GUJARAT TECHNOLOGICAL UNIVERSITY

INSTRUMENTATION AND CONTROL (APPLIED INSTRUMENTATION) (03)
DIGITAL CONTROL
SUBJECT CODE: 2720301
SEMESTER: II

Type of course: Core II

Prerequisite: Control Engineering

Rationale: This course provides an overview and fundamentals of design of Digital control for different types of control systems. Also covers different types of controller structures and it's design for special applications in digital domain.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks		Practical Marks				
				ESE (E)	PA (M)	ESE (V)		PA (I)		
						ESE	OEP	PA	RP	
3	2#	2	5	70	30	20	10	10	10	150

Content:

Sr. No	**Topics**	**Teaching Hrs.**	**Module Weightage**
1.	**Transfer Function Approach to Controller Design Structures and Specifications** Control Structures , Feed Forward Controller, One Degree of Freedom Feedback Controller, Two Degrees of Freedom Feedback Controller, Proportional Control , Nyquist Plot for Control Design, Stability Margins Internal Stability and Realizability , Forbid Unstable Pole–Zero Cancellation ,Internal Stability ,Internal Stability Ensures Controller Realizability ,Closed Loop Delay Specification and Realizability, Internal Model Principle and System Type , Internal Model Principle , System Type , Introduction to Limits of Performance , Time Domain Limits , Sensitivity Functions ,Frequency Domain Limits, Well Behaved Signals, Small Rise Time in Response , Small Overshoot in Response , Large Decay Ratio , Solving Aryabhatta's Identity, Euclid's Algorithm for GCD of Two Polynomials , Aryabhatta's Identity , Algorithm to Solve Aryabhatta's Identity	**10**	**25-30%**
2.	**Proportional, Integral, Derivative Controllers** Sampling Revisited, Discretization Techniques , Area Based Approximation, Step Response Equivalence Approximation, Discretization of PID Controllers , Basic Design , Ziegler–Nichols Method of Tuning , 2-DOF Controller with Integral Action at Steady State , Bumpless PID Controller with $Tc = Sc$, PID Controller with Filtering and $Tc = Sc$,2-DOF PID Controller with $Tc = Sc(1)$, 2-DOF PID Controller with $Tc(1) = Sc(1)$.	**05**	**10-20%**
3	**Pole Placement Controllers** Dead-Beat and Dahlin Control , Pole Placement Controller with Performance Specifications, Implementation of Unstable Controllers , Internal Model Principle for Robustness, Redefining Good and Bad	**05**	**10-20%**

	Polynomials, Comparing 1-DOF and 2-DOF Controllers , Anti Windup Controller, PID Tuning Through Pole Placement Control		
4	**Special Cases of Pole Placement Control** Smith Predictor, Internal Model Control , IMC Design for Stable Plants , IMC in Conventional Form for Stable Plants , PID Tuning Through IMC	**04**	**5-10 %**
5	**Minimum Variance Control** *j*-Step Ahead Prediction Error Model , Control Objective for ARMAX Systems , Prediction Error Model Through Noise Splitting , Interpretation of the Prediction Error Model , Splitting Noise into Past and Future Terms ,ARIX Prediction Error Model , ARIMAX Prediction Error Model , Minimum Variance Controller , Minimum Variance Controller for ARMAX Systems ,Expression for Sum of Squares , Control Law for Nonminimum Phase Systems , Minimum Variance Controller for ARIMAX Systems, Generalized Minimum Variance Controller , GMVC for ARMAX Model , GMVC for ARIMAX Model, PID Tuning Through GMVC	**07**	**20-35%**
6	**Model Predictive Control** Generalized Predictive Control, GPC for ARIX Model, ARIMAX Model,Steady State Weighted Generalized Predictive Control (GPC), Model Derivation, Optimization of Objective Function, Predictive PID, Tuned with -GPC, Dynamic Matrix Control	**05**	**5-10 %**
7	**Linear Quadratic Gaussian Control** Spectral Factorization , Controller Design , Simplified LQG Control Design ,Introduction to Performance Analysis of Controllers	**04**	**5-10 %**
8	**State Space Techniques in Controller Design** Pole Placement , Ackermann's Formula, Control Law when System is not in Canonical Form , Controllability , Estimators , Prediction Estimators, Observability , Current Estimators , Regulator Design – Combined Control Law and Estimator , Linear Quadratic Regulator , Formulation of Optimal Control Problem , Solution to Optimal Control Problem , Infinite Horizon Solution to LQR Design, Kalman Filter	**05**	**5-15 %**

Reference Books:

1. Digital Control by Kannan M. Moudgalya , Wiley Interscience
2. Computer Controlled Systems. Theory and Practice by K. J. Astrom and B. Wittenmark, Prentice-Hall
3. Digital Control of Dynamic Systems G. F. Franklin, J. D. Powell and M. Workman, , Addison Wesley Longman, Menlo Park, CA, 3rd edition, 1998.
4. Digital Control Systems, Second Edition, Benjamin C. Kuo , Oxford University Press
5. Digital Control Systems , Second Revised Edition by Rolf Isermann, Springer-Verlag.
6. Published Research Papers on Digital controller design

Course Outcome:

After learning the course the students are able to

1. Understand the structure of various types of Digital Structures
2. Design of different types of Digital PID Controllers
3. Design of different types of Pole Placement Controllers
4. Design of Model Predictive Controller
5. Design of digital controllers with transfer function and state space approach.

List of Experiments:

Student has to prepare computer programs and simulations for various Digital Controller Design techniques covered in this course with any computing tools (,MatLab, Scilab, etc...).

Prepare research paper and submit report of various Digital Controller Design covered in this course with presentation.

Open Ended Problem: Solution of the open ended problem(s) in guidance of course instructor is mandatory. Few of the problems are specified as under.

Design and implementation of Digital system for Radar application.
Design and implementation of Digital system for Biomedical application.
Design and implementation of Digital system for robotics application.
Design and implementation of Digital system for motion control application.
Design and implementation of Digital system for process control application.

Major Equipment:

Computer Laboratory

List of Open Source Software/learning website:

- Matlab, Scilab
- NPTEL

Review Presentation(RP): The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.