GOVERNMENT COLLEGE OF ENGINEERING, AURANGABAD

(An Autonomous Institute of Government of Maharashtra)

Department of Electrical Engineering

Teaching and Evaluation Scheme

M. TECH. ELECTRICAL (Electrical Power Systems) Full-Time CBCS Pattern

(From 2018-19 onwards)

SEMESTER-I

Sr. No	Course Code	Subject	Scheme of Teaching (Hrs/Week)			Total Credits	Scheme of Evaluation (Marks)					
			L	T	P		Theory			Term Work	Practical/ Viva-voce	Total
							Class Test	TA	ESE			
	THEORY COURSES											
1	EE51001	Computer Aided Power System Analysis	03	0	0	03	20	20	60	-	-	100
2	EE51002	EHV AC Power Systems	03	0	0	03	20	20	60	-	-	100
3	*	Program Elective -I	03	0	0	03	20	20	60	-	-	100
4	*	Program Elective-II	03	0	0	03	20	20	60	-	-	100
5	*	Research Methodology	02	0	0	02	20	20	60	-	-	100
	LABORATORY COURSES/SEMINAR etc.											
6	EE51003	Simulation Laboratory-I	-	-	04	02	-	-	-	25	25	50
7	EE51004	Lab- High Voltage Engineering	-	-	04	02	-	-	-	25	25	50
8		Audit Course	2	-	-	-	-	-	-	-	-	-
		TOTAL	**16**	**0**	**08**	**18**	**100**	**100**	**300**	**50**	**50**	**600**

SEMESTER-II

Sr. No	Course Code	Subject	Scheme of Teaching (Hrs/Week)			Total Credits	Scheme of Evaluation (Marks)					
			L	T	P		Theory			Term Work	Practical/ Viva-voce	Total
							Class Test	TA	ESE			
	THEORY COURSES											
1	EE51005	Power system Dynamics & Stability	03	0		03	20	20	60	-	-	100
2	EE51006	HVDC and FACTS	03	0		03	20	20	60	-	-	100
3	*	Program Elective-III	03	0		03	20	20	60	-	-	100
4	*	Program Elective-IV	03	0		03	20	20	60	-	-	100
5	*	Program Elective-V	03	0		03	20	20	60	-	-	100
	LABORATORY COURSES/SEMINAR etc.											
6	EE51007	Simulation Laboratory-II	-	-	04	02	-	-	-	25	25	50
7	EE51008	Lab-Renewable Energy Technology	-	-	04	02	-	-	-	25	25	50
8	EE51009	Mini Project with Seminar	-	-	04	02	-	-	-	50	50	100
9	#	Internship/ Industrial Training	-	-	-	-	-	-	-	-	-	-
		TOTAL Semester II	**15**	**0**	**12**	**21**	**100**	**100**	**300**	**100**	**100**	**700**
		Total First Year	**31**	**0**	**20**	**39**	**200**	**200**	**600**	**150**	**150**	**1300**

L-Lectures, T-Tutorials, P-Practicals, TA-Teacher Assessment, ESE-End-Semester Examination

SEMESTER III

THEORY COURSES												
Sr. No.	Course Code	Subject	Scheme of Teaching (Hrs/Week)			Total Credits	Scheme of Evaluation (Marks)					
			L	T	P		Theory			Term Work	Practical/ Viva-voce	Total
							Test	TA	ESE			
1	**	Open Elective	03	0	0	03	20	20	60	-	-	100
LABORATORY COURSES/SEMINAR etc.												
1	EE61002	Dissertation-I	-	-	20	10	-	-		50	50	100
		TOTAL Semester III	**03**	**0**	**20**	**13**	**20**	**20**	**60**	**50**	**50**	**200**

SEMESTER-IV

THEORY COURSES												
Sr. No.	Course Code	Subject	Scheme of Teaching (Hrs/Week)			Total Credits	Scheme of Evaluation (Marks)					
			L	T	P		Theory			Term Work	Practical/ Viva-voce	Total
							Test	TA	ESE			
1	EE61003	Dissertation-II	-	-	32	16	-	-	-	100	150	250
		TOTAL SECOND YEAR	**03**	**0**	**52**	**29**	**20**	**20**	**60**	**150**	**200**	**450**
		GRAND TOTAL	**34**	**0**	**72**	**68**	**220**	**220**	**660**	**300**	**350**	**1750**

**** Students can choose online course such as MOOCs/SWAYAM/NPTEL/QEEE etc in place of open elective with prior intimation and approval of department**
 # Internship/Industrial Training Preferably to Power Stations/ Generating Plants Thermal /Hydropower stations: The student has to undergo internship/industrial training of minimum one month after second semester. Student has to give presentation on the same in subsequent semester.

	***List of Program Electives**				
	Program Electives I, II , III , IV and V				
Program Electives	**A**	**B**	**C**	**D**	**E**
Program Elective I	EE 51010 Power System Planning Operation & Control	EE51011 High Voltage Engineering	**EE52010 Fuzzy-Logic & Artificial Neural Networks**	**EE52001 Advanced Power Electronics**	EE51012 Illumination Engineering
Program Elective II	EE51013 Advanced Switchgear Protection	EE51014 Smart Grid Technology	**EE52014 Microcontroller & Its Application**	**EE52002 Electrical Machine Modeling and Analysis**	EE51015 Wind Energy Systems
Program Elective III	EE51016 Power System Transients	EE51017 Life Estimation of Power Equipments	**EE52018 Digital Signal Processing**	**EE52006 Advanced Electrical Drives**	EE51018 Solar Energy Systems
Program Elective IV	EE51019 Restructured Power Systems	EE51020 Power System Reliability	EE51021 Power Quality	**EE52005 Advanced Control Systems**	**EE52019 Optimization Techniques**
Program Elective V	EE51022 Power System Design	EE51023 Engineering Materials	CSXXXXX Internet of Things	**EE52023 Electric Vehicles**	**EE52022 Biomedical Instrumentation**

****Open Elective offered by Electrical Department**

EE61001	**Renewable Energy Technology (Offered by Electrical Engineering Department)**

EE51001: COMPUTER AIDED POWER SYSTEMS ANALYSIS	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 0 Hr/Week Credits : 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description: This is an elective course which covers fault analysis, different power flow methods & state estimation techniques of power systems.

Course Objectives:
The objectives of the course are to:
1. Understand graph theory for power system applications.
2. Develop and solve the positive, negative and zero sequence network for a given system for different faults
3. Formulate the power flow problems using load flow methods.
4. Understand large scale power systems solution techniques.
5. Understand large scale power systems solution techniques

Course Outcomes:
After completing the course, students will able to:

CO1	Determine impedance & admittance matrix of a given system
CO2	Draw the sequence network for a given system
CO3	Estimate Fault currents under different fault conditions
CO4	Determine power flow for a given system
CO5	Apply sparse matrix techniques to solve large power systems

Detailed Syllabus:

Unit 1	**Network Modeling:** System graph, loop, cut set and Incidence matrices, Primitive network and matrix, Formation of various network matrices by singular transformation. Bus Impedance Algorithm: Singular transformation, Direct inspection, Building Block algorithm for bus impedance matrix, Addition of links, addition of branches, (considering mutual coupling), modification of bus impedance matrix for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron's reduction)
Unit 2	**Analysis of symmetrical & unsymmetrical Faults:** Shunt Faults, Shunt Fault Calculations, Series Faults, Sequence Impedances of Transmission Lines, Sequence Capacitance of Transmission Lines, Sequence Impedance of Synchronous and Induction Machines, Transformers, Three Winding Transformers
Unit 3	**Computer Solution of Power Flow Problem:** Solution using Admittance and Impedance Matrix, Comparison of Admittance and Impedance Matrix Techniques. Power-Flow Problem, Gauss-Seidal, Newton - Raphson Methods, Power Flow Studies in System Design and Operation, Decoupled Power Flow Method
Unit 4	**State Estimation:** Method of least squares ,statistics , errors, estimates, test for bad data, structure and formation of Hessian matrix, power system state estimation
Unit 5	**Sparse Matrix techniques for large scale power systems:** Optimal ordering schemes for preserving sparsity, Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bi-factorization and Gauss elimination methods; Repeat solution using Left and Right factors and L and U matrices

Text and Reference Books

1. J. J. Grainger and W.D. Stevenson, *Power System Analysis*, McGraw Hill, 1994
2. G.W. Stagg and A. H. EI-Abiad, *Computer methods in Power System Analysis*, McGraw Hill 1968
3. I.J. Nagrath and D.P. Kothari, *Modern Power System Analysis*, Tata McGraw Hill, 1980
4. G.L.Kusic, *Computer Aided Power Systems Analysis*, Prentice Hall, 1986
5. Pai, M.A., *Computer Techniques in Power System Analysis*, Tata McGraw hill, New Delhi, 2006.
6. P.S.R. Murty, *Power System Operation & control*, Tata McGraw Hill
7. L.K. Khirchmayer, *Economic operation of Power System*, Willey Eastern Ltd.
8. Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., New York.

Teacher's Assessment:

Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problem
3. Quiz
4. MCQ

EE51002: EHV AC POWER SYSTEM			
Teaching Scheme		**Examination Scheme**	
Lectures:	03 Hrs/Week	Test	: 20 Marks
Tutorial:	0 Hr/Week	Teachers Assessment	: 20 Marks
Credits:	03	End Semester Exam	: 60 Marks

Course Description:
This course introduces the concepts of **EHV AC Transmission System** & covers the various aspects of **EHV AC Power System.**

Course Objectives: The objectives of the course are to
1. Understand the basic aspects of A.C. power transmission
2. Learn Reflection and Refraction of Traveling Waves
3. Learn various causes for over-voltages**.**

Course Outcomes:
After completing the course, students will able to:

CO1	Enlist methods of measurement of electrostatic field
CO2	Explain lightning phenomenon and lightning protection.
CO3	Explain the causes of switching surges
CO4	Explain the methods of reactive power control
CO5	Determine magnitude of maximum power angle at voltage stability limit

Detailed Syllabus:

UNIT-1	Basic Aspects of A.C. Power Transmission: line trends and preliminary aspects of A.C. Power Transmission, Power-Handling Capacity and Line Loss, standard transmission voltages, Surface Voltage Gradient on Conductors, Electrostatic Field of EHV Lines. Measurement of Electrostatic Fields. Electromagnetic Interference.
UNIT-2	Traveling Waves and Standing Waves: Line Energization with Trapped - Charge Voltage. Reflection and Refraction of Traveling Waves. Transient Response of Systems with Series and Shunt Lumped Parameters. Principles of Traveling-Wave Protection Lightning & Lightning Protection, Insulation Coordination Based on Lightning
UNIT-3	Over Voltages in EHV Systems: Caused by Switching Operations, Origin of Over Voltages and their Types, Over Voltages Caused by Interruption of Inductive and Capacitive Currents, Ferro-Resonance Over Voltages, Calculation of Switching Surges, Control of Power Frequency Voltages and switching Over Voltages, Power Circle Diagram.
UNIT-4	Reactive Power Flow and Voltage Stability in Power Systems: Steady - State Static Real Power and Reactive Power Stability, Transient Stability, Dynamic Stability. Basic Principles of System Voltage Control. Effect of Transformer Tap Changing in the Post- Disturbance Period, Effect of Generator Excitation Adjustment, Voltage Collapse in EHV Lines, Reactive Power Requirement for Control of Voltage in Long Lines. Voltage Stability
UNIT-5	Power Transfer at Voltage Stability Limit of EHV Lines: Magnitude of Receiving End Voltage at Voltage Stability Limit. Magnitude of Receiving End Voltage During Maximum Power Transfer. Magnitude of Maximum Power Angle at Voltage Stability Limit. Optimal Reactive Power at Voltage Stability Limit

Text and Reference Books:

1. A. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,"Performance, operation & control of EHV power transmission system " , wheeler publications

2. Rakosh Das Begamudre,"Extra high-voltage A.C. transmission Engineering" New Age International Pvt. Ltd.

3. S. Rao, "EHVAC & HVDC Transmission Engineering & Practice" , Khanna Publications

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Assignments
2. MCQ
3. Quiz

***RESEARCH METHODOLOGY	
Teaching Scheme Lectures: 02 Hrs/Week Tutorial: 0 Hrs/Week Credits : 02	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

*** For syllabus refer institute website

EE51003: SIMULATION LABORATORY- I	
Teaching Scheme Practical : 04 Hrs/Week Credits : 02	**Examination Scheme** Term Work : 25 Marks Viva-voce : 25 Marks Total : 50 Marks

Term Work Shall consist of record of minimum eight experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity.

EE51004: LAB HIGH VOLTAGE ENGINEERING	
Teaching Scheme Practical: 04 Hrs/Week Credits: 02	**Examination Scheme** Term Work : 25 Marks Viva-voce : 25 Marks Total : 50 Marks

Course Objectives: The objectives of course are to-

1. To familiarize students to various high voltage generation methods
2. To familiarize students to various high voltage engineering phenomena

Course Outcomes: After completion of this course students will be able to:

COl. Calculate breakdown strength of transformer oil
C02. Calibrate breakdown strength of solid insulating material
C03. Calibrate E.S.V. w.r.t. Sphere gap
C04. Explain HVDC Transmission System

List of the Experiments:

The term work shall consist of record of minimum twelve experiments from the list given below.

