JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY - GURAJADA - VIZIANAGARAM
VIZIANAGARAM – 535 003 Andhra Pradesh (India)
(Established by Andhra Pradesh Act No.22 of 2021)

DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

M.TECH-CONTROL SYSTEMS
(Course Code:95)
COURSE STRUCTURE & SYLLABUS

(Applicable for batches admitted from 2025-2026)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY - GURAJADA - VIZIANAGARAM
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CONTROL SYSTEMS

COURSE STRUCTURE

I Year M.Tech I – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	M259501	**Program Core – 1** Power Electronics Converters	3	1	0	4
2	M259502	**Program Core – 2** Smart Grid Technologies	3	1	0	4
3	M259503	**Program Core – 3** Advanced Control theory	3	1	0	4
4	M259504A	**Program Elective – I** System identification and Adaptive control	3	1	0	4
	M259504B	Embedded Control systems				
	M259504C	Multi variable Control systems				
	M259504D	CONTROL SYSTEM DESIGN				
5	M259505A	**Program Elective – II** Renewable Energy Technologies	3	1	0	4
	M259505B	Electric Vehicles Technologies				
	M259505C	Industrial internet of things				
6	M259506	**Laboratory – 1** Advanced Control Systems Laboratory	0	1	2	2
7	M259507	**Laboratory – 2** Power Electronics Simulation Laboratory	0	1	2	2
8	M259508	Seminar-I	0	0	2	1
		TOTAL	**15**	**7**	**6**	**25**

I Year MTech II – Semester

S.No.	Course Code	Course Title	L	T	P	C
1	N259501	**Program Core – 4** Power Electronics control of Electrical drives	3	1	0	4
2	N259502	**Program Core – 5** Switched mode power conversion	3	1	0	4
3	N259503	**Program Core – 6** Non-Linear Dynamical systems	3	1	0	4
4	N259504A	**Program Elective – III** Advanced process Control	3	1	0	4
	N259504B	Digital control systems				
	N259504C	Automotive control systems				
	N259504D	Robust Control				
5	N259505A	**Program Elective – IV** Artificial Intelligent techniques	3	1	0	4
	N259505B	Control and integration of Renewable Energy Systems				
	N259505C	Applications of power converters				
6	N259506	**Laboratory – 3** Power converters and drives Lab	0	1	2	2
7	N259507	**Laboratory – 4** Advanced control systems Lab	0	1	2	2
8	N259508	Seminar – II	0	0	2	1
		TOTAL	**15**	**7**	**6**	**25**

II Year MTech I – Semester

S.No.	Course Code	Course Title	L	T	P	C
1	O259501	Research Methodology and IPR / Swayam 12 week MOOC course – RM&IPR	2	0	0	2
2	O259502	Summer Internship/ Industrial Training (8-10 weeks)*	-	-	-	2
3	O259503	Dissertation Part – A$^{\$}$	-	-	20	10
		TOTAL	**2**	**-**	**20**	**14**

* Student attended during summer / year break and assessment will be done in 3rd Sem.

$ Dissertation – Part A, internal assessment

II Year MTech II – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	P259501	Dissertation Part – B$^{\%}$	-	-	32	16
		TOTAL	**-**	**-**	**32**	**16**

% External Assessment

I- Semester	Power Electronic Converters (Program Core – 1)	Category PC	L-T-P 3-1-0	Credits 4

Pre-Requisite: Power Electronics.

Course Objectives:

- To understand the static and dynamic characteristics of power switching devices including MOSFET, IGBT, GTO, GaN devices, and their gate drive circuit requirements.
- To apply operational principles and control techniques of single-phase and three-phase fully controlled AC-DC converters, including power factor evaluation and harmonic analysis.
- To analyze various PWM inverter modulation schemes for single-phase and three-phase voltage and current source inverters, including sinusoidal, third harmonic, and space vector PWM. Analyze advanced PWM modulation techniques for multi-level inverters.
- To understand multilevel inverter topologies such as diode-clamped, cascaded H-bridge, and modular multilevel converters.

Course Outcomes:

- Understand the characteristics and switching behavior of modern power devices and corresponding gate driver circuits. Understand the operation of AC-DC converters, two-level inverters and various multilevel inverter configurations.
- Apply various control strategies to improve input power quality and perform harmonic reduction in AC-DC conversion systems.
- Analyze and compare different PWM techniques for two-level and multi-level inverters to reduce harmonics.

UNIT– 1

Overview of Switching Devices

Power MOSFET, IGBT, GTO, GaN devices-static and dynamic characteristics, gate drive circuits for switching devices.

UNIT– 2

AC-DC converters

Single phase fully controlled converters with RL load– Evaluation of input power factor and harmonic factor- Continuous and Discontinuous load current, Power factor improvements, Extinction angle control, symmetrical angle control, PWM control, Single-phase single stage boost power factor corrected rectifier.

Three Phase AC-DC Converters, fully controlled converters feeding RL load with continuous and discontinuous load current, Evaluation of input power factor and harmonic factor-three phase dual converters.

UNIT– 3

PWM Inverters: Voltage control of single-phase inverters employing phase displacement Control, Bipolar PWM, Unipolar PWM. Three-phase Voltage source inverters: Six stepped VSI operation-Voltage Control of Three-Phase Inverters employing Sinusoidal PWM, Third Harmonic PWM, Space Vector Modulation- Comparison of PWM Techniques- Three phase current source inverters.

UNIT– 4

Multilevel Inverters:

Introduction, Multilevel Concept, Types of Multilevel Inverters, Diode-Clamped Multilevel Inverter, Principle of Operation, Features of Diode-Clamped Inverter, Improved Diode Clamped Inverter, Cascaded H-bridge Multilevel Inverter, Principle of Operation, Features of Cascaded H-bridge Inverter, Fault tolerant operation of CHB Inverter, Comparison of DCMLI & CHB, Modular multilevel converters, principle of operation.

UNIT– 5

PWM Multilevel Inverters:

CHB Multilevel Inverter: Stair case modulation-SHE PWM- Phase shifted Multicarrier modulation-Level shifted PWM- Diode clamped Multilevel inverter: SHE PWM-Sinusoidal PWM- Space vector PWM-Capacitor voltage balancing.

Text Books

1. Power Electronics: Converters, Applications, and Design- Ned Mohan, Tore M. Undeland, William P. Robbins, John Wiley&Sons, 2nd Edition, 2003.
2. Power Electronics-Md.H.Rashid –Pearson Education Third Edition- First IndianReprint-2008.

Reference Books:

1. Power Electronics Semiconductor Switches – Ram Shaw, 1993. . Power Electronics Daniel W. Hart - McGraw-Hill, 2011.
2. Elements of Power Electronics – Philip T. Krein, Oxford University press, 2014.
3. Power Converter Circuits – William Shepherd & Li Zhang-Yes Dee CRC Press, 2004.

I-Semester	SMART GRID TECHNOLOGIES (Program Core – 2)	CATEGORY	L-T-P 3-1-0	CREDITS 4

Pre-requisite: Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

Course Objectives:

- To understand concept of smart grid and developments on smart grid.
- To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc.
- To have knowledge on smart substations, feeder automation and application for monitoring and protection.
- To understand the Concepts of micro grid and applications
- To analyze the effects of power quality in smart grid and to understand latest developments in ICT for smart grid

Course Outcomes:

At the end of this course, the students will be able to:

- Analyse the smart grid policies and its developments.
- Develop the concepts of smart grid technologies in hybrid electrical vehicles etc.
- Understand smart substations, feeder automation, GIS etc.
- Analyze micro grids and its applications.
- Analyze the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

UNIT- I

Introduction to Smart Grid: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient &Self-Healing Grid, Present development & International policies on Smart Grid. Case study of Smart Grid.

UNIT – 2

Smart Grid Technologies: Part-1: Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.

UNIT – 3

Smart Grid Technologies: Part-2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Phase Measurement Unit(PMU),Wide Area Measurement System(WAMS).

UNIT – 4

Micro grids: Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid.

UNIT – 5

Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

Textbooks:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press

Reference Books:

1. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, AkihikoYokoyama, "Smart Grid: Technology and Applications", Wiley
2. Jean Claude Sabonnadière, NouredineHadjsaïd, "Smart Grids", Wiley Blackwell 19
3. Peter S. Fox Penner, "Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities", Island Press; 1 edition 8 Jun 2010
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, "Microgrids and Active Distribution Networks." Institution of Engineering and Technology, 30 Jun 2009
5. Stuart Borlase, "Smart Grids (Power Engineering)", CRC Press.
6. Andres Carvallo, John Cooper, "The Advanced Smart Grid: Edge Power Driving Sustainability: 1", Artech House Publishers July 2011.

I-Semester	ADVANCED CONTROL THEORY (Program Core – III)	CATEGORY PC	L-T-P 3-1-0	CREDITS 4

Pre-requisite: Engineering Physics, Basic Electrical and Electronics Engineering.

Course Objectives: The primary objectives of this course are to

- Understand the structure and function of conventional vehicle systems and configurations.
- Learn about vehicle modeling, propulsion loads, and various drive cycles.
- Study the types and functions of suspension, chassis, and body systems.
- Explore transmission, braking, and steering systems and their advancements.
- Understand electric motors, battery technologies, and battery management in vehicles.

