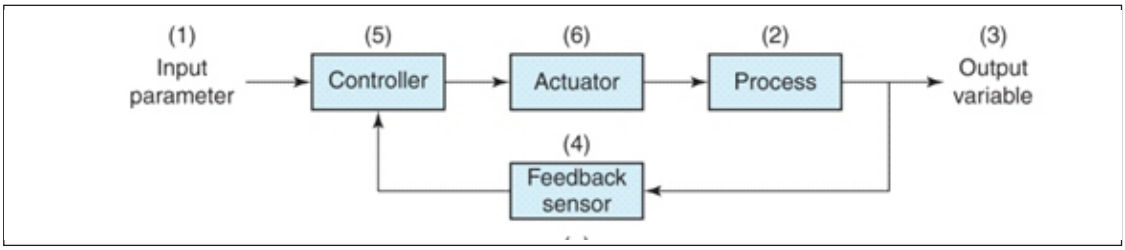


Fig. 2.2.6 Closed-Loop System

Advantages

- **Accuracy:** They are more accurate than open-loop systems due to their complex construction. They are equally accurate and are not disturbed in the presence of non-linearities.
- **Noise reduction ability:** Since they are composed of a feedback mechanism, they clear out the errors between input and output signals and remain unaffected by the external noise sources.

Disadvantages

- **Construction:** They are relatively more complex in construction, and hence it adds up to the cost making them costlier than the open-loop system. Since it consists of the feedback loop, it may create the oscillatory response of the system, and it also reduces the overall gain of the system.
- **Stability:** It is less stable than the open-loop system, but this disadvantage can be stroked off since we can make the system's sensitivity minimal to make the system as stable as possible.

Notes

Scan the QR Code to watch the related videos

https://youtu.be/Zla-D7wOvO4
Mechatronics System

https://youtu.be/NhmVFu1duRA
Advantages and Disadvantages of Mechatronics System

https://youtu.be/br-ezdmEq7A
Scope of Mechatronics in Automation

https://youtu.be/Md-j1Ko0dbA
Pneumatic System

https://youtu.be/bXXL-0sf8gs
Pneumatic Valves

https://youtu.be/s2na8CumNR0
Proximity Sensors

https://youtu.be/Zp6jf4lbF6A
Cascade Amplifier sensors

UNIT 2.2: Circuits, Electrical Components and Pneumatic Systems

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the basic circuit concepts.
2. Explain the semiconductor circuit elements.
3. Explain different types of circuits used in mechatronic devices.
4. Explain how to interpret the pneumatic symbols in pneumatic systems.
5. Describe the function and operation of pneumatic valves.
6. Describe the logic functions used in the pneumatic system.
7. Describe the function of relays and their working in the pneumatic system.
8. Explain the need for the proximity sensor and its application in a pneumatic cylinder.
9. Explain the design of cascade circuits.
10. Describe the process of programming PLCs in the Ladder diagram.
11. Explain the principles of operation, characteristics and applications of power semiconductor devices.
12. Explain the concept of fluid power.

2.2.1 Electric Circuit

A channel through which electric current flows is known as an electric circuit. An electric circuit can also be a loop if it is a closed path (both ends are connected). Because of the closed circuit, electric current may flow freely. An open circuit is in which the passage of electrons is interrupted because the circuit is broken. An open circuit does not allow an electric current to flow.

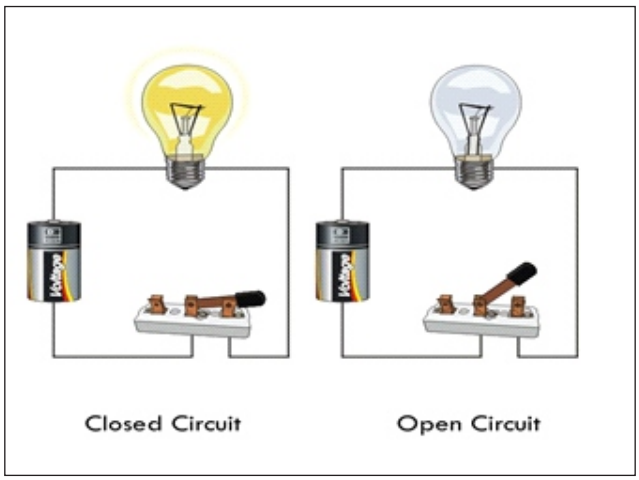


Fig. 2.2.1. Electric Circuit

Parts of Electric Circuit

The functions of parts of an electric circuit are:

- Cell or electric source: This is a device that provides electric current.
- Load: The load is a resistor. It's just a light bulb that illuminates when the circuit is activated.
- Conductors: Copper wires with no insulation are used as conductors. The wire transmits current from the power source to the load and from the load to the power source on one end and from the power source on the other.
- Switch: A switch is a component of a circuit that regulates the flow of electricity through it. Its purpose is to open or close a circuit.

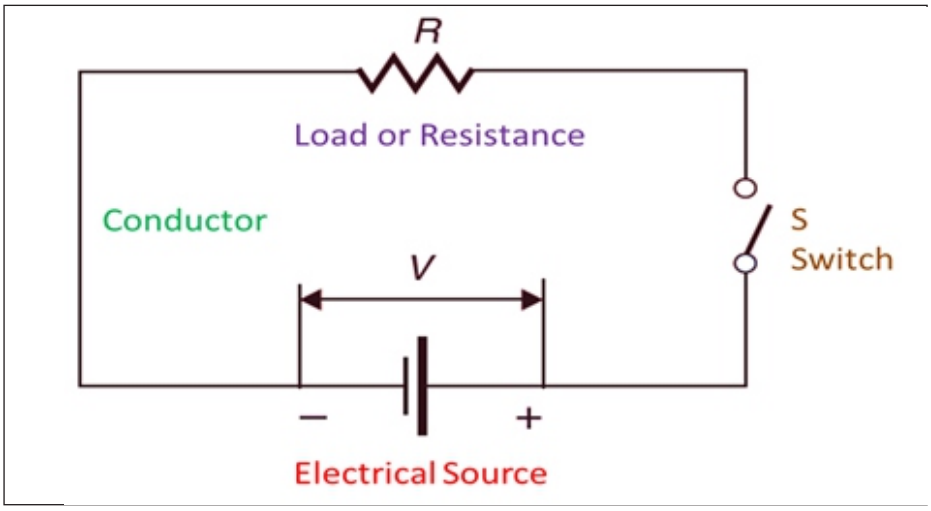


Fig. 2.2.2. Parts of Electric Circuit

Types of Electric Circuit

There are two types of electric circuits;

- Series circuit.
- Parallel circuit.

Series circuit: In a series circuit, electrons can only flow in one direction. At the same moment, the circuit is closed or open. The fundamental drawback of a series circuit is that no current flows in the circuit in the event of a circuit break since the whole circuit is open. If any light bulbs are linked in a series circuit, for example, if one goes out, the others will likewise go out.

- Switch: A switch is a component of a circuit that regulates the flow of electricity through it. Its purpose is to open or close a circuit.

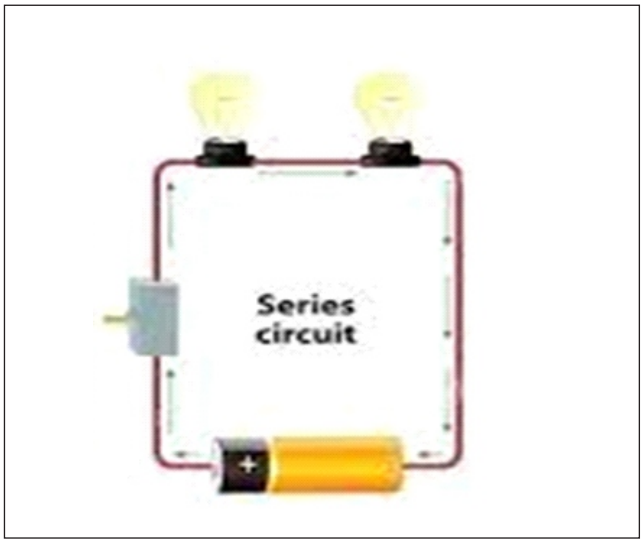


Fig. 2.2.3. Series Circuit

- **Parallel circuit:** Different circuit components are linked across different branches in a parallel electric circuit. As a result, electron flow happens in several stages. If a circuit break occurs in one channel, electric current flows in other paths. In domestic appliance wiring, parallel circuits are utilized to ensure that if one light bulb fails, the other will continue to function.

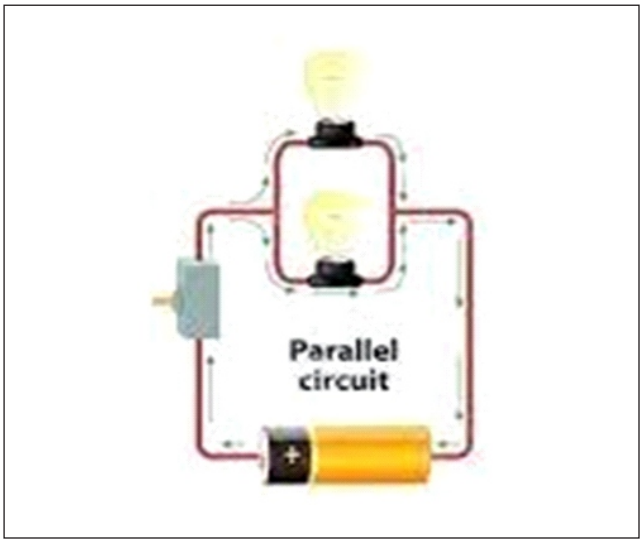


Fig. 2.2.4. Parallel Circuit

2.2.2 Electronic Components

Electronic components are the elements of the circuit that help in its functioning. They can be classified into two types, i.e. Active Components and Passive Components. Active components include transistors, batteries, etc., while passive components include transformers, inductors, resistors, capacitors, etc.

The electronic components and their functions are:

1. **Resistors:** In an integrated circuit, a resistor is one of the components that will be encountered. The gadget, as its name implies, opposes current flow. Power ratings (the amount of power they can withstand without exploding) and resistance values are used to grade resistors (capacity to resist current). Ohms are the units used to measure resistance. The unit's electrical symbol is O.

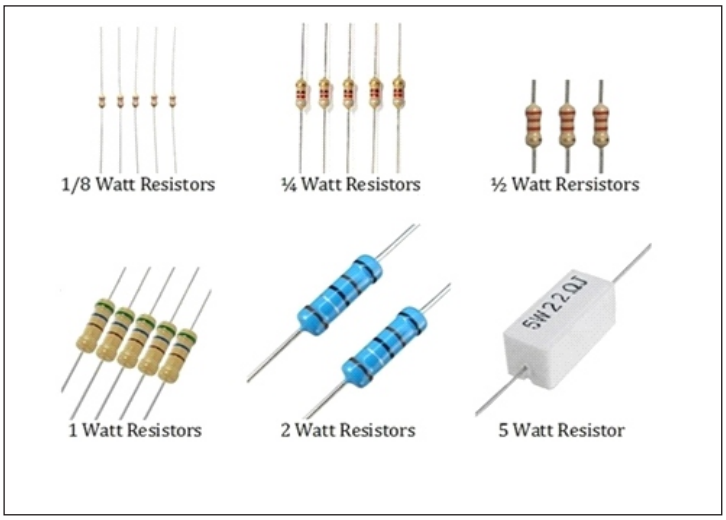


Fig. 2.2.5. Resistors

2. **Capacitors:** These components have the ability to temporarily store electric charge. The components come in a variety of shapes and sizes, with electrolytic and ceramic discs being the most popular. A component's capacity is commonly expressed in microfarads (ÂµF).

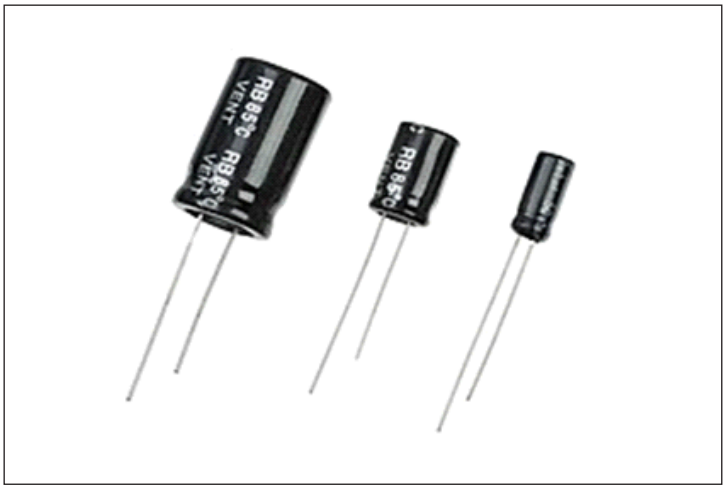


Fig. 2.2.6. Capacitor

3. **Diodes:** Electric current can only travel in one way through diodes. The anode and cathode are the two terminals of each diode. When the anode is charged with a positive voltage and the cathode is charged with a negative voltage, an electric current can flow. The current will not flow if these voltages are reversed.

Fig. 2.2.7. Diode

4. **Transistors:** The three terminals on these components make them easier to spot. Voltage must be provided to one of the components, the base terminal, in order for it to function. The current flow in the two additional terminals can then be controlled by the base (the emitter and collector).

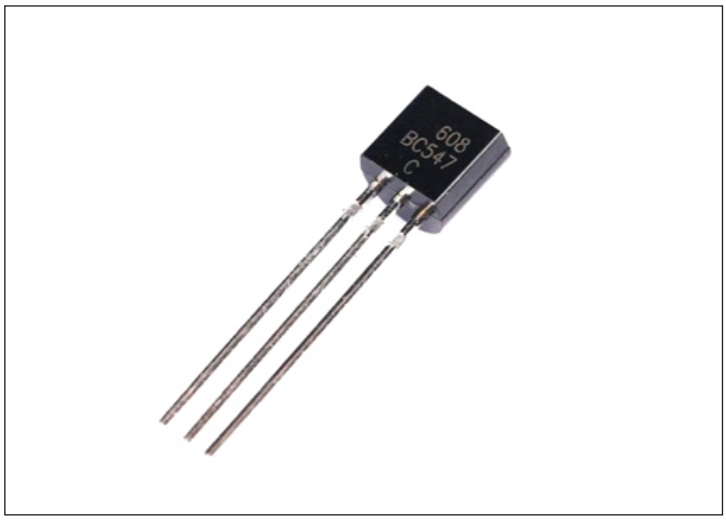


Fig. 2.2.8. Transistors

5. **Inductors:** These are energy-storing components that take the shape of a magnetic field. An inductor is basically a coil of wire coiled around a core of some sort. A magnet or air might be used as the core. A magnetic field is formed around the inductor as electricity passes through it. If a magnet is employed as the core, the magnetic field is greater.

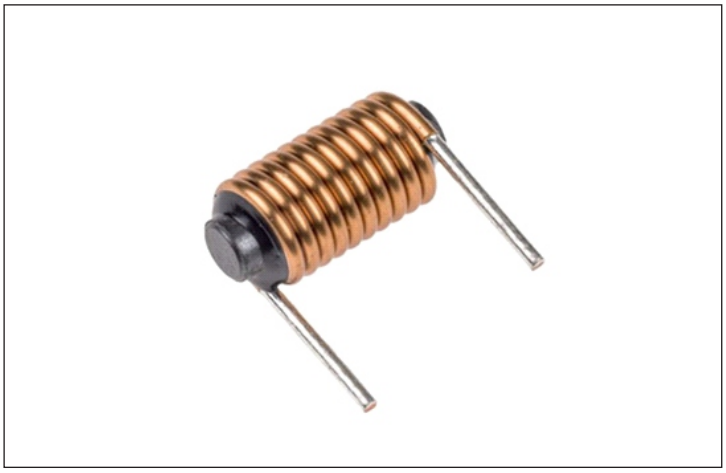


Fig. 2.2.9. Inductors

6. **Integrated Circuits:** An integrated circuit is a particular device containing all electronic circuit components. Diodes, transistors, and other devices are all etched on this component's small piece of silicon. Many electrical gadgets, like watches and computers, employ the components.

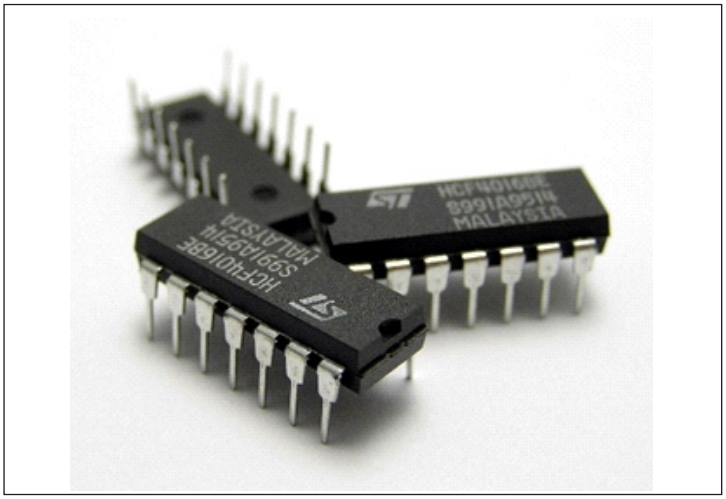


Fig. 2.2.10. Integrated Circuits

7. **Microcontrollers:** Microcontrollers are tiny computers that control a wide range of devices, including power tools, remote controls, medical equipment, and office machinery.

Fig. 2.2.11. Microcontrollers

8. **Transformers:** Transformers are regularly used to step up or down power and are made up of two coils of wire.

Fig. 2.2.12. Transformers

9. **Batteries:** Chemical energy is converted to electrical energy by batteries. Anode (+) and cathode (-) are the two types of cells in a battery (-).

Fig. 2.2.13. Batteries

10. Fuses: Fuses protect components from overheating due to excessive current. A fuse comprises a connecting body, support, contacts, and a zinc or copper-based metal fuse material.

Fig. 2.2.14. Fuse

11. **Relays:** These electromechanical switches turn on and off the electricity. An electromagnet, an armature, a set of electrical connections, and a spring make up a relay.

Fig. 2.2.15. Relays

12. **Switches:** The current is interrupted by switches. Single pole single throw (SPST), double pole single throw (DPST), single pole double throw (SPDT), and double pole double throw (DPDT) are the four types of switches (DPDT).

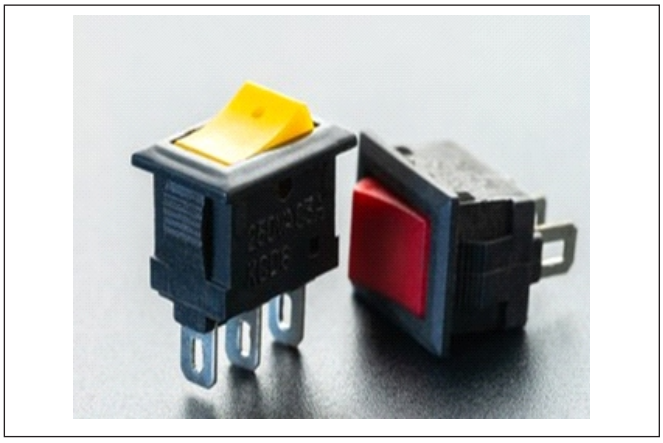


Fig. 2.2.16. Switches

13. **Motors:** Electrical energy is converted into mechanical energy by motors. A rotor, bearings, stator, conduit box, enclosure, and eye bolt are all important components.

Fig. 2.2.17. Motors

14. **Circuit Breakers:** A circuit breaker can be operated using a remote switch as a safety precaution. Its purpose is to prevent the circuit from being overloaded or short-circuited.

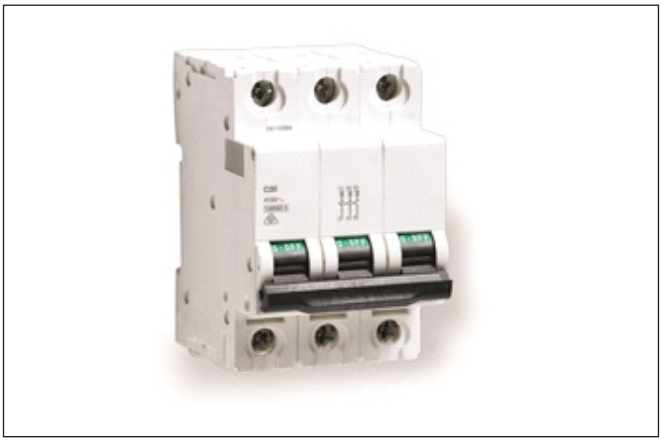


Fig. 2.2.18. Circuit Breakers

Semiconductor

A semiconductor is a material with an electrical resistance that is halfway between that of metals and insulators, allowing it to "semi"-conduct electricity. Because we can regulate the flow of electrons in this material, such as with a regulating current, semiconductors are employed in many electrical circuits.

Semiconductors are also employed for a variety of other purposes. In actuality, a solar cell is made up of light-sensitive semiconductors. The quantity of light energy that strikes the semiconductors determines how much electrical current is created by the solar cells' semiconductors.

2.2.3 Pneumatic System

A pneumatic system is a mechanism that controls actions such as holding, moving, and shaping things together using pressured air. The performance of pneumatic equipment is dependent mainly on enormous volumes of compressed air. Therefore, conveying and maintaining steady air output is critical for many types of equipment.

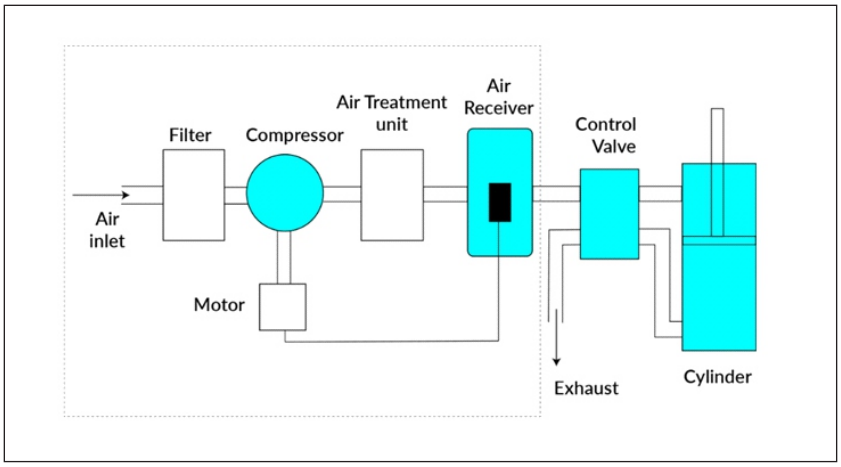


Fig. 2.2.19. Pneumatic System

Pneumatic systems are composed of:

Compressor

A pneumatic tool that compresses the air that humans breathe is known as an air compressor. The pressurized air is then dispersed throughout the pneumatic system. The air compressor is usually powered by a gas tank, which drives air into the system to create pressure. There are a variety of air compressors to choose from to get the necessary air pressure and flow rate. Piston, rotary, centrifugal, and axial flow air compressors are the many types of air compressors available.

Fig. 2.2.20. Compressor

Intake Filter

An intake filter, also known as an air filter, is used to remove contaminants from the air.

Fig. 2.2.21. Intake Filter

Receiver

Air receivers accept air from the compressor and store it in the air receiver, which is a larger tank. The air receiver may smooth the flow and keep it cold as air enters the tank. A big tank can disperse heat considerably faster than a smaller one. The air receiver holds compressed air at a greater pressure to compensate for air loss. This guarantees that the proper energy is delivered.

