KONERU LAKSHMAIAH EDUCATION FOUNDATION
(Deemed to be University estd, u/s, 3 of the UGC Act, 1956)
(NAAC Accredited "A++" Grade University)
Green Fields, Guntur District, A.P., India – 522502
Department of Basic Engineering Science - II

I B.Tech. II Semester – CSE / AI & DS / ECE / EEE / CS & IT / IOT

A.Y.2024-25 - EVEN SEMESTER

Digital Design and Computer Architecture (23EC1202)

CO – 1: Combinational Digital Logic Circuits

Session 7: Encoders & Decoders

1. Course Description (Description of the subject):

The course on "Digital Design and Computer Architecture" provides a comprehensive exploration of the foundational principles in digital design process and computer organization. Students explore the concepts of combinational and sequential circuits, memory circuits. The curriculum extends to the Basic computer architecture concepts, memory hierarchies, and input/output fundamentals, fostering a deep understanding of computer organization. Through practical projects and simulations, students develop the skills to design and implement digital circuits. Graduates emerge with a robust skill set, ready to embark on careers in hardware design, computer architecture, and related fields, equipped to contribute to the ever-evolving landscape of digital technology.

2. Aim of the Course:

The course aims to equip students with the knowledge and skills related to:

i. Proficiency in designing and optimizing Combinational and Sequential Circuits using Boolean algebra and programmable logic devices with a solid foundation in digital design.

ii. Skill development using hands-on experience in designing digital circuits which includes latches, flip-flops, and counters in combination with memory, registers, and timing and sequence control modules using hardware & modeling tools.

iii. Explore the architecture of modern computers, including the organization and structure of central processing units, memory systems, and input/output interfaces.

iv. Bridge theoretical concepts with real-world applications by examining case studies and examples of digital design and computer architecture in modern computing systems.

Overall, the aim of the course is to prepare the student well-equipped to apply their knowledge to the design and analysis of digital systems and computer architectures, preparing them for careers in areas such as hardware design, computer engineering, and embedded systems development.

3. Instructional Objectives (Course Objectives):

The course objectives for "Digital Design and Computer Architecture" typically include:

i. To Understand and apply foundational concepts in digital design which results in proficiency over designing and analyzing combinational and sequential logic circuits.

ii. To Gain hands-on experience with industry-standard simulation and modeling tools, for verifying and testing digital designs.

iii. To analyze the architecture of a computer system, including the organization and operation of the CPU, memory hierarchy, and input/output subsystems.

iv. To apply digital design and computer architecture principles to solve real-world engineering problems and challenges by reinforcing theoretical knowledge with hands-on experience.

4. Learning Outcomes (Course Outcomes):

i. Able to build the combinational and programmable digital logic circuits using logic gates and optimization methods.

ii. Able to construct the sequential and memory circuits using flip-flops, demonstrating a comprehensive understanding of the principles governing clocked sequential logic.

iii. Able to organize computer architecture and instructions sequence through a grasp of the foundational principles that govern the organization and functioning of a computer system.

iv. Capable of modeling Memory Architecture and I/O Organization modules proficiently.

v. Able to develop and analyze the computer architecture modules using basic combinational, sequential and memory logics.

5. Module Description (CO - 1 Description):

The module covers essential topics in digital electronics, starting with Boolean algebra and progressing to the representation and optimization techniques of digital logic using SOP/POS forms. Students will delve into the design of key components such as adders, subtractors, multiplexers, de-multiplexers, decoders, and encoders. The module introduces the concept of reversible gates, exploring their unique properties. Additionally, students will gain insights into Programmable Logic Devices (PLDs) like PROM, PAL, and PLA, understanding their design principles. The implementation of Complex Programmable Logic Devices (CPLDs) with macrocells and Field-Programmable Gate Arrays (FPGAs) featuring Configurable Logic Blocks (CLBs) and Look-Up Tables (LUTs) will be covered. Practical applications of these digital logic modules in various scenarios will be emphasized, providing students with a comprehensive understanding of digital electronics and its real-world applications.

6. Session Introduction:

Encoders and decoders are essential components in digital electronics, facilitating the conversion of information between different formats and codes. Encoders take multiple input lines and encode them into fewer output lines, simplifying data representation for transmission or processing. Conversely, decoders perform the inverse operation by taking a binary input and producing a specific output pattern, expanding the input into multiple output lines for various applications such as memory address decoding. Together, these devices play a crucial role in data conversion tasks, ensuring efficient data handling and accurate communication within digital systems.

