PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR
SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B. TECH. IN ELECTRICAL ENGINEERING

Semester VII			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	20EE401T	Electrical Machine Design	4	0	0	4	4	25	50	25	--	--	100
2	20EE402T	Smart Grid: Technologies and Applications	3	0	0	3	3	25	50	25	--	--	100
3	20EE403T	Electricity Sector in India: Policies and Regulations	2	0	0	2	2	25	50	25	--	--	100
4	20EE4XXT	Professional Elective Course – IV	3	0	0	3	3	25	50	25	--	--	100
5	20EE4XXP	Professional Elective Course - IV Laboratory	0	0	2	1	2	--	--	--	50	50	100
6	20EE4XXT	Professional Elective Course – V	3	0	0	3	3	25	50	25	--	--	100
7	20EE4XXP	Professional Elective Course - V Laboratory	0	0	2	1	2	--	--	--	50	50	100
		Total	**15**	**0**	**04**	**17**	**19**						**700**

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 – IV & V (Theory). Professional Elective Course – IV & V Laboratory will be offered based on the selected Professional Elective Course – IV & V (Theory).

Subject Code	Professional Elective Course		Professional Elective Course
20EE404T	FACTS and HVDC Power Transmission	20EE404P	FACTS and HVDC Power Transmission Laboratory
20EE405T	Digital Control	20EE405P	Digital Control Laboratory
20EE406T	Power Quality	20EE406P	Power Quality Laboratory
20EE407T	Modelling and Analysis of Electrical Machines	20EE407P	Modelling and Analysis of Electrical Machines Laboratory
20EE408T	Electric Vehicles Technologies	20EE408P	Electric Vehicles Laboratory

20EE401T					Electrical Machine Design					
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 understand the design concepts, design factors, materials used in the electrical machines, temperature rise and duties/ratings of electrical machines
2. To understand the specifications, and procedure of design of induction machines and synchronous machines
3. To understand the procedure of design of Transformers
4. To introduce the students with the concept of CAD of electrical machines

UNIT I: BASIC CONSIDERATIONS IN ELECTRICAL MACHINES DESIGN **08 Hrs**

Introduction, Design factors, Limitations in design, Modern trends in design of electric machines, Conducting materials, Magnetic materials, Insulating materials and its classification. Temperature rise, Expression for temperature rise, heating and cooling time constants, Types of duties and ratings, Selection of motor capacity.

UNIT II: INDUCTION MACHINES DESIGN **18 Hrs**

Introduction, Choice of specific electric and magnetic loadings, Output equation, Separation of D & L.

Design of Stator: Turns per phase, Stator conductors, Shape of stator slots, Number of stator slots, Area of stator slots, Length of mean turn, Stator teeth, Stator core, Length of air gap. **Squirrel Cage Rotor Design:** Number of rotor slots, Harmonic torques and its Reduction, Design of rotor bars & slots, Design of end rings, **Wound Rotor Design:** Number of rotor slots, number of rotor turns, area of rotor conductors, design of rotor core. Estimation of operating characteristics- No load and S.C. current, leakage reactance calculation, Circle diagram, Dispersion coefficient and its effects, Performance calculation.

Design of single phase induction motor: Output equation, Choice of specific loadings, Main dimensions, Design of stator and rotor, Air gap length, Operating characteristic and parameters, Design of starting winding.**A.C. Armature Winding**: Number of phases and phase spread, classification and design of ac windings.

UNIT III: SYNCHRONOUS MACHINES DESIGN **12 Hrs**

Introduction, Choice of specific electric and magnetic loadings, Design of Salient pole machines: Output equation, Main dimensions, Short Circuit Ratio, Effect of SCR on machine performance, Length of air gap and shape of pole face.

Armature Design: Number of armature slots, Coil span, Turns per phase, Conductor section, Slots dimension, Stator Core, Elimination of harmonics, Armature resistance and Leakage reactance, Estimation of air gap length, **Design of rotor**, Height of pole, Design of damper winding, Height of pole shoe, Pole profile drawing, Design of magnetic circuit, Design of field winding, **Design Of Turbo Alternators**: Main dimensions, Length of air gap, Stator and Rotor design.

UNIT IV: DESIGN OF TRANSFORMERS **16 Hrs**

Specification, Output equation of transformer, Relation between EMF per turn and transformer rating, Stacking factor, Choice of design parameters: flux density, current density and window space factor, Design of core, window dimensions, Design of yoke, Overall dimensions, Types of transformer windings, Design of high voltage and low voltage winding, Estimation of operating characteristics: resistance, Leakage reactance of windings, Regulation, Mechanical forces, No load current calculation, Temperature rise of transformer, Design of tank, **Concept of CAD of Electrical Machines:** Advantages and Limitations of CAD**.** Different approaches for CAD**.** Selection of Optimal Design, lowest cost and significance of Kg/kVA. Flowchart for the CAD of transformer, induction machines.

TOTAL HOURS **54 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the basic design concepts/factors, thermal loading and ratings of electrical machines

CO2 – Classify and select proper material for the design of electrical machines

CO3 – Acquire knowledge to carry out a detailed design of induction and synchronous machines

CO4 – Acquire knowledge to carry out a detailed design of transformers

CO5 – Estimate and analyze the various performance parameters of Induction and synchronous machines and transformers

CO6 – Understand the concept ofcomputeraided design (CAD) of electrical machines and optimization

TEXT/REFERENCE BOOKS

1. A. K. Sawhney and A. Chakrabarti, "***A course in Electrical machine design***", Dhanpat Rai and Co.
2. V. N. Mittal and A. Mittal, "***Design of electrical machines***", Standard Publishers distributors.
3. M. G. Say, "***The performance and design of alternating current machines***", CBS Publishers and Distributors.
4. K M Vishnu Murthy, "***Computer Aided design of electrical machines***", B S 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 , 2 from unit II, 1 from unit III and 1 form unit IV, carrying 10 marks 40 Marks

20EE402T					Smart Grid: Technologies and Applications					
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 smart grid and micro Grid
2. To introduce communication technologies for smart grid
3. To acquire knowledge about smart substations and operation of energy management systems

UNIT I: SG AND SMART ENERGY RESOURCES **08 HRS**

Evolution of smart grid, Need for SG, SG Definitions, characteristic of SG, SG technology framework **Smart Energy Recourses:** Renewable power generation; Energy Storage; Electric Vehicle; Microgrid (MG) and its drivers, MG benefits, challenges for MG development, types of MG, building blocks of MG, DC microgrid, Energy Resources Integration standards and their grid impacts

UNIT II: COMMUNICATION TECHNOLOGIES FOR SMART GRID **12 Hrs**

Communication Technologies for SG: Review on communication channels, Wired Communication, Optical Fibre, Radio Communication, Layered Architecture and Protocol, IEEE 802 standards for sub-networks, Ethernet LAN, wireless LAN, Bluetooth, Zigbee, 6LoWPAN, Standards for information exchange, Evolution of smart metering and its key components and hardware; Communication Infrastructure and Protocol for Smart Metering, HAN, NAN, Data Concentrators and protocols for communication, PMU and WAMS.

UNIT III: SMART SUBSTATIONS **08 Hrs**

Sub-station automation equipment, IED for protection, measurement and recording, sensors, RTUs, one-line diagram of smart sub-station, station-bay-process level; **SCADA:** Master Station/Energy Management Systems (EMS), structure of EMS, Data flow architecture, RTU data flow architecture, Server-based substation control system architecture, Smart substations in the smart grid architecture, **Interoperability and IEC 61850:** Interfaces within a substation automation system, Engineering approach in IEC 61850

UNIT IV: DEMAND SIDE MANAGEMENT **12 Hrs**

Demand Side Management (DS): DS planning, key definitions, DS requirement, issues in DS planning, hierarchy of planning objectives, load shape objectives, residential demand-side technology alternatives; implementation of demand side integration (DSI), price-based and incentive-based DSI, hardware support for DSI; Fault location, isolation and restoration; Power flow analysis using forward/backward sweep algorithm; Volt/var Control with optimization approach.

TOTAL HOURS **40 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand concept and significance of smart grids and microgrid
CO2 – Understand the communication technologies for smart grid
CO3 – Understand the smart metering, communication networks and WAMS technology
CO4 – Implement SCADA system for smart sub stations
CO5 – Implement demand side management to efficiently operate distribution network
CO6 – Manage distribution network and take corrective action for its performance improvement

TEXT/REFERENCE BOOKS

1. Ekanayake, J. B et al, "Smart grid : technology and applications", John Wiley & Sons, Ltd, 2012
2. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
3. Stuart Borlase, "Smart Grids: Infrastructure, Technology, and Solutions", CRC Press, 2013
4. James A.Momoh, "**Smart grid: fundamentals of design and analysis**". Vol. 63. John Wiley & Sons, 2012.
5. Stephen F. Bush, "**Smart grid: Communication-enabled intelligence for the electric power grid**". John Wiley & sons, 2014

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

21EE403T					Electricity Sector in India: Policies and Regulations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	-	-	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart knowledge on the electricity sector institutional framework in India.
2. To understand overall policy and regulatory framework of the electricity sector in India.
3. To gather knowledge on recent amendments and introductions with regard to upgradation in the electricity sector.
4. To be familiar with the acts and policies related to electricity sector in India.