Sr. No.	Name of the Experiments
1.	Measurement of dielectric strength of transformer oil
2	Measurement of High A.C. Voltage using sphere gap
3	Measurement of breakdown strength of solid insulating material
4	Impulse voltage test on insulator
5	Power frequency test on insulator
6	Tan δ measurement of insulator
7	Study of Impulse Generator
8	Calibration of Electrostatic Voltmeter using sphere gap
9	Study of HVDC Transmission System
10	A visit to HVDC Terminal Station and report based on it
11	Mapping of electric field lines between two charges using MATLAB or any software
12	Measurement of insulation resistance of cable
13	Plotting φ- q-n pattern for corona discharge using partial discharge detector
14	Travelling wave characteristics with different line terminations using PSCAD or any software.
15	Study of impulse generator using high voltage lab simulator

Term work:

The term work shall consist of submitting a file for minimum twelve experiments. The term work will be assessed by the course coordinator

Viva-Voce Examination:

The Viva-Voce Examination shall comprise of questions based on the term work.

The assessment will be done by two examiners, one will be internal examiner and other will be external examiner appointed by DSB

EE51005: POWER SYSTEM DYNAMICS AND STABILTY	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Sem Exam : 60 Marks

Course description: This is a compulsory course & covers different stability aspects of power systems.

Course Objectives: The objectives of the course are to:

1. Explain the basics of power system stability.
2. Explain different methods to determine the transient stability of power systems.
3. Acquaint the students with small signal stability of power systems.
4. Introduce the concepts of voltage stability.
5. Explain the methods of stability improvement.

Course Outcomes: After completing the course, students will able to:

CO 1	Describe stability conditions of power systems.
CO 2	Apply numerical method to determine stability under various fault conditions.
CO 3	Explain the effect of excitation on small signal stability.
CO 4	Explain the concepts related to voltage stability.
CO 5	Describe various methods of stability enhancement.

Detailed Syllabus:

Unit 1	Power System stability considerations: definitions- classification of stability – rotor angle and voltage stability- synchronous machine representation- classical model – load modeling- concepts- modeling of excitation systems – modeling of prime movers.
Unit 2	Transient stability: Swing equation-equal area criterion-solution of swing equation-Numerical methods-Euler method-Runge-Kutta method-critical clearing time and angle-effect of excitation system and governors-Multi-machine stability –extended equal area criterion- transient energy function approach.
Unit 3	Small signal stability: State space representation – Eigen values- modal matrices-small signal stability of single machine infinite bus system – synchronous machine classical model representation-effect of field circuit dynamics-effect of excitation system-small signal stability of multi machine system.
Unit 4	Voltage stability: Basic concepts related to voltage stability, voltage collapse, voltage stability analysis, prevention of voltage collapse
Unit 5	Methods of improving stability: Transient stability enhancement – high speed fault clearing – steam turbine fast valuing -high speed excitation systems- Fundamentals and performance of Power System Stabilizer – Multi band PSS – Three dimensional PSS – Location & dispatch of reactive power by VAR sources.

Text and Reference Books

1. P. M. Anderson and A.A. Fouad, *Power System Control and Stability*, IOWA state university press, USA
2. P.Kunder, *Power System stability and Control*, McGraw Hill, New York
3. P. Sauer and M.A. PAI, *Power system dynamics and stability*, Prentice Hall, 1997
4. K.R.Padiyar, *Power System Dynamics, Stability and Control*, Edition II Interline Publishers, Bangalore, 1996
5. Van Cutsem, T. and Vournas, C.,*Voltage Stability of Electric Power Systems*, Kluwer Academic Publishers, 1998.
6. Taylor.C.W, *Power System Voltage Stability*, McGraw-Hill, 1994.
7. P.S.R. Murty, *Power System Operation & control*, Tata McGraw Hill
8. Allen J. Wood, and Bruce F. Wollenberg, "Power Generation, Operation and Control", John Wiley & Sons, Inc., New York.

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE51006: HVDC and FACTS	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Sem Exam : 60 Marks

Course Objectives:

The objectives of the course are to-

1. Understand the configuration and working of HVDC systems
2. Analyze harmonics and to understand the different protection schemes of HVDC systems
3. Understand operating principle of FACTS devices
4. Analyze the operation of shunt, series and combined compensators
5. Impart knowledge on application of shunt, series and combined compensator to improve AC transmission.

Course Outcomes: After completing the course, students will able to:

CO1	Review the HVDC transmission systems, design the HVDC converters
CO2	Identify the suitable methods to review and reduce the harmonics in HVDC system
CO3	Analyze the reactive power compensation in AC transmission systems
CO4	Analyze suitable compensation for AC transmission systems
CO5	Apply the concepts to electrical power transmission systems

Detailed Syllabus:

UNIT-1	**Introduction:** Comparison of AC and DC transmission systems, application of DC transmission, types of DC links, layout of a HVDC converter station. HVDC converters, pulse number, analysis of Gratez circuit with and without overlap, converter bridge characteristics, equivalent circuits or rectifier and inverter configurations of twelve pulse converters
UNIT-2	**Converter & HVDC System Control:** Principles of DC Link Control — Converters Control Characteristics — system control hierarchy, firing angle control, current and extinction angle control, starting and stopping of DC link.
UNIT-3	**Harmonics, Filters and Reactive Power Control:** Introduction, generation of harmonics, AC and DC filters. Reactive Power Requirements in steady state, sources of reactive power, static VAR systems. **Power Flow Analysis in AC/DC Systems:** Modeling of DC/AC converters, Controller Equations-Solutions of AC/DC load flow —Simultaneous method-Sequential method.
UNIT-4	**Introduction to FACTS:** Flow of power in AC parallel paths and meshed systems, basic types of FACTS controllers, brief description and definitions of FACTS controllers. **Static Shunt Compensators:** Objectives of shunt compensation, methods of controllable VAR generation, static VAR compensators, SVC and STATCOM, comparison between SVC and STATCOM.
UNIT-5	**Static Series Compensators** : Objectives of series compensation, variable impedance type-thruster switched series capacitors (TCSC), and switching converter type series compensators, static series synchronous compensator (SSSC)-power angle characteristics-basic operating control schemes. **Combined Compensators:** Introduction, unified power flow controller (UPFC), basic operating principle, independent real and reactive power flow controller, control structure.

Text Books:

1. HVDC Transmission, S. Kamakshaiah, V. Kamaraju, The Mc-Graw Hill
2. HVDC power Transmission systems by K.R. Padiyar, Wiley Eastern Limited
3. Understanding of FACTS by N.G. Hingorani & L. Gyugyi, IEEE Press.
4. Flexible AC Transmission Systems (FACTS) Young Huasong & Alian T. hons, The Institution of Electrical Engineers, IEE Power and Energy Series 30.

Teacher Assessment:

Assessments will be based on any two following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

EE51007: Simulation Laboratory _II		
Teaching Scheme	**Examination Scheme**	
Practical: 04 Hrs/Week	Term Work	: 25 Marks
Credits: 02	Viva-voce	: 25 Marks
	Total	: 50 Marks

Term Work Shall consist of record of minimum eight experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity

EE51008: LAB RENEWABLE ENERGY TECHNOLOGY	
Teaching Scheme Practical : 04 Hrs/Week Credits : 02	**Examination Scheme** Term Work : 25 Marks Viva-voce : 25 Marks Total : 50 Marks

Term Work shall consist of record of minimum twelve experiment/assignment using engineering computation software such as MATLAB, PSCAD, ETAP with moderate to high complexity.

Following is the list of experiments is just a guide line (Hardware and Software base)

1. Plot I-V and P-V characteristics of single Solar PV Module with radiation and temperature changing effects
2. Plot I-V and P-V characteristics with series and parallel combination of Solar PV modules.
3. Study effect of shading on output power of Solar PV Module
4. Measure output power of solar PV system with effect of tilt angle
5. Plot charging and discharging characteristics of battery
6. Measure performance parameters of DC load system with and without battery (with variable rated capacity system) in Solar PV stand-alone system.
7. Measure performance parameters of AC load system with and without battery in Solar stand-alone PV system.
8. Measure performance parameters of Combine AC and DC load system with and without battery in Solar stand-alone PV system.
9. Study of biomass plant
10. Identify and measure the parameters of a solar PV Module at Specific location
11. Measure the spectral response of a solar cell and Calculate quantum efficiency
12. Study solar resource assessment station and record associated parameters
13. Simulate characteristics of fuel cell using electrical software
14. Simulate operation of wind turbine and measure associated parameters using electrical software
15. Study of Tri-brid system

EE52009: MINI PROJECT WITH SEMINAR	
Teaching Scheme Practical : 04 Hrs/Week Credits : 02	**Examination Scheme** Term Work : 50 Marks Viva-voce : 50 Marks Total : 100 Marks

Prerequisite: Not applicable

Course Description: The student shall collect, review, compile, comprehend, present research literature and identify the problem for the dissertation in the field of Electrical Power System. Student will present seminar on work done by them on any topic of the recent technology. The seminar may include some simulation carried out by the student.

Course Objectives:

- To understand the "Product Development Process" including budgeting through Mini Project
- To plan for various activities of the project and distribute the work amongst team members
- To inculcate electronic hardware implementation skills
- To develop student's abilities to transmit technical information clearly and test the same by delivery of Seminar based on the Mini Project
- To understand the importance of document design by compiling Technical Report on the Mini Project work carried out

Course Outcomes: At the end of course students will be able to **:**

- Understand, plan and execute a Mini Project
- Implement electronic hardware by learning PCB artwork design, soldering techniques, testing, and troubleshooting etc.
- Prepare a technical report based on the Mini project
- Deliver technical seminar based on the Mini Project work carried out

Course Contents:

- Mini Project Work should be carried out in the Laboratory.
- Data sheets may be referred, well known project designs ideas can be necessarily adapted from recent issues of electronic design magazines
- Hardware/Software based projects can be designed
  Following areas are just a guideline
- Instrumentation and Control Systems
- Power Electronics
- Embedded Systems/ Microcontroller based projects should preferably use Microchip PIC controllers/ATmega controller/AVR microcontrollers
- Power system based
- Demonstration and Group presentations. Logbook for all these activities shall be maintained and shall be produced at the time of examination
- A project report with following contents shall be prepared:
- Specifications/Block diagram/Circuit diagram/Selection of components, calculations
- Simulation results
- Layout versus schematic verification report
- Testing procedures/Test results Conclusion
- References

Term Work:

The Mini Project with Seminar shall consist of collection of literature from a chosen field of Electrical Engineering from various sources such as refereed journals, proceedings of national international conferences, PG/PhD theses etc. Based on the literature survey, case studies, data collection, surveys, pilot studies, mathematical/analytical modeling, etc., as necessary the candidate shall define the problem for the dissertation.

The candidate shall prepare a technical report in a prescribed format and present before a panel of examiners consisting of guide and at least one faculty member of the department.

Viva-Voce Examination: It consists of two parts.

Part-I: Mid-Term Evaluation for 25 Marks: A mid-term evaluations for 25 marks out of 50 marks shall be done as per the schedule given in the institute academic calendar. Student should prepare a power point presentation and present before the panel of examiners and class students and should be able to answer questions asked by the panel of examiners and class students. Panel of examiner consists of guide as internal examiner and one faculty members appointed by the DCoE as external examiners. The panel of examiner will assess the contents and presentation and give the suggestions, if any and assigns the marks out of 10. In this phase student is expected to collect and present substantial literature.

Part-II: End Semester Evaluation for 25 Marks: Student should prepare technical report in prescribed format duly incorporating suggestions of Part-I and present power point presentation before the panel of examiners and class students. The student should be able to answer the questions asked. The panel of examiner will assess the seminar contents and seminar presentation and assigns the marks out of 25. In this phase the students is expected to define the problem for dissertation through further literature survey, case studies, data collection, surveys, pilot studies, mathematical/analytical modeling, etc., as necessary.

Syllabus of Program Electives I, II, III, IV and V

EE51010: POWER SYSTEM PLANNING, OPERATION & CONTROL (Program Elective I)	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End-Semester Examination : 60 Marks

Course Description: This is an elective course which covers aspects planning & operation of power systems.

Course Objectives: The objectives of the course are to introduce & explain:
1. Planning & forecasting of loads
2. Methods to determine transmission loss
3. Hydro-Thermal co-ordination
4. Load frequency & reactive power control
5. Operation & control of interconnected power systems

Course Outcomes: After completing the course, students will able to:

CO1	Explain different planning & load forecasting methods.
CO2	Determine transmission loss using B-coefficients.
CO3	Explain Hydro-Thermal co-ordination.
CO4	Explain load frequency & reactive power control using various methods.
CO5	Explain functions of SCADA system in operation & control of interconnected power systems.