Course Outcomes: At the end of the course, student will be able to

- Explain the fundamentals of vehicle systems and evaluate the forces acting on a moving vehicle.
- Analyze different vehicle configurations, drive cycles, and engine performance parameters.
- Classify various chassis, suspension, wheel, and tire systems and assess their advantages.
- Compare transmission types, braking systems, and steering mechanisms used in vehicles.
- Evaluate battery technologies, their thermal and performance management in electric vehicles.

UNIT- 1

Mathematical modelling of LTI control systems: impulse response model, differential equation model, transfer function model, frequency response model, state space model- Introduction to state and state variables – State space - physical systems - Representation using state space approach- Modelling of electrical systems

UNIT – 2

Controllability structure of multivariable linear systems: Introduction, Distinct eigen values, confluent eigen values associated with single Jordan block, confluent eigen values associated with a number of distinct Jordan blocks

UNIT – 3

Observability matrices: Distinct eigen values, confluent eigen values, mode observability structure of multi variable linear system: Introduction, Distinct eigen values, confluent eigen values

UNIT – 4

Control system Design in State space: Pole placement approach to Regulator Design-Full order observer- Observer based regulator design

UNIT – 5

Stability concept: Stability in the sense of Lyapunov - stability of linear systems – Lyapunov equation- Generation of Lyapunov functions-Krasovskii's method Quadratic optimal control-Lyapunov's approach to quadratic optimal regulator design.

Textbooks:

1. Katsuhiko Ogata, Modern control Engineering, Pearson Education India, 2020, 5th Edition.
2. M. Gopal, Modern Control Systems Theory, New Age International Publisher, 2023, 5th Edition.
3. https://nptel.ac.in/courses/108106150
4. https://nptel.ac.in/courses/101108057

Reference Books:

1. P.J. Antsaklis, A.N. Michel, A Linear Systems Primer, Birkhauser Boston Inc, 2007, 1st Edition.
2. Roy Choudhary, Modern Control Engineering, Prentice Hall India, 2005, 1st Edition.
3. Brogan W. L, Modern Control Theory, Prentice Hall, 2011, 3rd Edition.

I-Semester	SYSTEM IDENTIFICATION & ADAPTIVE CONTROL (Program Elective–I)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Communication Networks, Wireless Communication Systems

Course Objectives: The primary objectives of this course are to

- Understand the fundamentals, architecture, and applications of VANET-based cooperative vehicular systems.
- Explore vehicular mobility and traffic modeling techniques across different levels.
- Analyze physical and MAC layer challenges specific to high-mobility vehicular communication.
- Study and evaluate various routing protocols used in VANETs.
- Understand the regulatory standards, layered architecture, and protocol stack for DSRC in VANETs.

Course Outcomes: At the end of the course, student will be able to

- Describe the core principles, challenges, and cooperative safety applications in VANETs.
- Apply and differentiate between various vehicular mobility and behavioral models.
- Analyze the wireless channel effects and MAC protocols for vehicular communications.
- Compare VANET routing techniques, including ad-hoc, geographic, and geocast routing.
- Interpret standards, protocols, and regulatory frameworks used in VANET communications.

UNIT-1:
System Modelling approaches:
Modelling by first principle approach of simple mechanical, electrical, thermal, chemical systems. Energy approach-based modelling using Euler-Lagrangian and Hamiltonian methods.

UNIT-2:
Representation of dynamical systems:
Linearization of nonlinear models- state space approach for analyzing the dynamic models: Continuous time and discrete time system- Z-transform-Models of Discrete Time Linear Time invariant (LTI) Systems – Difference equations- Stability of Discrete time LTI system- Discretization, Sampling and Hold operations, Sampling theorem.

UNIT-3:
Discrete time series models:
Finite Impulse Response (FIR) and Auto regressive exogeneous (ARX) models- Parametric model structures – ARX by least square estimation, Auto Regressive Moving Average exogeneous (ARMAX), Output Error (OE), Box Jenkins (BJ) models. Regression methods: Non-parametric models based on impulse response, step response and frequency response models. Estimating parameters in Dynamical Systems, Experimental conditions, Prior information,

maximum likelihood estimation (MLE), Recursive least square (RLS), Instrument variable method.

UNIT-4:
Routing Protocols:
Deterministic Self tuning regulators (STR): Pole placement design, Indirect self tuning regulators, Continuous time self tuners, Direct self tuning regulators, disturbances with known characteristics.

UNIT-5:
Model reference adaptive control (MRAS):
The MIT Rule, Determination of adaptation gain, Lyapunov theory, Design of MRAS using Lyapunov theory, BIBO stability, Output feedback, Relations between MRAS and STR.

Textbooks
1. L. D. Landau, R. Lozano, M. M'Saad, A. Karimi, Adaptive Control: Algorithms, Analysis and Application, Springer, 2013, 2nd Edition.
2. Sankar Sastry, Marc Bodson, Adaptive Control: Stability, Convergence and Robustness, Springer, 2011, 1st Edition.
3. A.K. Tangirala, Principles of System Identification: Theory and Practice, CRC Press, 2017,1st Edition

Reference Books:
1.P.A. Ioannou, J. Sun, Robust Adaptive Control, Dover Publications, 2013, 1st Edition.
2. K. J. Astrom, B. Wittenmark, Adaptive Control, Pearson Education, 2008, 2nd Edition.
3. P.A. Ioannou, B. Fidan, Adaptive Control Tutorial, SIAM, 2007, 11th Edition.
4. K. Ogata, System Dynamics, Pearson Education India, 2014, 4th Edition.
5. Karel J. Keesman, System Identification – An Introduction, Springer, 2011, 1st Edition.

Online Readings:
1. https://nptel.ac.in/courses/108102113
2. https://nptel.ac.in/courses/112101312
3. https://nptel.ac.in/courses/112104158
4. https://nptel.ac.in/courses/108105056
5. https://nptel.ac.in/courses/103106149

I-Semester	EMBEDDED CONTROL SYSTEMS (Program Elective–I)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Basic Electrical and Electronics Engineering, Digital Electronics, Signals and Systems, Microprocessors and Microcontrollers.

Course Objectives: The primary objectives of this course are to

- Understand the fundamentals and performance characteristics of sensors and actuators.
- Study the working principles and applications of temperature and optical sensors.
- Learn the functionality of electric, magnetic, and mechanical sensors.
- Explore chemical, MEMS, and smart sensor technologies and their integration.
- Analyze circuit-level interfacing and microcontroller-based integration of sensors and actuators.

Course Outcomes: At the end of the course, student will be able to

- Explain sensor and actuator types, classifications, and performance parameters.
- Analyze temperature and optical sensor types and their working principles.
- Evaluate electric, magnetic, and mechanical sensors for real-world applications.
- Distinguish between chemical, MEMS, and smart sensors and their usage in systems.
- Design basic interfacing circuits and apply microcontroller-based sensor integration.

Unit-1:
System Design:
Definitions, Classifications and brief overview of micro-controllers, microprocessors and Digital Signal Processors. Embedded processor architectural definitions. Typical application scenario of embedded systems.

Unit-2:
Data acquisition basics:
Introduction to data acquisition on PC, Sampling fundamentals, Input/Output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements, Interface Issues Related to Embedded Systems: A/D, D/A converters, timers, actuators, power, FPGA, ASIC, diagnostic port.

Unit-3:
Techniques for Embedded Systems:
State Machine and state tables in embedded design, Simulation and Emulation of embedded systems. High-level language descriptions for embedded system, Java embedded system design.

Unit-4:
Real time Models, Language and Operating Systems:
Event based, process based and graph-based models, Petrinet models – Real time languages – The real time kernel, OS tasks, task states, task scheduling, interrupt processing, clocking communication and synchronization, control blocks, memory requirements and control, kernel services**.**

Unit-5:

Software programming:

Optimization, concurrent programming. Real time scheduling, I/O Management, Embedded Operating Systems. Developing Embedded Systems, Building Dependable Embedded Systems, Controller Implementation. Case Studies: Discussion of specific examples of complete embedded systems using mc8051, DSP TMS320F28069, PIC series of microcontroller.

Text Books:

1. S. Chattopadhyay, Embedded System Design, PHI Learning Pvt. Ltd, 2023, 3rd Edition.
2. Herma K, W. Steiner, Real Time Systems – Design for Distributed Embedded Applications, Springer International Publishing AG, 2022, 3rd Edition.

Reference Books:

1. C.M. Krishna, Kang G. Shin, Real Time Systems, McGraw Hill, 2017, 1st Edition.
2. Tim Wiscott, Applied control for embedded systems, Elsevier Publications, 2011,1st Edition.
3. Jim Ledin, Embedded control systems in C/C++, CRC Press, 2003, 1st Edition.

Online reference:

1. https://nptel.ac.in/courses/108102045

2. https://nptel.ac.in/courses/108102169

I-Semester	MULTI VARIABLE CONTROL SYSTEMS (Program Elective -I)	Category PE	L-T-P 3-1-0	Credits 4

Pre requisite: Power Electronics.