UNIT I INTRODUCTION TO THE ELECTRICITY SECTOR OF INDIA **05 Hrs.**

Indian Power sector at a glance, Policy formulation in India, Power sector administration, Power trading with foreign, Power infrastructure funding, Reforms in Power Sector (as per latest 5-year plan): Capacity addition, Green energy corridor, Integrated Power Development Scheme (IPDS), Rural Electrification in India, Private sector in India. Issues/Barriers with the Indian Power Sector.

UNIT II POWER SECTOR POLICIES **05 Hrs.**

Indian Electricity Act, 1910 and Electricity (Supply) Act, 1948, Electricity Regulatory Commissions Act, 1998, Electricity Act (EA) 2003, Policies Under the EA 2003: Rural Electrification Policy, National Tariff Policy, National Electricity Policy, National Electricity Plan. National Renewable Energy Policy, New Government Policies and Programmes, 24x7' Power for All'

UNIT III TRANSMISSION LINES STANDARDS **09 Hrs.**

CEA (Technical Standards for Electric Lines) Regulations, 2010: Technical standards; Lines (66kV and above) and Lines (33kV and below): Electrical design parameters, line construction: clearance from ground, clearance from other infrastructure, routing of lines, Lighting Protection. **CEA Grid Standards Regulation, 2010:** Standards for operation and maintenance of transmission lines, Operation and Maintenance planning, Categorization of grid incidents and grid disturbance based on severity of tripping.

UNIT IV REGULATIONS FOR GRID CONNECTIVITY **09 Hrs.**

Technical Standards for Connectivity to the Grid Regulations, 2007: Objectives, Conditions for connectivity, Standards for connectivity to the grid: Codes of Practice, Sub-station grounding, Basic insulation, Coordinated Protection system. Grid connectivity standards for: new and existing generating plants; Transmission lines and substation; Distribution Systems and Bulk Consumers. Notified amendments. Indian Electricity Grid Code Regulations, 2010 and amendments, **Technical Standards for Connectivity of the Distributed Generation Resources, 2013**: Codes of Practice, Protection to sense abnormal conditions, Notified amendments.

28 Hrs.

COURSE OUTCOMES

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

CO1 - Gather knowledge on the power sector administration and institutional framework in India.
CO2 - Understand the power sector policies of India.
CO3 - Analyze the Indian electricity grid connectivity standards and regulations.
CO4 - Gather knowledge about the Technical Standards for Electric Lines of India.
CO5 - Understand Grid Standards Regulation for India.
CO6 - Analyze the Technical Standards for Connectivity of the Distributed Generation Resources.

RESOURCES

1. MoP, Policies and Regulation, Ministry of Power, Government of India. <LINK>.
2. CEA, Notified Regulations, Central Electricity Authority, Government of India.
   Metering Regulations: https://cea.nic.in/regulations-category/metering-regulations/?lang=en.
   Technical Standards for Electric power lines: https://cea.nic.in/regulations-category/construction-standards/?lang=en.
   Technical Standards for Connectivity to the Grid Regulations: https://cea.nic.in/regulations-category/grid-connectivity-regulations/?lang=en
3. Harish, V. S. K. V., & Kumar, A. (2014). Demand side management in India: action plan, policies and regulations. *Renewable and Sustainable Energy Reviews*, *33*, 613-624, 10.1016/j.rser.2014.02.021.
4. Kumar, A., & Chatterjee, S. (2012). Electricity sector in India: policy and regulation. *OUP Catalogue*, 10.1093/acprof:oso/9780198082279.001.0001

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: 2 Questions , one each from unit III and IV, each carrying 20 marks 40 Marks

20EE404T					FACTS and HVDC Power Transmission					
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 characteristics of ac transmission and the effect of shunt and series reactive compensation.
2. To acquire knowledge about flexible power transmission system.
3. To acquire the knowledge about HVDC system: concept, components and operating characteristics.
4. To acquire the knowledge about FACTS Controllers: concept, components and operating characteristics.

UNIT I: FLEXIBLE TRANSMISSION SYSTEM **08 Hrs**

Basics of AC Transmission, Comparison of AC and DC Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. **HVDC System**: Introduction, Types of HVDC Systems: Monopolar Link, Bipolar Link, Homopolarlink. **FACTS**: Compensation of Transmission lines, Basic types: SVC, STATCOM, TSSC, TCSC, SSSC, UPFC, IPFC. Flexible Systems Vs Conventional transmissions Systems.

UNIT II: HVDC SYSTEM **14 Hrs**

Components of HVDC systems: Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems DC line: Corona Effects. Insulators, Transient Over-voltages. DC breakers. Monopolar Operation. Ground Electrodes. **Line Commutated Converters (LCCs):** Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters. Effect of Commutation Failure, Misfire and Current Extinction in LCC links, DC line faults in LCC systems. **Voltage Source Converters (VSCs)**: Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC, DC line faults in VSC systems

UNIT III: FACTS CONTROLLERS **14 Hrs**

Thyristor-based Flexible AC Transmission Controllers: Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter. **Voltage Source Converter based FACTS controllers:** Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator, Fault Current Limiter.

UNIT IV: FLEXIBLE TRANSMISSION FOR SMART GRIDS **04 Hrs**

DC Microgrid configuration, Synchro-Phasor Measurement Technology: PMUs, Future Developments and Challenges.

TOTAL HOURS **40 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Distinguish between DC and AC power transmission system
CO2 – Understand the operation of Line Commutated Converters and Voltage Source Converters for HVDC system
CO3 – Understand the working principles of HVDC devices and their operating characteristics
CO4 – Analyse the application of flexible transmission for futuristic power grid
CO5 – Analyse operation of thyristor-based and voltage source converter based FACTS controllers
CO6 – Understand the working principles of FACTS devices and their operating characteristics

TEXT/REFERENCE BOOKS

1. Kundur, Prabha, Neal J. Balu, and Mark G. Lauby. ***"Power system stability and control"***. Vol. 7. New York: McGraw-hill.
2. Hingorani, N. G., Gyugyi, L. ***"Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems"***, Wiley-IEEE Press, ISBN: 978-0-780-33455-7,Dec 1999.
3. Sood, Vijay K. ***HVDC and FACTS controllers: applications of static converters in power systems***. Springer Science & Business Media, 2006.
4. Surjit Singh, **"Electrical Estimating and Costing"**, Dhanpat Rai and Co.
5. Acha, E., Roncero-Sánchez, P., de la Villa-Jaen, A., Castro, L. M., & Kazemtabrizi, B. (2019). ***VSC-FACTS-HVDC: Analysis, Modelling and Simulation in Power Grids***. John Wiley & Sons.

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: 2 Questions , one each from unit II and III, each carrying 20 marks 40 Marks

20EE404P					FACTS and HVDC Power Transmission 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 understand simulation studies and mathematical models of HVDC and FACTS system.
2. To vary the control and design inputs and analyse operation for HVDC and FACTS system
3. To gather knowledge about the computation tools and simulation software that can be used for transmission system

LIST OF EXPERIMENTS

1. To develop simulation models for cables and transmission Lines.
2. To develop a 6-pulse bridge circuit model and analyse its operation without commutation overlap feeding an inductive load.
3. To develop a 6-pulse bridge circuit model and analyse its operation with commutation overlap less than 60 degfeeding an inductive load.
4. To analyse PWM Pattern Generation Techniques.
5. To develop a Voltage-Source Converter (VSC) inverter feeding an inductive load from a dc supply and analyse the currents and voltages in *pu*.
6. To develop a Voltage-Source Converter (VSC) inverter model with AC current PWM control.
7. To develop a model for unipolar HVDC system and analyse DC current and voltages of the line.
8. To develop a model for bipolar HVDC system and analyse DC current and voltages of the line
9. To develop a model for homopolar HVDC system and analyse DC current and voltages of the line
10. To analyse a HVDC system with DC line fault in terms of current and voltages.
11. Design power system with using PSCAD
12. To develop simulation model of a SVC for power system studies
13. To develop simulation model of a TCSC for power system studies

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Operate simulation software to analyze performance of power transmission systems
CO2 – Develop HVDC transmission line models and analyze their performance characteristics
CO3 – Develop converter models for HVDC transmission system
CO4 – Conduct current and voltage based operation analysis for different HVDC and FACTS models
CO5 – Develop FACTS controller models using simulation software
CO6 – Analyze and compare current and voltage waveforms for different HVDC links

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

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

20EE405T					Digital 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 represent the discrete time system in discrete transfer function and discrete state space model.
2. To analyse the stability of discrete control system.
3. To learn the discrete control system design and state observers.
4. To learn the modern control strategies.

