GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Electrical Engineering / Bio-Medical Engineering

Course / Subject Code: DI02000161

Course / Subject Name: Fundamental of Digital Electronics

w. e. f. Academic Year:	2024-25
Semester:	2nd
Category of the Course:	ESC

Prerequisite:	A Basic Understanding of Electrical Circuits & Fundamentals Concepts of Electronics
Rationale:	Digital electronics plays a vital role in all branches of engineering, particularly in electrical engineering. As digital systems continue to replace analog ones, the diploma engineering pass-outs are required to effectively engage with modern digital technology used across various industries, including consumer electronics, automation and control systems etc. Therefore, the fundamental knowledge of Number Systems, logic gates, basic combinational and sequential logic circuits as well as digital ICs will enable the students to design, interpret and maintain these digital systems. Therefore, this course is intended to provide this funda. Knowledge of digital electronics so that students will be able to tackle the increasing digital landscape of modern technology.

Course Outcomes:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
01	Use number systems and codes for interpreting the working of digital systems.	R, U, A
02	Use logic gates and Boolean Expressions to realize logic circuits.	R, U, A
03	Apply Karnaugh map for optimized circuit implementation.	U, A
04	Build simple combinational circuits based on simplified Boolean expressions.	U, A
05	Recognize Flip-flops as Sequential circuits.	R, U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
2	0	2	3	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weigh-tage
1.	**Unit 1 – Number Systems** 1.1 Analog Vs Digital, Number Systems – Binary, Octal, Decimal, Hexadecimal Numbers 1.2 Conversion of Number from One Number System to Another Number System: Decimal to Other Number Systems and Vice versa 1.3 Conversion of Number between Binary, Octal, Hex. and Vice versa 1.4 Arithmetic Operations with Binary Numbers: Binary Addition, Subtraction, Multiplication and Division 1.5 1's and 2's Complement of Binary numbers. Binary subtraction using 1's and 2's Complement method 1.6 Concepts of Digital codes: Weighted Codes: BCD Code, Non-weighed codes: Gray Code, Excess-3 Code	06	21%
2.	**Unit 2 – Logic Gates & Boolean Algebra** 2.1 Positive & Negative Logic, Logic Gates: NOT, AND, OR, NAND, NOR, EX-OR & EX-NOR: Symbol, Equi. Circuit & Truth-table 2.2 NAND as Universal Gates 2.3 NOR as Universal Gates 2.4 Boolean Logic Operations, Laws of Boolean Algebra 2.5 De-Morgan's Theorems, Simplification of given Boolean equations 2.6 Converting Boolean expressions to logic circuits	06	21%
3.	**Unit 3 – Boolean Function Implementation** 3.1 Boolean Expression: Need for simplification	05	15%

	3.2 Sum of Product (SOP) and Product of Sum (POS) expressions 3.3 Simplification by Karnaugh map method: 2 variable K-map, 3 variable K-map 3.4 4-variable K-map and Don't-Care conditions (Basic Problems)		
4.	**Unit 4 – Basic Combinational Circuits** Arithmetic and Logical Combinational Circuits: Block diagram, Logic diagram, truth table and working: 4.1 Half Adder, Full Adder 4.2 Half Subtractor, Full Subtractor Data Transmission Combinational Circuit: 4.3 Multiplexers (Data Selectors) - 2 to 1 Mux, 4 to 1 Mux, 4.4 Multiplexers (Data Selectors) - 8 to 1 Mux, Applications. 4.5 Demultiplexer (Data Distributors): 1-2, 1-4, 1-8 Demultiplexer 4.6 Encoder: Octal to Binary (8 to 3) & Decimal to BCD Encoder 4.7 Decoder: 2 to 4 Decoder, 3 to 8 Decoder 4.8 Decoder: BCD to Seven Segment Decoder	08	28%
5.	**Unit 5 –Basics of Sequential Circuits** 5.1 Introduction to Sequential Circuits, Comparison between Combinational and Sequential Circuit, Flip-Flips: SR Flip Flop, 5.2 D Flip Flop, T Flip Flop 5.3 JK Flip Flop 5.4 Master Slave JK Flip Flop, Applications of Flip-flops	05	15%
	Total	**30**	**100%**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25 %	**40 %**	**35 %**	**00**	**00**	**00**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Reference Books:

