PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR
SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B.TECH. IN ELECTRICAL ENGINEERING

Semester V			B. Tech. in Electrical Engineering											
Sr. No.	Course/Lab Code	Course/Lab Name	Teaching Scheme					Examination Scheme					
								Theory			Practical		Total
			L	T	P	C	Hrs/Wk	MS	ES	IA	LW	LE/Viva	Marks
1.	20EE301T	Power System Operations and Control	4	0	0	4	4	25	50	25	--	--	100
2.	20EE301P	Power System Simulation Laboratory	0	0	2	1	2	--	--	--	50	50	100
3.	20EE302T	Power Electronic Converters	3	0	0	3	3	25	50	25	--	--	100
4.	20EE302P	Power Electronic Converters Laboratory	0	0	2	1	2	--	--	--	50	50	100
5.	20EE303T	Instrumentation and Control	3	0	0	3	3	25	50	25	--	--	100
6.	20EE303P	Instrumentation and Control Laboratory	0	0	2	1	2	--	--	--	50	50	100
7.	20EE304T	High Voltage Engineering	3	0	0	3	3	25	50	25	--	--	100
8.	20EE304P	High Voltage Engineering Laboratory	0	0	2	1	2	--	--	--	50	50	100
9.	20EE3XXT	Professional Elective Course - I	3	0	0	3	3	25	50	25	--	--	100
10.	20EE3XXP	Professional Elective Course – I Laboratory	0	0	2	1	2	--	--	--	50	50	100
11.	20EE3XXT	Open Elective – III	3	0	0	3	3	25	50	25	--	--	100
12.	20HS301P	Communication Skills III	0	0	2	1	2	-	-	-	50	50	100
		Total	**19**	**0**	**12**	**25**	**31**						**1200**

IA- Internal Assessment, MS-Mid Semester; ES – End Semester Exam

The students have to select one theory course from the following basket for Professional Elective Course – I (Theory). Professional Elective Course – I Laboratory will be offered based on the selected Professional Elective Course – I (Theory).

Course Code	List of Professional Elective Course – I (Theory)	Course Code	List of Professional Elective Course – I Laboratory
20EE305T	Digital Signal Processing	20EE305P	Digital Signal Processing Laboratory
20EE306T	Analog and Digital Communication	20EE306P	Analog and Digital Communication Laboratory
20EE307T	Artificial Intelligence in Electrical Systems	20EE307P	Artificial Intelligence in Electrical Systems Laboratory

Department will offer Open Elective based on availability of expertise/faculty. This open elective will be offered to the students enrolled in B.Tech. programs of School of Technology other than Electrical Engineering.

Student of Electrical Engineering will have a choice for one open elective course from the basket of open electives announced by the other departments of School of Technology/other schools of university.

Course Code	Open Elective – III
20EE308T	Energy Management and Audit
20EE309T	Systems Thinking
20EE310T	Wind and Solar Energy

20EE301T					Power System Operations and Control					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
4	0	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To give exposure on power flow analysis methods for steady state solution of power system.
2. To analyse power system faults under balanced and unbalanced conditions.
3. To analyse the behaviour of power system subjected to transient disturbances.

UNIT I: POWER FLOW ANALYSIS AND ECONOMIC DISPATCH OF POWER SYSTEM **16 Hrs**

Per unit system, bus admittance matrix(*Y* Bus), static load flow equation, bus classification, load flow solution using Gauss Seidel, Newton-Raphson and FDLF method, line flow equations and losses calculation, **ECONOMIC DISPATCH (ED)**: Operating cost of thermal generating unit, ED neglecting line losses and generator limits, ED considering line losses and generator limits, Kuhn-Tucker Conditions, derivation of loss formula.

UNIT II: FAULT ANALYSIS OF POWER SYSTEM **15 Hrs**

Symmetrical Fault Analysis: R-L Circuit with sinusoidal excitation, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machine under transient conditions, Analysis of Symmetrical Fault using Thevenin's Equivalent circuit, **Symmetrical Components:** Symmetrical components of unbalanced phasors, power in terms of symmetrical components, sequence impedances and sequence networks for power system components. **Unsymmetrical Fault Analysis:** Analysis of faulted power system considering unsymmetrical faults.

UNIT III: POWER SYSTEM STABILITY **12 Hrs**

Classification of power system stability, solution of swing equation for synchronous generator, synchronous machine model without and with saliency for stability studies, transient stability analysis with equal area criteria, numerical solution of swing equation, multi-machine stability, small disturbance steady state stability, voltage stability, PV-QV curve, factors affecting voltage stability. Methods for power system stability improvement.

UNIT IV: AUTOMATIC GENERATION CONTROL **09 Hrs**

Frequency Control: Basic voltage and frequency control loops for generator, mathematical model of speed governing system, prime mover, generator, load and speed droop characteristic for load frequency control, and its importance. Automatic generation control in single area and multi area without and with secondary frequency controller, tie-line bias control.**Reactive Power and Voltage Control**: Mathematical model of amplifier, exciter, generator, sensor. Excitation system stabilizer with rate feedback and PID controller.

TOTAL HOURS 52 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Analyse steady state performance of power system by developing numerical methods for power flow analysis.
CO2 – Apply optimization techniques to obtain economic operation of power system.
CO3 – Analyse different types of balanced and unbalanced faults in power systems using per unit representation and symmetrical component.
CO4 – Classify power system stability and evaluate transient performance of power system with different small and large disturbances.
CO5 – Analyse voltage stability of power system and suggest measures for improvement.
CO6 – Model power system components to perform frequency and voltage control.

TEXT/REFERENCE BOOKS

1. Hadi Saadat, "Power System Analysis", Tata McGraw Hill
2. John J. Grainger and William D. Stevenson, "Power System Analysis", McGraw-Hill, 1994
3. J.D. Glover, M.S. Sharma and T.J. Overbye, "Power System Analysis and Design", 6th Edition, Cengage Learning
4. B R Gupta, "Power System Analysis and Design", S Chand
5. D Das, "Electrical Power Systems", New Age International
6. Kothari and Nagrath, "Modern Power System Analysis", TataMcGraw Hill
7. N V Ramana, "Power System Analysis", Pearson Education India, 2011

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 20 marks 80 Marks
Part B/Question: 2 Questions, one each from unit II and III, each carrying 10 marks 20 Marks

20EE301P					Power System Simulation Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To introduce students to computational tool and simulation software in power system
2. To learn programming to analyze power systems
3. To propose measures for power system performance improvement

LIST OF SIMULATIONS AND EXPERIMENTS

1. Introduction to MATLAB/Simulink, MiPower,PSCAD and PowerWorld software.
2. To calculate voltage regulation of transmission line under different loading conditions.
3. To perform compensation of transmission line under different loading conditions.
4. To simulate transient behaviour of long transmission line.
5. To obtain bus admittance matrix (*Y*bus) of a test power system.
6. To simulate power flow analysis using Gauss-Siedel, Newton-Raphson and Fast Decoupled Methods.
7. To perform economic operation of interconnected power system without constraints and line losses.
8. To perform economic operation of interconnected power system with constraints and line losses.
9. To simulate symmetrical fault and unsymmetrical faults for a test power system
10. To simulate transient stability of SMIB system using equal-area criteria for different large disturbances.
11. To simulate transient stability of SMIB by solving swing equation for different large disturbances.
12. To obtain PV and QV curve to analyze voltage stability of a test power system
13. To perform load frequency control for single area power system.
14. To perform load frequency control for multi-area power systems.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Operate computational tool and simulation software to analyze performance of power systems.

CO2 – Energize the transmission line, analyze its performance and suggest measures for its performance improvement.

CO3 – Simulate interconnected power network and carry out power flow analysis with different methods.

CO4 – Carry out short circuit analysis of power system for different symmetrical and unsymmetrical faults.

CO5 – Assess power system stability for different types of disturbances.

CO6 – Model power system for frequency and voltage control.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE302T					Power Electronic Converters					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To give exposure of power electronics domain and its applications in various sectors
2. To gain knowledge about the operating characteristics and working of power semiconductor switches
3. To analyse the operation and comprehend the applications of different power converters

UNIT I: POWER SEMICONDUCTOR SWITCHES **10 Hrs**

Significance of Power Electronics, Classification of Power Converters & their Applications, Power Semiconductor Switches (Power Diode, SCR, DIAC, TRIAC, Power BJT, MOSFET, IGBT, GTO), Introduction to Commutation Techniques, Gating Characteristics, Gating Techniques, Optical Isolation, Snubber Circuit Design, Heat Sink Design, Series - Parallel Operation of SCR.

UNIT II: CONTROLLED RECTIFIERS AND DC–DC CONVERTERS **11 Hrs**

1-Phase Controlled Rectifier: Half Wave, Full Wave and Semi Controlled Rectifiers, Effect of Free-Wheeling Diode on Converter Operation, Triggering Circuit Design, Dual Converters. **3-Phase Controlled Rectifier:** Half Wave, Full Wave, Semi Controlled Rectifiers, Effect of Free Wheeling Diode on Converter Operation, Comparison of Controlled Rectifier & PWM Rectifier. **Choppers & dc-dc Converters**: Classification of Choppers, Design of Buck Converter, Boost Converter, Buck-Boost Converter, Cuk Converter, Triggering Circuit Design for dc-dc converters.