UNIT I: INTRODUCTION TO DISCRETE TIME SYSTEMS **10 Hrs.**

Introduction to the representation of discrete time systems, Properties and uses of the z- transform for discrete time signals and systems. Sampling and reconstruction of continuous time signals, ZOH equivalent, Relationship between s-plane (continuous-time) and z-plane (discrete time), Bilinear transformation, Pulse transfer function, Stability analysis and stability tests for discrete-time systems, Jury's stability criterion.

UNIT II: DISCRETE STATE SPACE MODELS **10 Hrs.**

Introduction to discrete state space models, canonical models, Conversion of continuous to discrete state space model, state transition matrix, solution of state difference equation, Controllability, observability, reachability, constructability of discrete state space models, effect of sampling on stability, controllability and observability.

UNIT III: DIGITAL CONTROLLER DESIGN **10 Hrs.**

Digital controller design via classical techniques, Discrete PID control, Position and velocity algorithms for PID controller implementations, Deadbeat control, State feedback control, discrete pole placement control, Design of full order State observers and estimators.

UNIT IV: MODERN CONTROL TECHNIQUES **10 Hrs.**

Introduction to optimal control, discrete linear regulator problem, Performance indices, Linear Quadratic Regulator (LQR) design, Riccati equation, Model Predictive Controller, Problem formulation, Objective functions, Receding horizon control.

Max Hrs: 40

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Interpret discrete time systems under the z-domain transfer functions and discrete state-space models.
CO2 – Analyze stability and transient response of linear discrete-time systems, analytically.
CO3 – Design digital control systems using transform techniques and state-space methods.
CO4 – Test the controllability and observability of linear discrete systems.
CO5 – Understand the concepts of optimal control
CO6 – Understand the working and formulation of Model Predictive Control.

TEXT/REFERENCE BOOKS

1. K. Ogata, Discrete Time Control Systems, Pearson Education/PHI, 2nd Edition, 2003.
2. M. Gopal, Digital Control and State Variable Methods, Tata McGraw Hill, 3/e, 2008.
3. K. M. Moudgalya, Digital Control, Wiley-Interscience; 1/e , 2008
4. G. F. Franklin, J. D. Powell and M. L. Workman, Digital Control of Dynamic Systems, Pearson Education, Asia, 3/e, 2000.
5. K. J. Astroms and B. Wittenmark, Computer Controlled Systems - Theory and Design, Prentice Hall, 3/e, 1997.
6. E. F. Camacho and A. C. Bordons, Model Predictive Control, 2/e, Springer, 2007

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

20EE405P					Digital 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 gain practical knowledge of discrete systems
2. To learn the identification of discrete control relevant models of physical processes.
3. To develop the simulation skills prior to the design of a controller
4. To learn and implement discrete control strategies
5. To verify the concepts of controllability and observability using simulations

LIST OF EXPERIMENTS

1. Introduction to control system tool box and MATLAB commands for representing discrete systems.
2. Identification of discrete state space model of Single Board Heater System using step response data.
3. Linearization of a non-linear process using Taylor Series Expansion.
4. Simulation of discrete PID controller using MATLAB /Simulink.
5. Discrete PID control of Single Board Heater System: An experimental study
6. Discrete PID control of liquid level interacting System: An experimental study.
7. Effect of sampling time on controllability, observability and stability of a discrete system: A simulation study.
8. Simulation of discrete Pole Placement Control using MATLAB /Simulink.
9. Model Predictive Control of Single Board Heater System: A simulation study.
10. Model Predictive Control of Single Board Heater System: An experimental study.
11. Pole placement control of Inverted Pendulum: A simulation study.
12. Speed control of a DC motor: An experimental study.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Translate the discrete system in discrete state space and transfer function model.

CO2 – Model the physical process into control relevant state space/transfer function model

CO3 – Simulate and control the linear process using MATLAB simulation environment.

CO4 – Perform Hands-on experiment to implement the discrete PID controller

CO5 – Understand the effect of sampling time on stability, controllability and observability.

CO6 – Implement Model Predictive Controller strategy using MATLAB simulation environment.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

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

20EE406T					Power Quality					
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 basic concepts, terminologies and standard related to Power Quality
2. To gain knowhow about the significance of Power Quality, its impact, monitoring and the related analysing instruments
3. To get a fair knowledge about the operational analysis, applications, features of different custom power devices

UNIT I: INTRODUCTION TO POWER QUALITY **08 Hrs**

IEEE Standards 519:2014,Terms and definitions of transients, Long Duration Voltage Variations: under Voltage, Under Voltage and Sustained Interruptions; Short Duration Voltage Variations: interruption, Sag, Swell; Voltage Imbalance; Notching, D C offset,; waveform distortion; voltage fluctuation; power frequency variations. Electromagnetic Interference

UNIT II: POWER QUALITY ISSUES **14 Hrs**

Voltage Sag & Swell: Sources of voltage sag & swell, motor starting, arc furnace, fault clearing etc; estimating voltage sag &swell, performance and principle of its protection; solutions at end user level- Isolation Transformer, Voltage Regulator, Static UPS, Rotary UPS, Active Series Compensator. **Electrical Transients:** Sources of Transient Over voltages- Atmospheric and switching transients- motor starting transients, PF correction capacitor switching transients, ups switching transients, neutral voltage swing etc; devices for over voltage protection. **Harmonics:** Causes of harmonics, current and voltage harmonics: measurement of harmonics; effects of harmonics on – Transformers, AC Motors, Capacitor Banks, Cables, and Protection Devices, Energy Metering, Communication Lines etc. harmonic mitigation techniques

UNIT III: POWER QUALITY MONITORING **06 Hrs**

Power quality measurement devices - Harmonic Analyzer, Transient Disturbance Analyzer, wiring and grounding tester, Flicker Meter, Oscilloscope, Multimeteretc.

UNIT IV: INTRODUCTION TO CUSTOM POWR DEVICES **12 Hrs**

Passive Filters (Types/ Analysis/ Design/ Issues), Introduction to custom power devices and their Applications in power system; Load compensation and voltage regulation using DSTATCOM; protecting sensitive loads using DVR; Unified power Quality Conditioner (UPQC).

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Define the basic concepts, terminology used in power quality assessment and know various standards related to power quality

CO2 – Understand various power frequency disturbance issues & working principles of passive, hybrid and active power filter

CO3 – Comprehend the power quality monitoring equipments

CO4 – Analyze different power quality issues from the information gathered with the help of various instruments and equipment

CO5 – Evaluate variety of power quality improvement solutions suitable to particular situation/application

CO6 – Design &develop specific solution in terms of harmonic filters/ custom power device for power quality improvement

TEXT/REFERENCE BOOKS

1. R. C. Dugan, McGrahan, Santoso&Beaty, "***Electrical Power System Quality***", McGraw Hill.
2. Arinthom Ghosh and Gerard Ledwich, Kluwer,"***Power Quality Enhancement Using Custom Power Devices***", Academic Publishers.
3. C. Sankaran, "***Power Quality***", CRC Press.
4. Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, "Power Quality: Problems and Mitigation Techniques", Wiley.
5. Hirofumi Akagi, Edson HirokazuWatanable and Mauricio Aredes, **"Instantaneous Power Theory and Applications to Power Conditioning (IEEE Press Series on Power Engineering)",** Wiley-Interscience A John Wiley and Sons Publication-2007.

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: 2 Questions, one from unit II and one form unit IV, each carrying 10 marks 40 Marks

20EE406P					Power Quality 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 understand the basic concepts, terminologies and standard related to Power Quality
2. To gain knowhow about power quality analysis of linear and nonlinear loads
3. To get a fair knowledge about harmonic analysis with the help of FFT analysis

LIST OF EXPERIMENTS

1. Generation of voltage Sag and Swell.
2. Generation of voltage interruption, voltage flicker and voltage unbalance.
3. Generation of voltage notching & power frequency voltage variation.
4. Power Quality analysis of linear and non-linear load.
5. Harmonic analysis using FFT and Power GUI block in MATLAB.
6. Impact of harmonics and unbalanced voltage on induction motor.
7. Measurement of power factor of a load.
8. Measurement of displacement factor, distortion factor and power factor for linear load.
9. Measurement of displacement factor, distortion factor and power factor for nonlinear load.
10. Measurement of power quality parameters using power analyzer.
11. Experimental study on power quality analysis for linear and nonlinear loads.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the basic concepts, terminology used in power quality assessment and know various standards related to power quality analysis
CO2 – Generate various power frequency disturbances on simulation platform
CO3 – Carry out harmonic analysis using FFT and Power GUI tool in MATLAB
CO4 – Measure various power quality factor of linear and non-linear load
CO5 – Evaluate impact of poor power quality on performance of electrical equipments
CO6 – Measure power quality parameters experimentally for linear and non-linear load

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

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

20EE407T					Modelling and Analysis of Electrical Machines					
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 magnetic circuits and electromechanical energy conversion.
2. To get a knowledge of basic machine modelling and various kind of reference frames.
3. To acquire the knowledge of various equations used for modelling and analysis of electrical machine.
4. To analyse the dynamic performance of electrical machines.

