GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Electrical and Electronic Measurement
(Course Code: 4332405)

Diploma programmer in which this course is offered	Semester in which offered
Power Electronics	Third

1. RATIONALE

With the advancement of technology measurement techniques have taken rapid strides with the introduction of different types of instrumentation devices. This course is intended to enable the student to understand the facts, concepts, principles and applications of the Electrical and electronic measuring instruments that will be able to apply the same in almost all areas of power electronics required to use and maintain different types of electrical and electronic instrumentation used in the industry. More drill and practice in the lab would prove more useful to develop the skills.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

Measure various electrical and electronic parameters.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO 1) Use AC and DC bridges for specific applications.
CO 2) Measure various electrical parameters using relevant instruments.
CO 3) Measure various electrical quantities using CRO and DSO.
CO 4) Maintain various electronic measuring instruments.
CO 5) Maintain various waveform generating instruments.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
4	-	2	5	30	70	25	25	150

(*): For this practical only course, 25 marks under the practical CA has two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15 marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.
Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit,* ***CA*** *- Continuous Assessment;* ***ESE*** *-End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) that are thesub-components of the Course Outcomes (Cos). Some of the ***PrOs*** *marked* ***'*'*** *are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Build/Test Wheatstone bridge.	1	2*
2.	Build/Test Kelvin double bridge.	1	2
3.	Build/Test Maxwell Bridge.	1	2
4.	Build/Test Hays Bridge.	1	2
5.	Build/Test De Sauty's Bridge.	1	2
6.	Build/Test Wein Bridge.	1	2*
7.	Measure power in DC circuit with and without wattmeter.	2	2
8.	Measure power in 1-Phase AC circuit with and without wattmeter	2	2*
9.	Measure power in 1-phase AC circuit using instrument transformer.	2	2
10.	Measure power in 3-phase AC circuit in 1 wattmeter, 2wattmeter and 3 wattmeter methods.	2	4*
11.	Measure frequency using frequency meter.	2	2
12.	Measure power factor in 1-phase and 3-phase circuit using power factor meter.	2	4*
13.	Measure different voltage using CRO	3	4
14.	Measure phase:(Lissajous Patterns)using CRO	3	4*
15.	Measure frequency :(Lissajous Patterns) using CRO	3	2
16.	Measure different voltage using DSO	3	2
17.	Measure resistance, capacitance and inductance using LCR meter	4	2*
18.	Implementation of Digital to Analog converter using trainer kit.	4	2*
19.	Implementation of Analog to Digital converter using trainer kit.	4	2*
20.	Build/Test RC Phase shift oscillator.	5	2
21.	Build/Test Hartley oscillator.	5	2
22.	Build/Test crystal oscillator.	5	2*
23.	Build/test square wave and pulse wave generator.	5	2
24.	Test different parameters using Function Generator.	5	2*
		Total	**28***

Note

i. *More* ***Practical Exercises*** *can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Multimeter** 3 1/2 digits resolutions with all basics measurement facility like DC Voltage: 200 mV ~ 1000 V, DC Current: 200 µA ~ 10 A, AC Voltage: TrueRMS, 200 mV ~ 750 V, AC Current: True-RMS, 20 mA ~ 10 A, 2-Wire Resistance: 200 Ω ~ 100 MΩ, Capacitance Measurement: 2 nF ~ 100µF, Frequency Measurement: 20 Hz ~ 100 kHz etc., AC Voltage Accuracy 1%, DC Voltage Accuracy 0.5%.	7,8,20,21, 22,24
2	**LCR Meter** Basic measurement accuracy 0.1% & speed upto 10 meas / sec; Large LCD display with bright white backlight. Ultra low power consumption, battery powered for 24 hours of continuous use, Automatic identification function (Ai). Percentage display &tolerance comparator: 1%, 5%, 10% & 20%; 9V battery & External power supply provision, Automatic correction function with data hold, max. / min. / average recording. Utility function configuration & current setup recovery after power off. Standard Mini-USB interface, SCPI compatible, Auto power Off, Constant output impedance : 100 ohm Measurement Parameter: Primary Parameters : L / C / R / Z ; Secondary Parameter : D / Q / u / ESR Equivalent Mode Auto LCR Function Ranging Mode, Test Terminals Measurement Speed Correction Tolerance Mode, Input Protection Fuse, Interface Test Signal; Signal Frequency Test Signal Level Output Impedance Basic Accuracy 0.1% L 4mH ~ 1000H Range for Display 0.001mH ~ 1000.0H C , 4pF ~ 20mF Range for Display 0.001pF ~ 20.000mF, R / Z 0.4V ~ 10MV Range for Display 0.0001V ~ 10.000MV Time Display on LCD Safety and EMC compliance :IEC 61010-1 : 2001, IEC 61326-2-1 : 2005	17