Fig. 2.2.22. Air Reciever

Air Valves

Air valves are an essential pneumatic component because they stop, and the air valve changes the direction of air. In order to move the actuator, they regulate the direction of airflow. One or more valves can be found in pneumatic systems. These can be manual, such as a foot valve, or electronic, such as a solenoid valve.

Fig. 2.2.23. Air Valves

Pneumatic Actuators

Pneumatic actuators are the “movers” or needed movement of the pneumatic system. Air cylinders or robotic arms that move and lift materials or drill bits are examples of output devices. The majority of actuators travel in a straight line.

Fig. 2.2.24. Actuators

Motor Control Center

The motor is used to supply mechanical energy to the compressor because the motor function is to change the energy from electrical to mechanical.

Cooler

The cooler is used to decrease the temperature of the compressed air.

Fig. 2.2.25. Air Cooler

Separator

The separator separates the moisture or water vapour within the air.

Fig. 2.2.26. Separator

Air Treatment

The air treatment in the system described above may be divided into three steps. As a result, an intake filter prevents big particles from entering the compressor in the first stage. Because the air leaving the compressor may be hot, it is treated in the following stage. In the last stage, the compressed air temperature is lowered using a cooler, and the compressed air can be dried with a dryer.

Pressure Switch

Either adjustable or not, pressure switches are employed in the above system to detect an increase or reduction in air pressure. In vacuum or pressure applications, these switches are employed.

Fig. 2.2.27. Pressure Switch

Pneumatic Relay

The Pneumatic Relay is a pilot-operated valve that provides the higher air or gas flow rates required by pneumatic drive cylinders larger than 3 inches in diameter. The Oscillamatic Controller generates pulses that activate the pneumatic relay.

Fig. 2.2.28 Pneumatic Relay

2.2.4 Symbols of Pneumatic Systems

The symbols are:

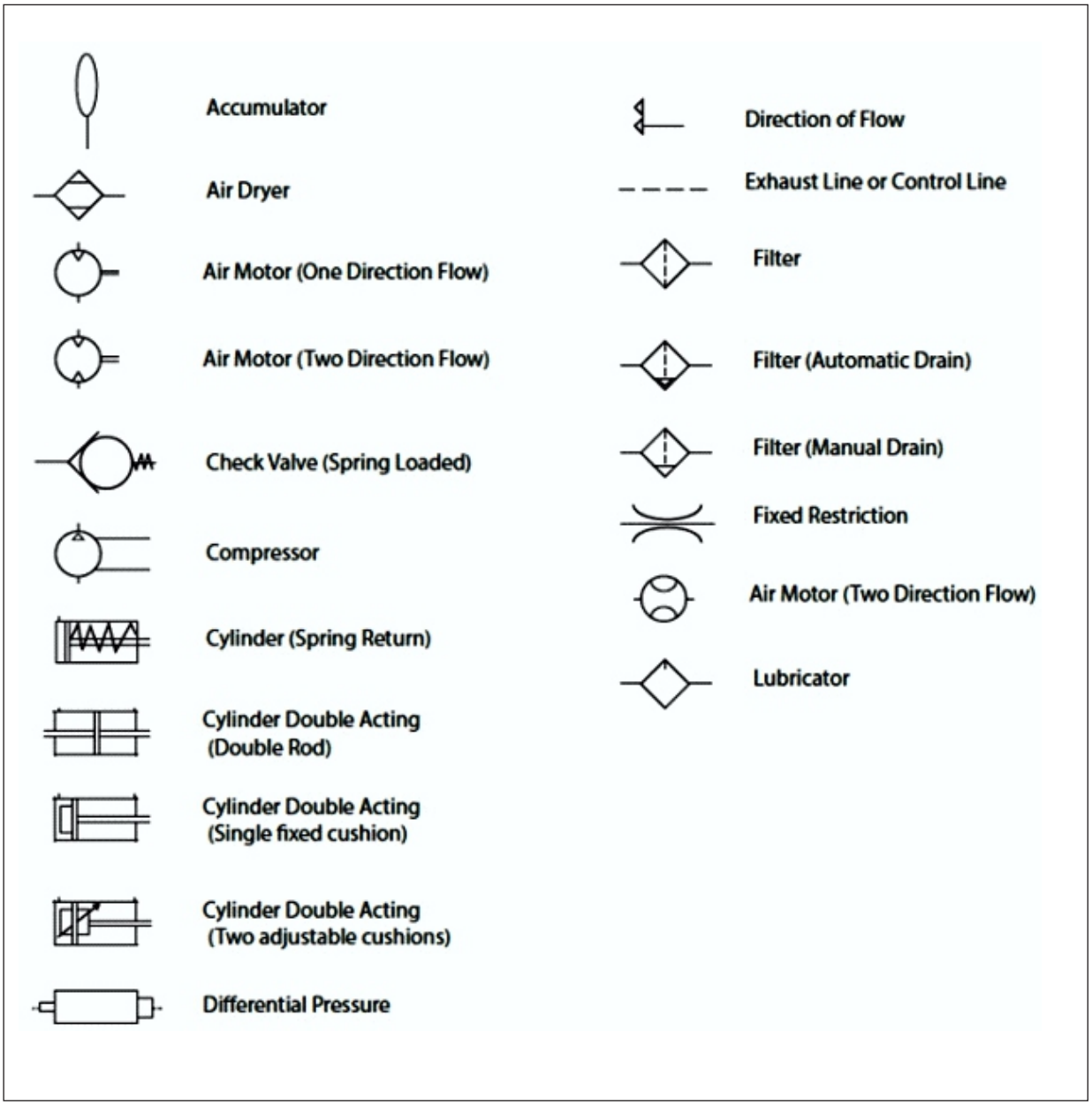


Fig. 2.2.29 Symbols of Pneumatic Systems

2.2.5 Advantages and Disadvantages of Pneumatic Systems

Advantages

- **Design and control simplicity:** Machines may be readily built using conventional cylinders and other components and work with a simple on-off switch.
- **Reliability:** Pneumatic equipment is less prone to damage since gas is compressible. Gas absorbs excessive force, whereas hydraulic fluid delivers force immediately. Because compressed gas can be stored, the equipment can continue to operate even if electricity is lost.
- **Safety:** When compared to hydraulic oil, there is a relatively minimal fire risk. Furthermore, modern devices are frequently overload-protected.

Disadvantages

- **Prone to leakage:** This is where frequent preventative maintenance checks may save a lot of time and money. One can detect leaks before they become significant issues by following a regular maintenance routine.
- **Repairs and maintenance:** Industrial pneumatics frequently retain pressure in their pipes for extended periods, making repairs more difficult. Before beginning any repairs, the system must be appropriately depressurized.
- **Sensitivity:** The pneumatic equipment will require a quiet environment in which to work. Temperature and vibration fluctuations affect pneumatic systems.

2.2.6 Pneumatic Valves

Pneumatic valves, also known as air valves, are used in industrial pneumatics to stop and start airflow. These can be manual, such as a foot valve, or electronic, such as a solenoid valve.

Pneumatic Solenoid Valves

By supplying electricity to the solenoid, these electric directional control valves can stop, start, or modify the airflow direction.

Fig. 2.2.30 Pneumatic Solenoid Valves

Types of solenoid valves:

- Direct-acting valves “directly” use the power supply from the electromagnet to open and close the valve.
- Pilot-operated valves use the electromagnetic power combined with the flowing air/liquid/gas pressure to open and close the valve.

Fluid Control Valves

Fluid control valves regulate the flow of essential fluids such as air, gas, water, oil, steam, and other liquids. When electricity is applied to the solenoid, the fluid flow is rapidly stopped, started, or changes direction.

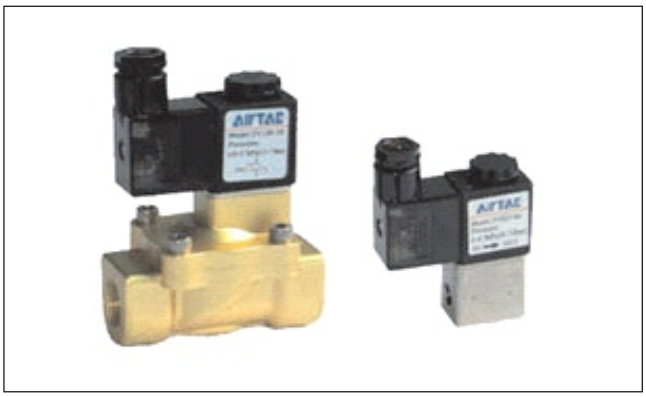


Fig. 2.2.31 Fluid Control Valves

Manual Valves and Mechanical Valves

Manual and mechanical valves use manual or mechanical actuation to start, halt, or alter airflow direction. A manual foot valve, for example, is operated by pushing a pedal.

Fig. 2.2.32 Manual Valves and Mechanical Valves

Non-Return Valves and Flow Control Valves

Non-return valves, often known as check valves, allow just one direction of fluid flow. A flow control valve, on the other hand, regulates the flow or pressure of a fluid.

2.2.7 Proximity Sensors

In situations where position feedback is critical, pneumatic cylinders utilize sensors to determine the linear position of the piston. Magnetic proximity sensors detect the magnetic field of a magnet incorporated in the cylinder piston and are the most frequent form of sensor used for pneumatic cylinders. The sensor is attached to the pneumatic cylinder's body and indicates "ON" or "OFF" depending on the magnet's proximity. Depending on the application, various magnetic proximity sensor technologies may be employed to enhance performance, space, and reliability.

Fig. 2.2.33 Different pneumatic cylinder proximity sensors

2.2.8 Cascade Amplifiersensors

A cascade amplifier is a two-port network with amplifiers connected in series, with each amplifier transmitting its output to the second amplifier's input in a daisy chain. The non-perfect coupling between two stages due to loading is complex when evaluating the gain of a cascaded stage. The following circuit depicts the two phases of cascaded CE (common-emitter). The voltage divider may be created here by using the first and second stage's input and output resistances. Individual stages alone cannot account for the total benefit.

In a TV receiver, this amplifier is used to boost the signal power. The main stage of the amplifier can be linked to the secondary stage of the amplifier with this amplifier. A single-stage amplifier is insufficient to construct a viable electronic system.

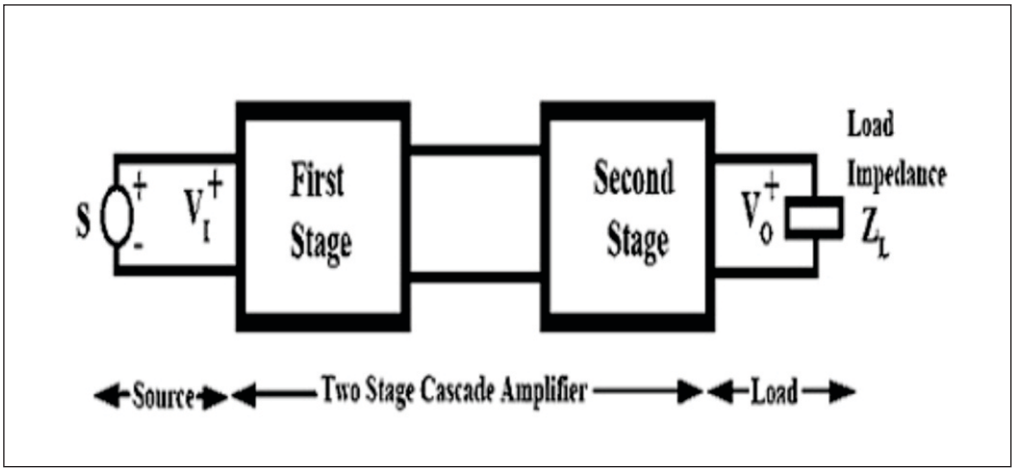


Fig. 2.2.34 Cascade Amplifier

Cascade Amplifier Circuit

The circuit diagram of the cascade amplifier is shown below. The circuit can be designed with two transistor configurations: CB (common-emitter) and CE (common-emitter) are two terms for the same thing (common base). High-frequency operation is made possible by the CB (common base) setup.

The current gain and the i/p resistance of the cascade arrangement are equivalent to the corresponding value of a common emitter single-stage amplifier. Likewise, the o/p resistance can be equivalent to the standard base configuration. This is because the miller's capacitor shunting the common emitter input stage is extremely small.

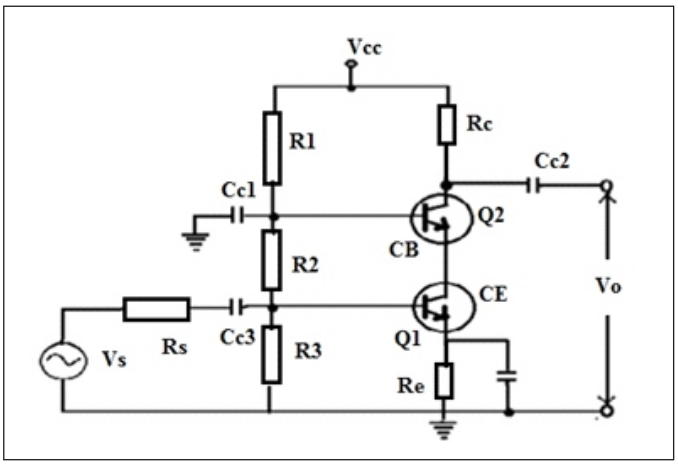


Fig. 2.2.34 Cascade Amplifier Circuit

2.2.9 PLC Programming

The main components of industrial automation and control systems are programmable logic controllers (PLCs). PLCs may operate everything from a single motor to multiple complicated control systems using simple push-button switches. As a result, PLC programming is critical in designing and implementing control systems tailored to clients' demands. A PLC programme is a set of written or graphical instructions that reflect the logic that must be applied for certain real-time industrial applications.

A dedicated PLC programming software comes with a certain manufacturer's PLC hardware, and it allows users to enter and build user application code, which can then be downloaded to the PLC hardware. This programme also ensures Human Machine Interface (HMI) as a graphical representation of variables. Once this programme has been downloaded to the PLC and the PLC has been set to Run mode, the PLC will continue to operate in accordance with the programme. Let us first review the foundations of the PLC programming lesson and its essential notions before moving on to the PLC programme.

PLC Programming Basics

A CPU of the PLC executes two different programs:

1. The Operating System
2. The User Program

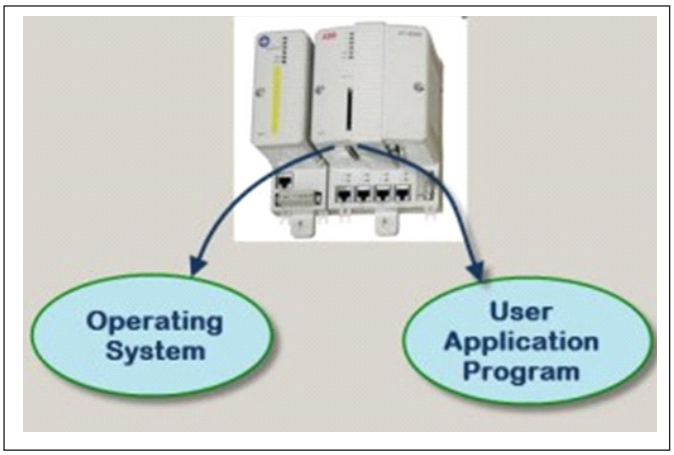


Fig. 2.2.35 PLC Programming Basics

The Operating System

The operating system groups together all of the CPU's functions, activities, and sequences that aren't related to a control job.

- Handling a hot restart and warm restart
- Updating and outputting the process image tables of input and outputs
- Executing the user program
- Detecting and calling the interrupts
- Managing the memory areas
- Establishing communication with programmable devices

The User Program

It's a set of functions that work together to complete a task that's been automated. The users must generate this and download it to the PLC's CPU. The user software can do the following tasks:

- Initiating all the conditions for starting the specified task
- Reading and evaluating all binary and analog input signals
- Specifying output signals to all binary and analog output signals
- Executing interrupts and handling errors

Several leading PLC manufacturers in the current industrial automation market create conventional PLCs ranging from tiny to high-end. Every PLC manufacturer has its own software for programming and configuring the PLC hardware. However, depending on the vendor, the PLC programming language varies. Some manufacturers use comparable programming languages, while others use different ones. PLC standard programming languages are separated into two categories, each of which is further subdivided into multiple types, as follows:

1. Textual language

- Instructions List (IL)
- Structured Text (ST)

2. Graphical language

- Ladder Diagrams (LD)
- Function Block Diagram (FBD)
- Sequential Function Chart (SFC)

Many users prefer graphical languages to text-based languages for programming a PLC because of their easy and convenient programming capabilities. Each PLC software's standard library contains all of the essential functions and functional blocks. Timers, counters, strings, comparators, numeric, arithmetic, bit-shift, calling functions, and so on are examples of function blocks.

PLC Programming Devices

Various programming devices are employed to input, change, and debug a PLC programme. Handheld and PC-based programming terminals are among the devices available. A proprietary device is linked to the PLC through a connecting cable in the portable programming device technique. This device is made up of a set of keys that may be used to enter, modify, and dump code into a PLC. The instruction that has been programmed is displayed on these portable devices, which have a tiny display. These portable gadgets are small and simple to use, yet they have limited capabilities.

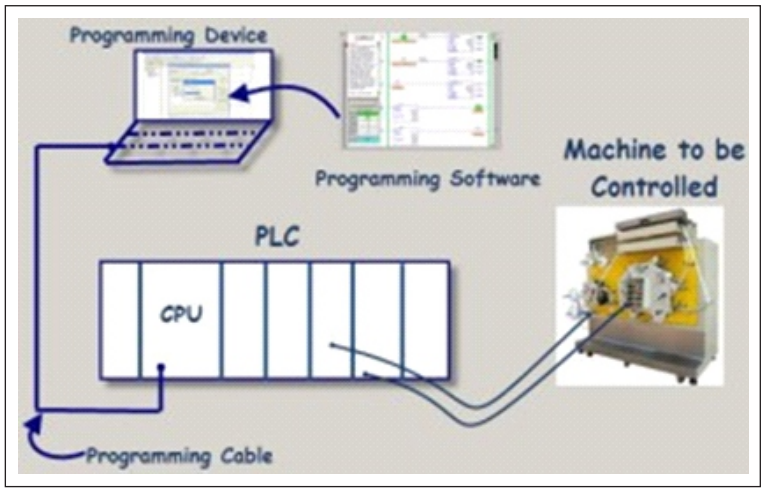


Fig. 2.2.36 PLC Programming Devices

The most common method of programming the PLC is to utilize a Personal Computer (PC) in combination with the manufacturer's software. We may use this PC to execute the software in online or offline mode and edit, monitor, debug, and troubleshoot the PLC's programme. The above diagram depicts the method of transferring the programme to the PLC, in which the PC has programme code matching the control application, which is delivered to the PLC CPU via the programming cable.

Ladder Logic PLC Programming

Ladder logic (also known as ladder diagram or LD) is a programming language used to program a PLC (Programmable Logic Controller). It is a graphical PLC programming language which expresses logic operations with symbolic notation. Ladder logic is made out of rungs of logic, forming what looks like a ladder – hence the name 'Ladder Logic'.

Ladder logic is mainly for bit logic operations, although it can scale a PLC analog input. However, even simple bit logic operations can benefit more advanced PLC programs and SCADA system programming.

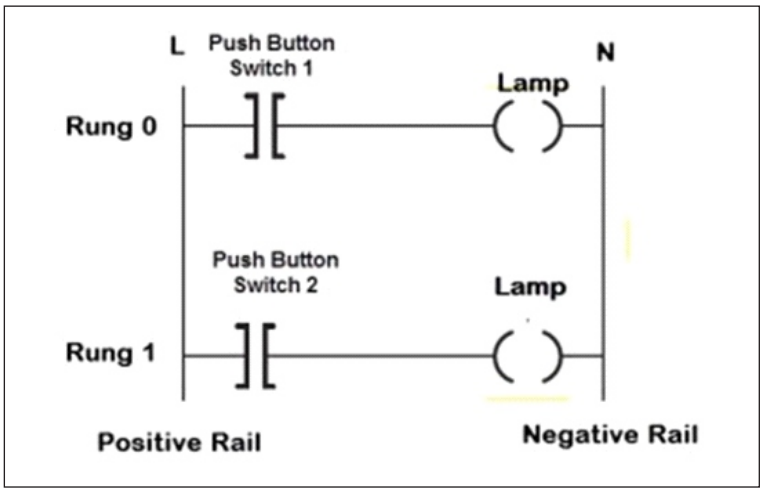


Fig. 2.2.37 Ladder logic in PLC programming

The most basic and simplest way of programming the PLC is the ladder logic diagram, which is one of the various programming languages. Before beginning to write a PLC with this language, it is necessary to have a fundamental understanding of it. The hardwired-ladder graphic below demonstrates how two push button switches control the same light load, with the lamp glowing if one of the switches is closed. Rungs are two horizontal lines that are joined by rails, which are two vertical lines. Each rung ensures that current flows from the input to the output devices by establishing electrical continuity between the positive (L) and negative (N) rails. The picture depicts some of the symbols used in ladder logic programming.

As indicated above, two types of input switches are generally closed and normally open. In addition to the above-mentioned functional symbols, the standard library contains various functions such as timer, counter, PID, and others that may be used to programme complicated tasks.

Steps for Programming PLC Using Ladder Logic

The technique for programming a PLC for a specific application is determined by the type of standard manufacturer software tool used and the type of control application being used.

Step 1: Analyze and Develop a Control Application Concept

The first stage in programming a PLC is to develop a concept to create an application-based programme. For example, may use a DC motor to drive a line follower robot when the push button is pressed. The LED light must reflect this state when the motor is turned on. The motor is also connected to a sensor (which may be thought of as a second switch) that detects obstructions, so when this is activated, the motor should be shut off. When the motor is shut off, the buzzer should also be turned on.

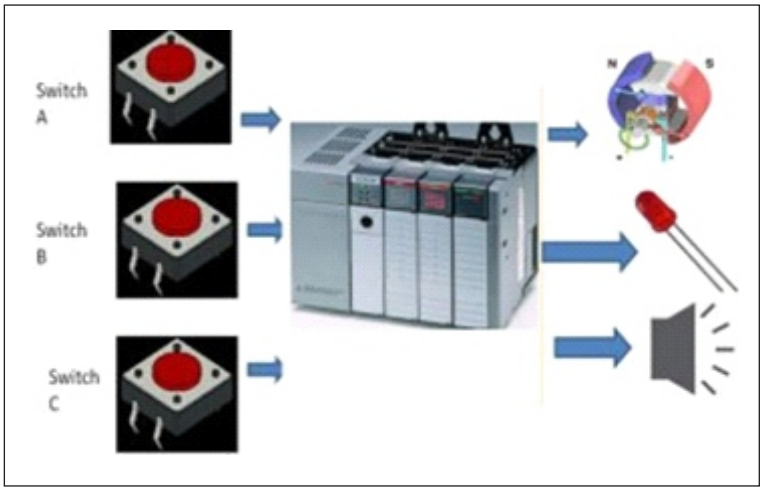


Fig. 2.2.38 PLC Control Application

Step 2: List All the Conditions and Get the Design using a Flowchart

The variables of the above project are M: Motor, A: Input Switch 1, B: Input Switch 2, L: LED and Bu: Buzzer, and the designing of the logic is easy with the implementation of a flow chart, which is given below for the above application.