UNIT III: DC–AC & AC–AC CONVERTERS **14 Hrs**

dc–ac Converters: Principle of Operation, 1-Phase Half Bridge and Full Bridge Inverter, 3-Phase Voltage Source Inverter (180^o and 120^o Mode of Conduction), Pulse Width Modulation Techniques, Unipolar and Bipolar Modulation, Harmonics, Power Factor, Distortion Factor, Displacement Factor, Harmonic Factor, Impact of Harmonics on Load Operation, Current Source and Voltage Inverters, Triggering Circuit Design for Inverters. **ac–ac Converters:** Classification, Operational Analysis of 1-phase ac voltage controllers feeding R and R-L Loads, 3-Phase ac Voltage Controller, ac Voltage Controller as a Soft Starter, Operating Principle & Topological Overview of Cycloconverter

UNIT IV: POWER ELECTRONIC CONVERTERS – RECENT TRENDS & APPLICATIONS **05 Hrs**

Wide Band Gap Semiconductor Devices, Applications of Power Converters in Electric Drives, Electric Vehicles, Wind Energy Conversion System, Solar Photovoltaic Systems, Industrial Automation, Electronics Appliances & Smart Grids

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the characteristics, features and construction of power semiconductor switches and associated circuit components

CO2 – Classify and apply the power semiconductor switches and power converters in different applications

CO3 – Examine the power structure and operation of ac-dc converters

CO4 – Design dc-dc converter as per the specified parameters

CO5 – Analyze the power structure and operation of dc-ac converters

CO6 – Classify different ac-ac converters and inspect their working

TEXT/REFERENCE BOOKS

1. M. H. Rashid, “Power Electronics: Circuits, Devices and Applications,” Prentice Hall of India Ltd., 2004.
2. Ned Mohan, T. M. Undeland and W. P. Robbins, “Power Electronics: Converters, Applications and Design,” Wiley India Ltd., 2003.
3. B. K. Bose, “Modern Power Electronics and ac Drives,” Prentice Hall Inc., 2001.
4. P. S Bimbhra, “Power Electronics,” Khanna Publishers-Delhi, 2004
5. D. W. Hart, “Power Electronics,” Tata McGraw-Hill, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks — 60 Marks

Part B/Question: 4 Questions, one each from unit I and II and two from unit III, each carrying 10 marks — 40 Marks

20EE302P					Power Electronic Converters Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To impart the practical knowledge about working of power semiconductor switches and power converters
2. To gain knowledge about the design of gating circuitry for power semiconductor switches and power converters
3. To understand the operation of power converters through experimental and simulation studies

LIST OF SIMULATIONS AND EXPERIMENTS

1. To design and implement dc power supply with the help of BJT and regulator ICs.
2. To determine holding and latching current of SCR and demonstrate the static V-I Characteristic of SCR
3. To design and implement gate drive circuit for MOSFET
4. To demonstrate the operation of different configurations of 1-Phase Uncontrolled Rectifier feeding R-Load and R-L Load
5. To demonstrate the operation of different configurations of 3-Phase Uncontrolled Rectifier Feeding R-Load, R-L Load, and R-L Load
6. To demonstrate the operation of different configurations of 1-Phase Controlled Rectifier feeding R-Load, R-L Load, and R-L Load with Freewheeling Diode
7. To demonstrate the operation of different configurations of 3-Phase Controlled Rectifier Feeding R-Load, R-L Load, and R-L Load with Freewheeling Diode
8. To demonstrate the operation of buck, boost and buck-boost converter
9. To demonstrate the operation of Class A, B, C Chopper
10. To demonstrate the operation of 1-Phase ac voltage regulator feeding lamp load
11. To demonstrate the operation of 1-Phase cycloconverter
12. To demonstrate the operation of 3-phase inverter with different modulation techniques
13. To design and implement a 1-phase full bridge inverter
14. To carry out simulation study related to power electronic converters
15. To study the application of power converters in different applications.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the significance of power semiconductor switches and power converters

CO2 – Experiment with power semiconductor switches to determine their characteristics and features

CO3 – Design the gate drive circuitry for power semiconductor switches

CO4 – Experimentally validate the performance of the power electronic converters

CO5 – Validate the performance of the power electronic converters through simulation studies

CO6 – Design power converters with the appropriate gate driver and power circuitry

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE303T					Instrumentation and Control					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concept of measurement systems and transducer characteristics.
2. To get a fair knowledge about various sensors and transducers for the measurement of various physical quantities.
3. To understand the concept of data acquisition and signal transmission in a measurement system.
4. To learn the various control strategies used in industrial process control.

UNIT I: MEASUREMENT SYSTEM **08 Hrs.**

Introduction to measurement system, types of measurements, components of measurement system, sensors and transducers, static and dynamic characteristics of measuring device, transducer classifications, electrical transducers, Digital measuring instruments like Digital voltmeter, Digital wattmeter, Digital energy meter, digital power factor method, transducer calibrations.

UNIT II: SENSORS & TRANSDUCERS **10 Hrs.**

Position sensors, speed and vibration measurements, force and pressure measurement, capacitive and Piezo-electric transducers, stain gauge, LVDT, temperature measurement using resistance thermometer, thermistors, RTD, thermocouples, pyrometer, measurement of liquid level, flow measurements, smart sensors, proximity sensors.

UNIT III: DATA ACQUISITION & SIGNAL TRANSMISSION **06 Hrs.**

Signal conditioning of the inputs, data conversion, analog to digital and digital to analog converters, telemetry system, current to voltage, voltage to current, current to pressure convertors, industrial data communication signals and communication protocols, Differential pressure transmitters, smart transmitters.

UNIT IV CONTROL STRETEGIES **16 Hrs.**

Principle and elements of process control, process characteristics, continuous and discontinuous control, proportional, integral, derivative and composite control modes (PI,PD,PID), tuning of PID controller, cascade control, feed-forward control, Pole placement control, Introduction to optimal control, Application of the process control in a power plant, Introduction to SCADA, Programmable Logic Control, PLC architecture, Working of PLC, input-output modules, Introduction to PLC programming using ladder logic, Introduction to distributed control system (DCS) and its architecture.

TOTAL HOURS 40

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Classify the components of a measurement system and to understand various sensor characteristics.

CO2 – Understand the working principle and identify various sensors/transducers for the measurement of physical variables.

CO3 – Examine the working of conventional control strategies for the process control.

CO4 – Understand the concept of data acquisition and to classify various communication protocols.

CO5 – Summarize the components and working of Programmable Logic Control (PLC) & Distributed Control System (DCS).

CO6 – Develop control strategies using state space approach.

TEXT/REFERENCE BOOKS

1. Ernest O. Doebelin, Measurement Systems: Application and Design, 5th edition, McGraw Hill, 2007.
2. D. Patranabis, Principles of Industrial Instrumentation, Tata McGraw Hill Publishing Company Ltd, 2008
3. A. K. Sawhney, Advanced Measurements and Instrumentation, Dhanpat Rai and Co., New Delhi, Johnson .C.D., Process Control Instrument Technology, Prentice Hall Inc. 2009.
4. B. Wayne Bequette, Process Control: Modelling, design and Simulation, Prentice-Hall International Series in the Physical and Chemical Engineering Sciences, 2002.
5. John R. Hackworth, Frederick, D. Hackworth, Programmable Logic Controllers: Programming Methods and Applications, Prentice-Hall, 2003.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks

Part B/Question: 4 Questions, one from unit I , one form unit II and two from unit IV, each carrying 10 marks 40 Marks

20EE303P					Instrumentation and Control Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To get a practical knowledge about various sensors and transducers and its industrial applications.
2. To simulate control strategies using control system design tool box in MATLAB/Simulink environment.
3. To design and implement various control strategies used in industrial process control.
4. To understand the concept of data acquisition and signal transmission in a measurement system.
5. To understand the working of programmable logic controllers and its programming.

LIST OF EXPERIMENTS

1. Introduction to control system design tool box in MATLAB.
2. Study various types of Sensors/Transducer and its characteristics.
3. To study the Analog to Digital (A /D) Converter.
4. To study the Digital to Analog (D/A) Converter.
5. To perform Displacement measurement using LVDT.
   Part A: Investigating the variable properties of the LVDT
   Part B: Investigating the differential properties of the LVDT
   Part C: Linear Measurement with the LVDT
6. To perform Force measurement using the Strain Gauge.
   Part A: The Strain Gauge Potential Divider
   Part B: The Quarter Strain Gauge Bridge
   Part C: The Half Strain Gauge Bridge
   Part D: The Full Strain Gauge Bridge
7. To measure linear displacement using Variable Area Capacitance transducer.
8. To measure rotary speed using Optical Techogenerator& Variable Reluctance probe (Inductive Pickup Sensor).
9. To conduct PLC programming using ladder logic and experimental demonstrate on dual conveyor belt system.
10. To study temperature measurement using Thermocouple, RTD and Thermistor sensors.
11. To design and implement PID controllers for single board heater system.
12. To design and implement PID controllers for pressure, flow and level control.
13. To study of level and flow control system with Cascade control loop.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the use of various MATLAB commands, Simulink environment and simulation tool boxes using MATLAB Computational Software.

