SYLLABUS OF
MASTER OF ENGINEERING
(POWER SYSTEM AND CONTROL)
DEPARTMENT OF ELECTRICAL ENGINEERING

DEPARTMENT OF ELECTRICAL ENGINEERING, SGSITS, INDORE

POs for M.E. (POWER SYSTEM AND CONTROL)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: An ability to create, select learn and apply appropriate techniques and resources in the area of Power System and Control with modern software's.

PO5: Apply the knowledge of science and mathematics in design, analysis and developing power converters for real-life problems.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-I

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 60003	Microprocessor Based System Design	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Basic knowledge about microprocessors.

COURSE OBJECTIVES:

1. Review the concept of 8-bit and 16-bit microprocessors and microcontrollers.
2. Enhance low level programming skill for system design
3. Describe the architecture and interfacing of programmable peripheral devices.
4. Develop the capabilities of design and develop industrial and domestic embedded system using digital techniques.

COURSE CONTENTS:

UNIT:1
Review of 8085/8086 microprocessors – Architecture, pin description, memory interfacing.

UNIT:2
Instruction set, Addressing modes, assembly language programming, interrupts of 8086.

UNIT:3
8051 Microcontroller families - Architecture, Instruction set, on-chip peripherals,

Comparison of different microcontrollers Atmel, Philips, Siemens.

UNIT:4
Peripherals – PIC 8259, DMA Controller 8237, Timer 8254, PPI 8255, USART 8251.

UNIT:5
Application of microcontrollers in PID controller, speed control of DC motors, static VAR systems, stepper motor control.

TEXT BOOKS:

1. A. K. Ray, K. M. Bhurchandi, "Advanced microprocessors and peripherals architecture, programming and interfacing", forth reprint, TMH Publishing company Ltd., New Delhi 2004.
2. Douglas V Hall, "Microprocessors, Hardware & Programming", Glencoe 1992.
3. Mazidi Muhammad Ali "8051 Microcontroller and Embedded Systems", Second edition Pearson Education, 2008.

REFERENCE BOOKS:

1. Yu Chang Liu and Glenn A. Gibson, "Microcomputer system;The 8086/8088 family Architecture programming and design", Prentice-Hall International 1986.
2. S. K. Mandal, "Microprocessor and Micro controller Architecture Programming and interfacing using 8085, 8086 8051", McGraw Hill 2011.
3. J. Kenneth, "8051 Microcontroller Architecture Programming and Application", Second edition USP 1996.

COURSE OUTCOMES:

Student will able to:

CO1: Develop program at low level to implement algorithms of engineering problems.

CO2: Identify and explore architecture of microprocessor and microcontroller for the specific application.

CO3: Extend capabilities of microprocessor based system using various programmable peripherals devices.

CO4: Design microprocessor based embedded system for industrial, domestic and social applications.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through two mid-term tests with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.

(b) The end-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-I

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr.	Total
EE 60014	Advanced Control System	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Basic knowledge of Mathematics, Network Analysis, Linear Systems and Control Systems.

COURSE OBJECTIVES:
Following are the objectives of the course:

1. Interpreting major concepts of Control System Applications.
2. Apply Basic Control theory towards assessment of Controllers in Electrical Engineering design.
3. Be capable of applying the Modelling Concepts in solving the real life problems of Engineering, physical systems and Science.
4. Explain the possible failure cases of Stability and Develop Tuning Controllers.
5. Modern Software tools applied in practical understanding of Real Time Control Problems.

COURSE CONTENT:

UNIT:1
Review of Linear Control System: Modelling through differential equations and difference equations, State space method of description and its solution, Discretization of continuous-time state space model, Laplace and z-domain analyses of control systems, Controllability, Observability & Stability, Bode & Nyquist analysis, Root Loci, Effect of load disturbance upon control actions.

UNIT:2
Development of feedback control laws through state space technique, Modal control, Pole placement problem.

UNIT:3
Variable Structure Control and its applications. Examples on variable structure control.

UNIT:4
Control of nonlinear dynamics: Lyapunov based control function, Phase plane technique, Lyapunov Stability analysis.

UNIT:5
Optimal Control: Calculus of variation, Euler-Lagrange equations, Boundary conditions, Transversality condition, Bolza problem, Pontryagin's maximum principle.

TEXT BOOKS:

1. B. C. Kuo, "Automatic Control Systems", eight edition, Wiley India 2009.
2. K. Ogata, "Modern Control Engineering", fifth edition, Prentice-Hall 2010.

3. B. C. Kuo, “Digital Control Systems”, Oxford University Press 1992.

REFERENCE BOOKS:

1. K. Ogata, “Discrete-Time Control Systems”, second edition, Pearson Education 2005.
2. Andrew P. Sage, “Optimum System Control”, Pearson Education Canada, 1977.

COURSE OUTCOMES:

After completing the course, student will able to:

CO1: Demonstrate an understanding of the concepts of Control engineering, various Design mechanisms and physical system Realization.

CO2: Identify importance of Several Conventional and Soft Tuned Controllers to estimate different parameters for Conventional Control engineering applications and Smart AI and Machine Learning Based Minimum Failure Systems.

