VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Undergraduate Programme Leading to
Bachelor of Technology (B. Tech.) Degree
in
Electrical Engineering

Implemented from the batch admitted in Academic Year 2018-19

Proposed Revised Scheme for B.Tech Electrical Engineering (SemVII & VIII)

Academic Year 2021-2022 onwards

Sem-VII

Scheme of Instruction						Scheme of Evaluation				
Sr. No.	**Course Code**	**Course name**	**Hr/week**			**Credits**	**TA**	**MST**	**ESE**	**ESE Hrs**
			L	**T**	**P**					
1.	R4EE4001S	Energy Management and Costing	3	0	0	3	20	20	60	3
2.	R4EE4002T	Power System Analysis	4	0	0	4	20	20	60	3
	R4EE4002P	Power System Analysis Lab	0	0	2	1	60	-	40	2
3	R4EE4003S	Power System Protection	4	0	0	4	20	20	60	3
4	R4EE41**S	Program Elective – II	3	0	0	3	20	20	60	3
5	R4EE4601S	Open Elective – II	3	0	0	3	20	20	60	3
6	R4EE4004A	Industrial Issues case study	3	0	0	**MNC**	-	-	-	-
7	R4EE4901D	Project – I	0	0	4	2	20	20	60	3
8	R4EE4701I	Internship	0	0	2	2				
		Total	**18**	**0**	**8**	**22**				

Sem-VIII

Scheme of Instruction						Scheme of Evaluation				
Sr. No.	**Course Code**	**Course name**	**Hr/week**			**Credits**	**TA**	**MST**	**ESE**	**ESE Hrs**
			L	**T**	**P**					
1.	R4EE4005S	Restructured Power Systems	3	0	0	3	20	20	60	3
2.	R4EE4006T	Industrial Automation and Controllers	3	0	0	3	20	20	60	3
	R4EE4006P	Industrial Automation and Controllers Lab	0	0	2	1	60	-	40	2
3	R4EE41**T	Program Elective – III	3	0	0	3	20	20	60	3
	R4EE41**P	Program Elective – III Lab	0	0	2	1	60	-	40	2
4	R4EE41**S	(Program Elective –IV)	3	0	0	3	20	20	60	3
	R4EE4902D	Project – II	0	0	8	4	20	20	60	3
		Total	**12**	**0**	**12**	**18**				

Abbreviations: **L**: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment / Term work Assessment, M**ST**: Mid Semester Tests, **ESE**: End Semester Written Examination, **CIE**: Continuous In-semester Evaluation
** Refer List of Electives

List of Electives

Course Code	Elective I	Course Code	Elective II
R4EE3111T	Renewable Energy Sources	R4EE4101S	Optimization Techniques
R4EE3111P	Renewable Energy Sources Lab		
R4EE3112T	Internet of Things	R4EE4102S	Applied Linear Algebra
R4EE3112P	Internet of Things Lab		
R4EE3113T	Basics of Communication	R4EE4103S	Electrical Machine Design
R4EE3113P	Basics of Communication Lab		
R4EE3114T	Biomedical Instrumentation		
R4EE3114P	Biomedical Instrumentation Lab		

Course Code	Elective III	Course Code	Elective IV
R4EE4104T	Sensors and Transducers	R4EE4108S	Micro grid and Grid Integration
R4EE4104P	Sensors and Transducers Lab		
R4EE4105T	DSP in Electric Drives	R4EE4109S	FACTS
R4EE4105P	DSP in Electric Drives Lab		
R4EE4106T	Image and Video Processing	R4EE4110 S	Electrical Distribution system
R4EE4106P	Image and Video Processing Lab		
R4EE4107T	High Voltage Engineering		
R4EE4107P	High Voltage Engineering Lab		

Course Code	Open elective I	Course Code	Open elective II
R4EE3612S	Electric Vehicles	R4EE4601S	Industrial Automation

Semester VII

Programme Name	B. Tech. (Electrical Engineering)	Semester -VII			
Course Code	R4EE4001S	L	T	P	Credit
Course Title	Energy Management and Costing	3	-	-	3

B. Tech. (Electrical Engineering) Semester -VII

COURSE OUTCOMES

Students should be able to:

1. Identify energy saving opportunities in electrical power distribution and mechanical systems.
2. Implement energy conservation program to HVAC, pumps, compressors DGs, Illumination Boilers, Furnaces etc.
3. Formulate and implement method of auditing energy.
4. Calculate various energy efficiency and performance parameters for industrial, residential and commercial loads.

COURSE CONTENTS

Module I	Introduction
	Energy conservation in compressor, HVAC, refrigeration, fans and blowers, types of pumps, system characteristics, pump curves, EC opportunities, cooling tower, efficient operation, flow control strategies, DG set systems- selection, installation and operational factor, energy saving measures, energy efficiency calculations and case studies in thermal utilities such as boilers, steam systems, furnaces, refractors, need and benefits of cogeneration and waste heat recovery schemes, case studies.
Module II	**Basics of Energy and its Laws**
	Basics of Energy and its various forms: Electricity basics - DC & AC currents, Electricity tariff, Load management and Maximum demand control, Power factor. Material and Energy balance: Facility as an energy system, Methods for preparing process flow, Material and energy balance diagrams
Module III	**Impact of Energy on Environment**
	Commercial and Non-Commercial Energy, Primary Energy Resources, Commercial Energy Production, Final Energy Consumption, Energy Needs of Growing Economy, Long Term Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy and Environment: Air Pollution, Climate Change, Energy Security, Energy Conservation and its Importance, Energy Strategy for the Future, Energy ConservationAct-2001 and its Features.
Module IV	**Energy Management**
	Energy Management & Audit: Definition, Energy audit-need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments.

Text Books:	1. “Energy for a sustainable world”, by Jose Goldenberg, Thomas Johansson, A.K.N. Reddy. 2. “Energy policy”, by B.V.Desai,Robert Williams, Wiley Eastern Ltd. 3. “Modeling approach to long term demand and energy implication”, by J.K.Parikh, MartinusNijhoff Publishers.
Reference Books:	1. “Energy efficiency in thermal utilities”, Guide book for National Certification Examination for Energy

Course Code	R4EE4002T	L	T	P	Credit
Course Title	Power System Analysis	4	-	-	4

COURSE OUTCOMES

Students should be able to:

1. Analyse power system for both steady state condition and dynamic condition.
2. Calculate economic and merit order dispatch.
3. Model and design load frequency control loop and voltage control loop.
4. Justify use and concept of stability in interconnected power system
5. Describe different methods to keep system stable for both small and large disturbances.

