GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Digital Control System
(Course Code: 4351706)

Diploma programmer in which this course is offered	Semester in which offered
Instrumentation and Control Engineering	5th Semester

1. RATIONALE

In instrumentation and control engineering Digital Control System is a branch of control system with continuous time process in the region associated with the digital controller as the controller of the control elements that control systems and computing discrete time. Digital controller can be shaped microcontroller and ASIC to a standard desktop computer.

2. COMPETENCY

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

- Observe past and present status of control system

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:

a) Describe the basics of digital control systems.
b) Understand Laplace transform and Z transform.
c) Describe signal processing in digital control system.
d) Understand sample and hold operation.
e) Demonstrate a model of different engineering problems

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	2	4	30*	70	25	25	150

(*): 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

The following practical outcomes (Pros) are the subcomponents 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	Generate Discrete signal using MATLAB.	1	2
2	Convert A to D convertor using MATLAB.	1	2
3	Test the z transform of unit step signal for any system	2	2
4	Test the inverse z transform of unit step signal for any system	2	2
5	Observe the sampling effect using signal in MATLAB.	3	2
6	Observe the quantization effect using signal in MATLAB.	3	2
7	Convert given continuous system to a discrete system using the zero order hold operation(MATLAB)	4	2
8	Analyze the transient response from pole location in the z plane. (MATLAB)	4	2
9	Generate root locus using z transform. (MATLAB)	5	2
10	Plot the step response of a discrete-time system. (MATLAB)	5	2

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.*

Sr. No.	Sample Performance Indicators for the Pros	Weightage in %
1	Experimental setup, Procedure /Simulation Circuit	30
2	Conceptual clarity	30
3	Interpretation of Results and Ethical values.	20
4	Record Observation correctly	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	MATLAB SOFTWARE	ALL

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 (while doing a micro-project).
b. Follow safety practices while using D.C. and AC supply and electrical equipment.
c. Work as a group member (while performing experiments and taking readings)

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	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
UNIT 1 Introduction to Digital control system	**1a. Explain Different Control System Terminology.** **1b. Draw block diagram of computer controller system.** **1c . Describe Computer based control in brief (History and Trends).** **1d. Describe Control Theory in brief (History and Trends).** **1e. Explain Generalized block diagram of a feedback system.**	**1.1 Control system terminology** • **Control system** • **Controller** • **Digital Control system** • **Analog Control system** • **Continuous Time signals** • **Discrete Time signals** **1.2 Computer controlled system** • **Basic structure of a computer controller system** • **Example of Liquid Level Control system** **1.3 Computer based control: History and Trends** **1.4 Control Theory :History and Trends** **1.5 An overview of the classical approach to analog controller design** • **General linear feedback system** ❖ **A feedback system with two inputs** ❖ **A feedback system without disturbance inputs**

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
UNIT 2 Introduction to Laplace transform and Z transform	**2a.Introduce Laplace Transform(Only Equations)** **2b.Introduce Z transform** **2c.List the properties of Z transform(Only Equations)**	**2.1 Introduction of Laplace Transform** **2.1.1 Properties of Laplace Transform** • Linearity • Scale change • Differentiation • Multiplication • Convolution **2.2 The direct Z transform** **2.2.1. Inverse Z transform** **2. 3 Properties of Z transform** • Linearity • Time shifting • Time scaling • Time reversal • Differentiation • Convolution
UNIT 3 Signal Processing in Digital Control	**3a.Write advantages of digital control.** **3b.Explain Sampling and Quantization Effects in digital control.** **3c.Configure the digital control scheme** **3d.Explain Principles of signal conversion** **3e.Explain properties of discrete time signals.** **3f.List out time domain models**	**3.1 Advantages of Digital Control** **3.2 Implementation Problem in Digital Control** • Sampling effects • Quantization effects **3.3 Basic digital control scheme configuration** **3.4 Signal conversion principle** • D/A converter circuit • A/D converter circuit **3.5 Basic discrete time signals** • Properties of discrete time signals (Unit Sample Sequence, Unit Step Sequence, Sinusoidal Sequence) **3.6 Time domain models for discrete time systems** • State Variable models • Difference equation models
UNIT 4 Sample and Hold system	**4a.Explain discrete time processing of continuous time signals.**	**4.1 Sample and Hold operation model** • Discrete time processing of continuous time signals • Input and output behavior of a sample and hold system