CO3: Evolve the Development of complex Control Higher Order systems using ANN and Fuzzy Logic Based Systems.

CO4: Estimate Different Control models for Continuous and Discrete Time Systems using Classical Control mechanisms and State Space Analysis.

CO5: Determine the Applications of Optimal Control for Evaluation of different dynamical System.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through two mid-term tests with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
(b) The end-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALIZATION - POWER SYSTEM AND CONTROL)

SEMESTER-I

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
MA 60015	Advanced Engineering Mathematics	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Basic knowledge of Matrices, Linear and Non-linear Programming, Graph theory and basics of probability theory is required**.**

COURSE OBJECTIVES:
Following are the objective of the course:

1. To explore various solution of linear systems of equations, eigen values, eigenvectors and Applications of various Eigen-value problems.
2. To explain the different methods for solving non- linear programming problems and various graph theoretic algorithms useful in solving practical problems.
3. To study the basic concepts of the theory of stochastic processes and Marcov chain, most important types of stochastic processes various properties and characteristics of processes, methods for describing and analyzing complex stochastic and Markovian models.
4. To introduce the basic concepts of neural networks and design methodologies for artificial neural networks

COURSE CONTENTS:

Unit 1
Linear system of equations: Basic concepts, rank of matrix, linear independence, solution of linear systems of equations: existence, uniqueness and general form, homogeneous and non-homogeneous equations, Eigen values, Eigen vectors, Matrix Eigen-value problems, Applications of Eigen value problem.

Unit 2
Non-Linear Optimization: Formulation of non-linear programming, general non- linear programming problem, Lagrangean method, Kuhn-Tucker condition, Fibonacci Search, Quadratic Interpolation.

Unit 3
Combinatorial Optimization: Introduction and basic terminology of graphs, path, circuit, Eulerian circuits, Hamiltonian cycles, shortest path problem, Dijkstra's algorithm. Tree, spanning tree, minimum spanning tree algorithms: Kruskal's and Prim's algorithm. Flow augmented paths, Ford-Fulkerson algorithm, Max. Flow min. cut Method theorem.

Unit 4

Elements of Stochastic Process: Random variable, sample space, state space, random process (Stochastic process), Classification of stochastic process, Autocorrelation and auto covariance.

Markov Process: probability vector, stochastic matrix, regular stochastic matrix and their applications, transition matrix, Poisson Process.

Unit 5

Neural Network: Basic Idea, Artificial neural network and its building blocks, Terminologies learning rules, back propagation network and its rule, feedback network, Adaline and madaline network, Neurons as function of single monotocity, Perceptrons, Functional link network and fuzzy logic.

TEXT BOOKS:

1. Erwin Kreyszig: Adance Engineering Mathematics, John Wiling & Sons, 8th Edition.
2. S. S. Sastry: Engineering Mathematics, VolII, 2nd Edition, PHI, NewDelhi.

REFERENCE BOOKS:

1. K.K. Vinoth, Neural Network and Fuzzy Logic, 1st Edition, KATSON Book, 2009.
2. Pannerselvam R., Operations Research, Prentice Hall of India Pvt. Ltd, New Delhi, 2004.

COURSE OUTCOMES:

After completing the course, student will able to:

CO1: Identify and apply algebraic skills essential for the study of systems of linear equations, matrix algebra, eigen values, eigenvectors and analyze Matrix Eigen-value problems and their Applications.

CO2: Critically analyze and construct general non- linear programming problem and solve them through various techniques.

CO3: Concluding the fundamental concepts in graph theory and applying some basic graph theoretic algorithms for solving practical problems.

CO4: Explore the basic concepts of stochastic processes and Marcov chain, describe and analyze complex stochastic models.

CO5: Implementing the concept of neural network to train and analyze the data.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
(b) The end-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-I

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63001	Power System Operation & Control	4	-	-	4	-	70	30	-	-	100

PRE-REQUISITES: Knowledge of basic Power System

COURSE OBJECTIVES:
- To instantiate the operation of electrical transmission lines including phase shifting transformer.
- To know the importance of load forecasting in power system and study the different forecasting techniques.
- Learn modern numerical techniques and analytical methods for dealing with and solving operation-related problems in electric power systems.

COURSE CONTENTS:

UNIT:1
An overview of power system operation and control - system load variation - load characteristics - load curves analysis. Modeling of power system components, Loadability and compensation of a transmission line. Advances in transmission system integration. Concept of Real Time Thermal Rating (RTTR).

UNIT:2
Forecasting Techniques- Extrapolation and correlation Techniques. Estimation of stochastic component: Kalman filtering approach. Optimal generation scheduling with renewable sources. Hydrothermal coordination with and without losses. Unit commitment and solution methods,

UNIT:3
Sensitivity analysis of power system: Real and Reactive Power Control. Power system security, security levels, Contingency analysis, Pre and post contingency corrective rescheduling. Voltage Stability, Voltagestability v/s Angle stability. Assessment of voltage stability and enhancement methods.

UNIT:4
State estimation, objective of power system state estimator. Line flow state estimator, fast decoupled state estimator, bad data detection, monitoring of power system, SCADA configuration.

