ADITYA UNIVERSITY

Department of Electrical and Electronics Engineering

Ph.D. Course Work

(Applicable for the scholars admitted from the AY: 2025-26)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on 'Research Methodology' and 'Research and Publication Ethics' for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

Table 1: Course Structure

S. No.	Course Code	Name of the Course	Credit (s)
1	2517UC01	Research Seminar -I	1
2	2517UC02	Research Methodology	2
3	2517UC03	Research and Publication Ethics	2
4	2517UC04	Research Seminar -II	1
5	-	Domain Specific Course -I	3
6	-	Domain Specific Course -II	3
Total			**12**

List of Domain-Specific Courses

S. No.	Course Code	Name of the Course
1	2517EE01	Electrical Machine Modeling and Analysis
2	2517EE02	Intelligent Control Techniques in Electric Drives
3	2517EE03	Power Converter Technologies
4	2517EE04	Digital Control Systems
5	2517EE05	Electric Vehicles & Drives
6	2517EE06	Power System Optimization
7	2517EE07	Modelling and Control of Sustainable Energy System
8	2517EE08	Power System Dynamics and Control
9	2517EE09	Intelligent Control Systems
10	2517EE10	Control Systems Components
11	2517EE11	Power Electronic Converters
12	2517EE12	Smart Grid
13	2517EE13	Soft Computing Techniques and Applications
14	2517EE14	Linear control Theory
15	2517EE15	Estimation and Adaptive Control
16	2517EE16	Optimal and Robust Control
17	2517EE17	Advanced Power Electronic Converters

Research Methodology

Course Code: 2517UC03

UNIT -I:

Research Design

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case Studies.

UNIT-II:

Data Collection and Sources

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT-III:

Data Analysis and Reporting

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT-IV:

Intellectual Property Rights

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V:

Patents

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Text Books:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4th Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4th Edition, 2013.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2nd Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

Web Links:

1. https://archive.nptel.ac.in/courses/121/106/121106007/#
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

Research and Publication Ethics

Course Code: 2517UC04

Unit-I:
Philosophy & Ethics
Introduction to Philosophy:
Definition, Nature & Scope, Concept, Branches
Ethics:
Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

Unit-II:
Scientific Conducts
Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity
Scientific Misconducts:
Falsification, Fabrication & Plagiarism
Redundant Publications:
Duplicate & Overlapping Publication, Salami Slicing, SelectiveReporting & Misrepresentation of Data

Unit-III:
Publication Ethics:
Definition, Introduction and Importance
Best Practices/ Standard Setting Initiatives and Guidelines:
COPE, WAVE, etc., Conflictsof Interest
Publication Misconduct:
Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

Unit-IV:
Open Access Publishing
Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

Unit-V:
Publication Misconduct Group Discussions:
Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad
Software tools:
Use of Plagiarism software like Turnitin, Urkund and other open source software tools
Database and Research Metrics:
Database:
Indexing database, Citation database: web of science, Scopus etc.
Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score
Metrics: h-index, g-index, i-10 index, AL metrics etc.

Text Books:

1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

Reference Book:

1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

Weblinks:

1. www.niehs.nih.gov/research/resources/bioethics/whatis
2. https://onlinecourses.swayam2.ac.in/nou22_ge73/preview

Electrical Machine Modeling and Analysis

Course Code: 2517EE01

UNIT-I:
Basic concepts of Modelling
Basic two-pole machine representation of Commutator machines, representations of 3- phase synchronous machine with and without damper bars and 3-phase induction machine, Kron's primitive Machine voltage, current and torque equations.

UNIT-II:
DC Machine Modelling
Mathematical model of separately excited D.C motor – Steady state analysis-transient State analysis sudden application of inertia load-transfer function of separately excited D.C motor-Mathematical model of D.C Series motor, Shunt Motor-Linearization techniques for small perturbations.

UNIT-III:
Modelling of single-phase Induction Machines
Linear transformation-Phase transformation - three phase to two phase transformation (abc to αβ0) and vice-versa, transformation to rotating reference frame, (αβ0 to dqo) and vice versa -Power equivalence- Mathematical modeling of single-phase induction machines.

UNIT-IV:
Modelling of three phase Induction Machines:
Generalized model in arbitrary reference frame-Derivation of commonly used induction machine models- Synchronously rotating reference frame model, Stator reference frame model-Rotor reference frame model--power equation, electromagnetic torque equation, state space model in induction motor with flux linkages as variables.

UNIT-V:
Modelling of Synchronous Machine
Synchronous machine inductances –derivation of voltage equations in the rotor's dq0 reference frame electromagnetic torque-current in terms of flux linkages-three phase synchronous motor. State space models with flux linkages as variables.