Detailed Syllabus:

Unit 1	Objectives of planning – Long and short term planning- Load forecasting – characteristics of loads – methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting
Unit 2	System Interconnection and Integrated Operation, Optimal Generation Scheduling, Representation of Transmission Loss by B-coefficients, Derivation of Transmission Loss formula. Representation of Transmission Loss by Power Flow equations, Optimal Load Flow solution. Inequality constraints
Unit 3	Hydro-thermal co-ordination-Hydroelectric plant models –short term hydrothermal scheduling problem - gradient approach – Hydro units in series - pumped storage hydro plants-hydro-scheduling using Dynamic programming and linear programming
Unit 4	Automatic Generation and Voltage Control, Load Frequency Control (Single Area and Two Area Load Case) and Economic Dispatch Control, Basic Concepts of Load Dispatch Centers, Functions of Energy Management Centers, Emergency and Restoration of Power System, Automatic Voltage Control, Load Frequency Control with GRCS, Digital LF Controllers, Decentralized Control. Reactive Power Control, Methods for Reactive Power Control
Unit 5	Operation and Control of Interconnected Power System, Functions of SCADA System, Common Features to All SCADA System, Alarm Function, Integration of Measurement, Control and Protection Functions by SCADA System, SCADA Configuration, Distribution Automation and Control

Text and Reference Books

1. R.N. Sullivan, “Power System Planning” , Tata McGraw Hill
2. A.S. Pabla, “Electrical Power System Planning”, Mc Millan India Ltd.
3. L.K. Khirchmayer, “Economic operation of Power System”, Willey Eastern Ltd.
4. P.S.R. Murty, “Power System Operation & control”, Tata McGraw Hill
5. I. J. Nagrath, D.P.Kothari, “Modern Power System Analysis”, Tata McGraw Hill
6. S. Rao, “EHV-AC, HVDC Transmission & Distribution Engineering”, Khanna Publishers
7. Allen J. Wood, and Bruce F. Wollenberg, “Power Generation, Operation and Control”, John Wiley &Sons, Inc., New York.

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE51011 : HIGH VOLTAGE ENGINEERING (Program Elective- I)	
Teaching Scheme Lectures: 03 Hrs/Week Tutorial: 0Hrs/Week Credits: 03	**Examination Scheme** Test : 20Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description:

This course introduces the concepts of High Voltage Engineering The course contains the basic breakdown theories related to various insulating materials and covers the various aspects of overvoltages generation and insulation coordination.

Course Objectives: The objectives of the course are to

1. Develop an understanding of breakdown phenomenon in case of solid, liquid and gaseous insulating medium
2. Develop an understanding with various methods of generation of high voltages
3. Develop an understanding with various methods of measurement of high voltages
4. Develop an understanding of over voltage phenomenon & concepts of insulation coordination
5. Develop an understanding of importance of testing of power apparatus

Course Outcomes: After completing the course, students will able to:

CO1	Calculate breakdown strength of various insulating materials for power system applications
CO2	Describe the breakdown phenomenon in case of various insulating materials
CO3	Explain the concepts of generation of high voltages & currents
CO4	Explain the causes and protection from over-voltages and of insulation coordination
CO5	Explain the direct and indirect testing methods

Detailed Syllabus:

UNIT-1	Conduction & Break Down in Gases: Ionization Process & Current Growth, Townsends Criterion for Break Down, Determination of Alpha & Gamma, Streamer Theory of Break Down in Gases, Paschen’s Law, Breakdown in Non-Uniform Field & Corona Discharge. Conduction & Break Down in Pure Liquid & Commercial Liquid--cavitation mechanism, suspended particle mechanism etc.; Breakdown in Solid Dielectrics-ntrinsic, electromechanical, thermal breakdown etc.
UNIT-2	Generation of High Voltage & Currents: Generation of High D. C. Voltages: voltage doubler, voltage multiplier, electrostatic machines etc.; Generation of High Alternating Voltages: cascade circuits, resonating circuits etc. Generation of transient voltages: Single stage and multistage impulse generator circuits, tripping and synchronization of impulse generator; Generation of switching surge voltages; Generation of Impulse Currents
UNIT-3	Measurement of High Voltages & Currents: Measurement of High Direct Current Voltages, High Alternating Voltages & Impulse Voltages- use of potential dividers, gaps and other methods of measurement; Measurement of High Direct Currents, High Alternating Currents & High Impulse Currents
UNIT-4	Over Voltage Phenomenon & Insulation Coordination: Natural Causes for Over Voltages, Lightning Phenomenon, Over Voltages Due to Switching Surges, System Faults & Other Abnormal Conditions, Principles of Insulation Coordination on High Voltage & Extra High Voltage Power Systems, concept of statistical factor of safety, risk of failure
UNIT-5	High Voltage Testing of Power Apparatus: High voltage testing of bushings, transformers, cables etc. Non-destructive insulation test techniques: High voltage dielectric loss measurements, discharge measurements

Text and Reference Books:

1. M. S. Naidu , V. Kamaraju, "High Voltage Engineering" , Tata McGraw –Hill publications
2. E. kuffel, W.S. Zaengl, J. Kuffel, "High Voltage Engineering fundamentals", Butterworth – Heinemann publishers
3. D. kind, K. Feser, "High Voltage Test Techniques", Vieweg/ SBA publications
4. M. Khalifa, "High Voltage Engineering- Theory & Practices", Dekker publications

Teacher's Assessment: Teachers Assessment of 20 marks is based on attendance of the student and one of the / or combination of few of following.

1. Assignments
2. MCQ
3. Quiz

EE52010 : FUZZY LOGIC AND ARTIFICIAL NEURAL NETWORKS (Program Elective I)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 0 Hrs/Week	Teachers' Assessment	: 20 Marks
Total Credits	: 3	End -Semester Exam	: 60 Marks

Course Description: - This course introduces students to the fundamental knowledge, theories and applications of fuzzy logic and neural networks. It gives the knowledge of principles of fuzzy sets and fuzzy logic, fuzzy inference and control. It also gives students an understanding of the structures and learning process of a neural network. Topics covered are: fuzzy set theory, fuzzy arithmetic and fuzzy logic operations, fuzzy functions and fuzzy relations, fuzzy logic control, basic concepts of neural networks, single-layer and multi-layer Perceptrons (MLP), self-organizing maps and neural network training.

Course objectives: -The objectives of the course are to

1. Introduce to basic concept of artificial neural network
2. Introduce to various neural network models and their learning and training
3. Introduce to basic concept of artificial neural network
4. Introduce to design of fuzzy logic system
5. Explain applications of fuzzy logic system and neural network

Unit wise Course Outcomes expected: Students will be able to

CO1. Construct simple neural network
CO2. Compare various models of neural network
CO3. Develop fuzzy logic system
CO4. Apply fuzzy logic system to any application
CO5. Apply neural network system to any application

Detailed Syllabus:

UNIT-I	**Artificial neural network:** Introduction, Neuron Physiology, Artificial Neurons, and Artificial Neural Networks supervised Learning, Early Learning Models, and Features of Artificial Neural Networks.
UNIT-II	**Neural Network Model:** Vector and Matrix Notation, Neural network model architecture, Back propagation, Recurrent Neural Network, Elman Back propagation Neural Network.
UNIT-III	**Fuzzy Logic Systems:** Introduction, Foundation of Fuzzy Systems, Representing Fuzzy Elements, Basic Terms and Operations, Properties of Fuzzy Sets, Fuzzification, Arithmetic Operations of Fuzzy Numbers, The alpha cut method, The extension method , Linguistic Descriptions and their Analytical Forms, Fuzzy Linguistic Descriptions, Fuzzy Relation Inferences, Fuzzy Implication and Algorithms, Defuzzification Methods, Centre of Area Defuzzification, Centre of Sums Defuzzification
UNIT-IV	**Application of neural network :**Application of neural network to various system at least three such as power system etc.
UNIT-V	**Application of fuzzy logic to power system:** Application of fuzzy logic to various system at least three such as power system etc.

Text Books:

1. N. P. Padhy, "Artificial Intelligence and Intelligent Systems", OXFORD University Press, New Delhi, 2005
2. Stamations V. Kartalopoulos, "Understanding Neural Networks and Fuzzy Logic: Basic concepts and Applications", PHI, New Delhi, 2002.
3. Kevin Warwick, Arthur Ekwue and Raj Aggarwal, "Artificial Intelligence Techniques in Power Systems", IEE Power Engineering Series, UK, 1997.
4. Springer Berlin Heidelberg, "Intelligent Systems and Signal Processing in Power Engineering", New York

1. Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

2. Teacher's Assessment: Teachers Assessment of 20 marks is based on one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

EE52001 : ADVANCED POWER ELECTRONICS (Program Elective –I)	
Teaching Scheme Lectures: 03 Hrs/Week Tutorial: 0 Hrs/Week Credits: 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam :60 Marks

Course description:
Advanced Power Electronics is a one-semester course. It is an advance course related to power electronics.

Course Objectives:
The objectives of the course are to-
1. Introduce advanced power semiconductor devices
2. Understand operation of DC to DC converters
3. Study and analyze DC-AC converters
4. Study and analyze AC-AC converters
5. Study power supplies and protection circuits

Course Outcomes:
After completing the course, students will able to:

CO1	Describe structure, characteristics, and applications of advanced power semiconductor devices
CO2	Explain and analyze DC-DC converters
CO3	Explain and analyze DC-AC converters and various control techniques
CO4	Explain and analyze AC-AC converters
CO5	Discuss types of power supplies, protection circuits and thermal modeling

Detailed Syllabus:

UNIT-1	Power Semiconductor Devices: Structure, working principle, V-I characteristics, switching characteristics and protection circuits of Thyristors, Triac, GTOs, BJT, Power MOSFETS, SIT, IGBT, MCT, IGCT, PIC
UNIT-2	Thyristor converters: Single phase and three phase converter, dual converter, converter control, EMI and line power quality problems, phase-controlled cyclo-converters, control of cyclo-converters, matrix converters, high frequency cyclo-converter
UNIT-3	DC-DC converter: Switching mode regulators, diode rectifier fed boost converter, chopper circuit diagram, static switches, AC Switches, DC switches, solid state relays, design of static switches
UNIT-4	Inverters: PWM inverters, resonant pulse inverters, series and parallel resonant inverters, Voltage control of resonant inverters, Class E resonant inverter and rectifier, zero current and zero voltage switching resonant converters, resonant DC link inverters, multilevel inverters, diode clamped multilevel inverters, flying capacitor multilevel inverters, cascaded multilevel inverters, applications and features of multilevel inverters, DC link capacitors voltage balancing
UNIT-5	Power supplies: DC power supplies, AC power supplies, Multistage converters, control circuits, magnetic design consideration, UPS

Text Books:

1. M. H. Rashid, “Power Electronics”, PHI publication
2. B.K. Bose, “Power Electronics and AC Drives”, Prentice Hall, 1986
3. Andrzej M. Trzynadlowski, “Introduction to Modern Power Electronics”, Wyley

Teachers' Assessment:

Assessments will be based on any one or two following components -

1. Assignment
2. MCQ
3. PPT
4. Surprise Test

EE51012: Illumination Engineering (Program Elective-I)	
Teaching Scheme Lectures: 03 Hrs/Week Tutorial: 0 Hrs/Week Credits: 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description:

Illumination Engineering is a one-semester course this student can opt this course as professional elective. It is the fundamental course related to Power System Engineering.

Course Objective:

The objectives of the course are to

1. To explain how light bulbs can transfer energy and the concepts behind different light bulb technologies, and to use ideas about reflection to design a flood light reflector.
2. To evaluate the impact of different technologies on society and different technological approaches to a challenge.
3. To conduct cost benefit analysis and evaluate different solutions using set criteria.
4. Students will be able to compare the relative proportions of light and heat released by different types of bulbs.
5. To design lighting scheme for indoor and outdoor

Course Outcomes: After completing the course, students will be able to:

CO1	Identify the criteria for the selection of lamps and lighting systems for an indoor or outdoor space;
CO2	Carry out field survey for the lighting conditions of a project site; .
CO3	Perform calculations on photometric performance of light sources and luminaires for lighting design;
CO4	Examine daylight in buildings and its effect on lighting design;Evaluate different types of lighting designs and applications , Design indoor and outdoor lighting systems.
CO5	Enlist state of the art illumination systems.

Detailed Syllabus:

Unit 1	**Lighting in Human Life:** Radiation, color, eye & vision; different entities of illuminating systems; Light sources: daylight, incandescent, electric discharge, fluorescent, arc lamps and lasers; Luminaries , time luminance, Good and bad effects of lighting & perfect level of illumination, physics of generation of light, Properties of light, Quantification & Measurement of Light, lighting for displays and signaling- neon signs, LED-LCD displays beacons and lighting for surveillance.
Unit 2	**Electrical Control of Light Sources:** Environment and glare., lighting for displays and signaling- neon signs, LED-LCD displays beacons and lighting for surveillance Types of Luminaries, factors to be considered for designing luminaries Types of lighting fixtures. Optical control schemes, design procedure of reflecting and refracting type of luminaries. Lighting Fixture types, use of reflectors and refractors, physical protection of lighting fixtures, types of lightingfixtures according to installation type, types of lighting fixtures according to photometric usages, luminaries standard (IEC-598-Part I).
Unit 3	**Light Sources:** Lamp materials: Filament, glass, ceramics, gases, phosphors and other metals and non-metals. design considerations and characteristics of Discharge Lamps low and high mercury and Sodium vapour lamps,Fluorescent Lamp, Compact Fluorescent Lamp (CFL) High Vapour Pressure discharge lamps - Mercury Vapour lamp, Sodium Vapour lamp, Metal halide Lamps, Solid Sodium Argon Neon lamps, SOX lamps, Electro luminescent lamps.
Unit 4	**Illumination scheme** Factors to be considered for design of indoor illumination scheme Indoor illumination design for following installations Residential lighting scheme , Hospitals Industrial lighting ,Special purpose lighting schemes Theatre lighting ,swimming pool lighting
Unit 5	**Design of lighting scheme**

	Factors to be considered for design of outdoor illumination scheme ,Outdoor Lighting Design: Road classifications according to BIS, pole arrangement, terminology, lamp and luminaire selection, point by point method, problems on point by point method. Outdoor illumination design for following installations Road lighting Flood lighting ,LED luminary designs ,Intelligent LED fixtures

Text and Reference Books:

1. H. S. Mamak, “Book on Lighting”, Publisher International lighting Academy
2. Joseph B. Murdoch, “Illumination Engineering from Edison’s Lamp to Lasers” Publisher - York, PA : Visions Communications
3. M. A. Cayless, A. M. Marsden, “Lamps and Lighting”, Publisher-Butterworth-Heinemann(ISBN 978-0-415-50308-2)
4. Designing with light: Lighting Handbook., Anil Valia; Lighting System 2002
5. “BIS, IEC Standards for Lamps, Lighting Fixtures and Lighting”, Manak Bhavan, New Delhi
6.. D. C. Pritchard, “Lighting”, 4th Edition, Longman Scientific and Technical, ISBN 0-582- 23422-

Teacher’s Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

Special Instructions if any: Nil

EE51013: ADVANCED SWITCHGEAR AND PROTECTION (Program Elective II)	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits : 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description:

This course is a one-semester course as an elective to fourth year Electrical Engineering students. It is the advance course related to power system protection.

