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Participant Handbook

Sector
Electronics

Sub-Sector
Semiconductor & Components

Occupation
Product Design-S&C

Reference ID: **ELE/Q1201 Version-3.0**
NSQF LEVEL: 5

VLSI Design Engineer

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Shri Narendra Modi
Prime Minister of India

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for

VLSI DESIGN ENGINEER - PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/Qualification Pack: **VLSI Design Engineer** QP **NSQF ELE/Q1201 Level 5**

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Authorised Signatory
(Skilling India In Electronics)

Acknowledgements

This participant's handbook meant for VLSI Design Engineer 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.

I would like to thank the team of Feedback Advisory for their support to develop the content, the SME and the team at the ESSCI along with the industry partners for the tireless effort in bringing the handbook in the current format.

This handbook will help deliver skill-based training in the field of drone service and maintenance. 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 VLSI Design Engineer. 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 VLSI Design Engineer. 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 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.

The Participant Handbook is designed based on the National Skill Qualification Framework (NSQF) aligned Qualification Pack (QP) and it comprises of the following National Occupation Stand rads (NOS)/ topics:

1.ELE/N1201: Develop function design of SOC module

2.ELE/N9905: Work Effectively at the Workplace

3.ELE/N1002: Apply Health and Safety Practices at the Workplace

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1. Introduction to the Role of VLSI Design Engineer

Unit 1.1 - Electronics Industry and its Sub-sectors- An Introduction

Bridge Module

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. List the role and responsibilities of a VLSI Design Engineer

UNIT 1.1 - Electronics Industry and its Sub-Sectors-An Introduction

Unit Objectives

At the end of this Unit the trainee will be able to:

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

1.1.1 Introduction to Electronic Industry

The electronics industry is the economic sector that manufactures electronic devices. It is one of the world's largest and fastest-growing industries. Today's society is dependent on a plethora of electronic devices manufactured in industrially run automated or semi-automated factories. Electronic products have a huge impact on our lifestyle. With the world more connected than ever before, and the digital push induced by the COVID-19 pandemic, demand for electronic devices has risen steadily and remained a significant economic driver around the world. The global electronics industry is rapidly expanding. In 2020, the global electronics industry is projected to be worth $2.9 trillion. In comparison, the global value of the electronics industry is nearly equal to India's current GDP of US$ 2.9 trillion. Asian countries such as China, Taiwan, Singapore, and South Korea dominate the electronic market. The industry is distinguished by rapid innovation and speed to market, a short product life cycle, highly automated manufacturing, and high-volume production, all of which result in consistent quality at a low cost and profit accrual through volume.

Exhibit 1: Global market size of key product segments in 2020-21 (US$ billion)[4]

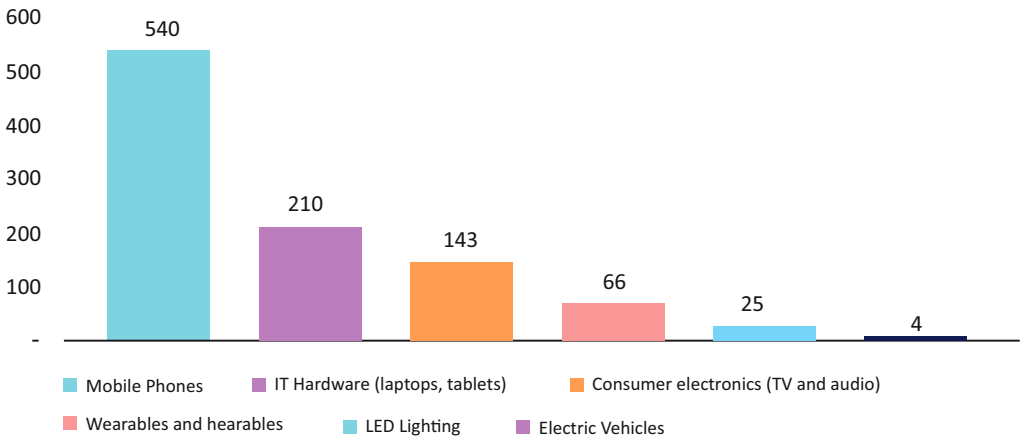


Fig. 1.1 Global Market Size 2020-21
(Source: IDC, Allied Market Research and ICEA estimates)

The electronics industry is not only self-sufficient in itself but also supports various other sectors like automotive, aviation, entertainment, healthcare, defence, telecommunications, etc. The industry is driven by innovation. Many resources are invested in research and development to design and improve electronic parts and products and improve various processes and procedures like manufacturing, quality, etc. Electronic companies always face tough competition to implement innovative ideas and first introduce the newest technology in the market. This creates a lot of pressure on the entire organization. For example, design and engineering teams need to develop innovative products and services faster and cheaper, and sales and marketing teams are pressured to drive sales and ensure that the profits always remain more than the production and operational costs.

The Government of India's National Policy for Electronics, 2019 ('NPE') recognizes the electronics industry's growth potential and strategic importance. NPE was founded to position India as a global hub for Electronics System Design and Manufacturing (ESDM), among other things, by creating an enabling environment for the industry to compete globally. Furthermore, the ESDM industry has been identified as one of the 25 priority sectors in the government's Make in India initiative and serves as a significant pillar in contributing to India's economic growth.

1.1.2 Sub-sectors of the Electronics Industry

Consumer electronics is the most crucial segment of the Indian electronics hardware industry. The segment accounts for approximately 28 per cent of the country's electronic industry production. In 2009, the estimated turnover for this segment was 260 billion. Around half of the workforce is employed in the consumer electronics sector's production function. The current consumer electronics employment pattern is around 0.9 million approx. The electronic components accounted for the lion's share of exports in 2008, accounting for 45 per cent of total exports. According to the report "Human Resource and Skill Requirements in the Electronics & IT Hardware Sector (2022)," the electronics industry's output is expected to rise from $844 billion in 2008 to $7,520 billion by 2022. This is a good sign because it would increase overall employment from 0.9 million to over 4 million by 2022.

The Indian electronics industry is segmented into several sub-sectors:

Communications and Broadcasting Electronics

- Mobile Phones, Tablets, Wired, and Wireless Connections

Consumer Electronics

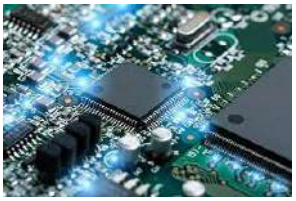
- Home Appliances, viz., Refrigerators, Washing Machines, Air Conditioners & Microwaves,Televisions, Music Systems, and Home Theatres, Direct-to-home and Set Top Boxes

Industrial Electronics

- UPS, Supervisory Control and Data Acquisition (SCADA), Programmable Logic Controller (PLC), AC Drive Systems

Medical Devices

- Heart-rate monitors, Dialysis machine, ventilator, x-ray machines etc.



Electronic Components

- Semi-conductors, Capacitors, Resistors, Picture-tubes, X-ray tubes, and caters to the Consumer
- Electronics, Telecom, Defense, and IT segment of the electronic industry

Strategic Electronics

- Satellite-based Communication, Navigation, and Surveillance Systems, Sonar, Underwater
- Electronics Systems, Radar, Infrared-based Detection and Ranging Systems

Computer Hardware

- Desktop Computers, Laptops, Notebooks, Netbooks, and Servers

LED

- LED Lights in Automobiles, Communications, Signage, Signalling, Architecture, and
- Entertainment Sectors

Fig. 1.2 Sub-Sectors of Electronic Industry

1.1.3 Semiconductor Industry in India

The semiconductor industry in India is witnessing high growth as the industries that use semiconductors like telecommunication, information technology, automobiles, the internet of things (IoT), etc. are themselves witnessing high demand. India is also growing in the Electronics System Design Manufacturing (ESDM) Industry. The government is providing subsidies and other incentives for setting up such electronics manufacturing units in the country. The National Electronics Policy and National Telecom Policy have outlined a few initiatives like Preferential Electronic Manufacturing Clusters (EMC), Market Access (PMS), Modified Special Incentive Package Scheme (M-SIPS), etc. The major semiconductor clusters in India are Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, Uttarakhand, West Bengal, etc.

UNIT 1.2 - Organisational Policies

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Discuss organisational policies on incentives, delivery standards, personnel management and public relations (PR)

1.2.1 Importance of Organisational Policies

Organisational policies are created to provide guidelines for the day-to-day operations and activities of the organisation. These policies help in internal processes, decision making and also being compliant with government and legal requirements. The policies have to be reviewed and update regularly or else they can become redundant. They can be beneficial only if they are followed, hence employees must be made aware of the policies by providing training, creating manuals and making them accessible to employees.

1. **Incentive Policy**

   Incentive policy is used by companies to motivate their workforce. Incentives are given to employees besides salaries. The incentives are given to encourage people to typically carry out activities that benefit the company as well as the individual. These policies are made to boost productivity, encourage innovation, aid recruitment, retain talented employees, etc. The policies are made in such a way it only promotes positive growth and discourages bad or negative behaviour. A poorly framed policy can be detrimental in the sense that the employees may underperform knowingly to get the benefits of incentives. Incentives can be in the form of recognition-based incentives, financial incentives, or special reward-based incentives.

2. **Delivery Standards Policy**

   The delivery standards are also known as performance standards, which are guidelines given to the employees regarding the company's expectations from them while as part of a team. Most of the incentive policies are based on the performance of the employees. There are various levels of performance standards, namely, individual level, operational level and strategic level.

The **individual level** is focused on the measurement of the performance of the individual employee and ways to improve the performance quality.	The **operational level** is focused on the performance of departmental or team-level activities and their contribution to the company's goals.	The **strategic level** is focused on the company-level performance and its alignment with the organisation's goals, values and vision.

Fig. 1.3 Various Levels of Performance Standards

On an individual level, a VLSI Design Engineer can be evaluated for technical skills, professionalism, time management, teamwork, accountability for one's action, communication and problem-solving skills, etc.

3. **Personnel Management Policy**

   The personnel management policy provides guidelines for people in the human resources (HR) department related to the recruitment and hiring process, wages and payroll information, work schedules and absence/leave policies, promotion and demotion, performance evaluation, training and development, transfers, job security, compliance with labour laws and policies of the Government, etc.

4. **Public Relations (PR) Policy**

   The PR policy aims at providing strategies for the company to grow by creating a positive image of the company. The primary function is to manage the company information and communicate the same to employees, the public, partners, stakeholders, investors, clients and customers. PR is also about building a brand image and brand awareness in the public with the help of media and other direct or indirect channels.

Notes

Unit 1.3 - Basics of Electronics and Related Concepts

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Define the basics of electronics and related concepts

1.3.1 Introduction to Electronics and Related Concepts

Electronics is a branch of physics, electrical engineering and technology involved in the study of electron flow (electricity) and their behaviour in various media like semiconductors, conductors, vacuum and gas. It includes a broad range of technology to manufacture electronic components, consumer electronics, computer hardware, industrial electronics, etc. Electronic devices are components that control the flow of electrical current for information processing and system control which include transistors, capacitors, resistors, integrated circuits, etc. The studies related to electricity which began during the 18th and 19th centuries led to the development of several electrical devices and also led to the concept of electronics in the 19th century after the discovery of electrons by Sir Joseph John Thomson, an English physicist.

The following table shows the definition and formulae for some of the common electrical and electronic parameters:

Name and Unit	Definition	Common formulae
Electric current, Ampere (*I*)	It is the number of electrons that pass through a fixed point in one second.	$I = V/R$
Electric pressure or Voltage, Volt (*V*)	When a voltage of 1 volt is applied to a circuit it will produce a current flow of 1 amp if the circuit resistance is 1 Ohm.	$V = IR$
Electrical resistance R, Ohm (Ω)	It is the resistance or opposition to the flow of current in a circuit when a voltage is applied across	$R = V/I$
Power, Watt (*W*)	Power of 1 watt is developed when a voltage of 1 volt causes a current of 1 amp to flow.	$P = VI$ $P = I^2R$ $P = V^2/R$
Conductance, Siemens (*G*)	It is the ability of a material to carry an electrical current. One Siemens equals 1 amp per volt.	$G = 1/R$

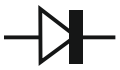
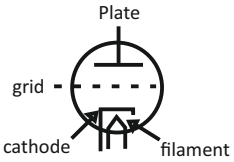
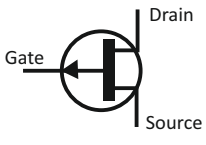
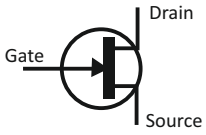
Continued...

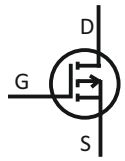
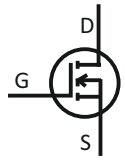
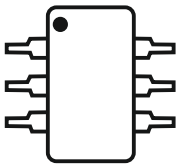
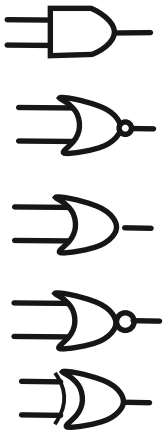
Name and Unit	Definition	Common formulae
Resistivity, Ohm metre (ρ)	It is a measure of the ability of a material to resist the flow of an electric current.	$R=\rho L/A$ where, L= length A = area
Conductivity, $Ohm^{-1}metre^{-1}$ (σ)	It is the reciprocal of resistivity.	$\sigma=1/\rho$
Capacitance, Farad (C)	It is the ability of a system to store electric charge for a given potential difference between the terminals.	$C=Q/V$ $C=\varepsilon A/d$ where A = Area of the plates d= distance between the plates ε= permittivity of the dielectric
Inductance, Henry (*L*)	It is the property of an electric conductor or circuit that causes an electromotive force (emf) to be generated by a change in the current flowing.	$i = \frac{V}{R}(1- e^{-Rt/L})$ where, i = instantaneous current R = resistance L = inductance t = time e = base of natural logs

Table 1.1 Common Electrical and Electronic Parameters

Notes

The following table shows the symbol and descriptions of some of the common electronic components:

Symbol	Name of the	Description
	Resistor	A resistor is a device having resistance to the passage of an electric current and are used to limit current flow and fixed voltage drops. They are chosen based on the ohmic value and power rating.
	Capacitor	A capacitor is a device consisting of one or more pairs of conductors separated by an insulator typically in the form of two plates separated by a dielectric and used to store an electric charge.
	Inductor	An inductor consists of a coil of wire wound on a former placed in a can and it stores energy in the form of a magnetic field.
	Diode	A diode is a simple PN junction that allows electrons to flow from the negatively biased N-type material to the positively biased P-type material. They are made from doped silicon and called one-way valves.
	Triode	A triode is an amplifying vacuum tube having three electrodes, a cathode or heated, a grid and an anode or plate inside an evacuated glass tube. They were used in amplified radio technology and long-distance telephony until transistors replaced them.
	Transistor	A transistor is constructed from the P and N-type semiconductor materials like in diodes and can be made in PNP or NPN format. It consists of three terminals called base, collector, and emitter.
 P-channel FET  N-channel FET	Field-effect Transistor (FET)	A FET is made in the basic form of P-channel or N-channel devices and has three terminals called a gate, source, and drain.

Symbol	Name of the	Description
 P-channel MOSFET  N-channel MOSFET	Metal Oxide Semiconductor Field-Effect Transistor (MOSFET)	A MOSFET is a FET fabricated by controlled oxidation of silicon. It also consists of the gate, source, and drain. The gate is insulated from the body with an insulating layer.
	Integrated Circuit	It is a chip of semiconductor material on which a set of electronic circuits are fabricated to carry out various tasks like switching, amplifying and other logic functions. It is a semiconductor on which millions of tiny resistors, capacitors, transistors, diodes, etc. are fabricated.
 AND gate NOT gate OR gate NOR gate XOR gate	Logic Gates	In digital circuits, a logic gate determines if an input pulse can pass through an output. They are the building blocks of a digital circuit. Logic gates can have two or more inputs but can produce only one output.
 Diode  Transistor	Active Components	These are components in a circuit that depends on an external power source to modify or control electrical signals. Transistors, vacuum tubes, diodes, etc. are examples of active components.

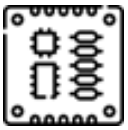
Symbol	Name of the	Description
Resistor Capacitor	Passive Components	These are components that do not depend on a source of power, except for the availability of the AC circuit that they are connected to.
	Printed Circuit Board	It is a board used to connect various electronic components to one another in a controlled manner.

Table 1.2 Common Electronic Components

1.3.2 Introduction to Very Large-Scale Integration (VLSI)

An electrical circuit can be called an electronic circuit if there is at least one active component. A discrete electronic circuit is constructed by combining components like resistors, capacitors, diodes and transistors joined by wires or by a printed circuit board (PCB). Whereas in an Integrated Circuit (IC), the interconnections between different components are formed on the same substrate like doped silicon, a semiconductor. Very Large-Scale Integration (VLSI) is the process of making Integrated Circuits (IC) by combining millions of transistors into a single chip. In 1964, General Microelectronics introduced the first Metal-oxide Semiconductor (MOS) IC and in the 1970s, these ICs enabled complex telecommunication and semiconductor technologies to develop. Later in the 1980s, about tens of thousands of MOS transistors were fabricated on a single chip. The early ICs had a few devices like resistors, capacitors, transistors and diodes, which allowed one or more logic gates on a single chip. As the technology evolved, circuitry became more complex, the number of components housed on the same substrate became larger. VLSI Technology allows designers to add all these into one chip through the fabrication process.

Based on the number of components in the Integrated Circuit (IC), they are classified as:

- **Small-scale integration (SSI) with 10s-100s of components**
- **Medium-scale Integration (MSI) with 100s – 1000s of components**
- **Large-scale integration (LSI) with more than 10000 components**
- **Very large-scale Integration (VLSI) with more than 300000 components**

Fig. 1.4 Classification of Integrated Circuits Based on the Number of Components

Unit 1.4 - Career Opportunities for A VLSI Design Engineer

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Discuss the various opportunities for a VLSI Design Engineer in the electronics industry
2. Discuss the role and responsibilities of a VLSI Design Engineer

1.4.1 Roles and Responsibilities of a VLSI Design Engineer

A VLSI Design Engineer is in charge of designing the functions of modules of the system-on-chip (SoC) as per the given input and output specifications using software and design tools. The individual should coordinate with other design teams involved in the SoC design process. The person should carry out coding, testing and debugging as per the requirements. The individual is responsible for assisting the Verification Engineer in design reviews and reworking the design to fix the identified defects. The individual is responsible to work independently and complete tasks without the any kind of supervision. The individual should have logical thinking skills and attention to detail to carry out the responsibilities as a VLSI Design Engineer. A VLSI Design Engineer requires the following skills to accomplish all the roles and responsibilities:

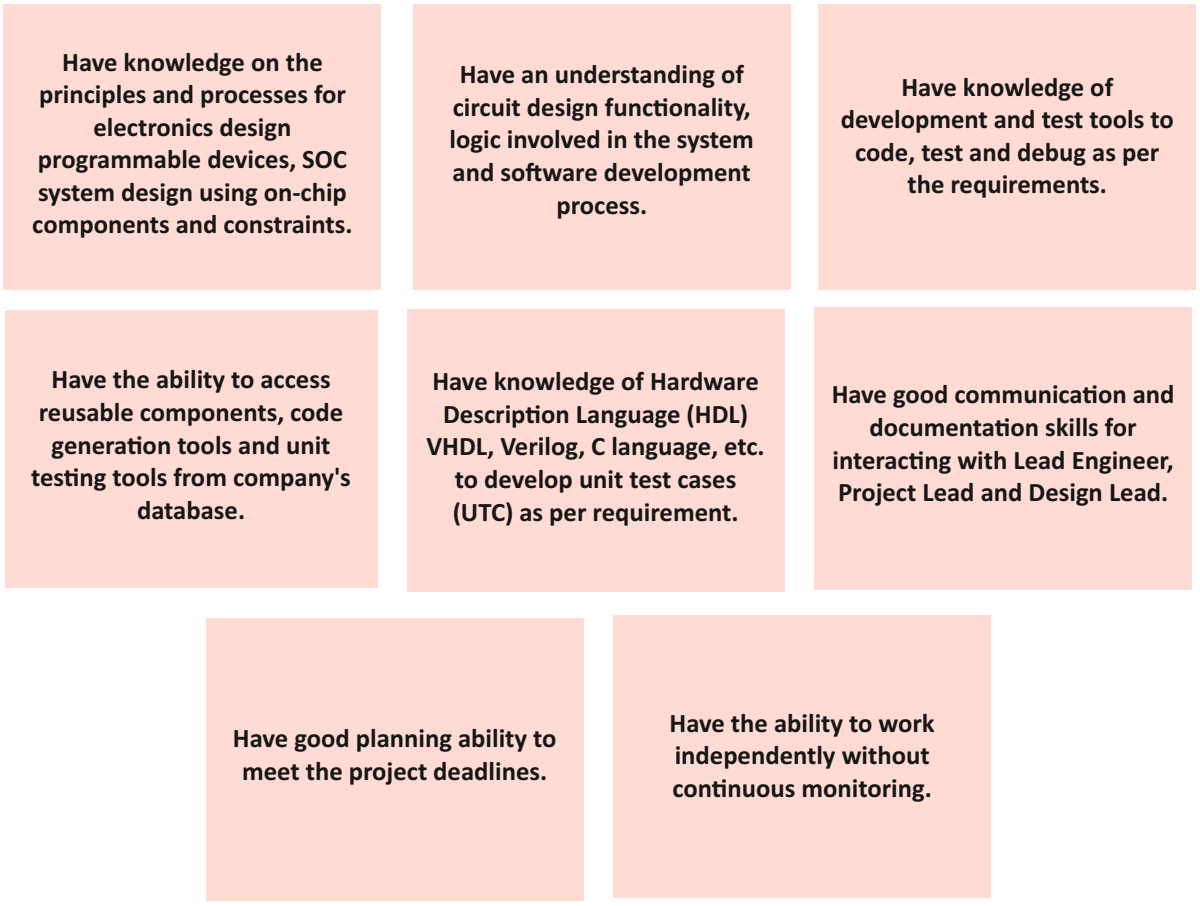


Fig. 1.5 Key Skills Required for a VLSI Design Engineer

1.4.2 Career Path for a VLSI Design Engineer

India has one of the world's fastest-growing GDPs, making it a haven for investors from all over the world. The area of VLSI is a highly technical field and technology is used in many sectors of the economy. The demand for VLSI Engineers is increasing due to the advancements in Artificial intelligence (AI), Smartphone technologies, Electric Vehicle (EV) technologies, etc. VLSI knowledge can be applied in digital design, system-on-chip (SoC), application-specific integrated circuit (ASIC), field programmable gate array (FPGA) and reconfigurable computing. The various companies based on VLSI are Electronic Design Automation (EDA) companies, Foundries, Service companies, Product companies, and Semiconductor Intellectual Property (IP) companies. Some of the job roles that a VLSI Design Engineer can get in the industry are ASIC front-end designer, Analog Mixed Signal (AMS) Designer, Verification Engineer, Layout Engineer, Test Engineer, Physical Design Engineer, Custom Circuit Designer, etc.

A VLSI Design Engineer with some experience in working with different projects and gaining more technical knowledge can get promoted to a middle-level position as a Lead VLSI Design Engineer and later as a VLSI System Design Engineer. At this level, the individual will be able to lead a team. With more experience the person can take on a managerial role as Head of the Design Group.

The career path for a VLSI Design Engineer

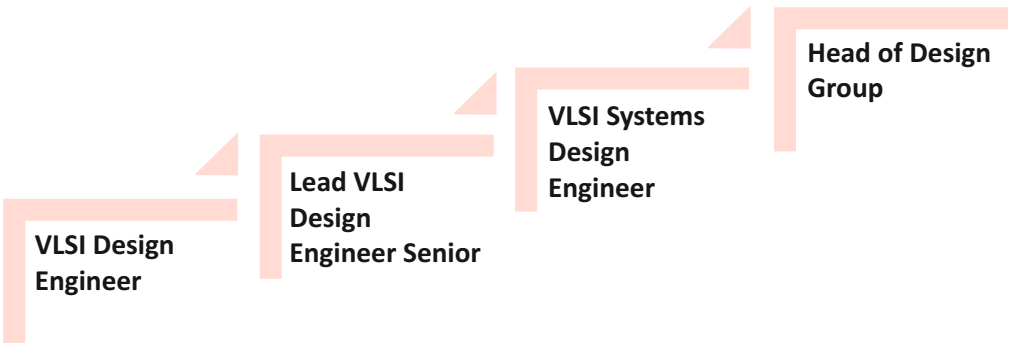


Fig. 1.6 Career Path for a VLSI Design Engineer

Notes

Summary

- The electronics industry is the economic sector that manufactures electronic devices. It is one of the world's largest and fastest-growing industries.
- With the world more connected than ever before, and the digital push induced by the COVID-19 pandemic, demand for electronic devices has risen steadily and remained a significant economic driver around the world.
- The electronics industry is not only self-sufficient in itself but also supports various other sectors like automotive, aviation, entertainment, healthcare, defence, telecommunications, etc. The industry is driven by innovation.
- The Government of India's National Policy for Electronics, 2019 ('NPE') recognizes the electronics industry's growth potential and strategic importance. NPE was founded to position India as a global hub for Electronics System Design and Manufacturing (ESDM), among other things, by creating an enabling environment for the industry to compete globally.
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- The semiconductor industry in India is witnessing high growth as the industries that use semiconductors like telecommunication, information technology, automobiles, the internet of things (IoT), etc. are themselves witnessing high demand.
- Organisational policies are created to provide guidelines for the day-to-day operations and activities of the organisation. These policies help in internal processes, decision making and also being compliant with government and legal requirements.
- Incentive policy is used by companies to motivate their workforce. Incentives are given to employees besides salaries. The incentives are given to encourage people to typically carry out activities that benefit the company as well as the individual.
- The delivery standards are also known as performance standards, which are guidelines given to the employees regarding the company's expectations from them while as part of a team. Most of the incentive policies are based on the performance of the employees.
- The personnel management policy provides guidelines for people in the human resources (HR) department related to the recruitment and hiring process, wages and payroll information, work schedules and absence/leave policies, promotion and demotion, performance evaluation, training and development, transfers, job security, compliance with labour laws and policies of the Government, etc.
- The PR policy aims at providing strategies for the company to grow by creating a positive image of the company. The primary function is to manage the company information and communicate the same to employees, the public, partners, stakeholders, investors, clients and customers.
- Electronics is a branch of physics, electrical engineering and technology involved in the study of electron flow (electricity) and their behaviour in various media like semiconductors, conductors, vacuum and gas. It includes a broad range of technology to manufacture electronic components, consumer electronics, computer hardware, industrial electronics, etc.

- An electrical circuit can be called an electronic circuit if there is at least one active component. A discrete electronic circuit is constructed by combining components like resistors, capacitors, diodes and transistors joined by wires or by a printed circuit board (PCB). Whereas in an IC, the interconnections between different components are formed on the same substrate like doped silicon, a semiconductor. Very Large-Scale Integration (VLSI) is the process of making Integrated Circuits (IC) by combining millions of transistors into a single chip.
- A VLSI Design Engineer is in charge of designing the functions of modules of the system-on-chip (SoC) as per the given input and output specifications using software and design tools. The individual should coordinate with other design teams involved in the SoC design process. The person should carry out coding, testing and debugging as per the requirements.
- India has one of the world's fastest-growing GDPs, making it a haven for investors from all over the world. The area of VLSI is a highly technical field and technology is used in many sectors of the economy. The demand for VLSI Engineers is increasing due to the advancements in Artificial intelligence (AI), Smartphone technologies, Electric Vehicle (EV) technologies, etc. VLSI knowledge can be applied in digital design, system-on-chip (SoC), application-specific integrated circuit (ASIC), field programmable gate array (FPGA) and reconfigurable computing.
- A VLSI Design Engineer can get promoted to mid-level and managerial level jobs with experience and gaining of technical knowledge.

Notes

Exercise

Answer the following questions :

1. Write a brief note on the electronics industry and its various sub-sectors.

   _____

   _____

   _____

2. Discuss the various electronic components.

   _____

   _____

   _____

3. Discuss the career growth opportunities for a VLSI Design Engineer.

   _____

   _____

   _____

Fill in the blanks:

1. _____ are created to provide guidelines for the day-to-day operations and activities of the organisation.
2. _____ is the number of electrons that pass through a fixed point in one second.
3. _____ is the process of making Integrated Circuits (IC) by combining millions of transistors into a single chip.

Scan the QR Code to watch the related video

https://youtu.be/PiR7PDEKy2A

Electronics Industry in India

www.youtube.com/watch?v=sXMFdPW2bPc

Introduction to Very Large-Scale Integration (VLSI)

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

2. Basics of System Designing

Unit 2.1 - Digital Electronics and Concept of Circuits

Unit 2.2 - Computer Architecture and Semiconductor Physics

Unit 2.3 - CMOS Circuit and its Components

Unit 2.4 - High-level Computer Languages - Cand C++

ELE/N1201

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. Recall the basics of digital electronics and computer architecture

UNIT 2.1 - Digital Electronics and Concept of Circuits

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Recall basics of system-on-chip design and digital electronics
2. Elucidate the concept of circuit
3. Illustrate ASIC and FPGA circuit designs
4. Elaborate ways to analyse the requirements of ASIC and FPGA circuit designs
5. Describe the application of the chip and end product

2.1.1 Introduction to Digital Electronics

Digital electronics involves the study of digital signals and the devices used to produce them. Digital circuits are made from large assemblies of logic gates and a simple electronic representation of the Boolean logic function. This is in contrast to analog electronics which have continuously variable signals. In analog systems, there is a proportional relationship between the signal and the current or the voltage that represents the signal. In digital electronics, the signal generally takes only two levels and a precise representation of a signal can be made by using binary digits.