Text Books:

1. Analysis of Electric Machinery and Drive Systems, 3rd Edition-Wiley-IEEE Press-Paul Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven Pekarek, ISBN: 978-1-118-02429-4, June 2013
2. Electric Motor Drives - Modeling, Analysis& control -R.Krishnan, New Delhi: Pearson Education, ©2003

Reference Books:

1. Generalized theory of Electrical Machines -Fifth edition, Khanna Publishers P. S. Bimbhra, ISBN-13. 978-9391505080 ; Edition. 7th ; Publisher. Khanna Book Publishing Co. P Ltd ; Publication date. 1 January 2021.

2. Dynamic simulation of Electric machinery using MATLAB / Simulink – Chee MunOng- Prentice Hall., November 1997
3. Magneto electric devices transducers, transformers and machines-G. R. Slemon- Wiley in New York, London. ISBN, 0471798401, Dec 6, 2007

Web Links:

1. https://nptel.ac.in/courses/108106023
2. https://innovationspace.ansys.com/product/modelling-and-analysis-of-electric-machines/

Intelligent Control Techniques in Electric Drives

Course Code: 2517EE02

UNIT-I:
Artificial Neural Networks
Models of Neuron Network, Architectures, Knowledge representation. Single-layer ANN, Multi-layer ANN, Radial basis function neural network. Various ANNs and training strategies for different applications, Application of the error back propagation algorithm, Nodes, layers. Back propagation training and learning.

UNIT-II:
Fuzzy Logic
Fuzzy versus Crisp, Fuzzy sets, Membership function, Basic Fuzzy set operations, Properties of Fuzzy sets, Fuzzy Cartesian Product, Operations on Fuzzy relations, Fuzzy logic, Fuzzy Quantifiers, Fuzzy Inference, Fuzzy Rule based system, Defuzzification methods.

UNIT-III:
Genetic Algorithms
Encoding –Fitness Function-Reproduction operators, Genetic Modeling –Genetic operators-Cross over, Mutation, Potential applications of Genetic algorithms. Tuning of membership functions using genetic algorithms, Application of genetic algorithms to neural networks, tuning of controllers using genetic algorithms.

UNIT-IV:
Metaheuristic Optimization Techniques
Particle Swarm Optimization (PSO), Anatomy of a particle- equations based on velocity and positions, PSO topologies, control parameters. Artificial bee colony (ABC) algorithm, Differential Evolution.
Multi Objective Optimization:
Multi-Objective optimization Introduction- Concept of Pareto optimality - Non-dominant sorting technique-Pareto fronts-best compromise solution-min-max method-NSGA-II algorithm and applications.

UNIT-V:
Artificial-Intelligence-Based Motor Drives
ANN based speed and torque estimation for a DC motor and slip-ring induction machine. Fuzzy-neural based speed estimator for a DC motor. Design and simulation of fuzzy-neural based induction motor drive.GA & PSO based steady-state and transient analysis of induction machines.

Text Books:
1. Artificial-Intelligence-based Electrical Machines and Drives,Peter Vas, Oxford University press. 1999
2. Recent Advances in Swarm Intelligence an Evolutionary Computation, Xin-She Yang, Springer International Publishing, Switzerland, 1st Edition, 978-3-319-35681-5, Published: 24 September 2016

Reference Books:

1. Neural Network & Fuzzy System, Bart Kosko; Prentice Hall., 1991
2. Fuzzy Set Theory Fuzzy Logic and Their Applications, A. K. Bhargava, S. Chand. 2013
3. Artificial Intelligence and Intelligent Systems, N P Padhy, Oxford University Press., 2005

Web Links:

1. https://nptel.ac.in/courses/108/104/108104157/
2. https://nptel.ac.in/courses/108/108/108108148/
3. https://nptel.ac.in/courses/112/105/112105235

Power Converter Technologies

Course Code: 2517EE03

UNIT-I:
Inverters for Induction Appliances
Types of Induction Heating and welding, Inverters for- induction heating, induction cooking, induction hardening, induction melting, and induction welding.

UNIT-II:
Power Converters Applications
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-III:
High Voltage Power Supplies
Power supplies for X-ray applications, power supplies for radar applications, power supplies for space applications.

UNIT-IV:
Low Voltage High Current Power Supplies
Power converters for modern microprocessor, computer loads, Audio systems and Electric Vehicles.