Course Objectives: The primary objectives of this course are to

- To understand the fundamental principles of renewable energy sources, distributed generation, and economic aspects including electricity generation cost and management options.
- To apply operational principles and mathematical models of induction generators including self-excitation, speed, and voltage control for renewable power systems.
- To analyze key factors in wind and photovoltaic power plant design, including site evaluation, turbine classification, PV cell characteristics, and maximum power point tracking techniques.
- To explore fuel cell technologies, their performance modeling, practical implementation challenges, and integration considerations for sustainable energy conversion and storage.

Course Outcomes: At the end of the course, student will be able to

- Understanding of renewable energy fundamentals, distributed generation concepts, and the economic/environmental impact of renewable power systems.
- Apply knowledge of induction generator operation and controls to model and control renewable energy conversion systems effectively.
- Analyze wind and solar energy system components, including turbine types, PV cell models, and MPPT algorithms, to optimize system performance.
- Explore fuel cell technologies, hydrogen storage issues, and system integration strategies for advancing renewable energy utilization.

UNIT– 1:

Multi Input Multi Output (MIMO) Systems:

Issues with Single Loop design- Limitations on Performance Right Half Plane Zeros and Poles-Bode's Integral Theorem, Waterbed effect-Representation of MIMO linear system

UNIT– 2:

Different Forms and its stability:

Transfer function matrix (TFM) and State space Matrix- Poles and Zeros of a TFM – Smith-McMillan form of a TFM- Matrix fraction description of a TFM- Internal Stability Generalized Nyquist stability criterion- Nyquist array and Gershgorin bands– Case Study.

UNIT– 3:

Decentralized and Decoupled Control:

System Decomposition, Grouping of Variables-Multi Loop control: Pairing Selection- Condition number, Relative gain array analysis, Stability analysis using Diagonal Dominance- Feedforward Decoupling, Feedback Decoupling, Singular Value Decomposition (SVD).

UNIT– 4: Performance and Robustness:
Principal gains (Singular values) and its usage- Principal gains and characteristic loci - Multivariable Design techniques – Sequential loop closing, Characteristic locus method- Direct Nyquist array (DNA) method -Inverse Nyquist array (INA) method- Perron Frobenius theory for Diagonal dominance- Pseudo diagonalization-– Case Study.

UNIT– 5
Control Methods:
Linear quadratic Gaussian (LQG) Method – Performance and robustness of optimal feedback- Loop transfer recovery (LTR) - Design procedure for square Systems- Shaping the principal gain- H-infinity control problem- The Youla parametrization –Case Study.

Text Books:

1. S.P.Bhattacharyya, L.H.Keel, Linear Multivariable Control Systems, Cambridge University Press, 2022, 1st Edition.
2. S Skogestad, I. Postlethwaite, Multivariable Feedback Control, Analysis and design, Wiley, 2014, 2nd Edition.

Reference Books:

1. F. Assadian, K.R. Mallon, Robust Control: Youla Parametrization Approach, Wiley-ASME Press series, 2022, 1st Edition.
2. P. Albertos, S. Antonio, Multivariable Control Systems: An Engineering Approach, Springer London Ltd, 2004, 1st Edition.
3. O. Gasparyan, Linear and Nonlinear Multivariable Feedback Control: A Classical Approach, Wiley, 2008, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/108103007
2. https://ocw.mit.edu/courses/6-245-multivariable-control-systems-spring-2004/download/

I-Semester	CONTROL SYSTEM DESIGN (Program Elective–I)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre requisite: Control systems

Course Objective

1. The course aims to know about the principles of control design.

2. This course aims to design classical controllers for continuous and discrete-time system using root-locus and Bode methods.

3. Find the controller parameter to minimize a given performance measure.

Course Outcome

At the end of this course, the students should be able to:

1. A student is able to design a lag or lead compensator for a system whose steady-state or transient performance need to be improved using root-locus and Bode methods.
2. A student can able to find a controller parameter to meet certain objective.
3. A student can able to determine state feedback controller using pole-placement
4. technique for a desired closed-loop behavior.
5. To know about centralized and decentralized control strategies of a multi-variable
6. systems.
7. A student is able to design a digital controller for a given system using z-plane synthesis
8. and also dead-beat response method.

SYLLABUS

UNIT– 1

Design of Linear Control Systems: Review of compensation techniques to obtain desired performance, Reshaping of Bode &Root locus plots to obtain desired response ,Initial condition and forced response, a simple lag–lead design.

UNIT– 2

Integral square error compensation: parameter optimization using Integral-square error criterion with and without constraints, principles of State variable Feedback compensation of continuous-time and discrete-time systems, simple problems to understand the concept.

UNIT– 3

MIMO Control design: Principles of Linear Quadratic Optimal Regulators, Discrete Time optimal Regulators, Observer Design, Linear Optimal Filters, State Estimate Feedback,

UNIT– 4

Transfer Function Interpretation, simple problems to understand the concept.

PID Controller: PID controller, Simulation of multi-loop control system using P, PI, PD,

PID controller, Standard compensator structures (P,PD, PI and PID control).

UNIT– 5

Design of digital control system: Protocol of Digital controller design, Classical Compensation of Discrete-time control systems: Forward path continuous, Forward-path,Digital Z-plane Synthesis approaches, Dead beat performance.

Text Books:

1. G.C.Goodwin, S.F.Graebe, M.E.Salgado,“Control System Design”, Prentice Hall of

India

2. Gupta and Hasdorf,'Fundamentals of Automatic control Willey Eastern,1970

3. B.C.Kuo,Automatic control systems'(5thEdition),Prentice Hall of India,1988.

Reference Books Books:

1. M.Gopal,“Digital Control and State Variable Method”,Tata McGraw Hill

2. Hadi Saadat, “Computational Aidsin Control System Using MATLAB”, McGraw Hill

International

3. Ogata K.,“Modern Control Engineering”,4th Edition,Prentice Hall

4. Norman S.Nise,“Control Systems Engineering”,3rd Edition,Wiley

I-Semester	Renewable Energy Technologies (Program Elective–II)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre requisite: Power Electronics.

Course Objectives:

- To understand the fundamental principles of renewable energy sources, distributed generation, and economic aspects including electricity generation cost and management options.
- To apply operational principles and mathematical models of induction generators including self-excitation, speed, and voltage control for renewable power systems.
- To analyze key factors in wind and photovoltaic power plant design, including site evaluation, turbine classification, PV cell characteristics, and maximum power point tracking techniques.
- To explore fuel cell technologies, their performance modeling, practical implementation challenges, and integration considerations for sustainable energy conversion and storage.

Course Outcomes:

At the end of the course, student will be able to,

- Understanding of renewable energy fundamentals, distributed generation concepts, and the economic/environmental impact of renewable power systems.
- Apply knowledge of induction generator operation and controls to model and control renewable energy conversion systems effectively.
- Analyze wind and solar energy system components, including turbine types, PV cell models, and MPPT algorithms, to optimize system performance.
- Explore fuel cell technologies, hydrogen storage issues, and system integration strategies for advancing renewable energy utilization.

UNIT– 1

Introduction: Renewable Sources of Energy; Distributed Generation; Renewable Energy Economics - Calculation of Electricity Generation Costs; Demand-Side Management Options; Supply-Side Management Options; Control of renewable energy based power Systems

UNIT– 2

Induction Generators: Principles of Operation; Representation of Steady-State Operation; Power and Losses Generated - Self-Excited Induction Generator; Magnetizing Curves and Self-Excitation - Mathematical Description of the Self-Excitation Process; Interconnected and Stand-alone operation - Speed and Voltage Control.

UNIT– 3

Wind Power Plants: Site Selection; Evaluation of Wind Intensity; Topography; Purpose of the Energy Generation- General Classification of Wind Turbines; Rotor Turbines; Multiple-Blade Turbines; Drag Turbines; Lifting Turbines - Generators and Speed Control Used in Wind Power Energy; Analysis of Small wind energy conversion system.

UNIT– 4

Photovoltaic Power Plants: Solar Energy; Generation of Electricity by Photovoltaic Effect; Dependence of a PV Cell on Temperature and irradiance input-output Characteristics - Equivalent Models and Parameters for Photovoltaic Panels; MPPT schemes: P&O,INC, effect of partial shaded condition. Applications of Photovoltaic Solar Energy-Economical Analysis of Solar Energy

UNIT– 5

Fuel Cells: The Fuel Cell; Low- and High-Temperature Fuel Cells; Commercial and Manufacturing Issues - Constructional Features of Proton Exchange-Membrane Fuel Cells; Reformers; Electrolyzer Systems; Advantages and Disadvantages of Fuel Cells - Fuel Cell Equivalent Circuit; Practical Determination of the Equivalent Model Parameters; Aspects of Hydrogen for storage

Text Books:

1.Felix A. Farret, M. Godoy Simo` es, Integration of Alternative Sources of Energy, John Wiley & Sons, 2006.