2.1.2 Number System in Digital Electronics

In digital systems, information is represented using the number system. A digital system can understand the positional number system where there are digits and the digits represent different values depending on the position they occupy in the number. The value of the digit in a number is determined using, the digit, the position of the digit in the number and the base of the number system. In the number system, the base is defined as the total number of digits available in the system. The different types of number systems used are:

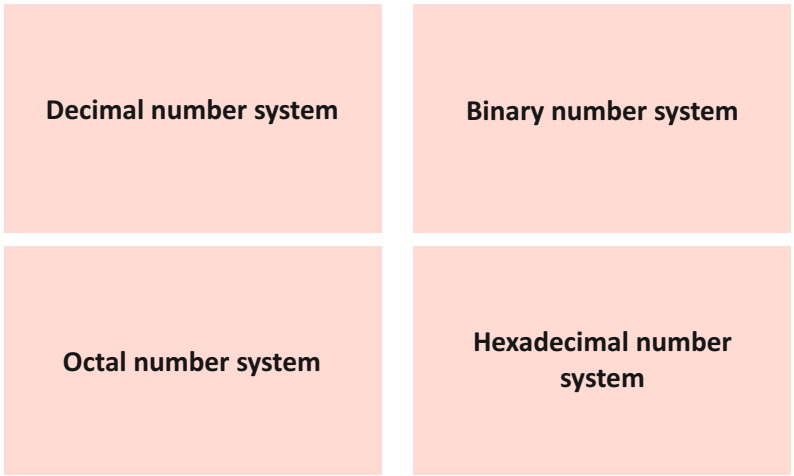


Fig. 2.1 Types of Number Systems

1. Decimal number system

The decimal number system uses 10 digits from 0 to 9 and has a base of 10 as it uses 10 digits. In this system, the units, tens, hundreds, thousands, etc., are represented by the decimal point's successive positions to the left. For example, for the number 4321, the positions and values can be written as shown below:

4	3	2	1
Thousands	Hundreds	Tens	Ones
4*1000	3*100	2*10	1*1
$4*10^3$	$3*10^2$	$2*10^1$	$1*10^0$
4000	300	20	1
4000+300+20+1			
4321			

Table 2.1 Decimal Number System

2. Binary number system

The binary number system uses 2 digits 0 and 1 and has a base of 2 as it uses 2 digits. In this system, each position represents a 0 power of the base 2 and the last position represents an x power of the base 2. For example, for the binary number 101_2, the decimal equivalent is as shown below:

$((1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0))_{10}$
$(4 + 0 + 1)_{10}$
$(21)_{10}$

Table 2.2 Binary Number System

3. Octal number system

The octal number system uses 8 digits from 0 to 7 and has a base of 8 as it uses 8 digits. In this system, each position represents a 0 power of the base 8 and the last position represents an x power of the base 8. For example, for the octal number 132_8, the decimal equivalent is as shown below:

$((1 \times 8^2) + (3 \times 8^1) + (2 \times 8^0))_{10}$
$(64 + 24 + 2)_{10}$
$(90)_{10}$

Table 2.3 Octal Number System

4. Hexadecimal number system

The hexadecimal number system uses 10 digits from 0 to 9 and 6 letters A=10, B=11, C=12, D=13, E=14, and F=15 and has a base of 16 as it uses a total of 16 digits and letters. In this system, each position represents a 0 power of the base 16 and the last position represents an x power of the base 16. For example, for the hexadecimal number $13AB_{16}$, the decimal equivalent is as shown below:

$((1 \times 16^3) + (3 \times 16^2) + (A \times 16^1) + (B \times 16^0))_{10}$
$((1 \times 16^3) + (3 \times 16^2) + (10 \times 16^1) + (11 \times 16^0))_{10}$
$(4096 + 256 + 160 + 11)_{10}$
$(4523)_{10}$

Table 2.4 Hexadecimal Number System

Notes

Conversion of numbers from one base system to another base system:

Numbers from any base system can first be converted to decimal base system as described earlier and then that decimal number can be converted to the required base system by using the following steps:

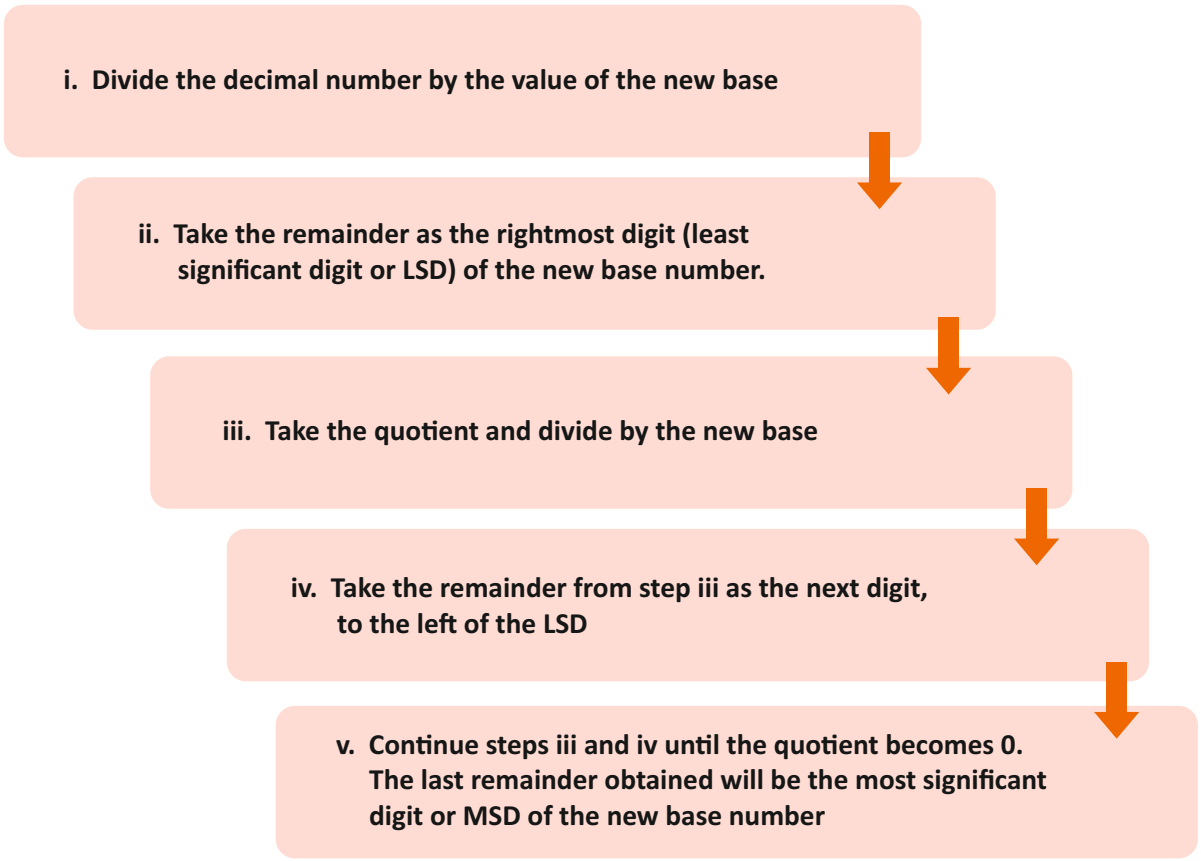


Fig. 2.2 Steps for Conversion of Numbers from one Base System to Another Base System

For example, decimal number10 can 31_{10} can be converted to binary number as follows:

Step	Division	Quotient	Remainder
I.	23/2	11	1 (LSD)
ii.	11/2	5	1
iii.	5/2	2	1
iv.	2/2	0	0 (MSD)

Table 2.5 Steps for Conversion of a Decimal Number to Binary Number

By arranging the remainders in the reverse order i.e., MSD to LSD, the binary number will be 0111_2

2.1.3 Boolean Algebra

Boolean algebra is also known as the algebra of logic and switching algebra as it was applied to solve relay logic problems. In Boolean algebra, digits/symbols 0 and 1 are used to represent logic levels. Logic 1 represents a high voltage, closed switch or a device's ON status and logic 0 represents a low voltage, open switch or a device's OFF status. At any given point in time, a digital device can be in any one of these two binary states. A binary decision requires the answer to be a 'yes or no', 'true or false' or 'on or off'. These binary decisions can be applied to formal logic.

Logical statement and constants

A **logical statement** is a statement that can be determined by a true or false or a binary decision. For example, 15-2 =13 is a true statement whereas 15 less than 13 is a false statement. True or false results are called **truth values,** which are depicted by **logical constants** 'true and false' or '1 and 0'. Logical variables or binary-valued variables are the variables that can store the truth values. If the logical statement is always true, then it is called tautology and if the logical statement is always false, then it is called a fallacy.

Bit

A **bit** is a unit of information in digital communications and computing and it represents the logical state with one of the two possible values as 1 or 0, true or false, on or off, etc.

Logical operations

Algebraic expressions are formed by combining algebraic variables like x, y, z, etc. with mathematical operators like +, -, x, and /, similarly the truth functions and logical statements are combined with logical operators like AND, OR and NOT to form a logical function or compound statement. Logical expressions can be formed by combining logical variables and logical operators.

Truth Table

A truth table represents all the possible values of logical statements and variables along with the possible answers to the given combination of values. Or in other words, in a truth table, the output for all combinations of inputs that can be applied to a circuit or logic gate is given. The values in the truth table are expressed as 1 for true logic and 0 for false logic.

The three different types of logic operations are NOT, OR and AND:

1. **NOT operator**

   It operates on a single variable and the operation is called complementation and the symbol used for it is a variable with a bar. For example, if X is the variable, then $\bar{X}$ is the complement. Therefore, $\bar{0} = 1$ and $\bar{1} = 0$

X	$\bar{X}$
1	0
0	1

Table 2.6 Truth table for NOT operator

2. OR operator

It operates logical addition and the symbol used is +. In logical addition, + means OR, therefore A+B means A OR B. The possible input and output combination for OR operations are: 0+0=0, 0+1=1, 1+0=1, and 1+1=1

A	*B*	A + B
0	0	0
0	1	1
1	0	1
1	1	1

Table 2.7 Truth table for OR operator

3. AND operator

It operates logical multiplication and the symbol used is a dot (.). In logical multiplication, (.) means AND, therefore A.B means A AND B. The possible input and output combination for AND operations are: 0.0=0, 0.1=0, 1.0=0, and 1.1=1

A	*B*	A . B
0	0	0
0	1	0
1	0	0
1	1	1

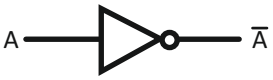
Table 2.8 Truth table for AND operator

Notes

2.1.4 Logic Gates

Initially, Boolean algebra was applied in telephone switching circuits and later in computer electronics, where the logic gates perform the Boolean operations. Gates are two-state digital circuits as the input and output signals are either low voltage (denoted by 0) or high voltage (denoted by 1). Logic gates allow data to be transferred by using logic to determine whether to pass a signal or not.

Types of Logic gates:

Type of Gate	Input	Output	Symbol of Logic Gates
NOT	*A*	$\overline{A}$	
	1	0	
	0	1	
OR	***A*** ***B***	***A + B =Y***	
	0 0	0	
	0 1	1	
	1 0	1	
	1 1	1	
AND	***A*** ***B***	***A . B =Y***	
	0 0	0	
	0 1	0	
	1 0	0	
	1 1	1	
NOR	***A*** ***B***	***A + B =Y*** $\overline{\quad\quad}$	
	0 0	1	
	0 1	0	
	1 0	0	
	1 1	0	

Type of Gate	Input		Output	Symbol of Logic Gates
NAND	*A*	*B*	$\overline{A \cdot B} = Y$	
	0	0	1	
	0	1	1	
	1	0	1	
	1	1	0	
XOR (Exclusive OR)	*A*	*B*	*A (+) B =Y*	
	0	0	0	
	0	1	1	
	1	0	1	
	1	1	0	
XNOR (Exclusive NOR)	*A*	*B*	$\overline{A (+) B} = Y$	
	0	0	1	
	0	1	0	
	1	0	0	
	1	1	1	

Table 2.9 Types of Logic Gates

2.1.5 Common Terminologies used in Digital Electronics

Gate arrays are logic gates that are pre-laid in a matrix of chips with no particular function except for the standard functions of NOR or NAND logic gates. These are used in the designing of field-programmable gate arrays (FPGA) and application-specific integrated circuits (ASIC).

Memory cells are electronic circuits that are used to store one bit of binary information. They must be set to store a logic of 1 (high voltage level) and reset to store a logic of 0, which will be stored until it is changed by the set/reset process. The most commonly used memory architecture Metal-oxide-semiconductor (MOS) memory cell, MOS field-effect transistors (MOSFETs) and MOS capacitors. Non-volatile memory (NVM), a type of memory that can retain stored data even after power is removed, stores data in floating-gate MOSFETS. The logic circuits which use memory cells are called **sequential circuits** and logic circuits which do not use memory cells are called **combinational circuits.**

Flip-flops, also known as latches are used as data storage elements. They store a single bit of data that has two stable states 1 and 0.

Logic blocks are used in FPGA architecture, these can be configured by the engineer. They are usually placed within a logic block array with an input/output pad as routing channels.

A lookup table (LUT) is an array (collection of data elements each identified by a key or array index) that replaces runtime computation with a simpler array indexing process called direct addressing, where the value v is stored in slot k. It saves a lot of processing time, as retrieving a value from memory is faster than carrying out a computation or I/O operation.

2.1.6 System-on-Chip (SoC)

A System-on-chip (SoC) is a chip or an integrated circuit that holds many components of electronic systems and computers like central processing unit (CPU), input/out interfaces, memory interfaces, secondary storage interfaces, graphics processing unit (GPU), etc. on a single substrate. An SoC integrates all these components into a single integrated circuit. They are used in embedded systems, personal computers, and mobile computing like smartphones and tablets, networking, chipsets, digital camera, game box, etc.

In the traditional computer motherboard-based architecture, the separate components based on their function are placed separately and connected through a central interfacing circuit board. The motherboard connects all these components or modules as discrete components or expansion cards.

There are three types of SoCs, they are:

I. Microcontroller-based SoC (a chip with CPU, RAM, ROM and other components)

ii. Microprocessor-based SoC (a chip with only a CPU)

iii. Application-specific Integrated Circuit (ASIC) SoC (this chip may or may not have a microprocessor or microcontroller)

SoCs consist of the following essential components:

SoCs consist of the following essential components:

Functional Components	Inter-module Communication
• Processor cores like microcontroller, microprocesor, digital signal processor, etc. • Memory like random-access memory (RAM), read-only memory (ROM), erasable programmable ROM (EEPROM), flash memory, etc. • Interfaces like external interfaces, wireless networking protocols, analog interfaces, etc. • Digital signal processor (DSP) cores • Timing sources, counter-timers, real-time timers, power-on reset generators, etc.	• Bus-based communication connects different components and transfers data and instructions back and forth between the components. • Network on a chip uses router-based packet switching and is a new trend being used instead of bus-based protocols.

Fig. 2.3 Essential Components in SoC

An SoC has all the components on one substrate, thus using less space and power compared to its multi-chip counterparts. This also improves the performance and reduces the cost of replaceability of the components.

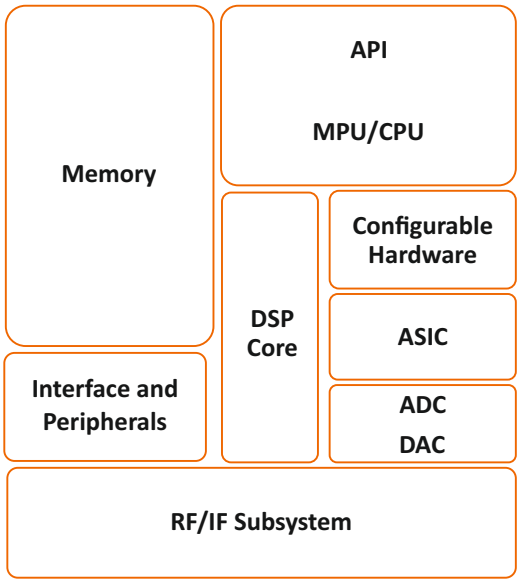


Fig. 2.4 Diagrammatic Representation of System-on-Chip
Source: Adapted from https://www.cs.ccu.edu.tw/

2.1.7 Concept of Circuit and Circuit Design

An electronic circuit consists of electronic components like resistors, capacitors, inductors, transistors, diodes, etc. connected by wires which allow the flow of electric current. The two main types of electronic circuits are analog and digital circuits.

In **analog circuits,** resistors, inductors, and capacitors are mainly used to process any analog input signal or data and produce an output in analog form. In these circuits, the signal is a continuous function of time and they can process the real-world signals that are analog directly without the need for signal converters. There are two types of analog circuits, active and passive circuits. Analog circuits are more susceptible to noise. The designing of analog circuits is complex as the components have to be placed manually and the implementation is also not flexible. They consume more power, have low processing speeds and are less accurate and precise compared to digital signals. Analog signals can be transmitted in these circuits in the form of waves either through wires or in wireless mode and they store data in the form of waves. Analog circuits cannot perform logical operations efficiently and are prone to observational error in the output.

In **digital circuits,** logic gates are the main components used to process discreet time signals (input) to digital signals (output). As real-world signals are analog, digital circuits require signal converters like Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC). Digital circuits are immune to noise. The designing of complex digital circuits is relatively easy as software can be used and have more flexibility in implementation. They consume lesser power, have higher processing speeds and are more accurate and precise compared to analog signals. Digital signals can be transmitted in these circuits only through wires in the digital form and they store data in the binary form. Digital circuits perform logical operations efficiently and are free from observational error in the output.

Circuit Design

The process of circuit design ranges from the design of an individual transistor in an integrated circuit to complex electronic systems. Electronic circuits are used in computation, data transfer and signal amplifications. They consist of various electronic components interconnected in different ways. Traditionally, circuits are first designed on a breadboard or PCBs as a prototype, which helps in the modification and enhancement of the circuit. Circuits produce the preferred output based on the input.

The process of circuit design involves several steps:

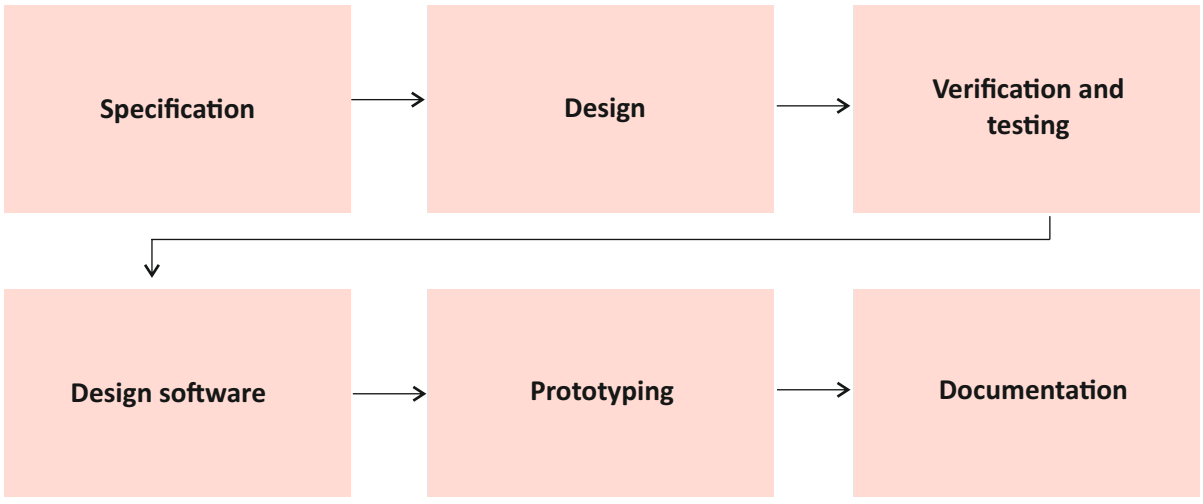


Fig. 2.5 Circuit- Design Process

1. **Specification**

   The circuit design process starts with getting the specifications from the customer, which details the functions of the final design without stating the methods to achieve them. It includes the requirements related to the type of input and output signals, the type of power supplies available, the permitted quantity of power consumption along with physical details like weight, size, thermal output, moisture resistance, temperature range, vibration tolerance, etc. The designers keep referring to the specifications throughout the design process to check if the conditions are being met and if any alterations are required. To meet the specifications, certain tests may have to be conducted to ensure that the conditions are met. In case of any changes or modifications that may be required, approval from the customer has to be taken.

2. **Design**

   After receiving the specifications, designing begins with making a block diagram keeping all the functions mentioned in the specifications in mind. At this stage, only the function is taken into account and not the components that go into each block. This helps to break down the main functions into smaller tasks. Next, each block is considered in detail related to the electrical functions, mathematical modelling, testing etc. in some cases, a certain block may not be able to meet all the specifications, then alterations may have to be done in the other blocks to meet the requirements. Once, all the individual components are chosen, the next step is to decide on the electrical connections and physical layout which depends on the base like a PCB or IC. The cost of designing is very often more than the cost of production.

3. **Verification**

   The verification process helps to go through every stage of the design to check if it meets the specifications through computer simulations of the designs. The problems detected at this stage typically required design rework to fix the issues. Unlike verification where a simulation is used, testing involves the assessment of a prototype of the design for its functionality.

4. **Design Software**

   The design software helps to create cheaper, more efficient and longer-lasting circuits. There are different types of software available like HDL, VHDL, Verilog, etc.

5. **Prototyping**

   In the prototyping process is important to know if there are any issues in the circuit which can cause damage to the product or the user. During the design and verification stages, designers keep detecting and fixing issues but prototyping is still required to see if all the physical parameters are met and also check if the product is safe for the customers.

6. **Documentation**

   The documentation process typically involves recording the specifications, design details, prototype details, verification and test procedures and results, compliance with regulatory guidelines, etc.

2.1.8 Field Programmable Gate Arrays (FPGA) Circuit Design

An FPGA is an integrated circuit that is designed to be configured or customized after the manufacturing process. The reprogramming can be done in the field instead of the semiconductor foundries. Earlier circuit diagrams were used to specify the configurations, but now Hardware Description Language (HDL) like VHDL and Verilog is used. They contain an array of programmable logic blocks/ configurable logic blocks (CLBs), reconfigurable interconnections which allow the blocks to be connected/wired together and I/O blocks, that are designed and numbered according to the function. The reconfigurable interconnections are made with vertical and horizontal routing channels and programmable multiplexers (PSM). The CLBs are made of look-up tables (LUTs) with a fixed number of inputs and memory elements like flip-flops, Flash or complete blocks of memory. The logic blocks can perform as simple logic gates like AND and XOR or perform complex combinational functions. They can be reprogrammed for implementing a different logic function. They allow concurrent development of system software along with the hardware, therefore making them suitable for embedded systems development. This also enables the simulations of system performance from an early stage of development.

The FPGAs also have hard-silicon blocks for different functions like DSP blocks, external memory controllers, block RAM, etc.

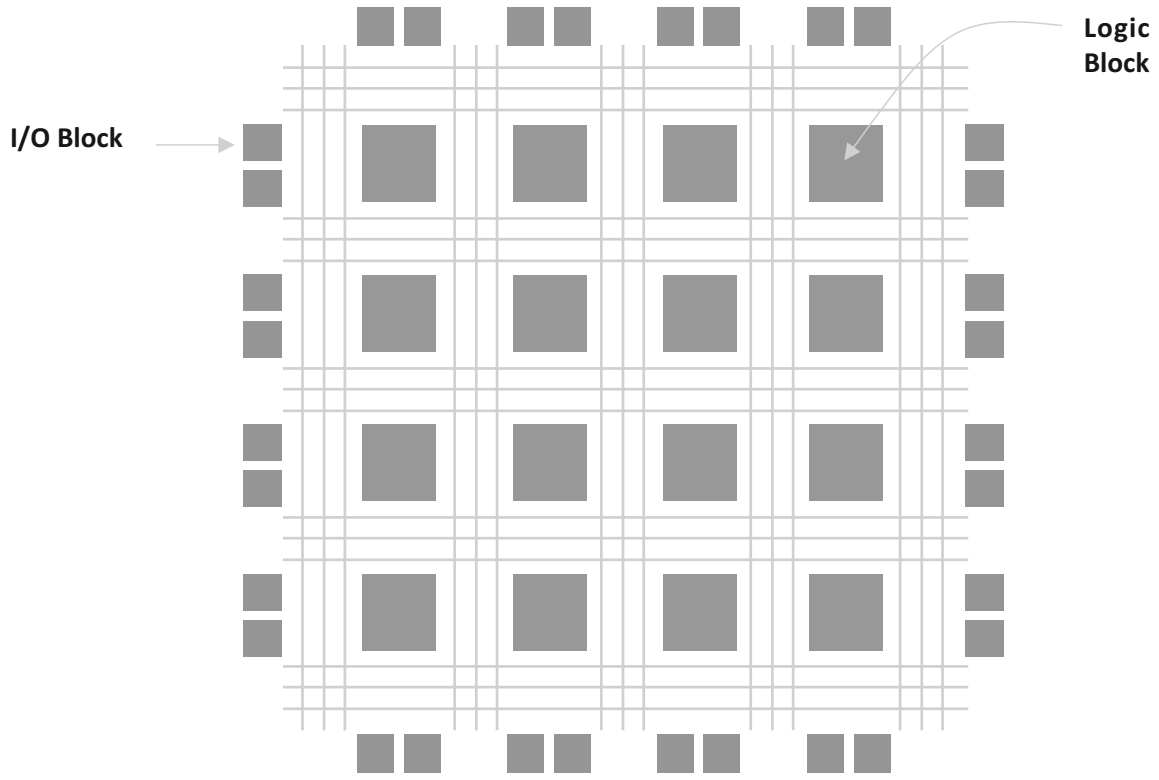


Fig. 2.6 Model of an FPGA Chip
Source: https://www.logic-fruit.com/

FPGA design process

The different stages of the FPGA design process are:

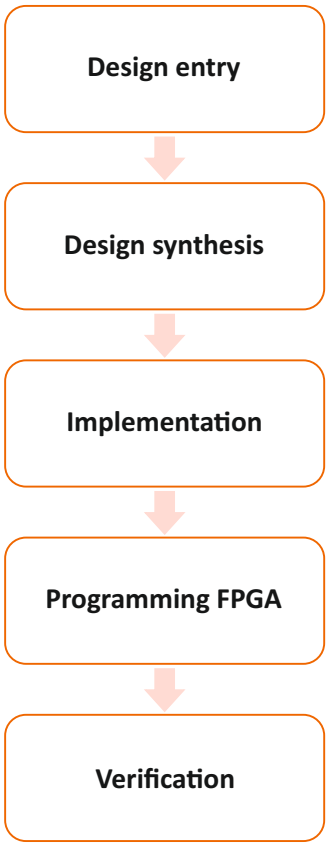


Fig. 2.7 FPGA Design Process

1. **Design entry**

   Design entry is done using schematics or HDL or a combination of the two. The schematic technique is suitable for small projects and designers creating hardware design as it is easier to read and comprehend and also gives more visibility. HDL methods are quick and easy to implement and area better option for complex designs. The HDL is converted into a netlist consisting of logic elements and interconnections required in the specific hierarchy.

2. **Design Synthesis**

   Design synthesis is carried out after it has been entered into the code. In this step, the code is translated into a circuit containing, logic gates, multipliers, flip-flops, etc. Synthesis is begun with a syntax check on the HDL-based design, optimised by removing redundant logic, reducing logic and shrinking the size of the design and then finally the design is connected to the logic.

An example of synthesizing the AND gate using Verilog is shown below:

AND gate using Verilog	Synthesized AND gate
module and2 (y, b, a); output y; input a, b; assign c=a&b; endmodule	

Table 2.10 Synthesizing AND Gate Using Verilog

3. Implementation

This step, consists of translating, mapping, placing and routing. The layout of the design is determined in the implementation of the phase. The FPGA design vendor provides the tool to translate the generated netlist into an FPGA. During translation, the tools gather all the constraints set by the consumer and the netlist files. The constraints include the position of the I/O blocks, requirements related to timing, etc. During mapping, the tool plots out the implementation by comparing the requirement of the specified resources in the files to the available resources on the FPGA design being used. The circuit is then divided into logic blocks and sub-blocks and the entire design is placed in the specific logic blocks. Finally, all the signals are routed as per the constraints set by the consumer.

4. Programming FPGA

A programming file is created to instruct the FPGA design to configure the internal LUTs and interconnections, components like DSP cores, DDR, BRAM, PLLs etc.

5. Verification

Verification is done at different stages of the process:

A. Behavioural simulation is carried out to verify the RTL (behavioural) code before the synthesis process and to confirm the design is functioning as required. Here, the signals and variables are seen, functions and procedures are tracked and the breakpoints are set. It can be performed on Verilog and VHDL designs. It is a quick simulation allowing the designers to change the HDL code in case the functional requirements are not met in a short period.