- Flowchart of PLC Programming
- Flowchart of PLC Programming

Step 3: Open and Configure the PLC Programming Software

Open the programming software installed in the PC that comes with PLC hardware. Select the hardware model of the PLC in the software and configure it with appropriate input and output modules. Select the ladder language (LD) from the list of the programming languages, choose the hardware processor and give a name for the program.

Step 4: Add the Required Rungs and Address Them

Add the required rungs based on the control application logic and give the address to every input and output. For example, the ladder logic diagram of the above-discussed example is given below.

Step 5: Check the Errors and Simulate It

Locate the Online section in the menu bar and select Online. Check for the errors and make necessary changes after selecting Offline. Then, again, go online and select the Run option to simulate it.

Step 6: Download the Program to PLC CPU Memory

After the successful simulation of the program, download the program to the CPU by selecting the Download option through a network or communication cable.

2.2.10 Fluid Power

Hydraulics and pneumatics technologies are referred to as "fluid power." Both systems employ a fluid (liquid or gas) to transport electricity from one point to another. However, the fluid in hydraulics is a liquid (typically oil), whereas the fluid in pneumatics is a gas (usually compressed air).

Both are examples of power transmission, which is the process of turning energy into a usable form and transferring it to where it is required. Electrical, mechanical, and fluid power are the most frequent forms of power transfer.

Despite being frequently considered competitors, no single type of power transmission is the optimum option for all purposes. In truth, the majority of applications are supported by a mix of technologies. Fluid power, on the other hand, has significant benefits over other technologies.

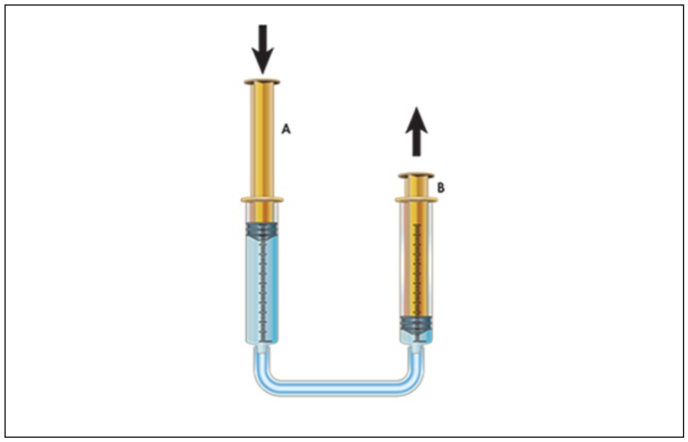


Fig. 2.2.39 Fluid Power

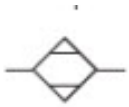
Fluid power systems create linear motion with hydraulic or pneumatic cylinders, but electrical and mechanical systems often need the employment of a mechanical device to convert rotational motion to linear motion.

Fluid power solutions, primarily when exceptionally high force or torque is required, can deliver equal power in a considerably smaller volume than mechanical or electrical drives.

Fluid power systems also use simple control valves to provide easy and effective direction, speed, force, and torque. Fluid power systems do not always require electricity, reducing the risk of electric shock, sparks, fire, and explosions.

Exercise

1. Explain the mechatronics system and differentiate between the traditional and mechatronics approach.
2. State the steps for programming PLC using ladder logic.
3. Explain in detail the open-loop and close-loop control systems.
4. Identify the following symbols of the pneumatic system:

Notes

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Transforming the skill landscape

3. Process of Installing, Testing and Using the Sensors and Actuators in the Mechatronics Systems

ESSCI
Skilling India in Electronics

Unit 3.1 - Sensors

Unit 3.2 - Actuators

ELE/N7110

Key Learning Outcomes

By the end of this module, participants will be able to:

1. Explain the use of contact and non-contact type sensors.
2. Explain the functions and application of Potentiometer Sensors, Strain Gauge Elements, Capacitive Elements, Eddy Current, Pressure Sensors, Pneumatic, Pyro Electrical, Piezoelectric Sensors, etc.
3. Explain the criteria for selecting sensors for use.
4. Explain the classification, need and scope of different types of actuators.
5. Describe the process of pneumatic actuation, hydraulic actuation and double-acting.
6. Explain the use of different types of motors, such as vane motors.
7. Explain the components of electrical actuation systems such as switching devices, keypads, electromechanical and solid-state relays, stepper motors etc.
8. Explain the criteria for the selection of different types of actuators.

UNIT 3.1: Sensors

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the use of contact and non-contact type sensors.
2. Explain the functions and application of Potentiometer Sensors, Strain Gauge Elements, Capacitive Elements, Eddy Current, Pressure Sensors, Pneumatic, Pyro Electrical, Piezoelectric Sensors, etc.
3. Explain the criteria for selecting sensors for use.

3.1.1 Sensors

Sensors/Detectors/Transducers are electrical, optoelectrical, or electronic devices that use specialized electronics or other sensitive materials to determine if a particular entity or function is present. Sensors, detectors, and transducers for sensing a physical presence, such as flame, metals, leaks, levels, or gas and chemicals, are among the wide varieties available. Some are intended to detect physical qualities like temperature, pressure, or radiation, while others are made to detect motion or proximity. Depending on the application, they can function in various ways, including using electromagnetic fields or optics, among other things. Sensors, detectors, and transducers of various types are used in various applications across a wide range of industries to test, measure, and regulate various processes and machine operations.

3.1.2 Types of Sensors

The types of sensors are:

1. **Vision and Imaging Sensors:** Electronic devices that detect the presence of objects or colours inside their fields of view and transform this information into a visual picture for display are known as vision and imaging sensors/detectors. Sensor type and intended application, as well as any special transducer properties, are essential parameters.

Fig 3.1.1. Vision and Imaging Sensors

2. **Temperature sensors:** Temperature sensors, detectors, and transducers are electrical devices that detect thermal characteristics and provide signals to control and display devices' inputs. An RTD or thermistor is used in most temperature sensors to monitor temperature and convert it to an output voltage. Sensor/detector type, maximum and lowest measurable temperatures, and diameter and length parameters are essential. The thermal characteristics of liquids, gases, and solids in many process industries are measured by temperature sensors and are configured for both general and special purpose uses.

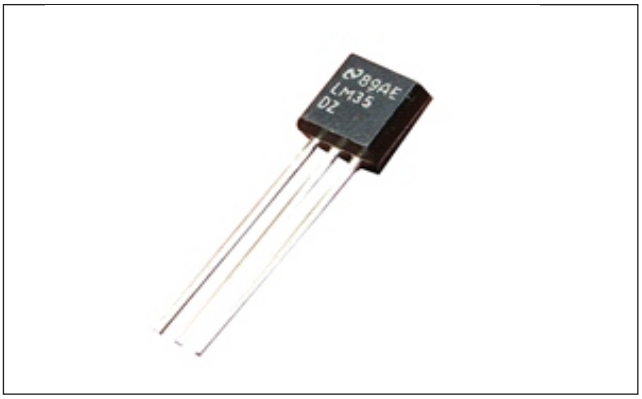


Fig 3.1.2. Temperature Sensors

3. **Radiation Sensors:** Electronic devices that detect the presence of alpha, beta, or gamma particles and send signals to counters and display devices are known as radiation sensors/detectors. Sensor type, as well as the lowest and maximum detectable energies, are essential criteria. For surveys and sample counts, radiation detectors are utilized.

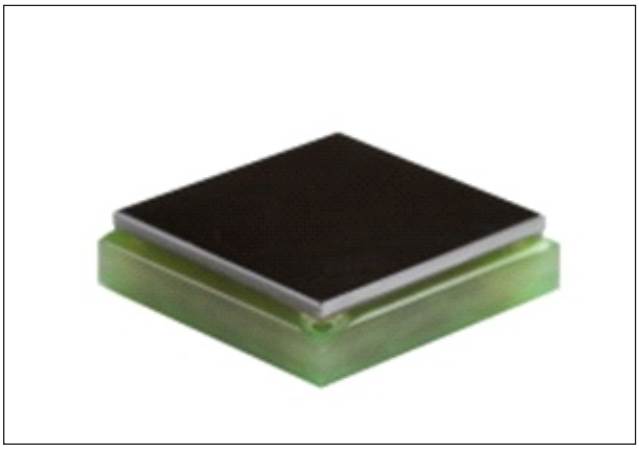


Fig 3.1.3 Radiation Sensors

4. **Proximity Sensors:** Proximity sensors are electrical devices that employ non-contact methods to detect the presence of surrounding objects. A proximity sensor may detect the presence of objects at a range of up to several millimetres and provide a dc output signal to a controller as a result. In many industrial operations, these sensors are utilized to detect the presence of goods and machine components.

Sensor type, maximum sensing distance, minimum and maximum working temperatures, and diameter and length measurements are all essential characteristics. Proximity sensors are typically short-range devices; however, variants that can detect things up to several inches away are also available. A capacitive proximity sensor is a type of proximity sensor that is extensively utilized.

This gadget determines the motion and location of the item from the sensor by measuring the change in capacitance caused by a reduction in the separation distance between the plates of a capacitor, one of which is attached to the object being viewed.

Fig 3.1.4 Proximity Sensors

5. **Pressure Sensors:** Pressure sensors, detectors, and transducers are electromechanical devices that detect forces per unit area in gases and liquids and provide signals to control and display systems. A pressure sensor/transducer generally employs a diaphragm and strain gauge bridge to detect and quantify the force applied to a unit area. These are essential criteria for sensor function, minimum and maximum working pressures, full-scale accuracy, and other device-specific characteristics. Wherever information about the pressure of a liquid or gas is needed for control or measurement, pressure sensors are utilized.

Fig 3.1.5 Pressure Sensors

6. **Position Sensors:** Position Sensors/Detectors/Transducers are electronic devices that sense the positions of valves, doors, throttles, and other similar devices and send signals to control or display devices' inputs. Sensor type, sensor function, measurement range, and sensor-specific properties are essential. Position sensors are utilized in various control applications where positioning information is required. A string-pot, sometimes known as a string potentiometer, is a typical position transducer.

Fig 3.1.6 Position Sensors

7. **Photoelectric Sensors:** Photoelectric sensors are electrical devices that detect items passing across their detection field, albeit they may also detect colour, cleanliness, and position if necessary. These sensors use an emitter and a receiver to measure changes in the light they emit. They're used for counting, robotic picking, and automatic doors and gates in manufacturing and material handling automation.

Fig 3.1.7 Photoelectric Sensors

8. **Particle Sensors:** Particle Sensors/Detectors are electronic devices that detect dust and other airborne particles and send signals to control or display devices' inputs. Particle sensors are commonly used to monitor bins and baghouses. Sensor type, minimum detectable particle size, operating temperature range, sample volume, and response time are all important considerations. Radiation detectors are particle detectors that are utilized in nuclear engineering.

Fig 3.1.8 Particle Sensors

9. **Motion Sensors:** Motion Sensors/Detectors/Transducers are electrical devices that detect the movement or stopping of components, people, or other objects and provide signals to control or display devices' inputs. Motion detection is commonly used to detect the stalling of conveyors or the seizing of bearings. The intended application, sensor type, function, and minimum and maximum speeds are all important characteristics.

Fig 3.1.9 Motion Sensors

10. **Metal Detectors:** Metal detectors are electrical or electromechanical devices that detect metal in various circumstances, from parcels to humans. Metal detectors can be portable or permanent, and they use various sensing technologies, the most common of which is electromagnetics. The desired application, maximum sensing distance, and feature options such as portable and fixed devices are all essential considerations. Metal detectors may be programmed to detect metal in specific production processes like sawmilling and injection moulding.

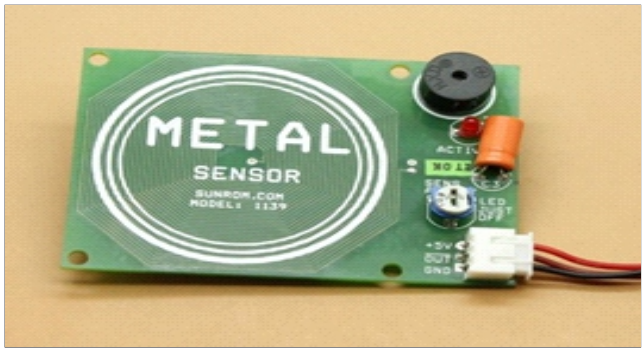


Fig 3.1.10 Metal Sensors

11. **Level Censors:** Level Sensors/Detectors are electrical or electromechanical devices that measure the height of solids, gases, or liquids in tanks or bins and provide signals to control or display devices. Most level sensors employ ultrasonic, capacitance, vibratory, or mechanical methods to estimate product height. Sensor type, function, and maximum sensing distance are all essential criteria. There are two types of level sensors/detectors: contacting and non-contacting.

Fig 3.1.11 Level Sensors

12. **Leak Sensors:** Leak Sensors/Detectors are electrical devices used to detect or monitor undesirable liquid or gas leaks. Some leak detectors, for example, use ultrasonic technology to detect air leaks. The soundness of pipe junctions is measured by other leak detectors using simple foaming agents. Other leak detectors are used to determine the efficacy of vacuum package seals.

Fig 3.1.12 Leak Sensors

13. Humidity Sensors: Humidity sensors, detectors, and transducers are electronic devices that measure the quantity of water in the air and transform the data into signals that may be utilized to control or display devices. The maximum response time, as well as the lowest and maximum working temperatures, are important requirements.

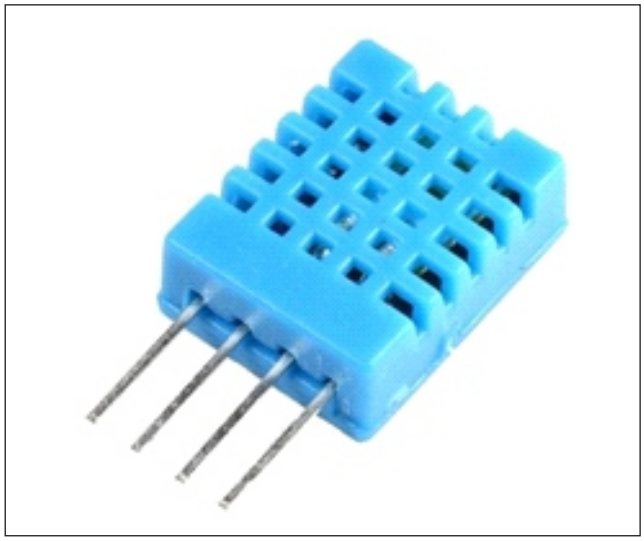


Fig 3.1.13 Humidity Sensors

14. Gas and Chemical Sensors: Gas and chemical sensors/detectors are permanent or portable electronic devices that detect the presence and characteristics of various gases or chemicals and send signals to controller inputs or visual displays. The desired application, sensor/detector type, measurement range, and characteristics are all important considerations. Gas and chemical sensors/detectors are commonly built to detect numerous gases and chemicals and are used for confined space monitoring, analytical instrumentation, leak detection, and other applications.

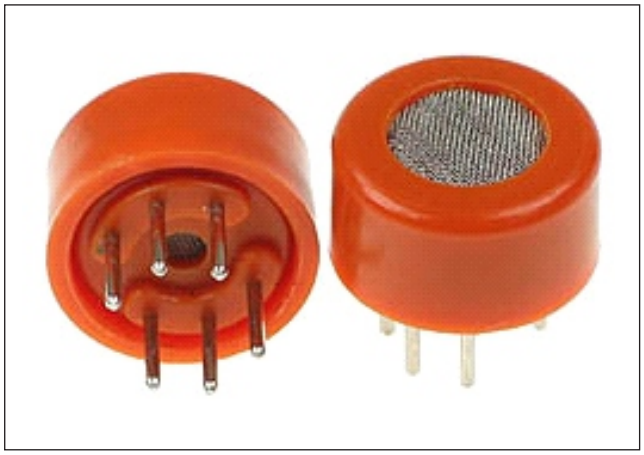


Fig 3.1.14 Gas and Chemical Sensors

15. **Force Sensors:** Force Sensors/Transducers are electronic devices that measure numerous characteristics linked to forces, such as load, weight, torque, etc., and provide signals to control or display devices' inputs. In force sensors, a load cell is a piezoelectric device whose resistance fluctuates owing to deforming stresses. Torque and strain can also be measured using other ways. Sensor function, minimum and maximum loads (or torques), number of axes, minimum and maximum working temperature, and sensor size are all essential requirements. From truck scales to bolt tensioning devices, force sensors are employed in various load measurement applications.

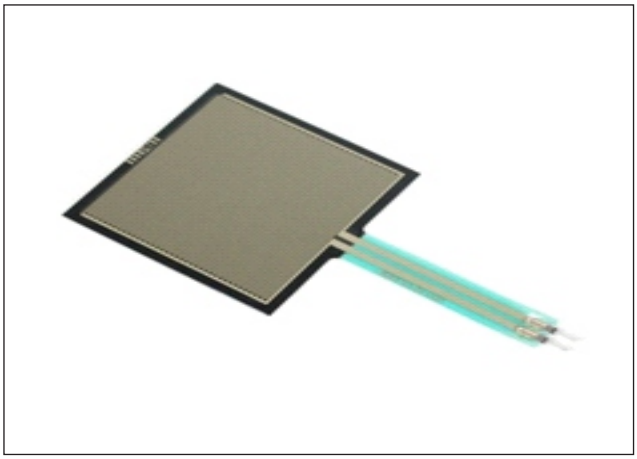


Fig 3.1.15 Force Sensors

16. **Flow Sensors:** Flow Sensors/Detectors are electrical or electromechanical devices that detect the flow of liquids, gases, or solids and provide signals to control or display devices' inputs. A flow sensor can be entirely electronic—for example, employing ultrasonic detection from outside a pipeline—or somewhat mechanical—for example, a paddlewheel that sits and spins directly in the flow stream. Sensor/detector type, function, maximum flowrate, maximum working pressure, and minimum and maximum operating temperatures are all essential requirements. In the processing industry, flow sensors are widely employed. Some panel mounting styles allow process operators to see flow conditions quickly.

Fig 3.1.16 Flow Sensors

17. Flaw Sensors: Flaw Sensors/Detectors are electronic devices used in several industrial processes to detect flaws on surfaces or in underlying materials like welds. Flaw detectors can be portable or stationary systems that employ ultrasonic, acoustic or other methods to detect faults in materials. Sensor type, noticeable flaw or thickness range, and intended application are critical considerations.

Fig 3.1.17 Flaw Sensors

18. Flame Sensor: Flame Detectors are optoelectronic devices that detect the presence and kind of fire and send signals to control devices' inputs. A flame detector detects the flame using UV or infrared light and is used in various combustion control applications such as burners. The detector type is an important characteristic. Flame detectors are used in various safety applications, including under-the-hood fire suppression systems.

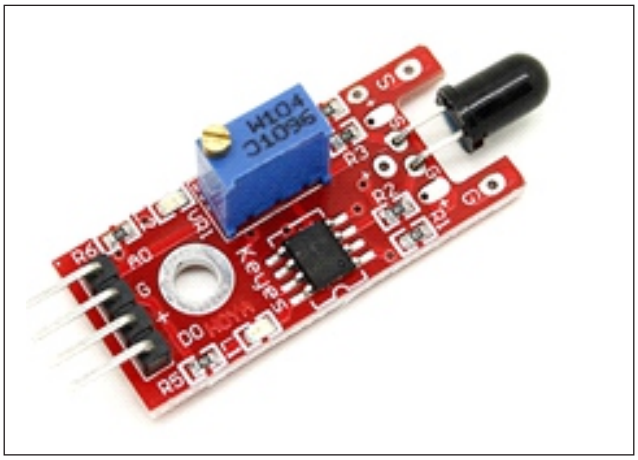


Fig 3.1.18 Flame Sensors

19. Electrical Sensors: Electrical sensors, detectors, and transducers are electrical devices that detect current, voltage, and other variables and send signals to control devices or visual displays. Hall effect detection is commonly utilized in electrical sensors; however, alternative approaches are also used. The essential criteria include sensor type, function, minimum and maximum measurement ranges, and operating temperature range. Electrical sensors are utilized in anything from railway systems to fan, pump, and heater monitoring and are used whenever information on the health of an electrical system is needed.

Fig 3.1.19 Electrical Sensors

20. Contact Sensors: Contact sensors are any sensing device that uses physical touch or contact between the sensor and the thing being viewed or monitored to identify a condition. Alarm systems employ an essential sort of touch sensor to monitor doors, windows, and other entry points. A magnetic switch sends an indicator to the alarm control unit when the door or window is closed, allowing the status of that entry point to be known.

When a door or window is opened, the contact sensor signals the alarm controller, which may cause an action such as the activation of an audio siren. Contact sensors may be used for various purposes, including temperature monitoring and proximity sensors in robotics applications and automated machinery.

Fig 3.1.20 Contact Sensors

21. Non-contact sensors: Non-contact sensors do not require physical contact between the sensor and the monitored item to function. The motion detector in security lights is an example of this sort of sensor. Objects within a motion detector's range are detected using non-mechanical or non-physical methods, such as passive infrared radiation, microwave energy, ultrasonic waves, etc. Another type of non-contact sensor is radar guns, which law enforcement employs to monitor vehicle speeds. Inductive sensors, Hall-effect sensors, Eddy current sensors, LVDTs (linear variable differential transformers), and RVDTs (rotary variable differential transformers) are only a few examples of non-contact sensors.

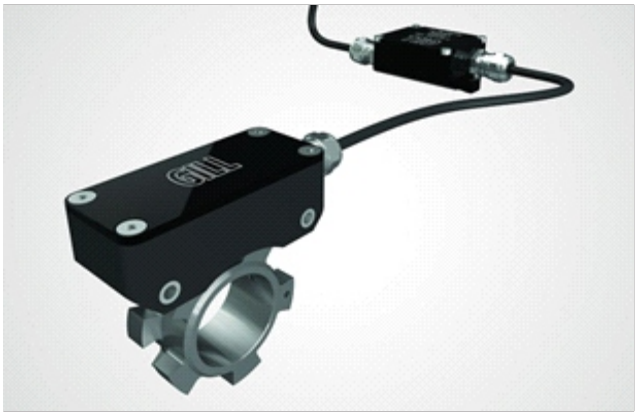


Fig 3.1.21 Non-Contact Sensors

3.1.3 Selection of Sensors

When choosing sensors, the following criteria are taken into account:

- The accuracy required is the difference between the measured and actual values. Therefore, the accuracy of the sensor should be as high as possible.
- Precision is the ability to reproduce repeatedly with a given accuracy. It should be very high. The error between sensed and actual values should approach zero.
- Sensitivity is the ratio of change in output to a unit change of the input. It should be chosen to allow sufficient work.
- The operating range is the difference between the maximum and minimum value of the sensed parameter. Therefore, sensors should have a wide operating range and good accuracy over the range.
- Resolution is the smallest change in the sensor which can differentiate. Therefore, sensors should have high resolution.
- Speed response is the time the sensor takes to respond should be minimum. Response time should be significantly less.
- The reliability of the sensor should be high. Mean time to failure (MTTF) should always be high.
- Maintenance should also be easy, and the required maintenance frequency should be less.
- The sensors need frequent calibration for many reasons. Hence, it should be easy to calibrate. Drift should be as minimum as possible.
- The cost of the sensor should be low.

