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 11: Reversible Gates

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.

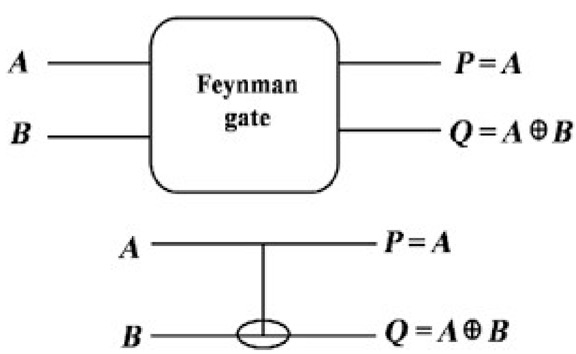
6. **Session Introduction:**

A reversible logic gate is a type of digital logic gate that operates in such a way that its input values can be uniquely determined from its output values, and vice versa. The primary characteristic of a reversible logic gate is that it satisfies the reversibility condition, ensuring a one-to-one mapping between input and output states. This reversibility property is crucial for minimizing energy dissipation in computation, making reversible logic gates valuable in the development of energy-efficient computing systems.

7. **Session Description:**

7.1 Feynman Gate

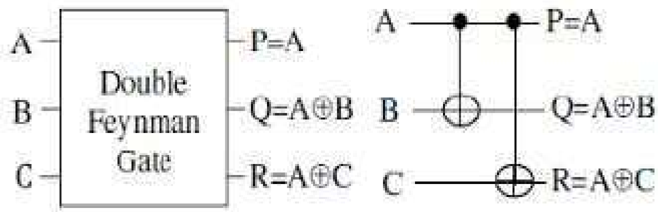
Feynman gate is a 2*2 one through reversible gate as shown in figure. The input vector is I (A, B) and the output vector is O (P, Q). The outputs are defined by P = A, Q = A $\oplus$ B. Quantum cost of a Feynman gate is 1. Feynman Gate (FG) can be used as a copying gate. This gate is useful for duplication of the required outputs.



A	B	P	Q
0	0	0	0
0	1	0	1
1	0	1	1
1	1	1	0

7.2 Double Feynman Gate (F2G)

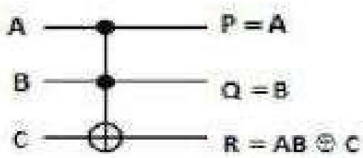
Figure shows a 3*3 Double Feynman gate. The input vector is I (A, B, C) and the output vector is O (P, Q, R). The outputs are defined by $P = A$, $Q = A \oplus B$, $R = A \oplus C$. Quantum cost of double Feynman gate is 2.



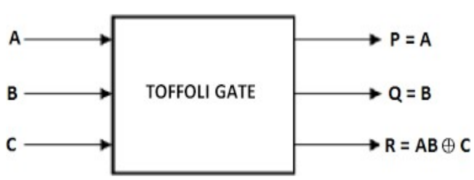
A	B	C	P	Q	R
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	1	1	1
1	0	1	1	1	0
1	1	0	1	0	1
1	1	1	1	0	0

7.3 Toffoli Gate

Fig shows a 3*3 Toffoli gate. The input vector is I (A, B, C) and the output vector is O(P,Q,R). The outputs are defined by $P=A$, $Q=B$, $R=AB \oplus C$. Quantum cost of a Toffoli gate is 5.

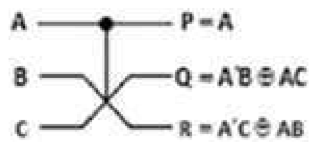


Input			Output		
A	B	C	P	Q	R
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	1	0	0
1	0	1	1	0	1
1	1	0	1	1	1
1	1	1	1	1	0



7.4 Fredkin Gate

Fig shows a 3*3 Fredkin gate. The input vector is I (A, B, C) and the output vector is O(P, Q, R). The output is defined by P=A, Q=A′B⊕AC and R=A′C⊕AB. Quantum cost of a Fredkin gate is 5.



A	B	C	P	Q	R
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	1	0
0	1	1	0	1	1
1	0	0	1	0	0
1	0	1	1	1	0
1	1	0	1	0	1
1	1	1	1	1	1

7.5 Applications of Reversible gates

Reversible computing may have applications in computer security and transaction processing

1. Low power CMOS
2. Quantum computer
3. Nanotechnology
4. Optical computing
5. Design of low power arithmetic and data path for digital signal processing (DSP)
6. Field Programmable Gate Arrays (FPGAs) in CMOS technology for extremely low power, high testability and self-repair

8. SAQ’s – Self Assessment Questions:

1. The output is high if either of the input is high. The statements represents
   I. NAND Gate
   II. OR Gate
   III. AND Gate
   IV. **EX-OR Gate**
2. Which one of the following is the reversible process**?**
   I. Heat Transfer through an infinitesimal temperature difference
   II. Throttling Process

III. Free Expansion
IV. More than one of the above

9. Summary:

Reversible gates can be used in regular circuits realizing Boolean functions. In the same way it is possible to construct multiple-valued reversible gates having similar properties. The applications in digital circuits like a Timer/Counter, building reversible ALU, reversible processor etc.

10. Terminal Questions:

i. Describe the concept of reversible gates.
ii. List out the advantages and applications of reversible logic gates.
iii. Analyze the functioning of Feynman logic gate.
iv. Summarize advantages and disadvantages of reversible logic gates.

11. Glossary:

Reversible logic gates has ability to to reduce the power dissipation which is the main requirement in low power VLSI design. It has wide applications in low power CMOS and Optical information processing, DNA computing, quantum computation and nanotechnology. Because, energy will not be dissipated from a system as long as the system allows the reproduction of the inputs from observed outputs. Reversible logic supports the process of running the system both forward and backward. This means that reversible computations can generate inputs from outputs and can stop and go back to any point in the computation history.

12. References books:

1. H. r. bhagyalakshmi, M. k. venkatesha," an improved design of a multiplier using reversible Logic gates" International Journal of Engineering Science and Technology Vol. 2(8), 2010, 3838-3845.

2. Thapliyal H, M. B.Ss hrinivas." A New Reversible TSG Gate and Its Application for Designing Efficient Adder Circuits". Centre for VLSI and Embedded System Technologies International Institute of Information Technology, Hyderabad, 500019, India

13. Sites and Web links:

https://www.academia.edu/34928486/Introduction_to_Reversible_Logic_Gates_and_its_Application