GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Instrumentation & Control

Course / Subject Code: DI02017011

Subject Name: Fundamentals of Electrical and Electronic in Instrumentation

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

Prerequisite:	Basic knowledge of Electrical Circuits, Electromagnetism, Semiconductor Physics, and Electronics Components.
Rationale:	The syllabus provides diploma Instrumentation Engineering students with foundational knowledge of electrical and electronic principles, including circuit laws, semiconductors, diodes, transistors, and their applications, essential for understanding and working with instrumentation systems.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
CO-1	Apply basic electrical concepts and laws to analyse and solve simple circuits.	R U A
CO-2	Understand electromagnetism and analyse the working of motors and transformers.	U A
CO-3	Analyze diode properties, illustrate their characteristics, and design rectifier and voltage regulator circuits.	R U A
CO-4	Identify transistor structures, analyze their modes and configurations, and apply transistors as switches and amplifiers in electronic circuits.	U A

**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 Weightage
1	**Basic Electrical Concepts and Circuit Laws**	08	30
	1.1 Basic Electrical Quantities: Charge, Electric Current, Electric Potential, Potential Difference, Electromotive Force (EMF), Power and Energy. **1.2 Introduction to AC and DC:** Definitions and Differences. **1.3 Ohm's Law:** Explanation and Applications in Simple Circuits. **1.4 Basic Circuit Elements:** • **Resistor (R):** Function, Types and Characteristics. • **Inductor (L):** Function and Behaviour in Circuits. • **Capacitor (C):** Function, Types and Applications. **1.5 Kirchhoff's Laws:** Kirchhoff's Current Law (KCL) and Kirchhoff's Voltage Law (KVL). **1.6 Series and Parallel Circuits:** Voltage and Current Division Rules. **1.7 Alternating Current (AC) Fundamentals:** • **AC Waveforms:** Sine, Square, and Triangular Waves. • **AC Parameters:** Cycle, Time period, Frequency, Amplitude, Peak Value, Instantaneous value, Average value, RMS (Root Mean Square) Value, Impedance.		
2	**Basics of Electromagnetism and Electrical Machine Applications**	08	25

	2.1 Definition and Concept of Electromagnetic Energy **2.2 Electric and Magnetic Fields** • **Electric Field Intensity:** Definition, relationship with voltage, and basic formula. • **Magnetic Field Intensity:** Definition, relationship with current, and basic formula. **2.3 Basic Relationship between Electricity and Magnetism** • **Electromagnetic Induction:** Faraday's Law of Electromagnetic Induction and Lenz's Law. • **Statically and Dynamically Induced EMF** • **Self-Inductance and Mutual Inductance:** Concepts of inductance in circuits. **2.4 Laws of electromagnetic forces:** Fleming's Right-Hand Rule & Left-Hand Rule **2.5 Introduction to AC and DC Motors** • **AC Motor:** Construction & working principle of Induction motors (single phase) and their applications. • **DC Motor:** Construction & working principle of DC motors (series and shunt types), and their applications. **2.6 Transformer (Single Phase):** • **Construction & working principle of Transformer** • **Types of Transformers:** Step-up and Step-down transformers. • **Applications**		
3	**Diodes and Their applications**	08	25
	3.1 Introduction to Semiconductors • **Difference between conductors, insulators, and semiconductors.** • **Intrinsic and Extrinsic type (P-type and N-type) Semiconductors.** o Definition and difference between intrinsic and extrinsic semiconductors.		

	○ Role of doping in semiconductor properties (N-type and P-type). • **Carrier Concentration in Semiconductors.** **3.2 Semiconductor Diodes** • **PN Junction Diode:** ○ Construction and symbol of a PN junction diode. ○ The formation of depletion region. ○ Forward Bias and Reverse Bias conditions. ○ V-I Characteristics.		
	3.3 Special Purpose Diodes • **Zener Diode:** Construction, Symbol, working and V-I Characteristics. • **Light Emitting Diode (LED):** Construction, Symbol and Working principle. • **Photodiode:** Construction, Symbol and Working principle. **3.4 Applications of Diodes** **Rectifiers:** • **Half-Wave Rectifier:** Circuit diagram, Working principle and operation. • **Full-Wave Rectifier (Center-Tapped and Bridge rectifier):** Circuit diagram, Working principle and operation. **Zener Diode as a Voltage Regulator:** Circuit diagram and operation.		
4	**Transistors and Their Applications**	06	20
	4.1 Transistor Basics • Basic Structure and Working of NPN and PNP Transistors. • **Transistor Parameters:** Current Gain, Input impedance, Output impedance. **4.2 Modes of Operation of a Transistor:** Cut-off, Active, Saturation. **4.3 Transistor Configurations**		

	• **Common Emitter (CE), Common Base (CB), and Common Collector (CC) transistor configuration:** Circuit diagram, Working and V-I Characteristic. **4.4 Transistor Applications** • **Transistor as a Switch:** Circuit diagram and Working. • **Transistor as an Amplifier (CE):** Circuit diagram and Working.		
	Total	**30Hrs.**	**100 %**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
23	**50**	**27**	**-**	**-**	**-**