COURSE CONTENTS

Module I	Basics and Fundamentals
	Basic components of a power system. Generator models, transformer model, transmission system model- load representation. Methods for formation of Y-Bus matrix.
Module II	**Power Flow Analysis**
	Importance of power flow analysis in planning and operation of power systems. Statement of power flow problem- classification of buses into P-Q buses, P-V (voltage controlled) buses and slack bus. Development of Power flow model in complex variables form and polar variables form. Iterative solution using Gauss-Seidel method including Q-limit check for voltage controlled buses– algorithm and flow chart. Iterative solution using Newton-Raphson (N-R) method (polar form) including Q-limit check and bus switching for voltage-controlled buses– Jacobian matrix elements–algorithm and flow chart. Development of Fast Decoupled Power Flow (FDPF) model and iterative solution–algorithm and flowchart; Comparison of the three methods. Control of Voltage Profile. Analysis using IEEE standard bus system.
Module III	**Economic Dispatch**
	Economic dispatch, neglecting generator limits and line losses, Economic dispatch with generator limits, Economic dispatch with line losses.
Module IV	**Automatic Generation and Voltage Control**
	Load Frequency control (Single area case), Load Frequency Control and Economic Dispatch Control, Two area LFC, Optimal LFC (Two Area), Automatic Voltage Control, LFC with Generation Rate Constraints , speed governor dead- band and its effect on AGC.
Module V	**Power System Stability**
	Importance of stability analysis in power system planning and operation - classification of power system stability- angle and voltage stability– simple treatment of angle stability into small-signal and large-signal (transient) stability Single Machine Infinite Bus (SMIB) system: Development of swing equation- equal area criterion- determination of critical clearing angle and time by using modified Euler method. Factors affecting steady state and transient stability and methods of improvement.
Text Books:	1. "Modern Power System Analysis", by Kothari & Nagrath, T Mc.Graw Hill. 2. "Power System Analysis", by Grainger and Stevenson, McGraw Hill
Reference Books:	1. "Power System Analysis and Design", by J. D. Glover, M. S. Sharma & T. J. Overbye, Cengage Learning, 2012. 2. "Modern Power System Analysis", by TuranGonen, CRC Press. 3. "Power System Analysis", byHadi Sadat, Tata McGraw Hill.

Programme Name	B. Tech. (Electrical Engineering)	Semester – VII			
Course Code	**R4EE4002P**	**L**	**T**	**P**	**Credit**
Course Title	**Power System Analysis Lab**	**-**	**-**	**2**	**1**

COURSE OUTCOMES:

Students should be able to:

1. Analyze power system for both steady state condition and dynamic condition.
2. Calculate economic and merit order dispatch.
3. Model and design load frequency control loop and voltage control loop.
4. Justify use and concept of stability in interconnected power system
5. Describe different methods to keep system stable for both small and large disturbances.

LIST OF EXPERIMENTS:

1. Computation of parameters and modelling of transmission lines.
2. Formation of y- bus using singular transformation method with and without mutual coupling.
3. Formation of jacobian for the system not exceeding 4 buses (no pv buses) in polar coordinates.
4. Transient and small signal stability analysis – single machine Infinite bus system.
5. Solution of power flow using gauss-seidel method.
6. Solution of power flow using newton-raphson method.
7. Economic dispatch in power system, solve the problem using Classical method with and without line losses.
8. Study construction and working of different protective devices like Fuse, MCB,ACB etc

Programme Name	B. Tech. (Electrical Engineering)	Semester - VII			
Course Code	R4EE4003S	L	T	P	Credit
Course Title	Power System Protection	4	-	-	4

COURSE OUTCOMES:

Students should be able to:

1. Calculate S.C. MVA and fault current for different type of faults.
2. Justify use of different circuit breakers in power system.
3. Calculate parameters for relay coordination.
4. Employ different protective devices for unit protection, line and busbar protection.
5. Differentiate between conventional relaying and numerical relaying.

COURSE CONTENTS:

Module I	**Circuit Interrupting Devices**
	Sequence of operation and interlocking, Fuse, types, characteristics, Isolators, Circuit breaker: Arc phenomena and arc extinction, working principle of Oil circuit breakers, Air break, Air Blast, Sulphur Hexa Fluoride (SF_6) and vacuum circuit breakers, Important terms related to circuit breakers, Auto-reclosure
Module II	**Elements of Protection**
	Need of protective system, Protection System and Its Attributes: Sensitivity, Selectivity, Reliability and Dependability, Various Power System Elements That Need Protection, Protection zones, Time grading and current grading, numerical relay used for protection, types of backup protection.
Module III	**Over-Current Protection using numerical relays**
	Introduction, different types, numerical & static over current relay, Implementation of IDMT principles, forward & reverse fault, directional features, Choice Between IDMT and DTOC Relays, Relay Coordination
Module IV	**Differential Protection**
	Simple Differential Protection, Behaviour During Load, Behaviour During External Fault, Behaviour During Internal Fault, Simple Differential Protection, Double-end-fed: Behaviour: During Internal Fault, Zone of Protection of the Differential Relay, Actual Behaviour of a Simple Differential Scheme, Through Fault Stability and Stability Ratio, Percentage Differential Relay, Earth Leakage Protection, Earth Leakage Protection for Single-phase Load, Earth Leakage Protection for Three-phase Loads.
Module V	**Distance Protection of Transmission Lines**
	Drawbacks of Over-current Protection, Introduction to Distance Protection, Simple Impedance Relay, Reactance Relay and mho Relay: Performance of during Normal Load Flow, Effect of Arc Resistance on Reach, Directional Property, Performance during Power Swing, Complete Protection of a Three-phase Line
Module VI	**Protection of Generator, Busbar and Transformer**
	Generator Protection: Types of fault in alternators, Protection against stator faults, Balanced earth fault protection, stator inter turn protection, loss of excitation, loss of prime mover, Transformer protection: Types of Faults in Transformers, Percentage Differential Protection of Transformers, Inrush Phenomenon, Percentage Differential Relay with Harmonic Restraint, High Resistance Ground Faults in Transformers, High Resistance Ground Faults on the Delta Side, High Resistance Ground Faults on the Star Side, Inter-turn Faults in Transformers, Incipient Faults in Transformers, Buchholz Relay, Protection Against Over-fluxing, Busbar Protection: Introduction, Differential

	Protection of Busbars, Selection of CT Ratios for Busbar Protection
Module VII	**Case Study**
	Using power system software implementation of small protective system & relay co-ordination.

Text Books:	1. "Fundamentals of Power System Protection", Y.G. Paithankar, S.R. Bhide, PHI Learning, 2010. 2. "Power System Protection, Ram B and Vishwakarma D. N.", TMH, New Delhi 3. "Switchgear protection and power System", S. Rao, Khanna Publication Art and Science of Protective Relaying, Mason

Reference Books:	1. "Power System Protection and Switchgear", B. Ravindranath, M. Chander, New Age International (P) Ltd. 2. "Power System Protection & Switchgear", Bhuvanesh Oza, Nirmal Kumar Nair, Vijay Makwana, Rashesh Mehta, Mcgrawhill

Program Elective II

COURSEOUTCOMES

Programme Name	B. Tech. (Electrical Engineering)	Semester - VII			
Course Code	R4EE4101S	L	T	P	Credit
Course Title	Optimisation Techniques (Program Elective II)	3	-	-	3

Students should be able to:

1. Appreciate the engineering examples which depend on decision theory.
2. Employ variety of models associated with real time systems in electrical engineering and appropriate solutions techniques.
3. Analyse network and forecasting models in electrical engineering
4. Implement decision making techniques

COURSE CONTENTS

Module I	Introduction
	Importance and Modeling Examples.
Module II	**Review of Calculus and Matrix Algebra**
	Existence of Minimum and Maximum, Concepts of Infimum, Supremum, Weierstrass Theorem, Multivariate Calculus, Differentiability, Partial Derivatives, Taylor Series Expansion. Linear Independence, Rank, Null Spaces, Solution of Linear System of Equations, Eigen Value and Eigen Vectors.
Module III	**Optimality Conditions**
	First order and Second order optimality conditions for unconstrained univariate and multivariate problems, Hessian Matrix, Positive Definiteness of Matrices, Steepest Descent Method. First order and Second order optimality conditions for Linearly Constrained Optimization Problems.
Module IV	**Introduction to Linear Programming**
	Linear Programming Problem, Formulation, Geometry and Simplex Tableau Approach, Sequential Linear Programming Algorithms.
Module V	**Nonlinear Programming Problems**
	Formulation and Examples of Equality and Inequality Constrained Problems, First order and Second Order Karush Kuhn Tucker (KKT) Optimality Conditions.