Course Objective:

The objectives of the course are to introduce & explain:

1. Arc interruption theories & switching transients under different switching operations
2. Design aspects & testing of circuit breakers
3. Principle & operation of different static relays.
4. Aspects of digital protection.
5. Concepts of GIS & embedded protection of power systems.

Course Outcomes: After completing the course, students will be able to:

CO1	Explain Arc Interruption theories & switching transients under different switching operations
CO2	Explain contact design of vacuum circuit breakers & standard testing of circuit breakers
CO3	Explain principle & operation of different static relays
CO4	Explain functional diagram & different aspects of numerical relaying
CO5	Describe concepts of GIS & embedded protection of power systems

Detailed Syllabus:

Unit 1	Arc Interruption Theories: The details study of – Slepian's theory, Prince's theory's, Cassies theory's, Mayr's theory, Browne's combined theory Switching Transients: Closing of a line, Reclosing of a line, Interruption of small capacitive currents, Interruption of Inductive load currents, Current chopping, Interruption of short line fault, Traveling waves : Velocity and characteristic impedance, Energy contents of Traveling waves, Reflection and Refraction of Traveling waves
Unit 2	Design of Circuit Breakers: Standards of Circuit Breakers, Design aspect of Vacuum Interrupters, contact shape and size, contact material, contact travel. Time-travel characteristics of moving contact of Vacuum circuit breaker, Contact Pressure, Contact Erosion Testing of Circuit Breakers :Introduction, Classification, Description of a simple testing station, Equipment used in the station, Testing procedure, Direct testing, Test report, Indirect testing
Unit 3	Static Relays: (i) Static Over Current Relays: Instantaneous over current relay, definite time over current relay, inverse-time over current relay, directional over current relay. (ii) Static Differential Relays: Differential relay scheme, single phase static comparator, poly phase differential protection. Differential protection for generator and transformer. (i) Static Distance Relays: Impedance relay, reactance relay and mho relay using amplitude and phase comparators. Protection of EHV lines against short circuit and over voltages. Distance and carrier aided schemes.
Unit 4	Digital Protection: Philosophy of Numerical relaying: Characteristics - Functional Diagrams - Architecture and algorithms -Anti –aliasing Filters, sampling, Measurements principles using Fourier and other algorithms and its application for implementation of various numerical relays. SCADA based protection systems
Unit 5	**a)** Design and Construction of GIS Station Introduction - Rating of GIS components - Design Features - Estimation of different types of Electrical Stresses -Design Aspects of GIS components - Insulation Design for Components -Insulation Design for GIS - Thermal Considerations in the Design of GIS

	- Effect of very Fast Transient Over-voltages (VFTO) on the GIS design - Insulation Coordination systems – Gas handling and Monitoring System Design. **b)** Embedded protection systems: General architecture & Essential requirements of an embedded protection system – metering, protection, automation and control modules; model/component based approach in designing an embedded system

Text and Reference Books

1. B. Ravindranath , M. Chander, "Power system protection and switchgear", New Age International Ltd.
2. Y.G.Paithankar& Marcel Dekker, "Transmission Network Protection"
3. Y.G. Paithankar& S. R. BhidePrentis, "Fundamentals of Power System Protection" PHI
4. T.S.Madhav Rao, "Power System Protection Static Relays with Microprocessor Applications" TMH 2nd Edition
5. C. Russell, "Switchgear : The art and science of Protective Relaying", Mason Wiley Eastern Ltd.
6. L. P. Sing, "Digital Protection".
7. Handbook of Switchgears, Bharath Heavy Electricals.
8. Dr. Khedkar M. K., Dr. Dhole G. M., "A Textbook of Electric Power Distribution Automation", University Science Press, Delhi, Laxmi Publications, 2010.
9. Arun G. Phadke, James S. Thorp, "Computer Relaying for Power Systems", Marcel Dekker, Inc.
10. Wright. A. and Christopoulos.C, "Electrical Power System Protection", Chapman & Hall, 1993.

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE 51014 : SMART GRID TECHNOLOGY (Program Elective II)	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hrs/Week Credits : 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End-Semester Examination : 60 Marks

Course Description: This course introduces the concepts of smart grid technology & covers the various aspects of smart grid.

Course Objectives:

The objectives of the course are to:

1. Understand concept of smart grid and its advantages over conventional grid
2. Know smart metering techniques
3. Learn wide area measurement techniques
4. Understand concept of power quality issues in Smart grid
5. Appreciate problems associated with integration of distributed generation & its solution through smart grid

Course Outcomes:

After completing the course, students will able to:

CO1	Differentiate between smart grid & conventional grid
CO2	Explain smart grid technologies
CO3	Explain the concept of micro grid & issues of micro grid interconnection
CO4	Identify the power quality issues in Smart grid
CO5	Explain different Communication Technology for Smart Grid

Detailed Syllabus:

Unit 1	Introduction to Smart Grid**:** Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid. CDM opportunities in Smart Grid
Unit 2	Smart Grid Technologies: Part 1:Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers. Part 2: Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit
Unit 3	Micro grids and Distributed Energy Resources: Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, Thin film solar Cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources.
Unit 4	Power Quality Management in Smart Grid: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.
Unit 5	Information and Communication Technology for Smart Grid: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Basics of CLOUD Computing & Cyber Security for Smart Grid. Broadband over Power line (BPL). IP based protocols.

Text and Reference Books

1. Ali Keyhani, Mohammad N. Marwali, Min Dai "Integration of Green and Renewable Energy in Electric Power Systems", Wiley
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press
3. JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, "Smart Grid: Technology and Applications", Wiley
4. Jean Claude Sabonnadiere, NouredineHadjsaid, "Smart Grids", Wiley Blackwell
5. Tony Flick and Justin Morehouse, "Securing the Smart Grid", Elsevier Inc. (ISBN: 978-1-59749-570-7)

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE 52014: MICROCONTROLLERS & ITS APPLICATIONS (Program Elective II)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 00 Hrs/Week Credits : 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description: The purpose of this course is to teach students the fundamentals of microprocessor and microcontroller systems. The student will be able to incorporate these concepts into their electronic designs for other courses where control can be achieved via a microprocessor/controller implementation.

Prerequisites:
Digital Electronics

Course Objectives:
The objectives of the course are to

1. Explain the architecture of microprocessor 8086 and micro controller 8051.
2. Explain the assembly language program for microprocessor 8086.
3. Explain the assembly language program for micro controller 8051.
4. Explain the interfacing of peripheral with microprocessor 8086.
5. Explain the interfacing of peripheral with micro controller 8051.

Course Outcomes:
After completing the course, students will able to:

CO1	Describe the architecture of microprocessor 8086 and micro controller 8051 and its peripheral devices.
CO2	Interface input output devices to micro processor 8086.
CO3	Write assembly language program in 8086 for various applications.
CO4	Write assembly language program in microcontroller 8051 for various application.
CO5	Interface the input output devices to micro controller 8051.

Detailed Syllabus:

Unit 1	**Advanced Microprocessors:** Architecture Of Typical 16 Bit Microprocessor(Intel 8086), Memory Address Space And Data Organization, Segment Registers And Memory Organization, Addressing Modes,8086 Configurations, Minimum Mode, Maximum Mode, Comparison of 8086 And 8088, Bus Interface, Interrupts and Interrupt Priority Management.
Unit 2	**Programming 8086:** Instruction Set, Assembly Language Programming, Input/ Output Operations, Interfacing Of Peripheral Devices Like 8255, 8259, LED etc.
Unit 3	**Multiprocessor System:** Queue Status And Lock Facility Of 8086 Based Multiprocessor System, 8087 Coprocessor, Concept, Architecture, Instruction Set And Programming.
Unit 4	**Microcontrollers:** Introduction, Evolution, Architecture, Comparison With Microprocessor, Selection Of A Microcontroller, MCS 51 Family, 8051 Architecture, I/O Ports And Memory Organization Addressing Modes, Instruction Set, Interrupts, Real World Interfacing. Overview of Atmel Microcontrollers 89CXX.
Unit 5	**Application of Microcontrollers and its interfacing:** Solenoids- Relay control and clamping pick/hold heaters, LED, LCD, DAC, Actuators. Motors-i) Stepper Motors- bipolar and unipolar operation, half stepping and micro-stepping, stepper motor driver circuit ii) DC Motors- driving dc motors, BLDC motor and its driving, DC motor controller Case Studies: Case study of 8051 based systems like Numerical Protection relays, Intelligent Transformer, Intelligent Switchgear, High efficiency Induction Motors, Electronic speed governors, Auto synchronizing unit.

Text Books:

1. B Ram, "Fundamentals of Microprocessors and Microcomputers", DhanpatRai and Sons, New Delhi, ivthEdition.
2. R.A.Gaonkar, "Microprocessor Architecture Programming and Applications with 8085",Penram
3. Badri Ram, "Advanced Microprocessor and interfacing", Tata McGraw Hill, New Delhi.

Reference Books:

1. MykePredko, "Programming and customizing the 8051 Microcontroller", Tata McGraw Hill, New Delhi.
2. Barry B Brey, "The Intel Microprocessor 8086 to Pentium architecture programming and interfacing", Tata McGraw Hill, New Delhi.
3. M.A. Mazidi&G.M. Mazidi," The 8051 Microcontroller and Embedded System ",Pearson education, 3rd Indian reprint.
4. Ajay Deshmukh, "Microcontrollers", Tata McGraw Hill, New Delhi.
5. Embedded Microcontroller Intel Manual
6. Intel Data Handbook for MCS96 Family
7. Kenneth Ayala, 8051 Microcontroller, Pen ram international, IInd edition
8. Online reference www.microchip.com

Teacher's Assessment:

Teachers Assessment of 20 marks is based on one of the / or combination of few of following-

1. Mini projects.
2. PPT presentation.
3. Assignment based on programming of microcontroller for different applications.

EE52002: ELECTRICAL MACHINE MODELING AND ANALYSIS (Program Elective II)	
Teaching Scheme	**Examination Scheme**
Lectures : 03 Hrs/Week	Test : 20 Marks
Tutorials : 0 Hrs/Week	Teachers Assessment : 20 Marks
Credits : 03	End Semester Exam : 60 Marks

Course Description:

Electrical Machines modeling and Analysis is a one-semester course. The student can opt this course as professional elective.

Course Objective:

The objectives of the course are to master the various fundamentals, machine design, machine modeling of various types of electrical machines. This will help you to gain knowledge and to do research in the area of electrical machine modeling.

The main objective of the course is to:

1. Know the concepts of generalized theory of electrical machines.
2. Model and analysis the electrical machines with voltage, and torque equations.
3. Known the steady state and transient behavior of the electrical machines.
4. Understand the dynamic behavior of the DC/AC, special machines machines.
5. Learn the issues affecting the behavior of different types machines such as sudden application of loads, short circuit etc.

Course Outcomes:

After completing the course, students will be able to:

CO1	The basic concepts of AC/ DC machine modeling.
CO2	The dynamic modeling and phase transformation
CO3	Analyze various methodologies in DC machine modeling.
CO4	Understand the modeling of induction, synchronous machine modeling
CO5	The performance and dynamic modeling of BLDC,PMSM machines

Detailed Syllabus:

Unit 1	Basic concepts of Modeling: Basic Principles of Electrical Machine Analysis, Need of modeling, Introduction to modeling of electrical machines
Unit 2	Concept of transformation: Commonly Used Reference Frames, change of variables & m/c variables and transform variables for arbitrary reference frame. Stationary Circuit Variables Transformed to the Arbitrary Reference Frame, Transformation Between Reference Frames, and Transformation of a Balanced Set, Balanced Steady State Phasor Relationships , And Balanced Steady State Voltage Equations
Unit 3	Modeling of Direct-Current Machine,: Voltage and Torque Equations in Machine Variables, Mathematical model of separately excited D.C motor – Steady State analysis-Transient State analysis, Application to D.C. machine for steady state and transient analysis,
Unit 4	Three phase Induction Machines: Modeling of 3 phase Induction Motor, Voltage, torque equations, Equivalent circuit, Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals.
Unit 5	Modeling Permanent Magnet Synchronous Machine: Introduction, Types of Permanent Magnet Synchronous Machines, PMAC & PMDC(BLDC) ,Voltage and torque equations in machine variables, voltage and torque equations in rotor reference frame variables

Text and Reference Books:

1. P.C. Krause, “Analysis of Electric Machinery, McGraw Hill”, NY, 1987
2. C.V. Jones, “The unified Theory of Electrical Machines”, Butterworth,-London, 1967
3. Stevenson, “Power System Analysis”, McGraw Hill, NY
4. Dhar R.N., “Computer Aided Power System Operation and Analysis”, Tata McGraw Hill
5. P.S. Bhimbra, “The Generalised Theory of Electrical Machines”, Tata McGraw Hill
6. B. Adkins & R. G. Harley, “The General theory of AC Machines”, Tata McGraw Hill
7. R. Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”, PHI Learning Private Limited, New Delhi, 2011.