2. Remus Teodorescu, Marco Liserre, Pedro Rodríguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley & Sons, 2011.

Reference Books:

1. Gilbert M. Masters, Renewable and Efficient Electric Power Systems, John Wiley & Sons, 2004

I-Semester	Electric Vehicles Technologies (Program Elective–II)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Knowledge of Power Electronics and Electric Drives

Course Objectives:

- To understand the fundamental components of conventional vehicles, propulsion loads, drive cycles, and terrains along with concepts of electric and hybrid vehicles.
- To apply hybridization techniques in automobiles, including the design and comparison of HEV, PHEV, and fuel cell vehicles.
- To analyze motor control strategies, power electronic converters, and regenerative braking systems used in electric and hybrid electric vehicles.
- To analyze different energy storage systems such as batteries, ultra-capacitors, flywheels, and other advanced technologies for their suitability in electric and hybrid vehicles.

Course Outcomes:

At the end of the course, student will be able to,

- Understand the key components of conventional vehicles and contrast them effectively with electric and hybrid vehicles.
- Apply knowledge of hybrid vehicle architectures, motor control startegies and energy management systems to design or select appropriate ev's.
- Analyze the functionality of motor controllers, power electronic devices, and regenerative braking to optimize electric vehicle performance.
- Analyze various energy storage technologies and their integration into electric and hybrid vehicles to improve overall system efficiency.

UNIT– 1

Introduction:

Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept and classification of electric vehicle and hybrid electric vehicle; History of electric and hybrid vehicles, Comparison of conventional vehicle with electric and hybrid vehicles.

UNIT– 2

Hybridization of Automobile:

Fundamentals of vehicle, components of conventional vehicle and propulsion load; Drive cycles and drive terrain; Concept of electric vehicle and hybrid electric vehicle; Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.

UNIT– 3

Motor Control in Electric Vehicles:

Role of motors in Electric Vehicles, factors to choose motors for EV, Comparison of motors for EV power train, Motor Controller Unit (MCU)- need and components, Motor control units of two- and four –wheel EVs, Regenerative braking.

UNIT– 4

Power Electronics in HEVs:

Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.

UNIT– 5

Battery and Storage Systems

Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource

Text Books

1. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.
2. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

Reference Books:

1. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
3. H. Partab: Modern Electric Traction – Dhanpat Rai & Co, 2007.

Research Books:

1. Pistooa G., “Power Sources , Models, Sustanability, Infrastructure and the market”, Elsevier 2008.
2. Mi Chris, Masrur A., and Gao D.W., “ Hybrid Electric Vehicle: Principles and Applications with Practical Perspectives” 1995.

I-Semester	Industrial Internet of Things (Program Elective–II)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisites:

Course Objectives:

- To understand IoT architectures, protocols, and communication principles.
- To apply programming skills for IoT device integration using Arduino and Raspberry Pi.
- To analyze domestic and industrial appliance technologies and embedded IoT solutions.
- To evaluate cloud and edge computing approaches for IoT data management and smart applications.

Course Outcomes: At the end of the course, the student will be able to

- Explain IoT communication models and interoperability.
- Develop IoT applications with sensors and actuators integration.
- Investigate IoT-enabled devices and optimize power and control systems.
- Critically assess IoT data analytics, SDN, and AI/ML applications in IoT.

UNIT-1

IoT Communication Technologies: Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications. Interoperability in IoT.

UNIT-2

IoT Control Technologies and Programming: Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Internet of Things Open-Source Systems. Introduction to Python programming, Introduction to Raspberry. Implementation of IoT with Raspberry Pi, Smart Grid Hardware Security.

UNIT-3

Domestic & Industrial Appliances (Part-1): Solid State Lamps: Introduction - Review of Light sources - white light generation techniques-Characterization of LEDs for illumination application. Power LEDs - High brightness LEDs - Electrical and optical properties. LED driver considerations-Power management topologies -color issues of white LEDs- Dimming of LED sources.

UNIT-4

Domestic & Industrial Appliances (Part-2): BLDC motors for pumping and domestic fan appliances, inverter technology-based home appliances, Smart devices and equipment. Industrial IoT applications Factories and Assembly Line- Power Plants, Plant Safety and Security (Including AR and VR safety applications)- Oil and chemical Industry- Applications of UAVs in Industries.

UNIT-5

IoT Cloud Computation and Applications: Introduction to SDN. SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor- Cloud. Fog Computing, Smart Cities and Smart Homes, Electric Vehicles, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring, Role of ML and AI in IoT.

Text Books:

1. Sudip Misra, Chandana Roy, Anandarup Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0, CRC press, 2021.
2. Kostas Siozios, Dimitrios Anagnostos, Dimitrios Soudris, Elias Kosmatopoulos, IoT for Smart Grids: Design Challenges and Paradigms, Springer publishers, 2019.
3. Vinod Kumar Khanna, Fundamentals of Solid-State Lighting: LEDs, OLEDs, and Their Applications in Illumination and Displays, CRC press, 2014, 1st Edition.

Reference Books:

1. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress Publishers, 2016.
2. Craig Di Louie, Advanced Lighting Controls: Energy Savings, Productivity, Technology and Applications, River publishers, 2006, e-book, 2021,1st Edition.
3. Chang-liang Xia, Permanent Magnet Brushless DC Motor Drives and Controls, John Wiley & Sons Singapore Pte. Ltd., 2012, 1st Edition.

Other Suggested Readings:

https://nptel.ac.in/courses/106105166

I-Semester	ADVANCED CONTROL SYSTEMS LAB (Laboratory – I)	CATEGORY Lab	L-T-P 0-1-2	CREDITS 2

Pre-requisite: Basics of Electrical Machines and Drives, Control Systems, Power Electronics and Battery and Energy Systems.

Course Objectives: The primary objectives of this course are to

- Develop and analyze simulation models for EV systems.
- Understand effects of rolling resistance, mass, and drag on vehicle range.
- Simulate motor speed control for induction, PMDC, and BLDC motors.
- Analyze regenerative braking and battery management via simulation.
- Learn embedded system architecture and automotive protocols for EV control.

Course Outcomes: At the end of the course, student will be able to

- Describe architecture and domains of automotive embedded systems.
- Apply CAN, LIN, FlexRay protocols and model-based design in simulations.
- Explain AUTOSAR layered architecture for vehicle embedded systems.
- Interpret ISO 26262 safety standards and automotive functional safety.
- Evaluate MIL, SIL, HIL testing methodologies and Automotive SPICE compliance.

List of Experiments:

1. State feedback controller design for Power converters system
2. Synthesis of State observer-based feedback gain controller for Position control system
3. Design of State feedback gain based Integral controller for Power converter system
4. Design of Infinite horizon Linear quadratic regulator (LQR) for robotic manipulator
5. Position Controller design for DC Servo system using Pole placement approach
6. Cascade Control scheme for DC Servo system: Speed and Position control
7. State feedback-based controller for angular position of Inverted Pendulum
8. LQR based position controller design for Unstable Magnetic levitation System
9. LQR based disturbance rejection controller design for Rotary flexible link system
10. Design of Multivariable controller for 2-DOF (pitch and yaw axis) Helicopter setup
11. Two degree of freedom controller for Industrial plant emulator position control system

	Power Electronics Simulation Laboratory (Laboratory – 2)	CATEGORY Lab	L-T-P 0-1-2	CREDITS 2

Pre-requisite: Power Electronics fundamentals

Course Objectives:

- To understand the switching characteristics and operational principles of power MOSFETs and IGBTs including their structural differences and performance parameters.
- To apply driver circuit design concepts for power MOSFET and IGBT to enable effective gate control and switching operations.
- To analyze the simulation results of various power converter topologies such as three-phase full converters, dual converters, and PWM-based inverters to understand waveforms and conduction modes.
- To evaluate different PWM techniques including unipolar, bipolar, space vector, third harmonic injection, and multilevel inverter modulation schemes for improving inverter output quality.

Course Outcomes:

At the end of the course, student will be able to,

- Understanding of power MOSFET and IGBT switching behavior, including their advantages and limitations in power electronic applications (Level 2).
- Capable of applying driver circuit designs for effective control of MOSFET and IGBT power devices in switching converters (Level 3).
- Analyze the performance of simulated converter and inverter circuits under various load conditions and modulation schemes for improved power electronic system design.
- Analyze multilevel inverter configurations through simulation to improve power quality and system performance in advanced applications.

Any 10 of the following experiments are to be conducted.

List of Experiments:

1. Illustrate the switching characteristics of power MOSFET and power IGBT
2. Illustrate the use of Driver circuit for power MOSFET and power IGBT
3. Simulation of three phase full converter with RL & RLE loads.
4. Simulation of three-phase dual converter.
5. Simulation of single-phase full bridge inverter using unipolar & bipolar PWM techniques.
6. Simulation of three-phase two-level inverter for 120º & 180º mode of conduction.
7. Simulation of three phase two-level inverter using SPWM.
8. Simulation of three phase two-level inverter using Third Harmonic PWM,
9. Simulation of three phase two-level inverter using space vector PWM.
10. Simulation of three phase three-level NPC inverter using SPWM

11. Simulation of three phase five-level diode clamped inverter using SPWM
12. Simulation of Stair case modulation and SHE PWM for single-phase seven-level cascaded H-bridge inverter.
13. Simulation of Multicarrier PWM techniques for three-phase five-level cascaded H-bridge inverter.
14. Simulation of Modular Multilevel Converter.