- When choosing a sensor, the type of output required, whether digital or analogue, must be considered.
- The curvature of the sensor should be linear. The variation from the best-fit linear calibration curve should be as small as possible. The sensors should operate over wide environmental conditions such as temperature, corrosion, pressure, shocks etc.
- The sensors should be compatible with different instruments for interfacing.
- The sensors should have small sizes and less weight.

Notes

Scan the QR Code to watch the related videos

https://youtu.be/S7z3DQiOWOQ

Types of Sensors

https://youtu.be/76TXYc_Ahvc

Selection of Sensors

UNIT 3.2: Actuators

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the classification, need and scope of different types of actuators.
2. Describe the process of pneumatic actuation, hydraulic actuation and double-acting.
3. Explain the use of different types of motors, such as vane motors.
4. Explain the components of electrical actuation systems such as switching devices, keypads, electromechanical and solid-state relays, stepper motors etc.
5. Explain the criteria for the selection of different types of actuators.

3.2.1 Actuators

An actuator is a part of the machine that receives input from a control signal and then begins movement. The actuator makes distinct motions based on the machine's function once it receives electricity.

The actuators are classified as:

- Motion: Linear Actuators and Rotary Actuators
- Source of Energy: Hydraulic Actuators, Pneumatic Actuators, Electric Actuators, Thermal and Magnetic Actuators, Mechanical Actuators, and Supercoiled Polymer Actuators.

3.2.2 Types of Actuators

The types of actuators are:

1. **Linear Actuators:** Linear actuators are devices that move in a straight line. They are commonly found in hydraulic and pneumatic equipment and can be mechanical or electronic. It is found in almost every machine, equipment, or device requiring straight motion.

   A fundamental linear actuator is made up of a nut, a cover, and a sliding tube. The room for motion is provided by the sliding tube, while the interlocking movement is provided by the nut and cover, which maintains the actuator in a straight path. Other, more complicated linear actuators will have additional components, but for straight movement, the mechanism described above provides the foundation.

Fig. 3.2.1 Linear Actuator

2. **Rotary Actuators:** Rotary actuators produce a round motion in contrast to linear actuators. As the word "rotary" implies, most machines require rotating elements to accomplish a turning action. Therefore, if a machine needs to move forward, backward, up, or down, they are frequently utilized in combination with a linear actuator.

   Many rotary actuators are driven by electricity, while hydraulic or pneumatic systems power others. Electric fans, windshield wipers, and manufacturing machinery that carry things from one location to another all use rotary actuators.

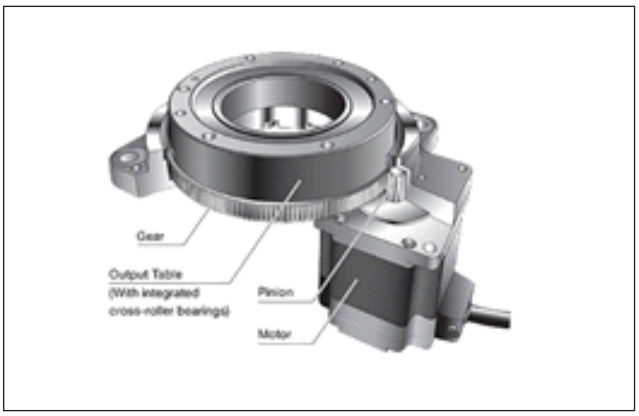


Fig. 3.2.2 Rotary Actuator

3. **Hydraulic Actuators:** Hydraulic actuators use a fluid-filled cylinder with a piston hung in the middle to function. Hydraulic actuators typically create linear motions, with a spring linked to one end for return motion. These actuators may be found in various fitness equipment, including steppers and automobile transfer carriers.

Fig. 3.2.3 Hydraulic Actuator

4. **Pneumatic Actuators:** Pneumatic actuators are one of the most dependable machine motion alternatives. To produce mechanical movement, they employ compressed gases. As a result, many businesses choose pneumatic actuators to perform highly accurate actions, particularly when starting and stopping machines.

   Bus brakes, Pressure sensors, Vane motors, Exercise machines, and Pneumatic mailing systems are examples of pneumatic actuators.

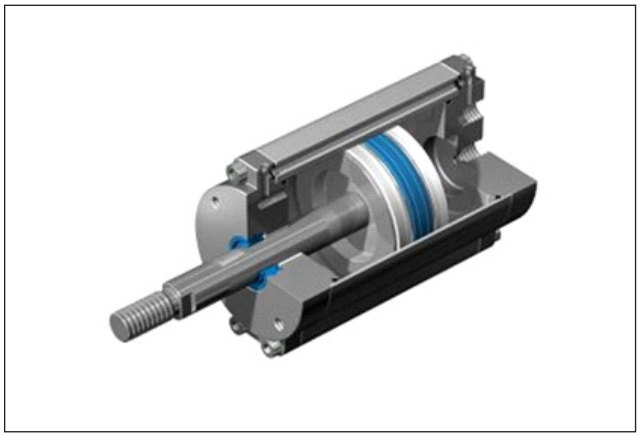


Fig. 3.2.4 Pneumatic Actuator

5. **Electric Actuators:** Electric actuators rely on electricity to function. For example, electric automobiles, robotics equipment, and manufacturing. As the flow of electrical power is continuous, they produce accurate motion in the same way as pneumatic actuators. The different types of electrical actuators include:

   - **Electromechanical actuators** convert electric signals into rotary or linear movements and may even be capable of combining both.
   - **Electrohydraulic actuators** are also powered electrically but give movement to a hydraulic accumulator. The force for movement is provided by the accumulator, usually seen in heavy industrial equipment.

Fig. 3.2.5 Electric Actuator

6. Thermal and Magnetic Actuators: Thermal and magnetic actuators often employ shape memory alloys that may be heated to create movement. The Joule effect is responsible for the movement of thermal and magnetic actuators, but it may also occur when a coil is put in a static magnetic field. The Laplace-Lorentz force is a continuous motion caused by a magnetic field. Although most thermal and magnetic actuators are small and light, they may provide a large and powerful range of motion.

Fig. 3.2.6 Thermal and Magnetic Actuator

7. Mechanical Actuators: Mechanical actuators include pulleys, rack and pinion systems. An additional mechanical force, such as pulling or pushing, is added, and the actuator uses that single movement to produce the desired outcomes. For moving an object from point A to B, for example, a single gear on a set of racks and pinions can be spun. The pulley's pulling motion may force the other side to raise or move towards the desired location.

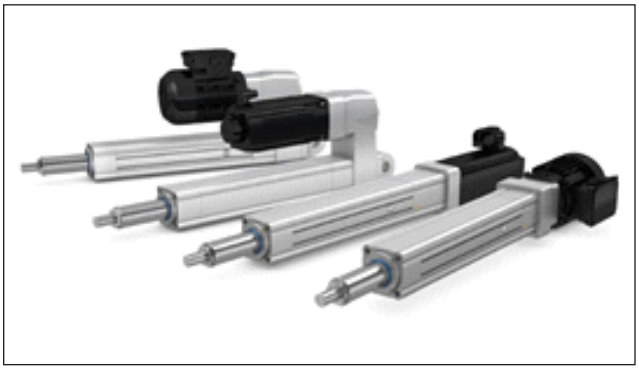


Fig. 3.2.7 Mechanical Actuator

8. Supercoiled Polymer Actuators: Actuators made of supercoiled polymer are a relatively new addition to the many forms of actuators. They are employed in robotics and prosthetic limbs because they can mimic human muscle movements using a coil that contracts and expands as it is heated or cooled.

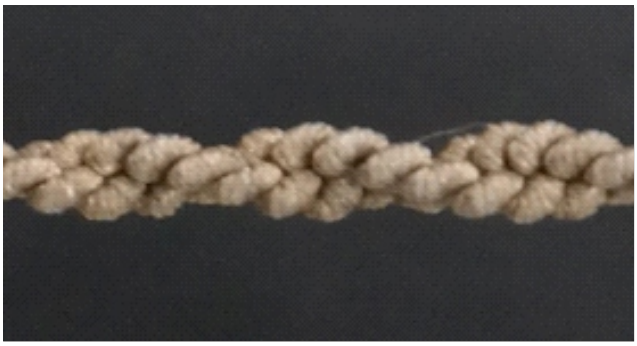


Fig. 3.2.8 Supercoiled Polymer Actuator

3.2.3 Selection of Actuator

The selection of actuator is dependent on the following:

1. **Availability of Power Source:** The compatibility of the power supply is the first item to examine. Electric actuators are likely the most acceptable option—and the option with the most options—if one owns an industrial location with an electrical supply. On the other hand, one chooses pneumatic or hydraulic kinds if there are no electrical sources in the region or if one wants a fully working piece of equipment without power.

2. **Required Movement:** Another consideration when selecting an actuator is the range of motion required. Check whether it is linear, rotational, or a hybrid of both. The custom-made actuators are usually combined or arranged chronologically to create these motions to help concretize the final equipment.

3. **Precision:** The accuracy of some actuators is higher than that of others. Because air pressure is known to be useful in beginning and halting movements, pneumatic actuators are utilized in the construction of air brakes, for example. Other actuators, such as hydraulic actuators, can move in a larger variety of directions.

   Actuators with distinctive movements should be considered in any business that requires great precision for safety and operational success.

4. **Safety:** Another element to consider when selecting an actuator for the equipment is safety. Electrical r thermal actuators should be cautiously utilized in regions with excessive temperatures or risks. Occupational danger can be provided by operating electrical actuators near a water body without sealing or other safety procedures.

3.2.4 Components of Electrical Actuation System

1. **Switching devices:** A switching device acts as a gate in an electrical circuit that must create a continuous loop. It is a device that opens and closes electrical circuits.

Fig. 3.2.9 Switching devices

2. **Keypad:** A keypad is a set of buttons or keys on a pad that contain numerals, symbols, and alphabetical letters that may be used as an efficient input device. A keypad can be solely numeric, like on a calculator or a mechanical door lock, or alphanumeric, like on a cellular phone.

Fig. 3.2.10 Keypads

3. **Electromechanical Relays:** An electromechanical relay connects contacts inside the output component of the relay using a physical moving portion. The movement of this contact is caused by electromagnetic forces created by the low-power input signal, allowing the circuit containing the high-power signal to be completed.

Fig. 3.2.11 Electromechanical Relays

4. **Solid State Relays:** A solid-state relay uses a low-power electrical signal to create an optical semiconductor signal, which transmits and energizes the output signal, generally via an optocoupler. When the input optical signal is active, it works as a "switch," allowing a high voltage signal to travel through the SSR's output component. There are various ways to achieve this, but they all have one thing in common: they do not have any moving components, making them solid-state.

Fig. 3.2.12 Solid State Relays

5. **Stepper Motors:** A stepper motor is an electric motor whose fundamental characteristic is that its shaft rotates in steps or progresses by a predetermined number of degrees. This capability is gained because of the motor's internal construction, allowing the user to determine the precise angular position of the shaft by counting the number of steps taken without needing a sensor. This functionality also allows it to be used in a variety of situations.

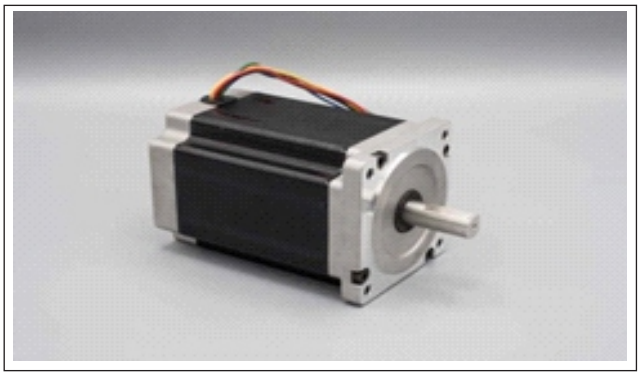


Fig. 3.2.13 Stepper Motors

6. **Vane Motors:** The vane motor is a mechanical drive that transforms inflowing gas or liquid pressure into rotational motion. It is employed in hydraulics and pneumatics. The stator is a stationary housing that turns an eccentrically placed rotor with moveable blades.

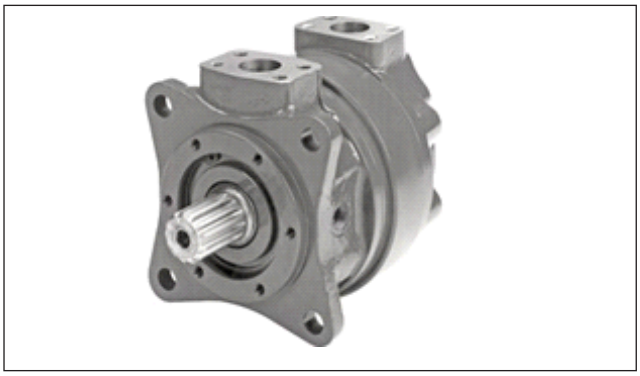


Fig. 3.2.14 Vane Motors

3.3.5 Maintenance of Actuator

Maintenance is required for any equipment. Keeping the actuators in good working order will help avoid catastrophic shutdowns, risks, and lost productivity.

Here are some general guidelines for keeping actuators in good working order:

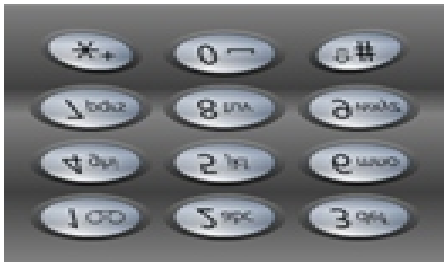
- Inspections should be performed regularly to detect early indicators of actuator problems. To examine for wear and tear, a mechanic with a good eye is required.
- Cylinder fluid change is required for hydraulic actuators on a regular basis. Always check for leaks and symptoms of low hydraulic fluid levels. Replace any loose or damaged coils, nuts, bolts, or screws in actuator components.
- Actuators may not show obvious signs of dysfunction, but their performance may reveal them. To detect more serious errors, automated graphing and output computation may be necessary.

Exercise

1. Identify the following Sensors:

2. Identify the following components of an electrical actuation system:

3. Explain the selection criteria of an actuator.

4. Define sensors.

Notes

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https://youtu.be/gokPA6OWaZ4
Types of Actuators

https://youtu.be/8HZDUwJmVr8
Selection of Actuator

Skill India
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N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

4. Process of Installing, Testing and Using Microcontroller in the Mechatronics System

ESSCI
Skilling India in Electronics

Unit 4.1 - Microcontroller

Unit 4.2 - Microprocessor

ELE/N7111

Key Learning Outcomes

By the end of this module, participants will be able to:

1. Explain different applications of mechatronic systems.
2. Explain the structure of different types of microcontrollers and their PIN configuration.
3. Explain the difference between a microprocessor and a microcontroller.
4. Explain the advantages, disadvantages and applications of microcontrollers.
5. Explain the interfacing of D/A converters and A/D converters with microcontrollers.
6. Describe the function of microcontroller structure in hardware interfacing units of the mechatronics system.
7. Explain the architecture of PIN configuration and ARM Processor.
8. Explain the criteria for selecting an appropriate microcontroller.
9. Describe the process of digital to analogue and vice versa conversion in a microcontroller.
10. Describe the process of controlling the temperature with a temperature sensor using a microcontroller circuit.
11. Define Microprocessor
12. State the programming concepts to interface the hardware units with a microprocessor.
13. Explain the classification of microprocessors.

UNIT 4.1: Microcontroller

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain different applications of mechatronic systems.
2. Explain the structure of different types of microcontrollers and their PIN configuration.
3. Explain the difference between a microprocessor and a microcontroller.
4. Explain the advantages, disadvantages and applications of microcontrollers.
5. Explain the interfacing of D/A converters and A/D converters with microcontrollers.
6. Describe the function of microcontroller structure in hardware interfacing units of the mechatronics system.
7. Explain the architecture of PIN configuration and ARM Processor.
8. Explain the criteria for selecting an appropriate microcontroller.
9. Describe the process of digital to analogue and vice versa conversion in a microcontroller.
10. Describe the process of controlling the temperature with a temperature sensor using a microcontroller circuit.

4.1.1 Microcontroller

A microcontroller is a self-contained computer-on-a-chip that may be utilized in an embedded system. For example, a few microcontrollers may use four-bit expressions and operate at frequency rates such as:

- An 8 or 16-bit microprocessor.
- A little measure of RAM.
- Programmable ROM and flash memory.
- Parallel and serial I/O.
- Timers and signal generators.
- Analog to Digital Conversion and Digital to Analog Conversion

Because many of the devices they control are battery-operated, microcontrollers must typically have minimal power consumption. As a result, microcontrollers are found in various products, including consumer electronics, automobile engines, computer peripherals, and test and measurement equipment. These are also well-suited to long-term battery usage. However, most of the microcontrollers in use today are embedded in other devices.

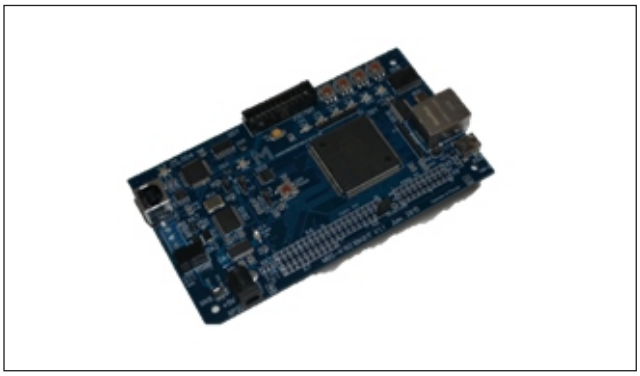

Fig. 4.1.1 Microcontroller

4.1.2 Working of Microcontrollers

The microcontroller chip is a high-speed device, yet it is prolonged compared to a computer. As a result, each command will be performed quickly within the microcontroller. The control logic register enables the quartz oscillator once the supply is turned on. Parasite capacitors will be charged for a few seconds during early preparation.

When the voltage reaches its maximum value and the oscillator's frequency stabilizes, the operation of writing bits across special function registers becomes steady. After that, everything happens based on the CLK of the oscillator and overall electronics will start operating. All of this happens in a matter of nanoseconds.

The main function of a microcontroller is to act as a self-contained system with a processor memory. Its peripherals are similar to those of an 8051 microcontroller. Microcontrollers are found in a variety of machines today, including cell phones, appliances, cars, and computer system peripherals.

4.1.3 Components of Microcontrollers

Some basic microcontroller components are:

1. **CPU:** The microcontroller is a CPU device since it is utilized to transport and decode data before efficiently completing the assigned duty. A central processing unit connects all microcontroller components to a given system. The CPU can decode instructions obtained from the programmable memory.

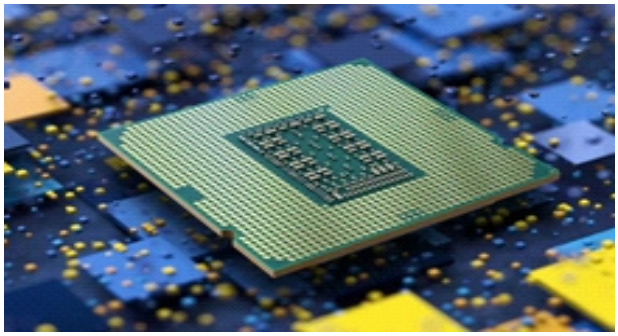

Fig. 4.1.2 CPU

2. **Memory:** A microcontroller's memory chip works similarly to a microprocessor in that it saves all data as well as programming. Microcontrollers have a limited amount of RAM/ROM/flash memory for storing programme source code.

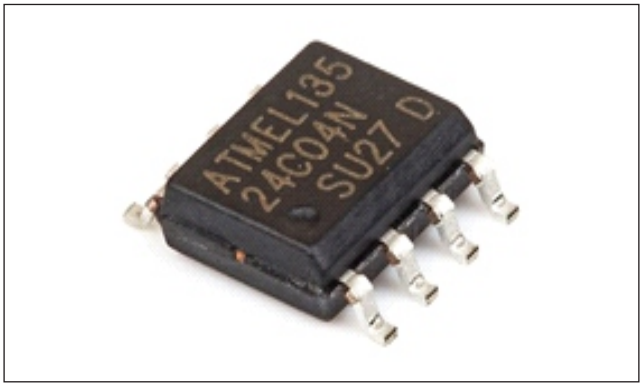

Fig. 4.1.3 Memory

3. **I/O Ports:** In general, these ports are used to interface or otherwise drive various appliances like LEDs, LCDs, printers, etc.

Fig. 4.1.3 I/O Ports

4. **Serial Ports:** Serial ports offer serial interfaces between the microcontroller and other peripherals, such as the parallel port.

Fig. 4.1.4 Serial Ports

5. **Timers:** A microcontroller has timers and counters. They are used to handle all time and counting activities in a microcontroller. A counter's primary function is to count external pulses, whereas timers, among other things, perform clock chores, pulse creation, modulations, frequency measurement, and oscillations.

Fig. 4.1.5 Timers

6. **ADC:** Analog to digital converter is abbreviated as ADC. The primary purpose of an ADC is to convert analogue signals to digital signals. The needed input signals for ADC are analogue, and the resulting digital signal is employed in a variety of digital applications such as measuring equipment.

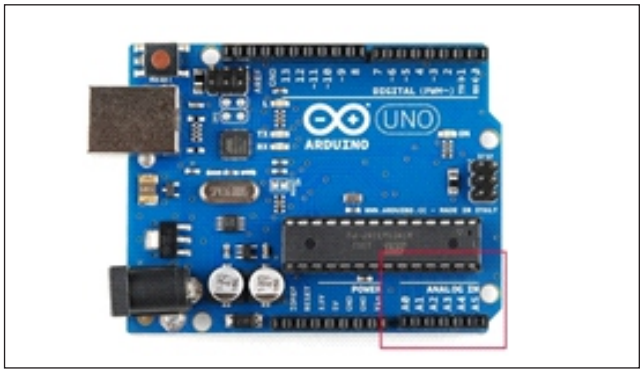

Fig. 4.1.6 ADC

7. **DAC:** The digital to analog converter (DAC) is an abbreviation for a device that does the opposite of an ADC. This gadget is typically used to control analogue devices such as DC motors.

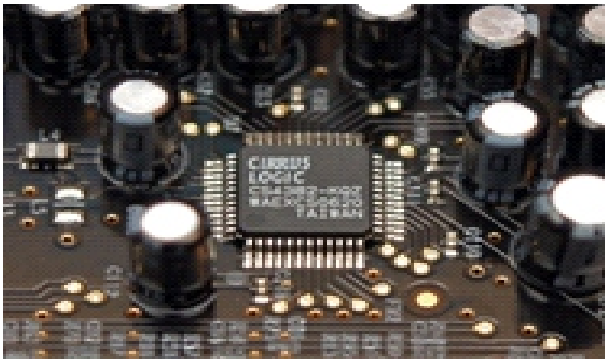

Fig. 4.1.7 DAC

4.1.4 Difference between Microcontroller and Microprocessor

Microprocessor	Microcontroller
The microprocessor is the heart of the Computer system.	The microcontroller is the heart of an embedded system.
It is only a processor, so memory and I/O components need to be connected externally	A microcontroller has a processor along with internal memory and I/O components.
Memory and I/O must be connected externally, so the circuit becomes large.	Memory and I/O are already present, and the internal circuit is small.
It cannot be used in compact systems	One can use it in compact systems.
The cost of the entire system is high	The cost of the entire system is low
Due to external components, the total power consumption is high. Therefore, it is not ideal for the devices running on stored power like batteries.	As external components are low, total power consumption is less. So it can be used with devices running on stored power like batteries.
Most microprocessors do not have power-saving features.	Most microcontrollers offer a power-saving mode.
It is mainly used in personal computers.	It is used mainly in washing machines, MP3 players, and embedded systems.
The microprocessor has fewer registers, so more operations are memory-based.	The microcontroller has more registers. Hence the programs are easier to write.
Microprocessors are based on the Von Neumann model	Microcontrollers are based on Harvard architecture

It is a central processing unit on a single silicon-based integrated chip.	It is a by-product of the development of microprocessors with a CPU and other peripherals.
It has no RAM, ROM, Input-Output units, timers, and other peripherals on the chip.	It has a CPU, RAM, ROM, and other peripherals embedded on a single chip.
It uses an external bus to interface to RAM, ROM, and other peripherals.	It uses an internal controlling bus.
Microprocessor-based systems can sprint because of the technology involved.	Microcontroller-based systems run up to 200MHz or more depending on the architecture.
It is used for general purpose Applications that allow handling loads of data.	It is used for application-specific systems.
It is complex and expensive, with many instructions to process.	It is simple and inexpensive, with less number of instructions to process.