Text Books:	1. "Operations Research– An introduction", by Hamdy A. Taha, 8^{th} Edition, Pearson Prentice Hall, 2007. 2. Practical Optimization", Philip E. Gill, Walter Murray and Margret H. Wright, Academic Press

Reference Books:	1. "Optimization Techniques",by S. S. Rao, John Wiley & Sons, 1996. 2. "Optimization Techniques",by S. D. Sharma. KNRN Publishers. .3 "Nonlinear Programming, Theory and Algorithms", Mokhtar S. Bazaraa, Hanif D. Sherali and C,M, Shetty, Wiley Student Edition.

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	R4EE4102S	L	T	P	Credit
Course Title	Applied Linear Algebra – (Program Elective II)	3	-	-	3

COURSE OUTCOMES

Students should be able to:

1. Carry out operations on matrices to solve electrical engineering problems
2. Carry out operations involving systems of linear equations
3. Apply mathematical reasoning in several different areas of Electrical Engineering.

COURSE CONTENTS

Module I	Vector Spaces
	Vector spaces, Subspaces, linear dependence, spanning sets, Basis, dimension, Four fundamental subspaces associated with a matrix, revisit the system of linear equations, Intersection and Sum of Subspaces, Direct Sums, Embedding of sub- spaces.
Module II	**Linear Transformations**
	Definition, Matrix representations, Change of Basis, Similarity transformations, Invertible transformations.
Module III	**Inner Products**
	Definition, induced norm, inequalities, Orthogonality, Gram-Schmidt orthogonalization process, Orthogonal projections, rank-one projections, Unitary transformations, isometry
Module IV	**Positive Definite Matrices**
	Minima, Maxima and saddle points, tests for positive definiteness, Single Value and Decomposition, Minimum Principles and the Finite Element Method.

Text Books:	1. "Linear Algebra and its applications", by Gilbert Strang, 4th Edition, Cengage Learning publications, 2007. 2. "Linear Algebra", by Kenneth Hoffman and Ray Kunze, 2nd Edition, Pearson publication, 2015.

Reference Books:	1. "Linear algebra and its applications", by D. C. Lay, Pearson (3rd edition), 2014. 2. "Linear Algebra", by S. H. Friedberg, A. J. Insel and L. E. Spence 4th Edition, PHI, 2003.

Programme Name	B. Tech. (Electrical Engineering)	Semester –VIII			
Course Code	**R4EE4103S**	**L**	**T**	**P**	**Credit**
Course Title	**Electrical Machine Design (Program Elective II)**	3	-	-	3

COURSE OUTCOMES

After completion of this course, students will be able to

1. Illustrate basic concepts and significance of various materials in electrical machine design
2. Design single phase and three phase transformers
3. Design three phase induction motors
4. Analyze the performance of three phase induction motors

COURSE CONTENTS

Module I	**Introduction**
	Design factors, limitations in design, magnetic circuit calculations, magnetic leakage calculations, magnetizing current calculations, unbalanced magnetic pull, heat dissipation, heating, cooling curve, estimation of minimum rise, cooling media, quantity of cooling media, design of fan and ratings. Magnetic, Electrical, Conducting and Insulating materials used in machines. Insulations used in transformer design, induction motor design
Module II	**Finite element method for electrical machines**
	Introduction to FEM, Applications of FEM to design insulation, eddy current loss calculation, evaluate torque speed characteristics of Induction motor, calculate leakage inductance of a transformer, calculate inrush current, and evaluate reluctance force and torque, Introduction to ANSYS RMxprt.
Module III	**Design of Single phase and Three phase transformers**
	Review on construction and parts of transformer, Output equation, Main Dimensions, Specific electric and magnetic loadings, Design of core, Selection of the type of winding, Design of LV and HV windings, Design of insulation. Resistance and leakage reactance of the winding, Mechanical forces, No load current; Cooling of transformers – design of cooling tank and tubes/ radiators, IS: 1180, IS: 2026
Module IV	**Design of Three phase Induction motors**
	Output equation, Choice of specific electric and magnetic loadings, Standard frames, Main dimensions, Design of stator and rotor windings, Stator and rotor slots, Design of stator core, air gap, Design of squirrel cage rotor, end rings, Design of wound rotor, Types of enclosures. Calculation of leakage reactance for parallel sided slot, Carter's coefficients, Concept of B60, Calculation of No load current, Short circuit current, Calculation of maximum output from Circle diagram, Dispersion coefficient, IS325, IS1231, IEC 60034. Design criteria of Energy Efficient Induction motor
Module V	**Design of Switched Reluctance Motor**
	Output equation, Choice of specific electric and magnetic loadings, Selection of dimensions, Selection of number poles, Selection of Core and Winding materials, Calculation of core and copper losses, Calculation of inductance of the designed motor as a function of rotor angle, Calculation of performance parameters of a Switched Reluctance Motor using ANSYS RMxprt, Evaluation of various parameters using ANSYS Maxwell.
Module VI	**Application of FEM to evaluate various parameters of Three Phase**

	Induction Motors
	Calculation of performance parameters of induction motors using ANSYS RMxprt or equivalent software, Evaluation of various parameters using ANSYS Maxwell or equivalent software.

Text Books:	[1] S. V. Kulkarni and S. A. Khaparde, “Transformer engineering: design, technology, and diagnostics,” CRC press, 2012 (2012). [2] M. A. Bahmani, “Design and Optimization Considerations of Medium Frequency Power Transformers in High-Power DC-DC Applications,” Ph.D. thesis, Chalmers University of Technology (2016). [3] N. Bianchi, “Electrical Machine Analysis using Finite Elements,” CRC press, 2005. [4] S. V. Kulkarni, “Electrical Equipment and Machines: Finite Element Analysis,” NPTEL MOOC course.

Reference Books:	[5] V. Rajini and V. S. Nagarajan, “Electrical Machine Design,” Pearson Education India, 2018. [6] R. Krishnan, “Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications,” CRC press, 2017. [7] A. K. Sawhney, “Electrical Machine Design”, Dhanpat Rai & Co., 2016. [8] M. V. Deshpande, “Design and Testing of Electrical Machines”, PHI Learning, 2009.

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	**R4EE4601S**	**L**	**T**	**P**	**Credit**
Course Title	**INDUSTRIAL AUTOMATION (OPEN ELECTIVE II)**	3	-	-	3

COURSE OUTCOMES

Students should be able to:

1. State the advanced automation system used in industrial level.
2. Outline the different parts of PLC and different languages used in PLC.
3. Illustrate PLC hardware configuration for given application.
4. Analyse the given application and prepare a ladder logic program.
5. Propose a scheme for trouble shooting a PLC system.

