GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Electronics and Pneumatic Instrumentation
(Course Code: 4331704)

Diploma program in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	Third

1. RATIONALE

Electronic instruments are commonly used in industrial processes to measure and regulate process parameters of a plant. The pneumatic control loops use pneumatic instrumentation. Students will receive theoretical and practical knowledge of pneumatic and electronic equipment used in the process industries in this course.

2. COMPETENCY

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

- **Select and operate electronic & pneumatic instruments.**

3 COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- CO1: Use various test and measuring instruments for different types of electronics signals
- CO2: Build & test various applications of op-amp.
- CO3: operate the electronics and pneumatic instruments.
- CO4 Assemble and test the converter circuit.

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	
3	0	4	5	30	70	50	50	200

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***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) are the sub-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'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure controller output current using a PMMC (Permanent magnet moving coil) type instrument.	1	02
2	Obtain waveform of function generator.	1	02
3	Measure the DC output voltage of the thermocouple using DMM (Digital Multimeter).	1	02
4	Check the function and features of CRO (Cathode Ray Oscilloscope).	1	02*
5	Measure phase difference between two waveforms using CRO.	1	02*
6	Measure amplitude of signal using CRO.	1	02*
7	Develop Lissajous figures on CRO.	1	02
8	Check the function and features of DSO (Digital Storage Oscilloscope).	1	02*
9	Find the resistance of RTD (Resistance Temperature Detector) using Wheatstone Bridge.	1	02*
10	Find the resistance of RTD using the kelvin bridge.	1	02
11	Find Inductance of a given inductor using Maxwell bridge.	1	02
12	Find inductance of given inductor using Anderson bridge	1	02
13	Find the capacitance of a given capacitor using Desauty's bridge.	1	02
14	Test Inverting amplifier circuit using op-amp (Operational Amplifier).	2	02*
15	Test Non-inverting amplifier circuit using op-amp.	2	02*
16	Test a differential amplifier circuit using op-amp.	2	02
17	Test integrator circuit using op-amp.	2	02
18	Test differentiator circuit using op-amp.	2	02
19	Test comparator circuit using op-amp	2	02
20	Test Summing amplifier circuit using op-amp	2	02*
21	Test instrumentation amplifier circuit.	2	02*
22	Build and test an electronic on-off controller using an operational amplifier.	3	02*
23	Develop electronic P (Proportional) controller using an operational amplifier.	3	02*
24	Develop electronic PI (Proportional Integral) controller using an operational amplifier.	3	02*
25	Develop electronic PD (Proportional Derivative) controller using an operational amplifier.	3	02*
26	Develop electronic PID (Proportional, Integral, and Derivative) controller using an operational amplifier.	3	02*
27	Operate the given pneumatic control valve using a pneumatic type PID (Proportional, Integral, Derivative) controller using the given trainer kit.	4	02*
28	Install and Check function of Pneumatic Transmitter	4	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
29	Develop resistance to current converter.	5	02*
30	Develop resistance to voltage converter.	5	02*
31	Develop voltage to current converter.	5	02
32	Develop a circuit to convert thermocouple output mV into current.	5	02*
		Total	64

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.*

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.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare 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.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Digital Multimeter, Voltage source, Current source, Function generator (step, pulse, ramp, sine) , RTD (Resistance Temperature Detector), Thermocouple and Electronic workbench.	1 to 26, 29 to 32
2.	Cathode Ray Oscilloscope (CRO), Digital storage oscilloscope (DSO).	2,4 to 8,14 to 26
3.	Permanent Magnet Moving Coil (PMMC) meter	1
4.	Wheatstone Bridge trainer Kit.	9
5.	Kelvin Bridge trainer Kit.	10
6.	Maxwell's Bridge trainer Kit.	11
7.	Anderson's bridge trainer Kit.	12
8.	De Sauty's bridge trainer Kit.	13

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
9.	Op-Amp Application Trainer Kit	14 to 21
10.	Instrumentation Amplifier Trainer Kit	22
11.	Electronic Controller Trainer Kit (On-Off, P, I, D, P+I, P+D, and P+I+D)	22 to 26
12.	Multi process control loop using pneumatic control Trainer Kit., pneumatic transmitter, Teflon tape for sealing, Compressor (Cut off : 7 kg/cm2 and Cut in:3.5 kg/cm2)	27,28

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 course competency.

a) Work as a leader/a team member.
b) Follow safety practices and procedure.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day to day observation.
e) Practice environmental friendly methods and processes. (Environment related)