CO2 – Develop the control strategies using MATLAB Simulation Environment.

CO3 – Perform hands-on experiments to verify the PID control strategies.

CO4 – Perform hands-on experiments with various sensors/transducers for the measurement of force, pressure and displacement measurement.

CO5 – Perform hands-on experiments with various sensors/transducers for the measurement of temperature measurement.

CO6 – Classify the components of a measurement system.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE304T					High Voltage Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concept of solid, liquid and gaseous dielectrics and various breakdown mechanisms
2. To get a fair knowledge about the generation and measurements of high dc, ac, impulse voltages and currents and understand various methods for the generation and measurements of High voltages.
3. To gain knowledge about the different testing technologies used for ensuring the qualities of insulating materials and high voltage equipments used in electrical network.

UNIT I: BREAKDOWN MECHANISMS IN VARIOUS DIELECTRICS 12Hrs.

Breakdown in Gases: Gases as insulating medium, Properties, Ionization processes, Townsend's theory, Current growth equation, Townsend's criteria of breakdown, Breakdown in electronegative gases and Vacuum, streamer theory, Paschen's law, Breakdown in non-uniform field.

Breakdown in Liquid Dielectrics: Liquid dielectrics: Application and properties, Classification of liquid dielectrics, Breakdown in pure liquid, Breakdown in commercial liquid: suspended particle, cavitation and bubble, stressed oil volume mechanism.

Breakdown in Solid Dielectrics: applications and properties, Various breakdown mechanisms: Intrinsic, electromechanical, thermal breakdown, breakdown due to treeing and tracking, breakdown due to internal discharges, breakdown in composite dielectrics.

UNIT II: GENERATION OF HIGH VOLTAGES AND CURRENTS 10Hrs.

Need of Generation of High ac, dc and impulse voltages, Different techniques used for the generation of high dc and ac voltages. Generation of high frequency high voltages, Generation of high impulse voltages and currents, Specifications of standard impulse wave, circuits for producing impulse waves and its analysis and control, Multistage impulse generators, Modified Marx circuit, tripping and control of impulse generators.

UNIT III: MEASUREMENT OF HIGH VOLTAGES AND CURRENTS 08Hrs.

Different methods/techniques used for the measurement of High dc, ac and impulse voltages, measurement of High dc, ac and impulse currents, CRO/DSO for impulse voltage and current measurements.

UNIT IV: HIGH VOLTAGE TESTING OF ELECTRICAL APPARATUS 10Hrs.

High Voltage Testing: High voltage testing of line Insulators, Bushings, isolators, circuit Breakers and surge arresters, high voltage testing of Cables, High voltage Testing of Transformers, Measurement of breakdown strength of transformer oil, Radio interference measurement. **Non-Destructive Testing:** Measurement of dc resistivity, measurement of dielectric constant and loss factor, partial discharge measurements, High Voltage Schering bridge.

TOTAL HOURS 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the fundamentals of High voltage Engineering, behaviour and properties of dielectrics

CO2 – Identify the different breakdown mechanism in solid, liquid and gaseous dielectrics

CO3 – Discuss and compare different techniques for the generation of high AC, DC and Impulse voltages

CO4 – Analyze different methods of measurement for high voltages and currents

CO5 – Classify and discuss different high voltage testing methods for Electrical apparatus

CO6 – Discuss and determine various non-destructive testing methods for Electrical apparatus

TEXT/REFERENCE BOOKS

1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill.
2. C. L. Wadhwa, "High Voltage Engineering", Wiley Eastern Ltd.
3. Subir Ray, "An Introduction to High Voltage Engineering", Prentice Hall of India.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 20 marks 80 Marks

Part B/Question: 2 Questions, one each from unit I and II, each carrying 10 marks 20 Marks

20EE304P					High Voltage Engineering Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To perform various breakdown mechanisms in solid, liquid and gaseous dielectrics
2. To generate and measure high dc, ac, impulse voltages and currents
3. To test the insulating properties of electrical equipments.

LIST OF EXPERIMENTS

1. Design, planning and layout of the high voltage laboratory.
2. To measure the breakdown strength of transformer oil.
3. To measure the insulation level of solid material.
4. To determine the breakdown characteristics of air for different types/shapes of electrodes
5. Electric field plotting by electrolytic tank
6. To Measure the A.C. Voltage using Rod gap apparatus
7. To Measure the D.C. Voltage using sphere gap apparatus
8. To understand the components, control and operation of 140kV, 1kJ impulse generator and observe the Impulse Voltage waveform as per IS (1.2/50 microseconds) on digital storage oscilloscope
9. To perform generation of switching surges impulse wave.
10. To study the phenomenon of corona formation (using horn gap Apparatus).
11. Testing of 11kV pin insulator
12. Determination of loss factor tanδ and capacitance C of the dielectrics by using high voltage Schering Bridge

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Design and planning of High voltage Engineering Laboratory

CO2 – Evaluate the performance of various dielectrics by performing breakdown testing

CO3 – Visualize and analyse the corona effects

CO4 – Experiment with sphere gap/Rod gap apparatus for measurement of High voltages

CO5 – Develop and analyze the lightning and switching Impulse voltage waves as per IS standards in the Lab.

CO6 – Determine the ability of the insulation of Line insulators by conducting high voltage withstand tests

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE305T					Digital Signal Processing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce discrete time system.
2. To understand different transformation techniques & algorithms to simplify those techniques.
3. To design & implement digital filters with different structure.
4. To study the application of digital signal processing.

UNIT I: DISCRETE-TIME SIGNALS AND SYSTEMS **10Hrs.**

Overview of Digital Signal Processing, Applications of Digital Signal Processing.

Discrete-time Signals and its properties, Discrete Systems and its properties, Convolution, Difference Equations, Discrete-time Fourier Transform (DTFT), Properties of DTFT, Frequency Domain Representation of LTI Systems, Sampling and Reconstruction of Analog Signals

UNIT II: THE Z- TRANSFORM &THE DISCRETE FOURIER TRANSFORM **10 Hrs.**

Z-TRANSFORM: Bilateral z-Transform, Important Properties of z-Transform, Inversion of z-Transform, System Representation in z-Domain, Solutions of Difference Equations.

DISCRETE FOURIER TRANSFORM: Discrete Fourier Series, Sampling and Reconstruction in the z-Domain, Discrete Fourier Transform, Properties of Discrete Fourier Transform, Linear Convolution using DFT, Fast Fourier Transform.

UNIT III: IMPLEMENTATION OF DISCRETE-TIME FILTERS **10Hrs.**

Basic Elements, IIR Filter Structures, FIR Filter Structures, Lattice Filter Structures, Overview of Finite-Precision Numerical Effects, Representation of Numbers, Process of Quantization and Error Characterizations, Quantization of Filter Coefficients

FIR FILTER DESIGN: Properties of Linear-phase FIR Filters, Window Design Techniques, Frequency Sampling Design Techniques, Optimal Equi-ripple Design Technique.

IIR FILTER DESIGN: Characteristics of Prototype Analog Filters, Analog-to-Digital Filter Transformations, Low-pass Filter Design, Frequency-band Transformations.

UNIT IV: DSP on ARM Processors **10Hrs.**

Introduction to STM32, Basic DSP notions, Data types, Floating point, Fixed point, Fixed-point vs. floating-point, Cortex® DSP instructions, Saturation instructions, MAC instructions, SIMD instructions, CMSIS Library, FFT demonstration, FFT performance, FIR filter demonstration, FIR filter design specification, FIR performance

TOTAL HOURS 40

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand basic concepts of signals & systems.

CO2 – Determine the use of Fourier transform & Z transform.

CO3 – Classify & design digital filter using different techniques.

CO4 – Develop the knowledge about hardware component of digital signal processor.

CO5 – Make use of different algorithms & techniques to process discrete signal

CO6 – Prioritize different transformation methods to process signal.

TEXT/REFERENCE BOOKS

1. John G. Proakis, Dimitris Manolakis, “Digital Signal Processing - Principles, Algorithms and Applications”, Pearson
2. Alan V. Openheim, “Discrete Time Signal Processing”, Pearson Education India
3. Sanjit K. Mitra, “Digital Signal Processing”, Mc-graw Hill
4. Richard G. Lyons, “Understanding Digital Signal Processing”, Prentice Hal

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks

Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE305P					Digital Signal Processing Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To improvise the use of different software tools.
2. To implement DSP Algorithms on MATLAB.
3. To understand Cortex-M4, M7 DSP optimization strategies
4. To improve the software handling skills of students.