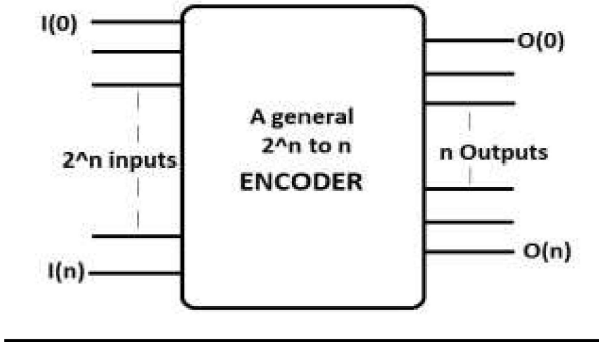
7. Session Description:

7.1 Encoder

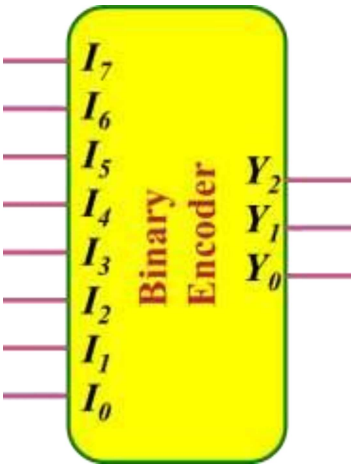
In digital circuits, an encoder is a fundamental component responsible for converting information from one format or code to another. Specifically, an encoder typically takes multiple input signals and encodes them into a smaller number of output lines, effectively reducing the amount of data required to represent the input information. Encoders are commonly used in various applications where data aggregation, simplification, or transmission efficiency is crucial. For instance, in digital communication systems, encoders are employed to compress and encode data before transmission, reducing bandwidth requirements and improving data transmission

efficiency. Additionally, encoders find applications in address encoding for memory devices, where they convert a set of input address lines into a binary code for selecting specific memory locations. Overall, encoders play a vital role in digital circuits by enabling the efficient conversion and processing of information.

- It has maximum of 2n input lines and 'n' output lines.
- It will produce a binary code equivalent to the input, which is active High.
- Therefore, the encoder encodes 2n input lines with 'n' bits.

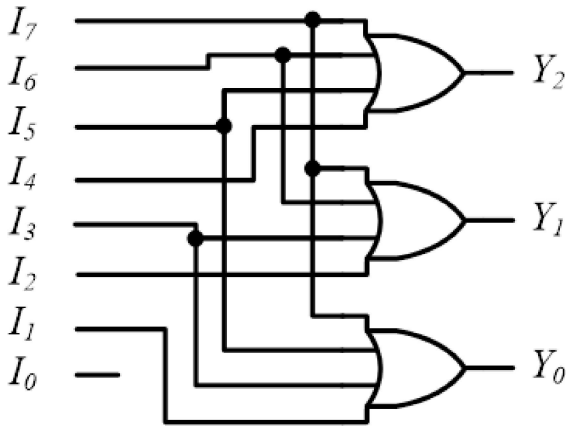


Example: 8 to 3 Encoder



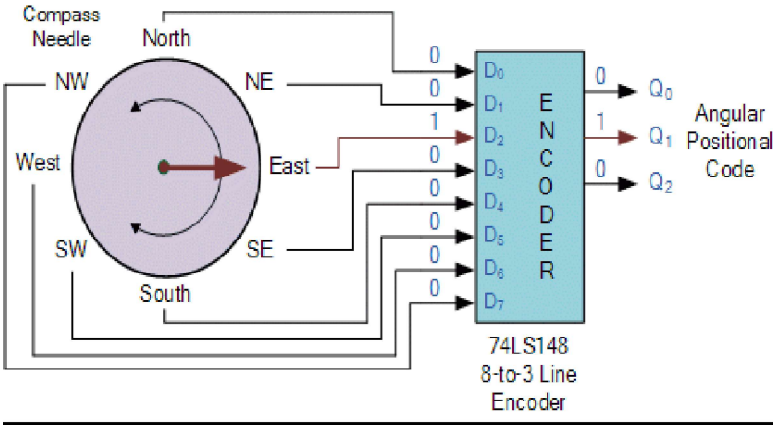
I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0	Y_2	Y_1	Y_0
0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	1
0	0	0	0	0	1	0	0	0	1	0
0	0	0	0	1	0	0	0	0	1	1
0	0	0	1	0	0	0	0	1	0	0
0	0	1	0	0	0	0	0	1	0	1
0	1	0	0	0	0	0	0	1	1	0
1	0	0	0	0	0	0	0	1	1	1