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

Text Books:
1. Uninterruptible Power Supplies and Active Filters by Ali Emadi, A. Nasiri, and S. B. Bekiarov: CRC Press., 2017
2. Modern Electric, Hybrid Electric and Fuel Cell Vehicles by M. Ehsani, Y. Gao, E. G. Sebastien and A. Emadi, CRC Press, 2018

Reference Books:
1. Hand book of Induction Heating, Valery Rudnev, Don Loveless, Raymond L. Cook, CRC Press. 2nd Edition, 2017
2. Power Supplies for LED Driving, Steve Winder, Newnes., 2008

Web Links:
1. http://digimat.in/nptel/courses/video/108104013/L05.html
2. https://nptel.ac.in/courses/113104074

Digital Control Systems

Course Code: 2517EE04

UNIT – I

Introduction to Digital Control: Introduction, Discrete time system representation, Mathematical modelling of sampling process, Data reconstruction

Modelling Discrete-Time Systems by Pulse Transfer Function: Revisiting Z-transform, Mapping of s-plane to z-plane, Pulse transfer function, Sampled signal flow graph

UNIT – II

Time Response of Discrete systems: Transient and steady-state responses

Stability Analysis of Discrete Time Systems: Jury stability test, Stability analysis using bi-linear transformation

UNIT – III

Design of Sampled Data Control Systems: Root locus method, Nyquist stability criteria, Bode plot, Controller design using root locus, Lag-lead compensator design in frequency domain

Discrete State Space Model: Introduction to state variable model, State transition matrix, Solution of discrete state equation

UNIT – IV

Controllability, Observability and Stability of Discrete State Space Models: Controllability and Observability, Stability, Lyapunov stability theorem

State Feedback Design for Discrete Systems: Pole placement by state feedback, Full order observer, Reduced order observer

UNIT – V

Introduction to Optimal Control for Discrete Systems: Basics of optimal control, Performance indices, Linear Quadratic Regulator (LQR) design

Text Books:

1. Digital Control and State Variable Methods, M. Gopal, Tata McGraw-Hill Publishing Company Limited., ISBN-13. 978-0070668805, 2009
2. Digital Control Systems, B. C. Kuo, Oxford University Press. ISBN 0-03-012884-6, 2009

Reference Books:

1. Discrete Time Control Systems, K. Ogata, Prentice Hall International, 2005
2. Digital Control of Dynamic Systems, G. F. Franklin, J. D. Powell and M. L. Workman, Addison- Wesley, ISBN: 0-9791226-3-5, 2022

Web Links:

1. https://nptel.ac.in/courses/108103008
2. https://www.coursebuffet.com/course/826/nptel/digital-control-system-iit-guwahati

Electric Vehicles and Drives

Course Code: 2517EE05

UNIT-I:
History of electric vehicles
Origin of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies-Challenges and Key Technologies of EVs – Challenges for EV Industry in India

UNIT-II:
Electric Drivetrains
Basic concept of electric traction - introduction to various electric drivetrain topologies - Power flow control in electric drive-train topologies - various drive-train topologies - Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT-III:
Energy Storage
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles -Battery based energy storage and its analysis - Fuel Cell based energy storage and its analysis - Super Capacitor based energy storage- Flywheel based energy storage and its analysis

UNIT-IV:
Charging Infrastructure
Domestic charging infrastructure - public charging infrastructure - Normal charging station - Occasional charging station - Fast charging station - Battery swapping station - Types of charging: constant voltage - Constant current- Pulse charging – Inductive -Conductive charging.

UNIT-V:
Energy Management Strategies
Introduction to Energy Management Strategies used in hybrid and electric vehicle, Classification of different Energy Management strategies - Comparison of different Energy Management Strategies – Implementation issues of energy strategies - Effect of charging infrastructure on grid protection and control.

Textbooks:
1. Emerging Technologies for Electric and Hybrid Vehicles, Christopher H. T. Lee, Springer, 2024.
2. The Electric Cars, Plug-Ins and Hybrids Handbook, Augustin Stucker, 2022.

Reference Books:
1. Electric and Hybrid Vehicles: Design Fundamentals,Iqbal Husain, CRC Press, 2021.
2. Electric Vehicles: Modern Technologies and Trends, Nil Patel, Springer, 2021.
3. Electric Vehicle Engineering, Per Enge, Nick Enge, Stephen Zoepf, McGraw Hill, 2021.

Web Links:

1. https://nptel.ac.in/courses/108102121
2. https://nptel.ac.in/courses/108103009
3. https://nptel.ac.in/courses/108106170
4. https://www.nrel.gov/research/transportation-hybrid-electric.html

Power System Optimization

Course Code: 2517EE06

UNIT – I
Introduction to optimization problems, Classification of optimization techniques, Traditional and non-traditional optimization techniques, Constrained optimization, linear and non-linear optimization problems in power systems

UNIT – II
Solution ofoptimization problems with traditional method (Steepest descent and Newton's method), Solution ofoptimization problems with non-traditional method (GA and PSO algorithm).

UNIT – III
Economic load dispatch (ELD) of thermal power plant, Formulation of optimization problem considering loss and without considering loss, Solution of ELD problem with optimization techniques, Emission economic dispatch, Effect of valve point in ELD problem.