B. Functionality simulation can be carried out at two stages:

i. Post-translation where the simulation gives information on the logic operations of the circuit after the translation process. If the functional requirements are not met, then the designer will have to make changes in the code and follow the design flow steps.

ii. Post placing and routing (PAR) simulation helps when the functional simulation works but fails to give the expected result when targeted to an FPGA device. This can happen due to rigorous optimization in the placing and routing operation and constraints not being met. The design can be implemented successfully if the PAR simulation test is all right.

C. Static timing analysis is carried out after mapping which gives the signal path delays of the design obtained from the design logic or after placing and routing provides time delay information as a comprehensive timing summary of the design.

2.1.9 Application Specific Integrated Circuit (ASIC) Design

An ASIC is a microchip that is custom designed for a particular application. ASIC design aims at reducing the size of an electronic circuit or system by integrating and reduction of individual components and their functionality into a single element. This reduction and integration process also reduces the cost of the ASIC. The current-day ASICs combine both analog elements like an amplifier, analog to digital converter (ADC), phase-lock loop (PLL), etc. and digital elements like microcontroller, ROM, RAM, etc. The analog elements are designed using transistor-level design techniques and a manual layout process. The digital elements are designed using hardware description languages (HDL) and the layout is carried out by an automated place and route (PnR) process. The different types of ASIC design are full custom design, semi-custom design and programmable ASIC.

ASIC Design Process

The first step in the design process is to understand the requirements of the customer and prepare a specification document. This document is prepared by the design team. The design process consists of logic design, verification, design synthesis and physical design.

1. **Design specification document**

   This document contains the details of the functional requirements of the device and the performance requirement in various operational situations. Apart from the functional and performance requirements, the customer's expectations like new features, design improvements, low power consumption, high processing speeds, etc. have to be considered. While creating the specification the final product has to be kept in mind rather than just the ASIC.

   Some of the aspects that need to be considered after knowing the specifications are:

- **Analysing the block diagrams and system schematics**
- **Foreseeing design problems and challenges**
- **Knowing the operating environment**
- **Understanding the operational requirements of the end product, complaint certification and regulatory requirement for the product**
- **Designing of the ASIC block diagram with all functional components, specifications and layout**
- **Selecting the best and most cost-effective board-level architecture**

Fig. 2.8 Factors to be Considered After Getting Specifications

2. Logic Design

The design team first analyses the specification to define and create a logical design architecture. The architecture includes a block diagram with details of the functional relationship between digital logic elements like processors, memories, combinational logic, sequential logic, finite state machines, data path design, communication buses, and interconnections between them. The next step is to describe the functionality of each block and the connections between the respective functional blocks. This can be done using schematics (graphical depiction) or HDL code like Verilog and VHDL. The different types of coding are:

Gate-level coding is the least abstracted and begins from the transistor-level logic. It describes the design using logic gates like AND, OR, NOR, NAND, Flip-flop, etc. This level of coding does not require synthesis and suitable for less complicated designs or for designs that require very specific implementation for performance. It does not offer the efficiency that comes with higher level abstraction like Electronic Design Automation (EDA) tools.

Register-Transfer Level (RTL) coding is abstracted from gate-level description and synthesized with EDA tools to produce gate-level and transistor-level implementations. It describes the required hardware by implying logic, defines laches, flip-flops, etc. and means to transfer data between them. It uses the capabilities of EDA tools to create, modify and optimize the logic used for implementation but not for functional behaviour.

HDL coding is written at various levels of abstraction, the lowest being the transistor level and the highest being the behavioural level. The choice of level of abstraction depends on the complexity and size of the systems. Behavioural level is coded using languages like System Verilog, Verilog, VHDL and C. Behavioural level is useful for modelling and verification, but cannot be used directly synthesized to gate-level logic.

Fig. 2.9 Types of Coding Used in Logic Design

3. Verification

Verification is carried out to see if the original design intent is being met and also if the implementation at the various stages throughout the design process is as per the requirement. It is also carried out at additional stages of the design using EDA tools to compare the gate-level netlists with the design description and actual layout implementation with the synthesized netlist. If the verification test fails at any point of the process, it is sent back for correction to the concerned design team. This continuous verification of the design and implementation stages helps to spot errors and deficiencies, which help in improving efficiency, and reducing in time and cost of development.

4. Design Synthesis

Design synthesis is carried out to translate the logical design into a gate-level netlist that can be implemented as a physical structure. It uses advanced EDA tools which can recognize the capabilities and limitations of the fabrication process or the target technology to which the high-level abstracted design is being ported.

5. Physical design

It is also known as the back-end design where the synthesized gate-level netlist is converted into functional ASIC hardware. The various steps involved in physical design are:

I. **Floor planning** involves placing the functional blocks in the chip area, assigning routing areas between them, planning for critical power and ground connections and deciding the I/O pad locations. Careful floor planning ensures minimum die area, optimum signal routing channels for ease of layout and signal performance, minimum interference and maintenance of signal integrity.

II. **Partitioning** is the process of segmenting the chip into smaller blocks to facilitate easier placement and routing of the functional blocks. This can be carried out during the logical design phase when the entire design is divided into sub-blocks for development or during the physical design phase to helping in placing and routing activities.

III. **Power planning** considers the energy usage of every block, individual block voltage supplies, ground paths and interactions between them. The location for ground and power rings, cross-die trunks and isolated routes for circuits are assigned during this step. The constraints related to core circuitry, special power pad requirements if any, to reduce series resistivity, inductive impedance, etc. that affect voltage drop, high-speed performance, etc. are addressed.

IV. **Placement** involves the process of dividing the chip into smaller blocks and placing them in correct position to standard cells ensuring that there are no overlaps on the chip. It is performed in stages as pre-placement, in-placement, post-placement before and after clock tree synthesis.

Continued...

V. **Clock tree synthesis** is carried out to prevent clock timing related errors by ensuring that the clock signals are distributed evenly to all the sequential elements in the design. Clocking in gates of high-speed designs occur due to the clock edge not arriving at the exact time as it is expected relative to when it arrived in other parts of the circuit. This timing error is called clock skew and can be minimized or balanced by inserting buffers or inverters along the clock paths of important clock signal chains and ensuring that proper timing is achieved across the entire design.

VI. **Routing** is carried out to connect standard cells, macros, I/O ports, power, clock, etc. physically with metal traces. First the wire or trace length and the route channel congestion are estimated in the global routing and then in detailed routing, the actual connections are made within each block.

Fig. 2.10 Steps Required in Physical Design of ASIC

2.1.10 Application of Chips in End Products

FPGAs, ASICs and ICs are extensively used in many modern electronic devices. Some of the examples in various fields are given below:

Aerospace and defence	In aerospace industry for cabin management systems, engine controls and systems, RF and microwave systems, actuation systems, and in defense applications like radars, electronic warfare, communication devices in autonomous weapons, missiles, etc.
Consumer electronics	In wearable devices, mobile devices, computers, scanners, printers, television sets, home appliances, etc.
Video and image processing	In applications like television sets, video players, traffic applications, desktop publishing, multimedia, medical imaging, etc.
Security systems	In security alarm systems, security for IoT devices, automotive security systems, device monitoring, cyber intelligence, device identity and safety, etc.
Medical electronics	In medical devices like pacemakers, heart and respiratory monitors, drug delivery systems, glucose meters, ultrasound devices, neurological stimulators, etc.
Wireless communications	In cellular telephones, wireless local area networks, global positioning systems (GPS), radios for IoT, etc.

Fig. 2.11 Applications of Chip on End-Products

Unit 2.2 - Computer Architecture and Semiconductor Physics

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Describe basics of computer architecture and semiconductor physics

2.2.1 Introduction to Computer Architecture

Computer architecture is a set of specifications describing the functionality, performance, organisation and implementation of computer systems. It provides details related to the interactions between a set of software and hardware technology standards interact to form a computer system. It involves the process of determining the requirements of the user, technology and the system and creating a logical design based on the requirements.

It can be divided into the following categories:

1. **System design –** It includes hardware components in the system like a graphic processing unit, direct memory access, memory controllers, data paths, and components for multiprocessing and virtualization.
2. **Instruction set architecture (ISA) –** defines how the CPU is controlled by the software, it acts as an interface between the software and the hardware. It also specifies the processor capabilities. It includes processor register types, memory addressing modes, word size, data formats, etc. ISA translates the high-level language to binary language. It can be described as an instruction manual describing the way the instructions are encoded.
3. **Microarchitecture -** It is also known as the computer organisation and it describes how a particular processor will implement the instructions from ISA. It defines the data paths, data processing and storage elements and determines how it should be implemented in the ISA.

A computer consists of various components like a control unit, memory unit, I/O controllers, and arithmetic logic unit (ALU) which are realized with transistor circuits. Computers have a cache, which is a small extremely fast unit that can store information that is frequently and quickly required. The logic design helps to carry out the operations of the control unit, ALU, I/O controllers and other hardware. **A very important area related to computer architecture is the design of microprocessors on a single IC chip.** The microprocessors have the entire CPU- control unit, memory and ALU. Additional memory and I/O control circuitry are connected to the IC chip to form a complete computer. **These tiny IC chips or the VLSI microprocessors consist of millions of transistors that implement the processing and memory units of present-day computers.**

2.2.2 Basics of Semiconductor Physic

A semiconductor is a material that has a conductivity between that of a conductor and insulator. It can be a pure element like silicon or germanium or a compound like gallium arsenide. Typically, silicon is used in the fabrication of electronic circuits. **In semiconductors, holes (valence electrons) and electrons enable the flow of current. Holes are positively charged and electrons are negatively charged particles with equal magnitude.** Holes have lesser mobility compared to electrons as they

travel in different bands. Holes travel in the valence band whereas electrons travel in the conduction band. The mobility of holes is 475 $cm^2 (V . s)^{-1}$ and the mobility of electrons is 1500 $cm^2 (V . s)^{-1}$ for intrinsic silicon at 300 K. In **semiconductors, there is a level known as fermi level, which is present between the valence and conduction bands.** At absolute zero, the fermi level is the highest occupied molecular orbital and the charge Ω carriers in this state do not generally interact with each other. The charge carriers will occupy states above fermi when the temperature rises above absolute zero.

Classification of semiconductors

They can be classified as:

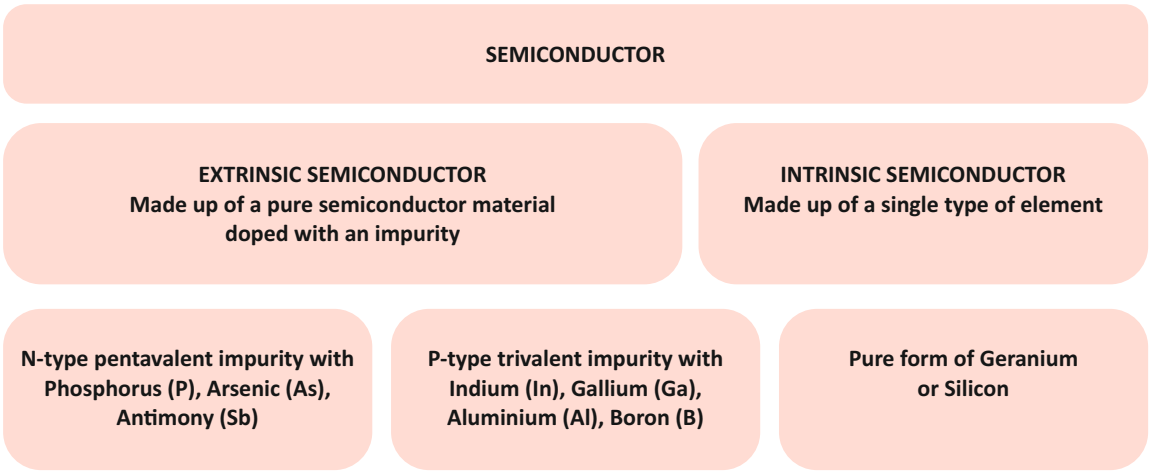


Fig. 2.12 Classification of Semiconductors

There is an increase in the density of unfilled states in a p-type semiconductor, therefore, it accommodates more electrons at the lower energy levels but in an n-type semiconductor, the density of state increases, which accommodates more electrons at higher energy levels.

Properties of semiconductors

Semiconductors conduct electricity only when the charge carriers are aroused because of external energy. This makes them an excellent material to conduct electricity in a controlled way. When an external energy is applied, a few of the valence electrons cross the energy gap and jump into the conduction band, leaving an equal number of holes or unoccupied energy states.

The resistivity of semiconductors is in the range of 10^{-5} *to* $10^{6} \Omega m$ and conductivity of 10^{5} *to* $10^{-6} mho/m$. When the temperature increases, the resistivity of semiconductors decreases due to the number of charge carriers increasing rapidly and vice-versa. The resistivity of semiconductors is higher than conductors but lower than insulators.

Semiconductors have the advantage of being small and light in weight and also have lesser power losses. At Zero-degree Kelvin, they act like insulators and at higher temperatures, they act as conductors. They can be doped to make semiconductor devices suitable for amplifiers, switches, energy conversion, etc. Switches in electrical circuits like transistors and MOSFET are made using semiconductors.

UNIT 2.3 - CMOS Circuit and its Components

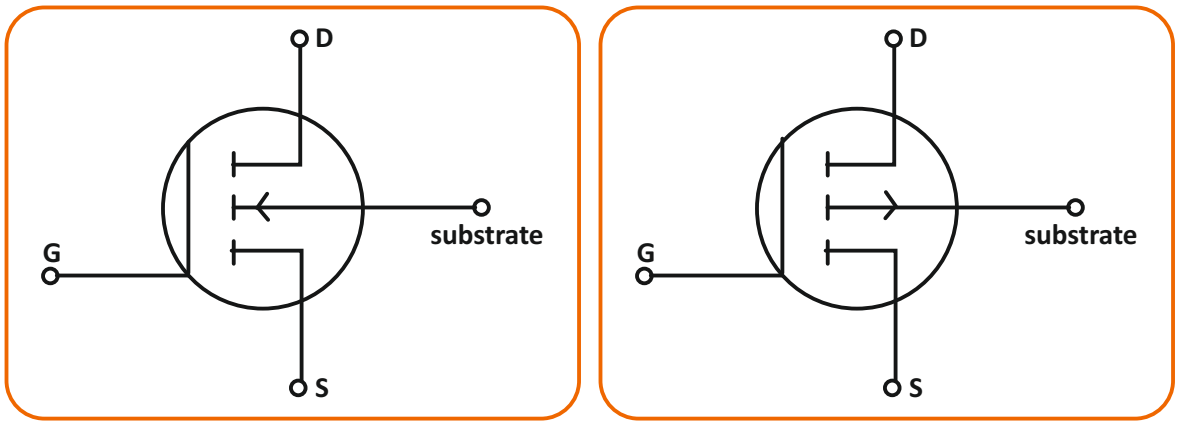
Unit Objectives

At the end of this Unit the trainee will be able to:

1. Illustrate the layout of CMOS circuit
2. List the components of a CMOS integrated circuit such as transistors, diodes, triodes etc

2.3.1 Introduction to CMOS and CMOS Circuit

Complementary Metal Oxide Semiconductor (CMOS) is a combination of PMOS (p-channel MOSFET) and NMOS (p-channel MOSFET) transistors, where PMOS and NMOS are the types of MOSFETs. In semiconductor technology, CMOS has gained importance due to its low power dissipation and low operating currents and comparatively easier manufacturing processes than bipolar junction transistors. CMOS transistors are used in amplifiers, logic circuits, switching circuits, microprocessors, IC chips, etc.



NMOS (n-channel MOSFET) PMOS (p-channel MOSFET)

Fig. 2.13 N and P Channel MOSFETs

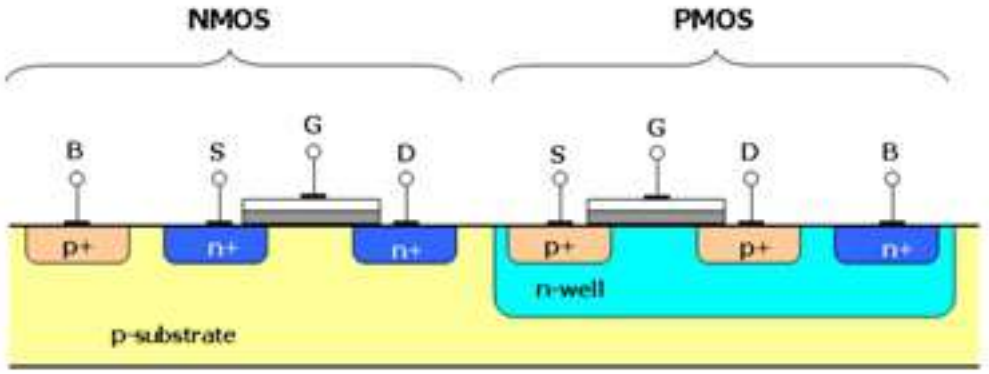
In MOSFET, G means gate terminal, S means source terminal and D means drain terminal.

NMOS has a p-type substrate consisting of a majority carrier holes and the n-channel consisting of a majority carrier electron. As the flow of electrons is faster than the holes, NMOS transistors are more rapid than PMOS.

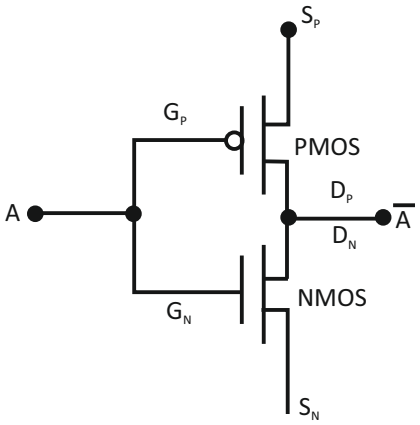
PMOS has a n-type substrate consisting of a majority carrier electrons and when a negative voltage is applied to the gate, it repels the electrons and attracts the holes resulting in the formation of the p-channel between the source and the drain. Due to the slow flow of holes, the process of current control is easier in PMOS transistors than in NMOS transistors.

2.3.2 Layout of CMOS Circuit

In the layout shown below, the CMOS transistor consists of NMOS transistor with N+ regions at the drain and the source terminals and a p-type substrate and PMOS transistor with P+ regions at the drain and the source terminals and a N-type substrate in a N-well. It consists of P-substrate with three N+ regions, two small and one large. The two small regions are part of the NMOS transistor and one large region is part of the PMOS transistor. The two P+ regions are diffused into a N-well to form the PMOS transistor. The top layer is covered with silicon dioxide layer and aluminum metallization for protection.



(a)



(b)

Fig. 2.14 (a) Layout of CMOS (b) Symbol of CMOS
Source for (a): www.wikipedia.com Source for (b): www.javatpoint.com

Notes

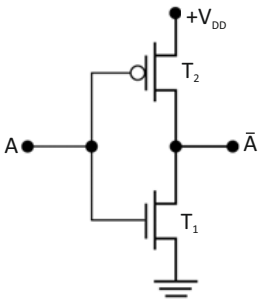
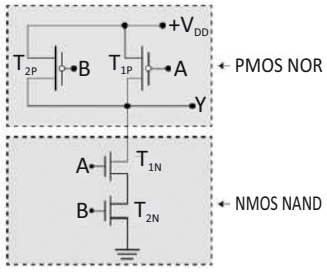
2.3.3 CMOS Logic gates

CMOS Logic gates are constructed using PMOS and NMOS field-effect transistors, where NMOS transistors work as positive logic elements and PMOS transistors work as negative logic elements. Therefore, the PMOS and NMOS transistors in a CMOS perform complementary logic functions. Some of the features of CMOS logic gates are:

- **Large logic swing and fan-out capability**
- **High noise margin**
- **Low propogation delay and power dissipation**
- **High speed and excellent temperature stability**
- **Less packaging density**
- **Reduced costs**

Fig. 2.15 Features of CMOS Logic Gates

The different types of CMOS Logic gates are:

CMOS Inverter	It is formed by connecting the NMOS and PMOS transistors as shown in the figure. Here, in the inverter, PMOS transistor is on the top and NMOS transistor is at the bottom. The positive voltage of +VDD (DC voltage supplied to the drain) at the gate input of NMOS transistor will turn it 'on' and the same positive voltage at the gate input of PMOS transistor will keep it 'off'. The vice-versa happens when the voltage is 0 volts at the gate inputs of NMOS and PMOS transistors.	
CMOS NAND	It is a combination of NMOS NAND and PMOS NOR. It can have a NMOS NAND gate with PMOS NOR as its load as shown in the figure or vice-versa. Here, the input terminal of the transistors is A and B, if A = 0 and B = 0, then NMOS transistors will remain 'off' and the two PMOS transistors will conduct as output Y = logic 1 = VDD.	

Continued...

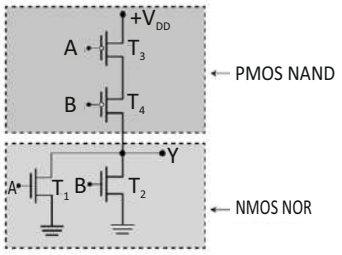
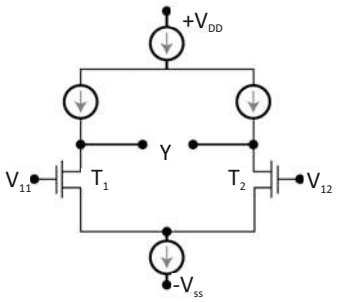
CMOS NOR	It is a combination of NMOS NOR and PMOS NAND and when the inputs A = 0 and B = 0, then NMOS NOR will remain 'off' and PMOS NAND will conduct, therefore [Equation] will be 'off' and [Equation] will conduct. CMOS NOR conducts only when the two inputs are 0 and at all other inputs, the output will be 0.	
CMOS Operational Amplifiers	It can be used as an amplifier when the operating point is fixed in the active region. Its main function is to amplify and output the voltage difference between the two input pins.	

Table 2.11 Types of CMOS Logic Gates
Source: www.javatpoint.com

2.3.4 Components in an Integrated Circuit (IC)

An IC is a chip of semiconductor material on which a set of electronic circuits are fabricated to carry out various tasks like switching, amplifying and other logic functions. It is a semiconductor on which millions of tiny **resistors, capacitors, transistors, diodes,** etc. are fabricated. It is also known as a chip or a microchip. It is the building block for the modern-day electronic devices. It is an integration of multiple miniature components that are interconnected and embedded in a thin substrate of semiconductor material. **A brief description of all these components have already been discussed in the previous module.**

Notes

UNIT 2.4 - High-level Computer Languages – C and C++

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Recall basics of high level computer languages such as C, C++

2.4.1 Introduction to High-level Computer Languages–C & C++

C languages is also known as mother language as it is the base for other programming languages and they can directly interact with hardware devices. It was developed by Dennis Ritchie in 1972 at bell laboratories of American Telephone and Telegraph (AT&T) in the USA to construct utilities running on Unix. It is used in device drivers, operating systems, protocol stacks, etc. It is also used in computer architecture ranging from large supercomputers to small microcontrollers to embedded systems. It is a successor of B language. It is one of the most widely used programming languages and C compliers are available for the latest computer architectures and operating systems. C language can be considered as:

- **Mother language as most of the programming languages follow C syntax like C++ and Java, also most of the kernel, compilers are written in C language.**
- **System programming language as it is used to carry out low-level programming and create system software**
- **Procedural and structured programming language as it specifies the steps to be taken while programming and breaks it into parts, blocks, functions, etc.**
- **Mid-level programming language as it supports both low-level (specific to one machine) and high-level (machine independent) languages.**

Fig. 2.16 Highlights of C Language

Notes

Some of the features of C language are:

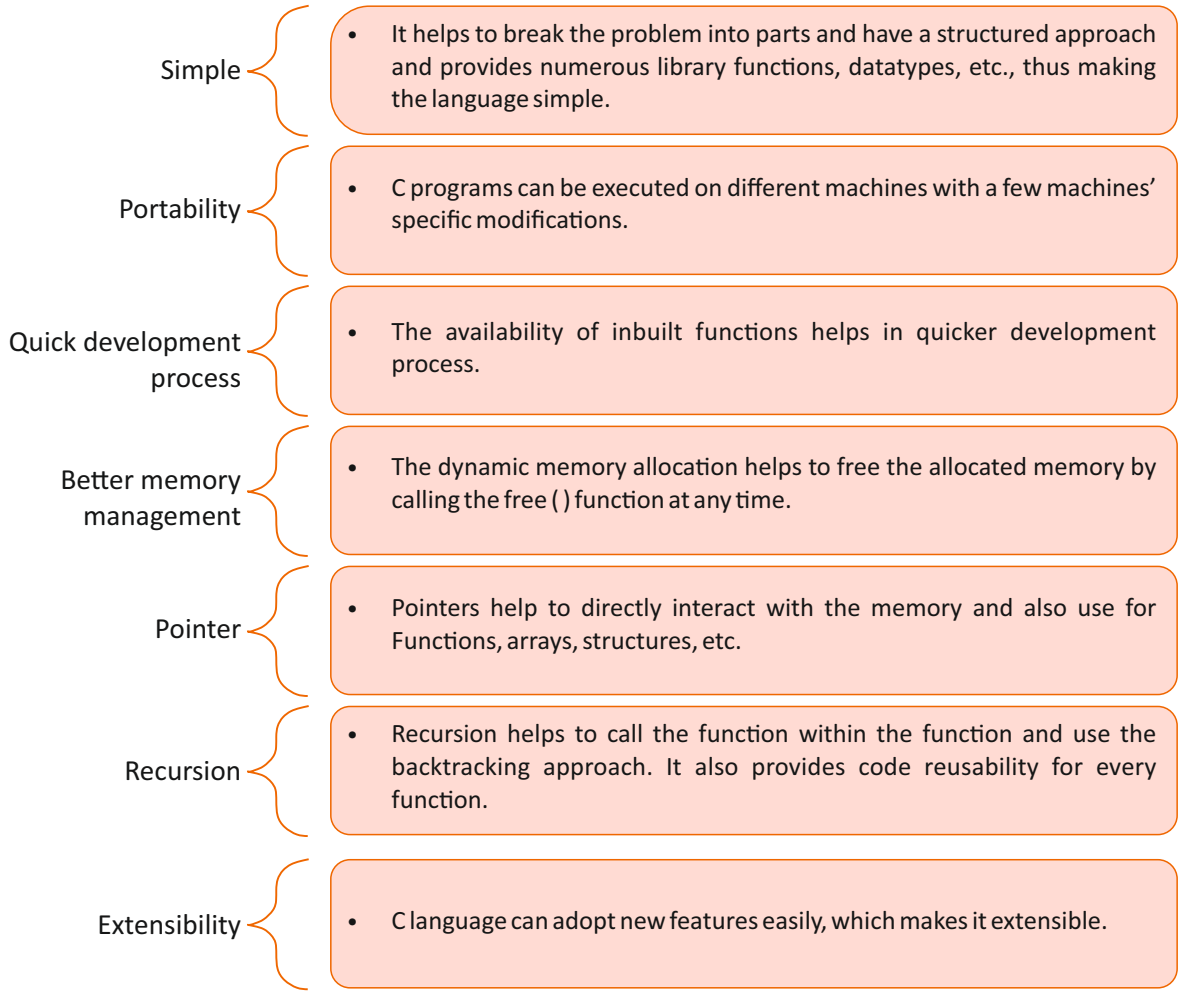


Fig. 2.17 Features of C Language

C++ languages

C++ is an extension of C programming and is an object-oriented, generic and procedural programming language. It is a mid-level language with features of both high-level and low-level language features. It supports inheritance, polymorphism, encapsulation and abstraction which are part of the object-oriented programming. It is used in client-server applications, windows application, device drivers, embedded firmware, etc. In addition to the features of C language, C++ also have features like compilers, reusability, easy error detection, modelling real-world problems, clarity, flexibility, etc.

Summary

- Digital electronics involves the study of digital signals and the devices used to produce them. Digital circuits are made from large assemblies of logic gates and a simple electronic representation of the Boolean logic function. This is in contrast to analog electronics which have continuously variable signals.
- In digital systems, information is represented using the number system. A digital system can understand the positional number system where there are digits and the digits represent different values depending on the position they occupy in the number.
- The different types of number systems used are decimal, binary, octal and hexadecimal.
- Numbers from any base system can first be converted to decimal base system as described earlier and then that decimal number can be converted to the required base system.
- Boolean algebra is also known as the algebra of logic and switching algebra as it was applied to solve relay logic problems. In Boolean algebra, digits/symbols 0 and 1 are used to represent logic levels.
- A logical statement is a statement that can be determined by a true or false or a binary decision. For example, 15-2 =13 is a true statement whereas 15 is less than 13 is a false statement. True or false results are called truth values, which are depicted by logical constants 'true and false' or '1 and 0'.
- A bit is a unit of information in digital communications and computing and it represents the logical state with one of the two possible values as 1 or 0, true or false, on or off, etc.
- Algebraic expressions are formed by combining algebraic variables like x, y, z, etc. with mathematical operators like +, -, x, and /, similarly the truth functions and logical statements are combined with logical operators like AND, OR and NOT to form a logical function or compound statement.
- A truth table represents all the possible values of logical statements and variables along with the possible answers to the given combination of values.
- NOT operates on a single variable and the operation is called complementation and the symbol used for it is a variable with a bar.
- OR performs the operation of logical addition and the symbol used is +. In logical addition, + means OR, therefore A+B means A OR B.
- AND performs the operation of logical multiplication and the symbol used is a dot (.). In logical multiplication, (.) means AND, therefore A.B means A AND B.
- Initially, Boolean algebra was applied in telephone switching circuits and later in computer electronics, where the logic gates perform the Boolean operations. Gates are two-state digital circuits as the input and output signals are either low voltage (denoted by 0) or high voltage (denoted by 1).
- Gate arrays are logic gates that are pre-laid in a matrix of chips with no particular function except for the standard functions of NOR or NAND logic gates.
- Memory cells are electronic circuits that are used to store one bit of binary information. They must be set to store a logic of 1 (high voltage level) and reset to store a logic of 0, which will be stored until it is changed by the set/reset process.
- The logic circuits which use memory cells are called sequential circuits and logic circuits which do not use memory cells are called combinational circuits.
- Flip-flops, also known as latches are used as data storage elements. They store a single bit of data and that has two stable states 1 and 0.