List of Experiments:

1. To generate discrete sequence using software tool
2. To perform Operation on Sequence using software tool.
3. To represent basic signals (Unit step, unit impulse, ramp, exponential, sine and cosine).
4. To develop program for discrete convolution
5. To develop program for discrete correlation.
6. To understand stability test.
7. To perform Z Transform and Inverse Z-Transform and to find Poles, Zeroes and gain from a given Z-Transform using software tool.
8. To understand sampling theorem
9. To design analog filter (low pass, band pass, band stop, high pass filter).
10. To design digital IIR filter.
11. To design FIR filter using windows technique.
12. To write a program to compare direct realization values of IIR filter
13. Understand Cortex-M4, M7 DSP optimization strategies
14. Perform convolution using the ARM CMSIS-DSP Library
15. Perform Fast Fourier Transform (FFT) using the CMSIS-DSP Library
16. Develop Windowed-Sinc filters on ARM Processors

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Learn software tools to operate signal.

CO2 – Write the MATLAB and C++ codes for processing signals for different applications.

CO3 – Design digital filters using different techniques.

CO4 – Build passive Low-pass and High-pass filters

CO5 – Develop and test DSP algorithm on ARM Processor

CO6 – Perform spectral analysis on signals on ARM Processors

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE306T					Analog and Digital Communication					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the basic concepts and terminologies related to electronic communication
2. To gather knowledge about various modulation techniques and their merits and demerits
3. To learn analog modulation techniques and comparison amongst them
4. To learn about theoretical bounds on the rates of digital communication system and represent a digital signal using several modulation methods

UNIT I: Introduction To Electronic Communication **10 Hrs.**

Review of signals and systems, Frequency domain representation of signals, Principles of Amplitude Modulation Systems- DSB, SSB and VSB modulations. Angle Modulation, Representation of FM and PM signals, Spectral characteristics of angle modulated signals.

UNIT II Introduction to Random Processes and Pulse Modulation **10 Hrs.**

Review of probability and random process. Gaussian and white noise characteristics, Noise in amplitude modulation systems, Noise in Frequency modulation systems. Pre-emphasis and De-emphasis, Threshold effect in angle modulation. Pulse modulation. Sampling process. Pulse Amplitude and Pulse code modulation (PCM),Differential pulse code modulation. Delta modulation, Noise considerations in PCM, Time Division multiplexing, Digital Multiplexers.

UNIT III Digital Communication Basics **10 Hrs.**

Elements of Detection Theory, Optimum detection of signals in noise, Coherent communication with waveforms- Probability of Error evaluations. Baseband Pulse Transmission- Inter symbol Interference and Nyquist criterion. Pass band Digital Modulation schemes- Phase Shift Keying, Frequency Shift Keying, Quadrature Amplitude Modulation, Continuous Phase Modulation and Minimum Shift Keying.

UNIT IV Digital Modulation Trade-offs **10 Hrs.**

Optimum demodulation of digital signals over band-limited channels- Maximum likelihood sequence detection (Viterbi receiver). Equalization Techniques. Synchronization and Carrier Recovery for Digital modulation.

TOTAL HOURS 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Review the basic concepts of signals and systems and frequency domain representation of signals

CO2 – Understand different analog modulation schemes for their efficiency and bandwidth

CO3 – Analyze the behaviour of a communication system in presence of noise

CO4 – Investigate pulsed modulation system and analyze their system performance

CO5 – Evaluate different digital modulation schemes and can compute the bit error performance

CO6 – Elaborate various schemes used in digital communication

TEXT/REFERENCE BOOKS

1. Haykin S., "Communications Systems", John Wiley and Sons, 2001.
2. Proakis J. G. and Salehi M., "Communication Systems Engineering", Pearson Education, 2002
3. Taub H. and Schilling D.L., "Principles of Communication Systems", Tata McGraw Hill, 2001.
4. Wozencraft J. M. and Jacobs I. M., ``Principles of Communication Engineering'',John Wiley, 1965.
5. Barry J. R., Lee E. A. and Messerschmitt D. G., ``Digital Communication'', Kluwer Academic Publishers, 2004.
6. Proakis J.G., ``Digital Communications'', 4th Edition, McGraw Hill, 2000

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks

Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE306P					Analog and Digital Communication Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To study the basic concepts and terminologies of analog and digital modulation techniques
2. To verify frequency response of pre-emphasis and de-emphasis
3. To learn the functioning of balanced modulators for SSB generation and demodulation using diode detector
4. To study PAM, PWM, PPM and PCM through experimentation

List of Experiments

1. To observe the double sided full carrier AM waveform and calculate the depth of modulation (Modulation Index) also observe the AM detection using diode detector circuit.
2. To observe the FM waveform and to measure peak frequency deviation for 2V peak to peak modulating signal also observe the FM detection using PLL detector.
3. To observe the frequency response of the Pre-emphasis and de-emphasis circuits.
4. To observe the generation of SSB signal using balance modulator and single sideband filter.
5. To observe the demodulation of SSB signal using diode detector and product modulator.
6. To study PAM, PWM and PPM modulation and demodulation and also sketch the output waveform.
7. To observe the working of Radio receiver and analyze the significance of the AGC circuit.
8. To study the output of the Sample and Hold circuit and it's reconstruction at 4KHz sampling frequency (to analyze the Nyquist Rate/ Criteria)
9. To understand the concept of PCM and observe the PCM waveforms.
10. To understand the concept of Delta modulation and achieve delta modulation and demodulation.
11. To study the ASK modulation and demodulation also to sketch the modulated and demodulated waveforms.
12. To study the FSK modulation and demodulation also to sketch the modulated and demodulated waveforms.
13. To study the PSK modulation and demodulation also to sketch the modulated and demodulated waveforms.
14. To study the QPSK modulation and demodulation also to sketch the modulated and demodulated waveforms.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the basic concepts of analog and digital modulation techniques
CO2 – Understand terminologies of analog modulation schemes for their efficiency and bandwidth
CO3 – Analyze the behaviour frequency response of the Pre-emphasis and de-emphasis circuits
CO4 – Investigate ASK, FSK, PSK, and QPSK and analyze their system performance
CO5 – Evaluate performance of PAM, PWM, PPM & PCM schemes
CO6 – Analyze AGC circuit and understand working of Radio receiver

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE307T					Artificial Intelligence in Electrical Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To give exposure to Artificial Intelligence and its applications in Electrical Systems.
2. To gain knowledge about fuzzy logic and artificial neural networks and their applications in electrical systems
3. To comprehend the application of Genetic Algorithms and machine learning in electrical systems

UNIT I: INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND FUZZY SYSTEMS **10 Hrs**

Artificial Intelligence: Definition, Significance, Scope and Applications. **Fuzzy Systems:** Fuzzy Sets and Operations, Membership Functions, Fuzzification and Defuzzification, Rule Base, Introduction to Fuzzy Logic Control, Architecture of Mamdani and Takagi-Sugeno Fuzzy Models, Application Example

UNIT II: ARTIFICIAL NEURAL NETWORKS **10 Hrs**

Introduction to Artificial Neural Networks, Biological Neuron, Artificial Neuron, Activation Functions of Artificial Neuron, Structure of Artificial Neural Network, Feedforward and Recurrent Artificial Neural Networks, Training of Artificial Neural Networks, Learning Methods, Back Propagation Algorithm, Application Example

UNIT III: GENETIC ALGORITHM **10 Hrs**

Optimization, categories of optimization, biological optimization; Binary Genetic Algorithm (BGA):Components of BGA, variable selection and cost function, variable encoding and decoding, population, selection, mating, mutation, next generation, convergence; Continuous GA: Variable encoding, precision and bounds, pairing, mating, mutation, next generation, Application Example

UNIT IV: MACHINE LEARNING **10 Hrs**

Introduction to Machine Learning (ML), Types of ML (Supervised Learning, Unsupervised Learning, Reinforcement Learning & Evolutionary Learning), Support Vector Regression, Support Vector Machine (SVM), Logistic Regression

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the concept of Artificial Intelligence and its applications in electrical systems.

CO2 – Apply the knowledge of fuzzy system and fuzzy controller to several electrical systems.

CO3 – Build the structure of artificial neural network for a given problem and train the network as per the given data.

CO4 – Apply artificial neural networks in various domain of electrical systems.

CO5 – Implement Genetic Algorithm to minimize different objective functions

CO6 – Understand the concepts and different types of Machine Learning Algorithms.