UNIT:5
Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency, tie-line control and tie-line bias control. AGC implementation –its features - static and dynamic response of controlled two area system.

TEXT BOOKS:

1. Power System Analysis, Operation and Control, Abhijit Chakrabarti and Sunita Halder PHI, Third edition, 2012
2. S Sivanagaraju and G Sreenivasan, “Power System Operation and Control”, Dorling Kindersley (India) Pvt.Ltd., 2012.

3. Power system Analysis by John J. Grainger & William D. Stevenson, JR: Tata McGraw-Hill Edition,2003.
4. Elgerd O.I, , “Electric Energy System Theory - an Introduction”, - Tata McGraw Hill, New Delhi, 2002.
5. Hadi Saadat, Power System Analysis , Tata McGra-Hill, Edition, 2002.
6. P Kundur, Power system Stability and Control, McGraw-Hill, Inc.,1994.
7. Power Generation Operation and Control, Allen J. Wood, Bruce F. Woolenburg, Wiley, New York, 1994.

COURSE OUTCOMES:
At the end of the course the student will be able to:

CO1: Develop mathematical models of individual power system components like transmission lines and phase shifting transformer.
CO2: Acquire knowledge of load forecasting for power system planning purposes.
CO3: Create awareness of Power system security -factors affecting power system security - contingency analysis, voltage stability issues.
CO4: Select and identify the most appropriate state of the power system network-voltage magnitude and phase angle at each bus.
CO5: To impart the knowledge of Automatic Generation Control in coordination with economic load dispatch problem.

COURSE ASSESSMENT:
Students will be assessed on

a. Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b. The End-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-I

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63002	Power Electronics Application to Power System	4	-	-	4	-	70	30	-	-	100

PRE-REQUISITE: Knowledge of power electronics.

COURSE OBJECTIVES:

To acquaint students with application of power electronics to power system operation, control, and design in generation, transmission and distribution with current trends.

COURSE CONTENTS:

UNIT:1
Review of power electronics system, power semiconductor devices & their characteristics, converter topologies, control circuits, requirements of synchronization, isolation, amplification devices, and device data sheets.

UNIT:2
Flexible ac transmission systems, reactive power control, description and definition of FACTS controllers, Shunt compensators, Configuration and operating characteristics of TCR, FC-TCR, TSC, Comparison of SVCs.

UNIT:3
Series compensators, variable impedance type series compensators, configuration and operating characteristics of TSSC, TCSC, switching converter type series compensators, configuration and operating characteristics of SSSC, combined compensators, UPFC and IPFC.

UNIT:4
HVDC transmission system, HVDC system configurations and components, converter theory and performance equations, control and protection of HVDC systems, MTDC operation, modern trends.

UNIT:5
Power electronics applications for renewable energy sources, power converters for solar photovoltaic power systems, and wind power systems.

TEXT BOOKS

1. K. R. Padiyar, “HVDC power transmission systems”, New Age International Publishers, 2010.

2. M. H. Rashid, “Power electronics circuits, devices, and applications”, PHI, Pvt. Ltd, 2004.

3. N. G. Hingorani and L. Gyugyi, “Understanding FACTS – Concepts and technology of flexible AC transmission systems”, IEEE Press, Standard Publishers Distributors, 2001.

REFERENCE BOOKS

1. N. Mohan, T. M. Undeland, & W. P. Robbins, “Power electronics converters, applications and design”, John Wiley & sons, 2009.
2. P. Kundur, “Power system stability and control”, McGraw-Hill, 2008.
3. R. M. Mathur and R. K. Verma, “Thyristor based FACTS controller for electrical transmission systems”, John Wiley and sons, 2002.

COURSE OUTCOMES:
After completing this course student will able to:

CO1: Exemplifying the application of power electronics to power systems.

CO2: Implementation of the flexible AC transmission systems (FACTS) for reliable operationand control of the power system.

CO3: Design and develop the various FACTS controllers in current trends.

CO4: Summarize the analysis of the HVDC transmission system configurations and components.

COURSE ASSESSMENT:
Students will be assessed on

a. Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b. The End-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALIZATION - POWER SYSTEM AND CONTROL)

SEMESTER-II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE63501	Digital Protection Of Power System	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Digital Signal Processing, Power System, Microprocessor & Micro-controller

COURSE OBJECTIVES:

1. To acquaint students with the basic concepts of discrete system and various transform.
2. To introduce concept of filter design techniques.
3. To explain power system protection concepts.
4. To impart the knowledge of digital protection, signal conditioning and smart grid protection.
5. To teach students protection of power system equipment.

COURSE CONTENTS:

UNIT: 1
Review of Discrete time signals, Discrete time structures, Various Transforms, Convolution, Filter Design techniques, System functions frequency response for rational systems. DFT and FFT algorithms.

UNIT: 2
The Z-transform and its properties, Properties of the region of Convergence for the Z-transform, Inverse z-transforms using counter integration. Basics of Complex Convolution, Parseval's relation, Unilateral z-transform. Basic structure of IIR system, Transposed forms, Basic network structures for FIR system. Computer aided design for discrete-time IIR filters, Design of FIR filters by windowing techniques.