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VIZIANAGARAM – 535 003 Andhra Pradesh (India)
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I-Semester	SEMINAR - I	CATEGORY	L-T-P 0-0-2	CREDITS 1

II-Semester	Power Electronic Control of Electrical Drives (Program Core – 4)	CATEGORY PC	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Knowledge of Power Electronics and Electrical Machines.

Course Educational Objectives:

- To understand the principles and working of different control methods for induction motor drives including V/f control, vector control, and direct torque control techniques.
- To apply sensorless control methods and state observers such as MRAS and Kalman filters to estimate motor parameters without speed sensors in induction motor drives.
- To analyze the control strategies and performance trade-offs of Permanent Magnet Synchronous Machines, Brushless DC motors, and Switched Reluctance Motors for efficient torque and speed control.

Course Outcomes: After the completion of the course, student will be able to

- Explain the concepts of vector control, sensorless speed estimation, DTC, and their significance in the operation of induction motor and permanent magnet motor drives.
- Demonstrate the implementation of rotor and stator field-oriented control and adapt sensorless control algorithms for real-time motor speed and torque control.
- Compare and analyze different motor control schemes including direct torque control and vector control techniques based on steady-state accuracy and dynamic response.
- Analyze the effectiveness of control strategies for the performance evaluation of Permanent Magnet Synchronous Machines, Brushless DC motors, and Switched Reluctance Motors for efficient torque and speed control.

UNIT– 1

Vector Control of Induction Motor Drive:

Open loop and closed loop V/f control, Principle of vector control – direct and indirect vector control, implementation of direct and indirect vector control, rotor field-oriented control, implementation of rotor field-oriented control, stator field-oriented control, field weakening control of induction motor.

UNIT– 2

Sensor less Control of induction Motor Drive:

Advantages of speed sensor less control, voltage current based speed sensor less control, MRAS-model reference adaptive systems, state equation of an induction motor, state observers, full-order observer, reduced order observer, Extended Kalman filter observers.

UNIT– 3

Direct Torque Control of Induction Motor Drive:

Principle of Direct torque control (DTC), concept of space vectors, DTC control strategy of induction motor, comparison between vector control and DTC, modified DTC of induction motor with constant switching frequency, space vector modulation based DTC of induction motors.

UNIT– 4

Control of Permanent Magnet Synchronous Machines (PMSM) and Brushless DC (BLDC) Motor Drives:

Advantages and limitations of Permanent magnet machines, operating principle of PMSM, vector control for PMSM, operating principle of BLDC, modeling of BLDC, similarities and difference between PMSM and BLDC, need for position sensing in BLDC motors, control strategies for PMSM and BLDC, methods of reducing torque ripples of BLDC motor.

UNIT– 5

Control of Switched Reluctance Motor (SRM) Drive:

SRM structure, Merits and limitations, stator excitation, converter topologies, SRM waveforms, Torque control schemes, speed control of SRM, torque ripple minimization, instantaneous -torque control using current controllers and flux controllers.

Text Books:

1. Bose B. K., "Power Electronics and Variable Frequency Drives', IEEE Press, Standard Publisher Distributors. 2001.
2. Kwang Hee Nam, "AC Motor Control and Electrical Vehicle Applications" Second Edition, CRC Press.

Reference Books:

1. Seung-Ki Sul, "Control of Electric Machine Drive Systems" IEEE Press, A John Wiley & Sons, Inc. Publications. 2011.
2. Krishnan R., "Electric Motor Drives – Modeling, Analysis and Control", Prentice Hall of India Private Limited.
3. Switched Reluctance Motors and Their Control-T. J. E. Miller, Magna Physics, 1993.
4. Power electronic converters applications and design-Mohan, Undeland, Robbins-Wiley publications.

II-Semester	Switched Mode Power Conversion (Program Core – 5)	CATEGORY PC	L-T-P 3-1-0	CREDITS 4

Pre-requisite: Concepts of electrical circuit analysis and power electronics.

Course Educational Objectives:

- To understand the fundamental principles, topologies, and operating modes of non-isolated, isolated, and resonant power converters, including essential design considerations for components and control.
- To apply appropriate modeling techniques and analytical methods to design, simulate, and implement dc-dc converter circuits and their control systems.
- To analyze and interpret the effects of non-ideal components, magnetic and thermal considerations, and control strategies on the performance of power converters.

Course Outcomes: At the end of the course, student will be able to

- Explain the operation of non-isolated, isolated, and resonant DC-DC converters.
- Design power converter circuits with appropriate selection of components, magnetic designs, and control techniques.
- Develop averaged large signal, steady state and small signal mathematical models for controller design

UNIT– 1
Non-isolated switch mode converters:
Control of DC-DC converters: Buck converters, Boost converters, Buck-Boost converter, CUK Converter, continuous and discontinuous operation, Converter realization with non-ideal components.

UNIT– 2
Isolated switched mode converters:
Forwarded converter, flyback converter, push-pull converter, half-bridge converter, full bridge converter.

UNIT– 3
Resonant converters:
Basic resonant circuit concepts, series resonant circuits, parallel resonant circuits, zero current switching quasi-resonant buck converter, zero current switching quasi-resonant boost converter, zero voltage switching quasi-resonant buck converter, zero voltage switching quasi-resonant boost converter, load resonant converter.

UNIT– 4
Design of Power Converters Components: Magnetic concepts - design of inductor, design of transformer, Selection of filter capacitors, Selection of ratings for devices, input filter design, Thermal design

UNIT– 5

Modelling and Controller design:

Circuit averaging method and average switch model technique to obtain averaged large signal model, steady state model, small signal models of buck, boost, buck-boost converters, Derivation of converter transfer functions for buck, boost and buck-boost topologies. Voltage mode control, Current mode control, current mode control instability, slope compensation, Controller design using Bode approach.

Text Books:

1. Fundamentals of Power Electronics-Erickson, Robert W., Maksimovic, Dragan, Springer, 2011.
2. Power switching converters-Simon Ang, Alejandro Oliva, CRC Press, 2010.
3. Power Electronics: Essentials and applications- L. Umanand, Wiley publications

Reference Books:

1. Design of Magnetic Components for Switched Mode Power Converters- Umanand, S.P. Bhat, John Wiley &Sons Australia, 1992.
2. Switching Power Supply Design-Abraham I. Pressman, McGraw-Hill Ryerson, Limited, 1991.
3. Power Electronics – IssaBatareseh, Jhon Wiley publications, 2004.
4. Power Electronics: converters Applications & Design – Mohan, Undeland, Robbins-Wiley publications.

II-Semester	Nonlinear Dynamical Systems (Program Core – 6)	CATEGORY PC	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Basic understanding of electric vehicles, vehicle systems, and automotive regulations.

Course Objectives: The primary objectives of this course are to

- Understand EV construction, safety regulations, energy measurement methods, and type approval standards.
- Learn AC/DC charging standards and certification requirements for EV and HEV systems.
- Explore regulatory standards for hybrid and electric vehicle retrofitment and propulsion kits.
- Study the safety requirements and certification procedures for traction batteries.
- Analyze national EV policies and government schemes promoting electric mobility.
- **Course Outcomes**: At the end of the course, student will be able to
  - Explain EV type approval processes and functional safety requirements under CMVR and ISO26262.
  - Describe EV and HEV charging standards and their compliance requirements.
  - Interpret retrofitment standards for hybrid and electric propulsion systems across vehicle categories.
  - Evaluate safety standards and certification protocols for traction batteries and EV components.
  - Analyze and summarize key national policies such as NEMMP, FAME, and NITI Aayog mobilityframeworks.

UNIT-1:
Introduction:
Introduction: Characteristics of nonlinear systems, classification of equilibrium points, Phase plane analysis, limit cycles, analysis of systems with piecewise constant inputs, perturbation techniques, periodic orbits, stability of periodic solutions, singular perturbation model, slow and fast manifolds.

UNIT-2:
Lyapunov Stability:
Stability of Nonlinear Systems - Lyapunov stability, local stability, local linearization and stability in the small, Direct method of Lyapunov, generation of Lyapunov function for linear and nonlinear systems, variable gradient method, Centre manifold theorem, region of attraction, Invariance theorems - Input output stability, L2 stability, Lyapunov based design, Lyapunov redesign, Robust stabilization, Lyapunov stability analysis for Discrete time linear system

UNIT-3:
Harmonic Linearization and Describing Function Method:
Harmonic linearization, describing function (DF) of standard nonlinearities, study of limit cycles (amplitude and frequency) using Single Input DF, Dual Input Describing function, study of sub-harmonic oscillations, correction on describing functions.

UNIT-4:
Liapunov Stability:
Autonomous Systems: Stability of equilibrium point. Concepts of positive definite/semi definite, negative definite/semi definite, in definite functions, Lyapunov function, Liapunov Stability: asymptotic stability, global asymptotic stability, instability.