TEXT/REFERENCE BOOKS

1. Saifullah Khalid, **"Aapplications of Artificial Intelligence in Electrical Engineering,"**Business Science Reference, 2020.
2. T.J.Ross, **"Fuzzy Logic with Engineering Applications,"** 3rdEdition , Wiley, 2011.
3. Simon S. Haykin, **"Neural Networks – A Comprehensive Foundation,"** Pearson Education, 1997.
4. Thomas Weise, **"Global Optimization Algorithms Theory and Application,"** 2nd Edition, Institute of Applied Optimization.
5. Rajesh Kumar Arora, **"Optimization Algorithms and Applications,"** CRC Press, 2015.
6. Ethem Alpaydin, **"Introduction to Machine Learning,"** MIT press, 2010
7. Stephen Marsland, **"Machine Learning: An Algorithmic Perspective,"** CRC Press, 2015.
8. Randy L. Haupt, Sue Ellen Haupt, "Practical Genetic Algorithm", 2nd Edition, John Wiley & Sons Inc. Publication, 2004

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks

Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE307P					Artificial Intelligence in Electrical Systems Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To impart the knowledge about Artificial Intelligence and its applications
2. To implement fuzzy systems, artificial neural networks, Genetic Algorithm and machine learning
3. To learn about the application of fuzzy systems, artificial neural networks, Genetic Algorithm and machine learning in electrical systems through simulation studies

LIST OF EXPERIMENTS

1. Design of fuzzy PID controller for the given plant
2. Design of fuzzy system for estimation of electrical motor parameter
3. Demonstrate training of an artificial neural network for the given mathematical function
4. Demonstrate training of an artificial neural network for filtering
5. Demonstrate application of an artificial neural network in electric power system
6. Demonstrate an application of machine learning classification algorithm in electrical systems
7. Demonstrate an application of machine learning regression algorithm in electrical systems
8. To write MATLAB code to minimize Rosenbrock's function using GA
9. To minimize/maximize objective functions using Genetic Algorithm toolbox in MATLAB
10. To formulate Economic Dispatch problem and minimize operating cost function using GA

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Implement artificial intelligence algorithms using simulation tools.
CO2 – Simulate the application of fuzzy system to electrical systems.
CO3 – Comprehend structure and training of artificial neural network on simulation platform .
CO4 – Interpret the working of artificial neural network in an electrical system.
CO5 – Write code for GA and use GA toolbox in MATLAB to optimize different objective functions
CO6 – Demonstrate the use of machine learning in electrical engineering applications.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE308T					Energy Management and Audit					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concept of energy management and audit.
2. To understand energy management procedures for electric motor, pumps & pumping systems and lighting system including understanding of energy monitoring.
3. To know energy audit procedure.
4. To understand the concepts of different energy efficient technologies in electrical systems.

UNIT I: GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT **12Hrs.**

Energy Scenario: Commercial and Non-commercial energy, primary energy resources, energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, re-structuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act- 2001 and its features. **Basics of Energy and its various forms:** Electricity basics, electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors. **Energy Management & Audit:** Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments, Case Studies on Energy Audit

UNIT II: ENERGY MANAGEMENT IN ELECTRIC SYSTEM AND ENERGY MONITORING **10Hrs.**

Energy Monitoring and Targeting: Defining monitoring & targeting, elements of monitoring & targeting, data and information-analysis, techniques -energy consumption, production, cumulative sum of differences (CUSUM).**Electrical system:** Electricity billing, electrical load management and maximum demand Control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses.

UNIT III: ENERGY EFFICIENCY IN ELECTRICAL AND THERMAL UTILITIES **10Hrs.**

Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, motor replacement issues, energy saving opportunities with energy efficient motors.**Pumps and Pumping System:** Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities.**Lighting System:** Light source, choice of lighting, luminance requirements, and energy conservation avenues.**Energy Efficiency in Thermal Utilities:** Energy efficiency in thermal utilities like boilers, furnaces, pumps and fans , compressors, cogeneration (steam and gas turbines), heat exchangers, Motors belts and drives, refrigeration system.

UNIT IV: ENERGY EFFICIENT TECHNOLOGIES IN ELECTRICAL SYSTEMS **08Hrs.**

Energy Efficient Technologies in Electrical Systems: Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

TOTAL HOURS 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the general aspects of energy management and audit

CO2 – Identify the demand supply gap of energy in Indian Scenario

CO3 – Select appropriate energy conservation method to reduce wastage of energy

CO4 – Apply knowledge of the subject to carryout energy management and audit in Industry/organization

CO5 – Estimate and improve the energy efficiency in electrical and thermal utilities

CO6 – Determine the technologies used for energy efficiency in electrical systems

TEXT/REFERENCE BOOKS

1. Bureau of Energy Efficiency (BEE), material. https://beeindia.gov.in
2. Albert Thumann, William J. Younger, Handbook of Energy Audits, CRC Press
3. D. Yogi Goswami, Frank Kreith, Energy Management and Conservation Handbook, CRC Press
4. G.G. Rajan, Optimizing energy efficiencies in industry, Tata McGraw Hill, Pub.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks

Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE309T					Systems Thinking					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To teach the history behind industrial dynamics.
2. To introduce the concepts of system thinking.
3. To introduce to concept of state, state space and system dynamics.
4. To apply the concepts of system thinking to analyse Engineering systems

UNIT I: SYSTEM DYNAMICS **10 Hrs.**

Definition, Introduction to Industrial Dynamics (ID), Historical background, Evolution of system dynamics, Nature of systems, simple to complex systems, Concept of state and state space, types of processes, linear, non-linear, continuous , discrete process, distributed parameter, lumped parameter process.

UNIT II: SYSTEM DYNAMICS MODELS **14 Hrs.**

Differential equations verses Integration, First principle modelling, Data based modelling, Role of data in system dynamics models, Principles of influence, Causal loop diagrams, Principles of stock flow diagram, Introduction to discrete event systems, Modelling of discrete event system and simulations, state space models, Transfer function models, Effect of system poles and zeroes on system dynamics, Optimization in system dynamic models.

UNIT III: INTRODUCTION TO SYSTEMS THINKING **08 Hrs.**

System thinking and design, Theories of system thinking, System thinking tools, Quantitative tools of system thinking, Introduction to Control Engineering, Open loop and closed loop systems, Control system examples, Types of feedback and feedback system theory.

UNIT IV: CASE STUDIES **08 Hrs.**

Case studies related with system thinking approach in Engineering and Management systems, First principle and data based modelling of Electrical, Mechanical , Chemical, Thermal, Environmental systems, Simulation studies using MATLAB/Scilab.

TOTAL HOURS 40

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the theories of system thinking.
CO2 – Apply the first principle laws to model the simple systems.
CO3 – Understand the evolution of system and industrial dynamics
CO4 – Learn the concepts of feedback system theory.
CO5 – Apply the optimization theory in modelling of dynamical systems.
CO6 – Apply the system thinking approach in Engineering.

TEXT/REFERENCE BOOKS

1. Forrester J.W., Industrial Dynamics, MIT Press, Mass.
2. Daniel H. Kim, Introduction to Systems Thinking, Pegasus.
3. Richardson GP and Pugh AL, Introduction to System Dynamics Modelling with DYNAMO, MIT Press, Cambridge, MA. (1981).
4. I.J. Nagrath and M.Gopal , Systems Modelling and Analysis, Tata McGraw-Hill Publishing Company Limited.
5. Jerry Banks, John S. Carson-II and Berry L. Nelson, Discrete Event System Simulation, 5/e, Pearson.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks
Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE310T					Wind and Solar Energy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To discuss the importance of energy in human life, relationship among energy, economy and environment.
2. To understand the process of harnessing solar energy and wind energy.
3. To discuss the basic of solar thermal and solar photovoltaic energy systems
4. To discuss classification of wind energy conversion systems, its advantages and disadvantages.

UNIT I: INTRODUCTION TO ENERGY ENGINEERING **08 Hrs.**

Introduction, Energy, Economy and Social Development, Fundamentals and Classification of Energy Sources, Significance of Renewable Energy, Global and Indian Energy Statistics, Important Aspects of Energy Conservation, Global Efforts, Achievements and Future Planning, Energy Conservation/Efficiency Scenario in India, Energy Audit, Energy Conservation Opportunities.

UNIT II: SOLAR ENERGY BASICS **08 Hrs.**

Introduction, The Sun as Source of Energy, The Earth, Sun, Earth Radiation Spectrum, Extra-terrestrial and Terrestrial Radiations, Spectral Power Distribution of Solar Radiation, Depletion of Solar Radiation. Measurement of Solar Radiation, Solar Radiation Data, Solar Time, Solar Radiation Geometry, Solar Day Length, Extra-terrestrial Radiation on Horizontal Surface, Empirical Equations for Estimating Terrestrial Solar Radiation on Horizontal Surface, Solar Radiation on Inclined Plane Surface.

UNIT III: SOLAR ENERGY CONVERSION SYSTEM **08 Hrs.**

Solar Thermal Systems: Introduction, Solar Collectors, Solar Water Heater, Solar Passive Space Heating & Cooling Systems, Solar Industrial Heating Systems, Solar Refrigeration & Air Conditioning Systems, Solar Cookers. **Solar Photovoltaic Systems:** Solar Cell Fundamentals, Solar Cell Characteristics, Solar Cell Classification, Solar Cell Technologies, Solar Cell, Module, Array, Maximizing Solar PV Output & Load Matching, Maximum Power Point Tracker, Balance of System Components, Applications.

