Digital Logic Design

Code: EE-221 **Credit Hours:** 3- 1

Course Description

Digital Logic Design is a one-semester course taken by Electrical Engineering students during the second year of their engineering program. This course introduces the logic operators and gates to lay the framework for strengthening the basic understanding of computer building blocks. Both combinational and sequential circuits are studied in this course along with their constituent elements comprising Arithmetic circuits, Comparators, Decoders, Encoders, and Multiplexers, Tristate gates as well as Latches, Flip-flops, Counters and Registers. It lays down foundations for advanced studies in Microprocessor Systems to be taught in the following semester.

Text Book:

Digital Design with an Introduction to the Verilog HDL, VHDL, and SystemVerilog(Sixth edition) by M. Morris Mano and Michael Ciletti/Fundamentals of Digital Logic with Verilog Design (Third Edition) by Stephen Brown

Reference Books:

1. Digital Fundamentals (Eleventh Edition) by Floyd
2. Logic and Computer Design Fundamentals (Fourth Edition) by M. Morris Mano and Charles R. Kime
3. Fundamentals of Logic Design (Sixth Edition)by Charles H. Roth Jr
4. Digital Systems: Principles and Applications (Tenth Edition) by TocciWidmer
5. Contemporary Logic Design (Second Edition) by Randy H. Katz

ASSESSMENT SYSTEM FOR THEORY

Quizzes	10-15%
Assignments	5-10%
Mid Terms	30%
ESE	50%

ASSESSMENT SYSTEM FOR LAB

Lab Work and Report	70-80%
Lab ESE/Viva	20-30%

Teaching Plan

Week No	Topics	Learning Outcomes
1.	Introduction: Introduction to Digital Systems, Number Systems: Binary, Octal, Decimal and Hexadecimal Numbers and Base Conversions, Complements: Subtraction of Unsigned Numbers using Complements.	Motivation for Studies. Familiarize students with number systems and base conversions. Learn arithmetic operations of unsigned numbers supported by logic circuits
2.	Signed Binary Numbers Arithmetic: Addition and Subtraction of Signed Binary Numbers. Binary Codes. Binary Storage and Registers. Binary Logic: Definition of Binary Logic and Logic gates.	Perform arithmetic operations with signed numbers. Study different binary codes.
3.	**Introduction**: Boolean Algebra: Basic and Axiomatic Definition of Boolean Algebra; Two-Valued Boolean Algebra. Basic Theorems and Properties of Boolean Algebra. Boolean Functions; Canonical and Standard Forms.	Introduction to Boolean Algebra Familiarize with theorems and postulates of Boolean Algebra Study a Boolean function and its representations
4.	Other Logic Operations. Digital Logic Gates and Integrated Circuits.	Understand different Logic operations, digital logic gates and Integrated Circuits (ICs).
5.	**Introduction**: The K-Map Method; Two, Three, Four, and Five -Variable K- Maps. Sum-of-Products (SOP) simplification using map method. Essential and Non-essential Prime Implicants.	Introduction to map method Perform simplification of Boolean functions in sum-of-products (SOP) using map method.
6.	Product- of- Sums (POS) Simplifications and Don't Care conditions. Quine-McCluskey Minimization algorithm (Tabulation). NAND and NOR implementations.	Learn functions simplification in product-of-sums (POS) Perform functions simplification in sum-of-productd (SOP) using tabulation method. Implement functions using NAND and NOR gates only.
7.	Other Two-Level implementations. Exclusive-OR function: Parity Generation and Checking.	Implement functions using any combinations of AND, NAND, OR, and NOR gates. Study Exclusive-OR function and its applications.
8.	**Introduction**: Combinational Circuits: Design Procedure with Code Conversion Example. Combinational Circuits: Analysis Procedure. Design of 4-bit Ripple Carry and Carry Look-ahead Adder-Subtractor using Full Adders. Overflow	Introduction to combinational logic circuits Study design and analysis of MSI logic circuits. Learn the function of a half and full adder and using these components, design 4-bit Adder circuit. Understand overflow and its significance in arithmetic operations.
9.	**Mid Term Exam**	

10.	Decimal Adder. Binary Multiplier. Magnitude Comparator. Decoders/De-multiplexers.	Study different commonly used combinational logic circuits.
11.	Encoders. Multiplexers and Tri-State Gates.	Familiarization with different data selection, buffering, and encoding devices.
12.	**Introduction**: Sequential Circuits and different types of Latches and Flip-Flops.	Learn basic primitive storage devices like Latches and Flip-Flops.
13.	Analysis of Clocked-Sequential Circuits; State Equations, State Table, State Diagram, and Flip-Flop input equations. Analysis with D Flip-Flops, JK Flip-Flops, and T Flip-Flops. Mealy and Moore Models. Mealy-Moore Conversion Procedure.	Analyze clocked sequential circuits that consist of D, JK, and T Flip-Flops. Study Mealy and Moore Finite State Machines (FSM).
14.	State Reduction using Row Matching and Implication Table Techniques. State Assignment Method. Design Procedure-Synthesis using D, JK, and T Flip-Flops.	Study design optimization methods. Design clocked sequential circuits using different types of Flip-Flops.
15.	**Introduction**: Registers with Parallel Load. Shift Registers; 4-Bit Shift Register; Serial Transfer and Serial Addition. 4-Bit Universal Shift Register.	Introduction to registers. Study different types of registers like Registers with parallel load, shift registers, and universal shift registers.
16.	Ripple Counters; Binary and BCD Ripple Counters. Synchronous Counters; Binary and BCD Counters.	Introduction to counters. Study different types of counters like Ripple and Synchronous counters.
17.	Other Counters; Counter with unused States. Ring Counter and Johnson Counter. Simple Arithmetic Logic Unit (ALU), Introduction to FPGA.	Study counters with unused states.
18.	**End Semester Exam**	

Practical:

Experiment No	Description
1	Familiarization of Basic Gates and Digital ICs
2	Introduction to Verilog HDL. Basic language constructs and design entry using Verilog HDL.
3	Design of Simple Practical Circuits
4	Minimization of Boolean Functions and its Hardware implementation.
5	Design of Binary-to-Gray/Gray-to-Binary Code Converter using basic Gates
6	Design a display system of a rolling dice
7	Design of a 2-bit Adder/Subtractor Circuit.
8	Design of Excess-3 to Gray Code Converter using NAND gates
9	Design of a 2-bit Magnitude Comparator
10	Voting Machine Design.
11	Design of 4-bit ALU.
12	Design of BCD-to-Seven segment Decoder with two-digits multiplexed display. (Open Ended Lab)
13	Memory Elements: Latches and Flip-flops
14	Serial Sequence Detector Design
15	Verilog for Sequential Circuits: Digital Combinational Lock
16	Design Project (Complex Engineering Problem)