1 "Fundamentals of Digital Circuits", A. Anand Kumar, PHI Learning Pvt. Ltd., 4th edition or latest edition, ISBN-13: 978-81-203-5268-1
2 "Digital Circuits", Dr. Menka Yadav, All India Council for Technical Education (AICTE), latest edition, ISBN-13: 978-81-959863-0-9 [**E-book Available on AICTE e-KUMBH Website**]
3 "Modern Digital Electronics", R. P. Jain, McGraw-Hill Education, 4th edition or latest edition, ISBN-13: 978-0070669116
4 "Digital Principles & Applications", Albert Paul Malvino & Donald P. Leach, McGraw Hill Education, 8th edition or latest edition, ISBN-13: 978-9339203405
5 "Digital Design", M. Morris Mano and Michael D. Ciletti, Pearson Education, 6th edition or latest edition, ISBN-13: 978-1292231167
6 "Digital Electronics: Principles and Applications", Albert Paul Malvino and Jerald A. Bates, McGraw-Hill Education, 8th edition or latest edition, ISBN-13: 978-0073373775
7 "Digital Systems: Principles and Applications", Ronald J. Tocci, Neal S. Widmer, and Gregory L. Moss, Pearson Education, 12th edition or latest edition, ISBN-13: 978-0134220137
8 "Digital Fundamentals", Thomas L. Floyd, Pearson Education, 11th edition or latest edition, ISBN-13: 978-0132737965
9 "Principles of Digital Electronics", K. Meena, PHI Learning Pvt. Ltd., Fourth Printing, 2013
10 "Digital Electronics", Sanjay Sharma, S.K. Kataria & Sons, latest edition
11 "Digital Electronics", Dr. B.R. Gupta & V. Singhal, S.K. Kataria & Sons, latest edition
12 "Digital Electronics (for Polytechnics)", Pratima Manhas & Shaveta Thakral, S.K. Kataria & Sons, latest edition

(b) Open-source software and website:

1. **Circuit Simulation Websites:**
   a. https://www.tinkercad.com/
   b. https://wokwi.com/
   c. https://circuitverse.org/
   d. https://www.circuitlab.com/editor/
2. **Various Software**: Psim, Matlab 2011a, Logic.ly, Logisim, Digital-Works, Multisim, Proteus, AMD Xilinx Vivado (Standard Edition), eSim (Oscad), Electronics Workbench etc.
3. **Datasheets Websites:** www.alldatasheet.com , www.datasheetcafe.com
4. **Virtual Labs**:
   Virtual Labs Phase I: www.vlab.co.in
   a. DE-1 Lab: https://de-iitr.vlabs.ac.in/List%20of%20experiments.html

b. DE-2 Lab: https://de-iitg.vlabs.ac.in/List%20of%20experiments.html
c. DE Circuits Lab: https://dec-iitkgp.vlabs.ac.in/List%20of%20experiments.html
d. DE Logic Design Lab: https://dld-iitb.vlabs.ac.in/List%20of%20experiments.html
e. Hybrid Electronics Lab: https://he-coep.vlabs.ac.in/List%20of%20experiments.html
f. Digital Applications Lab: https://da-iitb.vlabs.ac.in/List%20of%20experiments.html
g. ADE I Lab: https://ade-iitr.vlabs.ac.in/List%20of%20experiments.html
h. ADE II Lab: https://ade2-iitr.vlabs.ac.in/List%20of%20experiments.html