- Logic blocks are used in FPGA architecture, these can be configured by the engineer.Lookup table (LUT) is an array (collection of data elements each identified by a key or array index) that replaces runtime computation with a simpler array indexing process called direct addressing, where the value v is stored in slot k.
- A System-on-chip (SoC) is a chip or an integrated circuit that holds many components of electronic systems and computers like central processing unit (CPU), input/out interfaces, memory interfaces, secondary storage interfaces, graphics processing unit (GPU), etc. on a single substrate.
- In analog circuits, resistors, inductors, and capacitors are mainly used to process any analog input signal or data and produce an output in analog form.
- In digital circuits, logic gates are the main components used to process discreet time signals (input) to digital signals (output).
- The process of circuit design ranges from the design of an individual transistor in an integrated circuit to complex electronic systems.
- The circuit design process starts with getting the specifications from the customer, which details the functions of the final design without stating the methods to achieve them.
- After receiving the specifications, designing begins with making a block diagram keeping all the functions mentioned in the specifications in mind. At this stage, only the function is taken into account and not the components that go into each block.
- The verification process helps to go through every stage of the design to check if it meets the specifications through computer simulations of the designs.
- The design software helps to create cheaper, more efficient and longer-lasting circuits. There are different types of software available like HDL, VHDL, Verilog, etc.
- The prototyping process is important to know if there are any issues in the circuit which can cause damage to the product or the user.
- The documentation process typically involves recording the specifications, design details, prototype details, verification and test procedures and results, compliance with regulatory guidelines, etc.
- An FPGA is an integrated circuit that is designed to be configured or customized after the manufacturing process. The reprogramming can be done in the field instead of the semiconductor foundries.
- Design entry is done using schematics or HDL or a combination of the two. Schematic technique is suitable for small projects and designers creating hardware design as it is easier to read and comprehend and also gives more visibility.
- Design synthesis is carried out after it has been entered into the code. In this step, the code is translated into a circuit containing, logic gates, multipliers, flip-flops, etc.
- Implementation consists of translating, mapping, placing and routing. The layout of the design is determined in the implementation of phase.
- A programming file is created to instruct the FPGA design to configure the internal LUTs and interconnections, components like DSP cores, DDR, BRAM, PLLs etc.
- Behavioural simulation is carried out to verify the RTL (behavioural) code before the synthesis process and to confirm the design is functioning as required.

- Post-translation where the simulation gives information on the logic operations of the circuit after the translation process.
- Post placing and routing (PAR) simulation helps when the functional simulation works but fails to give the expected result when the targeted to a FPGA device.
- Static timing analysis is carried out after mapping which gives the signal path delays of the design obtained from the design logic or after placing and routing provides time delay information as a comprehensive timing summary of the design.
- An ASIC is a microchip that is custom designed for a particular application. ASIC design aims at reducing the size of an electronic circuit or system by integrating and reduction of individual components and their functionality into a single element.
- This document contains the details of the functional requirements of the device and the performance requirement at various operational situations.
- The design team first analyses the specification to define and create a logical design architecture. The architecture includes a block diagram with details of the functional relationship between digital logic elements like processors, memories, combinational logic, sequential logic, finite state machines, data path design, communication buses, and interconnections between them.
- Verification is carried out to see if the original design intent is being met and also if the implementation at the various stages throughout the design process is as per the requirement.
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- CMOS transistor consists of NMOS transistor with N+ regions at the drain and the source terminals and a p-type substrate and PMOS transistor with P+ regions at the drain and the source terminals and an N-type substrate in an N-well. It consists of P-substrate with three N+ regions, two small and one large.
- CMOS Logic gates are constructed using PMOS and NMOS field-effect transistors, where NMOS transistors work as positive logic elements and PMOS transistors work as negative logic elements.
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- C++ is an extension of C programming and is an object-oriented, generic and procedural programming language. It is a mid-level language with features of both high-level and low-level language features.

Notes

Exercise

Answer the following questions:

1. Discuss the basics of System-on-Chip.

_____

_____

_____

2. Write a brief note on FPGA and ASIC.

_____

_____

_____

3. Write a brief note on computer architecture.

_____

_____

_____

Fill in the blanks:

1. _____ involves the study of digital signals and the devices used to produce them.

2. _____ also known as latches are used as data storage elements.

3. _____ is a FET fabricated by controlled oxidation of silicon.

Notes

_____

_____

_____

_____

_____

_____

Scan the QR Code to watch the related video

https://www.youtube.com/watch?v=crSGS1uBSNQ

Number System in Digital Electronics

https://www.youtube.com/watch?v=1CFhcBH52Rc

Application-Specific Integrated Circuit (ASIC) Design

https://www.youtube.com/watch?v=WW-NPtIzHwk

Boolean Algebra

https://www.youtube.com/watch?v=0lwhoQ5aQe8

Logic Gates

https://www.youtube.com/watch?v=CfmlsDW3Z4c

Field Programmable Gate Arrays (FPGA)

www.youtube.com/watch?v=Ado4CD7jd68&list=PLgwJf8NK-2e4TZ2RJa_GTZEop1rcDqUQQ

CMOS Circuit and its Components

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

ESSCI
Skilling India in Electronics

3. Develop Function Design of SOC Module

Unit 3.1 - Requirements for Designing Function of SoC Module

Unit 3.2 - Implementation of Designing Function of SoC Module

ELE/N1201

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. Identify the requirements for designing function of SOC module
2. Perform steps to carry out designing of function of SOC module

UNIT 3.1 - Requirements for Designing Function of SoC Module

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Describe the work flow of the company's SOC function designing process
2. Discuss the information derived from work schedules, different activities and project requirements by interacting with the lead engineer and other departments
3. Describe types of circuit design i.e. digital design and analogue design
4. Elaborate ways to analyse the project requirements based on the type of circuit design
5. Describe the design factors such as design cycle time, expense and custom design requirements for selecting the design type
6. Describe function of system architecture and its components memory, microcontroller, microprocessor, memory blocks, timers and oscillators, interfaces and power management

3.1.1 Process of SoC Function Designing

The designing process for SoC requires collaboration between customers, designers, developers, manufacturers, fabricators, etc. The implementation of all the tasks clear instructions, documentation, reviews and verification at every stage of the process. The concept, functionality and architecture have to be well defined for an efficient development process and reduction of re-deign work. In any organisation, the preliminary discussion with the customer, which is the basis for the design requirement, must be documented well. At this point, the specifications including the functions and various performance parameters like electrical, thermal, and mechanical properties, the device specifications, and constraints, if any, should be discussed with the design team, lead engineers, and people in other departments who will be involved in the work should be consulted. This helps to understand the challenges, the different activities involved, resources required, timelines for designing and implementing the project cost involved, etc.

Some of the factors to be considered during the design process are:

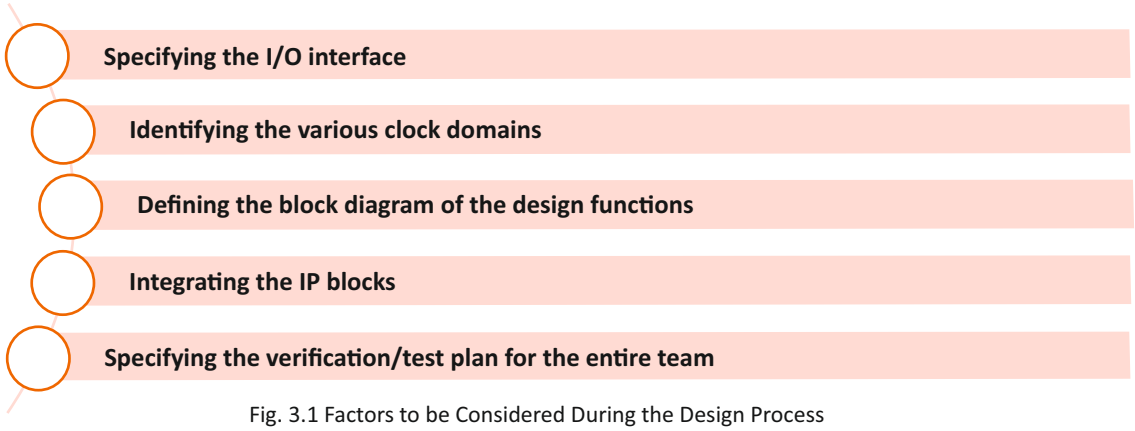

Fig. 3.1 Factors to be Considered During the Design Process

3.1.2 Analog and Digital Circuit Design

The basics of analog and digital circuits and the general steps for circuit design have already been discussed in the previous module.

Analog Circuit Design

The analog circuit design focuses on the designing of circuits that operate in and are optimised for continuous time-domain behaviour. All the basic devices in an integrated circuit respond to continuous time signals/stimuli, therefore analog design forms the foundation for IC design. The operations of many devices which are densely packed in an IC interact with each other and with the silicon substrate, board, package, etc. causing variations in the form of changes in voltage, temperature, performance, signal distortions etc. These variations can occur within a single IC or between devices. The main aims of analog design are signal precision, amplification and filtering.

Analog circuit design typically follows the top-down design and implementation process and a bottom-up verification process. The main steps for analog circuit design are:

Develop high-level specifications for the design including the performance, functions, power requirement, area, cost, etc.

Develop the design to achieve the required results using amplifiers, filters, comparators, etc.

Develop device-level circuit descriptors using resistors, capacitors, transistors, etc. as per the requirements.

Carry out verification using simulation to check if the design delivers all the requirements as per the specifications.

Implement the physical layout by following all the placement rules, and limitations of manufacturability including the signal integrity and optimization of cost and space.

Carry out physical verification to validate the physical layout.

Carry out logic versus schematic checking or LVS checking. Extract the circuit from the physical layout, include any other effects required and re-simulate to ensure everything is all right. Compare the extract design with the original design to ensure that all the required devices are present and connected correctly.

After all the above steps, the design is ready for manufacturing or integration into a digital design. The integration of analog design into a larger digital design is called analog/mixed-signal design.

Fig. 3.2 Steps for Analog Circuit Design

Digital Circuit Design

The digital circuit design techniques focus on the propagation of discreet values 0 and 1. Logic 1, represents the presence of supply voltage for the IC and logic 0 represents the absence of voltage. The circuits processing these signals should be consistent in their response to the logic levels 0 and 1 for the digital design to function properly and the responsibility of the analog design is to deliver this. This helps the behaviour of the circuit to be analysed using sequential and combinational modules, considering voltages 1 and 0, thus simplifying the design and verification process. The concept of logic operations, logic gates, truth tables, etc. are already discussed in the previous module. Digital circuits can be designed using:

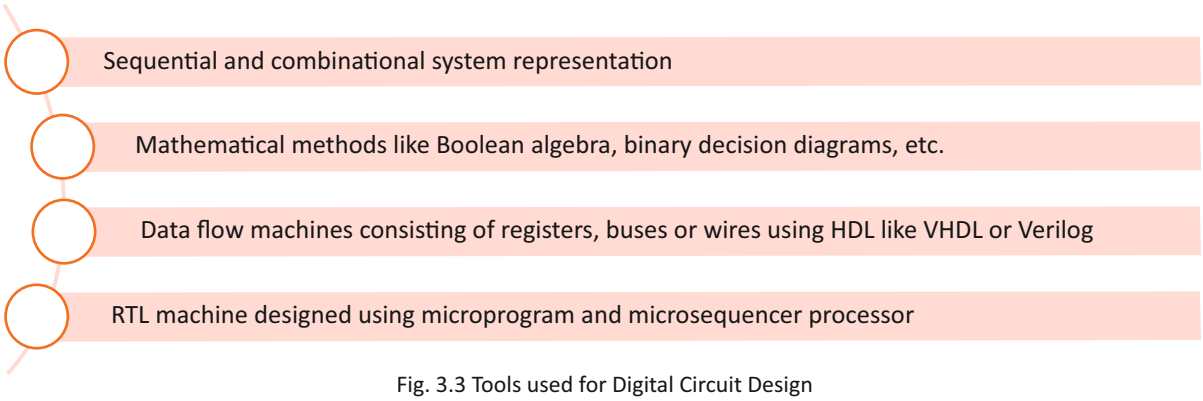

Fig. 3.3 Tools used for Digital Circuit Design

The main steps in digital circuit design are:

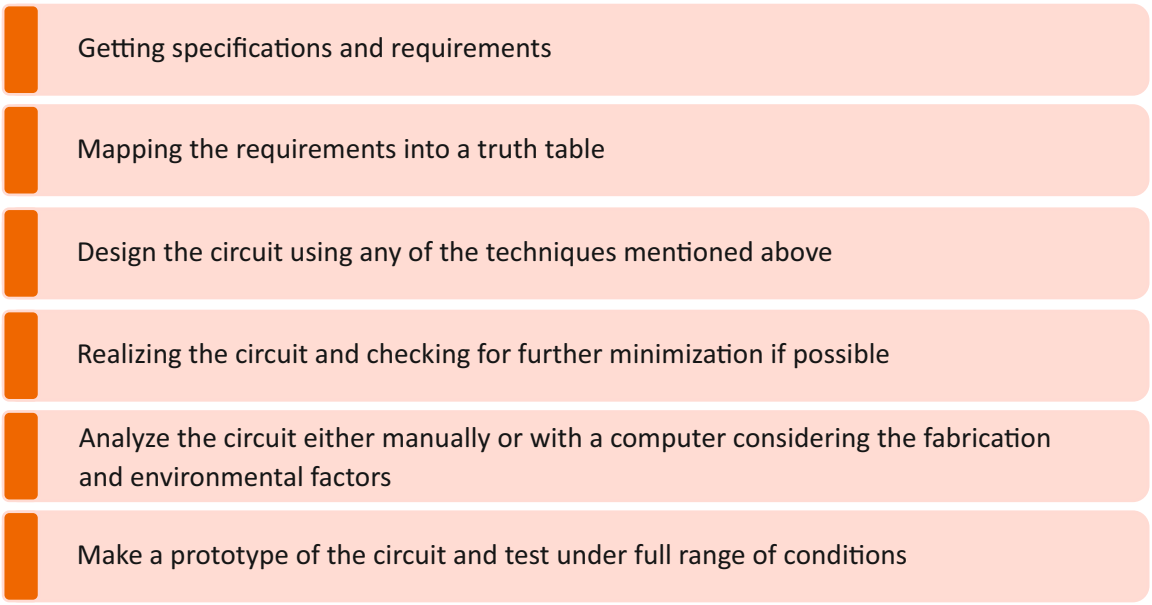

Fig. 3.4 Steps for Digital Circuit Design

While analyzing the project requirements the type of circuit becomes critical based on the devices used and the interconnections between them.

3.1.4 System Architecture and its Components

As discussed earlier, an SoC is designed to meet all the requirements by incorporating the electronic circuits of numerous computer components in a single IC instead of assembling many components onto a board. Some of the drawbacks of such an architecture are higher architecture and prototyping costs, lower yield and complex debugging processes. Another disadvantage is if one of the components malfunctions then the whole chip has to be replaced. With advancements in technology, some of the drawbacks are getting addressed.

Some of the common components in the SoC architecture are:

Component	Description
Memory like RAM and ROM	Volatile memories lose data after the power is switched off, they are cheaper and faster. Examples are Random Access Memory (RAM), Static RAM (SRAM) and Dynamic RAM (DRAM). SRAM is used for cache and DRAM is used for main memory. There are some types of RAM like Ferroelectric RAM (FRAM) and Magnetoresistive RAM (MRAM) which store data in a magnetic state and act as non-volatile memory. Non-volatile memory retains data even in the absence of a power source. Examples are Read-Only Memory (ROM), Erasable Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM) and Flash
Microcontroller	A microcontroller consists of a processor, memory, I/O peripherals, serial ports, timers, etc. on a single chip. It is designed to carry out a specific function.
Microprocessor	An SoC has multiple processor cores which allow different processes to run at the same time. This enables the operating system to consider the multiple processor cores as multiple CPUs, thus increasing the speed and performance of the system.
Timers and oscillators	Timers maintain the timing of an operation in synchronisation with an external clock, along with measuring time-generating delays. Oscillators generate clock signals using phase shift circuits or mechanical resonant devices. Crystal oscillators are preferred in microprocessors and microcontrollers as they are accurate, compact, have low power consumption, generate high frequency and are low cost.
External Interfaces	These are communication protocols like WiFi, USB, Ethernet, etc.
Analog Interfaces	Analog-to-digital converter (ADC) converts an analog input signal to a digital output form. Similarly, Digital-to-analog converter (DAC) converts a digital form to an anlog form.
Power management unit	It governs the power functions in digital circuits. Like charging batteries, monitoring power connections, controlling on and off functions, controlling power to other ICs, etc.

Table 3.1 Common Components in SoC Architecture

3.1.3 Design Factors for Selection of SoC Design Type

In the selection of the design type, there should always be a balance between the cost and performance of the product. The advancement in fabrication technology has enabled the transistors to become smaller. Some of the design factors to be considered while determining the design type for SoC are:

- Time includes the aspects which can speed up the instruction execution like partitioning instructions
- Area occupied by a feature plays a vital role and it also has an implication on the cost
- Power consumption affects the implementation and performance
- Reliability becomes crucial when dealing with deep submicron effects
- System support and portability like IP (pre-designed component) and architecture (known platform) reuse
- Process dependency and testability
- Partition based on functionality
- Partition based on hardware and software components
- Robustness of tools
- Consistency and accuracy at different levels

Fig. 3.5 Design Factors for Selection of SoC Design Type

UNIT 3.2 - Implementation of Designing Function of SoC Module

Unit Objectives

At the end of this Unit the trainee will be able to:

1. List the steps to be perform for preparing the system for designing the SOC module function
2. Discuss the selection criteria of languages for designing such as Hardware Design Language (HDL) i.e. Verilog, VHDL and high level language i.e. C, C++
3. Describe IP core block and its use in design
4. List tools, software and applications required for designing
5. List the steps to be perform for planning and designing the function of SOC module
6. Describe different types of design as per sections in VLSI processor such as high level design, operative part design, control part design, memory design and others
7. Describe how to design the logic for the system including structuring of blocks, interconnection pattern, structure of data path and its control sequences
8. Elaborate ways to analyse the coding and verification results of design
9. Discuss the importance of recording the observed outcomes and its use in rejecting the defective device
10. Discuss the documents needed to be maintained after completion of work

3.2.1 Hardware Description Language

Hardware description language (HDL) is a computer language used to describe the structure and behaviour of digital logic circuits. This helps to automate the analysis and simulation of an electronic circuit. It also helps in the synthesis of a netlist, which is a specification of all the physical components and their interconnections that can be placed and routed to create an integrated circuit. It is an integral part of electronic design automation (EDA) systems for circuits like ASI and programmable logic devices. It consists of expressions, statements and control structures similar to programming languages like C.

HDLs implement register-transfer level (RTL) abstraction, which is a model of data flow and timing of a circuit. The two major HDL are VHDL (Very high-speed integrated-circuit hardware description language) and Verilog. The different types of description in them are dataflow, behavioural and structural. The main difference between HDL and other high-level programming languages like C is that the HDL code involves parallel operations and other languages involve sequential operations. Most CAD tools support VHDL and Verilog.

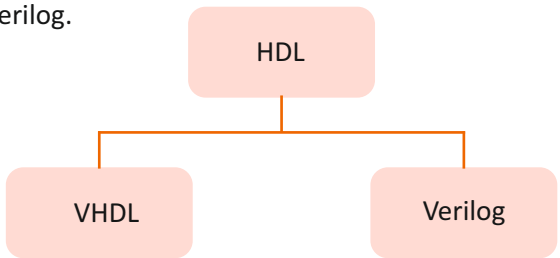

Fig. 3.6 Types of Hardware Description Languages

VHDL is used in electronic design automation for digital and mixed-signal systems like FPGA and ICs. It is also used as a general-purpose parallel programming language. Logic circuits are expressed by writing text models using VHDL. The model is processed by a synthesis program and then a simulation program is used to test the logic design. A testbench is a collection of simulation models are utilized to characterize the logic circuits that interface to the design. It is an event-driven simulator; therefore, every transaction is added to an event queue for a scheduled time. The simulations alternate between the statement execution and event processing. In statement execution, the triggered statements are evaluated and in event processing, the events in the queue are processed. Although VHDL is typically used for simulation test benches for data stimulus and verification, some compilers can be utilized to build executable binaries.

Verilog uses a textual format to describe electronic circuits and systems. It is used for verification through simulation for test analysis, fault grading, logic synthesis and timing analysis. Verilog requires fewer lines of code compared to VHDL. It has similarities with the C language and has a better grasp on hardware modelling and also a lower level of programming constructs.

The full-type system of VDHL is preferred by some designers as it provides the ability to write more structured code in comparison to the original Verilog and is very useful while declaring record types.

Notes

3.2.2 IP Core Block and its use in Design

Intellectual Property (IP) core is also known as semiconductor intellectual property (SIP) core or intellectual property (IP) block and it is the reusable unit of a cell, logic or an IC layout design that is the property of one company or party. It can be owned and used by a single party or licensed to other parties. The party that owns the design has the patent or copyright to the source code of the design. Each of the IP blocks is a reusable component of the design logic and has an interface and behaviour that can be verified by the creator and integrated into a design.

There are two types of IP cores:

Soft Cores	Hard Cores
Soft cores consist of sythesisable and netlist cores and both of them allow synthesis, placement and routing in the design flow. They are offered as synthesisable RTL in VHDL or Verilog and they are similar to low-level languages like C in computer programming. They are also offered as generic gate - level netlists, which are the Boolean algebraic representation of the IP cores logical function implemented as process - specific standard cells or generic gates. The gate level netlists are similar to the assembly code listing in computer programming.	Hard cores are also known as hard macros consisting of analog or digital cores. The functions of these cores cannot be modified significantly by designers. There are typically specific to particular process technology and defined as a lower- level physical description. These give better predictability of timing performance and area for their specific technology. Generally, along and mixed - signallogic are given as hardcore in a transistor-layout format like graphic database system information interchange (GDSII). The hard cores delivered to one design process or foundry cannot be ported to another easily.

Fig. 3.7 Types of IP Cores

IP hardening

IP hardening is a process to generate reuse designs/hard cores from soft cores. A digital signal processor can be developed from soft cores of RTL format and then it can be targeted to other foundries or technologies to yield different implementations. This helps to predict the characteristics of the hardcore as it has been pre-implemented and at the same time offers the flexibility of soft cores.

Notes

3.2.3 Tools and Software for Designing of SoC

The design flow process for SoC designing utilizes both software and hardware tools for architectural co-design. Software tools are used for controlling microprocessors, microcontrollers, processor cores, interfaces and peripherals. Computer-aided (CAD) tools like electronic design automation tools (EAD) are used to put hardware blocks together. SoC components are designed using high-level programming languages like C++, MATLAB and converted through high-level synthesis (HLS) tools to RTL designs like C to HDL. The HLS tools are called algorithmic synthesis and it allows designers to model and synthesise system circuit, software and verification using C++ in one high-level language specified in HDL.

3.2.4 Steps to Plan and Design the Function of SoC Module

The first step is to understand the need for SoC design which can be obtained through the process of ideation or through the specifications provided by the customer. The next step is to plan the architecture and the components required like processor, DSP, memory, SoC communication requirements etc. It is important to check if there is scope for using any IP cores in the design for increasing reusability. Next, the types of circuits, software and hardware languages required for development, integration and synthesising and verification have to be finalized. The layout placement and routing are carried out and then sent for fabrication. The design tools include simulation at various levels, design verification, layout generation and design synthesis.

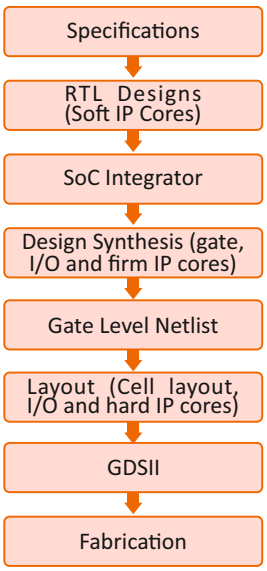

Fig. 3.8 Steps to Plan and Design the function of SoC Module

The **high-level design** consists of the RTL design where some parts may be based on the IP cores and others may be based on the application specific to the device. Both these will be integrated to form the full RTL description using HDL languages like Verilog or VHDL. This will then be verified using simulation tools.

The **operative part** of the design looks at the analysis of the internal circuit operations. The operations of digital signal processing are carried out by DSP, which includes the operations for sensors, actuators, data analysis and processing.

Memory design is based on the application requirements like the operating system, size and the variability of the process. It deals with the size of the memory and its implementation. The choice of the memory block like SRAM/DRAM, etc. is done at this stage considering the internal and external memory issues.

3.2.5 Interconnections and Communication On-chip

The bus architecture was mainly used for communication between units in the past. Now, network-on-chip interconnect technology has gained popularity. One of the popular bus communications is the advanced microcontroller bus architecture (AMBA) bus protocol by ARM. There are different architectures built according to the chip design and application by designers. The following is an example of an AMBA bus on an SoC:

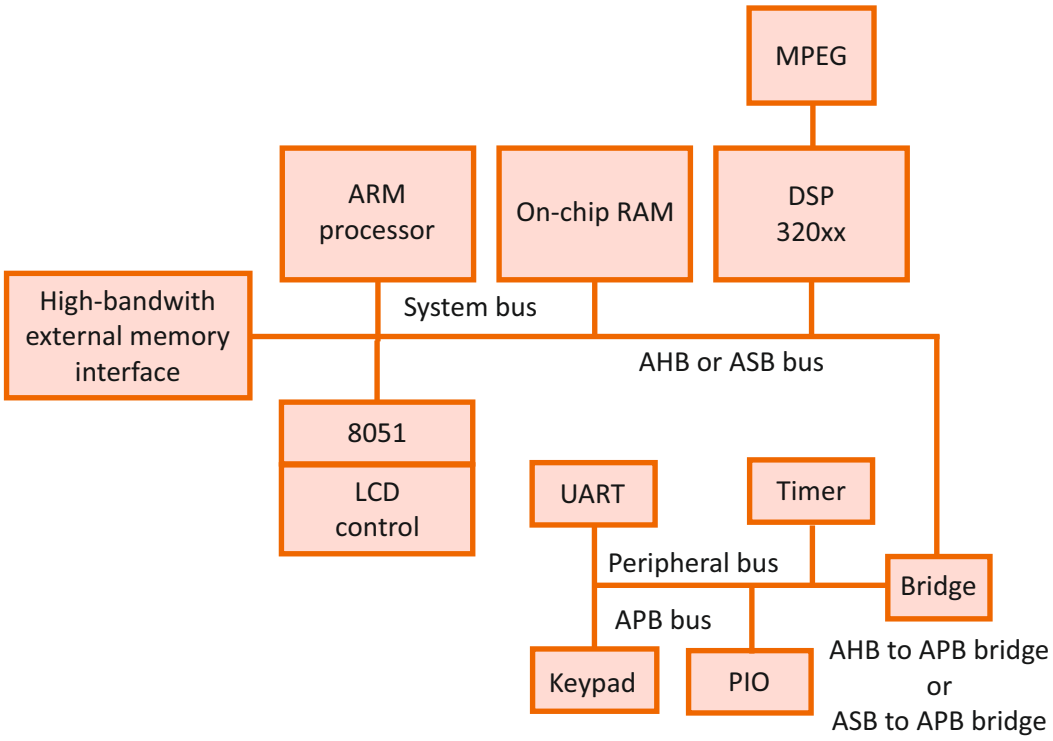

Fig. 3.9 Advanced Microcontroller Bus Architecture

Source: www.engineersgarage.com

The Network-On-Chip (NOC) uses system-level network techniques to reduce wire routing congestion on the chip, better timing closure and standardize ways to make changes in the IPs or in other words for better on-chip traffic management.

External interfaces like WiFi, USB, and Ethernet are used and if required analog interfaces can be added for interfacing actuators and sensors

3.2.6 Design Verification and Documentation

The functional verification of the chips is carried out to validate the correctness before sending for fabrication. Hardware verification languages like SystemC, SystemVerilog, OpenVera, etc. are used to identify anomalies and if bugs are found, then they are reported to the designer. Simulation acceleration or prototyping on reprogrammable hardware is also used to verify and debug both design hardware and software before finalising the design, this process is called tape-out. Tools like Certus are used to debug hardware and soft interactions in FPGAs. Along with the functional verification, verification of performance, power targets, and safety and security aspects of design are also done. The main tool for verification remains to be the simulation of the design model (RTL). The chip validation involves the process of testing the manufactured design for functional correctness in a laboratory.