Table 4.1.1 Difference between Microcontroller and Microprocessor

4.1.5 Advantages and Disadvantages of Microcontrollers

Advantages:

The advantages of the microcontroller are:

- The operation takes a short amount of time to complete.
- It is simple to use, and troubleshooting and system maintenance are simple.
- Many jobs are typically completed at the same time, saving the human effect.
- The processor chip is incredibly tiny, allowing for versatility.
- The system is less expensive and smaller in size.
- RAM, ROM, and I/O ports can easily connect to a microcontroller.
- Microcontrollers cannot be reprogrammed after they have been programmed.
- It will appear to be a microcomputer if the digital components are missing.
- It is simple to use, troubleshoot, and keep the system up to date.

Disadvantages

The disadvantages of the microcontroller are:

- It is commonly found in micro-equipment.
- It has got a complicated structure.
- A superior power device cannot be directly interfaced with a microcontroller.
- The number of people who can be executed is restricted.
- Because every microcontroller lacks analog I/O, there are difficulties.

4.1.6 Applications of Microcontrollers

In contrast to microprocessors, which are used in PCs and other general-purpose devices, microcontrollers are designed for embedded devices. Microcontrollers are used in a variety of automatically controlled innovations and appliances, including power tools, implanted medical devices, automotive engine control systems, office machinery, remote control appliances, toys, and a variety of other embedded systems. Microcontrollers make it affordable to digitally manage more and more appliances and processes by reducing the size and cost in contrast to a system that uses a different microprocessor, I/O devices, and memory. The use of non-digital electronic structures to put together analogue elements necessitated the use of mixed-signal microcontrollers.

Microcontrollers are widely used in various devices such as:

- Light sensing and controlling devices like LED.
- Temperature sensing and controlling devices like microwave ovens and chimneys.
- Fire detection and safety devices like fire alarms.
- Measuring devices like volt mete
- Front Panel Controls in devices like Oven, Washing Machine, etc.
- Function Generators
- Smoke and Fire Alarms
- Home Automation Systems
- Automatic Headlamp ON in Cars
- Speed Sensed Door Locking System

4.1.7 Classification of Microcontrollers

Microcontrollers are classified into groups based on their memory, architecture, bits, and instruction sets. They are:

1. According to the Number of Bits

- **8-bit microcontroller:** This type of microcontroller is used to execute arithmetic and logical operations like addition, subtraction, multiplication, division, etc. For example, Intel 8031 and 8051 are 8 bits microcontrollers.
- **16-bit microcontroller:** This type of microcontroller is used to conduct arithmetic and logical tasks that demand more precision and speed. The Intel 8096, for example, is a 16-bit microcontroller.
- **32-bit microcontroller:** This type of microcontroller is generally used in automatically controlled appliances like automatic operational machines, medical appliances, etc.

2. According to Memory Devices

- **Embedded Memory Microcontroller:** An embedded microcontroller is a microcontroller unit that has all of the functional blocks available on a single chip. An embedded microcontroller, for example, is a chip with programme and data memory, I/O ports, serial communication, counters and timers, and interrupts.
- **External Memory Microcontroller:** An external memory microcontroller is a microcontroller unit in an embedded system that does not have all of the functional blocks available on a chip. The 8031, for example, is an external memory microcontroller with no programme memory on the chip.

3. According to Instruction Set

- **CISC:** CISC is a Complex Instruction Set Computer. It allows the programmer to use one instruction in place of many simpler instructions.
- **RISC:** RISC stands for Reduced Instruction Set Computer. This type of instruction set reduces the design of microprocessors for industry standards. It allows each instruction to operate on any register or use any addressing mode and simultaneous access to program and data.

4. According to Memory Architecture

- **Harvard Memory Architecture:** When a microcontroller unit's programme and data memory address spaces are different, the microcontroller's processor has Harvard memory architecture.
- **Princeton Memory Architecture:** When a microcontroller's programme memory and data memory have the same memory address, the microcontroller's processor has Princeton memory architecture.

4.1.8 Types of Microcontrollers

The main types are:

1. 8051 microcontroller:

The most universally employed set of microcontrollers come from the 8051 family. 8051 microcontrollers persist in being an ideal choice for a huge group of hobbyists and experts. In the course of 8051, humankind became an eyewitness to the most ground- breaking set of microcontrollers. The original 8051 microcontroller was initially invented by Intel.

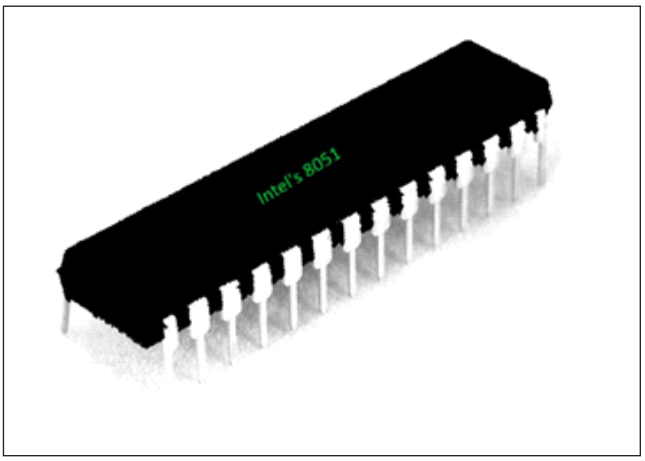

Fig. 4.1.7 8051 Microcontroller

The two other members of this 8051 family are:

- 8052-This microcontroller has three timers & 256 bytes of RAM. Additionally, it has all the features of the traditional 8051 microcontrollers. The 8051 microcontroller is a subset of 8052 microcontrollers.
- 8031 - This microcontroller is ROM-less. Other than that, it has all the features of a traditional 8051 microcontroller. For execution, an external ROM of size 64K bytes can be added to its chip.
- 8051 microcontroller brings into play two different sorts of memory such as - NV- RAM, UV - EPROM and Flash.

8051 Microcontroller Architecture:

8051 microcontroller is an 8-bit microcontroller launched in the year 1981 by Intel Corporation. It is available in 40 pin DIP (dual inline package). It has 4 KB of ROM (on-chip programmable space) and 128 bytes of RAM space which is inbuilt. If desired, 64 KB of external memory can be interfaced with the microcontroller. There are four parallel 8 bits ports which are easily programmable as well as addressable. An on-chip crystal oscillator is integrated into the microcontroller, which has a crystal frequency of 12MHz. In the microcontroller, there is a serial input/output port which has two pins. Two timers of 16 bits are also incorporated in it; these timers can be employed as timer for internal functioning as well as counter for external functioning. The microcontroller comprises of 5 interrupt sources, namely- Serial Port Interrupt, Timer Interrupt 1, External Interrupt 0, Timer Interrupt 0, External Interrupt 1. The programming mode of this microcontroller includes General Purpose Registers (GPRs), Special Function Registers (SFRs) and Special Purpose Registers (SPRs).

2. PIC Microcontroller:

Microchip technology uses the Peripheral Interface Controller (PIC) to classify its solitary chip microcontrollers. In 8-bit microcontrollers, these appliances have proved tremendously successful. The main reason for this is that Micro-chip Technology has been regularly improving the appliance design and adding much-needed peripherals to the microcontroller to meet the needs of the customers. The broad availability, low cost, vast user base, and serial programming capabilities of PIC microcontrollers have made them immensely popular among hobbyists and industrialists.

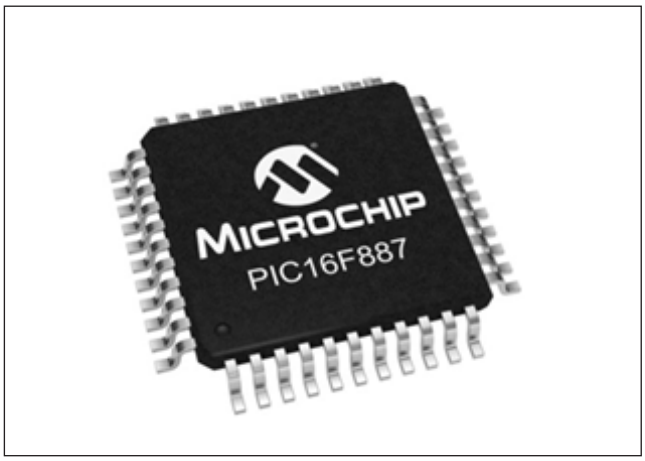

Fig. 4.1.8 PIC Microcontroller

PIC Microcontroller Architecture:

The architecture of the 8-bit PIC microcontrollers can be categorized as below:

- **Base Line Architecture:** In, the base-line architecture PIC microcontrollers of the PIC10F family are included. Other than that, a fraction of PIC12 & PIC16 families is also included. These gadgets make use of 12-bit program word architecture with six to twenty-eight pin package alternatives. A briefly defined attribute set of baseline architecture allows for the most lucrative product solutions. This architecture is perfect for battery-enabled gadgets. The PIC10F200 series is another reasonably priced 8-bit flash microcontroller with a 6-pin package.
- **Mid-Range Architecture:** In this midline member of PIC12 & PIC16 families are added that attribute 14 bit program word architecture. The midrange PIC16 gadgets proffer a broad variety of package alternatives (from 8 to 64 package), with low to high levels of peripheral incorporation. This PIC16 appliance attributes a variety of analog, digital & serial peripherals, like - SPI, USART, I2C, USB, LCD & A/D converters. The mid-range PIC16 micro-controllers have suspended controlling ability with an eight-level hardware load.
- **3High Performance Architecture:** The high performance architecture included the PIC18 family of appliances. These micro- controllers make use of 16 bit program word architecture along with 18 to 100 pin package alternatives. The PIC18 appliances are high performance micro-controllers with incorporated Analog to Digital converters. All PIC18 micro-controllers integrate a highly developed RISC architecture that supports flash appliances. The PIC18 has improved foundation attributes, 32 level deep load and several inner and exterior interrupts.

3. **AVR Microcontroller:** AVR, or Advanced Virtual RISC, is a Harvard architecture 8-bit RISC solitary chip microcontroller with a modified Harvard architecture. It was developed by Atmel in the year 1966. The Harvard architecture denotes that programmes and data are collected in various areas and used at the same time. It was one of the first microcontroller families to use on-chip flash memory for programme storage, as opposed to one-time programmable EPROM, EEPROM, or ROM, which were also used by other microcontrollers at the time. Flash memory is a programmable memory that is non-volatile (i.e., it does not lose its contents when the power is turned off).

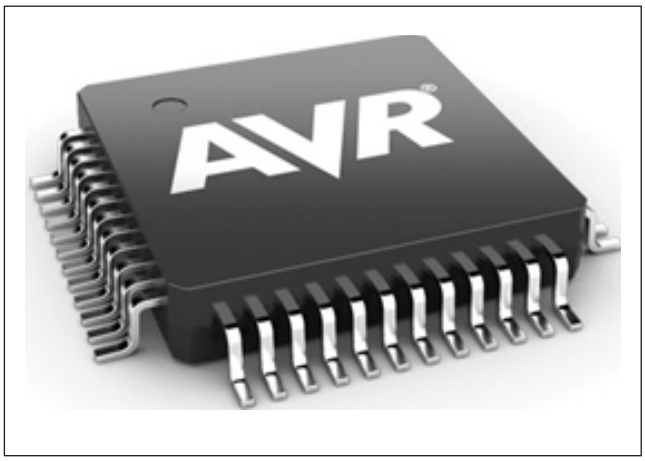

Fig. 4.1.9 AVR Microcontroller

AVR Microcontroller Architecture:

Alf-Egil Bogen and Vegard Wollan designed the AVR microcontroller architecture. The moniker AVR is taken from the names of the microcontroller's architects. The AT90S8515 was the first microcontroller based on the AVR architecture; on the other hand, the AT90S1200 was the first microcontroller to join the commercial market in 1997.

SRAM, Flash, and EEPROM are all integrated on a single chip, obviating the need for any extra external memory in most systems. A parallel external bus option is available on certain appliances, allowing for the addition of additional data memory devices. Almost all appliances, with the exception of TinyAVR chips, include a serial interface, which is utilised to connect massive serial Flash and EEPROM chips.

4. **AMR Microcontroller:**

   AMR is the name of a firm that creates the architecture for microprocessors. It also licences them to companies that manufacture real chips. In reality, AMR is a 32-bit true RISC architecture. It was created by Acorn Computers Ltd in the year 1980. There is no onboard flash memory on this AMR-based microprocessor. ARM is intended specifically for microcontroller devices; it is simple to learn and use yet powerful enough for even the most demanding embedded systems.

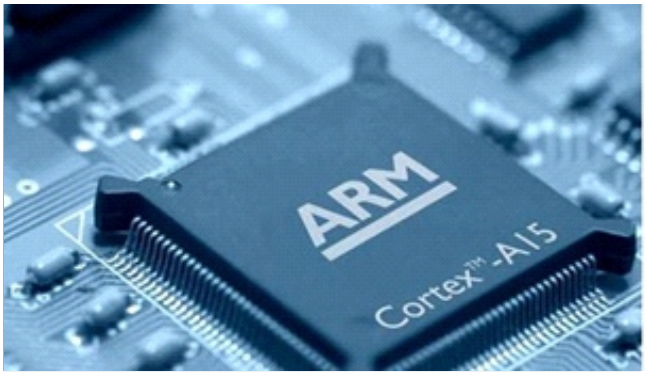

Fig. 4.1.10 AMR Microcontroller

AMR Microcontroller Architecture:

ARM Ltd developed the AMR architecture, which is a 32-bit RISC CPU. ARM central processor units are a popular choice in the mobile electronics sector because of their power-saving capabilities. The following RISC parts make up the ARM architecture:

- Maximum single cycle functioning
- Constant 16×32 bit register file.
- Load or store architecture.
- Pre-set instruction width of 32 bits to simplify pipelining and decoding at minimized code density.
- For misaligned memory access, there is no support

Notes

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Microcontroller

https://youtu.be/OHGzvnMFH0k
Working of Microcontrollers

https://youtu.be/nnquCs2wNCw
Classification of Microcontrollers

https://youtu.be/7KIMF2uebmA
Types of Microcontrollers

UNIT 4.2: Microprocessor

Unit Objectives

By the end of this unit, participants will be able to:

1. Define Microprocessor.
2. State the programming concepts to interface the hardware units with a microprocessor.
3. Explain the classifications of microprocessors.

4.2.1 Microprocessor Meaning

A microprocessor is an integrated circuit (IC) that houses the central processing unit (CPU) of a computer (CPU). It is a clock-driven, register-based programmable multifunctional silicon device that receives binary data as input and processes it according to instructions stored in the memory.

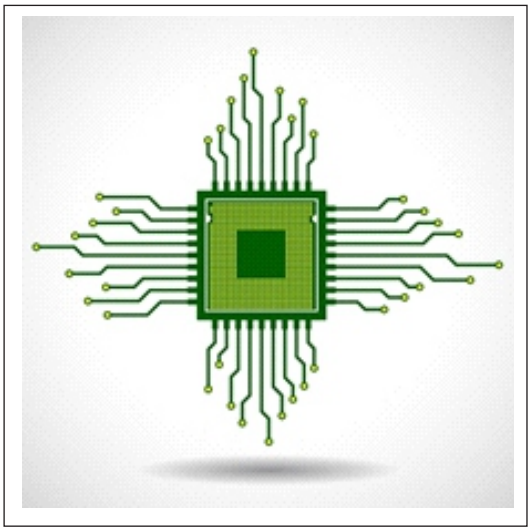

Fig. 4.2.1 Microprocessor

4.2.2 Microprocessors Characteristics

Microprocessors are multipurpose devices that can be designed for generic or specialized functions. The microprocessors of laptops and smartphones are general-purpose, whereas ones designed for graphical processing or machine vision are specialized ones. There are some characteristics that are common to all microprocessors.

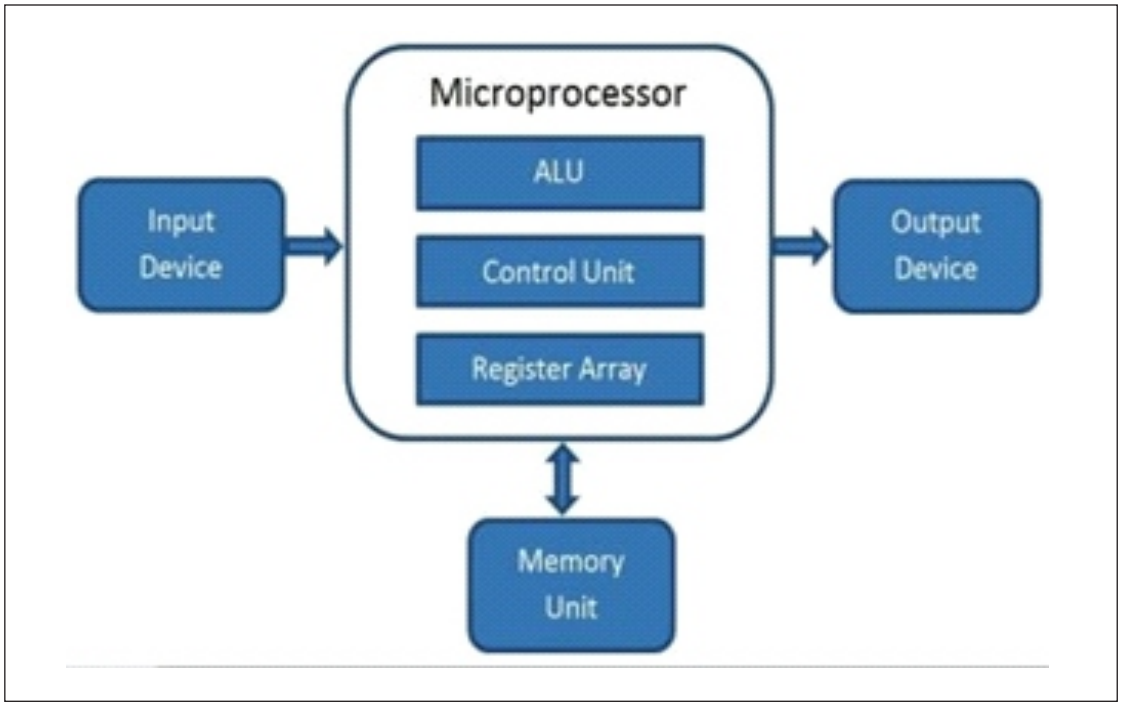

Fig. 4.2.2 Microprocessor Block Diagram

These are the most important defining characteristics of a microprocessor –

- Clock speed
- Instruction set
- Word size

4.2.3 Common terminology in Microprocessor

The common terminology used concerning microprocessors is:

- **Bus:** A bus is a set of conductors intended to transmit data, address or control information to different elements in a microprocessor. Usually, a microprocessor will have three types of buses: Data Bus, Control Bus and Address Bus. An 8-bit processor uses the 8-bit wide bus.
- **Instruction Set:** An instruction set is the group of commands that a microprocessor can understand. So instruction set is an interface between hardware and software (program). An instruction commands the processor to switch relevant transistors for doing some processing in data. For example, ADD A, B; is used to add two numbers stored in the register A and B.
- **Word Length:** Word Length is the number of bits in the internal data bus of a processor, or it is the number of bits a processor can process at a time. For example - An 8-bit processor will have an 8-bit data bus and 8-bit registers and will do 8-bit processing at a time. For doing higher bits (32-bit, 16-bit) operations, it will split that into a series of 8-bit operations.

- **Cache Memory:** Cache memory is a random access memory that is integrated into the processor. So the processor can access data in the cache memory more quickly than from a regular RAM. It is also known as CPU memory. Cache memory is used to store data or instructions that are frequently referenced by the software or program during the operation. So it will increase the overall speed of the operation.
- **Clock Speed:** Microprocessors use a clock signal to control the rate at which instructions are executed, synchronize other internal components and control the data transfer between them. So clock speed refers to the speed at which a microprocessor executes instructions. It is usually measured in Hertz and is expressed in megahertz (MHZ), gigahertz (GHz) etc.

4.2.4 Classification of Microprocessors

The microprocessor can be classified as:

Based on Word Length: Based on the word length of a processor, we can have 8-bit, 16-bit, 32-bit and 64-bit processors.

RISC – Reduced Instruction Set Computer

RISC is a type of microprocessor architecture which uses a small, general-purpose and highly optimized instruction set rather than a more specialized set of instructions found in others. RISC offers high performance over its opposing architecture CISC (see below). In a processor, the execution of each instruction requires a special circuit to load and process the data. So by reducing instructions, the processor will be using simple circuits and faster in operation.

Simple instruction set:

- Larger program
- Consists of a large number of registers
- Simple processor circuitry (small number of transistors)

More RAM usage

- Fixed-length instructions
- Simple addressing modes
- Usually fixed number of clock cycles for executing one instruction

CISC – Complex Instruction Set Computer

- CISC is the opposing microprocessor architecture for RISC. It is made to reduce the number of instructions per program, ignoring the number of cycles per instruction. So complex instructions are directly made into hardware, making the processor complex and slower in operation.
- This architecture is actually designed to reduce the cost of memory by reducing the program length.

Complex instruction set:

- Smaller program
- Less number of registers
- Complex processor circuitry (more number of transistors)
- Little RAM usage
- Variable-length instructions
- Variety of addressing modes
- Variable number of clock cycles for each instruction

Special Purpose Processors

There are some processors which are designed to handle some specific functions.

- DSP – Digital Signal Processors
- Coprocessors – Processors used along with the main processor (8087 math-coprocessor used with 8086)
- Input/output processors
- Transputer – Transistor Computer: Microprocessor with its own local memory

Exercise

1. Explain what a microprocessor is, and differentiate it from a microcontroller.
2. Explain the architecture of the PIC microcontroller.
3. What are the components of a microcontroller?
4. Classify the microcontroller according to the number of bits.

Notes

Scan the QR Code to watch the related videos

https://youtu.be/jrfZOlMuOJQ
Microprocessors Characteristics

https://youtu.be/XECWxP_MEa0
Common terminology in Microprocessor

https://youtu.be/AG_bHxI9ix0
Classification of Microprocessors

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5. Soft Skills and Work Ethics

Unit 5.1 - Effective Communication and Coordination at Work

Unit 5.2 - Working Effectively and Maintaining Discipline at Work

Unit 5.3 - Maintaining Social Diversity at Work

ELE/N9905

Key Learning Outcomes

By the end of this module, participants will be able to:

1. State the importance of work ethics and workplace etiquette.
2. State the importance of effective communication and interpersonal skills.
3. Explain ways to maintain discipline in the workplace.
4. Discuss the common reasons for interpersonal conflict and ways of managing them effectively.