Virtual Labs Phase II: http://vlabs.iitkgp.ac.in/vlt/project.html

i. DE Circuits Lab: http://vlabs.iitkgp.ac.in/dec/#

Virtual Labs Phase III: http://vlabs.iitkgp.ac.in/vlt/phase3_newlab.html

j. Digital Logic Circuit Design Lab: http://vlabs.iitkgp.ac.in/dlcd/loe.html

5. **E-books**: AICTE e-KUMBH Books: https://ekumbh.aicte-india.org/allbook.php
6. **NPTEL Course and Video Channels:**
   a. NPTEL Courses Home: https://nptel.ac.in/courses , www.youtube.com/nptelhrd
   b. DE Circuits: https://nptel.ac.in/courses/108105132 , https://tinyurl.com/4myfp3vx
   c. NPTEL Course - Digital Circuits: https://nptel.ac.in/courses/108105113
   d. AICTE mapped courses on SWAYAM: https://nmeict.ac.in/?page_id=1466, https://nmeict.ac.in/?page_id=3937, NMEICT: https://nmeict.ac.in/#
   e. GTU Lectures: https://lectures.gtu.ac.in/listview.aspx?br=09&course=DI
7. **Other Learning Websites**:
   a. https://www.tutorialspoint.com/digital-electronics/index.htm
   b. https://www.electronicshub.org/tutorials/
   c. https://www.javatpoint.com/digital-electronics
   d. https://www.electrically4u.com/category/digital-logic-circuits/
   e. https://www.daenotes.com/electronics/digital-electronics
   f. https://www.geeksforgeeks.org/digital-electronics-logic-design-tutorials/#blg/?ref=ghm
   g. https://archive.nptel.ac.in/courses/108/106/108106177/
   h. https://learn.circuitverse.org/
   i. https://www.khanacademy.org/computing/computers-and-internet
   j. www.instructables.com/search/projects/circuits?q=Digital+Electronics&projects=all
   k. https://ocw.mit.edu/
   l. https://www.electronics-tutorials.ws/
   m. https://www.allaboutcircuits.com/
   n. https://study.com/ , https://www.sparkfun.com/

o. www.slideshare.net/
p. www.asic-world.com/digital/tutorial.html
q. https://electrical-engineering-portal.com/technical-articles/categories

Suggested Course Practical List:

Sr. No.	Practical Outcome/Title of experiment	Unit No.	CO	Approx. Hours required
1	Convert Number from One Number system to another and Implement Various Operations on it.	1	1	4
2	Build a circuit to Convert 4-bit Binary to Gray Code using logic gates.	1	1	2
3	Analyze specifications of digital logic ICs from datasheets to understand pin configurations, truth tables, ratings and applications.	2	2	2
4	Verify the truth tables of the different Logic Gates.	2	2	2
5	Build and test basic Gates using NAND Universal Gate.	2	2	2
6	Build and test basic Gates using NOR Universal Gate.	2	2	2
7	Build the logic circuit on breadboard to verify De Morgan's theorems.	2	2	2
8	Implement and realize Boolean Expressions with Logic Gates.	2	2	2
9	Simplify given Boolean expression using K-map and design Logic Circuit using basic logic gates.	3	3	4
10	Simplify given Boolean expression using K-map and design Logic Circuit using Universal gates.	3	3	4
11	Build and test Half Adder Circuit.	4	4	2
12	Build and test Full Adder Circuit.	4	4	2
13	Build and test Half Subtractor Circuit.	4	4	2
14	Build and test Full Subtractor Circuit.	4	4	2
15	Build and test Eight channel Multiplexer and Demultiplexer.	4	4	4
16	Build and test the 4-bit Decoder circuit.	4	4	2
17	Build and test the 4-bit Encoder circuit.	4	4	2
18	Simulate any digital logic circuit with the help of simulation software.	4	4	2
19	Build and test the working of the R-S Flip-Flop.	5	5	2
20	Build and verify the truth table of D Flip-Flop.	5	5	2
21	Build and verify the truth table of JK Flip-Flop.	5	5	2
22	Build and verify the truth table of master-slave JK Flip-Flop.	5	5	2
				30Hrs

List of Laboratory / Learning Resources Required:

1. Digital Logic trainer Kit
2. Bread board with connecting wires & various logic input/output facilities (2 Power, 2 ground rails, 2 circuit areas, contact points > 200, Volt > 15 V, Current > 1 A)
3. Batteries, Connecting Wires/ Jumper Wires, LEDs, Resistors, Inductors and Capacitors of various range and types
4. Digital IC tester
5. Digital Storage Oscilloscope
6. Digital Function Generators
7. Digital Multimeter (3-1/2-digit display, 9999 counts digital multimeter measures: Vac, Vdc (1000V max), I_{dc}, I_{ac} (10-amp max), Resistance (0 - 100 MA), Capacitance and Temperature measurement)
8. Variable DC Power Supply (0- 30V, 0-2 A, 0-5 A, SC protection, display for voltage and current.)
9. Electronic Work Bench: Bread Board 840-1000 contact points, Positive and Negative power rails on opposite side of the board, 0-30 V, 2 Amp Variable DC power supply, Function Generator, 0-2MHz, CRO 0-30MHz Digital Multimeter.
10. Various ICs like:
    - Logic Gate ICs like AND (7408), OR (7432), NOT (7404), NAND (7400), NOR (7402), EX-OR (7486), and EX-NOR (74266)
    - Combinational Circuit IC like Multiplexer (74151, 74153), Demultiplexer (74138, 74139), Encoder (74147, 74148), Decoder (7442, 7447), Adder/Subtractor (7483, 74283), Comparator (7485)
    - Sequential Circuit ICs Like Flip-Flops (7474, 7476), Counters (7490, 7493, 74160, 74163), Shift Registers (7495, 74164, 74165), Latches (7475, 74373)

Suggested Project List:

(a) Sample Project Kit: For Implementing Basic Project, each student themselves can make a practical kit containing the essential components required to build and test basic digital electronic circuits. The kit will include….

- A plastic storage box which contains a breadboard for quick circuit assembly,
- Jumper wires for easy circuit connections, a 9V battery as power supply,

- Push buttons for user input control, A Few LEDs for visual output, and a small buzzer can be included for audio signaling in circuit testing.
- Any of the necessary commonly used digital ICs, such as Logic Gate ICs (AND, OR, NOT and NAND gates (e.g., 7400 series)) for creating basic digital circuits. Additionally, flip-flop ICs and Counter ICs can be taken if required.
- Along with these, the kit can contain various resistors (e.g., 1kΩ, 4.7kΩ, and 10kΩ) to provide the necessary pull-up and current-limiting functionality and a few capacitors to introduce timing elements.

(b) List of Suggested Projects: Using Above All, Majority of the suggested Projects given below can be implemented Easily under guidance of teacher. Suggested Project List as given below:

1. Prepare a Comparison Chart Illustrating All Number Conversion (with 1 Ex.) in Single Chart.
2. Prepare Number Conversion Solution Bank for All Practice Problem Given in Any book.
3. Make (1) Binary to Grey Code Conversion and (2) Grey to Binary Code Conversion Circuit.
4. Make (1) 3-byte odd parity generator, (2) 4-byte odd parity generator and Even parity generator circuit.
5. Make Chart on (1) Code Conversion (2) ASCIII code and EBCDIC code.
6. Make a Chart showing Pulsed Operation of Logic Gates. [Outputs of different gates against different Inputs (Square wave, etc having different frequencies) waveforms are given as Input.] [You can also Analyze Drawback of Combinational Circuits and Need of Memory Element that can be Fulfilled using Flipflop.] (Reference Book 1, Chapter 4)
7. Logic Gate Based Practical Application Circuits.
8. Simulate and/or Implement Logic Circuits to Verify Laws Boolean Algebra or De-Morgan's Theorems.
9. Simulate (On Tinker cad or Wokwi) and/or Implement Logic Circuit on Breadboard for Boolean expression. Ex. $Y= A\bar{B}+\bar{A}B+C$
10. Simulate (On Tinker cad or Wokwi) and/or Implement Logic Circuit on Breadboard using Universal gates Ex. (1) AND gates using NAND gates. (2) OR gates using NAND gates (3) AND gates using NOR gates. (4) OR gates using NOR gates.
11. Simulate (On Tinker cad or Wokwi) and/or Make Circuit on Breadboard of Different Combinational Circuits. Ex. (1) Adder, Subtractors using All Available Options (2) All Multiplexer (3) All Demultiplexer (4) Octal to Binary (8 to 3) Encoder (5) 2 to 4 decoder (6) common anode 7 segment display circuit to display 0-9 etc.
12. Prepare a Chart on Comparison of All Flip-Flops.
13. Prepare a Chart on Detailed Working / Operation of Each Flipflop showing Explanation with Detailed Table showing Current and Next State Values.