COURSE CONTENTS

Module I	Introduction to Automation and PLC Fundamentals
	Automation – Definition, Need, Benefits, Different tools for automation Evolution of PLC in automation, difference between relay control and PLC Control. Block diagram and description of different parts: CPU - Function, scanning cycle, speed of execution. Power supply- function, Block diagram. Memory – function & organisation of ROM & RAM. Input modules- function, diff. input devices used with PLC (only name & their uses)Output modules- function, diff. output devices used with PLC(only name & their uses)Fixed and Modular PLCs & their types. Specialty I/O modules: communication module, high speed encoder, RTD input module, stepper motor control module, Thermocouple module. Redundancy in PLC modules
Module II	**PLC Hardware**
	Discrete input modules: AC input modules- block diagram, description, typical wiring details, specifications. DC input modules- block diagram, description, typical wiring details, sinking and sourcing concept & specifications. Analog input modules- block diagram, description, typical interfacing of input devices & specifications. Discrete output modules: AC output modules- block diagram, description, typical wiring, and specifications. DC output modules- block diagram, description, typical wiring details, sinking and sourcing connections & specifications.Relay and Isolated o/p modules.(only description). Analog output modules- block diagram, description, typical wiringdetails & specifications.I/O module selection criterion.
Module III	**PLC Instruction Set**
	I/O addressing of PLC.Relay type instructions - NO, NC, One shot, Latch, and Unlatch.Timer instructions - On delay timer, off delay timer, Retentive timer, and Timer reset.Counter instructions - up counter, down counter, high speed counter, counter reset.Comparison instructions – Equal, Not equal, Greater, Greater than equal, Less, Less than equal.Data handling instructions – Move, Masked Move, and Limit test.Logical instructions – AND, OR, EX-OR, NOT. Miscellaneous instructions – Sequencer instructions, scale with parameter, subroutine and PID instructions.
Module IV	**Programming and Applications**
	Different PLC programming languages (only introduction) - FBD,Instruction list, structured text, sequential function chart, and ladder logic.Simple programming examples using ladder programming language based on relay, timer, counter, logical, comparison, Data handling and miscellaneous instruction.Application development based on description such as-Motor

	sequence control, Traffic light control, Elevator control, Tank level control, Reactor control, Conveyor system, Stepper motor control. (Any specific application can be considered in each above area to develop a ladder program). Speed Control of AC/ DC Motor using Programmable Drives
Module V	**Installation and Troubleshooting**
	PLC installation- enclosures, rack, master control relay, grounding, noise suppression, maintenance guidelines.PLC troubleshooting- input and output troubleshooting using module LED status, troubleshooting of ladder program.

Text Books:	1. "Introductionto programmable logic control", byGary Dunning, Cenage Learning 2. "Programmable logic controllers", by F.D. Petruzella (Third edition) Tata-McGraw-Hill 3. "Programmable logic controllers", by John Hackworth and Federic Hackworth, Pearson education

Reference Books:	1. "Industrial automation and process Control", by Jon Stenerson,Prentice Hall

Programme Name	B. Tech. (Electrical Engineering)	Semester – VII			
Course Code	**R4EE4004A**	**L**	**T**	**P**	**Credit**
Course Title	**INDUSTRIAL ISSUES CASE STUDY**	**3**	**-**	**-**	**MNC**

COURSE CONTENTS

Module I	**Development of inhouse project**
	Indentifying needs, issues in department, college, society, converting ideas into product
Module II	**Implementation of project**
	Testing, troubleshooting issues
Module III	**Report writing**
Module IV	**Outdoor case study**
	Visit to at least two industries, identifying issues/problems and providing solution for issues, suggesting possible solution, report writing for selected case study

Semester VIII

Programme Name	B.Tech(Electrical Engineering)	Semester - VIII			
Course Code	**R4EE4005S**	**L**	**T**	**P**	**Credit**
Course Title	**Restructured Power Systems**	**3**	**0**	**0**	**3**

COURSE OUTCOMES:

Students should be able to

1. Analyse different market structures.
2. Apply basic concepts of economics to power market, different market mechanisms, competition and market power
3. Formulate peculiarities of electricity as a commodity, models for competition and trading in the electricity sector, overview of different electricity markets
4. Justify the need of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services
5. Compare and analyse strategic bidding methodologies, FTRs, Power Trading in India, Electricity Markets Across the Globe

COURSE CONTENTS:

Module I	**Introduction to Restructuring**
	Background, overview of the restructured power industry, unbundling of power system players and the associated issues.
Module II	**Basic Concepts from Economics**
	Models for consumers and producers, market equilibrium, introduction to different market mechanisms, competition and market power.
Module III	**Markets for Electricity**
	Peculiarities of electricity as a commodity, models for competition and trading in the electricity sector, overview of different electricity markets.
Module IV	**Transmission Congestion Management**
	Understanding congestion and its impacts, congestion management schemes based on OPF and other methods, and their comparisons.
Module V	**Locational Marginal Pricing**
	Mathematical background, fundamentals of locational marginal pricing, LMP calculation methods.
Module VI	**Ancillary Services**
	Definition of ancillary services, ancillary services for supply-demand balance, voltage control and black-start, procurement of ancillary services.
Module VII	**Transmission Pricing**
	Rolled in schemes, marginal pricing schemes and comparative assessment.
Module VIII	**Strategic Bidding Methodologies**
Module IX	**Introduction to FTRs, Power Trading in India**
Module X	**Electricity Markets Across the Globe**

Text Books:	1. “Fundamentals of Power System Economics”, by Daniel Kirschen and GoranStrbac, John Wiley & Sons Ltd 2. “Electrical Power Trading”, by Sally Hunt, Wiley Finance.

Reference Books:	1.“Restructured Power Systems”, by Mohammad Shahidehpour and MuwaffaqAlomoush,Marcel Dekker, INC.

Programme Name	**B.Tech(Electrical Engineering)**	**Semester - VIII**			
Course Code	**R4EE4006T**	**L**	**T**	**P**	**Credit**
Course Title	**INDUSTRIAL AUTOMATION AND CONTROLLERS**	**3**	**0**	**0**	**3**

COURSE OUTCOMES:

Students should be able to:

1. State the advanced automation system used in industrial level.
2. Illustrate automation hardware configuration for given application.
3. Analyse the given application and prepare a ladder logic program.
4. Understand Distributed Control Systems.