UNIT-5:
Feedback Stabilization:
Analysis of feedback systems, Circle Criterion, Popov Criterion, Multiplier method, simultaneous Lyapunov functions, Feedback linearization, stabilization, regulation via integral control, gain scheduling, input state linearization, input output linearization, Input to state stability (ISS), Backstepping method.

Text Books:

1. Hassan K. Khalil, Nonlinear Control, Pearson Education, 2019, 1st Edition.
2. A Isidori, Nonlinear Control systems, Springer verlag, 2014, 4th Edition.

REFERENCE BOOKS:

1. H. Nijmeijer, A.J. Vander Schaft, Nonlinear Dynamic control Systems, Springer, 2016,1st Edition.
2. H. Marquez ,Nonlinear Control Systems: Analysis and Design, Wiley-Interscience, 2008, 1st Edition.
3. W.M. Haddad, V. Chellabonia, Nonlinear Dynamical Systems and Control: A Lyapunov-Based Approach, Princeton University Press, 2008, 1st Edition.

ONLINE resources:

1. https://nptel.ac.in/courses/108101002
2. https://nptel.ac.in/courses/108106024
3. https://nptel.ac.in/courses/112101429

II-Semester	Advanced Process Control (Program Elective–III)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Fundamental knowledge of vehicle dynamics, sensors, and basic machine learning or AI concepts.

Course Objectives: The primary objectives of this course are to

- Understand the levels of vehicle autonomy and key subsystems enabling intelligent driving.
- Learn machine learning paradigms and their applications in autonomous vehicle perception.
- Apply supervised learning techniques for object detection, classification, and regression.
- Explore deep learning methods and sensor fusion techniques for perception in autonomous driving.
- Study decision-making strategies and trajectory planning algorithms used in self-driving cars.

Course Outcomes: At the end of the course, student will be able to

- Describe levels of autonomy and identify essential components for intelligent autonomous vehicles.
- Apply supervised and unsupervised learning to solve perception tasks in self-driving systems.
- Implement classification and regression algorithms for object recognition and motion prediction.
- Analyze perception using deep learning and multiple sensors like LiDAR, RADAR, and cameras.
- Evaluate decision-making and real-time trajectory planning methods for autonomous navigation.

UNIT-1:
Introduction:
Hierarchy of control layers, Selection of controlled and manipulated variables. System linearization; state space and transfer function models, Controllability, Observability.

UNIT-2:
Regulatory control schemes:
Cascade control, feed-forward control, ratio control, split-range control, time delay compensator, and inverse response compensator.

UNIT-3:
Multivariable control:
Challenges; Control pairing; Interactions in closed-loop systems; Relative Gain Array (RGA) and variants. Centralized, decentralized, decoupled control schemes. Directionality, Design examples.

UNIT-4:
Model Predictive Control (MPC):
Concepts; Theory and implementation; Relation with Linear Quadratic regulator (LQR) control. Implementation of MPC, State update and model prediction. Receding Horizon implementation; Issues and Challenges, Design examples.

UNIT-5:
Extensions of MPC:
Economic MPC, Nonlinear Model Predictive Control (NMPC) – Theory and implementation. Controller performance assessment and diagnosis – minimum variance benchmark.

TEXTBOOKS:
1. D. E.Seborg, T. F. Edgar, D. AMillechamp,.F.J. Doyle III, Process Dynamics and Control, Wiley, 2016, 4th Edition.
2. R. Rengaswamy, B.Srinivasan, N. P. Bhatt, Process Control Fundamentals: Analysis, Design, Assessment, and Diagnosis, CRC Press, 2020,1st Edition.

REFERENCES:
1,F. Borrelli, A. Bemporad, M.Morari, Predictive Control for Linear and Hybrid Systems, Cambridge University Press, 2017, 1st Edition.
2. J-P Corriou , Process Control: Theory and Applications, Springer, 2018, 2nd Edition.
3. L. Wang, Model Predictive Control System Design and Implementation using MATLAB, Springer, 2009, 1st Edition.

Online Resources:

1. https://nptel.ac.in/courses/103101003
2. https://nptel.ac.in/courses/103101142

II-Semester	Digital Control Systems (Program Elective–III)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite:

Course Objectives: The primary objectives of this course are to

- Understand the fundamentals and performance characteristics of sensors and actuators.
- Study the working principles and applications of temperature and optical sensors.
- Learn the functionality of electric, magnetic, and mechanical sensors.
- Explore chemical, MEMS, and smart sensor technologies and their integration.
- Analyze circuit-level interfacing and microcontroller-based integration of sensors and actuators.

Course Outcomes: At the end of the course, student will be able to

- Explain sensor and actuator types, classifications, and performance parameters.
- Analyze temperature and optical sensor types and their working principles.
- Evaluate electric, magnetic, and mechanical sensors for real-world applications.
- Distinguish between chemical, MEMS, and smart sensors and their usage in systems.
- Design basic interfacing circuits and apply microcontroller-based sensor integration.

Unit-1:
Introduction:
Continuous and Discrete time system-Digital control systems - Quantizing and quantization error, Sampling theorem.

Unit-2:
Z-Transform:
Z-transforms of elementary functions, important properties and theorems, Inverse Z transform, Z-transform method of solving difference equations**.**

Unit-3:
Z-Plane Analysis of Discrete-Time Control Systems:
Impulse sampling and data hold, Pulse transfer function, Realization of digital controllers and digital filters, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in z-plane, Transient and steady state analyses.

Unit-4:

State Space Analysis of digital control systems:

Solution of discrete time state space equations, Discretization of continuous time state space equations, Lyapunov stability analysis for Discrete linear system, Pole Placement and Observer Design, Controllability, Observability concepts.

Unit-5:

Discrete Optimal Control Systems:

Linear Quadratic Regulator (LQR) Design via pole placement, Discrete State observers, Quadratic optimal control, Steady state quadratic optimal control, Quadratic optimal control of a servo system.

Text Books:

1. K. Ogata, Discrete time control systems, Pearson Education India, 2015, 2nd Edition.
2. M. Gopal, Digital Control and State Variable Methods, McGraw Hill Education, 2017, 4th Edition.

References:

1. C.L. Phillips, H.T. Nagle, A. Chakrabortty,Digital Control System Analysis and Design, Pearson, 2014, 4th Edition.
2. B.C. Kuo, Digital Control Systems, Oxford University Press, 2012, 2nd Edition.
3. C.A. Rabbath, N. Lechevin, Discrete-Time Control System Design with Applications, Springer-Verlag New York Inc, 2014, 1st Edition.

Online resources:

1. https://nptel.ac.in/courses/108105186
2. https://nptel.ac.in/courses/108103008

II-Semester	Automotive Control Systems (Program Elective–III)	CATEGORY PE	L-T-P 3-1-0	CREDITS 4

Pre-requisite: Basic understanding of electric vehicle systems, microcontrollers, and IoT communication protocols.

Course Objectives: The primary objectives of this course are to

- Introduce the fundamentals and architecture of IoT and its relevance in electric vehicles.
- Explore IoT-based solutions for battery management and real-time monitoring in EVs.
- Understand IoT applications in powertrain control, energy optimization, and predictive maintenance.
- Learn data security, encryption, and edge/cloud data management in IoT-enabled EV systems.
- Study IoT's role in autonomous driving, ADAS, perception systems, and V2X communication

Course Outcomes: At the end of the course, student will be able to

- Explain the structure and communication protocols of IoT systems in electric vehicle contexts.
- Implement IoT-enabled battery management systems for remote monitoring and diagnostics.
- Design IoT-based powertrain and energy management strategies for improved EV efficiency.
- Analyze IoT security challenges and apply techniques for secure and compliant data handling.
- Evaluate IoT-enabled control and communication systems for autonomous EV operation.

Unit-1:
Introduction:
Engine operations- Engine control loops- Control oriented Engine modelling- Coordinates and notation of vehicle dynamics- Vehicle control structures.

Unit-2:
Modeling of Drive Dynamics:
Vehicle dynamic modeling- Tire traction and force transfer-Vehicle motions:Longitudinal, lateral and Vertical behavior- Roll and Pitch Dynamics- Parameter and State estimation methods for vehicle dynamics

Unit-3: Dynamic Control of Chassis Components:
Different types of control -Braking control – Steering control systems– Suspension control systems.

Unit-4: Driver Assistance System:
On Driver-assistance system (DAS)- Advanced DAS for longitudinal and lateral guidance – Automatic driving: Classification- Longitudinal vehicle control –lateral vehicle control – Anti-collision control system – Autonomous driving.

Unit-5: **Automatic Driving**: Degrees of Automatic Driving - Driving Maneuvers, Design of Automotive Control Systems- Longitudinal Vehicle Control- Lateral Vehicle Control- Anticollision Control Systems- Automatic Driving

Text Books:
1. R. Isermann, Automotive Control: Modelling and Control of Vehicles, Springer, 2021, 1st Edition.
2. A. GailpUlsoy, H. Peng and M. Cakmakci, Automotive Control systems, Cambridge University Press, 2012, 1st Edition.