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) Books:

Sr.	Title of Book	Author Name	Publication/ISBN
1	Basic Electrical Engineering	D.C. Kulshreshtha	McGraw-Hill Education ISBN: 978-0070707799
2	Basic Electrical and Electronics Engineering	S. K. Bhattacharya	Pearson ISBN: 978-8131505564
3	Electronic Devices: Electron Flow Version	Thomas L. Floyd	Pearson ISBN: 0132678431
4	A text book of Electrical Technology-Vol.1 & 2.	Theraja B. L.	S. Chand Publication ISBN: 978-8121924375
5	Fundamentals of Electrical Engineering and Electronics	B.L. Theraja, A.K. Theraja	S. Chand & Company Ltd. ISBN: 978-8121918254

6	Basic Electronics	Grob, Mitchel E. Schultz	McGraw-Hill Education ISBN: 0073380653
7	Electronic Devices: Electron Flow Version	Thomas L. Floyd	Pearson ISBN: 0132678431
8	Electronic Devices and Circuit Theory	Robert L. Boylestad, Louis Nashelsky	Pearson Education ISBN: 978-9332542603
9	Principles of Electronics	V.K. Mehta, Rohit Mehta	S. Chand Publishing ISBN: 978-8121924504
10	Principles of Electronic Devices and Circuits	A. P. Malvino & David J. Bates	Tata McGraw-Hill Education ISBN: 978-0070668385

(b) Open-source software and website:

Open-Source Software

Software	Description	Link
LTspice	A powerful SPICE-based simulator for analyzing analog circuits and power systems.	LTspice
KiCad	A free, open-source software suite for electronic design automation (EDA).	KiCad
Fritzing	Open-source software for designing simple electronics, including circuits.	Fritzing
Qucs	A circuit simulator with a graphical user interface for analog and digital circuits.	Qucs
SimulIDE	A simple real-time electronics simulator, ideal for Arduino, PIC, and simple circuits.	SimulIDE
EasyEDA	A cloud-based EDA tool that allows students to design, simulate, and share circuits online.	EasyEDA

Educational Websites

Website	Description	Link
All About Circuits	A community-driven site with tutorials, circuit designs, and a forum for electronics.	All About Circuits

Website	Description	Link
Electronics-Tutorials	Free tutorials on electronics, including topics on diodes, transistors, and AC/DC circuits.	Electronics-Tutorials
Tinkercad Circuits	A free, easy-to-use online simulator for building and testing circuits (including Arduino).	Tinkercad Circuits
PhET Interactive Simulations	Offers interactive physics and electronics simulations for students to understand concepts.	PhET Simulations
MIT OpenCourseWare (OCW)	Free online course materials from MIT, including courses on electronics and electromagnetism.	MIT OCW
HyperPhysics	Provides concepts in physics, including electricity and magnetism, with easy-to-understand diagrams.	HyperPhysics

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	CO	Approx. hours required.
1	Measure electric current, potential difference, and power in a circuit using a digital multimeter.	1	1	2
2	Verify Ohm's Law by measuring voltage, current, and resistance in a simple circuit.	1	1	2
3	Investigate the voltage and current division rules in series and parallel circuits.	1	1	2
4	Verify Kirchhoff's Current Law using a simple circuit.	1	1	2
5	Verify Kirchhoff's Voltage Law in a closed loop circuit.	1	1	2
6	Generate and observe sine, square, and triangular waveforms using a signal generator.	1	1	2
7	Measure the amplitude, peak value, RMS value, and frequency of an AC signal.	1	1	2
8	Measure the impedance of a simple RL, RC, and RLC circuit.	1	1	2
9	Measure the inductive reactance and capacitive reactance in AC circuits.	1	1	2
10	Verify Faraday's law by inducing EMF in a coil using a changing magnetic field.	2	2	2

11	Demonstrate the Fleming's right-hand rule for the direction of induced current.	2	2	2
12	Demonstrate Fleming's left-hand rule for the direction of force in electric motors.	2	2	2
13	Measure the voltage and current on both primary and secondary sides of a transformer.	2	2	2
14	Perform open-circuit and short-circuit tests on a transformer to determine its equivalent circuit parameters.	2	2	2
15	To plot the forward and reverse bias V-I characteristics of a PN junction diode and determine its threshold voltage.	3	3	2
16	To plot the V-I characteristics of a Zener diode in reverse bias and determine its breakdown voltage.	3	3	2
17	To construct and test a half-wave rectifier circuit and observe its output waveform.	3	3	2
18	To construct and test a center-tapped full-wave rectifier and observe its output.	3	3	2
19	To construct and analyze a bridge rectifier circuit and measure the output voltage.	3	3	2
20	To demonstrate the use of a Zener diode as a voltage regulator and test load regulation.	3	3	2
21	To test the forward and reverse bias conditions of various diodes using a multimeter.	3	3	2
22	To compare the outputs of half-wave, full-wave center-tapped, and bridge rectifiers.	3	3	2
23	To identify and test NPN and PNP transistors using a multimeter.	4	4	2
24	To plot and analyze the V-I characteristics of a PN junction diode.	4	4	2
25	To plot the input and output characteristics of an NPN transistor in common emitter configuration.	4	4	2
26	To determine the current gain (β) of a transistor in the common-emitter configuration.	4	4	2
27	To calculate various parameters of the transistor, such as input impedance, output impedance, and current gain, from the characteristics.	4	4	2