UNIT: 3
General philosophy of protection- Qualities of relaying - Definitions - Characteristic Functions; Classification –analog-digital- numerical; schemes and design-factors affecting performance –zones and degree of protection; faults-types and evaluation; Instrument transformers for protection. Numeric relays.

UNIT: 4
Basic elements of digital protection –signal conditioning, ADCS and DACS, conversion subsystems-relay units-sequence networks-fault sensing data processing units- FFT and Wavelet based algorithms: least square and differential equation based algorithms-travelling wave protection schemes. Smart grid protection systems, Functional requirements of smart grid systems.

UNIT: 5
Protection of power system apparatus –protection of generators – Transformer protection – magnetizing inrush current – Application and connection of transformer differential relays – transformer over current protection. Bus bar protection, line protection, distances protection–long EHV line protection, Power line carrier protection. Self healing protection systems, Communication Protocols for smart grid systems.

TEXT BOOKS:

1. Donald Reimert, Protective relaying for power generation systems, Taylor & Francis-CRC press 2006.
2. Gerhard Ziegler-Numerical distance protection, Siemens, 2nd ed, 2006.

REFERENCES BOOKS

1. C. Russeil. Mason, The art and science of protective relaying, John Wiley &sons, 2002.
2. Power System Protection Vol. I, II , III&IV, The Institution Of Electrical Engineers, Electricity Association Services Ltd., 1995.
3. T S.Madhav Rao, Power system protection static relays with microprocessor applications, Tata McGraw Hill Publication, 1994.

COURSE OUTCOMES:
After completing this course student will able to :

CO1: Explain the basic characteristics and architecture of protection system of any power system.

CO2: Demonstrate end to end functionality and importance of various components of protection schemes and signal flow during fault occurrence.

CO3: Formulate and analyze the properties of fault and fault signals

CO4: Design a new protection scheme based on the power system requirement and troubleshoot of existing protection system under various operating conditions.

COURSE ASSESSMENT:

Students will be assessed on:

(a) Continuous evaluation through two mid-term test with a weightage of30% of the total marks. It includes class attendance as well as assignments on the course topics.

(a) The end-term theory examination weightage is 70%.

EEM.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63502	Digital Control System	4	-	-	4	-	70	30	-	-	100

PRE-REQUISITES: Knowledge of control system engineering.

COURSE OBJECTIVES:

- Knowledge about principles and techniques of Z-transform
- Knowledge in stability analysis of digital control systems
- Knowledge about the design of digital control systems for different engineering model

COURSE CONTENTS:

UNIT:1

Analysis in Z-domain: Review of Z Transforms, Sample data Systems , Pulse Transfer Function and sample and hold, effect of damping, mapping between the s plane and the z plane, stability analysis in s-plane and z- plane, Jury's test, Schur Cohn test, Bilinear Transformation. Discrete equivalents: Discrete equivalents via numerical integration-pole-zero matching-hold equivalents, Discrete Computer Control.

UNIT:2

Digital Controller Design for SISO and MIMO systems: Design based on root locus method in the z-plane and frequency response methods. Design of lag, lead compensator and lag lead compensator. Design of PID Controller based on frequency response methods- Direct Design-method of Ragazzini. Discretization of continuous time state space equations, Controllability, Observability, Control Law Design, decoupling by state variable feedback, effect of sampling period.

UNIT:3

Estimator/Observer Design: Full order observers -reduced order observers, Regulator Design, Separation Principle -case with reference input. MIMO systems: Introduction to MIMO systems, Design Concept -Case Studies, Such as application to Power systems and Power Electronics.

UNIT:4

Controllers – Review of basic control action , ON –Off control, P control, PI control, PD control, PID control , PID tuning – Nicholas- Zeigler method, Soft Computing , Neuro-Fuzzy, Fuzzy- Neuro system, Optimal Design of Controllers. Analysis of Robustness, System Sensitivity, Systems with uncertain parameters, Pseudo quantitative feedback systems, Disc drive readsystems, Robust PID Controllers, Turbojet engine controllers.

UNIT:5

Fundamentals of Ladder Diagrams, PLC, Boolean Logics, SCADA event detection, MACROS.

TEXTBOOKS/REFERENCES:

1. K. Ogata, “Modern Control Engineering”,Ninth edition, PHI Publication 2016.
2. Krishnakant “ Industrial Instrumentation”, PHI Publication, Delhi, 2015.
3. J. R. Liegh, "Applied Digital Control", Rinchart & Winston lnc., New Delhi, 2012.
4. M. Gopal, “Digital control and state variable methods”, Tata Mc Graw Hill, 1997.
5. . G. Jacquot, “Modern Digital Control Systems”, Marcel Decker, New York, 1995.
6. Benjamin C Kuo, “Digital Control Systems”, 2nd Edition, Saunders College publishing, Philadelphia, 1992.

COURSE OUTCOMES:
At the end of the course the student will be able to:

CO1 Paraphrasing the mathematical models of linear discrete-time control systems using transfer functionsand state-space models.