Teacher’s Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE 51015 : WIND ENERGY SYSTEMS (Program Elective II)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 0	Teachers' Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Engineering Physics, Electrical Machines, Power Systems

Course description:
In this curriculum, students will be explored to Wind Energy Technologies

Course objectives:
The objectives of the course are to
1. Calculate and analyze wind resource and energy production for a wind turbine from wind speed distribution, wind shear and power curve
2. Describe Weibull and Rayleigh statistics
3. Understand different types of generators in association with wind turbines
4. Describe different control methods for wind turbines
5. Grid integration of wind energy systems and its associated issues

Course outcomes:
After completing the course, students will able to

CO1	Analyze wind resources and energy production from wind turbines
CO2	Calculate annual energy using Weibull and Rayleigh statistics
CO3	Select different generators for a particular wind turbine
CO4	Discuss wind energy technologies and explain its control
CO5	Explain grid integration of wind energy systems and its associated issues

Detailed Syllabus:

UNIT-I	**Basics of Wind Energy:** Historical development of wind turbines, wind energy fundamentals, wind turbine aerodynamics, wind speeds and scales, terrain, roughness, power content, atmospheric boundary layer turbulence, Wind measurements, devices for measurements, analysis and energy estimates, Betz's limit.
UNIT-II	**Wind Power Probability:** Discrete wind histograms, Wind power Probability density function, Weibull and Rayleigh statistics, Average power in the wind, estimates of wind turbine energy, annual energy calculations, Wake effect in wind farms, capacity factor, impact of tower height
UNIT-III	**Wind Turbine Generators:** Synchronous generator, Induction generator, speed control for maximum power, importance of variable rotor speeds, pole changing induction generators, variable slip induction generators, idealized wind turbine power curve
UNIT-IV	**Wind Energy Technology:** Tip speed ratio, stall and pitch control, wind generator topologies, voltage and reactive power control, power quality standard for wind turbines
UNIT-V	**Grid Integration of Wind Energy:** Wind farms, real and reactive power regulation, voltage and frequency operating limits, wind farm behavior during grid disturbances, grid synchronization system, Economic aspects

Text and Reference Books:

1. Thomas Ackermann, Editor, “Wind Power in Power Systems”, John Willy and sons ltd., 2005,ISBN 0-470-85508-8.
2. Gilbert M. Masters, “Renewable and Efficient Electric Power Systems”, John Willy and sons,2004,ISBN0-471-28060-7.
3. Siegfried Heier, “Grid integration of wind energy conversion systems” John Willy and sons ltd.2006.
4. Fresis L. L., Wind Energy Conversion Systems, Prentice Hall, 1990.
5. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
6. Mathew Sathyajith, Geetha Susan Philip, Advances in Wind Energy Conversion Technology, Springer, 2011

Teacher’s Assessment: Teacher’s Assessment is based on one of the following.

1. Assignments
2. Models/ Presentations
3. multiple choice questions test
4. Quiz

Program Elective III

EE51016 : POWER SYSTEM TRANSIENTS (Program Elective- III)	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 3	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End-Semester Examination : 60 Marks

Course Description: This is an elective course which covers transients in power systems & protection against transients.

Course Objectives: The objectives of the course are to:

1. Develop a basic understanding of the power system transients.
2. Explain the traveling waves & its impact on power systems.
3. Develop a basic understanding of the transient effect of lightning, faults, and switching on power systems.
4. Provide a basic understanding of the principles used to protect power system equipments against transients.
5. Explain insulation coordination in AIS & GIS.

Course Outcomes: After completing the course, students will able to:

CO1	Explain basics of the power system transients.
CO2	Determine magnitude of reflected & refracted wave under different line terminations.
CO3	Explain lightning & different switching transients.
CO4	Explain protection systems against lightning & switching transients
CO5	Explain statistical approach in insulation coordination in AIS & GIS.

Detailed Syllabus:

Unit 1	Introduction : Review and importance of the study of transients - causes for transients. Sources of electrical transients, basic mathematical concepts for transient analysis , RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients. Different types of power system transients - effect of transients on power systems – role of the study of transients in system planning.
Unit 2	Travelling waves on transmission line: Travelling waves on transmission lines – Wave Equation – surge impedance and wave velocity – Specification of Travelling waves - Reflection and Refraction of waves – Bewley Lattice Diagrams – Attenuation and Distortion - Typical cases of line terminations – Equivalent circuit for Travelling wave studies – Forked line – Reactive termination – Analysis of trapezoidal wave - Analysis of complicated waves -– Multi-conductor system – Self and mutual surge impedance – Voltage and currents for two conductor systems
Unit 3	Lightning, switching and temporary overvoltages **:** Lightning: Physical phenomena of lightning – Interaction between lightning and power system – Factors contributing to line design – Switching: Short line or kilometric fault – Energizing transients - closing and re-closing of lines - line dropping, load rejection - Voltage induced by fault – Very Fast Transient Overvoltage (VFTO)
Unit 4	Protection of systems against surges: Transmission line insulation and performance – Ground wires – Protective angle – Tower footing resistance – Driven rods – Counterpoise – Protector tube – Substation protection – surge diverters – Selection of arrester rating – Location of arresters – Influence of additional lines – Effect of short length of cable – Surge capacitor, surge reactor and surge absorber – Shielding substation with ground wires – Protection of rotating machines
Unit 5	Insulation co-ordination: Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level –overvoltage protective devices – lightning arresters, substation earthing.

Text and Reference Books

1. Gupta.B.R, “Power System Analysis and Design”, S.Chand Publications 2004
2. Thapar.B, Gupta.B.R and Khera.L.K, “Power System Transients and High Voltage Principles”, Mohindra Capital Publishers
3. Allan Greenwood, “Electrical Transients in Power System”, Wiley & Sons Inc. New York, 1991.
4. Klaus Ragaller, “Surges in High Voltage Networks”, Plenum Press, New York, 1980.
5. Rakosh Das Begamudre, “Extra High Voltage AC Transmission Engineering”, (Second edition) New age International (P) Ltd., New Delhi, 1990.
6. Naidu M S and Kamaraju V, “High Voltage Engineering”, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

Teacher’s Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE 51017: LIFE ESTIMATION OF POWER SYSTEM EQUIPMENT (Program Elective III)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 3 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 0 Hr/Week	Teachers' Assessment	: 20 Marks
Total Credits	: 3	End -Semester Exam	: 60 Marks

Course Description: This course introduces the various aspects for estimating the residual life of power system equipments**.**

Course Objectives: -The objectives of the course are to

1. Introduce to Dielectric behavior of electric field
2. Introduce to insulation failure
3. Introduce to diagnostic techniques
4. Introduce to reliability assessment

.**Unit wise Course Outcomes expected:**

The students will be able to

CO1. Analyze the dielectric behavior of electric field
CO2. Understand the insulation failure
CO3. Diagnose in high voltage
CO4. Diagnose the faults in power system equipment
CO5. Assess the reliability of power system equipment

Detailed Syllabus:

UNIT-I	**Dielectric behaviour in electric and thermal fields:** Introduction, Mechanism of electrical conduction in matter, Charge storage in dielectric, Non-ideal dielectrics, Behaviour of dielectric in time varying fields, Conduction in dielectrics, breakdown in dielectrics Measurement of dielectric parameter: General, Permittivity and Tan δ, Volume and surface conductivity, Partial discharge measurements, Calibration of PD Measuring circuit and detector, Measurement of dielectric strength
UNIT-II	**Models for electrical insulation failure:** General, Physical models for insulation failure, single stress modelling, Multifactor models. Stochastic nature of electrical insulation failure: General, Statistical aspects of thermal ageing.
UNIT-III	**Concepts in life testing of insulation:** General, Life testing strategies, Miner's theory of cumulative damage, Accelerated stress testing, Censored life testing (CLT).
UNIT-IV	**Diagnostic testing of insulation in high voltage equipment:** General, Concepts in diagnostic testing, End point criteria, Relevance of diagnostic tests and evaluation of test results.
UNIT-V	**Equipment specific diagnostic and reliability assessment:** General, Types of insulation systems in power equipment, Equipment specific condition monitoring and diagnostic testing, Dry type systems, Gas insulated substations, Liquid impregnated and liquid filled systems.

TEXT BOOK:

Reliability and life estimation of power equipment by T.S. Ramu & Chakradhar Reddy "New age international publishers"

Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment: Teacher's Assessment based on assignments

EE52018 : DIGITAL SIGNAL PROCESSING (Program Elective- III)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 0 Hr/Week Credits : 3	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description: This is the course in Electrical Engineering which introduces the basic concepts and techniques for processing signals on a computer and be familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.

Course Objectives: The objectives of the course are to

1. Introduce the basic concepts and techniques for processing signals on a computer.
2. Be familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.
3. Emphasizes intuitive understanding and practical implementations of the theoretical concepts.

Course Outcomes : After completing the course, students will able to:

CO1	Represent discrete-time signals analytically and visualize them in the time domain.
CO2	Understand the meaning and implications of the properties of systems and signals.
CO3	Understand the Transform domain and its significance and problems related to computational complexity.
CO4	Be able to specify and design any digital filters using MATLAB.

Detailed Syllabus:

Unit 1	**Signals and Signal Processing:** Characterization and Classification of Signals, Typical Signal Processing Operations, Examples of Typical Signals, Typical Signal Processing Applications, Why Digital Signal Processing? **Discrete-Time Signals and Systems in the Time-Domain:** Discrete-Time Signals, Typical Sequences and Sequence Representation, the Sampling Process, Discrete-Time Systems, Time-Domain Characterization of LTI Discrete-Time Systems, Finite-Dimensional LTI Discrete-Time Systems, Correlation of Signals, Random Signals
Unit 2	**Transform-Domain Representations of Discrete-Time Signals** The Discrete-Time Fourier Transform, Discrete Fourier Transform, Relation Between the DTFT and the DFT, and Their Inverses, Discrete Fourier Transform Properties, Computation of the DFT of Real, Sequences, Linear Convolution Using the DFT, The z-Transform, Region of Convergence of a Rational z-Transform, The Inverse z-Transform, z-Transform Properties, Transform-Domain Representations of Random Signals **LTI Discrete-Time Systems in the Transform-Domain** Finite-Dimensional LTI Discrete-Time Systems, The Frequency Response, The Transfer Function, Types of Transfer Functions, Simple Digital Filters, All-pass Transfer Function, Minimum-Phase and Maximum-Phase Transfer Functions, Complementary Transfer Functions, Inverse Systems, System Identification, Digital Two-Pairs, Algebraic Stability Test, Discrete-Time Processing of Random Signals, Matched Filter
Unit 3	**Digital Processing of Continuous-Time Signals** Introduction, Sampling of Continuous-Time Signals, Sampling of Bandpass Signals, Analog Low pass Filter Design, Design of Analog Highpass, Bandpass, and Bandstop Filters, Anti-Aliasing Filter, Design of Sample-and-Hold Circuit, Analog-to-Digital Converter, Digital-to-Analog Converter, Reconstruction Filter Design, Effect of Sample-and-Hold Operation.

Unit 4	**Digital Filter Structures** Block Diagram Representation, Equivalent Structures, Basic FIR Digital Filter Structures, Basic IIR Filter Structures, Realization of Basic Structures using MATLAB, All pass Filters, Tuneable IIR Digital Filters, IIR Tapped Cascaded Lattice Structures, FIR Cascaded Lattice Structures, Parallel All pass Realization of IIR Transfer Functions, Digital Sine-Cosine Generator
Unit 5	**Digital Filter Design** Preliminary Considerations, Bilinear Transform Method of IIR Filter Design, Design of Low pass IIR Digital Filters, Design of Highpass, Bandpass, and Bandstop IIR Digital Filters, Spectral Transformations of IIR Filters, FIR Filter Design Based on Windowed Fourier Series, Computer-Aided Design of Digital Filters, Design of FIR Filters with Least-Mean-Square Error, Digital Filter Design Using MATLAB **Applications of Digital Signal Processing** Position and Speed Control of Stepper Motor, DC Motor Speed Control, Serial Communications and Data Transfer, Sine Modulated PWM Signal Generation

Text Books:

1. R. Babu. , “Digital Signal Processing”, Laxmi Publication Ltd.
2. A. Ambardar, “Digital Signal Processing: A Modern Introduction”, Penram International Publishing (India) Pvt. Ltd.

Reference Books:

2. Proakis, “Digital Signal Processing”, Pearson Education Limited
3. Oppenheim and Schafer, “Discrete-Time Signal Processing”, Prentice-Hall, 1989.
4. Rabiner, R. Lawrence, “Theory and Application of Digital Signal Processing”, Gold, Bernard, Prentice-Hall

Teacher’s Assessment: Assessments should be based on -

1. Assignment 10 Marks
2. MCQ 10 Marks

EE52006 : ADVANCED ELECTRIC DRIVES (Program Elective III)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 0	Teachers' Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Course Description: The objective of this course is to give exposure to the students of fundamentals, operations, control and analysis of DC motor and AC motor electrical drives. It also covers the industrial application of it.