UNIT – IV
Unit commitment and maintenance scheduling of thermal power plants, formulation of optimization problem and solution, Formulation of optimal power flow and its solution

UNIT – V
Reactive power optimization, Planning of capacitor bank in distribution system- problem formulation and solution

Text Books:

1. Power Generation, Operation, and Control, 2nd. ed., A.J. Wood and B.F. Wollenberg, John Wiley & Sons, 1996
2. Economic Operation of Power Systems, L.K. Kirchamayer, John Wiley & Sons., 2009

Reference Books:

1. Power System Optimization, D.Kothari, J. S. Dhillon, Prentice Hall India., 2nd edition, 2011
2. Engineering optimization- Theory and Practice, Singiresu S. Rao, John Wiley & Sons., 2009

Web Links:

1. https://nptel.ac.in/courses/112106064
2. https://nptel.ac.in/courses/108105019

Modelling and Control of Sustainable Energy System

Course Code: 2517EE07

UNIT – I
Introduction to renewable energy technologies, overview of micro grids and distributed generation.

UNIT – II
Modeling of Wind energy conversion systems, Solar PV based systems, Fuel cell and Aqua-electrolyser, Battery and Flywheel based storage system, and Hybrid power system.

UNIT – III
Power Electronics for Interfacing distributed generation system.

UNIT – IV
Control Strategies and Grid connection interface issues for Grid-Connected and Standalone Sustainable Energy System.

UNIT – V
Emerging Technologies for distributed generation system integration

Text Books:

1	N. Jenkins, J. B. Ekanayake, G. Strbac "Distributed Generation", 1st, IET London, 2010
2	S. Chowdhury, S.P. Chowdhury, P. Crossley "Microgrids and Active Distribution Networks", 1st Edition, IET London, 2009

Reference Books:

1	Olimpo Anaya-Lara, Nick Jenkins, Janaka Ekanayake, Phill Cartwright, Michael Hughes "Wind Energy Generation: Modelling and Control", 1st Edition, Wiley,2009
2	Munteanu, A. I. Bratcu, N.-A. Cutululis, E. Ceanga "Optimal Control of Wind Energy Systems", 1st Edition, Springer, 2008

Web Links:

1	https://elearn.nptel.ac.in/shop/iit-workshops/ongoing/modeling-and-digital-implementation-of-power-electronic-converters-for-renewable-applications/?v=c86ee0d9d7ed
2	https://onlinecourses.nptel.ac.in/noc24_me144/preview

Power System Dynamics and Control

Course Code: 2517EE08

UNIT – I

Introduction to Power System Stability problem. Solution of swing equations, the equal area criterion for stability studies, Power System Operation and Control. Stability Problems faced by modern Power Systems. Impact on Power System Operation and Control.

UNIT – II

Analysis and Modelling of Dynamical Systems. Concept of Equilibria, Small and Large Disturbance Stability. Example: Single Machine Infinite Bus System. Modal Analysis of Linear Systems. Analysis using Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff Systems.

Modelling of Synchronous Machines. Physical Characteristics. Rotor Position Dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit Transient Analysis of a Synchronous Machine. Synchronous Machine Connected to Infinite Bus.

UNIT – III

Modelling of Excitation and Prime Mover Systems, Transmission Lines and Loads. Physical Characteristics and Models. Control system components. Excitation System Controllers. Dynamic modelling of steam turbine, hydro turbine and governor, Prime Mover Control Systems. Transmission Line Physical Characteristics. Transmission Line Modeling. Load Models - induction machine model. Load modelling for stability studies. Other Subsystems - HVDC, protection systems.

UNIT – IV

Stability Issues in Interconnected Power Systems. Small signal stability of a Single Machine Infinite Bus System. Multi-machine Systems. Stability of Relative Motion. Frequency Stability: Centre of Inertia Motion. Concept of Load Sharing: Governors. Single Machine Load Bus System: Voltage Stability. Torsional Oscillations.

UNIT – V

Power System Stability Analysis Tools. Direct method of transient stability analysis. TransientStability Program. Small Signal Analysis Program. EMTP Programs. Real-Time Simulators.

Enhancement of Power System Stability. Methods of improving stability, Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control.Emergency Control.

Text Books:

1. Power System Dynamics, Stability & Control, K. R. Padiyar, 2nd Edition, B.S. Publications, Hyderabad, 2002.
2. Power System Stability and Control, P. Kundur, McGraw Hill Inc, New York, 1995.