COURSE CONTENTS:

Module I	**Introduction**
	Automation overview, Requirement of automation systems, Architecture of Industrial Automation system, Introduction of PLC and supervisory control and data acquisition (SCADA). Industrial bus systems: modbus & profibus
Module II	**Automation components**
	Sensors for temperature, pressure, force, displacement, speed, flow, level, humidity and pH measurement. Actuators, process control valves, power electronics devices.
Module III	**Computer aided measurement and control systems**
	Role of computers in measurement and control, Elements of computer aided measurement and control, man-machine interface, computer aided process control hardware, process related interfaces, Communication and networking, Data transfer techniques, Computer aided process control software, Computer based data acquisition system, Internet of things (IoT) for plant automation, P,PID, PI Controllers, Feedback controllers, feed forward controllers, Cascade Controllers, Tuning of Controllers.
Module IV	**Programmable logic controllers**
	Programmable controllers, Programmable logic controllers, Analog digital input and output modules, PLC programming, Ladder diagram, Sequential flow chart, PLC Communication and networking, PLC Hardware, PLC selection, PLC Installation& Troubleshooting, Advantage of using PLC for Industrial automation, Application of PLC to process control industries.
Module V	**Distributed Control System**
	Overview of DCS, DCS software configuration, DCS communication, DCS Supervisory Computer Tasks, DCS integration with PLC and Computers, Features of DCS, Advantages of DCS.
Module VI	**Introduction to Standards related to industry 4.0**
	Basics of CNC, working principle, applications, Conversions of signals/data from sensors PLC/SCADA to IOT and transfer of data to storage cloud

Text Books:	1. “Intro. To Programmable logic control”, by Gary Dunning , Cenage Learning 2. “Programmable logic controllers”, by F.D. Petruzella, (Third edition) Tata-McGraw-Hill 3. “Process Control Instrumentation Technology”, by C.D. Johnson,Prentice-Hall Of India Pvt. Limited 4.”Programmable logic controllers”, by John Hackworth and Federic

	Hackworth, Pearson education

Reference Books:	1. “Industrial automation and process Control”, by Jon Stenerson ,Prentice Hall 2. “Distributed control systems in industrial automation”, by D. Popovic, V. Bhatkar, Marcel Dekker Inc

Programme Name	**B.Tech(Electrical Engineering)**	**Semester - VIII**			
Course Code	**R4EE4006P**	**L**	**T**	**P**	**Credit**
Course Title	**INDUSTRIAL AUTOMATION AND CONTROLLERS LAB**	**0**	**0**	**2**	**1**

COURSE OUTCOMES:

Students should be able to:

1. State the advanced automation system used in industrial level.
2. Illustrate automation hardware configuration for given application.
3. Analyse the given application and prepare a ladder logic program.
4. Understand Distributed Control Systems.

LIST OF EXPERIMENTS:

1. Verify functions of logic gates by using PLC.
2. Ladder program for Start stop logic using two inputs.
3. Ladder program for push to start and push to stop. (Use single Push Button).
4. Write and verify ladder program for sequential control of DC motors.
5. Write and verify ladder program for stepper motor.
6. Use of Timers for Traffic Control.
7. Use of counters for pulse counting using limit switch/ proximity sensor.
8. Interfacing of thermocouple/RTD as an analog sensor with PLC.
9. Design of temperature On-Off control loop using PLC.
10. Use of PID control for Temperature control loop.
11. Use of sequencer instructions for stepper motor control.
12. Development of ladder program for washing system.
13. Development of ladder program for automated parking system.
14. Design of PLC based application using conveyor system.
15. Design of PLC based application using Elevator system.
16. Development of ladder program for security Gate to record entry and exit of employee andvisitors
17. Speed Control of AC/DC Motor using Programmable drives
18. Study of IEC61131 standard for PLC programming.

Program Elective (III and IV)

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	**R4EE4104T**	**L**	**T**	**P**	**Credit**
Course Title	**Sensors and Transducers (Program Elective III)**	3	-	-	3

COURSE OUTCOMES

Students should be able to:

1. Use concepts in common methods for converting a physical parameter into an electric quantity
2. Choose an appropriate sensor comparing different standards and guidelines to make sensitive measurements of physical parameters like pressure, flow, acceleration, etc.
3. Design and develop sensors using optical methods with desired properties
4. Create analytical design and development solutions for sensors.

COURSE CONTENTS

Module I	**Sensor fundamentals and characteristics**
	Sensor Classification, Performance and Types, Error Analysis characteristics
Module II	**Optical Sources and Detectors**
	Electronic and Optical properties of semiconductor as sensors, LED, Semiconductor lasers, Fiber optic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs.
Module III	**Intensity Polarization and Interferometric Sensors**
	Intensity sensor, Microbending concept, Interferometers, Mach Zehnder, Michelson, FabryPerot and Sagnac, Phase sensor: Phase detection, Polarization maintaining fibers.
Module IV	**Strain, Force, Torque and Pressure sensors**
	Strain gages, strain gage beam force sensor, piezoelectric force sensor, load cell, torque sensor, Piezo-resistive and capacitive pressure sensor, optoelectronic pressure sensors, vacuum sensors. Design of signal conditioning circuits for strain gauges, piezo, capacitance and optoelectronics Sensors
Module V	**Position, Direction, Displacement and Level sensors**
	Potentiometric and capacitive sensors, Inductive and magnetic sensor, LVDT, RVDT, eddy current, transverse inductive, Hall effect, magneto resistive, magnetostrictive sensors. Fiber optic liquid level sensing, Fabry Perot sensor, ultrasonic sensor, capacitive liquid level sensor. Signal condition circuits for reactive and self-generating sensors
Module VI	**Velocity and Acceleration sensors**
	Electromagnetic velocity sensor, Doppler with sound, light, Accelerometer characteristics, capacitive, piezo-resistive, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes.
Module VII	**Flow, Temperature and Acoustic sensors**
	Flow sensors: pressure gradient technique, thermal transport, ultrasonic, electromagnetic and Laser anemometer. microflow sensor, coriolis mass flow and drag flow sensor. Temperature sensors- thermoresistive, thermoelectric, semiconductor and optical. Piezoelectric temperature sensor. Acoustic sensors- microphones-resistive, capacitive, piezoelectric, fiber optic, solid state - electrect microphone.

ModuleVIII	Applications of Sensors and Transducers
	Use of Sensors for specific application. Condition based monitoring using sensors and transducers. Case study of sensors/transducer applications.

Text Books:	1 "Hand Book of Modern Sensors: physics, Designs and Applications", Jacob Fraden, 3rd edition, Springer, New York. 2015 2. "Sensor Technology Hand Book", Jon. S. Wilson, 1st edition, Elsevier, Netherland. 2011,

Reference Books:	1. "Optical Fiber Communications", GerdKeiser, 5th edition, McGraw-Hill Science, Delhi, 2017 2. "Measurement, Instrumentation and sensor Handbook", 2017, 2nd edition, John G Webster, CRC Press, Florida. 3. "Fiber optic sensors: An introduction for engineers and scientists", Eric Udd and W.B. Spillman, 2013, 2nd edition, Wiley, New Jersey. 4. "Fundamentals of photonics", Bahaa E. A. Saleh and Malvin Carl Teich, 2012, 1st edition, John Wiley, New York.

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	**R4EE4104P**	**L**	**T**	**P**	**Credit**
Course Title	**Sensors and Transducers Lab (Program Elective III)**	0	0	2	1

COURSE OUTCOMES

Students should be able to:

1. Demonstrate the sensor conditioning circuits
2. Develop sensor measurement system
3. Design and develop sensors with desired properties
4. Create analytical design and development solutions for sensors.