Documentation is used for the purpose of recording all aspects of the design flow process. Documentation begins from the project design specification stage to the final stage of fabrication. This helps to give clarity regarding the requirements and the process to be followed. It also helps to organise and communicate with all the stakeholders like customers, design team members, managers, etc. Documentation helps in designing and assembling the components as there are many steps involved and remembering every step becomes impossible. It is crucial for verification as well to verify if what is built is as per the design requirement or not. It is very important to record the failures or problems that are faced during the designing process for posterity. This helps avoid the mistakes made earlier. Inadequate documentation can create problems over time as there is no method to track the original steps taken and subsequent changes made. Documents have to be maintained to track the verification results and check if the results are within acceptable limits. If the results are not favourable and the device needs to be rejected, then documentation becomes important to present the case to the management and the reason for failure.

Notes

Summary

- The designing process for SoC requires collaboration between customers, designers, developers, manufacturers, fabricators, etc. The implementation of all the tasks clear instructions, documentation, reviews and verification at every stage of the process.
- This helps to understand the challenges, the different activities involved, resources required, timelines for designing and implementing the project cost involved, etc.
- The analog circuit design focuses on the designing of circuits that operate in and are optimised for continuous time-domain behaviour.
- Analog circuit design typically follows the top-down design and implementation process and a bottom-up verification process.
- The digital circuit design techniques focus on the propagation of discreet values 0 and 1. Logic 1, represents the presence of supply voltage for the IC and logic 0 represents the absence of voltage.
- In the selection of the design type, there should always be a balance between the cost and performance of the product. The advancement in fabrication technology has enabled the transistors to become smaller.
- Some of the common components of SoC architecture are memory blocks, microcontroller, microprocessor, timers, interfaces, power management unit, etc.
- Hardware description language (HDL) is a computer language used to describe the structure and behaviour of digital logic circuits. This helps to automate the analysis and simulation of an electronic circuit.
- HDLs implement register-transfer level (RTL) abstraction, which is a model of data flow and timing of a circuit. The two major HDL are VHDL (Very high-speed integrated-circuit hardware description language) and Verilog.
- **VHDL** is used in electronic design automation for digital and mixed-signal systems like FPGA and ICs. It is also used as a general-purpose parallel programming language. Logic circuits are expressed by writing text models using VHDL.
- **Verilog** uses a textual format to describe electronic circuits and systems. It is used for verification through simulation for test analysis, fault grading, logic synthesis and timing analysis.
- Intellectual Property (IP) core is also known as semiconductor intellectual property (SIP) core or intellectual property (IP) block and it is the reusable unit of a cell, logic or an IC layout design that is the property of one company or party. The two types of IP cores are soft and hard cores.
- IP hardening is a process to generate reuse designs/hard cores from soft cores.
- The design flow process for SoC designing utilizes both software and hardware tools for architectural co-design. Software tools are used for controlling microprocessors, microcontrollers, processor cores, interfaces and peripherals. Computer-aided (CAD) tools like electronic design automation tools (EAD) are used to put hardware blocks together.
- The high-level design consists of the RTL design where some parts may be based on the IP cores and others may be based on the application specific to the device.
- The operative part of the design looks at the analysis of the internal circuit operations.
- Memory design is based on the application requirements like the operating system, size and the variability of the process.

- The bus architecture was mainly used for communication between units in the past. Now, network-on-chip interconnect technology has gained popularity. One of the popular bus communications is the advanced microcontroller bus architecture (AMBA) bus protocol by ARM.
- The Network-On-Chip (NOC) uses system-level network techniques to reduce wire routing congestion on the chip, better timing closure and standardize ways to make changes in the IPs or in other words for better on-chip traffic management.
- The functional verification of the chips is carried out to validate the correctness before sending for fabrication. Hardware verification languages like SystemC, SystemVerilog, OpenVera, etc. are used to identify anomalies and if bugs are found, then they are reported to the designer.
- Documentation is used for the purpose of recording all aspects of the design flow process. Documentation begins from the project design specification stage to the final stage of fabrication.s communications is the advanced microcontroller bus architecture (AMBA) bus protocol by ARM.

Notes

Exercise

Answer the following questions:

1. Discuss the analog and digital circuit designs.

_____

_____

_____

2. Write a brief note on the system architecture of SoC.

_____

_____

_____

3. Write a brief note on Intellectual Property cores.

_____

_____

_____

Fill in the blanks:

1. _____ is a computer language used to describe the structure and behaviour of digital logic circuits.
2. The_____ techniques focus on the propagation of discreet values 0 and 1.
3. _____ is a type of volatile memory.

Scan the QR Code to watch the related video

www.youtube.com/watch?v=-Yczb63-aFU
System-on-Chip (SoC)

www.youtube.com/watch?v=l1J_3fmCqRE
Hardware Description Language

www.youtube.com/watch?v=CJ-wd7o2asM
IP Core Block and its use in Design

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Corporation
Transforming the skill landscape

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Skilling India in Electronics

4. Soft Skills and Work Ethics

Unit 4.1 - Work and Communicate effectively at workplace

Unit 4.2 - Work in a disciplined and ethical manner

Unit 4.3 - Uphold social diversity at the workplace

ELE/N9905

Key Learning Outcomes

At the end of this module, the trainee will be able to:

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

UNIT 4.1-Work and Communicate Effectively at Workplace

Unit Objectives

At the end of this Unit the trainee will be able to:

1. State the importance of effective communication and interpersonal skills
2. Explain the importance of conveying information/instructions as per defined protocols to the authorized persons/team members
3. Discuss ways of dealing with heightened emotions of self and others
4. Explain the importance of working as per the workflow of the organisation to receive instructions and report problems

4.1.1 Significance of Effective Communication & Interpersonal skills

Effective communication is required for all employees in the organization to perform basic management functions and carry out their jobs and responsibilities. The ability to communicate effectively at work is essential regardless of industry. Effective communication entails more than just exchanging information; it also encompasses the emotion and intentions behind the facts and conveying a message. Therefore, communicating more clearly and effectively requires learning some essential skills. Learning these skills can assist employees in developing stronger bonds, gaining more trust and respect, improving teamwork, problem-solving, and overall social and emotional health. As a result, we can state that "effective communication is a foundational component of successful organizations."

Build strong professional relationship with co-workers and clients	Helps to express thoughts and convey clear message	Manage and assist the team where required
Motivate and boost teamwork and lead to better project collaboration	Enhance leadership and negotiation skills	Bridge gaps between clinets, collegues, and partners
Recognize each others' good work and give constructive feedback	Resolves issues and conflicts	Improve productivity by sharing information and ideas

Fig. 4.1 Importance of Effective Communication and Interpersonal Skills

It is extremely difficult for **project managers** to manage their teams and coordinate efforts for successfully completion of a project without strong interpersonal communication skills. A project cannot be successful if there is no communication. Without effective communication skills, dealing with all of the intricate details, dependencies, decisions, and approvals that a project entails would be impossible. The project manager must possess following interpersonal communication skills.

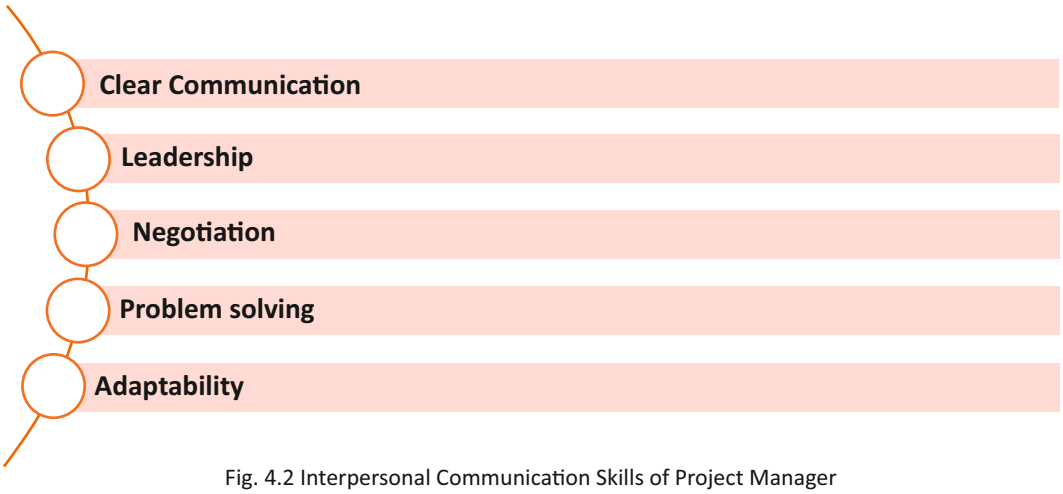

Fig. 4.2 Interpersonal Communication Skills of Project Manager

4.1.2 Communication Process

The process of communication is a dynamic structure that explains how a message is transmitted between a sender and a receiver via various communication channels. Its purpose is to ensure that the receiver accurately decodes the message and can provide feedback with precision and convenience.

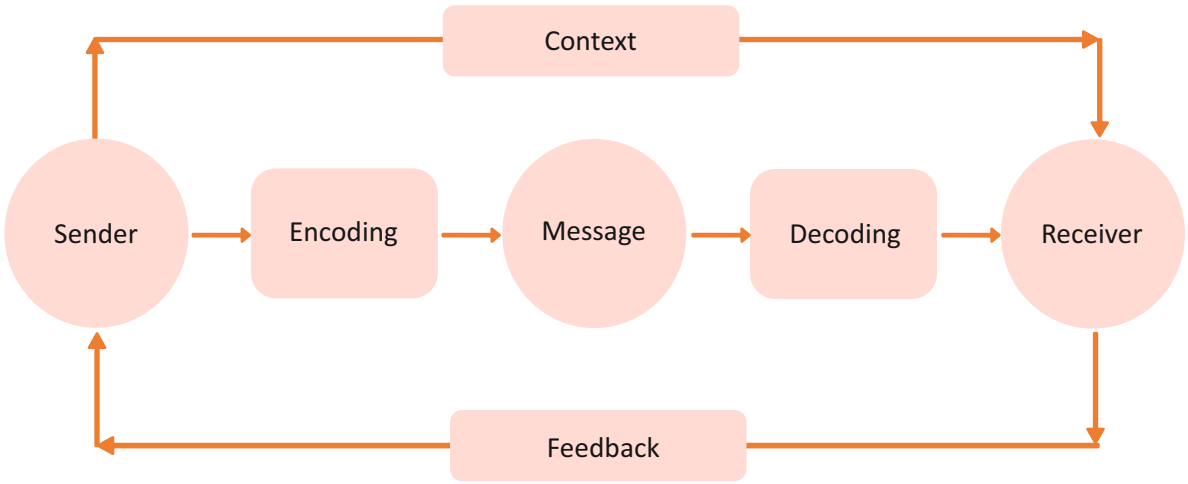

Fig. 4.3 Process of Communication

As demonstrated in the exhibit above, there are 8 elements of communication:

Sender
Who sends the message or is the source of the message.

Encoding
Transferring the message into a format that can be shared. It includes the language or tone chosen.

Message
The idea being communicated by the sender.

Channel
The mode chosen for communicating. Example- phone, oral, text, gestures, or writing.

Decoding
It means how the sender comprehends and understands the message that sender has communicated

Receiver
The idea being communicated by the sender

Feedback
The revert or the response communicated by the receiver to the source/sender after having decoded the message

Context
The environment, situation, or the circumstances in which the communication is happening

Fig. 4.4 Elements of Effective Communication

Notes

4.1.3 Communication Barriers

All of the elements depicted above can also act as a barrier to communication. Communication barriers are factors that prevent a message from being received in the way the sender sent it. People frequently face the problem of the message being received in an assumed manner when communicating. As a result, it leads to miscommunication and misunderstandings. Let us look at the table below to understand four significant barriers to communication.

Communication Barriers	
	**Physical or Environmental Barriers** • The barriers in the surroundings or in the environment are the physical barriers. • Example- Noise in the surroundings, the physical distance between the sender & receiver, defects in the communication system like network problems, poor signal, etc.
	**Language Barriers** • This barrier arises due to the different language or differences in the language of the sender and receiver. • This problem often occurs because of the different meanings perceived in the same word, or the receiver does not understand the jargon used in the message. The language barrier is not limited to spoken language. It also includes body language. • The same message is perceived differently by the receiver said with different body language.
	• **Psychological Barriers** • Barriers or problems arising due to the differences in perception, ego clashes, prejudices, state of mind, poor past experiences, behaviors, attitudes, moods, and value systems are psychological barriers. • These barriers are generally exceedingly difficult to overcome.

Inform immediately about any situation that needs attention

Follow the code of conduct that has been established by the organization

Igreet the supervisor with a smiling face

Don't argue with the supervisor in front of other employees

Concisely put your point of view, concerns, and requests in a polite and respectful manner

A loud voice tone suggesting impatience, sarcasm or taunt, is not acceptable by anyone

I Avoid words and topics which may offend someone

Communicate regularly with your supervisor to develop and maintain a successful professional relationship

Fig. 4.5 Tips for Effective Communication with Superior

Following proper communication, rules are critical to keeping a **healthy relationship with colleagues and co-workers**. The quality of the relationship with colleagues and co-workers will depend on the behavior you demonstrate while interacting with them. A relationship built on trust, excellent, clear communication, polite language, and appropriate behavior helps you succeed at work.

Notes

Communication Barriers	
	**Socio-Cultural Barriers** • Sometimes the differences in social or cultural norms cause communication problems. • These include how the people generally speak, wear, follow customs, behave, or eat is not completely understood by the receivers who are not accustomed to the differences. • For example, some communities are louder and more extravagant than others.

Table. 4.1 Potential Barriers in Communication

4.1.4 Significance of Effective Communication with Team members

It is significant to convey information as per defined protocols to the authorized person's/team members, as it reduces communication gaps, strengthens alignment with all levels of leadership, and ensures that employees receive consistent messages. The Communication Protocol specifies the types of information to be communicated to the organization, as well as the person(s) in charge of communicating specific topics. The audience, frequency, and suggested communication vehicles are also discussed. The Protocol, which is prominently displayed in all common areas such as lobbies and conferences, and is distributed to all new hires, ensures that communications align with the company's key strategic priorities.

Effective communication with the supervisor is essential for professional development and advancement. Refer to the exhibit below for tips on communicating with the supervisor effectively.

Listen to your supervisor carefully and understand the goals and requirements

Report the facts and problems and ask for possible solutions if necessary

In case of an unsuccessful attempts, highlight it to the supervisor rather than covering it up

Stay open to feedback and keep a positive attitude

Fig. 4.6 Tips for Effective Communication with Superior

4.1.5 Organizational Communication

Organizational communication can be divided into two categories: formal and informal communication.

1. **Formal communications** are those that are official and are part of a recognized communication system that is involved in the organization's operation. These communications can be either verbal or written.

   a. It can take place between a superior and a subordinate, or between a subordinate and a superior, administratively or externally.

   b. It can happen outside of the organization, i.e. with suppliers, clients, unions, government agencies, and community groups.

   c. It can sometimes be obligatory, indicative, or informative. Mandatory communication implies an order or command to be followed and is known by various euphemisms such as instructions, briefing, and so on.

   d. This type of communication is mostly vertical and usually one-way from top to bottom. Indicative or explanatory communication can occur at any level and may be vertical or horizontal.

2. **Informal communications** emerge from the social interactions of coworkers. These are bound by conventions, customs, and culture rather than any chart on the wall. In the form of grapevine, such communication provides useful information for upcoming events.




Verbal

- Use strong, confident speaking voice.
- Use active Listening
- Avoid filter words
- Avoid industry jargon when appropriate

Non-verbal

- Notice how your emotions feel physically
- Be intentional about your nonverbal communications
- Mimic nonverbal communications you find effective

Visual

- Ask others before including visuals
- Consider your audience
- Only use visuals if they add value
- Make them clear and easy to understand

Written

- Strive for simpilcity
- Is to the point and avoid unnecessary repetition
- Avoid offensive language

Fig. 4.7 Types of Communication and Ways to Use Them

4.1.6 Managing Emotions at Work

Humans are emotional beings. It is difficult for us not to be emotional. While it is generally beneficial to be in touch with our emotions and not suppress them, there are some situations in which we must manage our emotions especially well. This is especially true at work. Emotional outbursts at work could be caused by work-related issues or by stressors from our personal lives spilling over into our work lives. Handling our emotions (especially negative ones) at work is frequently regarded as a test of our professionalism. Although, it is never good to repress or suppress emotions, whether positive or negative. However, in order to function in a variety of situations, we must manage our emotions. The following are some coping strategies to deal with heightened emotions at work.

Line-and-staff organizational structure

- In this structure, authorities (e.g., managers) establish goals and directives that are them carried out but employees and other workers.

Flat organizational structure

- A flat organizational structure means that there are few (if any) levels of management between the workforce and the highest-level managers.

Matrix organizational structure

- A matrix organization is a work structure in which team members report to multiple leaders.

Network organization structure

- It is a type of internal structure that prioritizers communication and relationship goals over hierarchy.

Fig. 4.9 Types of Organizational Structure

4.1.8 Importance of Working as per the Organization's Workflow

Workflow, in a broad sense, is the set of tasks—grouped chronologically into processes—and the set of people or resources required to complete those tasks to achieve a specific goal. The workflow of an organization consists of the processes that must be completed, the people or other resources that are available to perform those processes, and the interactions between them.

Maintains digital copies of files automates task routing notifies those who need to act, and records everything relevant to the process	**Eliminate redundancy**

Continued...

Fig. 4.10 Importance of Working as per the Organization's Workflow

4.1.9 Organizational Communication Policies and Procedures

Communication is a vital management component of any organization. Effective communication is a critical issue for effective management, whether the purpose is to update employees on new policies, prepare for a natural disaster, ensure safety throughout the organization, or listen to employees' attitudes. To attain success, organizations should have comprehensive policies for communicating with their, employees, stakeholders, and the community at large. With a formal, defined and comprehensive communication strategy, organizations can make sure that they:

1. Communicate consistent messages
2. Establish a distinguishable brand
3. Deliver messages that are congruent with the organization's mission, vision, and culture

Communication policies of an organization establish expectations and manage the flow of communications within and outside the organization. As a result, it facilitates meaningful and necessary communication for employee productivity and morale without restricting employees' feeling intimidated and powerless. In addition, good communication policy, reduces conflicts and misunderstandings.

An organization has many channels for communication, running internally and externally. It is imperative to regulate these channels for the sake of business interests. Therefore, communication policy and procedures need to be written out in clear, straightforward language for all the employees. When outlining these communication policies and procedures, it is essential to consider existing policies and regulations that must comply with the organization. It is important for a workplace where employees need to understand proper lines of communication and behavior with one another. Communication policy and procedures guide the employees for handling information, either outgoing or incoming, that pertains to the organization. It focuses on spreading important news and information to other co-workers, customers and stakeholders. Creating clear rules avoids liability issues and embarrassing or damaging situations in the organization.

1. **Procedures for verbal communication -** It is essential to communicate well verbally to understand what others are saying to you. Following are the key points when communicating verbally in an organization:

   a. Employees should speak clearly and listen carefully when communicating with each other. If it is not clear, ask the person to repeat it or explain what they mean.

   b. Speak clearly and slowly to deliver the correct message. Avoid speaking quickly or in a mumbling tone. Repeat the message to make sure it is right.

   c. Pass on the urgent messages as soon as possible. If the person is busy, then then wait for your chance to speak. On the other hand, if the message is very urgent, inform them politely.

2. **Procedures for written communication -** Most workplaces have standard writing methods. They have special forms or layouts to use. These are sometimes called 'templates'. Using these is part of the organizational procedure. Each employee must use these standard layouts for written communication. For example, writing e-mails, letters, memos, faxes and messages and other office tasks. Below are the key points when using written communication in an organization:

   a. Keep it simple. Make your sentences, paragraphs, and the overall document as short and concise as possible.

   b. Strive for clarity

   c. Keep it in a structured form

   d. Use appropriate tone

   e. Give the right amount of detail

   f. Give copies to everyone concerned

Fig. 4.8 Strategies for Coping with Heightened Emotions at Work

4.1.7 Organizational Structure

An organizational structure is a system that defines how specific activities are directed in order to achieve an organization's goals. These activities may include rules, roles, and responsibilities. The organizational structure also governs how information flows within the company. There are numerous types of organizational reporting structures, each with its own set of benefits and drawbacks. The reporting structure is chosen based on the organizational requirements. The following are the top organizational reporting structures.

Hierarchical organizational structure

- It is a pyramid-like top-down management structure.

Hierarchical organizational structure

- It is a pyramid-like top-down management structure.

Functional organizational structure

- It is a business structure that divides a company into departments based on areas of expertise

Divisional or product organizational structure

- In a product-based structure (also known as a divisional structure), employees are assigned to self-contained divisiions based on the - market, product line and geography.

Fig. 4.9 Types of Organizational Structure

Keeps things open and transparent and ensures everyone's on the same page.	**Boosts motivation levels and encourages people to achieve more.**	**Balance out each other's strengths and weaknesses**	**Drives you to work together**
It tends to bigger accomplishment and rewards	**Boost work performance**	**Avoid delay and finish work on time**	**Helps to keep commitment to the organisation and team members**
	Strengthen relationships	**More flexible and provides alternative routes**	

Fig. 4.12 Benefits of Team Goals in an Organisation

4.12 Individual and Team goals

Team performance evaluation is a key factor in inspiring teams, improving the quality of work, and keeping them motivated. It is the best channel to understand how the team is performing and an effective measure to get feedback about how production is going, whether the employees are working positively towards achieving goals, and what can be done to improve employees' engagement. It also provides a foundation to determine increments and succession plans for the team and the development of an organization.

A comprehensive team performance evaluation process often consists of different evaluation methods to help judge a team's performance. Using multiple techniques can help in getting a broader perspective of the areas where a team needs to improve and the steps you can take to support the team's growth.

The following chart explains the need for employee performance measurement methods:

Define goals clearly	**Provide real-time feedback**	**Enhance employee performance**	**Spot training and development needs**
Offer insights on counter productive tasks	**Improve employee engagement and retention**	**Align individual performance with business goals**	**Transform the workforce into a strategic advantage**

Fig. 4.13 Importance of Performance Measurement

Notes

4.1.10 Sharing Information with Team Members

In the workplace, information drives communication, and communication, in turn, allows all members of the organization, from entry-level employees to the CEO, to work together to achieve the company's goals and maximize productivity. Transparently sharing data and information ensures that everyone is in the loop and aware of any potential issues with the business, product, or service that can be addressed collaboratively. Employees might have lots of knowledge that is crucial for the organization and other employees. **Sharing information helps them connect, perform better, and become more vital as professionals.** The following chart explains the importance of sharing information with team members in an organization:

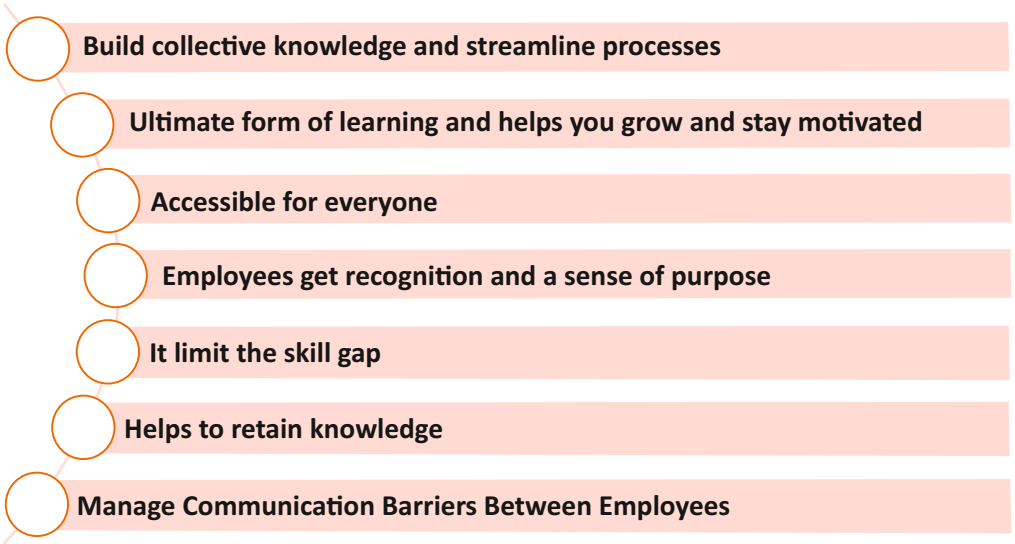

Fig. 4.9 Importance of Sharing Information with Team Members

4.1.11 Individual and Team goals

Goal setting is undoubtedly one of the most effective motivational tools in the organization. Almost every organization requires employees to set goals regularly. Even when times change, continuously updating and setting goals is necessary to keep your business on track. Goals in each organization should be **S.M.A.R.T: specific, measurable, actionable, realistic, and timely.** It helps you and your team feel a stronger sense of purpose and direction. In addition, setting goals in place will help you and your team feel productive with each bit of accomplishment and ensure that more significant production stays on track.

Individual goals are significant because they give direction to the employees. While team goals are great for the overall guidance, personal goals will allow your team members to take distinct paths to digest the larger plan and turn it into action.

Team goals are necessary to guide the entire organization. It includes broad objectives that can be broken down into team projects and initiatives with individual key results. In addition to helping the organizations achieve their objectives, setting team goals also **boost employee engagement, productivity and retention by ensuring that every team member has a complete understanding of their role in the overall approach.** This also **saves time and improve efficiency.** In addition, setting team goals also offers organizations the following benefits:

4.12 Individual and Team goals

Team performance evaluation is a key factor in inspiring teams, improving the quality of work, and keeping them motivated. It is the best channel to understand how the team is performing and an effective measure to get feedback about how production is going, whether the employees are working positively towards achieving goals, and what can be done to improve employees' engagement. It also provides a foundation to determine increments and succession plans for the team and the development of an organization.

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Fig 4.13 Importance of Performance Measurement

Performance evaluation methods include the following:

1. **Peer review:** This is one of the strategies that many organizations and employee evaluation software use to enhance the traditional evaluation process. The peer-review process consists of anonymous feedback from shift managers, colleagues, teammates, and peers on specific aspects of team members' performance.

    a. It provides a unique prospect to study the team member's skills and capabilities and help identify individuals' networking, leadership, occupational, and collaboration skills within an organization.

    b. This process provides a unique chance to determine each team member's strengths and weaknesses and use this valuable data to decide succession planning, building teams, and shift rotations.

2. **Self-evaluation:** Self-evaluation is a vital activity to help make the evaluation process more efficient. When done correctly, it can provide several critical inputs to the organization. In addition, this method offers a chance for the team to play an active role in their evaluation process. Thus, the employees are given a voice rather than simply receiving the management's feedback.

    This directly links their jobs and the evaluation process and thus, fosters better communication between the staff and the management. With active participation, employees tend to experience better engagement with the overall review process, while managers can better understand the individual's performance and their perception of their performance.

3. **Quantitative evaluation:** It is based on statistics and utilizes various standards to track the productivity. The process begins with the formulation of organizational standards against which employee data can be measured. Different industries have different ways to articulate their quantitative output. For example, the number of units produced in traditional manufacturing is generally a reliable quantitative metric. Similar metrics are still used in modern organizations.
4. **360-degree feedback:** This is another tool to evaluate employee's performance. To assess an employee's score, his managers, peers, subordinates, and customers are asked to provide feedback for specific areas. This feedback often gives an accurate and multi-perspective view of the employee's performance, skill level, and improvement points.

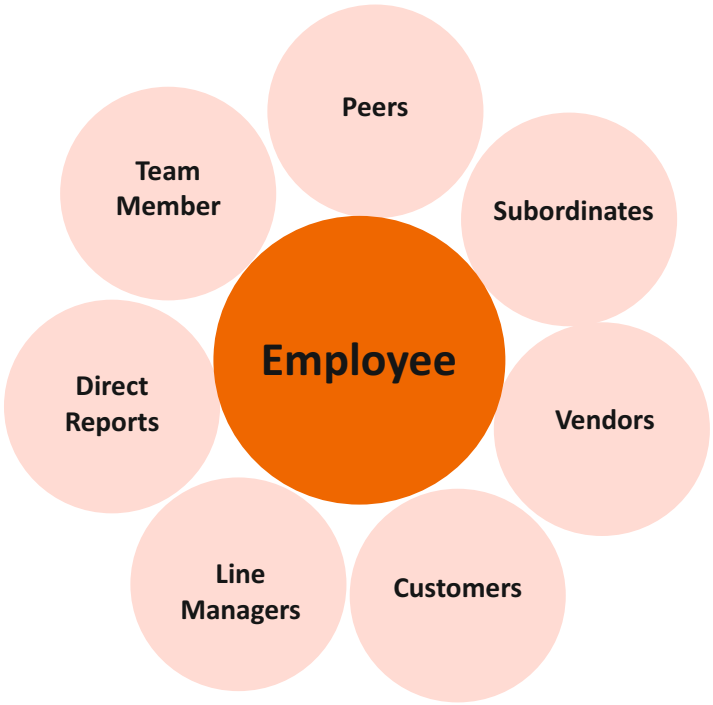

Fig. 4.14 360-degree Feedback Method

5. **Competency on a scale:** This is among the most frequently used employee performance evaluation techniques. In this method, the employee's performance in various job duties is rated on a defined scale. A wide range of criteria, including productivity, quality of work, concern for safety, customer service, teamwork etc., are evaluated. This method can be achieved with letters or numbers, and it usually consists of a range, unsatisfactory to outstanding. This method also allows employers to evaluate several employees simultaneously.
6. **Subjective appraisal by the manager:** In most organizations, performance is assessed several times a year during (bi-)annual performance reviews. Employees are evaluated on various criteria, the job-quality being the most common.
7. **Human Capital ROI:** It is a metric that assesses the human capital value (i.e., knowledge, habits, and social and personal attributes). Human Capital ROI can be determined by calculating the company's revenue (minus benefit-cost and operating expenses and compensation) and dividing this by the total compensation and benefit-cost that the company pays for its employees.