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

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such 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 different levels)	Topics and Sub-topics
Unit – I **Fundamentals of Electronic Measurement**	1a. Classify and list electronic instruments based on laboratory/testing/ Field instruments. 1b. Describe working principle, construction of electric meters/instruments with neat schematic diagram (1.2.1 to 1.2.4). 1c. Enlist applications of electric meters/instruments (1.2.1 to 1.2.4). 1d. Draw block diagram of basic instruments and explain operation in detail. (1.3.1 to 1.3.4) 1e. Enlist application of listed test instruments (1.3.1 to 1.3.4) 1f. Enlist additional features of DSO with reference to CRO. 1g. Classify and list types of Electronic Bridge. 1h. State Uses of bridges in Instrumentation. 1i. Explain the circuit diagram of Wheatstone bridge and derive the expression for unknown resistance. 1j. Explain the circuit diagram of Kelvin Bridge. 1k. Enlist applications for Wheatstone bridge and Kelvin Bridge. (1.4.1) 1l. Describe working principle and construction of AC bridge	1.1 Classification of electronic instruments as under • Laboratory/Testing instruments. • Field instruments. 1.2Electrical meters/Instruments 1.2.1 PMMC (Permanent Magnet Moving Coil) type 1.2.2 Rectifier type 1.2.3 Moving Iron type 1.2.4 Electro dynamic type 1.3 Test instruments 1.3.1 Function generator 1.3.2 Digital multimeter 1.3.3 CRO (Cathode Ray Oscilloscope) 1.3.4 DSO (Digital storage oscilloscope) 1.4 Classification of Electronic Bridge 1.4.1 DC (Direct current) bridges (for resistance measurement) • Wheatstone Bridge • Kelvin Bridge 1.4.2 AC (Alternating Current) bridges (for inductance/ capacitance measurement) • Maxwell's Bridge • Anderson's bridge • De Sauty's bridge 1.5 Isolation and its techniques 1.6 Need for standardization of

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	with neat diagram (1.4.2) 1m. Discuss the importance of isolation. 1n. Describe the isolation technique in detail. 1o. State need for standardization of signals. 1p. State standard unit and range for pneumatic signals used in instrumentation. 1q. State standard unit and range for electronic signals used in instrumentation.	signals-Current, voltage, and pneumatic signal standards
UNIT - II Basics of Operational-Amplifier	2a. Describe Op-amp in brief. 2b. Classify the IC package types and Identify the Pins of op-amp IC 2c. Define various op-amp Terminology. 2d. Compare ideal Op amp with a practical op-amp. 2e. Explain various applications of operational - amplifier with schematic diagrams and mathematical expression (2.5)	2.1 Introduction to op-amp 2.2 Op-amp IC package types, Pin identification, temperature Range, Power supply 2.3 Op-amp terminology • Input offset voltage • Input offset current • Input bias current • differential input resistance • offset voltage • adjustment range • Input voltage range • CMRR (Common-Mode Rejection Ratio) • SVRR • slew rate 2.4 comparison of ideal op-amp characteristics and practical op-amp characteristics 2.5 application of op-amp • Inverting op-amp • Non-Inverting op-amp • Differential amplifier • Integrator, • Differentiator, • Comparator

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		• Summing amplifier • Instrumentation amplifier
Unit– III **Electronics Instrumentation**	3a. Define Process terminologies 3b. Classify modes of control action. 3c. Define two position, P, I, D and composite mode control action, Proportional Band, Offset 3d. Classify the types of electronic controllers. 3e. Draw a general block diagram of different types of electronic controller and explain each block in detail. (3.3) 3f. Explain operation of various types of electronic controller with the help of op amp based circuit diagram (3.3.1,3.3.2) 3g. Draw the output response of P, I, D, P+I, P+D, P+I+D for step, pulse, ramp and sinusoidal input. 3h. State mathematical expression for P, I, D, P+I, P+D, P+I+D control action. 3i. State the need for controller tuning. 3j. Explain in brief tuning methods for the controller	3.1. Process terminologies: process equation, process load, process lag, self-regulation, measurement lag, control lag, transportation lag, dead time, cycling 3.2 Concept of Two position, P, I, D, P+I, P+D, P+I+D mode of control action, Proportional Band, Offset 3.3Classification of controllers 3.3.1Discontinuous Controllers • On-Off / Two-position controller(Electronics) 3.3.2Continuous Controllers (Electronics) • Proportional Controller • Integral controller • P+I Controller • P+D Controller • P+I+D Controller 3.4 Tuning methods for controller 3.4.1 Process Reaction Curve (open loop) 3.4.2 Ziegler Nichols (closed loop)
Unit– IV **Pneumatic Instrumentation**	4a. Compare electronic and pneumatic instruments 4b. Enlist components of self balancing instruments. 4c. Explain the self-balancing principle of pneumatic instruments with a neat schematic diagram. 4d. Explain construction and operation of pneumatic PID controller with the help of a	4.1Differentiate between pneumatic instruments and electronic instruments 4.2 Self-balancing instruments 4.3 Pneumatic Controllers • P+I+D Controller 4.4 Introduction of transmitter • Need of transmitter