$$Y_2 = I_7 + I_6 + I_5 + I_4$$
$$Y_1 = I_7 + I_6 + I_3 + I_2$$
$$Y_0 = I_7 + I_5 + I_3 + I_1$$



Application of Encoder

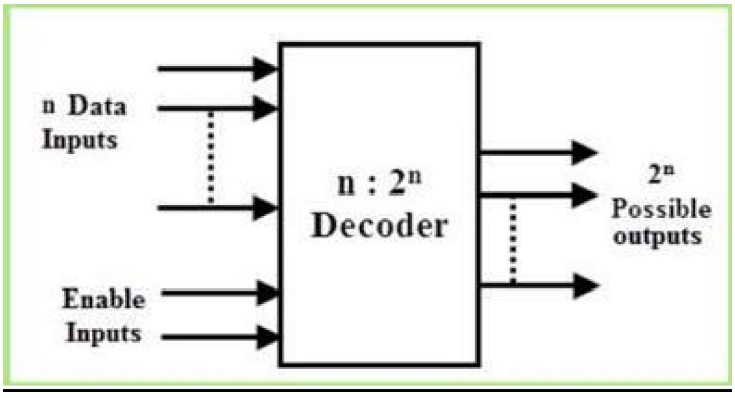
The 74LS148 encoder can serve as a valuable component in a direction navigator system, aiding in the conversion of directional inputs into a simplified code for efficient processing. In this application, directional inputs from sensors or user interfaces, such as north, south, east, and west, can be fed into the encoder's input lines. The encoder then converts these directional signals into a binary or other encoded format suitable for further processing by the navigation system. By utilizing the 74LS148 encoder, the direction navigator can effectively reduce the complexity of input signals and streamline the navigation algorithm, enhancing the system's responsiveness and accuracy. This application highlights the versatility of the 74LS148 encoder in simplifying input data for various digital systems, including navigation and control applications.



Compass Direction	Binary output		
North	0	0	0
North-East	0	0	1
East	0	1	0
South-East	0	1	1
South	1	0	0
South-West	1	0	1
West	1	1	0
North-West	1	1	1

7.2 Decoder

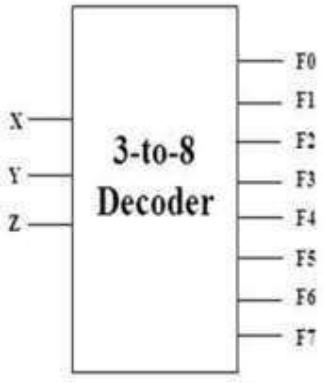
- A **Decoder** is a combinational circuit that converts binary information from input lines to unique output lines.
- **Decoder** is an electronic device used to convert digital signal to an analogue signal.
- Allows single input line and produces multiple output lines.
- Decoders are used in many communication projects that are used to communicate between two devices.
- Decoder has 'n' input lines and maximum of 2^n output lines.
- For example, if we give 2 inputs that will produce 4 outputs by using 4 by 2 decoder. If we give 3 inputs that will produce 8 outputs by using 8 by 3 decoder
- Apart from the Input lines, a decoder may also have an Enable input line.



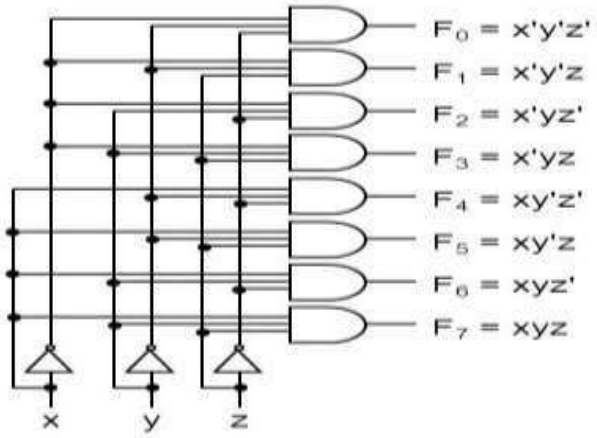
3 to 8 line decoder:

- This decoder circuit gives 8 logic outputs for 3 inputs and has a enable pin.
- It takes 3 binary inputs and activates one of the eight outputs.
- **3 to 8 line decoder circuit** is also called as binary to an octal decoder.

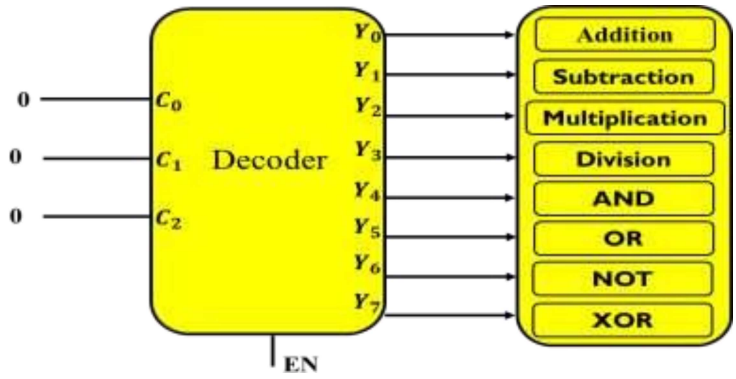
  Block diagram and the truth table which is shown below.