14. Simulate (On Tinker cad or Wokwi) and/or Make Circuit on Breadboard of Various Sequential Circuits. Ex. (1) All Shift Registers (2) All Up / Down Counters, (4) IC - 7490 Decade Counter and Many More.
15. Collection and Compilation Report on Different Digital ICs Datasheets. (ICs List Available in Appendix of Reference Book 1)
16. Prepare a report on different IC packages and mention different scales of integration. Also Compare Performance of TTL and CMOS based ICs and their Identification.
17. **K-map based Logic Circuit Implementation Problem**: A staircase light is controlled by two switches; one is at the top of the stairs and the other at the bottom of the stairs.
    (a) Make a truth table for this system.
    (b) Write the logic equation in the SOP form.
    (c) Realize the circuit using AOI logic.
    Realize the circuit using minimum number of (i) NAND gates, (ii) NOR gates. (**Example Problem is Given, Similar Problems in Reference Book 1 Chapter 6**)
18. K-map based Logic Circuit Implementation Problem: A safe has 5 locks v, w, x, y, and z; all of which must be unlocked for the safe to open. The keys to the locks are distributed among five executives in the following manner.
    Mr. A has keys for locks v and x.
    Mr. B has keys for locks v and y.
    Mr. C has keys for locks w and y.
    Mr. D has keys for locks x and z.
    Mr. E has keys for locks v and z.
    (a) Determine the minimal number of executives required to open the safe.
    (b) Find all the combinations of executives that can open the safe; write an expression f(A, B, C, D, E) which specifies when the safe can be opened as a function of what executives are present. (c) Who is the essential executive?

(c) Sample Project Report Format: Sample Project Report can have any of following elements (Any, if Applicable) such as: Problem Statement Analysis, Logic Expression Development (Using K-map), Logic Simplification (If Possible), Designed Logic Circuit, Circuit Analysis using Truth Table (With all possible input combinations & Expected Outputs), Rough Connection Diagram, Components Required, Pin Diagram of Required ICs, Result/ Output Analysis.

Suggested Activities for Students:

Beyond classroom and laboratory learning, the following co-curricular activities are recommended to enhance the achievement levels of various outcomes in this course. Students are encouraged to undertake these activities either individually or in groups and prepare comprehensive reports of approximately five

pages for each activity. Additionally, students should gather and document physical evidence for their portfolios, which could be beneficial during placement interviews:

a) **Make Practical Kit for Circuit Implementation and Undertake Micro-Projects in team/individually:**
   The approach should be as follows: By Learning the fundamental topics covered in the theory syllabus, students are expected to apply these basics in more advanced contexts. This includes implementing circuits such as shift registers, counters, A/D converters and exploring memory units (topics not covered in the syllabus) through reference books for deeper understanding.
   So, making such a practical kit that allows the students to work with real-world components, enhancing practical understanding of digital electronics by engaging in hands-on learning. By working directly with real-world components, students can enhance their understanding of core digital electronics principles, such as logic gates, circuit design, and troubleshooting. The hands-on experience gained from assembling and experimenting with circuits also helps to reinforce theoretical concepts, particularly logic gates, timing diagrams, and circuit behavior. The kit encourages independent experimentation, allowing students to test their knowledge, troubleshoot circuits, and apply critical thinking. Furthermore, by enabling the construction of diverse basic circuits, this will encourage creativity and innovation, as students can design, modify, and refine their own projects, laying a solid foundation for more advanced studies in digital electronics.
b) **Chart and Project Model Presentations:** Demonstrate project models or deliver seminars on various topics covered in the course content.
c) **Numerical Problem Solving**: Solve the numerical problems provided by the subject faculty in tutorial and Prepare their solutions Book.
d) **Solve real life problems using logic theory and implement them using digital logic circuits.**
e) **List the ICs used for different logic gates, Flip-flops, Shift registers, Counters with their pin diagram.**

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