Reference Books:

1 Power System Dynamics & Stability, P. Sauer & M. A. Pai, Prentice Hall, 1997.

2 Power System Dynamics and Control, Harry G. Kwatny, Karen Miu-Miller, https://doi.org/10.1007/978-0-8176-4674-5, 2018

Web Links:

1 https://archive.nptel.ac.in/courses/108/101/108101004/

2 https://archive.nptel.ac.in/courses/108/105/108105133/

Intelligent Control Systems

Course Code: 2517EE09

UNIT – I
Introduction to intelligent control, comparison study between conventional and intelligent control, intelligent supervisory control, intelligent adaptive control.

UNIT – II
Introduction to Neural Network, theory of neural network for classification and function approximation, supervised and unsupervised learning rules, RBF neural network, Support vector machines, intelligent control using Neural Network. Approximation capabilities by feed-forward and recurrent neural network, Neuro-control based on backpropagation algorithm, system identification with neural network.

UNIT – III
Introduction to fuzzy set theory and logic, application of fuzzy logic in control system, fuzzy quantization of knowledge, fuzzy controller design, Fuzzy T-S modelling for dynamic system and stability using Lyapunov theory.

UNIT – IV
Basic theory and operations of Genetic algorithm, GA based control system, optimization problem using GA related to control and other engineering problems.

UNIT – V
Bio-inspired evolutionary algorithms – like Particle swam optimization (PSO), simulated annealing, Fire-fly optimization, bacterial foraging etc. – only the concepts and case studies related control problems.

Text Books:
1. Intelligent Control System, S. Haykin, IEEE Press., 2009
2. Genetic Algorithms in Search, Optimization, and Machine Learning, Goldberg, Pearson Education.1989

Reference Books:
1. Fuzzy logic (intelligence control and information), J. Yen and R. Langari, Pearson Education. 1998
2. Simon Haykin, Neural Networks: A Comprehensive Foundation, 1997

Web Links:
1. https://nptel.ac.in/courses/108104049
2. https://onlinecourses.nptel.ac.in/noc24_ge60/preview

Control Systems Components

Course Code: 2517EE10

UNIT – I
Control System Parameters: Introduction, accuracy and mode of control, closed-loop control system, components of control system. Sensors: Position sensors, angular velocity sensors, proximity sensors, load sensors, pressure sensor, temperature sensors, flow sensors, level sensors.

UNIT – II
Potentiometers, ac and dc servomotors, stepper motors, tachogenerators, synchros, ac and dc bridges, self-balancing bridges, self-balancing potentiometer, switches and relays.

UNIT – III
Amplifiers, servo amplifiers, regulated power supply, attenuators, filters, converter/inverters, modulators, demodulators, phase sensitive detectors, electronic controllers.

UNIT – IV
Pneumatic, hydraulic, mechanical & electrical systems, hydraulic and pneumatic actuator/valves, PID controller, microprocessor-based control

UNIT – V
PC based control, dedicated customized controllers, PLC, DCS, SCADA.

Text Books:

1 Modern Control Technology: Components and Systems, Christopher T. Kilian, Delmar Thomson Learning, 1996

Reference Books:

1 Control System Components, M. D. Desai, PHI., 2008

Web Links:

1 https://archive.nptel.ac.in/courses/107/106/107106081/
2 https://archive.nptel.ac.in/courses/108/106/108106098/

Power Electronic Converters

Course Code: 2517EE11

UNIT-I:
AC Voltage Controllers
Single phase AC voltage controllers with Resistive, Resistive-inductive and Resistive-inductive-induced e.m.f. loads – ac voltage controllers with PWM Control – Effects of source and load inductances - Synchronous tap changers.
Three phase AC voltage controllers – Analysis of controllers with star and delta Connected Resistive, Resistive-inductive loads – Effects of source and load Inductances – Applications & Problems.

UNIT-II:
Cyclo-Converters
Single phase to single phase cyclo-converters – analysis of midpoint and bridge Configurations – Three phase to three phase cyclo-converters –analysis of Midpoint and bridge configurations – Limitations – Advantages – Applications & Problems - Matrix Converter.

UNIT-III:
Single Phase & Three Phase Converters
Single phase converters – Half controlled and Fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – single phase dual converters – power factor Improvements Techniques– Extinction angle control – symmetrical angle control, PWM – single phase sinusoidal PWM – single phase series converters – overlap analysis – Applications & Problems.
Three phase converters – Half controlled and fully controlled converters – Evaluation of input power factor and harmonic factor – continuous and Discontinuous load current – three phase dual converters – power factor Improvements Techniques– three phase PWM - twelve pulse converters – Applications – Problems – Design of converters.

UNIT-IV:
D.C. To D.C. Converters
Analysis of step-down and step-up dc to dc converters with Resistive and Resistive-inductive loads – Switched mode regulators – Analysis of Buck Regulators - Boost regulators – buck and boost regulators – Cuk regulators – Condition for continuous inductor current and capacitor voltage – comparison of regulators –Multi output boost converters – advantages – Applications – Problems.