UNIT 5.1: Effective Communication and Coordination at Work

Unit Objectives

By the end of this unit, participants will be able to:

1. Work effectively at the workplace.
2. Demonstrate practices related to gender and PwD sensitization.

5.1.1 Importance of Work Ethics and Workplace Etiquette

Workplace ethics are a set of moral and legal guidelines that organizations follow. These guidelines influence the way customers and employees interact with an organization. Workplace ethics essentially guide how an organization serves its clients and treats its employees.

For example, if a company seeks to fulfil the promises it makes, it may develop processes and set up a robust support system to address this policy and build customer/client loyalty. To achieve this goal, the company may implement specific incentive programs for employees to encourage them to produce high-quality work and ensure the organization fulfils the promises it makes to its clients/ customers.

Many organizations, often the large ones, set detailed ethical codes to guide their operations and control how the organizational processes impact the stakeholders. These ethics usually help organizations maintain certain standards of responsibility, accountability, professionalism and among others, as they navigate through different challenges and day-to-day circumstances. By following these guidelines, organizations often experience several benefits that improve the lives of stakeholders, such as customers, employees, leaders, etc.

Examples of Common Workplace Ethics

Fig. 5.1.1 Examples of Common Workplace Ethics

Workplace ethics are essential for a successful organization with a satisfied and loyal team. High ethical standards help in ensuring all stakeholders, such as customers, investors, employees, and other individuals involved in the workplace operations, feel the organization is safeguarding their interests. By creating and implementing ethical guidelines, organizations can keep the best interests of their employees in mind while maintaining a positive influence on those they impact through their processes.

As a result, employees maintain the organization's best interests by being ethical in their daily work duties. For example, fairly-treated employees of an organization who understand the organization's commitments to environmental sustainability are usually less likely to behave in a manner that causes harm to the environment. Thus, they help maintain a positive public image of the organization. It means that workplace ethics help in maintaining reciprocal relationships that benefit organizations at large and the individuals associated with and influenced by the organizational policies.

Benefits of Workplace Ethics

There are various benefits of implementing workplace ethics. When organizations hold themselves to high ethical standards, leaders, stakeholders, and the general public can experience significant improvements. Following are some of the key benefits of employing ethics in the workplace:

Fig. 5.1.2 Benefits of Workplace Ethics

5.1.2 Interpersonal Communication

Interpersonal communication is a process that involves sharing ideas and emotions with another person, both - verbally and non-verbally. It is essential to interact effectively with others in both personal and professional lives. In professional life or the workplace, strong interpersonal skills play a crucial role in achieving effective collaboration with colleagues.

Interpersonal Skills

Interpersonal skills, in other terms, are known as people skills, which are used to communicate and interact with others effectively. These are soft skills one uses to communicate with others and understand them. One uses these skills in daily life while interacting with people.

Examples of Interpersonal Skills

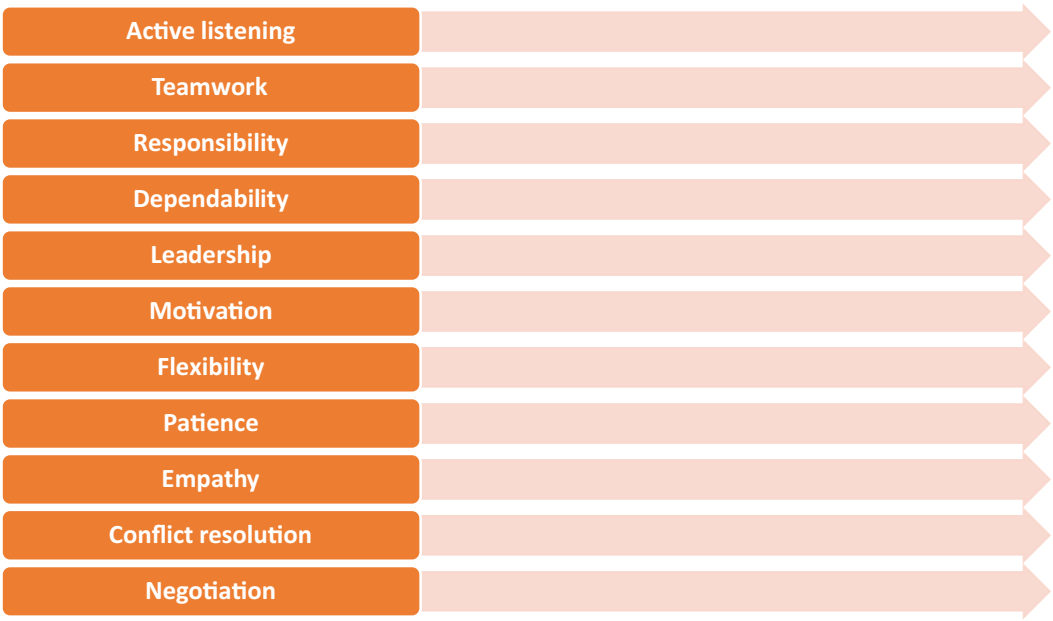


Fig 5.1.3 Examples of Interpersonal Skills

Numerous interpersonal skills involve communication. Communication can be verbal, such as persuasion or tone of voice — or non-verbal, such as listening and body language.

Importance of Interpersonal Skills

Interpersonal skills are essential for communicating and collaborating with groups and individuals in both personal and professional life. People with strong interpersonal skills often are able to build good relationships and also tend to work well with others. Most people often enjoy working with co-workers who have good interpersonal skills.

Among other benefits of good interpersonal skills is the ability to solve problems and make the best decisions. One can use the ability to understand others and good interpersonal communication skills to find the best solution or make the best decisions in the interest of everyone involved. Strong interpersonal skills help individuals work well in teams and collaborate effectively. Usually, people who possess good interpersonal skills also tend to be good leaders, owing to their ability to communicate well with others and motivate the people around them.

Interpersonal communication is the key to working in a team environment and working collectively to achieve shared goals. Following are the interpersonal communication skills that vital for success at work:

Verbal Communication

The ability to speak clearly, appropriately and confidently can help one communicate effectively with others. It is vital to select the appropriate vocabulary and tone for the target audience.

For example – one should speak formally and professionally in the work environment, while informal language is acceptable in an intimate environment with close friends and family. Also, one should avoid using complex or technical language while communicating with an audience that may not be familiar with it. Using simple language in a courteous tone helps achieve better communication, irrespective of the audience.

Active Listening

Active listening is defined as the ability to pay complete or undivided attention to someone when they speak and understand what they are saying. It is important for effective communication because without understanding what the speaker is saying, it becomes difficult to carry forward a conversation. One should ensure to use appropriate verbal and non-verbal responses, e.g. eye contact, nodding, or smiling, to show interest in what the speaker says. Active listening is also about paying attention to the speaker's body language and visual cues. Asking and answering questions is one of the best ways to demonstrate an interest in conversing with the other person.

Active listening is critical for communicating effectively without ambiguity. It helps one understand the information or instructions being shared. It may also encourage co-workers to share their ideas, which ultimately helps achieve collaboration.

Body Language

One's expression, posture, and gestures are as important as verbal communication. One should practice open body language to encourage positivity and trust while communicating. Open body language includes - maintaining eye contact, nodding, smiling and being comfortable. On the other hand, one should avoid closed body language, e.g. crossed arms, shifting eyes and restless behaviour.

Empathy

Empathy is the ability to understand the emotions, ideas and needs of others from their point of view. Empathy is also known as emotional intelligence. Empathetic people are good at being aware of others' emotions and compassionate when communicating with them. Being empathetic in the workplace can be good to boost the morale of employees and improve productivity. By showing empathy, one can gain the trust and respect of others.

Conflict Resolution

One can use interpersonal communication skills to help resolve disagreements and conflicts in the workplace. This involves the application of negotiation and persuasion skills to resolve arguments between conflicting parties. It is also important to evaluate and understand both sides of the argument by listening closely to everyone involved and finding an amicable solution acceptable to all.

Teamwork

Employees who communicate and work well in a team often have better chances of achieving success and common goals. Being a team player can help one avoid conflicts and improve productivity. One can do this by offering to help co-workers when required and asking for their feedback and ideas. When team members give their opinions or advice, one should positively receive and react to the opinions/advice. One should be optimistic and encouraging when working in groups.

Improving Interpersonal Skills

One can develop interpersonal skills by practising good communication and setting goals for improvement. One should consider the following tips to improve their interpersonal skills:

- One should ask for feedback from co-workers, managers, family or friends to figure out what needs improvement concerning their interpersonal skills.
- One can identify the areas of interpersonal communication to strengthen by watching others.
- One can learn and improve interpersonal skills by observing co-workers, company leaders and professionals who possess good interpersonal skills. This includes watching and listening to them to note how they communicate and the body language used by them. It is vital to note their speed of speaking, tone of voice, and the way they engage with others. One should practice and apply such traits in their own interactions and relationships.
- One should learn to control their emotions. If stressed or upset, one should wait until being calm to have a conversation. One is more likely to communicate effectively and confidently when not under stress.
- One can reflect on their personal and professional conversations to identify the scope of improvement and learn how to handle conversations better or communicate more clearly. It helps to consider whether one could have reacted differently in a particular situation or used specific words or positive body language more effectively. It is also vital to note the successful and positive interactions to understand why they are successful.
- One should practice interpersonal skills by putting oneself in positions where one can build relationships and use interpersonal skills. For example, one can join groups that have organized meetings or social events. These could be industry-specific groups or groups with members who share an interest or hobby.
- Paying attention to family, friends and co-workers and making efforts to interact with them helps a lot. One should complement their family, friends and co-workers on their good ideas, hard work and achievements. Trying to understand someone's interests and showing interest in knowing them can help one build strong interpersonal skills. Offering to help someone, especially in difficult situations, helps build stronger and positive workplace relationships.
- One should avoid distractions, such as a mobile phone, while interacting with someone. Giving someone full attention while avoiding distractions helps achieve a clear exchange of ideas. By listening with focus, one can understand and respond effectively.

- One can attend appropriate courses on interpersonal skills or sign up for workshops at work to improve interpersonal skills. One can find many resources online also, such as online videos.
- For personal mentoring, one can approach a trusted family member, friend, co-worker, or current/former employer. A person one looks up to with respect and admires is often a good choice to be selected as a mentor. One can even hire a professional career or communication coach.

Interpersonal communication skills often help one boost their morale, be more productive in the workplace, complete team projects smoothly and build positive and strong relationships with co-workers.

Good conflict resolution skills can help one contribute to creating a collaborative and positive work environment. With the ability to resolve conflicts, one can earn the trust and respect of co-workers.

Notes

UNIT 5.2: Working Effectively and Maintaining Discipline at Work

Unit Objectives

By the end of this unit, participants will be able to:

1. Discuss the importance of following organizational guidelines for dress code, time schedules, language usage and other behavioural aspects.
2. Explain the importance of working as per the workflow of the organization to receive instructions and report problems.
3. Explain the importance of conveying information/instructions as per defined protocols to the authorised persons/team members.
4. Explain the common workplace guidelines and legal requirements on non-disclosure and confidentiality of business-sensitive information.
5. Describe the process of reporting grievances and unethical conduct such as data breaches, sexual harassment at the workplace, etc.
6. Discuss ways of dealing with heightened emotions of self and others.

5.2.1 Discipline at Work

Discipline is essential for organizational success. It helps improve productivity, reduce conflict and prevent misconduct in the workplace. It is important to have rules concerning workplace discipline and ensure that all employees comply with them. In the absence of discipline, a workplace may experience conflicts, bullying, unethical behaviour and poor employee performance. An efficient workplace disciplinary process helps create transparency in the organization. Benefits of disciplinary standards:

All employees follow the same rules which helps establish uniformity and equality in the workplace

Managers and supervisors have defined guidelines on what action to take while initiating disciplinary action

With well-defined and enforced disciplinary rules, an organization can avoid various safety, security, rupational risks

Fig 5.2.1 Benefits of Disciplinary Standards

Maintaining an organized and cohesive workforce requires maintaining discipline in both personal and professional behaviour. It is important to follow the appropriate measures to keep employees in line without affecting their morale.

Defining Discipline

The first and crucial step in maintaining workplace discipline is to define what is meant by discipline. It helps to evaluate common discipline problems and devise guidelines for handling them effectively.

Among a number of areas, discipline usually covers:

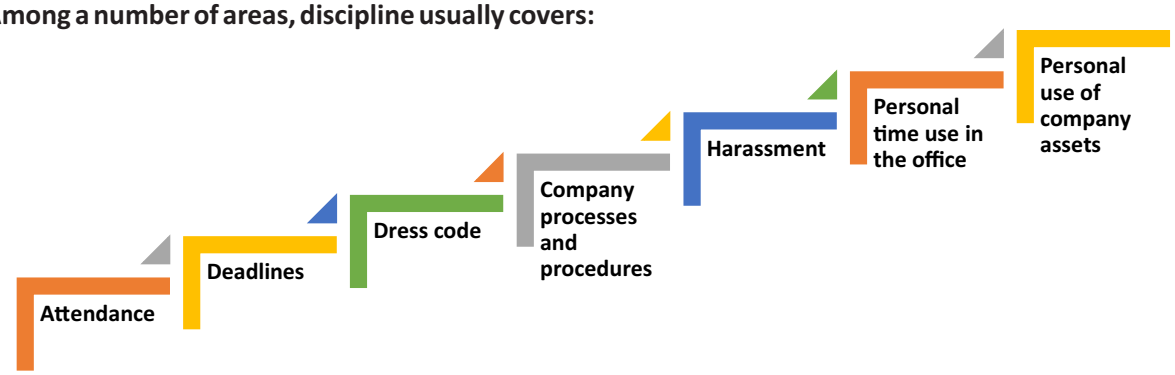


Fig 5.2.2 Examples of Workplace Discipline

According to demography and local issues, it may also include substance use and related issues.

It is vital for a workplace to have an employee handbook or company policy guide, to serve as a rulebook for employees to follow. The employee handbook/ company policy guide should be reviewed and updated periodically according to any issues or areas, or concerns identified concerning workplace discipline. Such manuals should also cover all the laws and regulations governing workplace behaviour.

Defining and documenting workplace rules aids in their implementation, ensuring little or no ambiguity. All employees in a workplace should also have easy access to the workplace guidelines so that they can refer to them to get clarity whenever required. To maintain discipline at work, it is also critical to ensure uniform application of workplace guidelines to all employees without exception.

5.2.2 Employee Code of Conduct

The employee code of conduct manual serves as a guide for employees to inform them regarding the behaviour expected from them at work. It helps create a good work environment with consistent behaviour from employees. The manual should list examples of acceptable and not acceptable behaviours at work. The code of conduct should be discussed with employees so that they have the clarifications required.

For example, an organization may create guidelines concerning the conduct with clients to ensure no contact is made with them except for business purposes, also prescribing the use of appropriate means of communication.

Employees should have a clear understanding concerning their job responsibilities and the behaviour expected from them with all stakeholders, e.g. company personnel, clients and associated third parties. It is critical to have documented guidelines for employees to follow concerning all aspects of work.

It should also document the disciplinary action to be followed in case of non-compliance, e.g. verbal and then written warning, temporary suspension or eventual termination of service in case of repeated non-compliance with the employee code of conduct. Employees should know what the company rules are and what will happen if they break the rules. However, disciplinary action should be initiated only when reasonably required to avoid its misuse for employee harassment.

There should also be an effective mechanism for employees to raise their concerns/ grievances and have them addressed while maintaining privacy, as required, e.g. raising concerns regarding the behaviour of a co-worker.

The employee code of conduct manual must be duly reviewed and approved by the concerned stakeholders, such as the Human Resources (HR) department and company executives.

5.2.3 Interpersonal Conflicts

Interpersonal conflict is any type of conflict between two or more people. These are found in both - personal and professional relationships - among friends, family, and co-workers. In the workplace, interpersonal conflict is often observed when a person or group of people interfere with another person's attempts at completing assignments and achieving goals. It is critical to resolve conflicts in the workplace to boost the morale of employees, repair working relationships among them, and improve customer satisfaction.

Reasons for Workplace Conflicts

Workplace conflicts are often observed when two or more people have different points of view. This can happen between managers, co-workers, or clients and customers. In general, interpersonal conflicts are caused by a lack of communication or unclear communication.

Some of the leading reasons for workplace conflicts are:

- Difference in values
- Personality clashes
- Poor communication

Example of poor communication – if a manager reassigns a task to another employee without communicating with the employee to whom it was originally assigned, interpersonal conflict can arise among them. This may potentially make the first employee, i.e. who was originally assigned the task, feel slighted and mistrusted by the manager. It may even cause animosity in the first employee toward the employee who has now been assigned the task.

Types of Interpersonal Conflict

Following are the four types of interpersonal conflicts:

1. **Policy-related interpersonal conflict**

   When a conflict relates to a decision or situation that involves both parties, it can be called a policy-related interpersonal conflict. Example – two people or groups working on the same project, trying to adopt different approaches. To resolve policy-related interpersonal conflicts, the parties involved should try to look for a win-win situation or make a compromise. This is especially critical to resolve trivial issues so that work is not affected and common goals are achieved.

2. **Pseudo-conflicts**

   Pseudo-conflict arises when two people or groups want different things and cannot reach an agreement. Pseudo-conflicts usually involve trivial disagreements that tend to hide the root of the issue.

3. **Ego-related interpersonal conflicts**

   In ego conflicts, losing the argument may hurt or damage a person's pride. Sometimes ego conflicts arise when a number of small conflicts pile up on being left unresolved. To resolve ego-related conflicts, it's best to find the root of the issue and work towards a resolution.

4. **Value-related interpersonal conflicts**

   Sometimes conflicts may occur between people when they have different value systems. Such conflicts can be difficult to identify initially, making the people involved think the other party is being disagreeable or stubborn, wherein they just have different values. Some co-workers may highly value their personal/ family time after office that they may be unreachable to clients during non-office hours, while others may place a high value on client satisfaction and may still be available for clients during non-office hours. Conflict may arise among such people when they may be required to coordinate to help a client during after-office hours. Value-related interpersonal conflicts are often difficult to settle since neither party likes to compromise.

Resolving Interpersonal Conflicts

Conflicts are usually likely in the workplace; they can, however, be prevented. Often resolving interpersonal conflicts through open communication helps build a stronger relationship, paving the way for effective coordination and success. Some ways to resolve interpersonal conflict:

- **Communication:** A great way to resolve interpersonal conflicts is for the opposing parties to listen to one another's opinions and understand their viewpoints. Meeting in person and keeping the conversation goal-oriented is important. One can have effective communication by following some measures, e.g. staying on the topic, listening actively, being mindful of the body language, maintaining eye contact, etc.

- **Active Listening:** One should patiently listen to what the other person is saying without interrupting or talking over them. It helps one display empathy and get to the root of the issue. Asking questions to seek clarification when required helps in clear communication and conveys to the other person that one is listening to them. Practising active listening is a great way to improve one's communication skills.
- **Displaying Empathy:** Listening attentively and identifying the anxieties/ issues of co-workers is a great way to show empathy and concern. It is essential to understand their feelings and actions to encourage honesty and avoid future conflict.
- **Not Holding Grudges:** With different types of people and personalities in a workplace, it is common for co-workers to have conflicts. It is best to accept the difference in opinions and move on. Being forgiving and letting go of grudges allows one to focus on the positive side of things and perform better at work.

Work-related interpersonal conflicts can be complicated because different people have different leadership styles, personality characteristics, job responsibilities and ways in which they interact. One should learn to look above interpersonal conflicts, resolving them to ensure work goals and environment are not affected.

5.2.4 Importance of Following Organizational Guidelines

Policies and procedures or organizational guidelines are essential for any organization. These provide a road map for the operations of the organization. These are also critical in ensuring compliance with the applicable laws and regulations by guiding the decision-making process and business operations.

Organizational guidelines help bring uniformity to the operations of an organization, which helps reduce the risk of unwanted and unexpected events. These determine how employees are supposed to behave at work, which ultimately helps the business achieve its objectives efficiently.

However, organizational guidelines are ineffective and fail to serve their purpose if they are not followed. Many people don't like the idea of following and abiding by specific guidelines. Such people should be made to understand the benefits of following the organizational guidelines. Some of the key benefits are given below:

With well-defined organizational guidelines in place, no individual can act arbitrarily, irrespective of their position in the organization. All individuals will know the pros and cons of taking certain actions and what to expect in case of unacceptable behaviour. Benefits of following organizational guidelines:

- **Consistent processes and structures:** Organization guidelines help maintain consistency in operations, avoiding any disorder. When all employees follow the organizational guidelines, an organization can run smoothly. These ensure that people in different job roles operate as they are supposed to, knowing what they are responsible for, what is expected of them, and what they can expect from their supervisors and co-workers. With clarity in mind, they can do their jobs with confidence and excellence. With every person working the way intended, it's easy to minimise errors.

  With all the staff following organizational guidelines, the organization has a better scope of using time and resources more effectively and efficiently. This allows the organization to grow and achieve its objectives.

- **Better quality service:** By following organizational guidelines, employees perform their duties correctly as per the defined job responsibilities. It helps enhance the quality of the organization's products and services, helping improve the organization's reputation. Working with a reputable organization, employees can take pride in their work and know they are contributing to the reputation.

- **A safer workplace:** When all employees follow organizational guidelines, it becomes easy to minimise workplace incidents and accidents. It reduces the liabilities associated with risks for the organization and limits the interruptions in operations. Employees also feel comfortable and safe in the workplace, knowing their co-workers are ensuring safety at work by following the applicable guidelines.

Different organizations may have different guidelines on dress code, time schedules, language usage, etc. For example – certain organizations in a client-dealing business requiring employees to meet clients personally follow a strict dress code asking their employees to wear formal business attire. Similarly, organizations operating in specific regions may require their employees to use the dominant regional language of the particular region to build rapport with customers and serve them better. Certain organizations, such as banks, often give preference to candidates with knowledge of the regional language during hiring.

Working hours may also differ from one organization to another, with some requiring employees to work extra compared to others. One should follow the organizational guidelines concerning all the aspects of the employment to ensure a cohesive work environment.

5.2.5 Workflow

Workflow is the order of steps from the beginning to the end of a task or work process. In other words, it is the way a particular type of work is organised or the order of stages in a particular work process.

Workflows can help simplify and automate repeatable business tasks, helping improve efficiency and minimise the room for errors. With workflows in place, managers can make quick and smart decisions while employees can collaborate more productively.

Other than the order that workflows create in a business, these have several other benefits, such as:

- **Identifying Redundancies:** Mapping out work processes in a workflow allows one to get a clear, top-level view of a business. It allows one to identify and remove redundant or unproductive processes.

Workflow gives greater insights into business processes. Utilizing such useful insights, one can improve work processes and the bottom line of the business. In many businesses, there are many unnecessary and redundant tasks that take place daily. Once an organization has insight into its processes while preparing workflow, it can determine which activities are really necessary.

Identifying and eliminating redundant tasks creates value for a business. With redundant tasks and processes eliminated, an organization can focus on what's important to the business.

- **Increase in Accountability and Reduction in Micromanagement:** Micromanagement often causes problems in a business setting as most employees don't like being micromanaged, and even many managers don't like the practice. Micromanagement is often identified as one of the reasons why people quit their job.