Unit	Major Learning Outcomes ('Course Outcomes' in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
	4b.Explain sample and hold circuit. **4c.Write sampling theorem.**	**4.2 Practical sample and hold circuit** **4.3 Sampling theorem**
UNIT 5 Model of Digital control Devices and Systems	**5a.Draw block diagram of basic control system design** **5b.Describe A/D converter and D/A converter in z domain** **5c.Explain Non interacting PID algorithm in digital PID controller(Only Equations).** **5d.Explain example of digital temperature control system** **5e.Explain Stepping motors and their control Example**	**5.1 Basic digital control scheme configuration** • **Block diagram for basic control system design** **5.2 z domain description of sample continuous time plants** • **Models of A/D converter** • **Models of D/A converter** **5.3 Digital PID controller** •**Non interacting PID algorithm** •**Interacting PID algorithm** **5.4 Digital Temperature Control System** **5.5 Stepping motors and their control**

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	**Introduction to Digital control system**	10	12	4	2	18
II	**Introduction to Laplace transform and Z transform**	10	10	2	2	14
III	**Signal Processing in Digital Control**	6	8	2	2	12
IV	**Sample and Hold system**	10	10	2	2	14
V	**Model of Digital control Devices and Systems**	6	8	2	2	12
Total		**42**	**48**	**12**	**10**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to 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 slightly vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

I.Students may be asked to collect photographs using the internet which is relevant to digital control system

II.Teachers guided self learning activities; Course/library/internet/lab based mini projects

III. Students activities like: course/ topic based seminars, Internet based assignments.

IV. Students should deliver a seminar in groups on advances/latest trends in digital control system.

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) Show animation/ video related to course content.

b) Internet based home assignment

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 a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **12-14 *(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) Model of discrete time signal
b) Chart/Model presentation
c) Power Point Presentation

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Digital Control and State Variable Methods	M Gopal	2nd edition Tata McGraw Hill Publishing Company Limited, New Delhi
2	Digital Control Systems	Benjamin C. Kuo	cbs publishers and distributors pvt ltd
3	Discrete time control systems	Kaushiko Ogata	PRENTICE HALL, Englewood cliffs second edition

4.	**Digital Signal Processing** **Principles, Algorithms and Applications**	**John G. Proakis** **Dimitris G.Manolakis**	**Prentice Hall International,INC Third edition**
5.	**Control System Engineering**	**I.J.Nagarth** **M.Gopal**	**NEW AGE INTERNATIONAL PUBLISHERS**

14. SOFTWARE/LEARNING WEBSITES

WEBSITE

- Learning Resource by NPTEL, http://nptel.ac.in/courses/108103008/, Contributors:
- Indrani Kar, Somanath Majhi, Dept. of Electronics and Electrical Engg., IIT, Guwahati
- Web Supplements provided by Gopal, M.: http://www.mhhe.com/gopal/dc4e

15. PO-COMPETENCY-CO MAPPING:

Semester I	**DIGITAL CONTROL SYSTEM (Course Code : 4351706)**						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / development of solution	PO4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	• Observe past and present status of control system						
Course Outcomes	2	-	-	-	-	-	-
CO1.Describe the basics of digital control systems	2	-	-	-	-	-	-
CO2.Understand Laplace transform and Z transform	2	-	2	2	-	-	-
CO3.Describe signal processing in digital control system	-	2	2	-	-	-	-
CO4.Understad sample and hold operation.	-	2		-	-	-	-
CO5.Demonstrate a model of different engineering problems	-	2	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. Suresh Z. Shyara, IC Engineering, AVPTI, Rajkot.

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

GTU Resource Persons

Prof. Jesika N. Kothari, IC Engineering, AVPTI, Rajkot.