UNIT I: FUNDAMENTALS OF ELECTRIC MACHINERY **05 Hrs.**

Introduction, Basics of Magnetic Circuit, Magnetically Coupled Circuits, Analysis of Singly Excited Electromechanical System, Energy and Co-Energy Principles in Linear and Non-Linear Magnetics, Analysis of Doubly Excited Electromechanical System, Machine Winding and Air Gap MMF, Winding Inductances and Voltage Equations.

UNIT II: REFERENCE-FRAME THEORY **10 Hrs.**

Introduction, Equations of Transformation, Stationary Circuit Transformed to Arbitrary Reference Frame, Balanced Steady-State Phasor Relationships, Commonly Used Reference Frames, Transformations Between Reference Frames, Reference Frames Power Invariance, Transformations of Balanced Set, Balanced Steady State Phasor Relationship, Balanced Steady State Voltage Equations.

UNIT III: MODELLING OF THREE PHASE AC MACHINE **15 Hrs.**

Induction Machine Analysis: Equivalent Circuit, Steady State Performance and its Equations, Dynamic Modelling of Induction Machine, Three Phase to Two Phase Conversion, Generalized Model, Analysis of Induction Machine - Synchronous Reference Frame - With Currents as Variables - With Rotor Flux as Variables, Equation of Flux Linkages, Per Unit Model, Basis for Vector Control, Small Signal Modelling of Induction Machine**Synchronous Machines Analysis:** Steady State and Transient Equations, Derivation of Cylindrical and Salient Rotor Machine Phasor Diagram, Concept of Synchronous Machine Reactance, Analysis of Equivalent Circuit of Synchronous Machine, Voltage and Torque Equation, Analysis of Steady State Operation, Dynamic Performance During Sudden Change in Load Torque, Dynamic Performance During Three Phase Short Circuitat Machine Terminals and Various Time Constants.

UNIT IV: BRUSHLESS DC MACHINE & DRIVES FOR BLDC **10 Hrs.**

Introduction and Concept of Brushless DC machines, Voltage and Torque Equations in Machine Variables, Voltage and Torque Equations in Rotor Reference Frame Variables, Analysis of Steady State Operations, Dynamic Performance of BLDC.Voltage Source Inverter Drives, Equivalence of VSI Schemes, Average-Value Analysis of VSI Drives, Steady State Performance of VSI Drives, Transient and Dynamic performance of VSI drives, Steady State Harmonics, Case Studies Related with BLDC Drives.

Max. 40. Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Relate the machine modelling aspects with basics of electrical machines
CO2 – Apply knowledge of reference frame theories used for transformations required during dynamic analysis of electrical machines
CO3 – Build mathematical model three phase AC machine for steady state and dynamic performance
CO4 – Evaluate steady state, dynamic and transient performance of three phase AC machine during normal conditions
CO5 – Analyse dynamic and transient performance of three phase AC machine during abnormal conditions
CO6 – To evaluate dynamic performance of BLDC machine and electric drives

TEXT/REFERENCE BOOKS

1. A.E Fitzgerald, Charles Kingsley, Stephen .D. Umans, Electric Machinery, 6th Edition, TMH.
2. Paul C. Krause, Oleg Wasynczuk and Scott D. Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley & Sons, New York, 2004.
3. R. Krishnan, Electric Motor Drives, Modelling, Analysis and Control, Prentice Hall.
4. P S R Murty, Modelling of Power System Components. B S Publication.
5. Dr.P.S.Bimbhra, Generalized Theory of Electrical Machines, Khanna Publishers.
6. Chee-Mun Ong, Dynamic Simulations of Electric Machinery, Prentice Hall.
7. John Nelson Chiasson, Modelling and High Performance Control of Electric Machines, John Willey & Sons.
8. D. P. Sen Gupta & John Williamson Lynn, Electrical Machine dynamics, Macmillan

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

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

Part A/Question: 4 Questions, one from each unit, each carrying 16 marks — 64 Marks
Part B/Question: 4 Questions, 1 from unit II and IV, and 2 from unit III, each carrying 10 marks — 36 Marks

20EE407P					Modelling and Analysis of Electrical Machines Laboratory					
Teaching Scheme					Examination Scheme					
					Theory			Practical		
L	T	P	C	Hrs/Week	MS	ES	IA	LW	LE/Viva	Total Marks
-	-	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. To implement the different transformations using reference frame theory
2. To develop mathematical model of electrical machines
3. To analyse the dynamic performance of electrical machines
4. To implement vector control in electrical machines

List of Experiments:

1. To simulate conversion of time varying waveforms of three phase (abc) quantities to two phase (dq0) by different reference frames
2. To simulate the transformation between various reference frames (abc to dq and dq to abc) and its comparison.
3. To develop the mathematical model and simulation of three phase symmetrical induction machines for analysis of its steady state characteristics.
4. To simulate the induction motor model to evaluate its dynamic performance.
5. To simulate single phase induction motor to study its characteristics.
6. To model a three phase synchronous machines to determine the operational characteristics of the generator with parameter variations.
7. To examine the response of synchronous generator operating under fixed rotor speed and fixed excitation voltage to several kinds of electrical faults at its stator terminals.
8. To perform 6 pulse operation for Brushless DC Motor Drive.
9. To perform PWM control for Brushless DC Motor Drive with Speed Feedback.
10. To simulate open loop induction motor drive.
11. To simulate closed loop volts/hertz speed control drive.
12. To simulate current regulated induction motor drive with indirect field oriented control.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Implement the conversation of three phase to two phase and vice-versa
CO2 – Relate the steady state and dynamic performance of electrical machines
CO3 – Develop the model of three phase induction motor and alternator
CO4 – Evaluate the performance of induction machine and synchronous machine with various types of external inputs
CO5 – Analyse the performance of BLDC drive
CO6 – Simulate the vector control in electrical machines

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

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

20EE408T					Electric Vehicle Technologies					
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 electric vehicle technology and government policies for electric vehicles
2. To gain knowledge about the operation of electric powertrain and charging infrastructure
3. To analyse the application of artificial intelligence, machine learning and embedded systems in electric vehicles

UNIT I:ELECTRIC VEHICLES **09 Hrs**

Concept, Significance, Classification, Components, Vehicle Dynamics, Merits and Demerits, Challenges and Constraints, Power Train, Charging Requirements, V2G and G2V technology, Technical Specifications of Commercial Electric Vehicles, Government Policies on Electric Vehicles

UNIT II: ELECTRIC POWERTRAIN **11Hrs**

Concept, Classification, Power Train Architecture, Components, Propulsion Motors, Permanent Brushless dc Motors, Sensors, Power Converters, Controller, Power and Control Architecture, Battery Management System, Regenerative Braking, Drive Cycle and Testing, 2-Wheeler and 4-Wheeler Electric Vehicle, Design of Electric Propulsion system, Hybrid Electric Vehicle Drive Trains

UNIT III: CHARGING INFRASTRUCTURES **11Hrs**

Energy Storage Elements, Battery, Fuel Cell, Ultracapacitors, Hybrid Energy Storage, Battery Charging, Battery Chargers, Off Board, On Board and Wireless Battery Charging, dc Chargers, Power Converters, Constant Voltage, Constant Current and Boost Charging, Impact of Battery Charging on Grid, Vehicle to Everything (V2X)

UNIT IV: EMERGING TRENDS IN ELECTRIC VEHICLES **09Hrs**

Wide Band Gap Semiconductor Devices, Application of Artificial Neural Networks, Fuzzy Logic, and Machine Learning and IoT in Electric Vehicles, Communication Systems, Integration of Electric Vehicles in Smart Grids, Solar Photovoltaic based Charging of Electric Vehicle.