UNIT-V:
Pulse Width Modulated Inverters
Principle of operation – performance parameters – single phase bridge inverter- evaluation of output voltage and current with resistive, inductive and Capacitive loads– Voltage control of single phase inverters – single PWM – Multiple PWM – sinusoidal PWM – modified PWM – phase displacement Control – Advanced modulation techniques for improved performance – Trapezoidal, staircase, stepped, harmonic injection and delta modulation – Advantages – Applications & Problems.

Three phase inverters – analysis of 180 degree conduction for output voltage And current with resistive, inductive loads – analysis of 120 degree Conduction – voltage control of three phase inverters – sinusoidal PWM – Third Harmonic PWM – 60 degree PWM – space vector modulation – Comparison of PWM techniques – harmonic reductions – Problems.

Text Books:

1. Power Electronics by Mohammed H. Rashid, Pearson Education Third Edition. 2013
2. Power Electronics by Ned Mohan, Tore M. Undeland and William P. Robbins, - John Wiley & Sons – Second Edition., 2023

Reference Books:

1. Milliman Shepherd and Lizang – "Power converters circuits" – Chapter 14 (Matrix converter) PP- 415-444. 2019
2. M.H.Rashid - Power electronics hand book, 2017
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition:" Control in power electronics" illustrated Published by Academic Press.2002

Web Links:

1. https://nptel.ac.in/courses/108/108/108108077/
2. https://www.electrical4u.com/speed-control-of-three-phase-induction-motor/
3. https://www.erode-sengunthar.ac.in/wp-content/uploads/2019/04/Unit4.pdf

Smart Grid

Course Code: 2517EE12

UNIT – I

Smart Grid Structure: Definition, Various components, Smart Grid architecture, Application and standards, Distributed Generation

UNIT – II

Communication Technologies for Smart Grid: Data communication, Communication Channel, Layered architecture and Protocols, Smart Grid communication layers

UNIT – III

Advanced Monitoring Infrastructure: Smart meters, Wide area monitoring system, Phasor measurement units, SCADA

UNIT – IV

Demand Side Management: Definition, Impact analysis of DSM, load curve, Energy consumption scheduling, Controllable load models and challenges

UNIT – V

Microgrid Protection: Mode of microgid operations, Islanding detection of microgrid, Protection issues of microgrid

Module-6:Cyber Security in Smart Grid: Possible threats and cyber security challenges in smart grid, Security of Information

Text Books:

1. Smart Grid: Fundamentals of design and analysis by James Momoh (John Wiley & Sons publisher). 2012
2. Smart Grid: Technology and applications by J. Ekanayake, N. Jenkins, K. Liyanage K, J. Wu, A. Yokoyama (Wiley publication). 2012

Reference Books:

1. Power Generation Operation and Control by A. J. Wood, B. F. Wollenberg (John Wiley & Sons publisher). 2013
2. Smart Grids, Bernd M. Buchholz, Zbigniew A. Styczynski, Springer, 2021

Web Links:

1. https://onlinecourses.nptel.ac.in/noc21_ee68/preview
2. https://onlinecourses.nptel.ac.in/noc23_ee60/preview

Soft Computing Techniques and Applications

Course Code: 2517EE13

UNIT – I:
Introduction to Soft Computing Techniques
Introduction to intelligence, biological intelligence, artificial intelligence (AI), computational intelligence. Evolution of computational intelligence, from conventional AI to computational intelligence, soft computing constituents, machine learning basics, overview of soft computing techniques, intelligent decision systems.

UNIT – II:
Evolutionary Algorithms
Introduction to genetic algorithm, genetic operators and parameters, genetic algorithms in problem solving, theoretical foundations of genetic algorithms, evolutionary programming, particle swarm optimization, differential evolution; implementation issues and application for solving problems.

UNIT – III:
Artificial Neural Networks
Neural model and network architectures, basic-concepts-single layer perception-Multi layer perception, supervised and unsupervised learning, back propagation networks, associative learning, competitive networks, Hopfield network, computing with neural nets and applications of neural networks.

UNIT – IV:
Fuzzy Systems
Introduction to fuzzy sets, operations on fuzzy sets, fuzzy relations, fuzzy measures, rule matrix, application of fuzzy set theory to different branches of science and engineering.

UNIT – V:
EA-Neuro-Fuzzy Modelling
Hybridization of EAs, Fuzzy and ANNs for increased intelligence for solving complex real-life problems.