CO2 Analyze transient and steady state behaviors of linear discrete time control systems.

CO3 Design controllers and observers for linear discrete-time control systems so that their performance meet specified design criteria.

COURSE ASSESSMENT:
Students will be assessed on

a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b) The End-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION – POWER SYSTEM AND CONTROL)

SEMESTER-II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE63503	Power System Planning and Reliability	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Power System Analysis, Electric Power Generation, Transmission and Distribution.

COURSE OBJECTIVES:

1. The course is designed to teach load forecasting, power system planning, power quality and reliability issues in power system planning and expansion.
2. It aims to arm the students with the concepts of evaluation of generation, transmission distribution system reliability and their impacts on system planning.
3. This course will provide the background material to prepare the student for analyzing various elements that constitute the power system planning function.
4. Analyze and evaluate the reliability of electric power system for generation and load demand.

COURSE CONTENTS:

UNIT:1

Electric utility industry, generation, transmission and distribution scenario, factors affecting planning, objectives of planning, long and short term planning, design and operational methodology, integrated resource planning, distribution system planning, generation and cost analysis,

UNIT:2

Load forecasting, multi-linear and non-linear regressive analysis, regressive and correlation analysis, classification and characteristics of loads, energy sources, methodology of forecasting, auto regressive moving average (ARMA/ARIMA).

UNIT:3

Reliability aspects of power system planning, adequacy and security, component reliability, hazard function, failure laws, exponential failure law, wear in period and its importance, hierarchical levels, relationship disparity between indices and Worth at different levels, probability theory, probability distribution function and their use in evolution of MTTF, MTTR, Markov model.

UNIT:4

System reliability indices, loss of load indices- LOLE, LOLP and loss of energy indices, EIR, EENS and their computation, generating capacity- frequency and duration method and its concept. System risk indices- individual state load model and cumulative state load model.

UNIT:5

System adequacy evaluation, simulation methods, Monte Carlo simulation (MCS), factors in contingency approach, selection of appropriate contingency levels, outages, load curtailment, study of failure analysis, distribution system adequacy and indices, factors like SAIFI, CAIFI, SAIDI, CAIDI, ENS, assessment of distribution system reliability indices, study of radial and ring main distribution networks.

Text Books:

1. E. E. Lewis, "Introduction to reliability Engineering", second edition Wiley 1995.
2. C.E. Ebeling, "Reliability and maintainability Engineering", Tata McGraw Hill, 2004.
1. Joel A.Nachlas, "Reliability Engineering, Probability Models and Maintenance methods", Taylor and Francis, 2005.
2. R. Billinton, R. N. Allan, "Reliability evaluation of engineering system: concept and techniques", second edition Springer US, 1992.
3. Sullivan, R.L., "Power System Planning" , Heber Hill, 1987.

COURSE OUTCOMES:

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

CO1: Perform load forecasting for better planning of system.

CO2: Evaluate the peak demand and energy requirements of system using forecasting techniques

CO3: Generalizing the principle of reliability and learn statistical distribution as applied to power system components in reliability consideration, redundancy technique and applications

CO4: Learn and analyze different aspects of reliability evaluation for distribution and transmission system.

CO5: Comparing the reliability of generating system and spinning system.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through three mid-term tests with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
(b) The end-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM & CONTROL)

SEMESTER-II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63504	Distribution System	4	-	-	4	-	70	30	-	-	100

PRE-REQUISITE: Knowledge of Power System.

COURSE OBJECTIVES:

To acquaint students with knowledge of the distribution system, its load characteristics, design and analysis of its different components with the distribution system load flow program.

COURSE CONTENTS:

UNIT: 1
Introduction to distribution systems, distribution substations, distribution feeder configurations and electrical characteristics, nature of loads, individual customer load, distribution transformer loading, feeder load, load allocation, voltage-drop calculations.

UNIT:2
Approximate methods of analysis, voltage drop, "K" Factors, uniformly distributed and lumping loads in geometric configurations, power loss calculations, series impedance of overhead and underground lines, transposed three-phase lines, untransposed distribution lines, Carson's Equations, primitive and phase impedance matrix, concentric neutral and tape-shielded cable, sequence impedances, shunt admittance of overhead and underground Lines.

UNIT: 3
Modeling of distribution system components, distribution system line models, exact line segment model, modified line model, approximate line segment model, regulation of voltages, standard voltage ratings, two-winding transformer theory, two-winding autotransformer, single-phase step-voltage regulators, three-phase step-voltage regulators.

UNIT: 4
Three-phase transformer models, generalized matrices, Delta–grounded Wye step-down connection, ungrounded Wye–Delta step-down connection, grounded Wye–grounded Wye connection, Delta–Delta connection, open Wye–open Delta connection, Thevenin equivalent circuit, load models, Wye and Delta-connected loads, two-phase and single-phase loads, shunt capacitors, three-phase induction motor.