UNIT IV: WIND ENERGY **16 Hrs.**

Wind Energy Physics: Introduction, Basic Principles of Wind Energy Conversion, History of Wind Energy, Power in the Wind, Forces on the Blades, Wind Energy Conversion, Wind Data and Energy Estimation, Site Selection Considerations, Betz Limit. **Wind Energy Conversion System:** Important Terms and Definitions Pertaining to Wind Energy Conversion System: Blade Angle, Pitch Angle, Tip Speed Ratio, Power Coefficient, Maximum Power Point Tracking, Yaw Control, Pitch Control, Stall Control, Wind Power, Wind Speed, Cut In Speed, Cut Out Speed, Rated Speed, Wind Histogram**,** Aerodynamic Forces Acting on the Blade, Components of Wind Turbine Generating System and its Function, Power-Speed & Power-Torque Characteristics, Classification of Wind Energy Conversion System, Types of Wind Energy Systems in Context with Type of Generator Used (Type A, B, C, D), Advantages and Disadvantages, Application, Working of Fixed speed Induction Generator, Working of Variable Speed Generators.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 – Understand the energy scenario and significance of power generation from renewable energy sources

CO2 – Define the basic terminologies involved in operation of solar and wind energy conversion systems

CO3 – Describe the process of harnessing solar energy and its applications in heating and cooling.

CO4 – Understand the basics of solar photovoltaic system

CO5 – Classify various types of wind energy generating system

CO6 – Explain basic principles of wind energy conversion, its advantages and disadvantages

TEXT/REFERENCE BOOKS

1. Masters G., "Renewable and Efficient Electric Power Systems", John Wiley & Sons, Inc., Publication.
2. Mathew S., Wind Energy-Fundamentals, Resource Analysis and Economics, Springer, 2006.
3. Rao &Parulekar, Energy Technology –Khanna Publications, New Delhi, 2007.
4. Patel M R. "Design, Analysis, and Operation Wind and Solar Power Systems", Taylor & Francis, Second Edition.
5. Sawhney G. S., "Non-conventional energy sources", PHI Learning Pvt. Ltd.
6. Rai, G. D, "Non-Conventional Sources of Energy", Khanna Publishers 4th Edition, 2009

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 20 marks 80 Marks

Part B/Question: 1 Questions from unit IV carrying 20 marks 20 Marks

20HS301P					Communication Skills – III					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	0	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To strengthen the communication skills of professionals to make them ready for the modern workplace.
2. To fine tune their professional skills and expertise using communication skills.
3. To participate in the life long learning process with confidence and certainty.

UNIT I **10 Hrs**

- Writing research proposals
- Writing technical projects

UNIT II **15 Hrs**

- The Art of Presentation
  - *Sapiens: A Brief History of Humankind* (2011), Yuval Noah Harari
  - *Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations* (2016), Thomas L. Friedman
  - (Presentation in teams of 4 students each, not more than two from the same branch, with a view to promote cross-disciplinary research)

UNIT III **5 Hrs**

Uploading portfolios on SlideShare

- ✓ Uploading Video modules

Max. 30 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Demonstrate enhanced communications skills for enhanced team work for a better result.

CO2 – Apply critical analysis for innovative thinking and well-rounded perspectives in different settings and contexts.

CO3 – Analysis of situations to identify opportunities for professional and career growth through strong communication skills.

CO4 – High competence of oral, written and visual communication skills for a workplace ready professional.

CO5 – Realization and application of communication skills and language processes for multiple perspectives and interdisciplinary approach in profession.

CO6 – Improved communication skills for improved research, organizational, and critical thinking and perspective.

TEXT/REFERENCE BOOKS

1. Kaul, Asha. Business Communication. Delhi: Prentice-Hall of India, 2006.
2. Maley, A. 'Literature in the Language Classroom', The Cambridge Guide to Teaching ESOL, Cambridge University Press, 2001.
3. Richards, Jack C., and Willy A. Renandya, eds. Methodology in Language Teaching: An Anthology of Current Practice. Cambridge University Press, 2002.
4. Sharma, Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. New Delhi: PHI Learning Pvt. Ltd., 2009.

Assessment Tool	Marks	Assignments
Lab Work	50	• Business Proposal – 15 • Research Project Proposal – 15 • Reviews on the two books – 20
Lab Exam/Viva	50	• Presentation on the reviews of the two books (Intra Branch) – 15 • Presentation on a technical topic (Inter Branch) – 15 • Slideshare/Video Modules (Prescribed Texts) – 20

PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR
SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B.TECH. IN ELECTRICAL ENGINEERING													
Semester VI			**B. Tech. in Electrical Engineering**										
Sr. No.	**Course/Lab Code**	**Course/Lab Name**	**Teaching Scheme**					**Examination Scheme**					
								Theory			**Practical**		**Total**
			L	**T**	**P**	**C**	**Hrs/Wk**	**MS**	**ES**	**IA**	**LW**	**LE/Viva**	**Marks**
1.	20EE311T	Power System Protection	3	0	0	3	3	25	50	25	--	--	100
2.	20EE311P	Power System Protection Laboratory	0	0	2	1	2	--	--	--	50	50	100
3.	20EE312T	Electric Drives	3	0	0	3	3	25	50	25	--	--	100
4.	20EE312P	Electric Drives Laboratory	0	0	2	1	2	--	--	--	50	50	100
5.	20EE3XXT	Professional Elective Course – II	3	0	0	3	3	25	50	25	--	--	100
6.	20EE3XXP	Professional Elective Course – II Laboratory	0	0	2	1	2	--	--	--	50	50	100
7.	20EE3XXT	Professional Elective Course – III	3	0	0	3	3	25	50	25	--	--	100
8.	20EE3XXP	Professional Elective Course – III Laboratory	0	0	2	1	2	--	--	--	50	50	100
9.	20EE3XXT	Open Elective - IV	3	0	0	3	3	25	50	25	--	--	100
10.	TP310	Industrial Training/ IEP (6 weeks)				2		--	--	--	--	100	100
		Total	**15**	**0**	**08**	**21**	**23**						**1000**

IA- Internal Assessment, MS-Mid Semester; ES – End Semester Exam

The students have to select two theory courses from the following basket for Professional Elective Course – II & III (Theory). Professional Elective Course – II & III Laboratory will be offered based on the selected Professional Elective Course – II & III (Theory).

Course Code	List of Professional Elective Course – II and III (Theory)	Course Code	List of Professional Elective Course – II and III Laboratory
20EE313T	Renewable Energy Engineering	20EE313P	Renewable Energy Engineering Laboratory
20EE314T	Advanced Power Electronic Converters	20EE314P	Advanced Power Electronic Converters Laboratory
20EE315T	Advanced Power System Analysis	20EE315P	Advanced Power System Analysis Laboratory
20EE316T	Embedded Systems	20EE316P	Embedded SystemsLaboratory

Department will offer Open Elective based on availability of expertise/faculty. This open elective will be offered to the students enrolled in B.Tech. programs of School of Technology other than Electrical Engineering.

Student of Electrical Engineering will have a choice for one open elective course from the basket of open electives announced by the other departments of School of Technology/other schools of university.

Course Code	Open Elective - IV
20EE317T	Electric Vehicles
20EE318T	Net Zero Energy Buildings

20EE311T					POWER SYSTEM PROTECTION					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce the students with basic concepts of Relays, Protection schemes, Switch gear and Modern trends in protection for protecting the power system equipments
2. To appreciate and understand scientific concepts underlying engineering and technological applications
3. To educate the basic concepts and new developments in power system protection & Switchgear
4. To emphasize the significance of protection for electrical equipments

UNIT I BASICS OF POWER SYSTEM PROTECTION **10 Hrs.**

Introduction and Philosophy of A Protective Relaying System: Types of Faults, Abnormalities, Functions of Protective Relay Schemes, major Components of Power system, Basic Tripping Circuit, Testing and Maintenance of Relay, Zones of Protection, Requirements of Protective Systems, Relay Operating Criteria, Main and Backup Protection, Historical Review of Protective Relay Technology. **Protective Current And Potential Transformer:** CT Equivalent Circuit, Vector diagram, Construction, magnetization Curve, Core, Errors, accuracy, Specifications, Factors affecting selection PT: Equivalent circuit, Construction, CVT, Specifications. **Different Types of Relays: Electromagnetic Relays**: Classification, Thermal O/L Relays, Types Over Current Relays, Differential Relay, Directional Relay, Impedance Relays. **Static Relays:** Advantages and Limitations, basic Elements, Static Relays Architecture. **Microprocessor Based Digital Protection:** Advantages of Numerical Relays, Numerical Relay Hardware, Digital Signal Processing, Estimation of Phasors, Full Cycle Fourier Algorithm, Half Cycle Fourier Algorithm, Practical Consideration for Selection of Algorithm, DFT- FFT.