Text Books:

1. Genetic Algorithms in Search, Optimization, and Machine Learning, D. E. Goldberg, Addison- Wesley, 1989
2. Neural Networks- A Comprehensive Foundation, S. Haykin, PH. 1997

Reference Books:

1. Neural Networks- A Classroom Approach, Satish Kumar, TMH. 2017
2. Fuzzy Sets and Fuzzy Logic: Theory and Applications, G. J. Klir, and B. Yuan, PH. 2015

Web Links:

1. https://archive.nptel.ac.in/courses/106/105/106105173/
2. https://nptel.ac.in/courses/106105173

Linear Control Theory

Course Code: 2517EE14

UNIT – I

Linear spaces and linear operators: fields, vectors and vector spaces; linear independence, dimension of linear space; inner product of vectors, quadratic functions and definite matrices, vector and matrix norms, scalar product and norm of vector functions; range space, rank, null space and nullity of a matrix, homogeneous equation, nonhomogeneous equation; eigenvalues, eigenvectors, generalized eigenvectors, similarity transformation, Canonical form representation of linear operators, diagonal form representation of linear operator, Jordan form matrix representation of linear operator; Cayley-Hamilton theorem.

UNIT – II

Review of time domain and frequency domain responses, analysis of time and frequency domain common tools, time and frequency domain specifications, and their relationship; design of lag-lead compensator; PID controller tuning.

Review of state space representations, controllable canonical form, observable canonical form, diagonal form; solution of vector-matrix differential equation, modal decomposition.

UNIT – III

Concept of controllability, observability, and their significance; state feedback controller; full order and reduced order observer design; observer-based state feedback controller.

Introduction to non-linear system, common differences with linear system; concept of linearization; describing function of common nonlinearities.

UNIT – IV

Lyapunov's concept of stability, asymptotically stable, uniformly asymptotically stable, uniformly asymptotically stable in the large, instability; Lyapunov function, Lyapunov's theorems, stability analysis of linear and non-linear systems using Lyapunov concept.

UNIT – V

Phase plane analysis, classification of singular points, limit cycle and closed trajectory; stability analysis using phase plane; stability analysis using describing function.

Text Books:

1. Linear Systems, Thomas Kailath, Prentice Hall. 1980
2. Control Systems – Principles and Design, Modan Gopal, C H Houpis, Tata McGraw Hill. 2012

Reference Books:

1. Linear Control System – Analysis and Design – Conventional and Modern, Johm J D'Azzo, C HHoupis, McGraw Hill International Edition. 1988
2. Modern Control System Theory, M. Gopal, New Age Int.(P) Limited. 1994

Web Links:

1 https://archive.nptel.ac.in/courses/108/106/108106150/
2 https://onlinecourses.nptel.ac.in/noc19_ee43/preview

Estimation and Adaptive Control

Course Code: 2517EE15

UNIT – I

Probability and Random Variables & Systems:

Meaning of Probability, Axioms of Probability, conditional probability, Bayes theorem, Bernoulli's Trial, concept of random variables, distribution and density functions, Statistical Properties ofRandom Variables – mean, variance and moments, Concept of Multi-variant Random variables

UNIT – II

Linear Discrete-time parameter & state estimation Theories (stochastic environment):

Linear measurement model, AR, ARMA, MA models, Least square estimation with batch processing,Least square estimation using SVD, Least square estimation with recursive processing

UNIT – III

Bes linear unbiased estimation (BLUE), likely-hood concept, Maximum-likelihood estimation, Kalman-Bucyfilter – complete derivation and implementation in MATLAB with applications, computational issues, Concept of Square root filter for nonlinear system, Concept and derivation of Extended Kalman filter(EKF).

UNIT – IV

Adaptive Control & System Identification-I

Concept of Adaptive Control – effect of process variation, need of adaptation, meaning of direct and indirect adaptive control, different adaptation control schemes. Self-tuning regulator, Model Reference adaptive control – concept, block diagram representation, MIT rules and its disadvantages, Lyapunov theory and design of MRAC, applications, difference between STR and MRAC. Gain Scheduling control

UNIT – V

Adaptive Control & System Identification-II

principle, design of gain scheduling control, discussion on application of gain scheduling control. Data based Identification method – system response and frequency response method (only principles and fundamental theories). Time-Invariant System Identification – static and dynamic system identification method (only principles and fundamental theories), Model validation – meaning and principle**.**

Text Books:

1. Probability, Random Variables and Stochastic Process, A. Papoulis, Mac Graw Hill, 3rd Edition. 1991
2. Lessons in Estimation theory for Signal processing, communication and Control, Jerry M Mendel, Prentice Hall. 1995.

Reference Books:

1. Adaptive Control, K.J Astrom, Second Edition. 1994
2. Identification of Continuous Systems, H Umbehauen and G P Rao. 2003

Web Links:

1 https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-ee50/
2 https://onlinecourses.nptel.ac.in/noc24_me76/preview

Optimal and Robust Control

Course Code: 2517EE16

UNIT – I
Introduction to optimization, concept of static optimization problem, some examples of optimum design problems.