Prerequisites: 1. Electrical Machines
2. Power Electronics

Course Objective: The objective of this course is to give exposure to the students of
1. Fundamentals of an electrical drives
2. Basics, Control and analysis of DC motor drives
3. Basics, Control and analysis of Induction motor drives
4. Vector control of Induction motor drives
5. Basics, Control and analysis of PM Synchronous and Brushless DC motor drives

Course Outcomes: After completing the course, students will able to:

CO1	Describe fundamentals of an electrical drives
CO2	Explain the operations and analysis of Phase controlled and Chopper controlled DC Motor drives
CO3	Explain the operations and analysis of Phase controlled and Frequency Controlled Induction Motor Drives
CO4	Discuss the principle and analysis of Vector controlled Induction Motor Drives
CO5	Discuss the principle of operation, analysis of P.M. Synchronous and Brushless DC Motor Drives

Detailed Syllabus:

Unit 1	**Phase Controlled and Chopper Controlled DC Motor Drives:** Phase Controlled- Introduction, Principle of DC motor speed control, Phase controlled converters, Steady state analysis of three phase converter controlled DC Motor drives, Applications. Chopper Controlled- Introduction, Principle of the chopper, Four quadrant Chopper circuit, Chopper for inversion, Steady state analysis of chopper controlled DC motor drives, Applications.
Unit 2	**Voltage Fed and Current Fed Converters:** Voltage Fed Converters- Introduction, Single phase inverters, Three phase bridge inverters, multi stepped inverters, PWM techniques, Three level inverters, hard switching effects, resonant inverters, soft- switched inverters, dynamic and regenerative drive braking, PWM rectifiers, Static VAR compensators. Current Fed Converters- Introduction, General operation of six stepped thyristor inverter, Load commutated inverters, Force commutated inverters, harmonic heating and torque pulsation, multi stepped inverters, inverter with self commutated devices.
Unit 3	**Induction Motor Slip – Power Recovery Drives:** Introduction, Doubly fed machine speed control by rotor rheostat, static Kramer drives, Static Scherbius drive, modified static Scherbius drive.
Unit 4	**Control and Estimation of Induction Motor Drives**: Introduction, Induction Motor control with small signal model, Scalar Control, Vector or Field oriented control, Sensorless vector control, direct torque and flux control, Adaptive control, Self commissioning drive.
Unit 5	**Control and Estimation of Synchronous Motor Drives:** Introduction, Sinusoidal SPM machine drives, Synchronous reluctance machine drive, sinusoidal IPM machine drive, trapezoidal SPM machine drive, Wound Field synchronous machine drive, switched reluctance motor drives.

TEXT BOOKS:

1. B. K. Bose, "Modern Power Electronics and AC drives", Pearson Education, Asia, 2003
2. R. Krishnan, "Electric Motor Drives- Modelling Analysis and Control", Pearson Prentice Hall.
3. G.K. Dubey, "Fundamentals of Electrical Drives", Narosa Publication
4. N.K. De and P.K.Sen "Electric Drives", Prentice Hall India
5. B.K. Bose, "Power Electronics and Variable Frequency Drive", IEEE Press, 2000
6. Vedam Subramanyam, "Electric Drives Concepts and Applications", Tata McGraw-Hill

Teacher Assessments: Assessments will be based on any one or two of the following:

1. Assignment : 10/20 Marks
2. MCQ : 10/20 Marks
3. PPT : 10/20 Marks
4. Surprise Test : 10/20 Marks

EE51018 : SOLAR ENERGY SYSTEMS (Program Elective III)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20Marks
Tutorial	: 0 Hr/Week	Teachers' Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Engineering Physics, Electrical Machines, Power System

Course description:
Solar Energy Systems This course will introduce the basics of solar Photovoltaic power generation and grid connection issues. This course will also describe thermal applications of solar power

Course Objectives:
The objectives of the course are to
1. Outline the technologies that are used to harness the power of solar energy
2. Design a stand-alone PV system
3. Understand the physics of solar PV systems and grid connected topologies
4. Understand different types of solar PV cells
5. Outline the different solar thermal technologies

Course Outcomes: After completing the course, students will able to

CO1.	Determine I-V and P-V Characteristics of Solar cell
CO2	Design the various parameters of stand alone solar pv system
CO3	Understand different grid connected topologies based on isolation and power stages
CO4	Understand different types of solar pv cells
CO5	Understand different solar thermal collectors

Detailed Syllabus:

UNIT-I	**Introduction to Solar Energy:** Solar Spectrum, Solar Geometry, Sun Earth angles, Solar radiation at given locations, Solar radiation measurement, sun path diagrams Light generated current, I-V & P-V Characteristics of silicon solar cell
UNIT-II	**Solar PV Technology:** Amorphous mono-crystalline, poly-crystalline, Shading impact, PV module, Array, Maximum Power Point Tracking, Standard test conditions, Impacts of temperature and Insolation on I-V curves Design of stand-alone systems
UNIT-III	**Solar PV Grid Integration:** Grid connection principle, Topologies for PV-Grid interface, Isolation, Number of power stages, Convertors based on control dynamics, d-q axis control methodology
UNIT-IV	**Thin film Technology:** Generic advantages of thin film technologies, Materials for thin film technologies, Cadmium Telluride solar cell, Introduction to Organic solar PV cell, Water pumping applications
UNIT-V	**Solar Thermal Technology:** Flat plate collector, Parabolic trough, Central receiver, parabolic dish, Fresnel, solar pond, solar still , Single node analysis of flat plate collectors, top loss and bottom loss coefficients

Text Books:

1. Chetan Singh Solanki, "Solar Photovoltaic Fundamentals, Technologies and applications", second edition, PHI Publication
2. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Willy and sons, 2004, ISBN0-471-28060-7.
3. S. P. Sukhatme and J.K.Nayak"Solar Energy principles of thermal collection and storage", Tata McGrew Hill, third edition,
4. A Elbaset Adel," Performance Analysis of Grid-Connected Photovoltaic Power Systems " Lambert Academic Publications

Reference Books:

1. Muhammad Sulaman, "Design & Analysis of Grid Connected Photovoltaic System" Lambert Academic Publications

2. Mullic and G.N.Tiwari, “Renewable Energy Applications”, Pearson Publications.

3. John A. Duffie, William A. Beckman, “Solar Engineering of Thermal Processes”, Wiley Inter science Publication, 1991.

Teacher’s Assessment: Teacher’s Assessment is based on one of the /or combination of the few of the following.

1) Home Assignments
2) Power point presentation
3) Develop working models
4) Surprise written Test with multiple choice questions
5) Quiz

Program Elective IV

EE51019 : RESTRUCTURED POWER SYSTEMS (Program Elective IV)	
Teaching Scheme Lectures: 3 Hrs/Week Tutorial: 0 Hr/Week Credits: 3	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End-Semester Examination : 60 Marks

Course Description: This is an elective course & covers the different aspects of power systems in restructured environment.

Course Objectives:

The objectives of the course are to learn:

1. Basic aspects of power system restructuring.
2. Different models of deregulated power systems.
3. Different methods to determine transmission pricing.
4. Available transfer capability.
5. Regulatory issues involved in the deregulation of the power industry.

Course Outcomes : After completing the course, students will able to:

CO1	Explain basic aspects of power system restructuring.
CO2	Explain different models of deregulated power systems.
CO3	Explain different methods to determine transmission pricing.
CO4	Determine available transfer capability.
CO5	Explain Ancillary Services management in various markets & regulatory issues.

Detailed Syllabus:

Unit 1	Introduction: Basic concept and definitions, privatization, restructuring, transmission open access, wheeling, deregulation, components of deregulated system, advantages of competitive system.
Unit 2	Deregulation of Power Sector: Separation of ownership and operation, Deregulated models, pool model, pool and bilateral trades model, multilateral trade model. Competitive electricity market: Independent System Operator activities in pool market, Wholesale electricity market characteristics, central auction, single auction power pool, double auction power pool, market clearing and pricing, Market Power and its Mitigation Techniques, Bilateral trading, Ancillary services.
Unit 3	Transmission Pricing: Marginal pricing of Electricity, nodal pricing, zonal pricing, embedded cost, Postage stamp method, Contract Path method, Boundary flow method, MW-mile method, MVA-mile method, Comparison of different methods.
Unit 4	Congestion Management: Congestion management in normal operation, explanation with suitable example, total transfer capability (TTC), Available transfer capability (ATC), Different Experiences in deregulation: England and Wales, Norway, China, California, New Zealand and Indian power system.
Unit 5	Ancillary Services and System Security in Deregulation: Classifications and definitions, AS management in various markets- country practices. Technical, economic, & regulatory issues involved in the deregulation of the power industry.

Text and Reference Books

1. Loi Lei Lai, "Power System Restructuring and Deregulation", John Wiley & Sons Ltd.
2. "Restructured power systems, operation, trading and volatility, "Mohammad shahidehpour, M.alomoush, CRC Press

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following.

1. Presentation on latest topics/Real life problems related with the subject
2. Simulations problems
3. Quiz
4. MCQ

EE 51020 : POWER SYSTEM RELIABILITY (Program Elective IV)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Test	: 20 Marks
Tutorials	: 0 Hr/Week	Teachers Assessment	: 20 Marks
Total Credits	: 3	End Semester Exam	: 60 Marks

Course Description:
Power System Reliability is a one-semester course as elective to post graduates of Electrical Engineering students. It is the fundamental course related to condition of reliability of power system

Course objectives:
The objectives of the course are to
1. Study the fundamentals of Generation system, Transmission system and Distribution system reliability analysis
2. Provide comprehensive knowledge on the various aspects of reliability of power system equipments
3. Explain methods of determination of risk indices and system reliability evaluation
4. Knowledge of assessing reliability of single and multi-area

Course Outcomes: After completing the course, students will be able to:

CO1	Understand the importance of maintaining reliability of power system components
CO2	Apply the probabilistic methods for evaluating the reliability of generation and transmission systems
CO3	Assess the different models of system components in reliability studies..
CO4	Assess the reliability of single area and multi area systems
CO5	Explain reliability of different power system equipments

Detailed Syllabus:

Unit 1	Generating system reliability analysis I Generation system model, capacity outage probability tables, Recursive relation for capacitive model building, sequential addition method, unit removal, Evaluation of loss of load and energy indices
Unit 2	Generating system reliability analysis II Frequency and Duration methods, Evaluation of equivalent transitional rates of identical and non-identical units, Evaluation of cumulative probability and cumulative frequency of non- identical generating units , level daily load representation, merging generation and load models
Unit 3	Basic concepts of risk indices:PJM methods, security function approach, rapid start and hot reserve units, Modelling using STPM approach. Bulk Power System Reliability Evaluation: Basic configuration, conditional probability approach, system and load point reliability indices, weather effects on transmission lines, Weighted average rate and Markov model, Common mode failures.
Unit 4	Analysis Probability array method: Two inter connected systems with independent loads, effects of limited and unlimited tie capacity, imperfect tie, Two connected Systems with correlated loads, Expression for cumulative probability and cumulative frequency. Distribution System Reliability Analysis – I (Radial configuration): Basic Techniques, Radial networks, Evaluation of Basic reliability indices, performance indices, load point and system reliability indices, customer oriented, loss and energy oriented indices
Unit 5	Reliability analysis of different power system equipment : Inclusion of bus bar failures, scheduled maintenance, temporary and transient failures, common mode failures, Substations and Switching Stations: Effects of short-circuits, breaker operation, Open and Short-circuit failures, Active and Passive failures, switching after faults, circuit breaker model, preventive maintenance, exponential maintenance times. Transmission System Reliability Evaluation and Composite Reliability Evaluation: Average interruption rate method, Stormy and normal weather effect, The Markov process approach, Two plant single load composite system reliability analysis

Text and Reference Books

1. Reliability Evaluation of Power Systems by Roy Billinton and Ronald N. Allan, Plenum press, New York and London (Second Edition), 1996.
2. Reliability Modeling in Electric Power Systems by J. Endrenyi, John Wiley and Sons, 1978
3 Electric Energy System Theory by O.I. Elgerd McGraw Hill Higher Education; 2nd edition
4 Power system Analysis by Stevenson and Grainger , McGraw Hill Education; 1 edition
5 Power System Planning by R. L. Sullivan ,Mc-Graw Hill International book company
6 Reliability Modelling in Electric Power Systems by J.Endrenyi A Wiley-Interscience Publication. Author, *J. Endrenyi*. Edition, illustrated. Publisher, Wiley, 1979.
7 Power System Control & Stability by P. Kundur *McGraw-Hill* Education; 1st edition

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

EE51021 : POWER QUALITY (Program Elective IV)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 00	Teachers' Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Power Electronics, Electrical Machines, Power System

Course Description:
This course gives an introduction on power quality causes and effects, requirement of power quality improvements and mitigation aspects of power quality problem .