UNIT II EQUIPEMENT PROTECTION **14 Hrs.**

Generator Protection: Differential Protection , Inter-turn fault Protection, stator E/F, Rotor E/F, NPS, Field Failure, Over Load, Over Voltage, Reverse Power, Pole-Slipping, Back-up Impedance, Under Frequency , Miscellaneous Protection. **Transformer Protection:** Faults in Transformers, Gas operated relays, Over Current Protection, REF Protection, Differential Protection, Protection against over fluxing, Protection of Grounding transformers, Protection Against Overheating, Protection for small transformers. **Induction Motor Protection:** Starting of IM, Faults in IM, Abnormalities of IM, Protection of small IM, Protection of Large IM. **Numerical Approach to Apparatus Protection (Overview):** Generator Protection, Transformer Protection, Induction Motor Protection

UNIT III PROTECTION OF TRANSMISSION LINES **10 Hrs.**

Protection of Lines by Over Current Relays and Distance Relays, Carrier Current Protection for lines. **Bus Zone Protection:** Protection Requirements, Non unit protection, Unit protection schemes, Breaker Back-up Protection

UNIT IV THEORIES OF CIRCUIT INTERRUPTION & CIRCUIT BREAKERS **06 Hrs.**

Theory Of Circuit Interruption: Introduction, Physics of arc phenomena, Maintenance of the arc, Essential properties of arc, Arc interruption theories.**Important Terms, Phenomena's &Ratings related to circuit breakers:** Introduction, Arc-voltage, Re-striking Voltage, Recovery voltage, RRRV, Current chopping, Capacitive current breaking, Resistance Switching, Circuit Breaker Ratings. **Theory and Practice Of Conventional Circuit Breakers:** Classification of Circuit breakers, Types-Construction- Operating Principle- Relative merit-demerits of conventional circuit breakers (OIL Circuit Breaker, AIR Circuit Breaker)**Recent Developments In Circuit Breakers:**, Sulphur hexafluoride (SF6) circuit breaker, Vacuum circuit breaker, HVDC circuit breaker

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 Understand physics of arc phenomena, basic theory of circuit interruptions, the construction and principle of operation for various types of circuit breakers
CO2 Understand basic philosophy of protective relaying practices
CO3 Compare electromagnetic, static and Microprocessor based relays
CO4 Analyze protective relaying schemes for power system components
CO5 Choose suitable protective relaying schemes for power system components
CO6 Estimate relay settings for protective relaying schemes for power system components

TEXT/REFERENCE BOOKS

1. Oza, Nair, Mehta, Makwana, "Power System Protection and switchgear", TMH.
2. Stanley H. Horowitz, Arun G. Phadke, "POWER SYSTEM RELAYING"-Third Edition,2008 Research Studies Press Limited
3. J. Lewis Blackburn, Thomas J. Domin, "Protective Relaying Principles and Applications" –Third Edition, CRC Press, T&F, 2006.
4. C. Russell Masson, "Art And Science Of Protective Relaying",
5. Y. G. Parithankar and S. R. Bhide, "Fundamentals Of Power System Protection" 2nd edition, PHI
6. Bhavesh Bhalja, Nilesh Chothani, "Protection and switchgear", Oxford Publication 2011
7. B. Ram, "Power System Protection" TMH Publication

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks
Part B/Question: 4 Questions, 1 from unit I and 2 from unit II, each carrying 10 marks 40 Marks

20EE311P					Power System Protection Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	50	50	100

Course Objectives:

1. To introduce the students with basic concepts of construction, operating Principle and working of various types of relays
2. To appreciate and understand scientific concepts underlying engineering and technological applications in the area of power system protections
3. To familiarise the students for relay setting procedures for various protection schemes
4. To emphasize & inculcate the significance of protection for electrical equipments through various performance based experiment through state of the art laboratory facilities

List of Experiments:

1. Introduction & familiarization with the laboratory
2. Study & Performance of MCB,ELCB,FUSE & plotting their performance characteristic
3. Study of the construction & Operation of Electromechanical Relay
4. Testing, Calibration of Electromechanical Over Current Relays (Normal Inverse, Very Inverse & Extreme Inverse Characteristics)
5. Principles of Radial feeder Protection – Calculations, Relay Settings
6. Principles of Radial feeder Protection –Verifications through Hardware Simulations
7. Study & familiarization of Numerical Relay
8. Principles of Over Voltage & Under voltage Protection – Calculations, Relay Settings
9. Principles of Over Voltage & Under voltage Protection – Verifications through Hardware Simulations
10. Principles of Parallel feeder Protection - Calculations, Relay Settings
11. Principles of Parallel feeder Protection– Verification through Hardware Simulations
12. Principles of Transformer Protection - Calculations, Relay Settings
13. Principles of Transformer Protection -Verification through Hardware Simulations
14. Principles of Transmission Line Protection (Distance Protection) – Calculations , Relay Settings & Verification through hardware simulations
15. Principles of Transmission Line Protection (Carrier Current Protection) – Calculations , Relay Settings & Verification through hardware simulations
16. Principles of Induction Motor Protection- Calculations , Relay Settings & Verification through hardware simulations
17. Principles of Generator Protection- Calculations & Relay Settings
18. Principles of Generator Protection -Verification through hardware simulation

COURSE OUTCOMES

On completion of the course, student will be able to;

CO1 – Understand the control & power circuit diagrams of Industrial grade panels
CO2 – Compare the performance characteristics of FUSE, MCB, and ELCB
CO3 – Understand construction, working, operation of Electromechanical / Electromagnetic, Microprocessor based / Numerical Relays
CO4 – Evaluate and validate relay settings for the over current protection, earth fault protections & distance protection of transmission lines
CO5 – Evaluate and validate relay settings for various protection schemes used for power transformers
CO6 – Evaluate and validate relay settings for various protection schemes used for rotating machines (Induction Motor, Alternator)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE312T					Electric Drives					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart knowledge about the significance, fundamental concepts and elements of electric drives
2. To gain knowledge about the fundamental concepts and speed control of electric motors
3. To understand the operational analysis, applications, features and control of dc and ac motor drives

UNIT I: FUNDAMENTALS OF ELECTRIC DRIVES **08 Hrs**

Introduction to Electric Drives, Significance of Electric Drives, Elements of Electric Drives, Fundamental Torque Equation, Four Quadrant Operation, Classification of Load Torque, Steady State Stability, Basic Design of Electric Drives.

UNIT II: DC MOTOR DRIVES **04 Hrs**

Introduction to dc Motors, Starting and Braking of dc Motors, Conventional Techniques for Speed Control of dc Motors (Armature Voltage Control and Field Control), Solid State Control of dc Motors, Controlled Rectifier fed dc Motor Drives, Chopper fed dc Motor drives.

UNIT III: INDUCTION MOTOR DRIVES **14 Hrs**

Introduction to Induction Motors, Starting and Braking of Induction Motors, Impact of Unbalanced Stator Voltage on Motor Performance, Impact of Non-Sinusoidal Stator Voltage on Motor Performance, Conventional Techniques for Speed Control of Induction Motors (Stator Voltage Control, Pole Changing Method, Rotor Resistance Control, Frequency Control, Slip Power Recovery Scheme), ac Voltage Controller fed Induction Motor Drives, VSI fed Induction Motor Drives, Scalar Control, Static Rotor Resistance Control, Static Kramer Drive, Static Scherbius Drive.

UNIT IV: PERMANENT MAGNET BRUSHLESS DC & STEPPER MOTOR DRIVES **14 Hrs**

PMBLDC Motor Drives: Permanent Magnet Materials, Applications, Construction, Operating Principle & Characteristics, Electronic Commutation, Hall Effect Sensors for Position Measurement, Mathematical Modelling, Speed Control of PMBLdc Motors. **Stepper Motor Drives:** Application, Construction, Classification, Operating Principle and Characteristics, Power Converters for Stepper Motors, Stepper Motor Drives. Introduction to Linear Induction Motor Drives, Synchronous Reluctance Motor Drives and Switched Reluctance Motor Drives.