TOTAL HOURS **40 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the electric vehicle technology, its significance and government initiatives for electric vehicles

CO2 – Classify different types of electric vehicles and list out the components being used in electric powertrain

CO3 – Examine the power and control architecture of electric powertrain

CO4 – Classify the different energy storage elements employed in electric vehicles

CO5 – Analyze the operation of charging infrastructure and battery management systems

CO6 – Examine the emerging trends in electric vehicle technology and understand the application of artificial intelligence and IoT in electric vehicles

TEXT/REFERENCE BOOKS

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, and Ali Emadi, ***"Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design,"*** CRC Press, 2004.
2. Iqbal Hussein, ***"Electric and Hybrid Vehicles: Design Fundamentals,"*** CRC Press, 2003.
3. B. K. Bose, ***"Modern Power Electronics and ac Drives,"***Prentice Hall Inc., 2001.
4. Sheldon S. Williamson, ***"Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles,"*** Springer, 2013.
5. C.C. Chan and K.T. Chau, ***"Modern Electric Vehicle Technology,"*** Oxford University Press, 2001.
6. Rodrigo Garcia-Valle and João A. Peças Lopes (Eds.), ***"Electric Vehicle Integration into Modern Power Networks,"*** Springer, 2012.

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

20EE408P					Electric Vehicles 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 learn concepts related to electric vehicle design
2. To acquire knowledge about Energy Storage Systems, Charging Techniques
3. To introduce the concepts related to drive train sizing

LIST OF SIMULATIONS AND EXPERIMENTS

1. To write a code to determine the tractive effort required to propel an EV on different terrains for the given drive cycle.
2. To write a code to determine the specifications of propulsions motor driving an EV on different terrains for the given drive cycle.
3. To develop mathematical model of a battery and determine the state of charge.
4. To develop mathematical model of ultra capacitor.
5. To develop mathematical model of fuel cell.
6. To simulate charging and discharging profile of batteries.
7. To write a code to design dc-dc converter for charging of EV batteries.
8. To simulate the battery charger operation.
9. Analyze the impact of battery charger on grid.
10. Demonstrate the performance of induction motor drive.
11. Demonstrate the performance of permanent magnet synchronous motor drive.
12. Demonstrate the performance of permanent magnet brushless dc motor drive.
13. Design decoder logic to determine the gate pulse for a VSI fed permanent magnet brushless dc motor drive based on the output of hall position sensors.
14. Study and compare the different EV powertrains.
15. Design and simulate an EV powertrain,
16. Study the application of artificial neural network in EV.
17. Study the application of fuzzy logic in EV.
18. Study the application of IoT in EV.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Determine the tractive effort and specifications of propulsion motor for an electric vehicle
CO2 – Create mathematical model of energy storage elements
CO3 – Analyze the power structure for charging of battery.
CO4 – Analyze the operation an electric drives being employed for propelling the electric vehicles
CO5 – Analyze the different types of electric vehicles power trains
CO6 – Assess the application of artificial intelligence and IoT in electric vehicles

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

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

PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR
SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B. TECH. IN ELECTRICAL ENGINEERING

Semester VIII			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	20EE410/20EE420	Major Project/Comprehensive Project	0	0	0	13	26	--	--	--	50	50	100
		Total	**0**	**0**	**0**	**13**	**0**						**100**

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

Students can either opt for Major Project or Comprehensive Project

20EE410					Major Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	13	26	-	-	-	50	50	100

COURSE OBJECTIVES

1. To investigate the development of student's ability to apply the basic concepts of engineering
2. To impart the managerial skill and team work spirit
3. To understand the present scenario and chance to work in inter disciplinary environment
4. To develop activities that lead to transformation of theoretical knowledge into practical

The student is required to identify and analyse problems in the field of electrical engineering. The project will include preliminary work in the area of interest based on which a simulation or experimental model will be developed. The student is required to submit detailed report consisting of objectives of study, scope of work, literature review and preliminary work done pertaining to the project undertaken, details of the simulation and/or hardware model developed. Also, the student will defend the work carried out before an evaluation committee.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Undertake problem identification, formulation and solution by considering ethical responsibility

CO2 – Demonstrate a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – Formulate and develop a hardware/software based prototype model

CO4 – Achieve skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – Identify and apply appropriate steps to solve problems they have met during implementation of their project

CO6 – Design engineering solutions to complex problems utilizing as system approach

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Synopsis	10 marks
First Review	20 marks
Second Review	20 marks
Final Review	50 marks

20EE420					Comprehensive Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	13	26	-	-	-	50	50	100

COURSE OBJECTIVES

1. To investigate the development of student's ability to apply the basic concepts of engineering
2. To impart exposure to the working environment of industry and various departments involved
3. To design and recommend solution to the industrial problem through the application of engineering knowledge
4. To develop the necessary communication, report writing and interpersonal skills

The student is required to carry out his Comprehensive project in an industry or a research organization. He/she is required to identify problem in the field of electrical engineering with the help of industry and institute mentor. The project will include preliminary work in the area of interest and defining a methodology to solve the problem. Further, a solution to the problem is to be recommended/designed. The student is required to submit detailed report consisting of objectives of study, scope of work, literature review and preliminary work done pertaining to the defined problem, details of the work carried out and proposed solution. Also, the student will defend the work carried out before an evaluation committee.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the industry operations and its working environment

CO2 – Formulate a problem in consultation with the industry and define a methodology to solve the identified problem while understanding the ethical responsibility

CO3 – Design and recommend solution to the identified problem through the application of engineering knowledge

CO4 – Achieve the necessary skills to write technical documents, deliver oral presentations and defend the work before the evaluation committee

CO5 – Recommend appropriate solutions to the problems faced during the course of the work.

CO6 – Comprehend appropriate methodology to carry out the project

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100

Synopsis	10 marks
First Review	20 marks
Second Review	20 marks
Final Review	25 marks
Review by Industry Mentor	25 marks

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

PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR

SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B. TECH. IN ELECTRICAL ENGINEERING													
Semester III			**B. Tech. in Electrical Engineering**										
Sr. No.	**Course/Lab Code**	**Course/Lab Name**	**Teaching Scheme**					**Examination Scheme**					
			L	**T**	**P**	**C**	**Hrs/Wk**	**Theory**			**Practical**		**Total**
								MS	**ES**	**IA**	**LW**	**LE/Viva**	**Marks**
1.	20MA203T	Mathematics-III	3	1	0	4	4	25	50	25	--	--	100
2.	20EE201T	Network Analysis	3	0	0	3	3	25	50	25	--	--	100
3.	20EE202T	Analog & Digital Electronics	3	0	0	3	3	25	50	25	--	--	100
4.	20EE202P	Analog & Digital Electronics - Lab.	0	0	2	1	2	--	--	--	50	50	100
5.	20EE203T	Transformers & Induction Machines	3	0	0	3	3	25	50	25	--	--	100
6.	20EE203P	Transformers & Induction - Machines Lab.	0	0	2	1	2	--	--	--	50	50	100
7.	20EE204T	Open Elective 1	3	0	0	3	3	25	50	25	--	--	100
8.	20HS201P	Communication Skills - II	0	0	2	1	2	--	--	--	50	50	100
		Total	**15**	**1**	**6**	**19**	**22**						**800**

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

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.

Subject Code	**Open Elective**
20EE204T	Climate Change: Impact and Solutions

20MA203T					Mathematics - III					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the concept of Fourier series and its application to the solution of partial differential equations.
2. To introduce the Fourier transforms and Z-transforms and understand the application part of it in electrical engineering.
3. To study the first and second order partial differential equations along with their applications in electrical engineering.
4. To study applications of advance Linear Algebra to electrical engineering.

UNIT I: FOURIER SERIES **10 Hrs**

Periodic functions, Euler's formulae, Dirichlet's conditions, expansion of even and odd functions, half range Fourier sine and cosine series, Parseval's formula, complex form of Fourier series.

UNIT II: FOURIER TRANSFORM AND Z-TRANSFORM **10 Hrs**

Fourier Transform: Integral transform, Fourier integral theorem, Fourier sine and cosine integrals, Fourier transforms, Fourier sine and cosine transforms, Properties of Fourier transform, Convolution, Parseval's identity, Relationship between Fourier and Laplace transform.

UNIT III: PARTIAL DIFFERENTIAL EQUATIONS OF FIRST ORDER **10 Hrs**

Formation of Partial Differential Equations (PDEs), Solutions of PDEs of first order, Cauchy problem for first order PDEs, Lagrange's method, Charpit and Jacobi methods for solving first order nonlinear PDEs.

UNIT IV: APPLICATIONS OF ADVANCE LINEAR ALGEBRA TO ELECTRICAL ENGINEERING **10 Hrs**

Introduction to vector space, subspace, basis and dimensions, column space, null space, Field, least squares solutions, orthogonalization, Linear transformation, Symmetric matrices and positive definite matrices, computing exponential of a Matrix, Linearization of non-linear systems using Taylor series expansion

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Identify the partial differential equations of first and second order in order to model or understand the Electrical Engineering applications

CO2 – Understand the techniques of Fourier transforms and Z-transforms to understand the critical mathematical problems.