LIST OF EXPERIMENTS:

1. Design of signal conditioning circuits for strain gauges- Strain, Force, pressure, and torque measurement
   i. Strain measurement with Bridge Circuit
   ii. Beam force sensor using Strain Gauge Bridge
   iii. Beam deflection sensing with Strain Gauge Bridge
   iv. Diaphragm pressure sensor using Strain Gauge Bridge
   v. Shear strain and angle of shift measurement of hollow shaft

2. Develop a displacement measurement system with the following sensors:
   i. Inductive transducer (LVDT)
   ii. Hall effect sensor

3. After studying the characteristics of temperature sensors listed below, develop a temperature measurement system for a particular application using the suitable sensor.
   i. Thermocouple principles
   ii. Thermistor and linearization of NTC Thermistor
   iii. Resistance Temperature Detector
   iv. Semiconductor Temperature sensor OA79
   v. Current output absolute temperature sensor

4. Develop a sensor system for force measurement using piezoelectric transducer

Programme Name	B.Tech (Electrical Engineering)	Semester -VIII			
Course Code	**R4EE4105T**	**L**	**T**	**P**	**Credit**
Course Title	**DSP in Electric Drives (Program Elective – III)**	**3**	**-**	**-**	**3**

COURSE OUTCOME

Students should be able to:

1. Justify use of applications of DSP in power electronics and power systems
2. Identify DSP/DSC architecture and its features along with its nomenclature.
3. Write a program code for DSP for simple applications.
4. Compare and evaluate various numerical integration methods used for digital control implementation.
5. Model, analyse and design various compensators for converter/inverter control.

COURSE CONTENTS

Module I	**Introduction**
	Digital signal processors (DSP) and digital signal controller (DSC) architectures, Fixed and floating-point processors, Fixed point and floating point number representations, Review of commonly used DSPs/DSCs in power and control applications, Introductions toTMS320C2000 processors.
Module II	**DSP/DSC model nomenclature, architecture, peripherals and programming**
	Overview of TMS320C2000 DSC family – Features, Architecture, Memory map, Clock system- Digital I/O -CPU Timers, Analog to Digital Converter(ADC), Pulse Width Modulator (PWM) Capture Module, Quadrature Encoder Pulse module and communication ports, Programming: assembler, linker processes, code structure, Code Composer Studio(CCS).
Module III	**Mathematical tools for Real Time DSP implementation**
	Review of numerical integration: Euler‘s implicit and explicit method, Heun‘s Method, Trapezoidal Method, Implementation of low pass filter, Review of reference frame transformation theory. Algorithms and programming of digital controllers, Implementation aspects and application of modern digital controllers
Module IV	**Digital Controller Design**
	Modelling buck, boost converter and three phase inverter with LC filter, Design of compensators voltage and current mode control for their closed loop applications,
Module V	**DSP Applications in Power factor correction:**
	Implementation of Active filters in DSP/DSC under balanced and unbalanced condition, harmonic oscillator and 3 phase lock loop, DSP based power factor correction, for AC-DC converters and DC-AC converters
Module VI	**Application to DC and AC motor drives**
	Closed loop control of DC motor drives using DSP interface, Frequency-controlled Induction Motor Drives, Space vector modulation, V/F control for Induction motor

Text Books:	1. "DSP Based Electromechanical Motion Control", by H. Toliyat and Steven Campbell, CRCPress, 2003 2. "Digital Signal Processors - Architectures,Implementations, and Applications", by Sen, M. Kuo and Woon-SengGan, Prentice Hall , 2005 3. .Digital Signal Processing: Steven W Smith 4. Modern Control Systems: John A Borrie

Reference Books:	1. "Power Electronics, Converters, Applications & Design", by N. Mohan, T. M. Undeland, W.P. Robbius, Wiley India PVT. Ltd. 2003 2. "Modern Power Electronics and AC Drives", B. K Bose, Pearson Education 3. Code Composer Studio v6: http://processors.wiki.ti.com/index.php/Category:Code_Composer_Studio_v6 4. Texas Instrument's c2000 DSC http://processors.wiki.ti.com/index.php/Category:C2000 5. C2000 teaching ROM

Programme Name	B.Tech (Electrical Engineering)	Semester -VIII			
Course Code	**R4EE4105P**	**L**	**T**	**P**	**Credit**
Course Title	**DSP in Electric Drives Lab (Program Elective – III)**	**-**	**-**	**2**	**1**

COURSE OUTCOME

Students should be able to:

1. Justify use of applications of DSP in power electronics and power systems
2. Identify DSP/DSC architecture and its features along with its nomenclature.
3. Write a program code for DSP for simple applications.
4. Compare and evaluate various numerical integration methods used for digital control implementation.
5. Model, analyze and design various compensators for converter/inverter control.

LIST OF EXPERIMENTS:

1. To study about DSP Processors and architecture of TMS320C000 Series DSP processor.

2. To introduce MATLAB and Code Composer Studio or its equivalent open source software along with drive model simulation.

3. Write a Program for the generation of basic signals such as unit impulse, unit step, ramp, exponential, sinusoidal and cosine.

4. To generate embedded code for PWM, Sine PWM generation.

5. To develop CCS code for measurement of AC/ DC voltage/ currents, use of CPU timers and Digital I/Os.

6. Assembly language programming, Real-time voltage/ current, speed sensing signal and processing.

7. PWM strategies realization through DSP and controlling power electronic and Drive Systems.

8. To perform analysis of speed control of three-phase DC motor and induction motor drive using V/f open loop control and obtained the speed-torque characteristics with frequency variations using CCS.

9. To perform analysis of speed control of three-phase induction motor drive using V/f open loop control and obtained the speed-torque characteristics with frequency variations using CCS.

10. Case Study:
    (i) Vector control one of the of AC machines
    (ii) Space vector modulation

Programme Name	B.Tech(Electrical Engineering)	Semester - VIII			
Course Code	R4EE4106T	L	T	P	Credit
Course Title	IMAGE AND VIDEO PROCESSING (Program Elective – III)	3	-	-	3

COURSEOUTCOMES

Students should be able to:

1. Analyse image enhancement techniques in spatial and frequency domain
2. Apply transform theory for image analysis and employ them for various applications
3. Compare methods of image segmentation and examine textural properties
4. Apply feature extraction methods and implement classification algorithms
5. Analyse basic video processing and motion estimation techniques

COURSE CONTENTS:

Module I	Image Fundamentals
	Image acquisition, sampling and quantization, Spatial and Tonal resolution of images, types and formats of images, basic relationship between pixels, color images, RGB and HSI models. Image Representation- Image Basis Functions
Module II	**Image Enhancement**
	Spatial Domain: Point Processing methods, Neighborhood Processing, histogram based processing Frequency domain: Discrete Fourier Transform (DFT), DCT, 2D Haar, Walsh, Hadamard
Module III	**Segmentation and Morphology**
	Segmentation based on discontinuities, Segmentation based on similarities and region based segmentation Morphology: Dilation, erosion, opening, closing, hit or miss transform, thinning and thickening, and boundary extraction on binary images, top-hat transform.
Module IV	**Feature Extraction and Classification**
	Texture analysis and content based image retrieval, Filtering techniques- Localized feature extraction- Boundary Descriptors- Run length features- Feature selection, Maximum Likelihood Estimation- Bayesian approach- Pattern Classification, k-means clustering, minimum distance to mean, parallel piped classifiers.
Module V	**Video Processing**
	Static and dynamic background modelling - frame subtraction- optical flow techniques- Handling occlusion- scale and appearance changes - Shadow removal.