TOTAL HOURS **40 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the significance, structure and components of electric drives
CO2 – Apply the fundamental concepts of dc motors for modelling and control of dc drives
CO3 – Design the power and control structure for speed control of dc motor drives and analyze its operation under different operating scenarios
CO4 – Apply the fundamental concepts of induction motors for analysing the classical speed control techniques
CO5 – Develop the solid state control of induction motor and analyze its operation under various operating scenarios
CO6 – Develop permanent magnet brushless dc and stepper motor drives after understanding the fundamental concepts related to the electric motors

TEXT/REFERENCE BOOKS

1. G. K. Dubey, "Fundamentals of Electrical Drives," 2nd Edition, Narosa Publication.
2. R. Krishnan, "Electric Motor Drives: Modelling Analysis and Control," Prentice Hall Inc.
3. B. K. Bose, "Modern Power Electronics and ac Drives," Prentice Hall Inc.
4. Vedam Subramanyam, "Electric Drives – Concepts and Applications," Tata McGraw Hill.
5. V.V. Athani, "Stepper Motors: Fundamentals, applications and Design", Tata McGraw Hill.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 15 marks 60 Marks
Part B/Question: 4 Questions, 2 from unit III and 2 from unit IV, each carrying 10 marks 40 Marks

20EE312P					Electric Drives Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To impart the practical knowledge about the components and structure of electric drives
2. To learn operation of control and power architecture of dc drives and induction motor drives
3. To understand the operation of permanent magnet brushless dc and stepper motor drives and unique aspects related to the control architecture

LIST OF SIMULATIONS AND EXPERIMENTS

1. To simulate the mathematical model of dc motors.
2. To study the operation of controlled rectifier fed separately excited dc motor drive operating in open loop control and closed loop control mode through experimental studies
3. To study the operation of chopper fed separately excited dc motor drive operating in open loop control and closed loop control mode through experimental studies
4. To simulate controlled rectifier and chopper fed dc motor drives.
5. To study the operation of voltage source inverter fed 3-phase induction motor drive with sinusoidal pulse width modulation through experimental studies
6. To study the operation of voltage source inverter fed 3-phase induction motor drive with space vector modulation through experimental studies
7. To study the operation of V/f control of 3-phase induction motor through simulation studies
8. To simulate the VVVF control of 3-phase induction motor.
9. To simulate the static rotor resistance control of 3-phase induction motor.
10. To study the closed loop control of permanent magnet brushless dc motor through experimental studies.
11. To design and simulate the 3:6 decoder logic for the generation of gating signals for six inverter switches from three hall position sensor outputs
12. To simulate the permanent magnet brushless dc motor drives.
13. To study the operation of stepper motor drive through experimental studies.
14. To understand the operation of industrial drives.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the fundamental concepts, components and different types of electric drives
CO2 – Analyze power and control structures of electric drives
CO3 – Analyze the operation ac and dc drives through experimental studies
CO4 – Comprehend the unique features of control and power structure of permanent magnet brushless dc motor drives and stepper motor drives
CO5 – Operate industrial drives and evaluate their features and performance
CO6 – Validate the performance of electric drives through simulation studies

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation	50 marks
End semester examination and Viva-voce	50 marks

20EE313T					Renewable Energy Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total/Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concept of generation of renewable energy sources and distributed generation of power sources.
2. To acquire knowledge of basic types of available energy sources and connection of sources in to the power grid.
3. To acquire knowledge of Solar Photovoltaics and Wind energy systems and their control aspects.
4. To know the basics about other renewable energy technologies.

UNIT I INTRODUCTION TO THE ENERGY ENGINEERING **03 Hrs.**

Fundamentals and Classification of Energy Sources, Significance of Renewable Energy, Global and Indian Statistics, Energy Efficiency and Conservation, Indian Electricity Grid Code, Electricity Act2003, MNRE and National Smart Grid Mission.

UNIT II SOLAR ENERGYCONVERSION SYSTEM **15 Hrs.**

Solar Energy: Basic Definitions and Angles Related with Solar Energy, History, Harnessing Solar Energy, Solar Water Heating, Passive and Active Solar Cooling, Solar Thermal Electricity, Solar Photovoltaics, Solar Collectors. **Solar Photovoltaic (SPV) System:** Operating Principle and Construction of PV Cell, Technologies-Amorphous, Monocrystalline, Polycrystalline, Equivalent Circuit of Cell, Cells to Modules to Arrays, Standard Test Conditions (STC) of Photovoltaics, I-V &P-V Characteristics, Impacts of Temperature and Insolation, Shading Effect, Bypass and Blocking Diode, SPV Balance of System(BOS), Sizing and Designing A SPV System, Power Electronic Converters for SPV Systems, Maximum Power Point Tracking (MPPT) Algorithms, Battery Energy Storage System(BESS), Lead-Acid, Nickel-Cadmium and Lithium, Grid Connected and Off-Grid Topologies, Socio-Techno-Economic Analysis.

UNIT III WIND ENERGY CONVERSION SYSTEM **15 Hrs.**

Wind Energy Physics: Components of Wind Turbine Generating System and its Function, Betz Limit, Tip Speed Ratio, Active and Passive Stall and Pitch Control, Yaw control, Performance Co-efficient, Wind Power, Power-Speed &Power-Torque Characteristics, Wind Speed Statistics- Wind Energy Estimation, Discrete Wind Histogram, Wind Power Probability Density Functions, Weibull and Rayleigh Statistics. **Wind Generators**: Classification of Wind Turbines, Review of Modern Technologies, Types of Wind Energy Systems in Context with Type of Generator Used (Type A, B, C, D), Performance Calculations, Working of Fixed Speed Induction Generator, Effect of Capacitance, FSIG with STATCOM, Working and Operation of Doubly Fed Induction Generator, Control from Rotor Side and Grid Side Convertor, Comparison of Gear and Direct Drive Generators, Operation of Fully Rated Convertor Types of Generator (DDPMSG-Direct Drive Permanent Magnet Synchronous Generator, Basics of Standalone and Grid Connected Systems.

UNIT IV OTHERRENEWABLE ENERGY SOURCES **07 Hrs.**

Small Hydro Power (SHP): Definition & Classification (micro, mini & small), Types of SHP Plants: Components & Characteristics; **Tidal Power**: Concept, Tidal Turbine, Types of Tidal Power Plant, **Biomass, Geothermal & Fuel Cell**: Definition & Overview; **Grid-Level Storage**: Pumped Hydro, Compressed Air, Ultra capacitor & Super Magnetic Energy Storage (SMES); **Decentralized Energy Systems**: Concept, Microgrids.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 – Understand the energy scenario and significance of power generation from renewable energy sources
CO2 – Define the basic terminologies involved in operation of solar and wind energy conversion systems
CO3 – Classify various types of wind energy generating system
CO4 – Analyze different topologies of solar energy conversion system
CO5 – Evaluate the performance characteristics of solar and wind energy systems
CO6 – Understand and introduce alternative energy sources for power generation

TEXT/REFERENCE BOOKS

1. Masters G., "Renewable and Efficient Electric Power Systems", John Wiley & Sons, Inc., Publication.
2. Lara O, Jenkins N, Ekanayake J, "Wind Energy Generation Modelling and Control", John Wiley & Sons, Ltd., 2009.
3. Mathew S., Wind Energy-Fundamentals, Resource Analysis and Economics, Springer, 2006.
4. Patel M R. "Design, Analysis, and Operation Wind and Solar Power Systems", Taylor & Francis, Second Edition.
5. Sawhney G. S., "Non-conventional energy sources", PHI Learning Pvt. Ltd.
6. Ackermann T., "Wind Power in Power Systems", John Wiley & Sons Ltd., 2005.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions, one from each unit, each carrying 13 marks 52 Marks
Part B/Question: 4 Questions, 2 from unit II, 2 from unit III and 1 from unit IV, each carrying 12 marks 48 Marks

20EE313P					Renewable Energy Engineering Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. To understand and verify the solar PV characteristics for solar modules
2. To evaluate and analyse the performance of solar PV under different operating conditions
3. To gain practical knowledge of the operation and control of wind turbine generating system
4. To simulate hybrid energy system including energy storage element.

List of Experiments:

1. To study electricity bill of house/office/building/commercial complex/industry for last one year and analyse consumption pattern.
2. To demonstrate the I-V and P-V characteristics of PV module with varying radiation and temperature level with artificial solar PV kit and under natural sunlight.
3. To demonstrate the I-V and P-V characteristics of series and parallel combination of PV modules with artificial solar PV kit and under natural sunlight.
4. To demonstrate the effect of variation in tilt angle on PV module power.
5. To demonstrate the effect of shading on the output power in PV panel for single module, series connection and parallel connection.
6. To demonstrate the working of bypass diode and blocking diode for Solar PV module.
7. To work out power flow calculations of standalone PV system of DC load with battery.
8. To evaluate cut-in speed of wind turbine experimentally using wind energy training system.
9. To evaluate the Tip Speed Ratio (TSR) at different wind speeds using wind energy training system.
10. To evaluate the coefficient of performance of wind turbine using wind energy training system.
11. To plot the turbine power versus wind speed curve using wind energy training system.
12. To carry out simulation of PV module connected with buck converter fed to the DC load.
13. To carry out simulation of PV module connected with boost converter fed to the DC load.
14. To implement the maximum power point tracking algorithm in solar power plant.
15. To implement the maximum power point tracking in wind turbine generating system.
16. To develop and simulate an integrated hybrid model having different renewable energy sources and energy storage.
17. To estimate the wind forecast and wind potential.

COURSE OUTCOMES

On completion of the course, student will be able to;

CO1 – Understand the practical aspects of solar and wind energy sources
CO2 – Analyze the performance characteristics of solar and wind energy systems
CO3 – Simulate the operating concepts of solar photovoltaics and wind energy sources
CO4 – Implement the maximum power point tracking for solar and wind energy systems
CO5 – Evaluate the performance of solar and wind energy systems using relevant software
CO6 – Analyze the performance of hybrid energy systems

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Continuous evaluation 50 marks
End semester examination and Viva-voce 50 marks