UNIT: 5
Distribution feeder analysis, power-flow analysis, forward and backward sweep (ladder iterative technique), direct approach, direct approach for weakly meshed systems, Gauss implicit Z-matrix method, unbalanced three-phase distribution feeder, applying the ladder iterative technique, short-circuit studies,

applications of distribution system analysis, distribution system analysis tools, distribution automation concepts, communication, sensors, supervisory control and data acquisition systems (SCADA), consumer information service(CIS), geographical information system (GIS), automatic meter reading (AMR), automation system.

TEXT BOOKS:

1. W. H. Kresting, Distribution System Modeling and Analysis, CRC Press, New York, 2002.
2. A. A. Sallam and O. P. Malik, Electric Distribution System, IEEE Press, Piscataway, NJ, 2011.
3. Edited by B. Das, Power Distribution Automation, IET Power and Energy Series, 75, London, 2016.
4. J. M. Gers, Distribution System Analysis and Automation, IET Power and Energy Series, 68, London, 2013.
5. R. F. Arritt and R. C. Dugan, Distribution system analysis and the future smart grid, IEEE Transactions on Industry Applications, vol. 47, no. 6, pp. 2343-2350, November/ December 2011
6. Integration of Distributed Generation in the Power System By Math H. Bollen, Willey IEEE Press.
7. A.S. Pabla, Electric Power Distribution, Tata Mc Graw Hill, 5 Edition, 2005.

COURSE OUTCOMES:
After completing this course student will able to:

CO1: Interpreting the principles of the distribution system, issues, challenges and opportunities.

CO2: Representing the nature of electrical loads and its characteristics.

CO3: Design and develop the models of distribution system components.

CO4: Distribution system feeder analysis using load flow in current trends.

COURSE ASSESSMENT:
Students will be assessed on

a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b) The end-term theory examination weightage is 70%.

M.E. FIRST YEAR ELECTRICAL ENGINEERING
(SPECIALISATION - POWER SYSTEM AND CONTROL)

SEMESTER-II (ELECTIVE-I)

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63701	Power Quality	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Basic knowledge of Power Electronics and Power System.

COURSE OBJECTIVES:
Following are the objective of the course:

1. To know the different terms of power quality.
2. To get the knowledge of nonlinear loads and disturbances on sensitive loads.
3. To illustrate the causes, effects and mitigation of voltage sag, interruption and over voltages.
4. To study about causes of voltage and current harmonics, different indices of harmonics and mitigation techniques.
5. To enhance the knowledge of power quality monitoring method, equipment and develop the ability to analyze the measured data.

COURSE CONTENTS:

UNIT I
Introduction to electrical power quality: definition of power quality, terms used in power quality, power quality issue, electric power quality standards.

UNIT II
Power frequency disturbance: common power frequency disturbances, voltage sag & interruptions, isolation transformer, voltage regulator, static UPS systems.

UNIT III
Electrical transients: types and causes of transients, atmospheric causes, switching on or off, interruption of fault circuits, capacitor bank switching, motor start transients, power factor correction, capacitor switching transients.

UNIT IV
Harmonics: definition of harmonics, causes of voltage and current harmonics, individual and total harmonics distortion, effects of harmonics on power system devices, guidelines for harmonic voltage and current limitation, harmonic current mitigation.

UNIT V
Power quality monitoring and conditioning: monitoring considerations, power quality measurement equipment, power quality monitoring standards, shunt and series compensators, DSTATCOM, DVR, and UPQC.

TEXT BOOKS:

1. R. C. Dugan, M. F. McGranaghan, Surya Santoso, H. W. Beaty “Electrical Power Systems

Quality", Tata McGraw Hill Education Pvt. Ltd., 2013.

2. C. Sankaran, "Power Quality", CRC Press.

Reference Books:

1. G. T. Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994.
2. A. Ghosh, G. Ledwich, "Power quality enhancement using custom power devices", Kluwer Academic Press, 2002.

COURSE OUTCOMES:

After completing the course, student will able to:

CO1: Differentiate various power quality terms.

CO2: Analyze current and voltage related power quality issues and their remedies.

CO3: Illustrate the various mitigation methods of various power quality problems.

CO4: Utilize the knowledge of various power quality phenomenon in the various equipment.

CO5: Assess the severity and solution to harmonics, a power quality problems in distribution system.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
(b) The end-term theory examination weightage is 70%.

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SEMESTER-II (ELECTIVE-I)

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63702	Power System Deregulation	4	-	-	4	-	70	30	-	-	100

PREREQUISITE: Basic knowledge of Power System

COURSE OBJECTIVES:
To study about the Indian power sector and power sector of other countries need to make radical changes in the policy and regulation such that barrier to entry for private players is removed.

COURSE CONTENTS:

UNIT: 1
Indian power sector-past and present status, overview of growth of power sector in India. Players in the Indian power sector. Reforms in the Indian power sector. Fundamentals of Economics: Consumer and supplier behavior, Market equilibrium.

UNIT: 2
Introduction of ancillary services – Types of Ancillary services – Classification of Ancillary services – Load generation balancing related services – Voltage control and reactive power support devices – Black start capability service - ancillary service –Co-optimization of energy and reserve services.

UNIT: 3
Deregulation of power industry, restructuring process, issues involved in deregulation, competitive market structure of deregulated power system, operation and control aspects of deregulated power system

UNIT: 4
Transmission Open Access and Pricing Issues: Introduction, power wheeling, transmission open access, cost components in transmission, pricing of power transactions, transmission open access and pricing mechanisms in various countries.