Reference Books:

1.P.Lunger and J. Edelmann, Vehicle Dynamics of Modern Passenger Cars, Springer, 2018, 1st Edition.
2. j. 2. Kiencke and L. Nielsen, Automotive Control systems: For Engine Driveline and Vehicle, Springer, 2005, 2nd Edition.
3. https://nptel.ac.in/courses/107106088

II-Semester	Robust Control (Program Elective–III)	CATEGORY PE	L-T-P 3-1-0	CREDITS 4

Pre-requisite: Basic understanding of electric vehicle systems, microcontrollers, and IoT communication protocols.

Course Objectives: The primary objectives of this course are to

- To know about stability and performance specifications in the frequency domain.
- To know about the preliminaries and the concept of robust control.

Course Outcomes: At the end of the course, student will be able to

- Identify sources of uncertainty and disturbances in control systems and understand their impact on system performance.
- Analyze the robustness of a control system using quantitative measures such as gain and phase margins.
- Apply robust control design techniques, such as H-infinity control, mu synthesis, and robust PID control, to design control systems that are robust to uncertainties and disturbances.
- Understand the limitations of robust control techniques and be able to select the appropriate approach for a given control problem.

Unit-1:
Introduction: Introduction to Robust Control, Control-Oriented Models for Linear-Time- Invariant Systems, Norms of Vectors and Matrices in Euclidean Spaces.

Unit-2:
State Feedback Optimal Control: Introduction, Norms for Signals and Systems, Power signals, Norms for Systems, Computing Norms for Systems, Well-Posedness and Stability, Stability and Performance Specifications in the Frequency Domain, Loop Shaping Using Frequency–Dependent Weights, State Feedback Optimal Control.

Unit-3: Output Feedback Control: Output Feedback Using Projective Controls, Linear Quadratic Gaussian with Loop Transfer Recovery, Summary, Loop Transfer Recovery Using the Lavretsky Method.

Unit-4: Robust Control: Modelling of uncertain systems-Unstructured Uncertainties Additive, multiplicative and other forms. Parametric uncertainty, Interval Systems, Structured uncertainties, Linear fractional transformation Robust design specifications: Small gain theorem and robust stabilization, Performance considerations, Structured singular values. Design - Mixed sensitivity optimization, 2-Degree of freedom design, Sub-optimal solutions,H2/H∞Systems.

Unit-5: Loop-shaping design procedures: Robust stabilization against Normalized co-prime factor Perturbation, Loop shaping design procedures, μ -Analysis and Synthesis-Consideration of robust performance, μ-synthesis :D–K iteration method, Schur Compliment &Linear Matrix Inequalities: Some standard LMI problems–eigen-value problems, generalized eigen-value problems; Algorithms to solve LMI problems–Ellipsoid algorithm, interior point methods.

Text Books:

1. Robust and Adaptive Control: With Aerospace Applications, Advanced text books in control and signal processing, by Eugene Lavretsky, Kevin A. Wise, publisher Springer 2012

Reference Books:

1 D.W.Gu,P.Hr.Petkov and M.M.Konstantinov, ‘Robust Control design with MATLAB’, Springer, 2005.

2 AlokSinha,‘Linear Systems-Optimal and Robust Controls’,CRC Press,2007.

3 S.Skogestad and Ian Postlethwaite,‘Multivariable feed back control’,John Wiley& Sons, Ltd, 2005.

II-Semester	Artificial Intelligence Techniques (Program Elective–IV)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre –requisite: Fundamentals of Neural networks and Fuzzy Logic

Course Objectives:

- To understand the fundamentals of artificial neural networks, biological inspiration, activation functions, and learning strategies including perceptron, ADALINE, and MADALINE models.
- To apply various ANN paradigms such as backpropagation, RBF networks, self-organizing maps, associative memories, and bidirectional networks for pattern recognition and data classification.
- To analyze classical and fuzzy set theories along with fuzzy logic components including fuzzification, inference, and defuzzification processes in intelligent control systems.
- To evaluate the application of AI techniques such as neural networks and fuzzy logic controllers in advanced motor control and harmonic elimination in power electronics.

Course Outcomes:

At the end of the course, student will be able to,

- Understanding of neural network architectures, learning algorithms, and fuzzy set fundamentals for intelligent system modeling.
- Apply neural network paradigms and fuzzy logic techniques to develop solutions for classification, clustering, and control problems.
- Analyze the structure and behavior of ANN models and fuzzy logic controllers to optimize control strategies and system performance.
- Evaluate AI-based applications such as neural network-based PWM and fuzzy logic motor controls for improved automation and power quality.

UNIT– 1

Introduction

Artificial Neural Networks (ANN) – Humans and computers – Biological neural networks – ANN Terminology – Models of Artificial neuron – activation functions –typical architectures – biases and thresholds – learning strategy(supervised, unsupervised and reinforced) learning rules, perceptron training and classification using Discrete and Continuous perceptron algorithms, ADALINE and MADLINE – linear separability and non-separability with examples.

UNIT– 2

ANN Paradigms

Generalized delta rule – Back Propagation algorithm- Radial Basis Function (RBF) network. Kohonen's self-organizing feature map (KSOFM), Learning Vector Quantization (LVQ) – Functional Link Networks (FLN) – Bidirectional Associative Memory (BAM) – Hopfield Neural Network.

UNIT– 3

Classical and Fuzzy Sets

Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

UNIT– 4

Fuzzy Logic Controller (FLC)

Fuzzy logic system components: Fuzzification, Inference engine (development of rule base and decision-making system), Defuzzification to crisp sets- Defuzzification methods.

UNIT– 5

Application of AI Techniques: Selected Harmonic Elimination PWM using feed forward neural network, instantaneous current control PWM using neural network, Speed control of DC motor using Fuzzy logic, Speed control of Induction motor using Fuzzy logic.

Text Books:

1. Fundamentals of Neural Networks: Architectures, Algorithms and Applications by Laurene Fausett, Pearson Education, 2008.
2. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.
3. Fuzzy logic with Fuzzy Applications – T.J Ross – McGraw Hill Inc, 1997.
4. Modern Power Electronics and AC Drives, Bimal K Bose, 1st Edition, Pearson Education,2002

Reference Books:

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharanand Pai – PHI Publication.
2. Introduction to Neural Networks using MATLAB 6.0 by S N Sivanandam,SSumathi,S N Deepa TMGH
3. Introduction to Fuzzy Logic using MATLAB by S N Sivanandam,SSumathi,S N Deepa Springer, 2007.

II-Semester	Control & Integration of Renewable Energy Systems (Program Elective–IV)	CATEGORY PE	L-T-P 3 -1-0	CREDITS 4

Pre-requisite: Power Electronics

Course Educational Objectives:

- To understand the fundamental concepts of electric power grids, including supply guarantee, power quality, and the impact of renewable energy penetration on grid stability and operation.
- To apply the principles and operational characteristics of both dynamic and static energy conversion technologies, such as turbines, fuel cells, photovoltaic systems, and energy storage devices, for effective grid integration.
- To analyze the challenges and control strategies for real and reactive power management in various energy conversion systems, implementing advanced controllers and modulation techniques to maintain grid stability.
- To analyze and design integrated hybrid energy conversion systems, assessing trade-offs in distributed versus centralized control, interfacing requirements, and stability and protection aspects for optimized grid-connected and islanding operations.

Course Outcomes: After the completion of the course, student will be able to

- Explain the structure and operational principles of electric grids including supply guarantees, power quality standards, and the impact of renewable energy sources on grid performance.
- Demonstrate the ability to model and apply control techniques for various dynamic and static energy conversion technologies, and integrate storage solutions to support stable and reliable grid operation.
- Critically analyze power control issues using advanced controllers and modulation techniques in diesel, PV, wind, and fuel cell based systems to maintain voltage and frequency stability under variable load and fault conditions.
- Analyze integrated hybrid energy systems for effective resource integration, determine appropriate control architectures (distributed vs centralized), and recommend solutions for load sharing, fault ride-through, and islanding to optimize grid reliability and resilience.

UNIT-1

Introduction: Electric grid introduction, Supply guarantee and power quality, Stability, Effects of renewable energy penetration into the grid, Boundaries of the actual grid configuration, Consumption models and patterns, static and dynamic energy conversion technologies, interfacing requirements.

UNIT-2

Dynamic Energy Conversion Technologies: Introduction to different conventional and nonconventional dynamic generation technologies, principle of operation and analysis of reciprocating engines, gas and micro turbines, hydro and wind based generation technologies, control and integrated operation of different dynamic energy conversion devices.

UNIT-3

Static Energy Conversion Technologies:

Introduction to different conventional and nonconventional static generation technologies, principle of operation and analysis of fuel cell, photovoltaic based generators, and wind based generation technologies, different storage technologies such as batteries, fly wheels and ultra-capacitors, plug-in-hybrid vehicles, control and integrated operation of different static energy conversion devices.

UNIT-4

Real and reactive power control:

Control issues and challenges in Diesel, PV, wind and fuel cell based generators, PLL, Modulation Techniques, Dimensioning of filters, Linear and nonlinear controllers, predictive controllers and adaptive controllers, Fault-ride through Capabilities, Load frequency and Voltage Control.