CO3 – Apply the methods of Fourier series, Fourier transform and Z-transform in understanding and solving the basic Electrical Engineering problems.

CO4 – Classify the second order partial differential equations and solve using method of separation of variables.

CO5 – Appraise the series representation of periodic functions using Fourier series.

CO6 – Formulate the first order partial differential equations and solve them using various analytical techniques.

TEXT/REFERENCE BOOKS

1. H. K.Dass, **Advanced Engineering Mathematics**, S. Chand & Company Ltd., New Delhi.
2. R.K. Jain & S.R.K. Iyenger, **Advanced Engineering Mathematics**, 3rd Ed., Narosa (2002).
3. E. Kreyszig, **Advanced Engineering Mathematics (Eighth Edition**), John Wiley & Sons.
4. Peter V. O'Neil, **Advanced Engineering Mathematics**, Cengage Learning.
5. K. Sankara Rao, **Introduction to Partial Differential Equations-Third ed.**, PHI Learning.
6. T. Amarnath, **An Elementary Course in Partial Differential Equations**, Narosa Publishing House, New Delhi.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs.**
Part A: 6 questions 4 marks each	24 Marks (40 min)
Part B: 6 questions 8 marks each	48 Marks (60 min)
Part C: 2 questions 14 marks each	28 Marks (40 min)

20EE201T					NETWORK ANALYSIS					
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 provide understanding of electrical networks & its analysis using network theorems, mesh current &nodal voltage method
2. To impart knowledge about AC & DC circuits and determine their behaviour under both steady state & transient condition
3. To understand different properties of signals and linear time-invariant systems
4. To introduce the concept of two port networks and applications of graph theory in network analysis

UNIT I:NETWORK THEOREMS AND GRAPH THEORY **10 Hrs**

Network theorems & circuit analysis techniques: Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem, Tellegen's theorem. Analysis with dependent &independent current and voltage sources. Node & Mesh Analysis. Concept of duality & dual networks. Dot convention & Magnetically Coupled Circuit Analysis. **Applications of Graph theory:** Definition of Graph & Various Related Terms, Paths & Circuit Connections, Trees of a Graph, Cut Sets & Tie Sets, Non-Separable Planner & Dual Graphs, Matrices of Oriented Graphs, Properties & Inter Relationships of Incidence, Tie & Cut Set Matrices, Complete Circuit Analysis using Tie Set & Cut Set Matrices

UNIT II: SIGNALS AND LINEAR TIME-INVARIANT SYSTEMS **8 Hrs**

Introduction to signals and systems: Signal properties: periodicity, absolute integrability, determinism & stochastic character. Standard signals: the unit step, the unit impulse, the sinusoid, the complex exponential, Time-limited signals; continuous & discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability. Examples. **Behaviour of continuous LTI systems:** Impulse response and step response, convolution, correlation, input-output behaviour with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations. Concepts of complementary function, particular integral, system function. Periodic inputs to an LTI system, notion of a frequency response and its relation to the impulse response.

UNIT III: DC AND AC TRANSIENT ANALYSIS **12 Hrs**

Transient analysis using time domain approach: Solution of first & second order differential equations for Series & parallel R-L, R-C, RL-C circuits, initial & final conditions in network elements, forced and free response, time constants, steady state and transient state response for AC & DC excitation **Transient analysis using Laplace transform approach**: Review of Laplace Transform, Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions, Transfer function representation, Concept of Poles &Zeroes representation

UNIT IV:TWO PORT NETWORKS AND NETWORK FUNCTIONS **10 Hrs**

Two Port Networks: Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interdependence & relationship, interconnections of two port networks. **Network functions:** Concepts of Complex Frequency, Transform Impedance, Network Functions of 1&2 Port Networks, Concept of Poles &Zeroes, Properties of Driving Point & Transfer Functions, Time Response Stability from Pole-Zero Plot

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Apply different circuit analysis techniques and network theorems for analysing an electrical circuit including a magnetically coupled circuit
CO2 – Apply graph theory to formulate network equations
CO3 – Understand concepts of signals and linear time invariant systems
CO4 – Apply differential equation & Laplace transform approaches to obtain transient response of linear time invariant system
CO5 – Analyse two port networks
CO6 – Understand concepts of network functions

TEXT/REFERENCE BOOKS

1. W.H.Hayt, J.E. Kemmerly, S.M.Durbin, "**Engineering Circuit Analysis**", Tata McGraw-Hill Education India, 8th ed., 2013
2. M.E.VanValkenburg, T.S.Rathore, "**Network Analysis**", Pearson, 3rd ed., 2013
3. F.F.Kuo, "**Network Analysis and Synthesis",** Wiley India Pvt. Ltd, 2nd ed., 2006
4. A.V.Oppenheim, A.V.Willsky, S.H.Nawab,"**Signals and systems**", Pearson, 2nd ed., 2015
5. D.R.Choudhury, "**Networks and Systems**", New Age Intl. Publishers, 2nd ed., 2013

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

20EE202T					Analog & Digital Electronics					
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 enable the students to understand the fundamentals of analogue integrated circuits and digital electronics.
2. To provide in-depth knowledge about Digital logic ICs, Combinational and Sequential circuits.
3. To emphasize on the significance of low power, small size, reliable, high performance Operational Amplifiers.
4. In addition, the course equips them with the knowledge of basic circuit designing for various applications.

UNIT I INTRODUCTION TO ANALOG DEVICES **10 Hrs.**

Characteristics of diodes, Simple diode circuits: clipping, clamping, rectifiers; Amplifiers: BJT Biasing, Equivalent circuit and Frequency response; Oscillators and Feedback amplifiers; Introduction to Operational Amplifiers (Op-Amp), Ideal Op-Amp, Op-Amp Characteristics, Differential, Inverting & Non-Inverting Amplifiers, Practical Op-Amp (Input Offset Voltage, Input Bias Current, Input Offset Current, Total Output Offset Voltage, Thermal Drift, Common Mode Configuration And CMRR), Op-Amp with Negative Feedback (Voltage-Series & Voltage-Shunt Feedback Amplifier), Frequency Response of Amplifiers.

UNIT II OP-AMP APPLICATIONS **10 Hrs.**

DC & AC Amplifiers, Peaking Amplifier, Summing, Scaling & Averaging Amplifier, Differential Input & Differential Output Amplifier, Integrator & Differentiator, Low Pass Filter, High Pass Filter, Band Reject Filter, Band Pass Filter & All Pass Filter, Basic Comparator, Zero-Crossing Detector, Schmitt Trigger, Window Detector, Voltage Limiters, Voltage to Frequency & Frequency to Voltage Converter, Analog to Digital & Digital to Analog Converters, Voltage Controlled Oscillator, Phase Locked Loop, Fixed & Adjustable Voltage Regulators, 555 Timer as Astable, Bi-Stable & Mono-Stable Multi-Vibrators.

UNIT III BOOLEAN ALGEBRA, LOGIC GATES & COMBINATIONAL CIRCUITS **10 Hrs.**

Binary Arithmetic, Binary Codes, Binary Logic, Basic Theorems & Properties of Boolean Algebra, Boolean Functions, Canonical & Standard Forms, Digital Logic Gates & Their Properties, K-Map Method, Four/Five Variable Map, POS & SOP Simplification, Don't Care Conditions, NAND & NOR Implementation, Exclusive OR Functions.

COMBINATIONAL LOGIC: Combinational Circuit – Analysis & Design, Binary Adder & Subtractor, Decimal Adder, Binary Multiplier, Decoder, Encoder, Multiplexer & De-Multiplexers.

UNIT IV SYNCHRONOUS SEQUENTIAL LOGIC **10 Hrs.**

Sequential Circuits, Latches, Flip-Flops & Excitation Tables, Analysis of Clocked Sequential Circuits, Design of Sequential Circuits, Registers, Shift registers, Ripple Counter, Synchronous Counters, Ring/Johnson Counter.

TOTAL HOURS 40 Hrs.

COURSE OUTCOMES

CO1 – Analyse basic op-amp circuits & feedback amplifiers
CO2 – Understand basic applications of op-amp for analogy & digital circuits
CO3 – Apply algebraic & mapping techniques to minimise the hardware implementation
CO4 – Design, analyse and implement sequential circuits with timing diagram
CO5 – Develop analogue & digital logic to solve real time engineering problems
CO6 – Demonstrate the ability to design practical circuits.