8. **Absenteeism Rate:** Absenteeism and performance are highly correlated constructs. Highly motivated and engaged employees generally take fewer sick days. Additionally, absent employees are less productive, and high absenteeism rates throughout an organization are a key indicator of lower performance.
9. **Overtime per Employee:**

   Overtime per FTE = Total hours of overtime / FTE

   The average overtime per FTE (full-time equivalent) is a final employee performance metric. Employees, eager to put in the extra effort are generally highly motivated and tends to produce more (in terms of work quantity).

Notes

Exercise

1 Fill in the blanks:

a) _____is a building block of successful organizations.

b) A healthy relationship with colleagues is built on _____, _____ and_____.

c) _____ is a part of your organization's duties to its community and stakeholders.

d) Sharing information helps employees to limit the _____ gap.

e) _____ is a mechanism or strategy that enables different entities to work together.

f) _____ facilitates meaningful and necessary communication for employee _____and manage the communication flow within and outside the organization.

g) Fill in the Blanks-

h) _____ is a set of rules indicating the proper and polite way to behave at work.

I) _____include how the people generally speak, wear, follow customs, behave by the receivers who are not accustomed to the differences.

j) _____ is the response communicated by the receiver to the source/sender after having decoded the message.

k) The quality of the relationship with colleagues and co-workers will depend on the _____ demonstrate while interacting with them.

2. Goals in each organization should be:

a) Specific, monthly, adjustable, realistic, and timely

b) Smart, measurable, actionable, realistic, and timely

c) Specific, measurable, actionable, realistic, and timely

3. The following are the types of communication at workplace, except:

a) Employer – employee

b) Colleagues

c) Stakeholders

d) Customer – friend

4. Which one is not the correct way of verbal and written communication?

a) Short

b) Irrelevant

c) Simple

d) Direct

5. Differentiate between team goals and individual goals.

6. What is effective communication?

7. How language barriers create gaps in workplace?

8. List any two tips for communicating effectively with superiors.

UNIT 4.2 - Work in a Disciplined and Ethical Manner

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Explain the importance of work ethics and workplace etiquette
2. Explain ways to maintain discipline at the workplace
3. Discuss the importance of following organisational guidelines for dress code, time schedules, language usage and other behavioural aspects
4. Discuss the common reasons for interpersonal conflict and ways of managing them effectively
5. Explain the common workplace guidelines and legal requirements on non-disclosure and confidentiality of business-sensitive information

4.2.1 Importance of Work Ethics and Workplace Etiquette

A professional code of ethics establishes an organization's ethical guidelines and best practices for maintaining honesty, integrity, and professionalism. Violations of the code of ethics can result in sanctions, including termination, for members of an organization. The following figure explains the standard practices and professional code of ethics follow in every organization.

Fig.4.15 Professional Code of Ethics

Work ethics are the morals or principles that govern a person's or group's behavior, whereas etiquette is a set of rules indicating the proper and polite way to behave at work. Both contributes positive energy and influence to the growth of an organization. Workplace etiquettes inspire healthy and interactive communication among employees and promote honesty, integrity, and respect for each other in the organization.

4.2.3 Maintaining Discipline at Workplace

Dealing with conflict at the workplace is inevitable. The ability to recognize conflict with your colleagues, understand its nature, and try to bring a quick and fair resolution to the conflict is critical to anyone who works in a team. **Conflict management** is a crucial skill that enables an individual to handle confrontations tactfully and constructively. It aims to yield a positive result from disputes and disagreements that occur between people in the workplace and resolve the conflict in a way that respects everyone's wants and needs. At some point, we need skills for managing conflict in the workplace. The following tips can help us resolve the conflict or a disagreement in that situation.

Fig. 4.18 Tips for Maintaining Discipline at Workplace

4.2.4 Confidentiality in the Workplace

Confidentiality, or not disclosing specific information, is essential in a variety of jobs. Confidentiality is important for legal and reputational reasons, but it is also important because future employment may be contingent on it. Some information, such as personally identifiable information and 'business secrets,' is legally protected in several countries. As a result, it is crucial to understand the nature of confidentiality and how to ensure that employees follow legal or ethical guidelines. Confidentiality refers to the state of keeping information secret or not disclosing it. Following are the type of information that comes under the non-disclosure and confidentiality of business-sensitive information.

Employee Information
- Includes the private information of employees such as name, address, maiden name and so on.

Managerial Information
- includes both information about individuals, such as disciplinary action, and also about broad management act ions such as planned redundancies or employee relations issues.

Organisational Information
- Also known as business information or 'trade secrets'

Customer or Contact Information
- Partially covered by 'trade secrets'

Professional Information
- information about individuals or organisations trhough their professional position

Fig. 4.19 Types of Confidential Information

Notes

Exercise

Answer the following questions:

1. Write a short note on work ethics and workplace etiquette.

2. List any 3 ways of maintaining discipline at the workplace.

3. What is conflict management?

4. Explain confidentiality in the workplace.

5. How language barriers create gaps in workplace?

UNIT 4.3 - Uphold social diversity at the workplace

Unit Objectives

At the end of this Unit the trainee will be able to:

1. Describe the process of reporting grievances and unethical conduct such as data breaches, sexual harassment at the workplace, etc
2. Explain the concept and importance of gender sensitivity and equality
3. Discuss ways to create sensitivity for different genders and Persons with Disabilities (PwD)

4.3.1 Grievance Management

Grievances results in collective disputes when they are not resolved timely. Also, this lowers the morale and efficiency of the employees. Frustration, employee dissatisfaction, low productivity, lack of interest in work, high absenteeism, etc. might be a result of unattended grievances. In short, grievance arises when the organization does not fulfill employees' expectations, resulting in a feeling of discontentment and dissatisfaction. This dissatisfaction must have cropped up from employment issues and not from the personal issues.

A grievance may result from the following factors-

a) **Working Conditions and Safety:** These consists of any complaint or grievance that directly addresses the employees' work environment. These can include everything from unsafe working conditions to difficult and indifferent managers.

b) **Unreasonable Management Policies:** If employees believe that a particular policy is unfair or unreasonable, they will want their concerns addressed. Such policies can include a gap in production standards or overtime regulation compliance.

c) **Violations of Rules and Policies:** These are related to any organizational rules which the employees feel are being violated by other workers and/or middle or senior management.

The project manager should immediately identify all grievances and take appropriate actions to eliminate the causes of such grievances to achieve employee's loyalty and commitment to their work. Thus, effective grievance management is an essential part of personnel management.

For Addressing Grievance, project manager should adopt the following approach to manage grievance effectively:

1. **Complaint:** As soon as the grievance arises, it should be identified and resolved. This lowers the detrimental effects of grievance on the employees and their performance.
2. **Acknowledging grievance:** Acknowledge the grievance put forward by the employee as a manifestation of true and genuine feelings of the employees. Acknowledgment implies that you are eager to look into the complaint impartially and without bias. This creates a conducive work environment with instances of grievance reduced.
3. **Gathering facts:** Gather relevant and adequate facts that explains the nature of the grievance. These facts must be recorded to be used at a later stage of grievance redressal.

4. **Examining the causes of grievance:** The actual cause of resentment should be identified. Consequently, remedial actions should be taken to prevent the repetition of the grievance.
5. **Decisioning:** After identifying the causes of grievance, an alternative course of action should be suggested to manage the grievance. The effect of each action on the existing and future management policies and procedures should be analyzed, and accordingly, the manager should take a decision.
6. **Execution and review:** The manager should implement the decision quickly, ignoring the fact that it may or may not hurt the concerned employees. After implementing the decision, a follow-up must ensure that the grievance has been resolved completely and adequately.

An effective grievance procedure ensures a pleasant work environment because it redresses the grievance to the mutual satisfaction of the employees and the supervisors.

Fig 4.19 Grievance Addressing Process

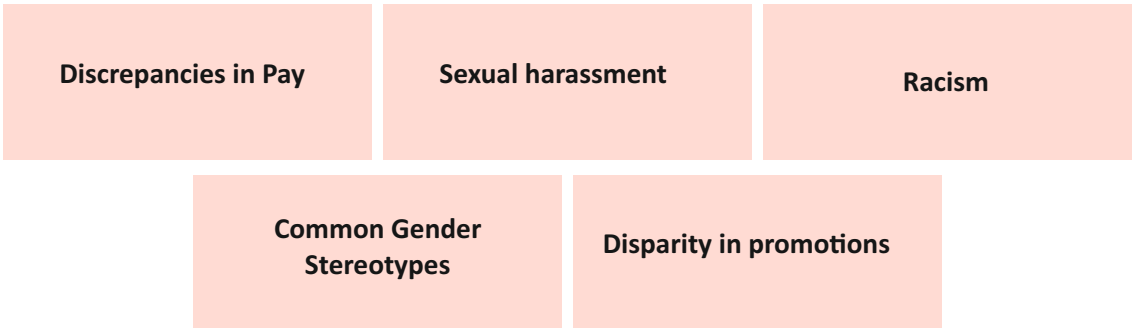

Fig. 4.21 Gender based Issues at Workplace

Females with disabilities are subjected to multiple layers of discrimination. Based on their gender and disability status, they often face double discrimination. They often face disproportionately high rates of gender-based violence, sexual abuse, neglect, maltreatment and exploitation. The exclusion experienced by women and girls with disabilities is a social issue that requires active participation of everyone.

It is important to follow organizational standards related to PwD at workplace because, it:

Protects them from any physical harm or any accidents

1. Provides them equal rights
2. Protects them from any kind of discrimination and racism
3. Provides security from any kind of violence and harassments
4. Protects their respect and dignity
5. Provides equal opportunities to deserving candidates

4.2.2 Gender Sensitivity

Gender sensitization is vital because representation is important. Representation of a person and community advocates equality and adds a sense of inclusion to the previously marginalized community. For a healthy performance-oriented culture, organizations need the correct mix of talent which is not bound by any gender. More than ever, accountability has become important now, organizations only have today to make the changes that count, as tomorrow they won't be able to hide under the pretext of ignorance. Each member of an organization seek out to learn and grow at their workplace, and an insensitive place of work not only hinders that but also tends to become an unfriendly workplace. Gender sensitization is extremely significant as it helps the employees feel appreciated and cared for within the organization. Lastly, for the betterment of society, organizations have got an ethical responsibility in shaping the current structures by breaking the old norms. Organizations that do not emphasize on gender sensitization usually develop cultures where inequality and discrimination becomes normal. This kind of culture leads to a higher attrition rate, a higher rate of employee absenteeism, etc. Such policies also propogates the presence of a superior gender.

4.3.2 Sensitivity for Person-With-Disability (PwD)

Disabled workers are a part of the diversity in today's workforce. However, being disabled does not imply that the individual is incompetent or unable to do his/her job. In fact, being disabled simply means the person has an impairment, which can be anything ranging from physical to psychological. Disabled co-workers and employees are not any different in that they are there to earn a living, advance their career, and better the organization through their contributions.
Listed below are some tips for interacting and communicating with people with disabilities.

Fig. 6.20 Communicating and Interacting with PWD

The RPWD Act, 2016 provides that "the appropriate Government shall ensure that the PwD enjoy the right to equality, life with dignity, and respect for his or her own integrity equally with others." The Government is to take steps to utilize the capacity of the PwD by providing appropriate environment.

The concept of gender sensitivity shows the path to reduce barriers to personal and economic development created by gender differentiation. In addition, it helps to generate respect for individuals regardless of their gender.

Gender sensitivity is not about fighting women against men. On the contrary, gender-sensitive education, benefits members of all genders. It helps the individuals determine what assumptions are valid and which are stereotyped generalizations in matters of gender. Gender awareness not only requires intellectual efforts but also sensitivity and open-mindedness. It opens up the broadest possible range of life options for both women and men.

Some of the best practices followed to stay gender-sensitive would be to

1. Use respectful language while communicating with each other. Do not reinforce gender stereotypes.
2. Provide fair opportunity to everyone irrespective of their gender
3. Do not promote creating gender-specific social groups.
4. Neither victimize nor patronize based on gender

Notes

4.2.3 Rights and Duties at Workplace Concerning PwD

The following chart explains the rights and duties at the workplace with respect to PwD:

Rights	Duties
1. To an accessible workplace free of hazards and risks	1. To provide complete and honest information as it relates to the job
2. To complete information about the job	2. To request reasonable accomodation or assistance if needed
3. To information, education, training and safely equipment that reduces risks and hazards	3. To practice safely procedures and use equipment to reduce risks to self and others
4. To equal access to benifits, conditions of employement and promotional opportunities	4. To report illness or injury promptly
5. To special safety procedures and considerations that may relate to one's disability in case of emergency	5. To cooporate and work with rehabitation professionals and employes in good faith regarding return to work.
6. To be treated with dignity and respect	6. To use the access and services provided to be fully productive
7. To special tools and services that be needed to accomodate a disability on the job or in the community	7. To advocate, educate and collaborate with legel, service and other systems to meet needs and resolve conflicts

Fig. 4.22 Rights and Duties at Workplace with Respect to PwD

Notes

Summary

- Effective communication is required for all employees in the organization to perform basic management functions and carry out their jobs and responsibilities.
- It is extremely difficult for project managers to manage their teams and coordinate efforts for successfully completion of a project without strong interpersonal communication skills. A project cannot be successful if there is no communication.
- The process of communication is a dynamic structure that explains how a message is transmitted between a sender and a receiver via various communication channels. Its purpose is to ensure that the receiver accurately decodes the message and can provide feedback with precision and convenience.
- Communication barriers are factors that prevent a message from being received in the way the sender sent it. People frequently face the problem of the message being received in an assumed manner when communicating.
- Effective communication with your supervisor is crucial to your professional development and career advancement. Refer to the exhibit below for tips on communicating with the supervisor effectively.
- Following proper communication, rules are critical to keeping a healthy relationship with colleagues and co-workers. The quality of the relationship with colleagues and co-workers will depend on the behavior you demonstrate while interacting with them.
- Transparently sharing data and information ensures that everyone is in the loop and aware of any potential issues with the business, product, or service that can be addressed collaboratively. Employees might have lots of knowledge that is crucial for the organization and other employees. Sharing information helps them connect, perform better, and become more vital as professionals.
- Organizational communication can be divided into two categories: formal and informal communication.
- Emotional outbursts at work could be caused by work-related issues or by stressors from our personal lives spilling over into our work lives. Handling our emotions (especially negative ones) at work is frequently regarded as a test of our professionalism.
- An organizational structure is a system that defines how specific activities are directed in order to achieve an organization's goals.
- The workflow of an organization consists of the processes that must be completed, the people or other resources that are available to perform those processes, and the interactions between them.
- Communication policies of an organization establish expectations and manage the flow of communications within and outside the organization. As a result, it facilitates meaningful and necessary communication for employee productivity and morale without restricting employees' feeling intimidated and powerless.
- Goals in each organization should be S.M.A.R.T: specific, measurable, actionable, realistic, and timely. It helps you and your team feel a stronger sense of purpose and direction. In addition, setting goals in place will help you and your team feel productive with each bit of accomplishment and ensure that more significant production stays on track.

- Team performance evaluation is a key factor in inspiring teams, improving the quality of work, and keeping them motivated. It is the best channel to understand how the team is performing and an effective measure to get feedback about how production is going, whether the employees are working positively towards achieving goals, and what can be done to improve employees' engagement.
- A professional code of ethics establishes an organization's ethical guidelines and best practices for maintaining honesty, integrity, and professionalism. Violations of the code of ethics can result in sanctions, including termination, for members of an organization.
- Work ethics are the morals or principles that govern a person's or group's behavior, whereas etiquette is a set of rules indicating the proper and polite way to behave at work.
- Dealing with conflict at the workplace is inevitable. The ability to recognize conflict with your colleagues, understand its nature, and try to bring a quick and fair resolution to the conflict is critical to anyone who works in a team.
- Discipline is most effective when there is mutual trust between managers and employees. It all begins with clear communication and continues with consistency. Discipline assists employees in correcting any shortcomings to become valuable, contributing members of the workforce.
- Confidentiality is important for legal and reputational reasons, but it is also important because future employment may be contingent on it.
- Disabled co-workers and employees are not any different in that they are there to earn a living, advance their career, and better the organization through their contributions.
- The RPWD Act, 2016 provides that “the appropriate Government shall ensure that the PwD enjoy the right to equality, life with dignity, and respect for his or her own integrity equally with others.” The Government is to take steps to utilize the capacity of the PwD by providing appropriate environment.
- Gender inequality in an organization's is a complex phenomenon that can be seen in organizational structures, processes, and practices.
- Females with disabilities are subjected to multiple layers of discrimination. Based on their gender and disability status, they often face double discrimination.
- For a healthy performance-oriented culture, organizations need the correct mix of talent which is not bound by any gender.
- Use respectful language while communicating with each other. Do not reinforce gender stereotypes.
- Gender sensitivity is not about fighting women against men. On the contrary, gender-sensitive education, benefits members of all genders. It helps the individuals determine what assumptions are valid and which are stereotyped generalizations in matters of gender.

Exercise

1. **Write a short note on:**

   a) Grievance Management.

   _____

   _____

   _____

   b) Rights and duties of PwD at the workplace

   _____

   _____

   _____

   c) Gender based issues at workplace

   _____

   _____

   _____

   d) Best practices for gender sensitivity.

   _____

   _____

   _____

   e) List down the steps for addressing grievance.

   _____

   _____

   _____

2. **Match the following**

Column A	Column B
Gender inequality	Gender-specific social groups
Listen attentively	Equal access to benefits
Rights at Workplace concerning PwD	With hearing disability person to get his attention
Tap a person on shoulder	Disparity in promotions
Do not promote	While talking with people having difficulty speaking

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Transforming the skill landscape

ESSCI
Skilling India in Electronics

5. Basic Health and Safety Practice

Unit 5.1 - Dealing with Workplace Hazards & Risks

Unit 5.2 - Fire Safety Practices

Unit 5.3 - Emergency, Rescue and First-aid Practices

Unit 5.4 - Effective Waste Management Practices

ELE/N1002

Key Learning Outcomes

At the end of this module, the trainee will be able to:

1. Apply health and safety practices at the workplace.

UNIT 5.1 - Dealing with Workplace Hazards & Risks

Unit Objectives

At the end of this Unit the trainee 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 the importance of maintaining appropriate postures while lifting heavy objects
4. Explain various warning and safety signs
5. Describe how to interpret warning signs while accessing sensitive work areas
6. Elaborate on electronic waste disposal procedures
7. List the name and location of concerned people, documents and equipment for maintaining health and safety in the workplace
8. Explain the importance of good housekeeping

5.1.1 Workplace Safety

Workplace safety is one of the key aspects of any manufacturing business or facility. Getting it right can boost overall operation performance and lead to growth. On the other hand, putting safety at risk can lead to lost time, money, occupational injuries, and even reputational damage. Although every employer is required by law to adhere to workplace safety standards established by governments in order to ensure the safety of its employees and workers, it must be understood that safety is everyone's responsibility. Nobody wants to be hurt at work. As a result, employees/workers must be aware of and strictly follow the safety procedures in place.

Project managers are in a unique position because, as project leaders and coordinators, they indirectly influence health and safety. As safety is an integral part of the workplace, project managers should not turn a blind eye and, if necessary, issue instructions. Project managers discuss health and safety during the following stages:

1. Planning because of its impact on accessibility and work methods
2. Initial workplace inspections due to the project's immediate environmental impact
3. Onsite meetings if the contractor or subcontractors are not addressing it
4. Site inspections and discussions as most important aspect of the worksite is health and safety

It is everyone's responsibility, whether the project manager or team member, to keep the workplace clean, healthy, and safe. Everyone in the workplace must be extremely cautious and adhere to the established safety guidelines. The following are the standard practices to ensure health and safety in an organization.

Take reasonable care of your safety and health

Avoid wearing hanging jewellery or loose clothing if operating machinery

If you have long hair, wear a headscarfor long muffler make sure it is tucked out of the way as it could get caught in appliances or electronic devices

Ensure not to put co-workers and other people at risk by your actions or inactions during your work

Co-operate with your employer, making sure you get proper training, and you understand and abide by the organisation's health and safety policies

Do not meddle or misuse anything that is provided in office premises to help safeguard health, safety, or welfare

Report any injuries, accidents, or illnesses you suffer from during your job

Follow electric safety measures

Fig. 5.1 Health and Safety Guidelines

5.1.2 Potential Risks & Hazards

A hazard is something or someone that has the potential to cause damage, harm, or adverse health effects. It can cause human injury or illness, property damage, environmental damage, or a combination of these. The following figure depicts the various workplace safety risks and hazards:

Safety Hazards

Slips,trips,falls, faulty equipments etc..

Physical Hazards

Radiations, Noise, Extreme Temperature etc..

Chemical and Dust Hazards

Cleaning Products,Color Dyes,Pesticides etc..

Continued...

Fig. 5.2 Hazards and Risks at Workplace

The safety hazards and risks in the electronics industry vary depending on the various sub-sectors:

1. Various chemical hazards in the semiconductor and fabrication industries include exotic and dangerous chemicals such as arsine, phosphine, and silane
2. Noise, ionizing and non-ionizing radiation used for testing, quality control, and curing operations are all physical hazards in electronic work
3. Repetitive assembly line work or manual handling results in cumulative trauma disorders, backache, and musculoskeletal strains
4. Low humidity in clean room work, causing dermatological symptoms
5. Prolonged visual inspection work, especially when using a microscope, frequently causes eyestrain
6. Biological hazards are uncommon in electronics work, but communicable diseases can easily spread to other workers
7. Negative psychosocial factors such as the fast and constant pace of work, the monotonous nature of work, and rotating shifts

It is significant to ensure a high level of safety that no machine tool should be used unless the risk management process outlined below is understood and applied by the user:

1. Determine the potential hazard(s) that the machine tool may produce.
2. Using the Risk Assessment Matrix, determine the likelihood and severity of the hazard(s). The following individuals have risk acceptance decision authority for the risk levels:
   a. very high
   b. very high
   c. moderate and low
3. Determine the risk-control measures that will eliminate or reduce the hazard(s). Then, implement risk control measures before and during machine tool operation to eliminate threats or mitigate their risks.
4. Monitor and evaluate the process. Enforce the established standards and risk management procedures. Evaluate the effectiveness of the control measures and make any necessary adjustments/updates.

5.1.3 Organizational Safety Procedures

An organizational safety procedure is a step-by-step instruction manual for carrying out a work procedure. It is used when a deviation from the procedure could result in injury or an accident.

When working with machinery, tools and equipment, employees are exposed to a variety of hazards and risks that can result in a variety of injuries. The following are the most common hazards in handling tools, hazardous materials and machining work:

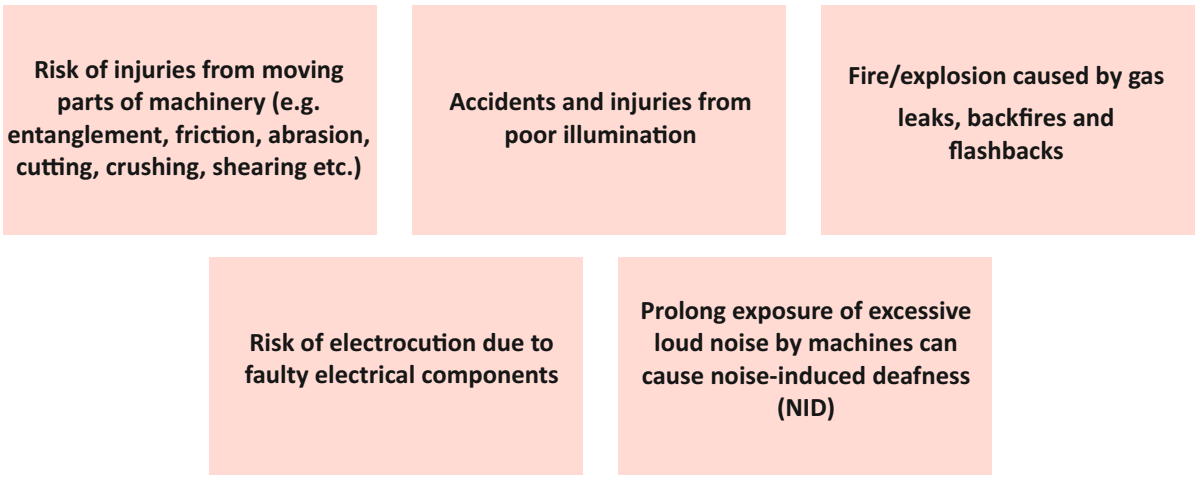
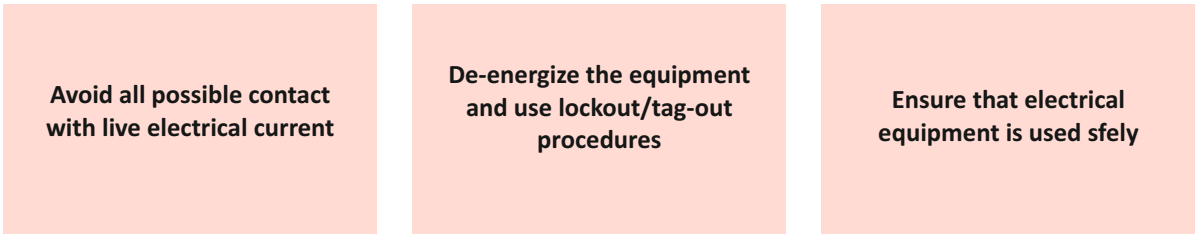


Fig. 5.3 Machine Hazards

Therefore, when working with tools and equipment in the workplace, specific safety procedures must be followed to prevent these hazards and accidents:

1. SOPs (Standard Operating Procedures) must be followed and maintained for all machinery in the manufacturing unit.
2. SOPs must be based on manufacturer recommendations and must include specific hazards associated with the machine as well as safe use recommendations.
3. SOPs (standard operating procedures) must be accessible at or near the machine.

Electricity is widely recognized as a serious workplace hazard that can cause electric shock, burns, fires, and explosions. Every year, many employees suffer pain, injuries, and even death as a result of electric shocks. To keep yourself and others safe, it is critical to adhere to electrical safety-related work practices.



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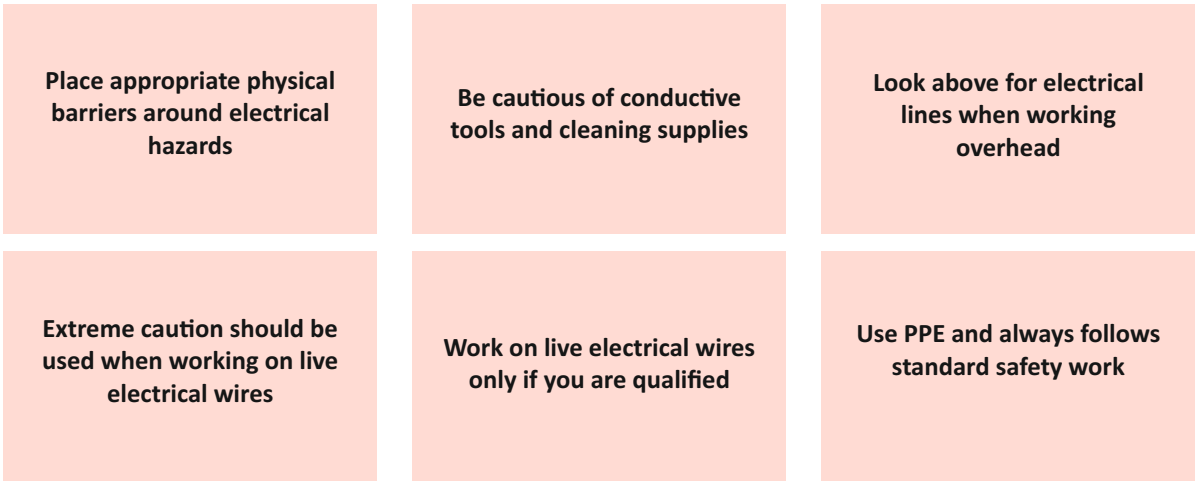

Fig. 5.4 Standard Procedures for Electrical Safety at Workplace

The following are some basic rules who work with or near hazardous materials should know and follow:

1. Pay close attention while working with or around hazardous materials.
2. Always wear the appropriate PPE.
3. Ensure that all containers are properly labeled and that hazardous materials are stored in an appropriate container.
4. Report damaged containers or illegible labels to your supervisor as soon as possible.
5. Read labels and the Safety Data Sheets (SDSs) before using any material to make sure you understand hazards and precautions Use hazardous materials solely for their intended purpose.
6. Never eat or drink while working with hazardous materials.
7. Store all hazardous materials properly, separate incompatibles, and keep them in well-ventilated, dry, and cool locations.
8. After handling any hazardous material, employees must keep themselves and the work area clean.
9. Gain knowledge about first-aid, emergency procedures, and evacuation procedures for dealing with fires or spills/leaks.
10. It also entails knowing what to do if a coworker is injured or poisoned by chemicals.