UNIT: 5
Transmission Congestion Management and Pricing- transmission cost allocation methods, LMP, FTR and Congestion Management. Role of FACTS devices in competitive power market, Available Transfer Capability, Distributed Generation in restructured markets.

TEXT BOOKS:

1. Steven Stoft, "Power system economics: designing markets for electricity", John Wiley & Sons, 2002.
2. Mohammad Shahidehpour, MuwaffaqAlomoush, Marcel Dekker, "Restructured electrical power systems: operation, trading and volatility" Pub., 2001.
3. W. H. J. R. Dunn, M. A. Rossi, B. Avaramovic: Impact of market restructuring on power systems operation, IEEE computer Applications on Power Engineering, vol. 8, January 1995, pp 42–47.
4. Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.

COURSE OUTCOMES:
At the end of the course, the student will be able to:

CO1: Executing the need for restructuring of Power Systems, discuss different market models, andmarket power.

CO2: Planning the functioning and planning activities of Independent System Operator (ISO).

CO3: Implementing the different utilizes participated in electricity market.

CO4: Outlining the transmission open access pricing issues and congestion management.

COURSE ASSESSMENT:

Students will be assessed on

1. Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
2. The End-term theory examination weightage is 70%.

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SEMESTER-II (ELECTIVE-I)

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE 63703	Energy Audit & Conservation	4	-	-	4	-	70	30	-	-	100

PRE-REQUISITES: Graduate in Engineering

COURSE OBJECTIVES:

To facilitate the students to achieve a clear conceptual understanding of technical and commercial aspects of energy conservation and energy auditing.

COURSE CONTENTS

UNIT: 1
Energy Audit, types of energy audit; methods: optimizing the input energy requirement; Energy audit instruments. Energy Management: Economic analysis; Duties and responsibilities of energy managers, Energy conservation Act.

UNIT: 2
Data gathering: Level of responsibilities, energy sources, control of energy and uses of energy Facts, data and impression about energy /fuel and system operations, Special tests on data and Questionnaire for data gathering.
Analytical Techniques: Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of Electric load characteristics, process and energy system simulation.

UNIT: 3
Sources of waste heat and its potential applications, Waste heat survey and measurements, Data collection, Limitations and factors affecting heat recovery equipment and systems, Heat Exchangers, Incinerators Regenerators and Recuperates.

UNIT: 4
Resources: Introduction, Definition and concepts, Energy and Water as a resource, Criticality of resources and needs of modern living. Evolution of Envelop heat loss and heat gain and its evaluation, Thermal Comport improvement methods, Optimum performance, Other building comports, IAQ requirements, Electrical Energy Conservation, Opportunities and Techniques for energy conservation in Buildings.

UNIT: 5
Energy storage systems: Need and importance of Energy storage in Conventional and Nonconventional Energy Systems. Technical Aspects of Measurements and Quantification. Various forms: Thermal, Chemical, Mechanical, Electrical and Nuclear Techno Commercial Analysis with Economical aspects.

TEXT BOOKS:

1. Carig,B. Saith, Energy Management Principles, Applications, Benefit and Saving, Per n Press, NewYork, 2011.
2. O.P. Gupta , Element Of Fuel Furnaces And Refractories, Edition-Second, 2001.
3. Energy Economics -A.V. Desai (Wieley Eastern),1999.
4. Industrial Energy Conservation Manuals, MIT Press, Mass, 1982.

COURSE OUTCOMES:
On completion of this course, the students will be able to exhibit

CO1: Focus on present energy scenario and its policy.

CO2: Analyze, calculate and improve the energy efficiency and performance of electrical utilities.

CO3: Ability to prepare an energy audit report.

CO4: Draw the energy flow diagram of an industry and identify the energy wasted or a waste stream.

COURSE ASSESSMENT:
Students will be assessed on

a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b) The End-term theory examination weightage is 70%.

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SEMESTER-II (ELECTIVE-I)

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE63704	HVDC Transmission System	4	-	-	4	-	70	30	-	-	100

PRE- REQUISITE: Basic knowledge of power electronics and power system.

COURSE OBJECTIVES:
Following are the objective of the course:

1. To develop the basic concept of AC-DC converter and DC-AC converter used in HVDC transmission system.
2. To know the effects of harmonics on transmission system.
3. To create knowledge about the AC/DC system power flow methods.
4. To develop the design ability of HVDC system.

COURSE CONTENTS:

UNIT:1
Comparison of AC/DC transmission. Application of DC transmission. Examples of HVDC lines. Analysis of HVDC converter, Pulse No. Six and twelve pulse converter analysis. Relation for current and voltage.

UNIT:2
HVDC system control, Principles of DC link control, converter control characteristics. Firing angle control, System control hierarchy. Harmonics and filters, Generation of harmonics and elimination.

UNIT:3
AC/DC system load flow, system modeling, PU system unified and sequential methods of solution, reactive power requirement at converter bus.