S. No.	Equipment Name with Broad Specifications	PrO. No.
3	**DSO:** Technical Specification: No. of Channels:4, Analog Bandwidth:100 MHz, Real Time Sampling Rate:1 GS/s on each analog channel, Input Impedance:1 MΩ, Input Coupling: AC,DC,GND, Vertical Resolution:8 bit, Bandwidth Limit:20 MHz, Time base range:2 ns to 100 Sec/div, Vertical Sensitivit:2 mV/div to 5 V/div at 1 M Ohm input impedance, Record Length: 1Mpts. Per channel, Acquisition Modes: Peak Detect, Sample, Average, Single sequence, Roll Mode, Waveform Capture rate:5,000 waveforms/sec, Trigger modes: Auto, Normal & Single, Trigger source: Any input channel, External ; Trigger Types: Edge, Pulse width, Video, Runt, Logic, Setup/Hold, Rise time/Fall time, Measurement: Period, Frequency, +Width, –Width, Rise Time, Fall Time, Max, Min, Peak-to-Peak, Mean, Cycle RMS. Operators – Add, Subtract, Multiply, FFT. Display: 7 inch liquid crystal TFT color display. Instrument Interface: Removable Data Storage via USB Port Instrument Software: Seamless PC Connectivity via USB Device Port, with fully interactive measurement software environment to instantly acquire, generate, analyze, compare, import, and save measurement data and signals using an intuitive drag-and-drop user interface must be provided at free of cost. I2C, SPI, RS-232, UART, RS485, RS422, and CAN, LIN buses decoding support: Must be available and future upgradable.	13,14,15,16
4	**RC Phase shift Oscillator:** To obtain oscillation of different frequencies by varying R-C. 02. To study the frequency response of Phase shift network. 03. To study two stages RC coupled amplifier, with and without negative feedback. The board consists of the following built-in parts: 01. A valve with base fixed on panel and wired internally 02. Adequate no. of other electronic components. * The unit should operative on 230V ±10% at 50Hz A.C. Mains, Adequate no. of patch cords stackable from rear both ends, Good Quality, reliable terminal/sockets are provided at appropriate places on panel for connections/ observation of waveforms, Strongly supported by detailed Operating Instructions, giving details of Object, Theory, Design procedures, Report Suggestions, Installation and inspection at consignee is required.	20
5	**LC oscillator:** Study of design and functioning of Hartley Oscillator, Technical Specifications: Biasing Voltage:+12V DC, Design of Oscillators: Passive Elements with NPN Transistors * The unit should operative on 230V ±10% at 50Hz A.C. Mains, Adequate no. of patch cords stackable from rear both ends, Good Quality, reliable terminal/sockets are provided at appropriate places on panel for connections/ observation of waveforms, Strongly supported by detailed Operating Instructions, giving details of Object, Theory, Design procedures, Report Suggestions, Installation and inspection at consignee is required.	21
6	**Miller Crystal Oscillator:** Features: The board consists of the following built-in parts: 01. Quartz Crystal, 1MHz fixed on a crystal socket. 02. Valve fixed on panel with 9 pin valve base. 03. Inductor (coil) and Radio Frequency Coil. 04. Adequate no. of other electronic components. The unit should operative on 230V ±10% at 50Hz A.C. Mains, Adequate no. of patch cords stackable from rear both ends, Good Quality, reliable	22

S. No.	Equipment Name with Broad Specifications	PrO. No.
	terminal/sockets are provided at appropriate places on panel for connections/ observation of waveforms, Strongly supported by detailed Operating Instructions, giving details of Object, Theory, Design procedures, Report Suggestions, Installation and inspection at consignee is required.	

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using measuring instruments.
c) Realize importance of errors while measuring electrical and electronic parameters.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit – I Measurement and Measurement of Circuit Parameters	1a. Describe requirement of measurement. 1b. State the tolerance limits for accuracy, precision, sensitivity and resolution. 1c. Differentiate various errors in measurement 1d. Describe the working of Kelvin's double bridge and Wheatstone bridge. 1e. Describe the working of Maxwell Bridge, Hays Bridge, De Sauty's Bridge and Wien Bridge.	1.1 Measurement: definition, requirement, advantages. 1.2 Define: Accuracy, Precision, Sensitivity and Resolution. 1.3 Errors: gross error, systematic error, random error. 1.4 DC bridges: Kelvin's double bridge, Wheatstone bridge. 1.5 AC bridges: Maxwell Bridge,Hays Bridge, De Sauty's Bridge, Wien Bridge