5.1.4 Significance of Maintaining Appropriate Postures While Lifting Heavy Objects

Lifting heavy objects is one of the leading causes of workplace injury. The main causes of these injuries were overexertion and cumulative trauma. Bending is the most frequently cited movement that resulted in back injuries, followed by twisting and turning.

Lifting loads incorrectly or carrying loads that are either too large or too heavy are common hazards associated with manually moving materials. Employees who use safe lifting techniques are less likely to sustain back sprains, muscle pulls, wrist injuries, elbow injuries, spinal injuries, and other injuries as a result of lifting heavy objects. The following figure explains on safe lifting and material handling at workplace.

When lifting heavier or awkward loads, use mechanical means (e.g., hand trucks, pushcarts, etc.).

Before using a forklift, make sure to have proper training and authorization.

Keep loads as close to the body as possible and avoid twisting while lifting, carrying, or setting down a load. The nose, shoulders hips and toes should all be pointing in the same direction.

Reduce your reaching. Bend at the keens, not the hips, as a general rule.

Get assistance as needed. Lift or carry anything that makes you uncomfortable, no matter how light the load is.

Plan ahead of time for all aspects of the lift, including lifting, carrying, and lowering. While lifting, try to use proper handholds.

If an item lacks a good handhold, consider alternatives such as placing the item in a container with good handholds, creating a safe and proper handhold with an appropriate tools, and so on.

Wear personal protective equipment, such as gloves with a good grip and steel-toed boots, as needed.

For frequent and/or heavy lifting, use rest breaks and job rotation.

Place the items to be lifted within the "power zone." The power zone is close to the body, between the person doing the lifting's mind-thigh and mid-chest.

Fig. 5.5 Tips for Maintaining Appropriate Postures While Lifting Heavy Objects

5.1.5 Warning and Safety Signages

Workplace safety signage evolved with the Industrial Revolution when workplace safety became a major concern. The purpose of a workplace safety sign is to identify and warn employees who may be exposed to various hazards. Safety signs help to communicate important instructions, reinforce safety messages, and provide emergency instructions. Workplaces that lack the necessary safety signs not only violate safety regulations but may also face hefty fines and regulatory action if they are audited by legal authorities. If an accident occurs and it is determined that proper safety signs were not present, the employer or other responsible parties could face legal consequences. It is essential to know the meaning of safety signs. Such signs warn us of danger and allow us to take precautions to keep safe. There are four main types of safety signs:

1. Prohibition signs
2. Mandatory signs
3. Warning signs
4. Information signs
5. Fire Safety signs
6. Danger Signs

The following table represents the various signages related to health and safety measures:

S. No.	Signage	Message
1.		Basic floor sign to stop moving ahead
2.		Stop Look Out for Forklifts
3.		Eye safety warnings
4.		Fire exit sign
5.		Authorized personnel only

S. No.	Signage	Message
6.		Fire hose notification
7.		Caution signage
8.		Caution signage
9.		Wet floor warning
10.		Watching out for step
11.		Water-saving signage

Table. 7.1 Safety & Warning Signages

5.1.6 Electronic Waste Disposal Procedures

E-waste is an abbreviation for electronic waste. That is, waste produced by broken, obsolete, or surplus electronic devices. It is also referred to as e-scraps. These electronics frequently contain toxic chemicals and hazardous materials. And if it is not disposed of properly, it can result in the release of toxic substances into our environment. The reprocessing and re-use of these electronic wastes are referred

to as e-waste recycling. It is straightforward. It is a method of recovering material from electronic waste. This allows you to incorporate them into new electronic products. These electronic wastes can take the form of household appliances such as air conditioners, televisions, electric cookers, air conditioners, heaters, DVDs, fans, microwaves, and radios. They can also take the form of information technology equipment such as computers, laptops, mobile phones, batteries, hard discs, circuit boards, and monitors. E-waste recycling is one of the most discussed issues in the world today due to its potential to reduce environmental hazards and pollution. It can also protect our lives as humans and other life forms in our world. E-waste recycling is the reuse and reprocessing of any type of discarded or obsolete electrical and electronic equipment.

Recycling electronics can be a difficult task. This is due to the fact that e-scraps are typically sophisticated and made from a variety of materials such as metals, plastics, and glass. While this process frequently varies, the following figure explains the standard process of electronic waste disposal.

Recycling electronics can be a difficult task. This is due to the fact that e-scraps are typically sophisticated and made from a variety of materials such as metals, plastics, and glass. While this process frequently varies, the following figure explains the standard process of electronic waste disposal.

Step 1 : Collection and Transportation

- This is the first stage of e-waste recycling. Recyclers set up take-back booths or collection bins in specific locations. When these bins are full recyclers transport the e-waste to recycling careers and planes.

Step 2 : Shredding and Sorting

- After collecting and transporting the e-waste, the next step is to shred and sort it. Shredding is the process of breaking down e-waste into smaller pieces for proper sorting. These tiny prices are sorted by hand and then manually dismantled. This is typically labor - intensive because waste ites are separated at this stage to retrieve different parts.

Step 3 : Dust Removal

- The tiny waste particles are evenly distributed on the conveyor belt by a shaking process. The uniformly distributed e-waste is then further broken down. The dust is extracted and disposed of in an environmentally responsible manner at this point. There is no environmental degradation in this manner.

Step 4 : Magnetic Separation

- Following that, a powerful overhead magnet aids in the separation of steel and iron from other wastes. It has successfully recycled the steel from the waste stream in this manner.

Step 5 : Water Separation

- Water separation technology is used to separate the glass from the plastic.

Step 6 : Purification of Waste Stream

- The next step is to locate and extract leftover metals from plastics to further purify the waste stream

Step 7 : Preparing Recycled Materials For Sale

- The last step is to prepare recycled materials for sale. The materials are separated here for sale as raw materials to manufacture new electronics.

Fig. 5.6 Standard Process of Electronic Waste Disposal

5.1.7 List of Concerned Authorities, Documents and Equipment for Workplace Health and Safety

It is simply a huge task for a single person to be solely responsible for workplace health and safety. As a result, the **health and safety executive (HSE), legal bodies, business owners, managers and supervisors, contractors, and employees at all levels in a company all share equal responsibility.** However, this does not imply that responsibilities are distributed evenly. Staff in various roles will have varying health and safety responsibilities. **Employers**, for example, bear more responsibility than their employees because they are held accountable for their employee's safety and well-being. They are required by law to protect their employees and anyone else who may be harmed by their business, including customers, visitors to the workplace, temporary workers, and contractors. Employers must perform the following duties in order to meet their health and safety obligations:

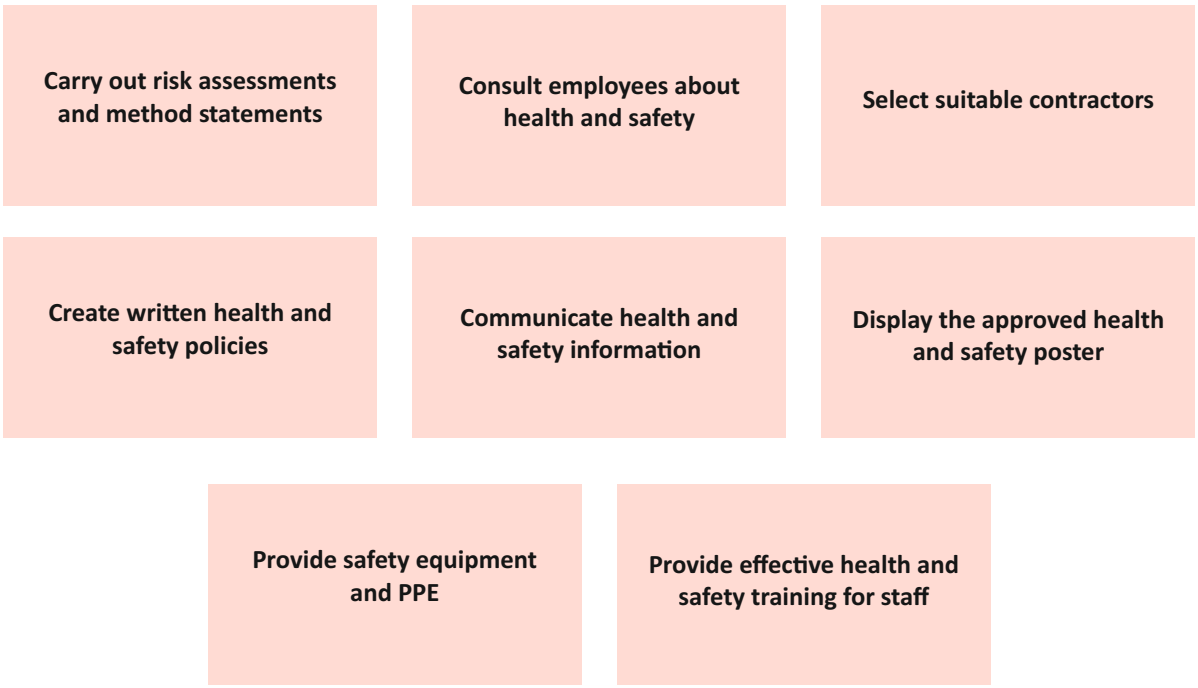

Fig. 5.7 Roles and Responsibilities of Employers for Workplace Health & Safety

Procedure for Reporting Workplace Health & Safety Issues to Concern Person

To raise a workplace health & safety issue with the concerned authorities, constructive steps should be taken immediately to resolve the problem. These steps may include:

1. Reporting the issue to your supervisor or manager
2. Reporting the issue through the workplace's hazard reporting procedures
3. Raising the issue with the health and safety representative
4. Raising the issue with management through union representative

Issues can be related to:

1. Personal hygiene
2. Handling of food and beverages
3. Storage and Work area
4. Suitable dress and personal protective equipment and clothing
5. Cross-contamination
6. Machinery, tools, and equipment
7. Inappropriate handling and disposal of garbage
8. Cleaning and sanitizing

List of documents for maintaining workplace health and safety

Health and safety documents assist in controlling risks and communicating safe working procedures. Many health and safety documents, such as risk assessments and health and safety policies, are also required by law.

1. Method Statements - Method statements include information such as project start and end dates, a project description, and all potential hazards associated with the project. Emergency procedures and guidelines for monitoring are also included.
2. Risk Assessment – Risk assessment documents serve as a strategic tool for planning for and responding to specific workplace risks. These documents help to raise awareness of hazards, identify specific people who may be at risk and note ways to eliminate or control that risk.
3. Near Miss Reports - A near-miss report is a document that details a problem or issue that occurred at work that had the potential to injure or harm someone. This usually happens when a break in a chain of events prevents harm or damage from occurring. This type of safety document is similar to an accident/incident investigation report in which the accident did not occur but could have.
4. Equipment and Machinery Inspection Reports - These reports detail when specific equipment or machinery was inspected, who inspected it, and what they discovered. Regular inspection reports also help to ensure that employees are using up-to-date and safe equipment.
5. Emergency Action Plan - These plans provide clear, detailed instructions on how people in a building should behave in the event of a specific disaster. Emergency action plans provide a comprehensive overview of all potential disasters, including fires, tornadoes, earthquakes, floods, and explosions.
6. Personal Protection Equipment Manual - This manual assists both employers and employees in doing the following:

   a. Understand the various types of PPE.

   b. Understand the fundamentals of conducting a "hazard assessment."

Personal Protective Equipment

Every worker at workplace is responsible for their safety as well as the safety of their coworkers. A person must take different precautions for different situations to avoid accidents and hazards. To begin, everyone on the job site must wear Personal Protective Equipment (PPE) for their safety.

Fig. 7.8 PPE

PPE refers to the clothing or equipment designed to protect the workers/employees from shop floor hazards. It includes items such as hard hats, safety boots, coveralls, gloves, safety glasses and goggles, earplugs, high visibility vests, lifejackets, fall protection, and respirators.

Common types of PPE include the following:

Eye and Face Protection

Hand Protection

Head Protection

Hearing protection

Foot Protection

Body Protection

Fall Protection

Respiratory protection

Fig. 7.9 Types of Personal Protective Equipment

5.1.8 Significance of Good Housekeeping at Workplace

Effective housekeeping assists in the control or elimination of workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the presence of paper, debris, clutter, and spills is accepted as normal, other, more serious hazards may be overlooked. Cleaning is only one aspect of housekeeping. It entails keeping work areas neat and orderly, keeping halls and floors free of slip and trip hazards, and removing waste materials (such as paper and cardboard) and other fire hazards from work areas. It also necessitates paying close attention to details such as the overall layout of the workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a fundamental component of incident and fire prevention. Effective housekeeping is a continuous process, not a one-time event. Effective housekeeping is a continuous process; it is not a one-time or sporadic clean-up. Periodic "panic" clean-ups are both costly and ineffective in terms of incident reduction.

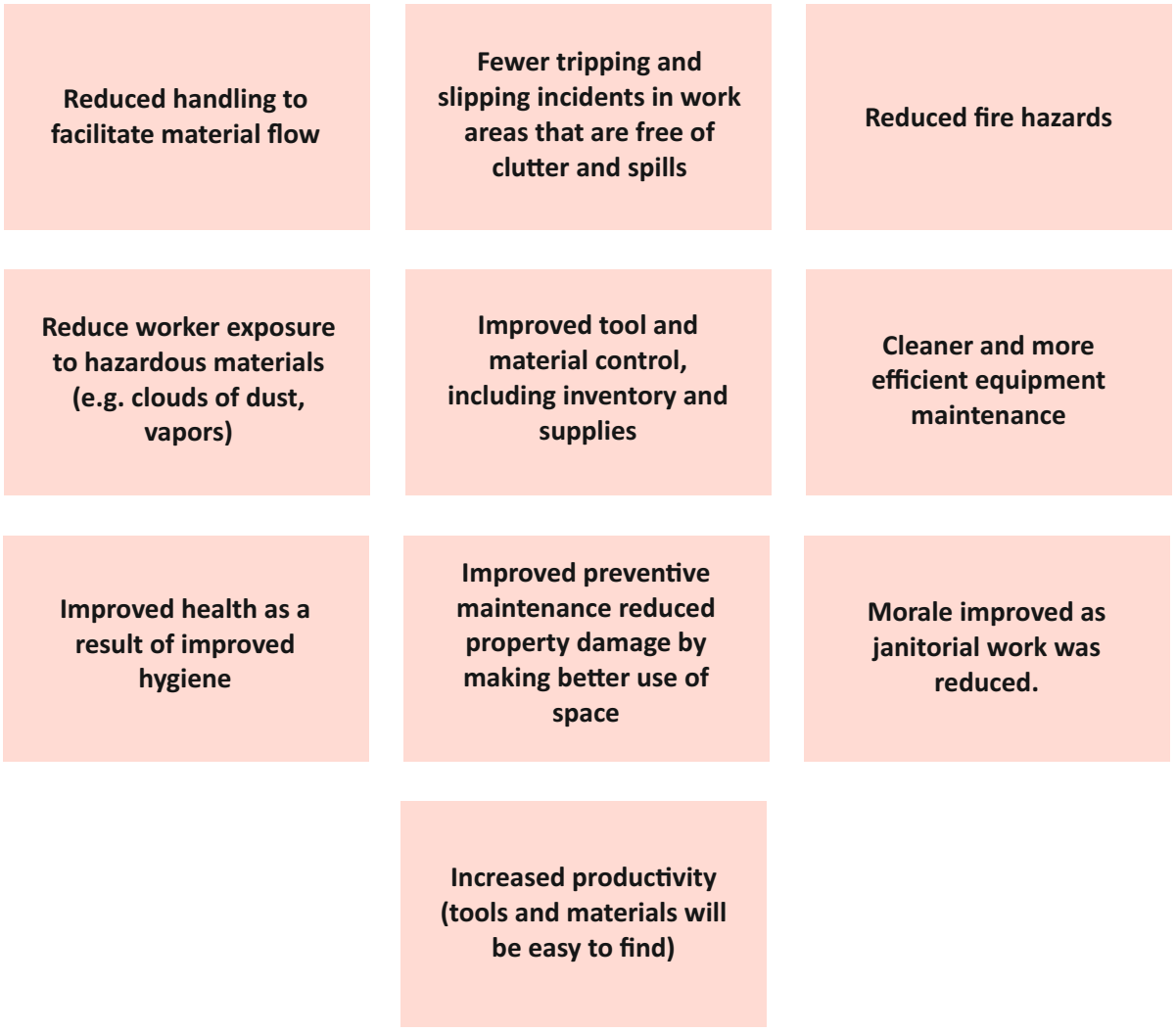

Fig. 7.10 Significance of Good Housekeeping at Workplace

Advantages of Implementing 5S Principle

1. **Sort:** It helps better allocate valuable resources, as additional space becomes available once the unnecessary items are removed from the area. Furthermore, the process forces inspection of the items, thereby recognizing the need to repair or eliminate any obsolete equipment and also preventing the equipment from being misplaced.
2. **Systemize:** A systematic work area also supports the efficiency of work. When kept at a fixed location, each object remains there until it is taken away while in use and is immediately kept back at the same place after use. Labeling and other identifying methods are also a part of this step. In addition, systematically storing and arranging things prevents a lot of time wasted searching for items. Overall, if each team member arranges things in an orderly fashion, it leads to the success of the whole organization.
3. **Shine:** It provides qualitative and quantitative results and improvises employee's pride and morale while working in a clutter-free pleasant work area. A clean area also results in a safe and healthy workplace.
4. **Standardize:** Following the standardized procedures helps achieve efficiency, improve workplace safety, and reduce workplace injuries.
5. **Sustain:** Maintenance of any system is essential as it increases its sustainability. Thus, maintaining the system is necessary; otherwise, the cost and effort spent on developing the system will go to waste.

Notes

5.1.9 5S

5S is intended to be a visually-oriented system of cleanliness, organization, and arrangement to attain greater productivity. It engages all employees and is a foundation for more self-discipline on the job for better work and better products. Along with engaging employees, it also builds a strong and positive culture of self-discipline at the workplace for better work and quality outcomes.

5S, sometimes referred to as 5s or Five S, refers to five Japanese terms used to describe the steps of the 5S system of quality management. Each term starts with an S. In Japanese, the five S's are **Seiri, Seiton, Seiso, Seiketsu, and Shitsuke**. The five S's are translated as Sort, Set in Order, Shine, Standardize, and Sustain in English**.**

S.No.	Japanese Words		English Translation	Definition
1	Seiri		Sort	Sorting means keeping only the essential items required in the workplace and removing all the nonessential items.
2	Seiton		Set in order	Ensures that all the items are organized and placed logically to make the task easier and convenient for the worker.
3	Seiso		Shine	Efforts to keep the orderly workplace area clean and maintain routine tasks are involved, like dusting, mopping, and maintenance of machinery, tools, and other equipment.
4	Seiketsu		Standardize	Create a set of standards for organization and processes where rules are made for how 3S will be maintained and when these tasks will be performed.
5	Shitsuke		Sustain	Sustain new practices and conduct audits to maintain discipline. Th2is means the previous four S's must be continued over time. This is achieved by developing a sense of self-discipline in employees who will participate in 5S.

Table. 5.2 5S

The guiding principles underlying the 5S technique involve organization, cleanliness, and standardization. Overall workplace cleanliness, created by removing waste from the work area, promotes internal organization and enhances visual communication. By reducing wasted time and materials, productivity is increased along with safety, and costs are reduced. The system as a whole minimizes waste and improves efficiency by ensuring that employees are spending time doing productive tasks rather than looking for misplaced items, sorting unnecessary through stacks of waste material, or rearranging the work environment at the change of shifts.

Notes

Exercise

Answer the following questions:

1. Explain potential risks and hazards at the workplace.

2. Explain the benefits of 5S principles.

3. Explain any two types of Personal Protective Equipment.

4. List the ways for maintaining appropriate postures while lifting heavy objects.

5. Discuss the importance of good housekeeping at workplace.

6. List of documents for maintaining workplace health and safety.

7. What is PPE?

5. Write a short note on organizational safety procedures.

Fill in the blan

1. To raise a _____ with the concerned authorities, constructive steps should be taken immediately to resolve the problem.
2. _____ is one of the key aspects of any manufacturing business or facility. Getting it right can boost overall operation performance and lead to growth.
3. As safety is an integral part of the workplace, _____ should not turn a blind eye and, if necessary, issue instructions.
4. _____ has the potential to cause human injury or illness, property damage, environmental damage, or a combination of these effects.
5. An _____ is a step-by-step instruction manual for carrying out a work procedure.
6. Lifting heavy objects is one of the leading causes of _____.
7. The purpose of _____ is to identify and warn employees who may be exposed to various hazards.
8. _____ is one of the most discussed issues in the world today due to its potential to reduce environmental hazards and pollution.
9. _____ bear more responsibility than their employees because they are held accountable for their employee's safety and well-being.
10. _____ documents assist in controlling risks and communicating safe working procedures.

Choose the correct answers (MCQ)

a) The way of protecting individuals' well-being of health is classified as:
   1) Safety
   2) Health
   3) Adverse Situation
   4) Security

b) What are the most common risks in the workplace?
   1) Risk of electrocution
   2) Risk of injuries from faulty equipment
   3) Being hit by falling objects
   4) All of the above

UNIT 5.2 - Fire Safety Practices

Unit Objectives

At the end of this Unit the trainee will be able to:

1. List the types of fire and fire extinguishers

5.2.1 Fire Safety

Fire safety refers to a set of practices designed to reduce the devastation caused by fire. Fire safety measures include those used to prevent the ignition of an uncontrolled fire as well as those used to limit the development and effects of a fire once it has begun. Following are the standard practices for fire safety at workplace.

Follow the emergency instruction in case of fire

1. Activate the ALARM.
2. Evacuate the area.
3. Call the fire department.
4. Stay Calm

Fight the fire only if:

1. You know-how.
2. The fire is small.
3. You are confined to the area where it started.
4. You have a way out.
5. You can work with your back to the exit.
6. You have the right type of extinguisher.
7. You feel confident that you can operate it effectively.

Do not fight the fire if:

1. You have any doubts about fighting it.
2. It is spreading beyond the area where it started.
3. It could block your escape route.

Precautions to be taken during the fire:

Following precautions are to be taken in case of fire –

1. Switch off the main switch.
2. Snuff the fire by throwing dry sand on it.
3. Make sure that the fire extinguisher is operational and not expired.
4. Do not use water to extinguish an electrical fire.
5. Know the location of emergency exits and procedures.

Fire can be prevented by following these do's and don'ts at the workplace:

Do's	Don'ts
Keep the work area clean.	Do not wear inflammable materials like nylon etc.
If empty containers contain inflammable materials, fill them with water.	Do not use inflammable materials near electrical lines.
Report any unsafe situation that may cause a fire.	Never weld near combustible materials.
Watch where the sparks and metals are falling from your work.	Never leave any cable without insulation.

Table. 5.3 Do's and Don'ts of Preventing Fire

Notes

5.2.2 Fire Extinguishers

Electrical fires are different from regular fires. They cannot be extinguished with water. Also, using water to put out an electrical fire is very dangerous and could lead to electrocution. To put out an electrical fire, the right type of fire extinguisher must be used. The following figure represents the different classes of fires:

Class of Fire - A

- Type of Fire - Ordinary Combustible : wood, paper, rubber, fabrics and many plastics.
- Type of Extinguisher- Water, dry powder, halon

Class of Fire - B

- Type of Fire - Flammable liquids and Gases: Gasoline, Oils, paint, lacquer and tar.
- Type of Extinguisher- Carbon Dioxide, dry powder, halon

Class of Fire - C

- Type of Fire - Fires involves live electrical equipment .
- Type of Extinguisher- Carbon Dioxide, dry powder, halon

Class of Fire - D

- Type of Fire -Combustible metals or combustible metal alloys
- Type of Extinguisher- Special Agents

Class of Fire - K

- Type of Fire - Fires in cooking appliances that involve combustible cooking media: vegetable or animal oils and fats.
- Type of Extinguisher - Wet Chemical

Fig. 7.11 Types of Fire

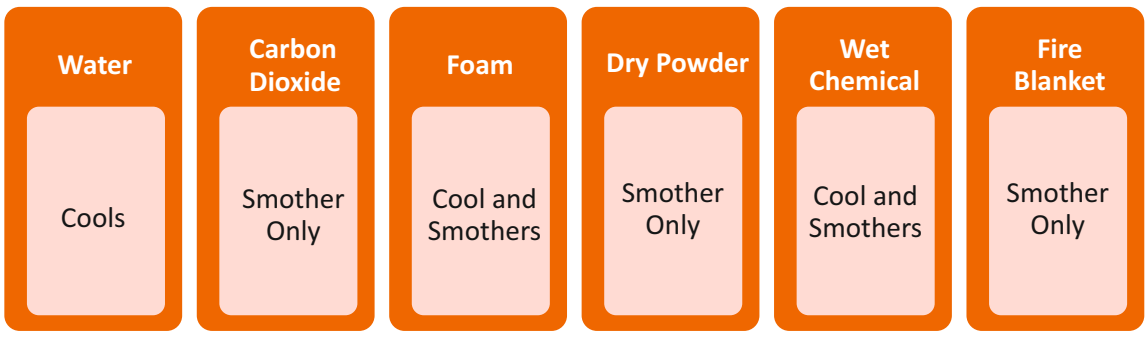

Fig. 7.12 Types of Fire Extinguishers

Fig. 7.13 Using a Fire Extinguishers

Notes

Exercise

Fill in the blanks:

a) _____cannot be extinguished with water.

b) Safety is _____ responsibility.

c) _____ in case of fire.

d) Do not fight the fire if_____.

Answer the following questions:

1. Explain various types of fire and fire extinguishers.

_____

_____

_____

2. Write a short not fire safety.

_____

_____

_____

3. Explain do's and don'ts of preventing fire.

_____

_____

_____

4. List the precautions to be taken during the fire.

_____

_____

_____

Unit 5.3 - Emergency, Rescues and First-aid Practices

Unit Objectives

At the end of this unit, the trainee will be able to:

1. Describe different ways of preventing accidents at the workplace

5.3.1 Different Ways of Preventing Accidents/Hazards at the Workplace

ISO 45001 is an international standard for health and safety at work developed by national and international standards committees of government. An Occupational Health and Safety Management System (OHSMS) is a fundamental part of an organization's risk management strategy.

Implementing an OHSMS enables an organization to:

a. Protect its workforce and others under its control

b. Comply with legal requirements

c. Facilitate continual improvement

The following figure explains different ways/methods to control hazards and prevent accidents at the workplace:

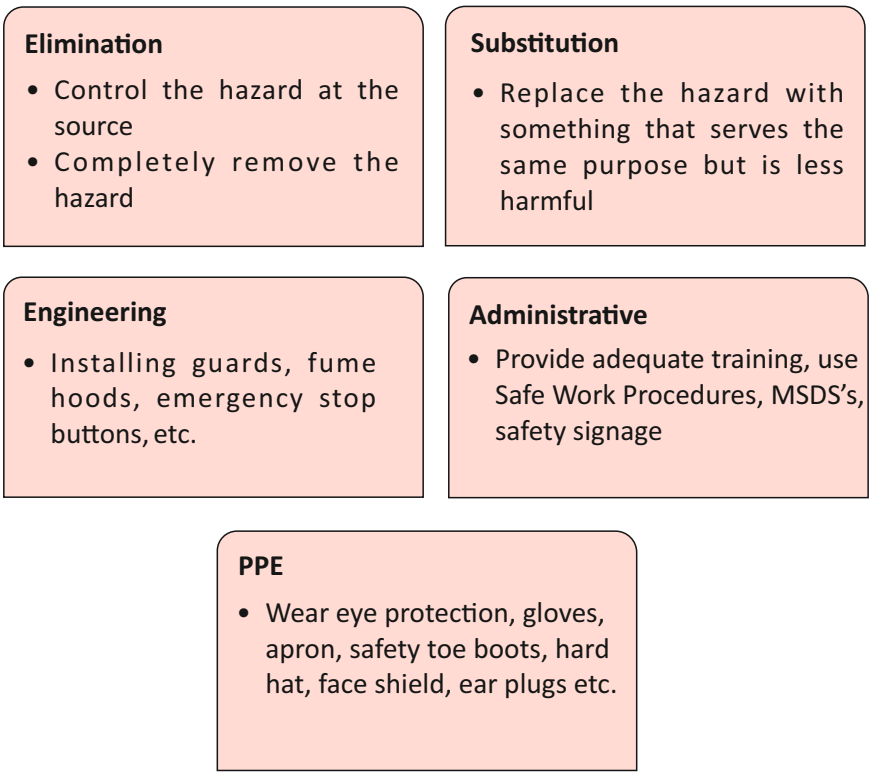

Fig 7.14 Steps to Control Hazards and Prevent Accidents

5.3.2 Emergency Procedures to Deal with Electric Shock and Accidents

When a person somehow comes in contact with the live wire and gets shocked and faints, the following are the steps to be undertaken immediately as a first aid to save his/her life:

Responsibilities	Descriptions
Recognize the symptoms	• Common shock signs and symptoms include the following: o Pale, cold, clammy skin. It may appear grayish, the lips and fingernails may look blue. o The pulse and breathing are rapid. o The person is exhibiting disorientation or giddiness. o Nausea or vomiting may occur. o The person seems weak, with vacant eyes.
Call local emergency services number	• It's crucial to have paramedics on the way while you administer the treatment since the shock is a severe condition that will require hospitalization. • Stay on the line with the emergency services dispatcher in case of any need and provide the proper first aid. • In India, the Ambulance Emergency number is – 102
Make the person lie down	• Be extremely gentle since any sudden movements could injure the person. If the person is not in pain, place his or her legs on a pillow to elevate them about 12 inches above the head. • Do not move the person's head. • Keep the person flat and still after he or she is lying down.
Check for signs of breathing	• Observe the person's chest to see if it rises and falls, and place your cheek next to his or her mouth to check for breath. If the person is not breathing, perform CPR. Check the breathing every 5 minutes until the emergency services arrive.
Make the person comfortable	• Loosen the collars and unbutton or cutaway tight clothing. Unbuckle the person's belt, loosen the shoes and remove all tight jewelry on the person's wrists or neck. Cover the person with a blanket. • Do not give the person food or water. • Reassure and comfort the person; try to keep him or her calm until help arrives.