UNIT-5

Integration of different Energy Conversion Technologies:

Resources evaluation and needs, Dimensioning integration systems, Optimized integrated systems, Interfacing requirements, integrated Control of different resources, Distributed versus Centralized Control, Synchro Converters, Grid connected and Islanding Operations, stability and protection issues, load sharing, Cases studies

Text Books:

1. G. Masters, Renewable and Efficient Electric Power Systems, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 2nd Edition.
2. A. Mahaboob Subahani, G. R. Kanagachidambaresan, M. Kathiresh, Integration of Renewable Energy Sources with Smart Grid, Willey 2021.
3. Felix A. Farret, M. Godoy Simoes, Integration of Renewable Sources of Energy, Wiley, 2017, 2nd Edition.

Reference Books:

1. Chetan Singh Solanki, Fundamentals, Technologies & Applications, Solar Photovoltaic, PHI Publishers, 2019, 3rd Edition.
2. Quing-Chang Zhong, Control of Power Inverters in Renewable Energy and Smart Grid Integration, IEEE-John Wiley and Sons Ltd. Publishers, 2013, 1st Edition.
3. Bin Wu, Yongqiang Lang, Navid Zargari, Power Conversion and Control of Wind Energy Systems, IEEE- John Wiley and Sons Ltd. Publishers, 2011, 1st Edition.
4. S. Chowdhury, S. P. Chowdhury, P. Crossley, Microgrids and Active Distribution Networks, IET Power Electronics Series, 2012.

Other Suggested Readings:

1. https://nptel.ac.in/courses/108/102/108102145/
2. https://nptel.ac.in/courses/103/103/103103206/

II-Semester	Applications of Power Converters (Program Elective–IV)	CATEGORY PE	L-T-P 3-1-0	CREDITS 4

Pre-requisites: Analysis of Power Electronic Converters

Course Educational Objectives:

- To understand inverter applications for induction heating and power conditioning systems.
- To analyze power converters for lighting, pumping, and refrigeration systems including PV-based drivers.
- To compare and contrast high voltage and low voltage high current power supplies for specialized industrial and computing loads.
- To develop and evaluate bi-directional DC-DC converters and active power filters for automotive and power quality applications.

Course Outcomes: At the end of the course, the student will be able to

- Describe the functioning and control of power electronic inverters and converters for various industrial applications.
- Analyze and interpret the performance of power supplies and converter circuits for lighting, HVAC, X-ray and space applications.
- Design power electronic converters including bidirectional DC-DC converters and power conditioners.
- Critically analyze power quality improvement techniques including active and hybrid power filters and UPS systems in practical scenarios.

UNIT-1
Inverters for Induction Heating:
For induction cooking, induction hardening, melting, and welding applications.

UNIT-2
Power Converters for Lighting, pumping and refrigeration Systems:
Electronic ballast, LED power drivers for indoor and outdoor applications. PFC based grid fed LED drivers, PV / battery fed LED drivers. PV fed power supplies for pumping/refrigeration applications.

UNIT-3
High Voltage Power Supplies –
Power supplies for X-ray applications - power supplies for radar applications - power supplies for space applications.
Low voltage high current power supplies: Power converters for modern microprocessor and computer loads

UNIT-4
Bi-directional DC-DC (BDC) converters: Electric traction, automotive Electronics and charge/discharge applications, Line Conditioners and Solar Charge Controllers

UNIT-5

Power Conditioners:

Uninterrupted Power Supplies - Active Power Filters - Shunt active power filters - Series active power filters - Hybrid active power filters - UPQC

Text Books:

1. Ali Emadi, A. Nasiri, and S. B. Bekiarov: Uninterruptible Power Supplies and Active Filters, CRC Press, 2005.

2. M. Ehsani, Y. Gao, E. G. Sebastien and A. Emadi: Modern Electric, Hybrid Electric and Fuel Cell Vehicles, 1st Edition,CRC Press, 2004.

References Books:

1. William Ribbens: Understanding Automotive Electronics, Newnes, 2003.

II-Semester	Power Converters &Drives Laboratory (Laboratory – III)	CATEGORY Lab	L-T-P 0 -1-2	CREDITS 2

Pre-requisite: Basics of Electrical Machines and Power Electronics, Control Systems and Embedded Systems Fundamentals

Course Objectives:

- To understand the principles and operational characteristics of single-phase and three-phase converters, inverters, and their modulation techniques including unipolar, bipolar, SPWM, and space vector PWM.
- To apply various PWM control methods and vector control algorithms for speed regulation in induction motors, permanent magnet synchronous motors, brushless DC motors, and switched reluctance motors.
- To analyze the dynamic performance and control behavior of different inverter topologies, advanced modulation schemes, and vector/direct torque control strategies in motor drives.
- To evaluate the effectiveness of multilevel inverter modulation techniques and advanced motor control methods such as direct torque control and vector control for improved system efficiency and dynamic response.

Course Outcomes:

At the end of the course, the student will be able to.

- Understanding of converter and inverter operation, PWM techniques, and their effects on power quality and load characteristics.
- Apply modulation schemes and vector control principles to develop open-loop and closed-loop speed control of various motor drives effectively.
- Analyze waveforms, modulation patterns, and motor drive responses under different control schemes including rotor flux-oriented vector control and direct torque control.
- Evaluate the performance and suitability of advanced inverter and motor control methods, selecting optimal strategies for industrial drive applications.

Any 10 of the following experiments are to be conducted.

List of Experiments:

1. Analysis of single-phase full converter with RL & RLE loads.
2. Analysis of three phase full converter with RL & RLE loads.
3. Analysis of single-phase full bridge inverter using unipolar & bipolar PWM techniques.
4. Analysis of three-phase two-level inverter for 120º & 180º mode of conduction.
5. Analysis of three phase two-level inverter using SPWM.
6. Analysis of three phase two-level inverter using space vector PWM.
7. Analysis of three phase three-level NPC inverter using SPWM
8. Analysis of Multicarrier PWM techniques for three-phase five-level cascaded H-bridge inverter.
9. Speed control of induction motor in open loop and closed loop using V/f method
10. Indirect vector control of induction motor with rotor field-oriented scheme.
11. Direct vector control of induction motor with rotor field-oriented scheme.

12. Switching table based direct torque control of induction motor.
13. Space vector modulation based direct torque control of induction motor.
14. Vector control of permanent magnet synchronous motor.
15. Speed control of brushless DC motor drive
16. Speed control of switched reluctance motor drive.

II-Semester	Advanced Control System Lab **(Laboratory – IV)**	**CATEGORY Lab**	**L-T-P 0 -1-2**	**CREDITS 2**

Pre-requisite: Basics of Embedded Systems and Microcontrollers (e.g., Arduino), Fundamentals of Wireless Sensor Networks and IoT.

Course Objectives: By the end of the course, students will be able to

- Identify and configure hardware components of WSNs including Xbee modules and Arduino boards.
- Program Arduino for sensor data acquisition and transmission.
- Develop IoT applications to upload sensor data to the cloud via HTTP and MQTT.
- Test and analyze vehicular communication protocols including V2X and IEEE 802.11p.
- Perform CAN communication, ECU simulation, and vehicle diagnostic services (UDS) in EVs.

Course Outcomes: Upon completion, students will

- Configure and operate WSN hardware and interfaces using XCTU and related tools.
- Write embedded code for sensor data acquisition and wireless communication.
- Implement IoT network protocols and cloud data uploading for sensor networks.
- Evaluate performance of V2X and vehicular networking protocols.
- Simulate and validate automotive communication systems including CAN and ECU diagnostics.

Any 10 of the following experiments are to be conducted.
List of experiments

1. Study on phase portrait for different linear system
2. Design of feedback linearization based control for Mechatronic system
3. Synthesis the Backstepping approach based controller for robotic system
4. Lyapunov redesign method based controller for mechatronic system
5. Motion control of an Industrial Plant Emulator System using loopshaping approach
6. Dynamic Programming based Stabilization of an Aircraft
7. Pontryagin's Maximum Principle based optimal control of robot path planning
8. H-infinity based robust controller design for mechatronic system
9. QFT based robust controller design for Power converters
10. Vehicle suspension control system design using the QFT approach.
11. Design of sliding mode controller (SMC) for Power converter

II-Semester	SEMINAR - II	CATEGORY	L-T-P 0-0-2	CREDITS 1

III-Semester	Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR*	**CATEGORY**	**L-T-P** **2-0-0**	**CREDITS** **2**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY - GURAJADA - VIZIANAGARAM
VIZIANAGARAM – 535 003 Andhra Pradesh (India)
(Established by Andhra Pradesh Act No.22 of 2021)

III-Semester	SUMMER INTERNSHIP/ INDUSTRIAL TRAINING (8-10 WEEKS) *	CATEGORY	L-T-P 0-0-0	CREDITS 2

III-Semester	DISSERTATION PART – A[$]	CATEGORY	L-T-P 0-0-20	CREDITS 10

IV-Semester	DISSERTATION PART – A[$]	CATEGORY	L-T-P 0-0-32	CREDITS 16