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Unit– II Electrical Measurement and Instrumentation	2.a Explain Power Measurement In Dc Circuits by voltmeter with ammeter, watt meter. 2.b Explain construction and Operation of Electrodynamometer-type Wattmeter. 2.c Explain the working of instrument transformers. 2.d Explain measurement of power in AC circuit.	2.1 Power Measurement In Dc Circuits by voltmeter with ammeter, watt meter. 2.2 Electrodynamometer-type Wattmeter: construction, Operation, Error due to connection 2.3 Basic principle of current and voltage transformer, applications. 2.4 Power Measurement In AC circuit: • 1-phase circuit: without watt meter, with watt meter, with instrument transformer. • 3-phase circuit: three wattmeter method, two watt meter method, one wattmeter method.
Unit– III CRO And DSO	3a. Explain the working of CRO using block diagram. 3b. Explain screens, Gratitude and Time base generators used in CRO 3c. Describe the measurement of voltage, current, phase and frequency using CRO. 3d. Compare the construction of CRO and DSO with block diagram. 3e. Explain construction of different types of probes and their applications.	3.1 Cathode Ray Oscilloscope (CRO): Block diagram, Construction. 3.2 CRO: screen, gratitude and time base generator. 3.3 CRO Measurement: voltage, current, phase and frequency (Lissajous Patterns) 3.4 Digital Storage Oscilloscope (DSO): Block diagram, Construction. 3.5 Probes: 1x, 10x, 100x with applications.
Unit– IV Electronic Measurement and Instrumentation	4a. Explain Basic Data Acquisition system. 4b. Describe various analog and automated data acquisition systems. 4c. Explain analog /Digital/Analog conversation. 4d. Explain Digital LCR meter	4.1 Data acquisition system: generalized block diagram, objectives and configuration. 4.2 Analog and automated data acquisition system: block diagram, single channel data acquisition system, multi channel data acquisition system, applications. 4.3 Analog /digital/analog conversation: process, procedure of conversion, components used in A/D conversion and D/A conversation. 4.4 Digital LCR meter: block diagram, features, and applications.
Unit– V	5a. Classify Oscillator	5.1 Classification of Oscillators.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application and above level)	Topics and Sub-topics
Instruments For Generation Of Waveforms	5b. Explain different Types of Feedback Oscillators. 5c. Explain Pulse generator circuit. 5d. State the uses of function generator	5.2 RC Oscillators, Hartley Oscillator, Crystal Oscillators 5.3 Basic Pulse generator circuit with waveform, applications. 5.4 Use and applications of Function generator

***Note**: The UOs need to be formulated at an 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Measurement and Measurement of Circuit Parameters**	9	3	6	6	15
II	**Electrical Measurement and Instrumentation.**	12	4	12	4	20
III	**CRO And DSO**	6	4	6	0	10
IV	**Electronic Measurement and Instrumentation.**	8	4	6	3	13
V	**Instruments For Generation Of Waveforms**	7	3	6	3	12
Total		**42**	**18**	**36**	**16**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Compare and analyze different AC bridges.
b) Compare various AC power measurement methods.
c) Compare various Oscillators.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Use video/animation films to demonstrate various Digital Circuits.
g) Guide students for reading data sheets.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Make measurement board for different 1-Phase AC power measurement.
b) Make measurement board for different 3-Phase AC power measurement.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Electrical and electronic measurements and instrumentation.	Rajput R. K.	S Chand, 2021 ISBN: 978-8121929899
2	Modern Electronic Instrumentation and Measurement Techniques	Helfrick, Albert D.,Cooper ,William D.	PHI Learning , New Delhi, latest publication

S. No.	Title of Book	Author	Publication with place, year and ISBN
3	A course in electrical and electronic Measurements and Instrumentation	Sawhney A. K.	Dhanput Rai and Co., New Delhi, 2015 ISBN: 978-8177001006
4	Electrical Measurements and Measuring Instruments	Gupta J. B.	S. K. Kataria and Sons, 2020 ISBN: 978-8188458264

14. SOFTWARE/LEARNING WEBSITES

a) https://onlinecourses.nptel.ac.in
b) https://www.classcentral.com
c) https://www.electrical4u.com
d) https://www.electrical-installation.org
e) https://www.electronics-tutorials.ws

15. PO-COMPETENCY-CO MAPPING

Semester III	Electrical and Electronic Measurement						
	POs and PSOs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Measure various electrical and electronic parameters.						
CO 1) Use AC and DC bridges for specific applications.	1	1	2	2	1	--	1
CO 2) Measure various electrical parameters using relevant instruments.	2	2	2	3	-	2	2
CO 3) Measure various electrical quantities using CRO and DSO	1	1	-	3	1	1	1
CO 4) Maintain various electronic measuring instruments.	1	1	1	2	1	1	1
CO 5) Maintain various waveform generating instruments.	1	1	2	3	-	1	1

Legend: '**3**' for high, '**2**' for medium, '**1**' for low or '**-**' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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