Responsibilities	Descriptions
Check for vomiting and bleeding from the mouth	• If you observe vomit or blood coming from the mouth or nose, turn the person on his or her side to prevent him or her from choking. Help to prop the person up with pillows.
Administer treatment for injuries or blood loss	• If the person sustained a trauma, you might need to stop blood flow from a wound or provide first aid for a broken bone. • Seek further instructions from the emergency personnel over the phone.

Table. 7.4 Emergency Procedures to deal with Accidents

7.3.3 Safety Mock Drills

Safety is a priority to provide a safe working environment. Efforts should be taken to reduce the scale & probability of hazards. However careful we can be, hazards may still occur. Effective action has been possible in the emergency. In dealing with such emergencies, effective action is likely a pre-planned and practiced procedures for dealing with such emergencies.

What is a Mock Drill?

Mock Drill is a situation in which a fake emergency is announced, and workmen are asked to follow an emergency evacuation plan. This allows the workman to get familiarized with the emergency and act according to plan. Mock drills for chemical accidents and firefighting drills should be organized at regular intervals at the sites.

At the time of emergency evacuation, one must:

1. Raise the alert by crushing the glass cover of the closest break-glass alarm unit.
2. Be calm and composed.
3. Switch off all electrical apparatus except lights.
4. If possible, shut doors around the fire area to stop it from spreading.
5. Leave the building/site area immediately.
6. Follow the evacuation queue.
7. Give first preference to the physically disabled, expectant mothers, and the elderly
8. If it's dark and smoky, get down on your hands and knees and crawl to the nearest exit by counting the number of doors. If manageable, cover your nose with a wet towel or handkerchief.
9. Be acquainted with the hot exit door and pay attention to the thick smoke in the staircase. If the stairs are free from smoke, follow the directional signs and handrails.
10. Gather at the designated assembly point.
11. Do not re-enter the building until the signal is given
12. Max. time for evacuation should be 2.5 to 3.0 minutes.

5.3.4 Procedure for Reporting Accidents and Hazards

The essential responsibilities of an individual for reporting hazards and accidents are:

1. The people responsible for health and safety at the workplace;
2. The name, designation, and location of the person responsible to contact at the time of emergency

Additionally, an individual should also be adept in writing accident reports. An accident report needs to include all the essential information about the incident or near-miss. The report-writing process begins with facts and ends with recommendations for preventing future accidents.

An accident report involves four steps:

Gathering Facts: Collect and note all the facts, including –

- Date, time, and location of the accident
- Names, job titles, workers, and immediate supervisors involved
- Events leading up to the accident
- Job that the worker was handling at the time of the accident
- Names of employee who witnessed the accident
- Surrounding conditions (e.g., greasy floor, insufficient lighting, noise, etc.)
- Circumstances at the time of the accident (including tasks, equipment, tools, materials, etc.)
- PPE worn by the worker at the time of the accident
- Injuries that occurred (name of the injured body part and characteristics and extent of injuries)
- Type of treatment for injuries (first aid, if given)
- Damage to equipment, materials that the worker was working on or any other equipment or material around it.

Determining the Sequence: Describe the sequence of events after gathering the facts –

- **Events leading up to the accident:** Task the employee was performing at the time of the accident. For example: bending over, climbing, lifting operating machinery, using a tool, handling hazardous materials, etc.
- **Events involved in the accident:** Was the employee struck/caught in the machine or caught in the fire? Did the worker fall on the same level or from a height? Did he inhale hazardous fumes or get splashed with a hazardous chemical?
- **Events immediately following the accident:** What did the employee do: started bleeding? The body caught fire? Complain about back pain? Put a hand over a bleeding wound? Response from other workers/supervisors. Did they call for help, administer first aid, shut down equipment, move the victim to another place, etc.?
- The accident should be described in the report in sufficient detail that any reader can picture what happened.

Analysing: Analyse the causes of the accident. Causes include:

- Primary cause (e.g., a slip and fall from a ladder)
- Secondary causes (e.g., an employee not wearing appropriate goggles or helmet)
- Other contributing factors (e.g., poor ventilation).

Recommending: Recommendations for corrective action might include immediate as well as long-term corrective actions such as:-

- Training on safe work practices
- Preventive maintenance exercises that keep equipment in excellent working condition.
- Assessment of job techniques with a proposal for changes.
- Conducting a job hazard analysis to evaluate the task for any other hazards and then train employees on these hazards.
- Engineering changes that make the task safer or administrative changes that might include changing the way the job is performed.

Fig. 5.15 Accident Report Procedure

Exercise

Answer the following questions:

1. What are the different ways/methods to control hazards and prevent accidents at the workplace?

2. Explain emergency procedures to deal with electric shock and accidents.

3. Write a short note on safety mock drills.

4. Discuss the process of reporting accidents and hazards.

UNIT 5.4 - Effective Waste Management Practices

Unit Objectives

At the end of this unit, the trainee will be able to:

1. List the common sources of pollution and ways to minimize it
2. Describe the concept of waste management and methods of disposing hazardous waste
3. Explain the importance of efficient utilization of water, electricity and other resources
4. Describe the process of disposal of hazardous waste

5.4.1 Workplace Pollution

Workplace pollution is defined as the presence of hazardous materials or noises within a workplace that may affect employees while they are performing their duties. Such workplace pollutants can harm workers' health, especially if they are exposed for extended periods, even at low levels. The most common type of exposure is workplace air pollution. This includes workplace hazards from airborne pollution or the presence of hazardous substances in the workplace indoor air as gases (fumes) or as particulate matter (tiny particles - dust) dispersed in the air. Other modes of exposure include skin contact, ingestion, and/or injection.

Good Air Ventilation	**Identifying and avoiding direct contact with corrosive or toxic materials,**	**Not eating or drinking the presence of toxic or hazardous materials,**
Wearing protective gear as and when required).	**Effective Waste management practices at workplace**	**Effective cleaning and hygiene practices among the employees**
Re-use and Recycle	**No to plastic bags**	**Carpool or using public transport**

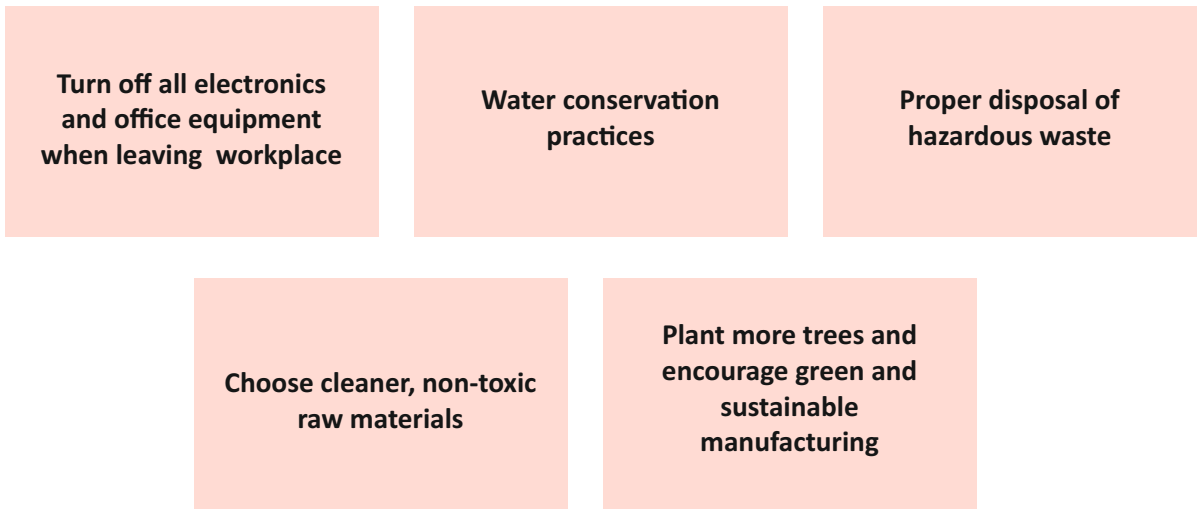

Fig. 7.16 Various Ways to Minimize Pollution

Notes

5.4.2 Effective Waste Management

Waste management refers to the activities and actions required to manage waste from its inception to its disposal. This includes the collection, transport, treatment, and disposal of waste and monitoring and regulation of the waste management process.

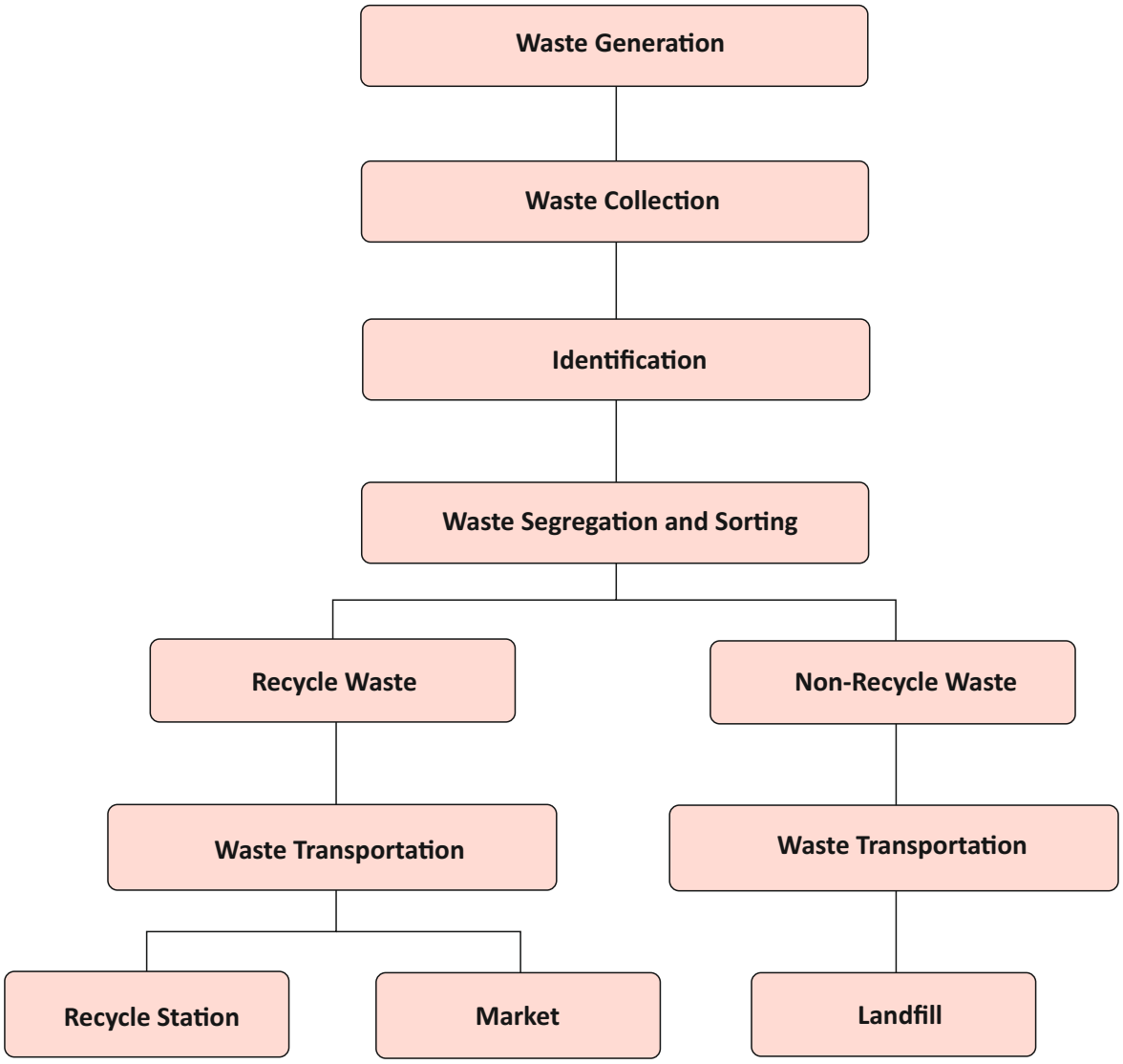

Fig 7.17 Waste Management Process

Waste elimination is one of the utmost effective ways to escalate the profitability of any trade or business. To eliminate waste, it is essential to understand exactly what waste is and where it exists. While products significantly differ between places, the typical wastes found in electronic manufacturing environments are pretty similar.

There is a strategy to decrease or eliminate its effect on a company for each waste, thereby refining overall performance and quality. Everything that is done in an organization is divided into two groups: value-adding and waste. Usually speaking, value-adding is something the consumer pays for, and waste

is anything the consumer does not care about. All non-value-added activities belong to waste.

Specifically, waste metal is often difficult for businesses to manage in the electronic industries. Often exceptionally heavy and problematic to store, proper scrap metal disposal is a continuous challenge for businesses that produce large amounts of metal waste.

That is where the concept of waste mineralization becomes a must for every employee to understand. There are many ways to define waste mineralization. However, in its broadest sense, waste mineralization includes all practices including waste prevention, reuse, and recycling that reduce the amount of waste entering the environment.

Fig 7.18 Waste Minimization

Waste Segregation

In general, waste is segregated as dry and wet waste. Dry waste includes wood, paper, plastic, glass, etc., related products that can be recycled, and wet waste refers to organic and biodegradable waste. The waste can be segregated using color-coded dustbins.

Fig 5.19 Waste Segregation

1. Green Bin

The green-colored bin is used to dump biodegradable waste, for example, wet/organic material, including cooked or leftover food, vegetable and fruit rinds, eggshell, rotten eggs, chicken/fish bones, tea or coffee grinds, coconut shells, and garden waste, including fallen leaves/twigs or the worship flowers/garlands.

2. Blue bin

The blue-colored bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrappers, and paper waste, including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes, or paper cups/plates, metallic items like tins/cans, foil paper, and containers.

Fig 5.20 Dry &Wet Waste Bins

Recyclable Waste	Non-Recyclable Waste
Recyclable waste is renewable. The waste material can be reused or converted into new products or raw material, like paper, corrugated cardboard, glass, plastics container and bags, hard plastic, metal, wood products, e-waste, textile, etc.	Non-recyclable waste commonly includes materials that can be easily degraded in nature. For example, fruit shells, vegetable leaves, food leftovers, flowers and leaves, etc. it also includes cigarette end, muck, coal, cinder, construction waste, and paint waste which do not have big value after being discarded.

Table 5.5 Recyclable and Non-Recyclable Waste

The most commonly used methods of waste disposal are:

Landfill

It is a man-made method of disposing of solid and hazardous waste on land.

Incineration

It is a waste treatment method that involves the combustion of organic substances found in waste materials.

Waste Compaction

It is the process of compacting waste in order to reduce its size.

Biogas Generation

It is a renewable fuel that is created through the breakdown of organic matter. It can be used for vehicle fuel, heating, and electricity generation.

Composting

It is the natural process of decomposing and recycling organic material into a humus-rich soil amendment.

Vermicomposting

It is the process by which worms are used to convert organic materials (usually wastes) into a humus-like material known as vermin-compost.

Fig 7.21 Methods of Waste Disposal

5.4.3 Hazardous Waste Management

Hazardous waste is defined as waste that poses significant or potential risks to public health or the environment. Characteristic hazardous wastes are materials that have been proven or tested to have one or more of the following hazardous properties:

1. Ignitability
2. Reactivity
3. Corrosively

Following are the impact of various hazardous material on the manufacturing process:

Increase risk and contamination	**Substandard quality and defective products**	**Certain hazardous substances also have the potential to explode or cause a fire**
Possible injuries and illness among the workers	**Possible damage of equipment and machinery**	**Low productivity**
Material and resources wastage	**Loss of time, money and goodwill**	**Economic consequences of recall and outbreak**

Fig 5.22 Impact of Hazardous Material in Production Process

There are several options for hazardous-waste management. The most desirable option is to reduce waste at its source or to recycle the materials for another productive use. Nonetheless, while reduction and recycling are desirable options, they are not regarded as the final solution to the hazardous-waste disposal problem. There will always be a need for hazardous waste treatment, storage, or disposal.

1. **Chemical Treatment -** Chemical treatment processes include ion exchange, precipitation, oxidation and reduction, and neutralization.
2. **Thermal Treatment -** Thermal methods include high-temperature incineration, which can not only detoxify but also destroy certain organic wastes. Thermal equipment of specialized design is used to burn waste in solid, liquid, or sludge form. Fluidized-bed incinerators, multiple-hearth furnaces, rotary kilns, and liquid-injection incinerators are some examples of thermal treatment.

3. **Biological Treatment -** The waste is carefully mixed with surface soil on a suitable plot of land in this technique. Microbes that can metabolize waste, as well as nutrients, may be added.

4. **Surface storage and land disposal -** Hazardous wastes that cannot be destroyed by incineration or other chemical processes must be properly disposed of. Land disposal is the ultimate destination for the majority of such wastes, though it is not an appealing practice due to the inherent environmental risks involved. Landfilling of hazardous solid or containerized waste is subject to stricter regulations than municipal solid waste landfilling. Hazardous wastes must be disposed of in so-called secure landfills, which must have at least 3 meters (10 feet) of space between the landfill's bottom and the underlying bedrock or groundwater table. Two impermeable liners and leachate collection systems are required for a secure hazardous-waste landfill.

Manufacturers of hazardous substances must provide warning labels and safety guidelines with their products. Employers must ensure that the safety guidelines for each hazardous substance used in the workplace are available to employees and warning labels on hazardous substances should feature:

- Hazard Pictograms
- Signal Words (e.g. Danger and Warning)
- Hazard Statements (e.g. Fatal If Swallowed)
- Precautionary Statements (e.g. Wear Protective Gloves).

The Safety guidelines must include important information on handling the product safely, including:

- Potential Health Effects
- Precautions for Use
- Safe Storage Suggestions
- Emergency First Aid Instructions
- Contact Numbers for Further Information.

5.4.4 Material Utilization

Material efficiency means producing the same result with reduced amounts or lower grades of raw materials. Material efficiency measures seek to decrease the number of natural resources required to produce a certain output level and recycle post-consumption waste material back in the manufacturing process.

The reuse of wear parts and components is also part of material efficiency, extending the lifetime of machinery, components, and spare parts through reconditioning. Material efficiency includes new product innovations to replace previous products that consume greater amounts of raw materials.

5.4.5 Energy Conservation Practices

In general terms, energy conservation refers to the simple practices that we follow in our day-to-day life to preserve energy. Manufacturing facilities are among the largest consumers of energy. Therefore, efforts to improve energy efficiency are an increasing concern for many manufacturing facilities. This can be accomplished by evaluating energy end uses e.g., lighting, processing equipment, and heating, air conditioning, and ventilation, HVAC systems, and by implementing measures to reduce the total amount of energy consumed for one or more of the end uses. The following exhibit suggests a few steps which can be followed for achieving energy efficiency and consumption.

Switching off lights remains one of the easiest ways to save on energy but it's surprising how often lights are kept on, even when no one is in the lit area. This problem is compounded in when employees go in and out of various buildings and work areas as they go about their duties.

Ensure you shut off machinery and equipment when not in use. Walking through your plant after-hours and ensuring equipment is powered down when not in use can result in significant savings over time.

Regular cleaning and planned maintenance of the electrical and mechanical equipment will go a long way towards optimising its performance and lifespan, which can translate to energy efficiency savings.

Newer heating and cooling systems will be far more efficient than old ones, so it may be worth getting systems more than 10 years old replaced.

Insulation acts as a barrier against temperature shifts. By installing insulation in the roof, and walls of your workspace, you can reduce the amount of energy needed to maintain room temperature during heat loss and heat gain.

Use fixed or adjustable shading, plant trees and vegetation or install sun filters on the windows and walls of the workplace— especially industrial sheds— to protect from acute heat during summers.

Use LED lights which are more energy efficient.

Continued...

Use natural airflow where possible to avoid usage of cooling systems.

Optimise the energy consumption settings of the appliances being used in the unit, like refrigerator and AC can be made to run by a couple of degrees higher.

Create awareness on importance of energy consumption among the employees

Fig 5.23 Energy Conservation Practices

5.4.6 Water Conservation Practices

Water conservation is the practice of using water efficiently to reduce unnecessary water usage. It is essential because fresh clean water is a limited resource and a costly one. We are already well aware of the financial costs of inefficient water use. Conservation of this natural resource is critical for the environment — and our wallets.

Fig 7.24 Water Conservation Practices

Summary

- Workplace safety is one of the most significant concerns for any manufacturing company or facility. Getting it right can improve the overall performance of the operation and lead to growth.
- It is the responsibility of everyone, whether employer or employee, to keep the workplace clean, healthy, and safe.
- As safety is an integral part of the workplace, Quality Managers should not turn a blind eye and, if necessary, issue instructions.
- A hazard is something or someone that has the potential to cause damage, harm, or adverse health effects.
- An organizational safety procedure is a step-by-step instruction manual for carrying out a work procedure. It is used when a deviation from the procedure could result in injury or an accident.
- Electricity is widely recognized as a serious workplace hazard that can cause electric shock, burns, fires, and explosions. Every year, many employees suffer pain, injuries, and even death as a result of electric shocks. To keep yourself and others safe, it is critical to adhere to electrical safety-related work practices.
- Lifting heavy objects is one of the leading causes of workplace injury. The main causes of these injuries were overexertion and cumulative trauma. Bending is the most frequently cited movement that resulted in back injuries, followed by twisting and turning.
- Workplace safety signage evolved with the Industrial Revolution when workplace safety became a major concern. The purpose of a workplace safety sign is to identify and warn employees who may be exposed to various hazards.
- Electronic-waste recycling is one of the most discussed issues in the world today due to its potential to reduce environmental hazards and pollution. It can also protect our lives as humans and other life forms in our world. E-waste recycling is the reuse and reprocessing of any type of discarded or obsolete electrical and electronic equipment.
- Recycling electronics can be a difficult task. This is due to the fact that e-scraps are typically sophisticated and made from a variety of materials such as metals, plastics, and glass.
- Employers bear more responsibility than their employees because they are held accountable for their employee's safety and well-being.
- Health and safety documents assist in controlling risks and communicating safe working procedures. Many health and safety documents, such as risk assessments and health and safety policies, are also required by law.
- PPE refers to the clothing or equipment designed to protect the workers/employees from shop floor hazards. It includes items such as hard hats, safety boots, coveralls, gloves, safety glasses and goggles, earplugs, high visibility vests, lifejackets, fall protection, and respirators.
- Effective housekeeping assists in the control or elimination of workplace hazards. Poor housekeeping practices frequently contribute to incidents.
- 5S is intended to be a visually-oriented system of cleanliness, organization, and arrangement to attain greater productivity. It engages all employees and is a foundation for more self-discipline on the job for better work and better products.

- Fire safety refers to a set of practices designed to reduce the devastation caused by fire. Fire safety measures include those used to prevent the ignition of an uncontrolled fire as well as those used to limit the development and effects of a fire once it has begun.
- Electrical fires are different from regular fires. They cannot be extinguished with water. Also, using water to put out an electrical fire is very dangerous and could lead to electrocution. To put out an electrical fire, the right type of fire extinguisher must be used.
- If you observe vomit or blood coming from the mouth or nose, turn the person on his or her side to prevent him or her from choking. Help to prop the person up with pillows.
- A mock Drill is a scenario in which a fake emergency is declared and employees are instructed to follow an emergency evacuation plan. This allows the worker to become acquainted with the emergency and act accordingly.
- Workplace pollution is defined as the presence of hazardous materials or noises within a workplace that may affect employees while they are performing their duties. Such workplace pollutants can harm workers' health, especially if they are exposed for extended periods, even at low levels.
- Waste management refers to the activities and actions required to manage waste from its inception to its disposal. This includes the collection, transport, treatment, and disposal of waste and monitoring and regulation of the waste management process.
- Waste elimination is one of the utmost effective ways to escalate the profitability of any trade or business. To eliminate waste, it is essential to understand exactly what waste is and where it exists. While products significantly differ between places, the typical wastes found in electronic manufacturing environments are pretty similar.
- In general, waste is segregated as dry and wet waste. Dry waste includes wood, paper, plastic, glass, etc., related products that can be recycled, and wet waste refers to organic and biodegradable waste. The waste can be segregated using color-coded dustbins.
- Recyclable waste is renewable. Non-recyclable waste commonly includes materials that can be easily degraded in nature.
- Hazardous waste is defined as waste that poses significant or potential risks to public health or the environment.
- Material efficiency means producing the same result with reduced amounts or lower grades of raw materials. Material efficiency measures seek to decrease the number of natural resources required to produce a certain output level and recycle post-consumption waste material back in the manufacturing process.
- In general terms, energy conservation refers to the simple practices that we follow in our day-to-day life to preserve energy. Manufacturing facilities are among the largest consumers of energy. Therefore, efforts to improve energy efficiency are an increasing concern for many manufacturing facilities.
- Water conservation is the practice of using water efficiently to reduce unnecessary water usage. It is essential because fresh clean water is a limited resource and a costly one.

Exercise

Fill in the blanks:

a) Dry waste includes _____, _____ and _____ etc.

b) _____ can be reused or converted into new products or raw material.

c) The waste can be segregated using _____ dustbins.

Answer the following questions:

1. Differentiate between recycle and non-recycle waste.

_____

_____

_____

2. Explain waste elimination.

_____

_____

_____

3. Name any methods of waste disposal.

_____

_____

_____

4. List various ways to minimize pollution at workplace

_____

_____

_____

Match the following:

Column A	Column B
Energy Conservation Practices	Strains and sprains from lifting loads
Water Conservation Practices	Reuse of wear parts
Potential injuries occurs during moving of materials manually	Shut off machinery when not in use
Material efficiency	Turn off the tap when it is not necessary

Notes

QR Code

Scan the QR Code to watch the related video

youtube.com/watch?v=ReL-DM9xhpI
Unit 5.2 Fire Safety Practices

youtube.com/watch?v=cqJ-ZM4UZNk
Unit 5.4 Effective Waste Management Practice

Skill India
कौशल भारत-कुशल भारत

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National
Skill Development
Corporation
Transforming the skill landscape

ASDC
AUTOMOTIVE SKILLS DEVELOPMENT COUNCIL

6. Employability Skills

https://www.skillindiadigital.gov.in/content/list

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7. Annexure

Annexure - QR Code

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
1.	Module 1 Introduction to the Role of VLSI Design Engineer	Unit 1.1 Electronics Industry and its Sub-Sectors-An Introduction	Electronics Industry in India	17	www.youtube/PiR7PDEKy2A	
		Unit 1.3 - Basics of Electronics and Related Concepts	Introduction to Very Large-Scale Integration (VLSI)		www.youtube.com/watch?v=sXMFdPW2bPc	
2.	Module 2 Basics of System Designing	Unit 2.1 - Digital Electronics and Concept of Circuits	Number System in Digital Electronics	54	www.youtube.com/watch?v=crSGS1uBSNQ	
		Unit 2.1 - Digital Electronics and Concept of Circuits	Application-Specific Integrated Circuit (ASIC) Design		www.youtube.com/watch?v=1CFhcBH52Rc	
		Unit 2.1 - Digital Electronics and Concept of Circuits	Boolean Algebra		www.youtube.com/watch?v=WW-NPtIzHwk	

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
		Unit 2.1 - Digital Electronics and Concept of Circuits	Logic Gates	54	www.youtube.com/watch?v=0lwhoQ5aQe8	
		Unit 2.1 - Digital Electronics and Concept of Circuits	Field Programmable Gate Arrays (FPGA)		www.youtube.com/watch?v=CfmlsDW3Z4c	
		Unit 2.3 - CMOS Circuit and its Components	CMOS Circuit and its Components		www.youtube.com/watch?v=Ado4CD7jd68&list=PLgwJf8NK-2e4TZ2RJa_GTZEop1rcDqUQQ	
3.	Module 3 Develop Function Design of SOC Module	Unit 3.1 - Requirements for Designing Function of SoC Module	System-on-Chip (SoC)	70	www.youtube.com/watch?v=-Yczb63-aFU	
		Unit 3.2 - Implementation of Designing Function of SoC Module	Hardware Description Language		www.youtube.com/watch?v=l1J_3fmCqRE	

Annexure - QR Code

Serial No.	Module No.	Unit Number	Topic Name	Page No.	URL	QR Code
		Unit 3.2 - Implementation of Designing Function of SoC Module	IP Core Block and its use in Design	70	www.youtube.com/watch?v=CJ-wd7o2asM	
4.	Module 5 Basic Health and Safety Practice	Unit 5.2 Fire Safety Practices	Fire Safety Practices	148	www.youtube.com/watch?v=ReL-DM9xhpI	
		Unit 5.4 Effective Waste Management Practice	Effective Waste Management Practice		www.youtube.com/watch?v=cqJ-ZM4UZNk	
5.	Employability Skills				https://www.skillindiadigital.gov.in/content/list	

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