However, the need for micromanagement can be minimized by clearly mapping out the workflow. This way, every individual in a team knows what tasks need to be completed and by when and who is responsible for completing them. This makes employees more accountable also.

With clearly defined workflow processes, managers don't have to spend much time micromanaging their employees, who don't have to approach the manager to know what the further steps are. Following a workflow, employees know what is going on and what needs to be done. This, in turn, may help increase the job satisfaction of everyone involved while improving the relationships between management and employees.

- **Improved Communication:** Communication at work is critical because it affects all aspects of an organization. There are instances when the main conflict in an organization originates from miscommunication, e.g. the management and employees disagreeing on an aspect, despite pursuing the same objectives. Poor communication is a common workplace issue that is often not dealt with.

This highlights why workflow is important. Workplace communication dramatically can increase with the visibility of processes and accountability. It helps make the daily operations smoother overall.

- **Better Customer Service:** Customers or clients are central to a business. Therefore, it is imperative to find and improve ways to improve customer experience. Relying on outdated manual systems may cause customer requests or complaints to be overlooked, with dissatisfied customers taking their business elsewhere. However, following a well-researched and defined workflow can help improve the quality of customer service.

By automating workflows and processes, an organization can also reduce the likelihood of human error. This also helps improve the quality of products or services over time, resulting in a better customer experience.

5.2.6 Following Instructions and Reporting Problems

All organizations follow a hierarchy, with most employees reporting to a manager or supervisor. For organizational success, it is vital for employees to follow the instructions of their manager or supervisor. They should ensure they perform their duties as per the given instructions to help achieve the common objectives of the organization and deliver quality service or products. This consequently helps maintain the reputation of the organization.

It is also important to be vigilant and identify problems at work or with the organizational work processes. One should deal with the identified within their limits of authority and report out of authority problems to the manager/ supervisor or the concerned person for a prompt resolution to minimise the impact on customers/clients and business.

5.2.7 Information or Data Sharing

Information or data is critical to all organizations. Depending on the nature of its business, an organization may hold different types of data, e.g. personal data of customers or client data concerning their business operations and contacts. It is vital to effective measures for the appropriate handling of different types of data, ensuring its protection from unauthorized access and consequent misuse.

One should access certain data only if authorised to do so. The same is applicable when sharing data which must be shared only with the people authorised to receive it to use it for a specific purpose as per their job role and organizational guidelines. For example – one should be extra cautious while sharing business data with any third parties to ensure they get access only to the limited data they need as per any agreements with them. It is also critical to monitor how the recipient of the data uses it, which should strictly be as per the organizational guidelines. It is a best practice to share appropriate instructions with the recipient of data to ensure they are aware of the purpose with which data is being shared with them and how they are supposed to use and handle it. Any misuse of data must be identified and reported promptly to the appropriate person to minimise any damage arising out of data misuse.

These days most organizations require their employees and business partners or associated third parties to sign and accept the relevant agreement on the non-disclosure of business-sensitive information. In simple terms, business-sensitive information is confidential information. It is proprietary business information collected or created during the course of conducting business, including information about the business, e.g. proposed investments, intellectual property, trade secrets, or plans for a merger and information related to its clients. Business-sensitive information may sometimes also include information regarding a business's competitors in an industry.

The release of business: Sensitive information to competitors or the general public poses a risk to a business. For example, information regarding plans for a merger could be harmful to a business if a competitor gets access to it.

5.2.8 Reporting Issues at Work

Most organizations have defined guidelines on appropriate reporting processes to be followed for reporting different types of issues. For example – one can report any grievances or dissatisfaction concerning co-workers to their manager/supervisor, e.g. data breaches or unethical conduct. If the concern is not addressed, then the employee should follow the organizational guidelines and hierarchy for the escalation of such issues that are not addressed appropriately.

For example: Any concern related to sexual harassment at the workplace should be escalated to the concerned spokesperson, such as Human Resources (HR) representative, and if not satisfied with the action taken, it should be reported to the senior management for their consideration and prompt action.

5.2.9 Dealing with Heightened Emotions

Humans are emotional beings. There may be occasions when one is overwhelmed by emotions and is unable to suppress them. However, there may be situations when one must manage emotions well, particularly at work.

Stress in one's personal and professional life may often cause emotional outbursts at work. Managing one's emotions well, particularly the negative ones, is often seen as a measure of one's professionalism. Anger, dislike, frustration, worry, and unhappiness are the most common negative emotions experienced at work.

Ways to manage negative emotions at work:

- **Compartmentalisation:** It's about not confining emotions to different aspects of one's life. For example, not letting negative emotions from personal life affect work-life and vice versa. One should try to leave personal matters and issues at home. One should train their mind to let go of personal matters before reaching work. Similarly, one can compartmentalise work-related stresses so that negative emotions from work don't affect one's personal life.

- **Deep breathing and relaxation:** Deep breathing helps with anxiety, worry, frustration and anger. One should take deep breaths, slowly count to ten - inhaling and exhaling until one calms down. One can also take a walk to calm down or listen to relaxing music. Talking to someone and sharing concerns also helps one calm down.
- **The 10-second rule:** This is particularly helpful in controlling anger and frustration. When one feels their temper rising, they should count to 10 to calm down and recompose. If possible, one should move away to allow temper to come down.
- **Clarify:** It is always good to clarify before reacting, as it may be a simple case of misunderstanding or miscommunication.
- **Physical activity:** Instead of losing temper, one should plan to exercise, such as running or going to the gym, to let the anger out. Exercise is also a great way to enhance mood and release any physical tension in the body.
- **Practising restraint:** One should avoid replying or making a decision when angry, not allowing anger or unhappiness to cloud one's judgement. It may be best to pause any communication while one is angry, e.g. not communicating over email when angry or upset.
- **Knowing one's triggers:** It helps when one is able to recognise what upsets or angers them. This way, one can prepare to remain calm and plan their reaction should a situation occur. One may even be able to anticipate the other party's reaction.
- **Be respectful:** One should treat their colleagues the same way one would like to be treated. If the other person is rude, one need not reciprocate. It is possible to stay gracious, firm and assertive without being aggressive. Sometimes, rude people back away when they don't get a reaction from the person they are arguing with.
- **Apologise for any emotional outburst:** Sometimes, one can get overwhelmed by emotions, reacting with an emotional outburst. In such a case, one should accept responsibility and apologise immediately to the affected persons without being defensive.
- **Doing away with negative emotions:** It is recommended to let go of anger, frustration and unhappiness at the end of every workday. Harbouring negative emotions affects one emotionally, affecting their job performance also. Engaging in enjoyable activities after work is a good stress reliever.

Notes

UNIT 5.3: Maintaining Social Diversity at Work

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain the concept and importance of gender sensitivity and equality.
2. Discuss ways to create sensitivity for different genders and Persons with Disabilities (PwD).

5.3.1 Gender Sensitivity

Gender sensitivity is the act of being sensitive towards people and their thoughts regarding gender. It ensures that people know the accurate meaning of gender equality, and one's gender should not be given priority over their capabilities.

Fig 5.3.1 Gender Equality

Women are an important source of labour in many sectors, yet they have limited access to resources and benefits. Women should receive the same benefits and access to resources as men. A business can improve its productivity and quality of work by providing better support and opportunities to women.

Important Terms:

- **Gender Sensitivity:** Gender sensitivity is the act of being sensitive to the ways people think about gender.
- **Gender Equality:** It means persons of any gender enjoy equal opportunities, responsibilities, and rights in all areas of life.
- **Gender Discrimination:** It means treating an individual unequally or disadvantageously based on their gender, e.g. paying different wages to men and women for similar or equal job positions.

Strategies for Enhancing Gender Equity

To enhance gender equity, one should:

- Follow gender-neutral practices at all levels at work.
- Participate together in decision-making.
- Help in promoting women's participation in different forums.
- Assist women in getting exposure to relevant skills and practices.
- Assist women in capacity building by mentoring, coaching or motivating them, as appropriate.
- Assist in the formation and operation of women support groups.
- Assist in the implementation of women-centric programmes.
- Combine technical training with reproductive health and nutrition for coffee farming households.
- Assist in making a work environment that is healthy, safe, and free from discrimination.

Bridging Gender Differences

Men and women react and communicate very differently. Thus, there are some work differences as both genders have their style and method of handling a situation.

Although, understanding and maturity vary from person to person, even between these genders, based on their knowledge, education, experience, culture, age, and upbringing, as well as how one's brain functions over a thought or problem.

In order to bridge the gap, one should:

- Not categorize all men and women in one way.
- Be aware of the verbal and non-verbal styles of communication of every gender to avoid any miscommunication and work better.
- Be aware of partial behaviour and avoid it.
- Encourage co-workers of different genders to make room by providing space to others.

Ways to reduce Gender Discrimination

- Effective steps against sexual harassment by the concerned authorities and general public.
- Gender stereotypes are how society expects people to act based on their gender. This can only be reduced by adopting appropriate behaviour and the right attitude.
- Objectification of females must be abolished.

Ways to Promote Gender Sensitivity in the Workplace

- Practices that promote gender diversity should be adopted and promoted.
- All genders should receive equal responsibilities, rights, and privileges.
- All genders should have equal pay for similar or the same job roles/ positions.
- Strict and effective workplace harassment policies should be developed and implemented.
- An open-minded and stress-free work environment should be available to all the employees, irrespective of their gender.
- Women should be encouraged to go ahead in every field of work and assume leadership roles.
- Follow appropriate measures for women's empowerment.
- Men should be taught to be sensitive to women and mindful of their rights.

5.3.2 PwD Sensitivity

Some individuals are born with a disability, while others may become disabled due to an accident, illness or as they get old. People with Disabilities (PwD) may have one or more areas in which their functioning is affected. A disability can affect hearing, sight, communication, breathing, understanding, mobility, balance, and concentration or may include the loss of a limb. A disability may contribute to how a person feels and affect their mental health.

Important Terms

- **Persons with Disabilities (PwD):** Persons with Disabilities means a person suffering from not less than 40% of any disability as certified by a medical authority.
- **Types of Disability:**
  a. Blindness – Visually impaired
  b. Low Vision
  c. Leprosy Cured
  d. Hearing impairment
  e. Locomotor disability
  f. Mental retardation
  g. Mental illness

PwD Sensitivity: PwD sensitivity promotes empathy, etiquette and equal participation of individuals and organizations while working with individuals with a disability, e.g. sensory, physical or intellectual.

Ways to be PwD Sensitive

To be sensitive to PwD, one should:

- Be respectful to all Persons with Disabilities (PwD) and communicate in a way that reflects PwD sensitivity.
- Always be supportive and kind towards a PwD with their daily chores.
- Be ready to assist a PwD to help them avail of any benefit/ livelihood opportunity/ training or any kind that helps them grow.
- Encourage and try to make things easier and accessible to PwD so that they can work without or with minimum help.
- Protest where feasible and report any wrong act/behaviour against any PwD to the appropriate authority.
- Learn and follow the laws, acts, and policies relevant to PwD.

Appropriate Verbal Communication

As part of appropriate verbal communication with all genders and PwD, one should:

- Talk to all genders and PwD respectfully, maintaining a normal tone of voice with appropriate politeness. It is important to ensure one's tone of voice does not have hints of sarcasm, anger, or unwelcome affection.
- Avoid being too self-conscious concerning the words to use while also ensuring not to use words that imply one's superiority over the other.
- Make no difference between a PwD and their caretaker. Treat PwD like adults and talk to them directly.
- Ask a PwD if they need any assistance instead of assuming they need it and offering assistance spontaneously.

Appropriate Non-verbal Communication

Non-verbal communication is essentially the way someone communicates through their body language. These include:

- **Facial expressions:** The human face is quite expressive, capable of conveying many emotions without using words. Facial expressions must usually be maintained neutral and should change according to the situation, e.g. smile as a gesture of greeting.
- **Body posture and movement:** One should be mindful of how to sit, stand, walk, or hold their head. For example - one should sit and walk straight in a composed manner. The way one moves and carries self, communicates a lot to others. This type of non-verbal communication includes one's posture, bearing, stance, and subtle movements.

- **Gestures:** One should be very careful with their gestures, e.g. waving, pointing, beckoning, or using one's hands while speaking. One should use appropriate and positive gestures to maintain respect for the other person while being aware that a gesture may have different meanings in different cultures.
- **Eye contact:** Eye contact is particularly significant in non-verbal communication. The way someone looks at someone else may communicate many things, such as interest, hostility, affection or attraction. Eye contact is vital for maintaining the flow of conversation and for understanding the other person's interest and response. One should maintain appropriate eye contact, ensuring not to stare or look over the shoulders. To maintain respect, one should sit or stand at the other person's eye level to make eye contact.
- **Touch:** Touch is a very sensitive type of non-verbal communication. Examples are - handshakes, hugs, pat on the back or head, gripping the arm, etc. A firm handshake indicates interest, while a weak handshake indicates the opposite. One should be extra cautious not to touch others inappropriately and avoid touching them inadvertently by maintaining a safe distance.

Rights of PwD

PwD have the right to respect and human dignity. Irrespective of the nature and seriousness of their disabilities, PwD have the same fundamental rights as others, such as:

- Disabled persons have the same civil and political rights as other people
- Disabled persons are entitled to the measures designed to enable them to become as self-dependent as possible
- Disabled persons have the right to economic and social security
- Disabled persons have the right to live with their families or foster parents and participate in all social and creative activities.
- Disabled persons are protected against all exploitation and treatment of discriminatory and abusive nature.

Making Workplace PwD Friendly

- One should not make PwD feel uncomfortable by giving too little or too much attention
- One should use a normal tone while communicating with a PwD and treat them as all others keeping in mind their limitations and type of disability
- Any help should be provided only when asked for by a PwD
- One should help in ensuring the health and well-being of PwD.

Expected Employer Behaviour

Some of the common behavioural traits that employees expect from their employers are:

- **Cooperation:** No work is successful without cooperation from the employer's side. Cooperation helps to understand the job role better and complete it within the given timeline.
- **Polite language:** Polite language is always welcomed at work. This is a basic aspect that everybody expects.
- **Positive Attitude:** Employers with a positive attitude can supervise the work of the employees and act as a helping hand to accomplish the given task. A person with a positive attitude looks at the best qualities in others and helps them gain success.
- **Unbiased behaviour:** Employers should always remain fair towards all their employees. One should not adopt practices to favour one employee while neglecting or ignoring the other. This might create animosity among co-workers.
- **Decent behaviour:** The employer should never improperly present oneself before the employee. One should always respect each other's presence and behave accordingly. The employer should not speak or act in a manner that may make the employee feel uneasy, insulted, and insecure.

Exercise

1. List down three examples of workplace ethics.
2. List down three examples of interpersonal skills.
3. Identify two reasons for workplace conflicts.
4. Identify two ways of resolving interpersonal conflicts.
5. List down two ways of dealing with heightened emotions at work.
6. List down two types of non-verbal communication.4. Basic Health and Safety Practices.

Notes

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

ESSCI
Skilling India in Electronics

6. Basic Health and Safety Practices

Unit 6.1 - Workplace Hazards

Unit 6.2 - Fire Safety

Unit 6.3 - First Aid

Unit 6.4 - Waste Management

ELE/N1002

Key Learning Outcomes

By the end of this module, participants will be able to:

1. Discuss job-site hazards, risks and accidents.
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials.
3. Describe how to interpret warning signs while accessing sensitive work areas.
4. Explain the importance of good housekeeping.
5. Describe the importance of maintaining appropriate postures while lifting heavy objects.
6. List the types of fire and fire extinguishers.
7. Describe the concept of waste management and methods of disposing of hazardous waste.
8. List the common sources of pollution and ways to minimize them.
9. Elaborate on electronic waste disposal procedures.
10. Explain how the administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning and also administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock.

UNIT 6.1: Workplace Hazards

Unit Objectives

By the end of this unit, participants will be able to:

1. Discuss job-site hazards, risks and accidents.
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials.
3. Describe how to interpret warning signs while accessing sensitive work areas.
4. Explain the importance of good housekeeping.
5. Describe the importance of maintaining appropriate postures while lifting heavy objects.
6. Explain safe handling of tools and Personal Protective Equipment to be used.

6.1.1 Workplace Safety

Workplace safety is important to be established for creating a safe and secure working for the workers. The workplace has to be administered as per the rules of the Occupational Safety and Health Administration (OSHA). It refers to monitoring the working environment and all hazardous factors that impact employees' safety, health, and well-being. It is important to provide a safe working environment to the employees to increase their productivity, wellness, skills, etc.

The benefits of workplace safety are:

- Employee retention increases if they are provided with a safe working environment.
- Failure to follow OSHA's laws and guidelines can result in significant legal and financial consequences.
- A safe environment enables employees to stay invested in their work and increases productivity.
- Employer branding and company reputation can both benefit from a safe working environment.

6.1.2 Workplace Hazards

A workplace is a situation that has the potential to cause harm or injury to the workers and damage the tools or property of the workplace. Hazards exist in every workplace and can come from a variety of sources. Finding and removing them is an important component of making a safe workplace.

Common Workplace Hazards

The common workplace hazards are:

- **Biological:** The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as biological hazards.

- **Chemical:** Chemical hazard is the hazard of inhaling various chemicals, liquids and solvents. Skin irritation, respiratory system irritation, blindness, corrosion, and explosions are all possible health and physical consequences of these dangers.
- **Mechanical:** Mechanical Hazards comprise the injuries that can be caused by the moving parts of machinery, plant or equipment.
- **Psychological:** Psychological hazards are occupational hazards caused by stress, harassment, and violence.
- **Physical:** The threats that can cause physical damage to people is called physical hazard. These include unsafe conditions that can cause injury, illness and death.
- **Ergonomic:** Ergonomic Hazards are the hazards of the workplace caused due to awkward posture, forceful motion, stationary position, direct pressure, vibration, extreme temperature, noise, work stress, etc.

Workplace Hazards Analysis

A workplace hazard analysis is a method of identifying risks before they occur by focusing on occupational tasks. It focuses on the worker's relationship with the task, the tools, and the work environment. After identifying the hazards of the workplace, organisations shall try to eliminate or minimize them to an acceptable level of risk.

Control Measures of Workplace Hazards

Control measures are actions that can be taken to reduce the risk of being exposed to the hazard. Elimination, Substitution, Engineering Controls, Administrative Controls, and Personal Protective Equipment are the five general categories of control measures.

- **Elimination:** The most successful control technique is to eliminate a specific hazard or hazardous work procedure or prevent it from entering the workplace.
- **Substitution:** Substitution is the process of replacing something harmful with something less hazardous. While substituting the hazard may not eliminate all of the risks associated with the process or activity, it will reduce the overall harm or health impacts.
- **Engineering Controls:** Engineered controls protect workers by eliminating hazardous situations or creating a barrier between the worker and the hazard, or removing the hazard from the person.
- **Administrative Controls:** To reduce exposure to hazards, administrative controls limit the length of time spent working on a hazardous task that might be used in combination with other measures of control.
- **Personal Protective Equipment:** Personal protective equipment protects users from health and safety hazards at work. It includes items like safety helmets, gloves, eye protection, etc.

6.1.3 Risk for a Drone Technician

A drone technician may require to repair the propeller, motor and its mount, battery, mainboards, processor, booms, avionics, camera, sensors, chassis, wiring and landing gear. A technician may face some risks while repairing the drones' equipment.

- The technician is susceptible to being physically harmed by propellers.
- Direct contact with exposed electrical circuits can injure the person.
- If the skin gets in touch with the heat generated from electric arcs, it burns the internal tissues.
- Major electrical injuries can occur due to poorly installed electrical equipment, faulty wiring, overloaded or overheated outlets, use of extension cables, incorrect use of replacement fuses, use of equipment with wet hands, etc.

6.1.4 Workplace Warning Signs

A Hazard sign is defined as 'information or instruction about health and safety at work on a signboard, an illuminated sign or sound signal, a verbal communication or hand signal.'

There are four different types of safety signs:

- Prohibition / Danger Alarm Signs
- Mandatory Signs
- Warning Signs
- And Emergency

1. Prohibition Signs

A "prohibition sign" is a safety sign that prohibits behaviour that is likely to endanger one's health or safety. The colour red is necessary for these health and safety signs. Only what or who is forbidden should be displayed on a restriction sign.

Fig. 6.1.1. Prohibition warning signs

2. Mandatory Signs

Mandatory signs give clear directions that must be followed. The icons are white circles that have been reversed out of a blue circle. On a white background, the text is black.

Fig. 6.1.2. Mandatory signs

3. Warning Signs

Warning signs are the safety information communication signs. They are shown as a 'yellow colour triangle'.

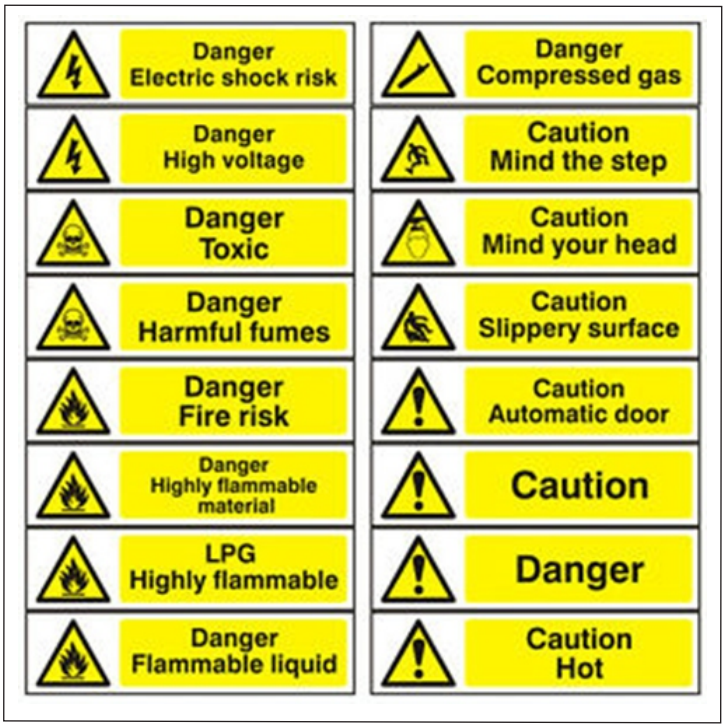


Fig. 6.1.3. Warning signs

4. Emergency Signs

The location or routes to emergency facilities are indicated by emergency signs. These signs have a green backdrop with a white emblem or writing. These signs convey basic information and frequently refer to housekeeping, company procedures, or logistics.

Fig. 6.1.4. Emergency signs

6.1.5 Cleanliness in the Workplace

Workplace cleanliness maintenance creates a healthy, efficient and productive environment for the employees. Cleanliness at the workplace is hindered by some elements like cluttered desks, leftover food, waste paper, etc. A tidy workplace is said to improve employee professionalism and enthusiasm while also encouraging a healthy working environment.

Benefits of cleanliness in the workplace:

1. **Productivity:** Cleanliness in the workplace can bring a sense of belonging to the employees, also motivating and boosting the morale of the employees. This results in increasing their productivity.
2. **Employee Well-being:** Employee well-being can be improved by providing a clean work environment. Employees use fewer sick days in a workplace where litter and waste are properly disposed of, and surfaces are cleaned regularly, resulting in increased overall productivity.
3. **Positive Impression:** Cleanliness and orderliness in the workplace provide a positive impression on both employees and visitors.
4. **Cost saving:** By maintaining acceptable levels of cleanliness in the workplace, businesses can save money on cleaning bills and renovations, which may become necessary if the premises are not properly kept.

