GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Electrical Engineering / Renewable Energy

Course / Subject Code : DI03000091

Course / Subject Name : Electrical Instrumentation

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	**Acquaintance with basic concepts of electrical circuit.**
Rationale:	Precise measurement of the quantities such as voltage, current, power, temperature, pressure etc. is essential to operate and maintain the electrical machines and systems effectively and efficiently. Transducers and instruments are the devices which are used to measure such parameters. The electrical diploma engineer should therefore be competent to use, calibrate and maintain different types of electrical instrumentation systems and transducers used in the industry and power systems. This demands a better understanding of the construction, material used and principle of operation of various types of measuring instruments. This course is therefore designed to meet these needs and hence it is a core course for any electrical engineer.

Course Outcome:

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

No	Course Outcomes	RBT Level
01	Understand different terms related to measurement and instrumentation	U
02	Use potentiometers and DC & AC bridges for measurement of electrical quantities.	A
03	Use electromechanical instruments for measurement of electrical quantities.	A
04	Calibrate ammeter, voltmeter, wattmeter and energy meter as per IS.	A
05	Use transducers to measure various non-electrical quantities.	A

**Revised Bloom's Taxonomy (RBT)*

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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(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**FUNDAMENTALS OF MEASUREMENT AND INSTRUMENTATION** • Methods of measurement -Direct and indirect method • Types of Instruments - Indicating, integrating and recording, absolute and secondary instrument • Generalised measurement system • Essential torques for electromechanical instruments: Deflecting, Controlling and damping torque • Terms regarding instrumentation: Range, true value, indicated value, error, correction, sensitivity, repeatability, reproducibility, precision, Accuracy, significant figure, etc. • Types of error: gross error, systematic error, random error • Sources of error • Instrumentation system	6	14
2.	**POTENTIOMETERS AND BRIDGES** • Construction and working of DC potentiometer, and its applications • Dial type and Crompton type (2 dial type only) • Low, medium, and high resistance • DC Bridges: Kelvin's double bridge, Wheatstone bridge,	10	22

	• High resistance measurement by Megger • Earth resistance measurement by Earth tester. • Types of AC Bridges for measurement of Inductance, Capacitance & frequency • AC Bridges • Maxwell's Bridge for measurement of Inductance • De Sauty's Bridge for measurement of Capacitance • Universal impedance bridge for measurement of resistance, inductance and capacitance		
3.	**ELECTROMECHANICAL INSTRUMENTS** • Classification of electromechanical instruments • Moving iron instruments: Ammeter, Voltmeter, Frequency meter • PMMC instruments: Ammeter, Voltmeter • Electrodynamometer type meter: Ammeter, Voltmeter, Wattmeter. • Measurement of 1-Ø power • Measurement of 3-Ø power by three wattmeter and two wattmeter method • Induction type Energy meter (single phase, three phase) • Maximum demand meter, Tri vector meter, Phase sequence indicator, Solid state energy meter, Clip on meter • Extension of range using shunt, multipliers and derive equation for them. • Extension of range of meters using instrument transformer like CT and PT	15	33
4.	**CALIBRATION AND TESTING** • Calibration and its importance • Calibration of ammeter, voltmeter and wattmeter and single-phase energy meter as per IS	4	9
5.	**TRANSDUCERS** • Basic requirements of transducers. • Classification based on: Transduction phenomenon, type of application, types of input and output signal, electrical principle involved etc.	10	22

	• Resistive Transducers • Inductive Transducers: LVDT, RVDT • Capacitive Transducers, Piezoelectric Transducers, Strain Gauge Transducers (unbonded and bonded), Thermocouple, RTD, Thermistor • Selection of Transducer • Measurement of non-electrical quantities using abovementioned transducers • Proximity sensor		
	Total	**45**	**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 %	**35 %**	**40 %**	**-**	**-**	**-**

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:

S. No.	Title of Books	Author	Publication
1.	Electrical and electronic instruments	Sawhney, A .K .	Dhanpat Rai Publications, New Delhi, 2010
2.	Electrical Measurements: fundamentals, concepts,	Reissland, M.U.	New Age International publishers, New Delhi, 2008

	applications		
3.	A course in electronics & electrical measurement & instrumentation	Gupta, J.B.	S.K. Kataria and Sons, New Delhi, 2011
4.	Principles of measurement & Instrumentation	Morris, Alan. S	PHI publication, New Delhi, 2011
5.	Electrical Instrumentation	Bakshi, U.A., Bakshi A.V.	Technical Publication, Pune,2009
6.	Mechanical and industrial measurements	Jain,R.K.	Khanna Publication, New Delhi, 2010
7.	Electrical Measurements and measuring instruments	Golding, E.W., Widdis, F.C.	Reem publications New Delhi, 2011
8.	Electronic Measurements and Instrumentation	K. Lal Kishore	Pearson, New Delhi, 2011

(b) Open-source software and website:

1. www.vlab.co.in
2. https://www.circuitlab.com/
3. www.nptel.iitm.ac.in
4. www.khanacademy.org
5. https://phet.colorado.edu/
6. https://ndl.iitkgp.ac.in
7. www.electrical4u.com
8. https://www.nde-ed.org/Physics/Magnetism/atommagnetism.xhtml
9. https://www.tinkercad.com/dashboard
10. https://www.allaboutcircuits.com/
11. https://www.electronicshub.org/
12. https://openstax.org/
13. https://ocw.mit.edu/courses/8-02t-electricity-and-magnetism-spring-2005/pages/syllabus/

Suggested Course Practical List:

Sr. No.	Practical Outcome/Title of experiment	CO1	CO2	CO3	CO4	CO5
1	Identify measuring instruments on the basis of symbols on dial, type, accuracy, class, position and scale.	√				
2	Measure medium resistance using Wheatstone bridge.		√			
3	Measure low resistance using Kelvin's double bridge.		√			
4	Measure inductance by using Maxwell bridge.		√			
5	Measure inductance by using Universal Impedance bridge.		√			
6	Measure capacitance by using Universal Impedance bridge.		√			
7	Measure insulation resistance of winding insulation by using Megger.		√			
8	Measure earth resistance by using earth tester.		√			
9	Measure power drawn by three phase load using two wattmeter method.			√		
10	Measure different electrical parameters using clip on meter.			√		
11	Test phase sequence of three phase AC supply using phase sequence indicator.			√		
12	Extend the range of ammeter and voltmeter using CT and PT.			√		
13	Extend the range of ammeter and voltmeter using shunt and multiplier.			√		
14	Calibrate Ammeter (MI/MC) as per IS.				√	
15	Calibrate Voltmeter (MI/MC) as per IS.				√	
16	Calibrate Wattmeter as per IS.				√	

17	Calibrate Single phase energy meter as per IS.				√	
18	Use LVDT to measure Linear displacement.					√
19	Use Thermocouple to measure the temperature of a furnace/machine part.					√
20	Use Strain gauge to measure strain.					√
						Total practical hours = 30 hrs.

List of Laboratory/Learning Resources Required:

1. DC potentiometer: 0 - 1.1V D.C, TEST TERMINALS, COARSE & FINE adjustment
2. Wheatstone bridge : Measuring Range- 1.000Ω to 10.00MΩ, Measuring Arm- x 1mΩ, x 10Ω + 10Ω x 10 + 100Ω x 10 + 1000Ω x10 (min. one step: 1Ω), Ratio Arms- x 0.001 x 0.01, x 0.01, x 0.1, x 1, x 10, 100, x 1000 (M10, M100, M1000 Murray & Varley loop testing), Galvanometer Power Source -Three 1.5V batteries (built-in), Range, ±0.1% of reading on 100Ω to 100kΩ Range, Accuracy- ±0.3% of reading on 10Ω to 1MΩ Range, ±0.6% of reading on 1Ω to 10MΩ Range
3. Kelvin double bridge: Range: 0.2 Micro - Ohms to 11 ohms, Accuracy: 0.1% (or ±1 Slide wire division whichever is greater), Multiplier: 5 Ranges (0.01, 0.1, 1, 10 & 100)
4. Universal impedance bridge: Basic accuracy- 0.3%, Versatile, portable, compact LCR Meter for L-Q, C-D , R-Q, |Z|-Q measurements, Measurement frequencies 100 Hz, 120 Hz and 1 kHz
5. LCR meter: Basic accuracy- 0.3%, Versatile, portable, compact LCR Meter for L-Q, C-D, R-Q, |Z|-Q measurements, Measurement frequencies 100 Hz, 120 Hz and 1 kHz
6. Energy meter: 1Ø and 3Ø analog and digital meters with latest specifications
7. Power factor meter: Analog and digital meters with latest specifications
8. Two element wattmeter: With latest specifications
9. Three phase power factor meter: Analog and digital meters with latest specifications
10. Megger: Mains / battery pack operated (Capable of continuous duty for P.I. measurement of large Generators) analog/digital insulation tester with selectable ranges of 50V, 250V, 500 V, 1000 V, 2500 V, 5000 V.
11. Phase sequence indicator: Analog and digital meters with latest specifications
12. Clip on meter: Analog and digital meters with latest specifications with true-rms ac voltage and current measurements, the Fluke 373 Clamp Meter reads up to 600 A ac and 600 V ac or dc.
13. Current transformer and Potential transformer

14. Decade resistance box: Accuracy: ± 1%, Max. D.C. voltage: 400 volts, jack-topped binding posts are used as output terminals
15. Range extension board: +12V D.C. at 50mA IC.regulated Power Supply for Sine wave Oscillator
16. Shunts with ammeters: Accuracy: ± 1%, Measuring Range in ohms like - x 0.001 x 0.01, x 0.01, x 0.1, x 1, x 10, 100, x 1000
17. Linear variable differential transducer: +12V D.C. at 50mA IC.regulated Power Supply for Sine wave Oscillator
18. Strain gauge: +12V D.C. at 50mA IC.regulated Power Supply for Sine wave Oscillator
19. Thermo-couple: Types B, E, J, K, R, S, T and C thermocouples
20. Thermistor: as per standard specification and latest configurations
21. Multiple transducer kit: Inbuilt power supply, measurement facility, expansion facility and with latest features like computer interface etc.

Suggested Project List:

1. Prepare a report on various measuring instruments used in Instrumentation laboratory.
2. Build a model to extend the range of ammeter with the help of shunt resistor.
3. Build a model to extend the range of voltmeter with the help of high resistor (multiplier).
4. Build a model of phase sequence indicator.
5. Prepare a report on transducers or sensors used in automation and robotics.
6. Design an instrument to generate electricity using piezoelectric device.
7. Case studies on transducer failure and its implications.
8. Compile the reports of past industrial/massive accidents, their causes, effect and strategies used and suggestion to prevent such incidents and present the same in seminar.
9. Prepare charts that spread awareness on environmental effect due to industrial accidents.

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 evidences for their portfolios, which could be beneficial during placement interviews:

a) Prepare and demonstrate project models or deliver seminars on various topics covered in the course content.

b) Present chart showing real-life examples indicating various types of electrical measuring equipment.

c) Prepare PowerPoint presentation for different types of electromechanical instruments.

d) Solve numerical related to Bridges.

These activities will not only reinforce the theoretical understanding but also provide practical exposure and critical thinking opportunities essential for professional growth.