TEXT/REFERENCE BOOKS

1. R. A. Gaikwad, "**Operational Amplifiers and Linear Integrated Circuits**", Prentice Hall of India.
2. Morris Mano, "**Digital Design**", Prentice Hall of India.
3. Donald Leach, Albert Malvino, and GoutamSaha, "**Digital Principles and Applications**", Tata McGraw-Hill.
4. Anand Kumar, "**Switching Theory and Logic Design**", Prentice Hail 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 15 marks 60 Marks
Part B/Question: 4 Questions, one from each unit, each carrying 10 marks 40 Marks

20EE202P					Analog & Digital Electronics – Lab.					
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 Objective

1. To illustrate different electronic circuits and their practical applications.
2. To test and evaluate the performance of different analogue and digital circuits.
3. To simulate various analogue and digital circuits using software based tools and draw parallel between the simulations and hardware circuits performance.

List of Experiments:

1 Observing Open-Loop Gain of an Operational Amplifier as a function of frequency and measuring Common Mode Rejection Ratio.

2 To Study Operational Amplifier as Inverting and Non Inverting Amplifier, Voltage Comparator, Integrator and Differentiator.

3 To study Active Low Pass Filters, Active High Pass Filter, Active Band Pass Filter using Op-Amp.

4 To study Astable, Mono-stable and Free Running Multi-vibrators using IC 555.

5 To Study Laws and Theorems of Boolean algebra.

6 Study of Logic Gates and Verification of truth tables of Logic gates Using Universal gates (NAND and NOR gates).

7 To verify (A) Truth Table of Binary Half Adder, (B) Truth Table of Binary Full Adder (using two half adders) and (C) Truth Table of Binary Half Subtractor

8 Study of Parity Generator/Checker.

9 To study and verify (A)Gray to Binary Converter, (B) Binary to Gray Converter, and (C) BCD to Excess-3 code conversion circuit.

10 To verify the truth table for 4 To 1 Line Multiplexer and 1 To 4 Line De-Multiplexer

11 To study and verify the Truth Table of 8-to-3 Line Encoder and 3-to-8 Line Decoder.

12 Study of Various types of Flip Flop.

13 Study of Left Right and Programmable Shift Register.

- A. Study of 4-bit serial in serial out shift register.
- B. Study of 4-bit serial in parallel out shift register.
- C. Study of 4-bit parallel in-serial out shift register.
- D. Study of 4-bit parallel in parallel out shift register.

14 Study of 4 Bit Counters (Synchronous and Asynchronous).

- A. Study of 4-bit Synchronous Binary up Counter.
- B. Study of 4-bit Asynchronous Binary up/down counter.

15 Study and verification of Diode VI Characteristics.

16 Application of Diode as Clipper and Clamper Circuits.

17 Conversion of AC to DC using Diode Rectifier Circuits.

18 Study and verification of Transistor in CB and CE configuration (Input and Output Characteristics).

19 To study importance of biasing of Transistor.

20 Study and experimental verification of Hartley Oscillator and Colpitts Oscillator.

COURSE OUTCOMES

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

CO1 – Understand basic operation of integrated circuits of analog and digital electronic devices such op-amps, logic gates etc.
CO2 – Develop basic analogue & digital circuits for real-time applications such as ac-dc converter, logic gates etc.
CO3 – Learn software tools available for simulating analogue & digital circuits
CO4 – Select appropriate IC modules for to build hardware for given application
CO5 – Verify and compare the performance through hardware operations and simulation results
CO6 -- Demonstrate the ability to design practical circuits.

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

20EE203T					Transformers & Induction Machines					
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 basic principles, working, construction, classification and operating characteristics of single phase as well as three phase AC machines such as Transformers and Induction machines
2. To evaluate and analyse the performance of Transformers & Induction machines
3. To enable students to identify and solve the AC machines related problems in Transformers & Induction motor
4. To impart sound knowledge about the different applications of Transformers & Induction machines

UNIT I Single Phase Transformers **10 Hrs**

Basics of Magnetics Circuits and Electromechanical Energy Conversion, Types, Working Principle, Construction, EMF Equation, Transformer on No-Load & ON Load, Ideal Transformer, Actual Transformer, Vector Diagrams, Equivalent Resistance & Reactance, Equivalent Circuits, Losses, Efficiency & Voltage Regulation, All Day Efficiency, Direct Load Test, O.C. &S.C. Tests, Sumpner's Test, Polarity Test, Parallel Operation & Load Sharing, per unit impedance, Auto Transformers, Applications, Testing and Trouble Shooting of Single Phase Transformer

UNIT II Three Phase Transformers **10 Hrs**

Construction, Types, Vector Groups, Connections (Including Open Delta), Parallel Operation of 3-Phase Transformers, Scott Connection, Three Winding Transformer, Tertiary Winding, Voltage Regulation & Tap Changers, Magnetizing Inrush, Harmonics in Transformer, Cooling Methods, Protective & Safety Devices Fitted on Transformers, Power & Distribution Transformer, Testing and Trouble Shooting of Three Phase Transformer

UNIT III Three Phase Induction Machine **15 Hrs**

Classification of AC Motors, Construction & Types, Working Principle, Production of Rotating Magnetic Field, Synchronous Speed, Slip, Frequency of Rotor Current, rotor parameters under standstill and running condition, Torque, Torque/Slip Characteristics, Power Stages, No Load & Blocked Rotor Tests, Phasor Diagram, Equivalent Circuit, Circle Diagram & Determination of Performance Parameters, Deep Bar & Double Cage Induction Motors, Starters: Automatic and Semi - Automatic starters, Methods of Speed Control, Harmonics & its Effects, Cogging & Crawling, Induction Generators: Working, Effect of Capacitor, Voltage Build up in Self-Excited Generators, Application, Testing and Trouble Shooting of Three Phase Induction Machine

UNIT IV Single Phase Induction Motor **05 Hrs**

Types of Single Phase Motors, Double Revolving Field Theory, Methods of Starting, Equivalent Circuit, No Load & Blocked Rotor Tests, Determination of Equivalent Circuit Parameters, Performance Calculations.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

- CO1 – Understand the construction, principle of operation and working of different kinds of single phase and three phase AC machines such as Transformers and Induction machines.
- CO2 – Analyze the performance of single phase and three phase transformers.
- CO3 – Understand the importance and application of three phase transformer connections.
- CO4 – Evaluate the performance of three phase induction machines by graphical and analytical methods.
- CO5 – Compare the different methods of starting and speed control of induction motor.
- CO6 – Determine the parameters of equivalent circuit of single phase motor and calculate its performance.

TEXT/REFERENCE BOOKS

1. B.L. Theraja& A.K. Theraja, **A text book of Electrical Technology Volume II-AC & DC Machines**, S. Chand & Co.
2. J.B.Gupta, **Theory and performance of electrical machines**, Katson Publication, S.K.Kataria& Sons.
3. Ashfaq Hussain, **Electric Machines**, Dhanpat Rai and Co.
4. D.P. Kothari and I. J. Nagrath, **Electric Machines**, Tata McGraw Hill
5. P. S. Bimbhra, **Electrical Machinery**, Khanna Publishers
6. M. G. Say, **Alternating Current Machines**, Pitman and Sons
7. J. G. Jamnani, **Electrical Machines**, Mahajan Publishing House

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 2 from unit III, each carrying 10 marks 40 Marks

20EE203P					Transformers & Induction Machines – Lab.					
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 of construction and working of electrical machines like Transformers and Induction machines
2. To perform different types of tests on electrical machines like Transformers and Induction machines
3. To determine the performance characteristics of rotating electrical machines like Transformers and Induction machines
4. To understand starting and speed control methods of Induction Motors.

List of Experiments:

1. To perform polarity and voltage ratio test on Single Phase Transformer.
2. To perform load test on Single Phase Transformer.
3. To perform open circuit and short circuit test on Single Phase Transformer.
4. To determine the parameters of an equivalent circuit of a Single Phase Transformer.
5. To perform Sumpner's Test on Single Phase Transformer
6. To perform parallel operation of Single Phase Transformers.
7. To perform load test on Three Phase Transformer to find out efficiency and regulation.
8. Parallel operation of two Three Phase Transformers.
9. To understand and verify the different vector groups in Three Phase Transformer connections.
10. To obtain 2-phase supply from 3-phase supply using Scott connection.
11. To understand the construction and operation of Three Phase Induction Motor by working cut section.
12. To determine equivalent circuit parameters of Three Phase Induction Motor by No load and Blocked rotor test.
13. To determine performance characteristics of Three Phase Induction Motor using circle diagram.
14. To perform load test on a Three Phase Induction Motor.
15. To study different types of starters used for Three Phase Induction Motor.
16. To determine equivalent circuit parameters of Single Phase Induction Motor by No load and Blocked rotor test.
17. To study starting methods of a Single Phase Induction Motor.
18. To perform load test on Single Phase Induction Motor.