UNIT:4
AC-DC system interactions, voltage interaction, dynamic voltage regulation, voltage instability, dynamic stability and power modulation. Harmonic, instability, torsional interactions with HVDC system.

UNIT:5
Fault modelling and analysis, over current characteristics of DC line, faults, detection of DC line faults, fault characteristics protection of DC line grounding. Main design aspects of HVDC transmission system. General requirements series/parallel arrangements of converters. Converter design. Converter transformer design aspects.

TEXT BOOKS:

1. J. Arrillaga, “High Voltage Direct Current Transmission”, IET edition 1998.
2. J. Arrillaga and N. R. Watson “Computer Modeling of Electrical Power System” John Wiley edition 2001.

REFERENCE BOOKS:

1. K. R. Padiyar, "HVDC power transmission systems", New Age International edition 1990.
2. E.W. Kimbark, "Direct Current Transmission", Wiley Inter science edition 1971.

COURSE OUTCOMES:
After completing the course, student will able to:

CO1: Define and illustrate the role AC-DC and DC-AC converter in HVDC system.

CO2: Recognizing the effects of various control methods and of harmonics.

CO3: Analyze the AC-DC system interactions in the context of HVDC system.

CO4: Examine and evaluate the design aspect of HVDC transmission system.

COURSE ASSESSMENT:
Students will be assessed on

a) Continuous evaluation through two mid-term test with a weightage of 30% of the total marks. It includes class attendance as well as assignments on the course topics.
b) The end-term theory examination weightage is 70%.

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SEMESTER -II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE-63851	LAB -III	-	-	4	-	4	-	-	40	60	100

COURSE OBJECTIVES:

1. To project the concept and applications of Proportional, Proportional-Integral, Proportional Derivative and Proportional-Integral-Derivative types of control.
2. Able to apply the laboratory techniques, tools, and practices of control engineering.
3. Get acquainted with the modeling of dynamical systems, to simulate and analyze the stability of the system using MATLAB software.

LIST OF EXPERIMENTS

1. Evaluate the effect of addition of poles to the forward path transfer function of a closed loop system: Effect of addition of poles to forward path of open loop system and a closed loop systems.

2. Evaluate the effect of addition of zeros to the forward path transfer function of a closed loop system. Effect of addition of zeros to forward path of open loop system and a closed loop systems.

3. To analyze the effect of PI controller on system performance.

4. To analyze the effect of PD controller on system performance.

5. To analyze the effect of PID controller on system performance.

6. To perform transient and small signal stability analysis on a given machine connected to an infinite bus.

7. MATLAB Program to find optimum loading of generators neglecting transmission lines.

8. MATLAB Program to find optimum loading of generators neglecting transmission line with penalty factors.

9. Develop Simulink model for multi-area power system.

10. Minor Project (for the group of two students).

LAB PROJECTS

For practical understanding to students, Several Lab projects are assigned in a group of 2 or 3 students in domain of diversified areas of Power System, which can be used as a primary basis for their major projects. Simulation exercises are carried out for various IEEE standard systems.

COURSE OUTCOMES:

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

CO1: Design the basic power system network theoretically and analyse the performance of the theoretical design through simulations.

CO2: Design controllers theoretically for closed loop systems and verify the performance specifications of the controllers through simulations.

CO3: Identify the design issues of different controllers for power system applications and accordingly select applicable conventional or intelligent controller.

CO4: Discriminate between analytical and practical designs and construct lab-prototypes for basic power system network while learning to deal with protection issues.

COURSE ASSESSMENT:

Students will be assessed on

(a) Continuous evaluation through lab report assessments (10%), mid semester and end semester internal submissions (10%). It includes class attendance (5%) as well as report questions based on lab experiments (5%). The minor project will be submitted at the end of semester and its outcome will be assessed by an internal examiner (10%). Total (40% marks)

(b) The end-term practical examination. (The student is asked to perform the given laboratory task based on experimentation done during the semester. The student is allowed to perform experiment and take observation and justify the obtained results. The exam will be conducted by external and internal examiners. Total (60% marks)

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SEMESTER-II

Subject Code	Subject Name	L	T	P	Th. Credit	Pr. Credit	Maximum Marks				
							TH	CW	SW	Pr	Total
EE63881	Seminar	-	-	-	2	-	-	-	100	-	100

COURSE OUTCOMES:

CO1: Develop adequate technical presentation and documentation capabilities

CO2: Effectively lead a team while creating a collaborative and learning environment for other group members

CO3: Present their design and analytical capabilities through the use of real life/ industry oriented problems

CO4: Demonstrate their expertise and research orientation in solving practical problems.

CRITERIA & RUBRICS:

Maximum Marks: 100 Marks Passing Marks: 40 Marks

Student will be judged using following criteria and rubrics:

1. Technical Content – 30 Marks (CO1, CO2, CO3, CO4)
2. Presentation Capabilities – 20 Marks (CO1, CO2, CO3, CO4)
3. Knowledge – 20 Marks (CO1, CO2, CO3, CO4)
4. Documentation – 20 (CO1, CO2, CO3, CO4)
5. Confidence – 10 (CO1, CO2, CO3, CO4)