28	Build circuit and obtain V-I characteristic of common emitter transistor configuration.	4	4	2
29	Build circuit and obtain V-I characteristic of common base transistor configuration.	4	4	2
30	To use a transistor as a switch in digital logic circuits.	4	4	2

List of Laboratory / Learning Resources Required:

1. Digital Multimeter
2. Function Generator / Signal Generator
3. Oscilloscope
4. Power Supply (DC and AC)
5. Breadboard
6. Connecting Wires and Clips
7. Alligator Clips
8. Ruler / Caliper
9. Safety Equipment (Gloves, Goggles, Lab Coats)
10. Resistors (Various Ratings)
11. Inductors
12. Capacitors
13. Variable Resistors (Potentiometers)
14. PN Junction Diodes
15. Zener Diodes
16. Light Emitting Diodes (LEDs)
17. Transistors (NPN and PNP)
18. Single-phase Transformers
19. AC and DC Motors
20. Fleming's Left and Right Hand Rule Apparatus
21. Diodes for Rectifiers (General Purpose, High Voltage, Zener Diodes)
22. Bridge Rectifier Kit
23. Center-Tapped Transformer
24. RLC Meter
25. LCR Meter
26. Current Clamp Meter
27. LTSpice / PSpice / Tinkercad Circuits
28. Experimentation Manual
29. Textbooks on Electrical and Electronics
30. Signal Probes
31. Clip Leads

32. Heat Sink and Fan
33. **Suggested Project List:**

The projects serve as practical learning experiences for students in the field of Instrumentation and Control Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing micro-projects:

1. **Verification of Ohm's Law**
   Objective: Verify Ohm's Law by measuring voltage, current, and resistance in different resistor configurations.
2. **AC and DC Signal Analysis with Oscilloscope**
   Objective: Build circuits to generate AC and DC signals, measure their waveforms, and analyze the frequency, amplitude, and other characteristics.
3. **Rectifier Circuits and their Performance Comparison**
   Objective: Design and compare half-wave, full-wave center-tapped, and bridge rectifier circuits, observe their output waveforms, and analyze performance.
4. **Transformer Testing and Analysis**
   Objective: Perform tests on a single-phase transformer, measure voltage and current on both primary and secondary sides, and carry out open-circuit and short-circuit tests.
5. **Electromagnetic Induction – Faraday's Law Experiment**
   Objective: Induce EMF in a coil using a changing magnetic field and verify Faraday's Law of electromagnetic induction.
6. **PN Junction Diode Characteristics and Applications**
   Objective: Plot the forward and reverse bias V-I characteristics of a PN junction diode and analyze its behavior.
7. **Transistor as a Switch and Amplifier**
   Objective: Use a transistor as a switch in a logic circuit and as an amplifier in a common-emitter configuration.
8. **Zener Diode as Voltage Regulator**
   Objective: Build and test a Zener diode-based voltage regulator and evaluate its performance in load regulation.
9. **Inductive Reactance and Impedance Measurement**
   Objective: Measure and analyze the inductive reactance and impedance of RL circuits and study their frequency dependence.

10. **Full-Wave Rectifier with Load Regulation and Ripple Reduction**

Objective: Design and test a full-wave rectifier with a smoothing filter, and observe its output voltage and ripple reduction performance.

Suggested Activities for Students:

In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups and should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

1. **Industry Visits and Guest Lectures**
   - **Objective:** Expose students to real-world applications and industry trends in electrical and electronics instrumentation.
2. **Interactive Simulations**
   - **Objective:** Help students visualize and experiment with circuits and concepts virtually through online platforms or software.
3. **Workshops on Soldering and PCB Design**
   - **Objective:** Equip students with practical skills for soldering, assembling, and testing electronic circuits on PCBs.
4. **Group Discussions and Problem-Solving Sessions**
   - **Objective:** Foster collaborative learning and deeper understanding of concepts through peer discussion and problem-solving.
5. **Competitions (e.g., Circuit Design Challenge)**
   - **Objective:** Encourage creativity and teamwork by designing and building circuits to meet specific challenges.
6. **Mini Projects**
   - **Objective:** Provide students with hands-on experience in designing and building functional electrical and electronics systems.
7. **Online Courses and Certifications**
   - **Objective:** Enhance students' knowledge and skills through additional online learning and certification programs.

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