X	Y	Z	F7	F6	F5	F4	F3	F2	F1	F0
0	0	0	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	1	0
0	1	0	0	0	0	0	0	1	0	0
0	1	1	0	0	0	0	1	0	0	0
1	0	0	0	0	0	1	0	0	0	0
1	0	1	0	0	1	0	0	0	0	0
1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	0	0	0	0	0	0	0



Application of decoder:

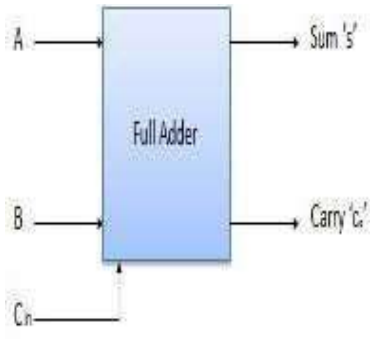


Combinational Logic Implementation Using Decoder:

A decoder takes input lines and has output lines. External OR gates that form their logical sums, can be used to form a circuit of any boolean function.

For example, if we need to implement the logic of a full adder, we need a 3:8 decoder and OR gates. The input to the full adder, first and second bits and carry bit, are used as input to the decoder. Let x, y and z represent these three bits. Sum and Carry outputs of a full adder have the following truth tables

The following circuit diagram shows the implementation of Full adder using a 3:8 Decoder and OR gates.

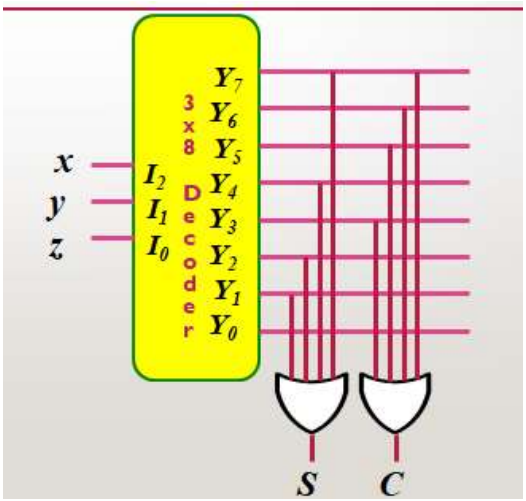


A	B	C_{in}	Sum	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

(Full Adder)

S (x, y, z) = ∑ m (1, 2, 4, 7)

C (x, y, z) = ∑ m (3, 5, 6, 7)



8. **SAQ's – Self Assessment Questions:**

1. **What is the primary function of an Encoder?**

    a) To combine multiple inputs into one output

    b) To decode digital signals into analog signals

    c) To convert digital data into a coded form

    d) To amplify signals

2. **How many input lines are required for a 4-to-2 Encoder?**

    a) 2

    b) 3

    c) 4

    d) 8

3. **What is the configuration of a Decoder?**

    a) One input, multiple outputs

    b) Multiple inputs, one output

    c) Multiple inputs, multiple outputs

    d) One input, one output

4. **In a 2-to-4 Encoder, if the input is 01, which output line will be active?**

    a) Output 0

    b) Output 1

    c) Output 2

    d) Output 3

9. **Terminal Questions:**

- Draw the truth table of a 8:3 encoder.
- Name any two practical applications where an encoder is commonly used.
- Design a 8-to-3 encoder in digital circuitry including the input, output lines and truth table.
- Sketch the 3-to-8 decoder in digital circuitry and examine its functionality with the help of truthtable and logic diagram.
- Design a Full Adder circuit utilizing an appropriate decoder and OR gates.

10. Glossary:

An encoder is a digital device that takes multiple input signals and converts them into a simpler, typically binary, output code, effectively reducing the amount of data required to represent the input information. Conversely, a decoder performs the reverse function by taking a binary input code and producing a specific output pattern or set of signals. Encoders and decoders are essential components in digital systems for data conversion tasks, such as signal processing, data transmission, and address decoding in memory systems, ensuring efficient data handling and accurate communication within digital circuits.

11. References books:

- Computer System Architecture by M. Moris Mano
- Fundamentals of Digital Logic with Verilog HDL by Stephen Brown and ZvonkoVranesic

12. Sites and Web links:

- https://www.prepbytes.com/blog/digital-electronics/difference-between-encoder-and-decoder/
- https://www.geeksforgeeks.org/difference-between-encoder-and-decoder/