Course Objectives: The objectives of the course are to
1. Understand power quality problem and classify power quality events
2. Understand different methods of monitoring power quality and standards for power quality
3. Outline concept of Passive shunt and series compensators
4. Understand Active Shunt And Series Compensators
5. Understand Unified Power Quality Compensators

Course Outcomes: After completing the course, students will able to

CO1.	Describe Power quality problems and classify power quality events.
CO2	Demonstrate power quality measurement methods
CO3	Explain principle of operation and control of Passive shunt and series compensators.
CO4	Design of Active Shunt And Series Compensators
CO5	Analyze Unified Power Quality Compensators

Detailed syllabus:

UNIT-I	**Power Quality an Introduction:** Introduction , Classification of Power quality problems, Causes of power quality problems, Loads that cause power quality problem, classification of nonlinear load, Effects of power quality problems on users, Classification of mitigation techniques for power quality problems
UNIT-II	**Power Quality Standards and Monitoring:** Power Quality Terminologies, Power Quality Definitions, Power Quality Standards, classification of passive power filter, principle of operation of passive power filter
UNIT-III	**Passive Shunt and Series Compensation:** Classification of Passive shunt and series compensators, Principle of operation of Passive shunt and series compensators, Analysis and design of Passive shunt compensators
UNIT-IV	**Active Shunt And Series Compensation:** Classification of DSTATCOMs, principle of operation and control of DSTATCOM, analysis and designed of DSTTCOM, Classification of active series compensators, principle of operation and control of active series compensators, Analysis and designed of active series compensators
UNIT-V	**Unified Power Quality Compensators:** Classification of Unified power quality compensators, principle of operation and control of Unified power quality compensators, analysis and designed of Unified power quality compensators

Text Books:

1. Bhim Singh, Ambrish Chandra(2015) "power quality problem and mitigation techinques" , wiley Publications (ISBN: 9781118922057)
2. C.Sankaran (2002)" power quality"CRC Press Publication.
3. Math,H.J.Bollen, "Understanding power quality problem", Standard Publication.
4. Roger C.Dugan, "Electrical power system quality"2nd edition, Macgraw-Hill Publication.
5. MohammedA.S.Masoum ,EwaldF.Fuchs" Power Quality in power systems and electric machines",2nd Edition,kindely edition,(ISBN: 978-0123695369)

Teacher's Assessment: Teacher's Assessment is based on one of the /or combination of the few of the following.

1) Home Assignments
2) Power point presentation
3) Develop working models
4) Surprise written Test with multiple choice questions
5) Quiz

EE52005: ADVANCED CONTROL SYSTEM (Program Elective- IV)	
Teaching Scheme Lectures : 03 Hrs/Week Tutorial : 0 Hrs/Week Credits : 03	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description:

This course is one semester mandatory course of four credits. This course introduces the basics of various control system which will be helpful for understanding the power system applications.

Course Objectives: The objectives of the course are to-

1. Explain the system representation in state space and design of state feedback
2. Explain the basics for design of robust control system
3. Explain the stability analysis of non linear control systems
4. Explain the representation of optimal control systems
5. Explain the applications industrial controllers
6. Explain the multiloop control systems

Course Outcomes: After completing the course, students will able to:

CO1	Represents system in state space and design state feedback
CO2	Design robust control system
CO3	Check the stability of non linear control systems
CO4	Represents the system in standard form of optimal control
CO5	Apply industrial control for system and realize multi loop control system

Detailed syllabus:

UNIT-1	State feedback control system: Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, physical systems and state assignment concept of controllability & observability, State feedback by pole placement, observers, Lag and Lead compensator design.
UNIT-2	Robust control system: Robust control systems and system sensitivity, Analysis of robustness, system with uncertain parameters, design of robust control system.
UNIT-3	Non-linear Control system: Introduction to non-linear systems, Describing function analysis, phase plane analysis, bang bang control system, Lyapunovs stability analysis,
UNIT-4	Optimal Control System: Introduction to optimal control system, problems, Quadratic performance index, Introduction to Adaptive control
UNIT-5	Process control system: Introduction to process control, various control configuration such as: feedforward, cascaded etc. PID controller and implementation.

BOOKS:

1. S. Sastry and M. Bodson, “Adaptive Control: Stability, Convergence, and Robustness”, Prentice-Hall, 1989.
2. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill, 1997.
3. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition, 1993.
4. Ogata, K., “Modern Control Engineering”, Prentice Hall, second edition, 1991.
5. Nagrath & Gopal, “Modern Control Engineering”, New Age International

Teacher Assessments:

Assessments will be based on following:

1. Assignment : 10 Marks
2. MCQ : 10 Marks

EE52019 : OPTIMIZATION TECHNIQUES (Program Elective- IV)	
Teaching Scheme Lectures: 03 Hrs/Week Tutorial : 0 Hrs/Week Credits : 3	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description: Electrical Power Systems is growing at a faster pace. An Electrical Engineer should be able to solve the optimization problems in electrical engineering. This course is aimed to cover the fundamental of LPP and NLPP optimization techniques for solving engineering problems.

Course Objectives: The objectives of the course are to

1. Introduce the fundamental concepts of Optimization Techniques;
2. Make the learners aware of the importance of optimizations in real scenarios;
3. Provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

Course Outcomes : After completing the course, students will able to:

CO1	formulate optimization problems
CO2	understand and apply the concept of optimality criteria for various type of optimization problems
CO3	solve various constrained and unconstrained problems in single variable as well as multivariable;
CO4	apply the methods of optimization genetic algorithm for real life situation
CO5	apply the methods of optimization techniques for the application in power system engineering

Detailed Syllabus:

Unit 1	Introduction: Concept of optimization and classification of optimization techniques, formation of optimization problems Linear Programming : Standard form of LPP Simplex Method of solving LPP, duality, decomposition principle, transportation problem and application of LPP to Electrical Engineering
Unit 2	Non-Linear Problem (NLP) **:** One dimensional methods, Elimination methods, Interpolation methods, Unconstrained optimization techniques-Direct search and Descent methods, constrained optimization techniques, direct and indirect methods
Unit 3	Dynamic Programming**:** Multistage decision processes, concept of sub-optimization and principle of optimality, conversion of final value problem into an initial value problem.
Unit 4	Genetic Algorithm: Introduction to genetic Algorithm, working principle, coding of Variables, fitness function. GA operators; Similarities and differences between Gas and traditional methods; Unconstrained and constrained optimization using Genetic Algorithm, global optimization using GA
Unit 5	Applications to Power system: Economic Load Dispatch in thermal and Hydro-thermal system using GA and classical optimization techniques, Unit commitment problem, reactive power optimization. Optimal power flow, LPP and NLP techniques to Optimal flow problems.

Text and Reference Books

Text book :

1. S.S.Rao, "Optimization - Theory and Applications", Wiley-Eastern Limited.
1. David G. Luenberger, "Introduction of Linear and Non-Linear Programming ", Wesley Publishing Company
2. Polak, "Computational methods in Optimization", Academic Press. Pierre D.A, "Optimization Theory with Applications", Wiley Publications.
4. Kalyanmoy deb, "Optimization for Engineering Design: Algorithms and Examples", Kalyanmoy deb, PHI Publication.
5. D.E. Goldberg & Addision, "Genetic Algorithm in Search Optimization and Machine Learning ", Wesley Publication, 1989
6. L.P. Singh, "Advanced Power System Analysis and Dynamics", Wiley Eastern Limited.
7. Hadi Saadat "Power System Analysis ", TMH Publication.
8. Olle I.Elewgerd " Electrical Energy System : An Introduction", TMH Publication, New Delhi.

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies: The teaching strategy is planed through the lectures, tutorials and team based home Assignments.

Program Elective V

EE51022: POWER SYSTEM DESIGN (Program Elective- V)	
Teaching Scheme Lectures: 03 Hrs/Week Tutorials: 0 Hr/Week Credits: 3	**Examination Scheme** Test : 20 Marks Teachers Assessment : 20 Marks End Semester Exam : 60 Marks

Course Description: -
The primary objective of this subject is the development of a working knowledge of design of power transmission line.. Emphasis is placed on selection of the power system components, mechanical and electrical design of transmission line with various voltage levels and power system earthing.

Course Objectives: The objectives of the course are to,
1. Understand the basic concepts of the power system components.
2. Demonstrate the basic concepts of mechanical design of transmission line
3. .Learn appropriate knowledge of power system earthing.
4. Compression understanding of essential knowledge for design of EHV AC transmission line. .
5. Demonstrate the need of voltage control and various voltage control methods.

Course Outcome: After completing the course students will able to

CO1	Describe various interconnections method and significance of Load Dispatch Centers.
CO2	Evaluate the various types of power system parameters for design of overhead Transmission Lines and underground cable.
CO3	Describe the methods for EHV Transmission Line with appropriate factor considerations for various voltage level..
CO4	Apply the appropriate methods to find Vigorous Solution of Long Transmission Line
CO5	Demonstrate the appropriate methods for power system earthing.

Detailed syllabus:

UNIT-1	Power System Components: Location of Main Generating Stations and Substations, Interconnections, Load Dispatch Centers.	08Hr
UNIT-2	Design of Transmission Lines: Selection of Voltage, Conductor Size, Span, Number of Circuits, Conductor Configurations, Insulation Design, Mechanical Design of Transmission Line, Towers, Sag- Tension Calculations	08Hr
UNIT-3	Design of EHV Transmission Line: Based Upon Steady State Limits and Transient Over Voltage, Design Factors Under Steady States, Design of 400kV, 1000mW Medium and Long Transmission Line Without and with Series Capacitance Compensation and Shunt Reactors at Both Ends, 750kVLong Transmission Line with Only Shunt Reactors. Extra High Voltage Cable Transmission, Design Basis of Cable Insulation, Search Performance of Cable Systems, Laying of Power Cables	08Hr
UNIT-4	Vigorous Solution of Long Transmission Line: Interpretation of Long Line Equations, Ferranti Effect, Tuned Power Lines, Equivalent Circuit of Long Line, Power Flow Thorough Transmission Line and Methods of Voltage Control	08Hr
UNIT-5	Power System Earthing: Earth Resistance, Tolerable and Actual Step and Touch Voltages, Design of Earthing Grid, Concrete Encased Electrodes, Tower Footing Resistance, Impulse Behaviour Earthing System	08Hr

Text/ Reference Books:

1. M.V. Deshpande, "Electrical Power System Design", Tata McGraw Hill
2. B.R.Gupta, "Power System Analysis and Design", Wheeler Publishing co.
3. I.J.Nagrath & D. P. Kothari, "Power System Engineering", Tata Mc Graw Hill
4. Rakosh Das Begamudre, "Extra high-voltage A.C. transmission Engineering", New Age International Pvt. Ltd.
5. S.S.Rao, "EHV AC & HVDC Transmission Engineering & Protection", Khanna Publishers

Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned weakly to the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment: Teacher's Assessment is based on one of the /or combination of the few of the following.

1) Home Assignments
2) Surprise written Test with multiple choice question
3) Quiz
4) Presentation.

EE 51023: ENGINEERING MATERIALS (Program Elective V)	
Teaching Scheme Lectures : 3 Hrs/Week Tutorial : 0 Hrs/Week Total Credits : 3	**Examination Scheme** Class Test : 20Marks Teacher Assessment : 20 Marks End -Semester Exam : 60 Marks

Course Description: The purpose of this course is to teach students the fundamentals of Engineering Materials.

Course Objectives:

The objectives of the course are to

1. Know the fundamental science and engineering principles relevant to materials.
2. Understand the relationship between nano/micro structure, characterization, properties and processing and design of materials.
3. Have the experimental and computational skills for a professional career or graduate study in materials.
4. Possess knowledge of the significance of research, the value of continued learning and environmental/social issues surrounding materials.

Course Outcome:

After completion of this course students will be able to

CO1. Apply core concepts in Materials Science to solve engineering problems.
CO2. Be knowledgeable of contemporary issues relevant to Materials Science and Engineering.
CO3. Select materials for design and construction.
CO4. Understand the importance of life-long learning.
CO5. Design and conduct experiments, and to analyze data.
CO6. Understand the professional and ethical responsibilities of a materials scientist and engineer.
CO7. Work both independently and as part of a team.
CO8. Possess the skills and techniques necessary for modern materials engineering practice

Detailed Syllabus:

UNIT-I	**Conductivity of Metals** : Structure of the Atom, Crystallinity , Anisotropy Factors affecting the resistivity of electrical materials , Motion of an electron in an electric field , Fermi- Dirac distribution , Photo- electric emission, Superconductivity, Electrical conducting materials, Thermoelectric effects, Operation of thermocouple.
UNIT-II	**Dielectric Properties:** Effect of a dielectric on the behaviour of a capacitor, polarization, Frequency dependence of electronic polarisability, Dielectric losses, Significance of the loss tangent, Dipolar relaxation, Frequency and temperature dependence of the dielectric constant of polar dielectrics, Dielectric properties of polymeric systems, insulating materials, ferroelectricity, piezoelectricity.
UNIT-III	**Magnetic properties of Materials:** Classification of magnetic materials, The origin of permanent magnetic dipoles, Diamagnetism, Paramagnetism, ferromagnetism, The origin of ferromagnetic dipoles, ferromagnetic domains, the magnetic curve, Magnetization curve, the hysterisis loop, magnetostriction, factors of affecting permeability and hysterisis loss, common magnetic materials, anti-ferromagnetic , ferromagnetic, magnetic resonance
UNIT-IV	**Semi-conductors**: Energy bands in solids, the Einstein relation, hall effect, electrical conductivity of doped materials, materials for fabrication of semi-conductor devices, **Measurement of electrical and magnetic properties** : conductivity measurements, dielectric measurements, magnetic measurements, Measurement of semi-conductor parameters **Conduction in liquids**: faraday's law of electrolysis, ionic velocities, chemical cells and concentration cells, irreversible and reversible cells, practical cell, electrolytic depositions

	corrosion of metals, nature of corrosion **Optical properties of solids**:photo-emission, photo-emission materials and types of photo-Cathodes, definitions of terms, electroluminescence, electroluminescent panels.
UNIT-V	**Materials for electric components:** Introduction, resistors, capacitors, inductors, relays **Mechanical properties**: The stress/strain relationship, plastic behaviour, block slip theory, hardening, ductility

Text Books :

1. Indulakar," Enginnering Material", S. Chand Publications
2. M F Ashby, David R H Jones, "Enginnering Materials".
3. Mathew Philip, William Bolton, "Technology of Enginnering Materials".
4. J A Charles, F A A Crane, J A G Furness "Selection and use of Enginnering Materials".
5. Joachim, Rosler, Harald, Harders, Martin Baker "Mechanical Behaviour of Engineering Materials"
6. Krishan Kumar Chawla, "Composite Materials: Science & Engineering

Teaching Strategies:

The teaching strategy is planed through the lectures, tutorials and team based home works. Exercises are assigned to stimulate the students to actively use and revise the learned concepts which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes are emphasized.