Reasons for Cleaning the Workplace

- Cleaning of dry floors, mostly to prevent workplace slips and falls.
- Disinfectants stop bacteria in their tracks, preventing the spread of infections and illness.
- Proper air filtration decreases hazardous substance exposures such as dust and fumes.
- Light fixture cleaning improves lighting efficiency.
- Using environmentally friendly cleaning chemicals that are safer for both personnel and the environment.
- Work environments are kept clean by properly disposing of garbage and recyclable items.

6.1.6 Lifting and Handling of Heavy Loads

Musculoskeletal Injuries (MSIs), such as sprains and strains, can occur while lifting, handling, or carrying objects at work. When bending, twisting, uncomfortable postures and lifting heavy objects are involved, the risk of injury increases. Ergonomic controls can help to lower the risk of injury and potentially prevent it.

Types of injuries caused while lifting heavy objects:

- Cuts and abrasions are caused by rough surfaces.
- Crushing of feet or hands.
- Strain to muscles and joints.

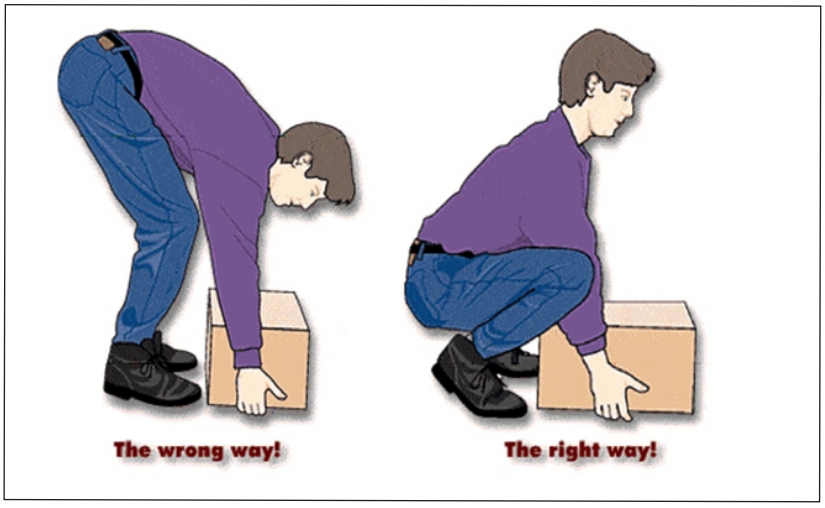


Fig. 6.1.5. Lifting loads technique

Preparing to Lift

A load that appears light enough to bear at first will grow increasingly heavier as one carries it further. The person carrying the weight should be able to see over or around it at all times.

The amount of weight a person can lift, depends on their age, physique, and health.

It also depends on whether or not the person is used to lifting and moving hefty objects.

Common Causes of Back Injuries

The Most Common Causes of Back Injuries are:

1. **Inadequate Training:** The individual raising the load receives no sufficient training or guidance.
2. **Lack of awareness of technique:** The most common cause of back pain is incorrect twisting and posture, which causes back strain.
3. **Load size:** The load size to consider before lifting. If the burden is too much for one's capacity or handling, their back may be strained and damaged.
4. **Physical Strength:** Depending on their muscle power, various persons have varied physical strengths. One must be aware of their limitations.
5. **Teamwork:** The operation of a workplace is all about working together. When opposed to a single person lifting a load, two people can lift it more easily and without difficulty. If one of two people isn't lifting it properly, the other or both of them will suffer back injuries as a result of the extra strain.

Technique	Demonstration
1. Ensure one has a wide base of support before lifting the heavy object. Ensure one's feet are shoulder-width apart, and one foot is slightly ahead of the other at all times. This will help one maintain a good balance during the lifting of heavy objects. This is known as the Karate Stance.	
2. Squat down as near to the object as possible when one is ready to lift it, bending at the hips and knees with the buttocks out. If the object is really heavy, one may wish to place one leg on the floor and the other bent at a straight angle in front of them.	

4. By straightening one's hips and knees, slowly elevate the thing (not the back). As one rises, they should extend their legs and exhale. Lift the heavy object without twisting the body or bending forward.	
5. Do not lift bending forward.	
6. Hold the load close to the body.	
7. Never lift heavy objects above the shoulder	

7. Never lift heavy objects above the shoulder	
8. Use the feet (not the body) to change direction, taking slow, small steps.	
9. Set down the heavy object carefully, squatting with the knees and hips only.	

Table 6.1.1 Techniques for lifting heavy objects

[3]*Source:https://www.braceability.com/blogs/articles/7-proper-heavy-lifting-techniques*

6.1.7 Safe Handling of Tools

Workers should be trained on how to use tools safely. When tools are misplaced or handled incorrectly by workers, they can be dangerous. The following are some suggestions from the National Safety Council for safe tool handling when they are not in use:

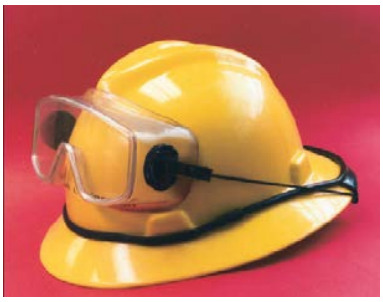
- Never carry tools up or down a ladder in a way that makes it difficult to grip them. Instead of being carried by the worker, tools should be lifted up and down using a bucket or strong bag.
- Tools should never be tossed but should be properly passed from one employee to the next. Pointed tools should be passed with the handles facing the receiver or in their carrier.
- When turning and moving around the workplace, workers carrying large tools or equipment on their shoulders should pay particular attention to clearances.
- Pointed tools such as chisels and screwdrivers should never be kept in a worker's pocket. They can be carried in a toolbox, pointing down in a tool belt or pocket tool bag, or in hand with the tip always held away from the body.

- Tools should always be stored while not in use. People below are put in danger when tools are left sitting around on an elevated structure, such as a scaffold. In situations when there is a lot of vibration, this risk increases.

6.1.8 Personal Protective Equipment

Personal Protective Equipment, or "PPE," is equipment worn to reduce exposure to risks that might result in significant occupational injuries or illnesses. *Chemical, Radiological, Physical, Electrical, Mechanical,* and other job dangers may cause these injuries and diseases.

PPE used for protection from the following injuries are:

Injury Protection	Protection	PPE
Head Injury Protection	Falling or flying objects, stationary objects, or contact with electrical wires can cause impact, penetration, and electrical injuries. Hard hats can protect one's head from these injuries. A common electrician's hard hat is shown in the figure below. This hard hat is made of nonconductive plastic and comes with a set of safety goggles.	
Foot and Leg Injury Protection	In addition to foot protection and safety shoes, leggings (e.g., leather) can guard against risks such as falling or rolling objects, sharp objects, wet and slippery surfaces, molten metals, hot surfaces, and electrical hazards.	 
Eye and Face Injury Protection	Spectacles, goggles, special helmets or shields, and spectacles with side shields and face shields can protect against the hazards of flying fragments, large chips, hot sparks, radiation, and splashes from molten metals. They also offer protection from particles, sand, dirt, mists, dust, and glare.	

Protection against Hearing Loss	Hearing protection can be obtained by wearing earplugs or earmuffs. High noise levels can result in permanent hearing loss or damage, as well as physical and mental stress. Self-forming earplugs composed of foam, waxed cotton, or fibreglass wool usually fit well. Workers should be fitted for moulded or prefabricated earplugs by a specialist.	
Hand Injury Protection	Hand protection will aid workers who are exposed to dangerous substances by skin absorption, serious wounds, or thermal burns. Gloves are a frequent protective clothing item. When working on electrified circuits, electricians frequently use leather gloves with rubber inserts. When stripping cable with a sharp blade, Kevlar gloves are used to prevent cuts.	
Whole Body Protection	Workers must protect their entire bodies from risks such as heat and radiation. Rubber, leather, synthetics, and plastic are among the materials used in whole-body PPE, in addition to fire-retardant wool and cotton. Maintenance staff who operate with high-power sources such as transformer installations and motor-control centres are frequently obliged to wear fire-resistant clothes.	

Table 6.1.2 Personal protective equipment

Notes

UNIT 6.2: Fire Safety

Unit Objectives

By the end of this unit, participants will be able to:

1. List the types of fire and fire extinguishers.

6.2.1 Fire Safety

Fire safety is a set of actions aimed at reducing the amount of damage caused by fire. Fire safety procedures include both those that are used to prevent an uncontrolled fire from starting and those that are used to minimise the spread and impact of a fire after it has started. Developing and implementing fire safety measures in the workplace is not only mandated by law but is also essential for the protection of everyone who may be present in the building during a fire emergency.

The basic Fire Safety Responsibilities are:

- To identify risks on the premises, a fire risk assessment must be carried out.
- Ascertain that fire safety measures are properly installed.
- Prepare for unexpected events.
- Fire safety instructions and training should be provided to the employees.

6.2.2 Respond to a Workplace Fire

- Workplace fire drills should be conducted on a regular basis.
- If one has a manual alarm, they should raise it.
- Close the doors and leave the fire-stricken area as soon as possible. Ensure that the evacuation is quick and painless.
- Turn off dangerous machines and don't stop to get personal items.
- Assemble at a central location. Ascertain that the assembly point is easily accessible to the employees.
- If one's clothing catches fire, one shouldn't rush about it. They should stop and descend on the ground and roll to smother the flames if their clothes catch fire.

6.2.3 Fire Extinguisher

Fire extinguishers are portable devices used to put out small flames or minimise their damage until fire-fighters arrive. These are maintained on hand in locations such as fire stations, buildings, workplaces, public transit, and soon. The types and quantity of extinguishers that are legally necessary for a given region are determined by the applicable safety standards.

Types of fire extinguishers are:

There are five main types of fire extinguishers:

1. Water.
2. Powder.
3. Foam.
4. Carbon Dioxide (Co2).
5. Wet chemical.

1. **Water:** Water fire extinguishers are one of the most common commercial and residential fire extinguishers on the market. They're meant to be used on class-A flames.

2. **Powder:** The L2 powder fire extinguisher is the most commonly recommended fire extinguisher in the Class D Specialist Powder category, and is designed to put out burning lithium metal fires.

3. **Foam:** Foam extinguishers are identified by a cream rectangle with the word "foam" printed on it. They're mostly water-based, but they also contain a foaming component that provides a quick knock-down and blanketing effect on flames. It suffocates the flames and seals the vapours, preventing re-ignition.

4. **Carbon Dioxide (Co2):** Class B and electrical fires are extinguished with carbon dioxide extinguishers, which suffocate the flames by removing oxygen from the air. They are particularly beneficial for workplaces and workshops where electrical fires may occur since, unlike conventional extinguishers, they do not leave any toxins behind and hence minimise equipment damage.

5. **Wet Chemical:** Wet chemical extinguishers are designed to put out fires that are classified as class F. They are successful because they can put out extremely high-temperature fires, such as those caused by cooking oils and fats.

Notes

UNIT 6.3: First Aid

Unit Objectives

By the end of this unit, participants will be able to:

1. Explain how the administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning.
2. Explain how to administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock.

6.3.1 First Aid

First aid is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.

The aim of first aid is to:

- Preserve life
- Prevent the worsening of a sickness or injury
- If at all possible, relieve pain
- Encourage recovery
- Keep the unconscious safe.

First aid can help to lessen the severity of an injury or disease, and in some situations, it can even save a person's life.

6.3.2 Need for First Aid at the Workplace

- In the workplace, first aid refers to providing immediate care and life support to persons who have been injured or become unwell at work.
- Many times, first aid can help to lessen the severity of an accident or disease.
- It can also help an injured or sick person relax. In life-or-death situations, prompt and appropriate first aid can make all the difference.

6.3.2 Need for First Aid at the Workplace

In the workplace, first aid refers to providing immediate care and life support to persons who have been injured or become unwell at work.

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It can also help an injured or sick person relax. In life-or-death situations, prompt and appropriate first aid can make all the difference.

6.3.3 Treating Minor Cuts and Scrapes

Steps to keep cuts clean and prevent infections and scars:

- **Wash Hands:** Wash hands first with soap and water to avoid introducing bacteria into the cut and causing an infection. One should use the hand sanitiser if one is on the go.
- **Stop the bleeding:** Using a gauze pad or a clean towel, apply pressure to the wound. For a few minutes, keep the pressure on.
- **Clean Wounds:** Once the bleeding has stopped, clean the wound by rinsing it under cool running water or using a saline wound wash. Use soap and a moist washcloth to clean the area around the wound. Soap should not be used on the cut since it may irritate the skin. Also, avoid using hydrogen peroxide or iodine, as these may aggravate the wound.
- **Remove Dirt:** Remove any dirt or debris from the area. Pick out any dirt, gravel, glass, or other material in the cut with a pair of tweezers cleaned with alcohol.

6.3.4 Heart Attack

When the blood flow carrying oxygen to the heart is blocked, a heart attack occurs. The heart muscle runs out of oxygen and starts to die.

Symptoms of a heart attack can vary from person to person. They may be mild or severe. Women, older adults, and people with diabetes are more likely to have subtle or unusual symptoms.

Symptoms in adults may include:

- Changes in mental status, especially in older adults.
- Chest pain that feels like pressure, squeezing, or fullness. The pain is most often in the centre of the chest. It may also be felt in the jaw, shoulder, arms, back, and stomach. It can last for more than a few minutes or come and go.
- Cold sweat.
- Light-headedness.
- Nausea (more common in women).
- Indigestion.

- Vomiting.
- Numbness, aching or tingling in the arm (usually the left arm, but the right arm may be affected alone, or along with the left).
- Shortness of breath.
- Weakness or fatigue, especially in older adults and in women.

First Aid for Heart Attack

If one thinks someone is experiencing a heart attack, they should:

- Have the person sit down, rest, and try to keep calm.
- Loosen any tight clothing.
- Ask if the person takes any chest pain medicine, such as nitro-glycerine for a known heart condition, and help them take it.
- If the pain does not go away promptly with rest or within 3 minutes of taking nitro-glycerine, call for emergency medical help.
- If the person is unconscious and unresponsive, call 911 or the local emergency number, then begin CPR.
- If an infant or child is unconscious and unresponsive, perform 1 minute of CPR, then call 911 or the local emergency number.

Notes

UNIT 6.4: Waste Management

Unit Objectives

By the end of this unit, participants will be able to:

1. Describe the concept of waste management and methods of disposing of hazardous waste.
2. List the common sources of pollution and ways to minimize them.
3. Elaborate on electronic waste disposal procedures.

6.4.1. Waste Management and Methods of Waste Disposal

The collection, disposal, monitoring, and processing of waste materials is known as waste management. These wastes affect living beings' health and the environment. For reducing their effects, they have to be managed properly. The waste is usually in solid, liquid or gaseous form.

The importance of waste management is:

Waste management is important because it decreases waste's impact on the environment, health, and other factors. It can also assist in the reuse or recycling of resources like paper, cans, and glass. The disposal of solid, liquid, gaseous, or dangerous substances is the example of waste management.

When it comes to trash management, there are numerous factors to consider, including waste disposal, recycling, waste avoidance and reduction, and garbage transportation. Treatment of solid and liquid wastes is part of the waste management process. It also provides a number of recycling options for goods that aren't classified as garbage during the process.

6.4.2 Methods of Waste Management

Non-biodegradable and toxic wastes, such as radioactive remains, can cause irreversible damage to the environment and human health if they are not properly disposed of. Waste disposal has long been a source of worry, with population increase and industrialisation being the primary causes. Here are a few garbage disposal options.

- **Landfills:** The most common way of trash disposal today is to throw daily waste/garbage into landfills. This garbage disposal method relies on burying the material in the ground.
- **Recycling:** Recycling is the process of transforming waste items into new products in order to reduce energy consumption and the use of fresh raw materials. Recycling reduces energy consumption, landfill volume, air and water pollution, greenhouse gas emissions, and the preservation of natural resources for future use.

3. **Composting:** Composting is a simple and natural bio-degradation process that converts organic wastes, such as plant remnants, garden garbage, and kitchen waste, into nutrient-rich food for plants.
4. **Incineration:** Incineration is the process of combusting garbage. The waste material is cooked to extremely high temperatures and turned into materials such as heat, gas, steam, and ash using this technology.

6.4.3 Recyclable, Non-Recyclable and Hazardous Waste

1. **Recyclable Waste:** The waste which can be reused or recycled further is known as recyclable waste.
2. **Non-recyclable Waste:** The waste which cannot be reused or recycled is known as non-recyclable waste. Polythene bags are a great example of non-recyclable waste.
3. **Hazardous Waste:** The waste which can create serious harm to the people and the environment is known as hazardous waste.

6.4.4 Sources of Pollution

Pollution is defined as the harm caused by the presence of a material or substances in places where they would not normally be found or at levels greater than normal. Polluting substances might be in the form of a solid, a liquid, or a gas.

- **Point source of pollution:** Pollution from a point source enters a water body at a precise location and can usually be identified. Effluent discharges from sewage treatment plants and industrial sites, power plants, landfill sites, fish farms, and oil leakage via a pipeline from industrial sites are all potential point sources of contamination.

  Point source pollution is often easy to prevent since it is feasible to identify where it originates, and once identified, individuals responsible for the pollution can take rapid corrective action or invest in longer-term treatment and control facilities.

- **Diffuse source of pollution:** As a result of land-use activities such as urban development, amenity, farming, and forestry, diffuse pollution occurs when pollutants are widely used and diffused over a large region. These activities could have occurred recently or in the past. It might be difficult to pinpoint specific sources of pollution and, as a result, take rapid action to prevent it because prevention often necessitates significant changes in land use and management methods.

Pollution Prevention

Pollution prevention entails acting at the source of pollutants to prevent or minimise their production. It saves natural resources, like water, by using materials and energy more efficiently.

Pollution prevention includes any practice that:

- Reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal;
- Reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (these practices are known as "source reduction");
- Improved efficiency in the use of raw materials, energy, water, or other resources, or Conservation is a method of safeguarding natural resources.
- Improvements in housekeeping, maintenance, training, or inventory management; equipment or technology adjustments; process or method modifications; product reformulation or redesign; raw material substitution; or improvements in housekeeping, maintenance, training, or inventory control.

6.4.5 Electronic Waste

Lead, cadmium, beryllium, mercury, and brominated flame retardants are found in every piece of electronic waste. When gadgets and devices are disposed of illegally, these hazardous compounds are more likely to contaminate the earth, pollute the air, and leak into water bodies.

When e-waste is dumped in a landfill, it tends to leach trace metals as water runs through it. The contaminated landfill water then reaches natural groundwater with elevated toxic levels, which can be dangerous if it reaches any drinking water bodies. Despite having an environmentally benign approach, recycling generally results in international shipment and dumping of the gadgets in pits.

Some eco-friendly ways of disposing of e-waste are:

- Giving back the e-waste to the electronic companies and drop-off points.
- Following guidelines issued by the government.
- Selling or donating the outdated technology-based equipment.
- Giving e-waste to a certified e-waste recycler.

Exercise

1. Name all five types of fire extinguishers.
2. Explain PPE in brief.
3. List the common workplace hazards.
4. Fill in the Blacks:
   i. A "_____ sign" is a safety sign that prohibits behaviour that is likely to endanger one's health or safety.
   ii. _____ entails acting at the source of pollutants to prevent or minimise their production.
   iii. _____ is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.
   iv. The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as _____.
   v. The workplace has to be administered as per the rules of the _____.

Notes

Annexure of QR Codes for Mechatronics Maintenance Specialist

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code	Video Duration
Chapter 1: Introduction to the Electronics Sector in India	Unit 1.1: Overview of the Electronics Industry	1.1.6 Scope of Electronic Industry	https://www.youtube.com/watch?v=JgLu40JBa-c	6	Scope of Electronic Industry	00:06:05
	Unit 1.2: Introduction to Mechatronics	1.2.1 Mechatronics	https://youtu.be/af9xQznYQAw	10	Mechatronics	00:15:37
	Unit 1.3: Role and Responsibilities of a Mechatronics Maintenance Specialist	1.3.2 Job Responsibilities of a Mechatronics Maintenance Specialist	https://youtu.be/4YjLZcQRLds	14	Job Responsibilities of a Mechatronics Maintenance Specialist	00:10:25
Chapter2: Process of Setting Up Circuits and Electrical Components in the Mechatronics System	Unit 2.1: Introduction to Mechatronics Systems	2.1.1 Mechatronics System	https://youtu.be/Zla-D7wOvO4	25	Mechatronics System	00:13:57
		2.1.3 Advantages and Disadvantages of Mechatronics System	https://youtu.be/NhmVFu1duRA	25	Advantages and Disadvantages of Mechatronics System	00:21:03
		2.1.4 Scope of Mechatronics in Automation	https://youtu.be/br-ezdmEq7A	25	Scope of Mechatronics in Automation	01:41:16
		2.2.3 Pneumatic System	https://youtu.be/Md-j1Ko0dbA	50	Pneumatic System	00:11:27
		2.2.6 Pneumatic Valves	https://youtu.be/bXXL-0sf8gs	50	Pneumatic Valves	00:06:00

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code	Video Duration
		2.2.7 Proximity Sensors	https://youtu.be/s2na8CumNR0	50	Proximity Sensors	00:09:33
		2.2.8 Cascade Amplifiersensors	https://youtu.be/Zp6jf4lbF6A	50	Cascade Amplifier sensors	00:09:08
Chapter 3: Process of Installing, Testing and Using the Sensors and Actuators in the Mechatronics Systems	Unit 3.1: Sensors	3.1.1 Sensors 3.1.2 Types of Sensors	https://youtu.be/S7z3DQiOWOQ	66	Types of Sensors	00:09:37
		3.1.3 Selection of Sensors	https://youtu.be/76TXYc_Ahvc	66	Selection of Sensors	00:17:45
	Unit 3.2: Actuators	3.2.1 Actuators 3.2.2 Types of Actuators	https://youtu.be/gokPA6OWaZ4	77	Types of Actuators	00:05:28
		3.2.3 Selection of Actuator	https://youtu.be/8HZDUwJmVr8	77	Selection of Actuator	00:05:00
Chapter 4: Process of Installing, Testing and Using Microcontroller in the Mechatronics System	Unit 4.1: Microcontroller	4.1.1 Microcontroller	https://youtu.be/3RkasPo9sRw	93	Microcontroller	00:13:23
		4.1.2 Working of Microcontrollers	https://youtu.be/OHGzvnMFH0k	93	Working of Microcontrollers	00:13:49
		4.1.7 Classification of Microcontrollers	https://youtu.be/nnquCs2wNCw	93	Classification of Microcontrollers	00:13:57
		4.1.8 Types of Microcontrollers	https://youtu.be/7KIMF2uebmA	93	Types of Microcontrollers	00:16:16

Chapter Name	Unit Name	Topic Name	URL	Page no.	QR Code	Video Duration
	Unit 4.2 - Microprocessor	4.2.2 Microprocessors Characteristics	https://youtu.be/jrfZOlMuOJQ	99	Microprocessors Characteristics	00:04:04
		4.2.3 Common terminology in Microprocessor	https://youtu.be/XECWxP_MEa0	99	Common terminology in Microprocessor	00:19:48
		4.2.4 Classification of Microprocessors	https://youtu.be/AG_bHxI9ix0	99	Classification of Microprocessors	00:09:42

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