Text Books:	1.“Digital Image Processing”, by Gonzales and Woods, Pearson Education India, Third Edition. 2.“Handbook of Image and Video Processing”,A.Bovik, 2nd Edition, Academic Press, 2005.

Reference Books:	1. “Pattern classification”, by Richard O. Duda, Peter E. Hart and David G. Stork., Wiley, 2001. 2. “The Image Processing Handbook”, by John C.Russ, CRC Press, 2007. 3. “Feature Extraction and ImageProcessing”, by Mark Nixon and Alberto Aguado,Academic Press, 2008.

Programme Name	B.Tech(Electrical Engineering)	Semester -VIII			
Course Code	**R4EE4106P**	**L**	**T**	**P**	**Credit**
Course Title	**IMAGE AND VIDEO PROCESSING LAB (Program Elective – III)**	**-**	**-**	**2**	**1**

COURSE OUTCOMES:
Students should be able to:

1. Analyse image enhancement techniques in spatial and frequency domain
2. Apply transform theory for image analysis and employ them for various applications
3. Compare methods of image segmentation and examine textural properties
4. Apply feature extraction methods and implement classification algorithms
5. Analyse basic video processing and motion estimation techniques

LIST OF EXPERIMENTS:

1. To perform basic algebraic operations on images (addition, subtraction, masking, averaging, weighted averaging)

2. To perform point processing for image enhancement using
    a) Various power and n^{th} root transformations
    b) Histogram processing; stretching, equalization, and matching

3. To perform neighbourhood processing for image enhancement using
    1) Smoothing mask
    2) Sharpening mask

4. To perform image enhancement in frequency domain
    a) Low pass filtering (Ideal, Butterworth, Gaussian)
    b) High pass filtering (Ideal, Butterworth, Gaussian)

5. To perform textural analysis in terms of GLCM

6. To perform basic morphological operations (erosion, dilation, opening, closing, thinning, thickening) on binary images

7. To study video frame interlacing and effect of time resolution

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	**R4EE4107T**	**L**	**T**	**P**	**Credit**
Course Title	**High Voltage Engineering (Program Elective – III)**	3	-	-	3

COURSE OUTCOMES

Students should be able to:

1. Appreciate the importance and role of insulation in electrical equipment.
2. Analyze deterioration and breakdown of electrical insulation.
3. Carry out partial discharge testing
4. Implement finite element methods

COURSE CONTENTS

Module I	**Maxwell's Equations and Its Role**
	Revision of various laws of electromagnetic, The impact of various electrode shapes and electric field line distribution, The role of frequency on insulation
Module II	**The Breakdown of Gases, Liquids, Solids & Vacuum**
	The Townsend's theory, Streamer theory of breakdown, The of breakdown, The paschen's law, Schumann's formula, Breakdown of air/ SF6 under uniform field at NTP. Breakdown under extremely non uniform fields, Various types of insulating liquids, filtration and purification of oil. Breakdown of oil. Breakdown of solids. Breakdown under Vacuum condition.
Module III	**Generation of High Voltage**
	Cascaded transformer, resonance transformer, Cockroft Walton circuit, Impulse voltage generator
Module IV	**Measurement of High Voltage and High Currents**
	Resistance voltage divider, Capacitance voltage divider Shunts, Rogowskii coil
Module V	**Partial Discharge**
	Partial discharge and its measurement, Testing for partial discharge in transformers, Importance of impedance matching.
Module VI	**Introduction to Finite Element Methods**
	Methods based on Finite Differences and Integral Formulations, the Finite Element Method, 2D - Finite element modeling of single phase transformer, Solenoid, Inductor, Capacitors, wire wound Resistor & Toroid.

Text Books:	1. "High Voltage Engineering", by M. S. Naidu and V. Kamaraju, Tata McGraw-Hill Education, 2004. 2. "High Voltage Engineering", by C. L. Wadhwa, 3rd Edition, New Age Publication, 2012.

Reference Books:	1."High voltage Engineering: Fundamentals", by W.S. Zaengl and E.Kuffel Elsevier, 2000. 2."High Voltage and Electrical Insulation Engineering", by Wolfgang Mosch and Ravindra Arora, Wiley-IEEE Press, 2011.

Programme Name	B. Tech. (Electrical Engineering)	Semester – VII			
Course Code	**R4EE4107P**	**L**	**T**	**P**	**Credit**
Course Title	**High Voltage Engineering Lab (Program Elective – III)**	**-**	**-**	**2**	**1**

COURSE OUTCOMES

Students should be able to:

1. Interpret electric field pattern between different electrode surfaces.
2. Evaluate breakdown of air using different electrode system modeling
3. Apply FEMM modeling on different elements and equipment of high voltage.
4. Evaluate breakdown in transformer oil.

LIST OF EXPERIMENTS:

1. To observe electric fields between parallel plates with two different dielectric keeping the gap length 1cm ,5cm,10cm and applying the potential at 50Kv, 200Kv, and 600Kv.
2. To observe electric field pattern between electrode and plate electrode.
3. To observe electric field pattern between two pointed electrodes
4. To observe electric field pattern between two pointed electrodes and spherical electrode
   2. Pointed electrodes and spherical electrode grounded
   3. Spherical electrode at high voltage
5. To observe electric field distribution pattern between two spherical electrodes.
6. Transformer oil break down
7. Lighting Impulse test
8. Breakdown of air in pointed electrode system
9. Breakdown of air in spherical electrode system
10. Tracking in rubber shut.
11. Finite Element Method Magnetics (FEMM) modelling of single phase transformer, Solenoid, Inductor, Capacitors, wire wound Resistor & Toroid.

Programme Name	B.Tech(Electrical Engineering)	Semester -VIII			
Course Code	**R4EE4108S**	**L**	**T**	**P**	**Credit**
Course Title	**MICRO GRID AND GRID INTEGRATION (Program Elective IV)**	**3**	**-**	**-**	**3**

COURSE OUTCOME:

Students should be able to:

1. Classify performance of different power generation techniques.
2. Justify the use of distributed generation and their interconnections with grid.
3. Analyse different components in microgrid, communication and power quality issues.
4. Compare islanding and integrated mode of microgrid and analyse issues of integration.

COURSE CONTENTS:

Module I	Introduction
	Conventional power generation, advantages and disadvantages, non-conventional energy source review; solar PV, wind energy, fuel cell, micro turbine and biomass, review of energy storing element
Module II	**Distributed Generation**
	Concept of distributed generation, topology, selection of sources, regulatory standard IEE 1547, DG installation classes, requirement for grid interconnection, security issue in DG ,implementation and limitation, islanding issue
Module III	**MicroGrid**
	Concept of microgrid, need and application of micro grid, formation of micro grid, typical structure and configuration of micro grid, ac-dc micro grid, power electronic interface in micro grid, modes of operation, control of micro grid; grid connected and islanding mode, active and reactive power control protection issue, anti-islanding scheme; passive, active and communication technique, regulatory slandered, difference between grid and micro grid, power quality and EMC in micro grid, and power quality issue of grid connected micro grid.
Module IV	**Introduction to smart grid**
	Basic introduction, need for communication interface in smart micro grid, advanced metering infrastructure(AMR), home area network(han),neighbourhood area network (NAN), wide area network (WAN),bluetooth, zigbee, GPS, Wi-Fi, Wi-maxed based communication, wireless mesh network, wide area measurement system (WAMS), phase measurement unit (PMU), cyber security for smart micro grid, IP based protocol, reliability, redundancy. introduction to IEC 61850
Module V	**Power electronic interface for micro grid**
	Need of power electronics interface, component and equipment for micro grid, type of power electronic converter; converter, rectifier, inverter, chopper, ac-ac converter, interface; pv, wind energy, fuel cell.
Module VI	**Integration of energy storage in micro grid**
	Need of energy storage in micro grid, type of energy storage; battery, flywheel, ultra capacitor. energy storage with micro grid, issue related to interfacing of energy storage with micro grid.