UNIT – II
Dynamic optimization problem and its solution: Concept of functional, variationalproblems and performance indices

UNIT – III
Euler-Lagrange equation to find extremal of a functional, transversality condition, application of variational approach to control problems, LQR problem and its solution

UNIT – IV
algebraic Riccati equation and its solution techniques, frequency domain interpretation of LQR problem, gain margin and phase margin of LQR controlled problem, optimal control with constraints on input, concept of time-optimal control problem.

UNIT – V
Robust control: Concept of system and signal norms, small-gain theorem, physical interpretation of H_∞ norm, computation of H_∞ norm, internal stability, sensitivity and complementarysensitivity functions

Text Books:
1. Optimal Control systems, D S Naidu, CRC Press, 2003
2. Linear Systems–Optimal and Robust Control, Alok Sinha, CRC Press, 2007.

Reference Books:
1. Optimal Control, Frank L. Lewis, John Wiley & Sons, 1986.
2. An Introduction to Optimal Control Theory, Onésimo Hernández-Lerma, Leonardo R. Laura-Guarachi, Saul Mendoza-Palacios, David González-Sánchez, Springer 2023

Web Links:
1. https://archive.nptel.ac.in/courses/108/107/108107098/
2. https://archive.nptel.ac.in/courses/108/105/108105019/

Advanced Power Electronic Converters

Course Code: 2517EE17

UNIT-I:
Modern Power Semiconductor Devices
Modern power semiconductor devices – Insulated Gate Bipolar Transistor (IGBT) – MOSFET-MOS Turn off Thyristor (MTO) – Emitter Turn Off Thyristor (ETO) – Integrated Gate-Commutated Thyristor (IGCTs) – MOS-controlled thyristors (MCTs)– Power integrated circuits (PICs) – symbol, structure and equivalent circuit – comparison of their features.

UNIT-II:
Resonant Pulse Inverters
Resonant pulse inverters – series resonant inverters – series resonant inverters with unidirectional switches – series resonant inverters with bidirectional switches – analysis of half bridge resonant inverter – evaluation of currents and voltages of a simple resonant inverter – analysis of half bridge and full bridge resonant inverter with bidirectional switches – Frequency response of series resonant inverters – for series loaded inverter – for parallel loaded inverter – For series and parallel loaded inverters – parallel resonant inverters – Voltage control of resonant inverters – class E resonant inverter – class E resonant rectifier – evaluation of values of *C*'s and *L's* for class E inverter and Class E rectifier – numerical problems.

UNIT-III:
Resonant Converters
Resonant converters – zero current switching resonant converters – L type ZCS resonant converter – M type ZCS resonant converter – zero voltage switching resonant converters – comparison between ZCS and ZVS resonant converters – Two quadrant ZVS resonant converters – resonant dc-link inverters – evaluation of L and C for a zero current switching inverter – Numerical problems.

UNIT-IV:
Multilevel Inverters
Multilevel concept – Classification of multilevel inverters – Diode clamped Multilevel inverter – principle of operation – main features – improved diode Clamped inverter – principle of operation – Flying capacitors multilevel inverter-principle of operation – main features – cascaded multilevel inverter – principle of operation – main features – Multilevel inverter applications – reactive power compensation – back to back intertie system – adjustable drives -Switching device currents – dc link capacitor voltage balancing – features of Multilevel inverters – comparisons of multilevel converters.

UNIT-V:

D.C & A.C Power Supplies

DC power supplies – classification - switched mode dc power supplies – fly back Converter – forward converter – push-pull converter – half bridge converter – Full bridge converter – Resonant DC power supplies – bidirectional power supplies – Applications. AC power supplies – classification – switched mode ac power supplies – Resonant AC power supplies – bidirectional ac power supplies – multistage conversions – control circuits – applications. Introduction – power line disturbances – power conditioners – Uninterruptible Power supplies – applications.

Text Books:

1. Power Electronics by Mohammed H. Rashid, Pearson Education Third Edition.
2. Power Electronics by Ned Mohan, Tore M. Undeland and William P. Robbins, - John Wiley &
   Sons – Second Edition.

Reference Books:

1. Milliman Shepherd and Lizang – "Power converters circuits" – Chapter 14 (Matrix converter) PP- 415-444.2019
2. M.H.Rashid - Power electronics hand book, 1990
3. Marian P. Kaźmierkowski, Ramu Krishnan, Frede Blabjerg Edition:" Control in power electronics" illustrated Published by Academic Pres. 2002

Web Links:

1. https://nptel.ac.in/courses/108/108/108108077/
2. https://www.electrical4u.com/speed-control-of-three-phase-induction-motor/
3. https://www.erode-sengunthar.ac.in/wp-content/uploads/2019/04/Unit4.pdf