Teacher's Assessment: Teacher's Assessment based on one of the /or combination of the few of the following.

1. Multiple choice question
2. PPT presentation

CSXXXX: INTERNET OF THINGS (Program Elective V)	
Teaching Scheme	**Examination Scheme**
Lectures : 3 Hrs/Week	Test : 20 Marks
Tutorial : 0 Hr/Week	Teachers Assessment : 20 Marks
Credits : 03	End Sem Exam : 60 Marks

Syllabus will be available on institute website

EE52023: ELECTRIC VEHICLES (Program Elective V)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20Marks
Tutorial	: 0	Teachers' Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-requisites: Nil

Course description: This course introduces the fundamental concepts, principles, analysis and design of hybrid and electric vehicles. Various aspects of hybrid and electric vehicles such as their configuration, types of electric machines that can be used, energy storage devices, etc. will be covered in this course.

Course Objectives: The objectives of the course are to introduce and explain-

1. The concepts of electrical vehicles and their operation.
2. The basic components of the EV and their design.
3. Power converters & energy storage devices for electrical vehicles

Course Outcomes :

After completing the course, students will able to:

CO1	Explain the operation of electrical vehicles.
CO2	Explain Power Converters for Electric and hybrid Vehicles
CO3	Identify the Electrical Machines for Electric and hybrid Vehicles
CO4	Design the components of the electrical vehicles.
CO5	Describe different Energy Storage options for the Electric and hybrid Vehicles

Detailed Syllabus:

Unit 1	History of electric & hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Dynamics of the electric and hybrid electrical vehicles- motion and dynamic equation for vehicles, Vehicle Power Plant and Transmission Characteristics, Basic Architecture of Hybrid Drive Trains and Analysis of Series Drive Train, Power Flow in HEVs, Torque Coupling and Analysis of Parallel Drive Train, Basic Architecture of Electric Drive Trains
Unit 2	Power Converters- DC-DC converters for EV and HEV applications, DC-AC converters in EV & HEV
Unit 3	AC Electrical Machines for hybrid and Electric Vehicles- Induction motors, Permanent Magnet Motors. SRM motors, their control and applications in EV/HEV
Unit 4	Design of Electrical EV/HEV – Principles, Drive cycles and its detail analysis, sizing of electrical machines
Unit 5	Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.

Text and Reference Books

1. James Larminie, John Lowry, "Electric Vehicle Technology Explained", WIELY USA, 2012.
2. Chris Mi, M. Abdul Masrur & David Wenzhong Gao , "Hybrid Electric Vehicles: Principles and Applications with practical prespective", WIELY, 2011
3. Electric Cars The Future is Now!: Your Guide to the Cars You Can Buy Now and What the Future Holds, by Arvids Linde, Veloce Publishing,2010.
4. Abu-Rub, Malinowski and Al-Haddad, "Power Electronics for renewable energy systems,

transportation, Industrial Applications", WILEY, 2014.

5. Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", Second Edition (Power Electronics and Applications Series) by CRC Press, 2009
6. John Miller, " Propulsion Systems for Hybrid Vehicles," Institute of Electrical Engineers, UK, 2004
7. C.M. Jefferson & R.H. Barnard, " Hybrid Vehicle Propulsion," WIT Press, 2002
8. Iqbal Husain, "Electric and Hybrid Vehicles – Design Fundamentals," CRC Press, 2010
9. James Larminie and John Lowry, " Electric Vehicle Technology Explained, " Oxford Brookes University, Oxford, UK, 2003

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student and one of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. MCQ
3. Simulations problems
4. Quiz

Teaching Strategies: The teaching strategy is planed through the lectures, tutorials and team based home Assignments.

EE52022: BIOMEDICAL INSTRUMENTATION (Program Elective V)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20 Marks
Tutorial	: 0	Teachers Assessment	: 20 Marks
Total Credits	: 03	End Semester Exam	: 60 Marks

Course Description:

Biomedical Instrumentation is a one-semester course elective to all fourth year Electrical Engineering students. It is the fundamental course related to Power System Engineering.

Course Objective: The objectives of the course are to

1. Provide an acquaintance of the physiology of the heart, lung, blood circulation and circulation respiration. Biomedical applications of different transducers used.
2. Introduce the student to the various sensing and measurement devices of electrical origin.
3. Provide awareness of electrical safety of medical equipments
4. Provide the latest ideas on devices of non-electrical devices.
5. Bring out the important and modern methods of imaging techniques.
6. Provide latest knowledge of medical assistance / techniques and therapeutic

Course Outcomes: After completing the course, students will be able to:

CO1	Known Physiology and proper transducer for measurement
CO2	Develop set up for measurement of human parameter for measurement
CO3	Select proper transducer for measurement of non electrical
CO4	Analysis medical imaging
CO5	Create a proper therapeutic experiment setup for measurement

Detailed Syllabus:

Unit 1	**PHYSIOLOGY AND TRANSDUCERS** Cell and its structure – Resting and Action Potential – Nervous system: Functional organisation of the nervous system – Structure of nervous system, neurons - synapse – transmitters and neural communication – Cardiovascular system – respiratory system – Basic components of a biomedical system - Transducers – selection criteria – Piezo electric, ultrasonic transducers – Temperature measurements - Fibre optic temperature sensors.
Unit 2	**ELECTRO – PHYSIOLOGICAL MEASUREMENTS** Electrodes –Limb electrodes –floating electrodes – pregelled disposable electrodes - Micro, needle and surface electrodes – Amplifiers: Preamplifiers, differential amplifiers, chopper amplifiers – Isolation amplifier. ECG – EEG – EMG – ERG – Lead systems and recording methods – Typical waveforms. Electrical safety in medical environment: shock hazards – leakage current-Instruments for checking safety parameters of biomedical equipments
Unit 3	**NON-ELECTRICAL PARAMETER MEASUREMENTS** Measurement of blood pressure – Cardiac output – Heart rate – Heart sound –Pulmonary function measurements – spirometer – Photo Plethysmography, Body Plethysmography – Blood Gasanalysers : pH of blood –measurement of blood pCO2, pO2, finger-tip oxymeter - ESR, GSR measurements .
Unit 4	**MEDICAL IMAGING** Radio graphic and fluoroscopic techniques – Computer tomography – MRI – Ultrasonography – Endoscopy – Thermography – Different types of biotelemetry systems and patient monitoring – Introduction to Biometric systems
Unit 5	**ASSISTING AND THERAPEUTIC EQUIPMENTS** Pacemakers – Defibrillators – Ventilators – Nerve and muscle stimulators – Diathermy – Heart – Lung machine – Audio meters – Dialysers – Lithotripsy

Text and Reference Books

1. R.S.Khandpur, 'Hand Book of Bio-Medical instrumentation', Tata McGraw Hill Publishing Co Ltd.,2003.
2. Leslie Cromwell, Fred J.Weibell, Erich A.Pfeiffer, 'Bio-Medical Instrumentation and Measurements', II edition, Pearson Education, 2002 / PHI.
3 M.Arumugam, 'Bio-Medical Instrumentation', Anuradha Agencies, 2003.
4 L.A. Geddes and L.E.Baker, 'Principles of Applied Bio-Medical Instrumentation', John Wiley &Sons, 1975.
5. J.Webster, 'Medical Instrumentation', John Wiley & Sons, 1995.
6. C.Rajarao and S.K. Guha, 'Principles of Medical Electronics and Bio-medical Instrumentation',Universities press (India) Ltd, Orient Longman ltd, 2000.

Teacher's Assessment: Teachers Assessment of 20 marks is based on **attendance** of the student andone of the / or combination of few of following. However, the course co-ordinator has to announce assessment components at the beginning of the course.

1. Presentation on latest topics/Real life problems related with the subject
2. Problems based on GATE questions
3. Simulations problems
4. Quiz

Teaching Strategies:

The teaching strategy planned through the lectures, and team based home works. Exercises assigned weekly to stimulate the students to actively use and revise the learned concepts, which also help the students to express their way of solving the problems fluently in written form. Most critical concepts and mistakes emphasized

EE61001: RENEWABLE ENERGY TECHNOLOGY (Open Elective offered by Electrical Department)			
Teaching Scheme		**Examination Scheme**	
Lectures	: 03 Hrs/Week	Class Test	: 20Marks
Tutorial	: 00	Teacher's Assessment	: 20 Marks
Total Credits	: 03	End -Semester Exam	: 60 Marks

Pre-Requisites: Engineering physics electrical machine, power system

Course Description:
In this curriculum, students will be explored to Renewable Energy Technologies such as Wind energy, Solar energy. They will be introduced to concepts of fuel cells and biomass energy.

Course Objectives:
The objectives of the course are to learn
1. Different types of energy sources
2. Various solar PV technologies and its characteristics
3. Various solar thermal technologies and its applications
4. Wind energy technologies and its operations
5. Grid integration of wind energy systems and its associated issues

Course Outcomes: After completing the course, students will able to

CO1.	Elaborate different types of energy sources
CO2	Explain various solar PV technologies and its characteristics and solve numerical on it
CO3	Describe various solar thermal technologies and its uses in various applications
CO4	Discuss wind energy technologies and explain its operations
CO5	Explain grid integration of wind energy systems and its associated issues

Detailed Syllabus:

UNIT-I	**Basics of Energy:** Energy and Power, Hubert peak, Energy Scenario in India, Environmental impact of fossil fuels, Different types of energy sources - solar, wind, tidal, geothermal, wave energy, Introduction to fuel cells and Biomass
UNIT-II	**Solar PV Technology:** Amorphous mono-crystalline, poly-crystalline, V-I characteristics, Shading impact, PV module, Array, Maximum Power Point Tracking, Grid connected and standalone systems
UNIT-III	**Solar Thermal Technology:** Solar Spectrum, Solar Geometry, Sun Earth angles, Solar radiation at given locations, Flat plate collector, Parabolic trough, Central receiver, parabolic dish, Fresnel, solar pond, solar still
UNIT-IV	**Wind Energy Technology:** History of wind power, types of wind turbines, power in the wind, Betz limit, Tip speed ratio, stall and pitch control, wind speed statistics, probability distribution, wind generator topologies, voltage and reactive power control, power quality standard for wind turbines
UNIT-V	**Grid Integration of Wind Energy:** Wind farms, real and reactive power regulation, voltage and frequency operating limits, wind farm behavior during grid disturbances, power system interconnection, Economic aspects

Text and Reference Books:

1. Thomas Ackermann, Editor, "Wind Power in Power Systems", John Willy and sons ltd., 2005,ISBN 0-470-85508-8.
2. Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Willy and sons,2004,ISBN0-471-28060-7.
3. S. P. Sukhatme, "Solar Energy", Tata McGrew Hill, second edition, 1996, ISBN 0-07-462453-9.
4. Chetan Singh Solanki, "Solar Photovoltaics", fundamental, technologies and applications, PHI- second edition, 2011.
5. Siegfried Heier, "Grid integration of wind energy conversion systems" John Willy and sons ltd.2006.

6. Mullic and G.N.Tiwari, “Renewable Energy Applications”, Pearson Publications.
7. John A. Duffie, William A. Beckman, “Solar Engineering of Thermal Processes”, Wiley Inter science Publication, 1991

Sample Assessment Table:

Assessment Tool	K1+K2+K3	K1+K2+K3	K2+K3	K2+K3	K4
Course outcomes	CO1	CO2	CO3	CO4	CO5
Class Test 20 Marks	10	10			
Teachers Assessment 20 Marks	4	4	4	4	4
ESE Assessment 60 Marks	12	12	12	12	12

Teacher’s Assessment: Teacher’s Assessment is based on one of the following.

1.Assignments
2.Models/ Presentations
3.multiple choice questions test
4.Quiz

EE61002: DISSERTATION PHASE – I	
Teaching Scheme Practical: 20 Hrs/Week Credits :10	**Examination Scheme** Term Work : 50 Marks Viva-voce : 50 Marks Total : 100 Marks

Student will present seminar on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have following structure.

1. Head Of the department
2. Guide- Member
3. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.

EE61003: DISSERTATION PHASE – II	
Teaching Scheme Practical: 32 Hrs/Week Credits :16	**Examination Scheme** Term Work : 100 Marks Viva-voce : 150 Marks Total : 250 Marks

Student will present seminar on the dissertation work carried out as a part of term work. The department will constitute a committee of three members to evaluate the presentation. The committee will have following structure.

4. Head Of the department
5. Guide- Member
6. Subject expert from institute/industry-member

The committee will monitor the quality of the dissertation work.