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
	neat sketch. 4e. Describe the need of a transmitter. (Concept of field area & control room area). 4f. Describe construction and working of pneumatic transmitters.(4.5.1,4.5.2)	4.5Pneumatic Transmitter 4.5.1Force Balance Transmitter 4.5.2 Motion Balance Transmitter
Unit–V **Signal Converters and instrument transformer**	5a. Explain the operation of the current transformer with the schematic diagram. 5b. Explain the operation of a potential transformer with a schematic diagram. 5c. Describe the characteristics of current transformer and potential transformer 5d. Enlist types of converters. 5e. Describe the construction and working of converters (5.3.1 to 5.3.5)	5.1 Current Transformer. 5.2 Potential Transformer. 5.3 Converters 5.3.1 Resistance to Current Converter 5.3.2Resistance to Voltage Converter 5.3.3 Voltage to Current Converter 5.3.4 mV to Current Converter for thermocouples 5.3.5AC to DC Converter for mA

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	Fundamentals of Electronic Measurement	10	4	10	4	18
II	Basics of Operational-Amplifier	8	4	4	4	12
III	Electronics Instrumentation	12	6	10	4	20
IV	Pneumatic Instrumentation	6	2	6	2	10
V	Signal converters and Instrument transformer	6	2	6	2	10
Total		**42**	**18**	**36**	**16**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

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 perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Present a seminar on listed technical topics in the EPI syllabus.
b) Set up electronic apparatus on their own during practical hours under the guidance of the lecturer as a mini project.
c) Debate on merits and demerits of pneumatic and electronic instruments.
d) Prepare a poster/chart on any one advanced topic related of course.
e) Collect the extracurricular information related to the course from the internet and shares it with other students.

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 assesseduring different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for reading manuals.

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-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro project should be about **14-16 *(fourteen to sixteen) student engagement hours*** during the course. The students 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) Build an Op-amp based, level, temperature control model.
b) Build a converter circuit.
c) Make demonstrable models of various types of control actions.
d) Compile a report on handling, recycling and disposal of electronics waste with figures, tables and comparative charts.
e) Prepare a micro project relevant to pneumatic or Electronics application.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	A Course in Electrical and Electronic Measurements and Instrumentation	A K Sawhney	DHANPAT RAI
2	Instrument Engineers Handbook	Bela G Liptak	ISA
3	Applied Instrumentation in the process industries	W G Andrews H B Williams	ISA
4	Op-Amps and linear Integrated Circuits	Ramakant A. Gayakwad	Asoke k. Ghosh, PHI Learning Private Limited, Rimjhim House,111, Patparganj industrial Estate, Delhi-110092 ISBN-978-81-203-2058-1
5	Process Control Instrumentation Technology	Curtis D Johnson	PHI
6	Instrumentation Training Course	D B Taraporewala	D.B. Taraporevala Sons
7	Industrial Instrumentation and Control	S.K.Singh	Tata, McGraw-Hill, New Delhi ISBN: 9789351340102, 9789351340102
8	Electronics measurement and instrumentation	K. Lal Kishore	Pearson

14. SOFTWARE/LEARNING WEBSITES

1. Multisim Software
2. Docircuits Software
3. www.nptel.ac.in
4. https://instrumentationtools.com
5. www.vlab.co.in

15. PO-COMPETENCY-CO MAPPING

Semester III	Electronics and Pneumatic Instrumentation(Course Code:4331704)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation&Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Select and operate electronic & pneumatic instruments**						
CO 1) Use various test and measuring instruments for different types of electronic signals.	3	1	1	3	1	3	2
CO 2) Build& test various applications of op-amp	3	2	3	3	1	3	3
CO 3) operate the electronics and pneumatic instruments	3	2	3	3	1	3	3
CO 4) Assemble and test the converter circuit.	3	2	3	3	1	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

Prof. S. Z. Shyara, IC Engineering, AVPTI, Rajkot

Prof. M. J. Vadhavaniya, IC Engineering, Government Polytechnic, Palanpur

GTU Resource Persons

Prof. Ms. P. R. Thumar, IC Engineering, AVPTI, Rajkot

Prof. N. P. Vasava, IC Engineering, Government Polytechnic, Vyara

Prof. Ms. B. P. Gandhi, IC Engineering, Government Polytechnic, Gandhinagar

Prof. Ms. D. M. Joshi, IC Engineering, Government Polytechnic, Ahmedabad

Prof. V. A. Chauhan, IC Engineering, Government Polytechnic, Palanpur