Text Books:	1. "Smart Grid: Technology and Application"s by J. B. Ekanayake, N. Jenkins, K. Liyanage, J. Wu, A. Yokoyama 2. "Smart Grid: Fundamentals of Design and Analysi"s by J. A. Momoh, March 2012, Wiley-IEEE Press 3. "voltage source converters in power systems: Modeling, Control and Applications", by Amirnaseryezdani and Reza, IEEE John Wiley Publications, 2010. 4. "Power switching converters: medium and high power", by Dorinneacsu, CRC Press, Taylor & Francis, 2006. 5. "Solar Photovoltaics", by Chetan Singh Solanki, PHI learning Pvt. Ltd., New Delhi, 2009.

Reference Books:	1. "IEEE-1547-2003: IEEE standard for interconnecting distributed resources with electric power systems", IEEE standards 2003. 2. "IEEE 1547-2: IEEE guide for monitoring, information exchange and distributed resources interconnected electric power systems", IEEE,2007 3. "IEEE 1547-4: IEEE guide for design operation & integration of distributed resources island system with electric power system", IEEE standards, 2011. 4. Consortium for electric reliability technology solutions (CERTS) white paper on integration of distributed energy resources: the CERTS microgrid concept, 2003. 5. "Fuel Cell System", by Lleo J.M.J. Blomen and Michael N. Mugerwa, New Yyork, plenum press, 1993.

Programme Name	B.Tech(Electrical Engineering)	Semester – VIII			
Course Code	**R4EE4109S**	**L**	**T**	**P**	**Credit**
Course Title	**FLEXIBLE AC TRANSMISSION SYSTEMS (FACTS)** **(Program Elective – IV)**	**3**	**0**	**0**	**3**

COURSE OUTCOMES:

Students should be able to

1. Interpret basic concepts of Flexible AC transmission system and their benefits
2. Analyze performance of static shunt compensators and different methods of static shunt compensation
3. Analyze static series compensation techniques and operation of TSSC and SSSC
4. Apply load compensation and voltage regulation in power systems.

COURSE CONTENTS:

Module I	**Introduction**
	Transmission Interconnections, Power flow in AC system, Loading Capability, Power Flow and Dynamic Stability Considerations of a Transmission Interconnection, Relative Importance of controllable Parameters, Basic Types of FACTS system, Advantages of FACTS.
Module II	**Static shunt compensation**
	Significance of shunt compensation, Methods of controllable VAR generation, static Var generator (TCR,TSR,TSC,FC-TCR), Switching converter type Var generators, basic operating principle.
Module III	**Static series compensation**
	Significance of series compensation- Variable impedance type series compensation (only TSSC), Switching converter type series compensation (only SSSC)
Module IV	**Load compensation**
	Significance in load compensation, ideal compensator, Practical considerations, Power factor correction and Voltage Regulation in single phase systems, Approximate reactive power characteristics with example, Load compensator as a voltage regulator, Phase balancing and power factor correction of unsymmetrical loads
Module V	**Static voltage and phase angle regulators**
	Significance of voltage and phase angle regulators- TCVR and TCPAR, Switching converter based voltage and phase angle regulators
Module VI	**Unified Power Flow Controller (UPFC)**
	Basic operating principle of UPFC, Conventional transmission control capabilities

Text Books:	1.“Understanding FACTS: Concepts and Technology of Flexible AC TransmissionSystems”, by N.G. Hingorani and L. Gyugi, Wiley-IEEE Press, 2011. 2. “Reactive power control in Electric Systems,” by Timothy J. E. Miller, Wiley India Edition, 2010.
Reference Books:	1. “FACTS Controllers in Power Transmission & Distribution” by K.R.Padiyar, New age international(P) Ltd 2. “HVDC and FACTS Controller, Applications of Static Converters in Power Systems”, by Vijay K. Sood, Springer

Programme Name	B. Tech. (Electrical Engineering)	Semester –VII			
Course Code	**R4EE4110S**	**L**	**T**	**P**	**Credit**
Course Title	**Electrical Distribution System (Program Elective IV)**	3	-	-	3

COURSE OUTCOMES

Students should be able to:

1. Model Distribution System and its components
2. Configure the distribution loads
3. Analyze the load flow in Distribution system
4. Learn tools for Distribution system analysis

COURSE CONTENTS

Module I	Introduction to Electrical Distribution System
	Structure of Distribution System, Components of Distribution System Substation and Busbar Layouts, Components of Distribution System and Feeder Configurations, Nature of Loads in a Distribution System, Load Allocation in a Distribution System
Module II	**Approximate methods of Distribution System Analysis**
	K Factors and Their Applications, Analysis of Uniformly Distributed, Lumping Loads in Geometric Configurations Rectangular, Lumping Loads in Geometric Configurations Triangular, Impedance of Distribution Lines and Feeders Part I, Series Impedance of Distribution Lines and Feeders Part II,
Module III	**Modelling of Feeders and Transformers for Distribution Systems**
	Models of Distribution Lines and Cables, Modelling of Single-Phase and Three-Phase Transformers, Modelling of Step Voltage Regulators
Module IV	**Modelling of Loads and Distributed generation**
	Load Models in Distribution System , Modelling of Distributed Generation, Applications and Modelling of Capacitor Banks
Module V	**Distribution Load Flow Analysis**
	Load Flow analysis-1: Backward/forward sweep method - Algorithm & Example, Load Flow analysis-1I: Direct approach based methods - Algorithm & Example, Impedance matrix (Z Bus) based method.
Module VI	**Distribution system analysis tools**
	Short-Circuit analysis-I : Short-circuit analysis of radial system, Short-circuit analysis - Example Distribution system analysis tools ; Applications: Feeder reconfiguration, volt-var optimization, load balancing, Distribution system analysis and future smart-grid

Text Books:	1. "Distribution System Modeling and Analysis", W. H. Kresting, CRC Press, New York, 2002. 2. "Electric Distribution System", A. A. Sallam and O. P. Malik, IEEE Press, Piscataway, NJ, 2011.

Reference Books:	1. "A direct approach for distribution system load flow solutions," J. H. Teng, IEEE Trans. on Power Delivery, vol. 18, no. 3, pp. 882–887, 2003. 2. "Power Distribution Automation", Edited by B. Das IET Power and Energy Series, 75, London, 2016. 3. "Distribution system analysis and the future smart grid," R. F. Arritt and R. C. Dugan, IEEE Trans. on Industry Applications, vol. 47, no. 6, pp. 2343-2350, November/ December 2011.