COURSE OUTCOMES

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

CO1 – Demonstrate the construction, working and operation of AC machines like Transformers and Induction Machine
CO2 – Verify and Analyze the performance characteristics of AC machines like Transformers and Induction Machine by conducting different tests
CO3 – Estimate the performance of Induction Machines by using circle diagram
CO4 – Understand the different configuration of Three Phase Transformers
CO5 – Understand the speed control of Induction Motors
CO6 – Understand the parallel operation of two Transformers

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

20HS201P					Communication Skills – II					
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 understand communication and its process and effect on giving and receiving information.
2. To learn and apply communication skills in different public and interpersonal contexts.
3. To develop analytical, research, and organizational skills through communication skills for a fulfilling career.

UNIT I: **7 Hrs**

- Technical Writing
  - ✓ Report Writing
  - ✓ Creating Lab Journals and Manuals
- Portfolio of Critical Writing and Creative Writing
  - ✓ Essay, Story-writing, etc.

UNIT II: **7 Hrs**

- Summarizing
- Writing Reviews (Books/Articles/Movies/websites)
- Reading Skills (Advanced)

UNIT III: **7 Hrs**

- Digital Literacy
  - ✓ Emails
  - ✓ Creating e-content
  - ✓ Editing and proofreading online
  - ✓ Using grammar and spell check software
  - ✓ Using plagiarism checkers

UNIT IV: **9 Hrs**

- Group Discussion
- Resume Writing
- Interview Skills

TOTAL HOURS **30 Hrs**

COURSE OUTCOMES

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

CO1 – Apply current technology for effective communication leading to better dissemination of knowledge &expertise.

CO2 – Demonstrate relevant knowledge of communication skills in different settings to cater to different purposes & audiences.

CO3 – A sound understanding of communication theory, practice and application to optimize career opportunities.

CO4 – Dynamic communication skills to build and maintain robust and effective professional relationships.

CO5 – Augmented communication skills to prepare and present messages, reports and documents in intent and to integrate different sources of information and knowledge.

CO6 – Monitoring and critical reflection on communication skills for the adoption of appropriate strategy required in achieving the desired outcomes

TEXT/REFERENCE BOOKS

1. Harmer, Jeremy. **The Practice of English Language Teaching**. Harlow: Pearson Longman, 2007.
2. Kaul, Asha. **Business Communication**. Delhi: Prentice-Hall of India, 2006.
3. Maley, A. '**Literature in the Language Classroom'**, The Cambridge Guide to Teaching ESOL, Cambridge University Press.
4. Richards, Jack C., and Willy A. Renandya, eds. **Methodology in Language Teaching: An Anthology of Current Practice**. Cambridge University Press, 2002.
5. 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	• Essay/Journal Writing – 10 • Report Writing – 10 • Creating e-content – 10 • Blog Writing – 10 • Review Writing – 10
Lab Exam/Viva	50	• Mock Interview – 15 • Group Discussion – 15 • Cover Letter/Curriculum – 20

20EE204T					Climate Change: Impact and Solutions					
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 climate change and current status.
2. To understand the concept present generation of renewable energy sources and distributed generation of power sources.
3. To acquire knowledge of basic types of available energy sources.
4. To know the basics about energy conservation and its methodology.

UNIT I: INTRODUCTION TO THE CLIMATE CHANGE **10 Hrs**

Earth's Climate, The Greenhouse Effect, The Carbon Cycle, Natural Climate Change, The Human Impact on climate change, Human and biological waste, Heat-waves and droughts, Melting of ice caps and Warming oceans, Losses of the species, Impact on ecological system, Societal impact, Documentaries reported on energy crises and their solutions, Carbon foot prints, Future prediction and summary.

UNIT II: THE ENERGY ENGINEERING **07 Hrs**

Basics of energy, unit conversions, Trends of energy consumption, Scenario of energy consumption in case of developed and developing country, Indian energy scenario, Environmental concern importance of renewable energy, Consumption from Fossil fuel, availability and limitations, Types of Renewable Energy Sources, Need to develop new energy sources- energy.

UNIT III: ENERGY EFFICIENCY AND ENERGY CONSERVATION **08 Hrs**

Concept of energy efficiency, Green transportation, Energy conservation and its importance, energy strategy for the future. Energy Conservation Act 2001 and related policies: Energy conservation Act 2001, Methods of Energy conservation.

UNIT IV: RENEWABLE ENERGY SOURCES AT A GLANCE **15 Hrs**

Solar Energy: Concept of Harnessing Solar Energy, Solar Water Heating, Solar Cooling, Solar Thermal Electricity, Solar Collectors, Introduction to Solar Photovoltaic.

Wind Energy: Concept, Motion of wind, Conversion of wind power, Wind turbine dynamics.

Tidal Power: Concept, Tidal Turbine, Types of Tidal Power Plant.

Biomass: Definition and types of biogas plants and its design for small community.

Geothermal: Definition and Overview of geysers and geothermal power station.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Remembering basic terms of climate change, non-renewable and renewable sources.
CO2 – Illustrate the basic terminologies related with energy engineering.
CO3 – Develop the concept of energy conservation and energy efficiency.
CO4 – Understand the energy scenario and significance of power generation from renewable energy sources.
CO5 – Understand the types of alternative energy sources.
CO6 – Distinguish the various renewable power generation sources

TEXT/REFERENCE BOOKS

1. J. Woodward, "**Eyewitness Climate Change**", DK Publishing.
2. Rao &Parulekar, **Energy Technology** - Khanna Publications, New Delhi, 2007.
3. Sawhney G. S., "**Non-conventional energy sources**", PHI Learning Pvt. Ltd.
4. G. D. Rai, "**Renewable Energy Sources**", Khanna Publishers
5. The Energy Conservation Act, 2001, Ministry of Law, Justice And Company Affairs, Legislative Department.

WEBPAGES

1. https://beeindia.gov.in/
2. https://mnre.gov.in/

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 from unit 1 and one from unit IV, each carrying 10 marks 20 Marks

PANDIT DEENDAYAL ENERGY UNIVERSITY, GANDHINAGAR
SCHOOL OF TECHNOLOGY

COURSE STRUCTURE FOR B. TECH. IN ELECTRICAL ENGINEERING

Semester IV			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.	20EE205T	Electric Power Generation, Transmission and Distribution	4	0	0	4	4	25	50	25	--	--	100
2.	20EE206T	Linear Control Theory	3	0	0	3	3	25	50	25	--	--	100
3.	20EE206P	Control Systems Laboratory	0	0	2	1	2	--	--	--	50	50	100
4.	20EE207T	Synchronous and DC Machines	3	0	0	3	3	25	50	25	--	--	100
5.	20EE207P	Synchronous and DC Machines Laboratory	0	0	2	1	2	--	--	--	50	50	100
6.	20EE208T	Microprocessors and Microcontrollers	3	0	0	3	3	25	50	25	--	--	100
7.	20EE208P	Microprocessors and Microcontrollers Laboratory	0	0	2	1	2	--	--	--	50	50	100
8.	20EE209T	Open Elective II	3	0	0	3	3	25	50	25	--	--	100
9.	20IF201T	Industry 4.0	2	0	0	2	2	25	50	25	--	--	100
10.	20IF201P	Industry 4.0 Laboratory	0	0	2	1	2	--	--	--	50	50	100
11.	TP210	Industrial Orientation	0	0	0	1	0	--	--	--	--	100	100
		Total	**18**	**0**	**08**	**23**	**26**						**1100**

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

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.

Subject Code	Open Elective II
20EE209T	Energy and Water Nexus

20EE205T					Electrical Power Generation, Transmission and Distribution					
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 understand the electrical power generation and its economics
2. To calculate parameters of transmission line and analyse its performance
3. To introduce design aspects of transmission line.
4. To understand characteristic of distribution systems

UNIT I: ELECTRICAL POWER GENERATION AND LOADS **12 Hrs**

Introduction to structure of power system. Schematic diagram for thermal, gas, hydro and nuclear power plant and associated equipment and auxiliaries. Load curves and load duration curves, associate terms and factors, importance of high load factor, different types of loads, tariffs, power factor improvement methods, derivation of most economical power factor,

UNIT II: OVERHEAD TRANSMISSION LINE **14 Hrs**

Types of conductors, resistance of transmission line. Calculation of inductance and capacitance of single phase & three phase line with different line configuration, Concepts of GMD, GMR, transposition of line. Characteristic and performance analysis of short, medium and long lines through ABCD parameters, voltage regulation and transmission efficiency of lines under different loading conditions, Surge Impedance Loading, Ferranti effect, active and reactive power flow through tine and their impact on bus voltage magnitude and phase angle, shunt and series compensation of line.

UNIT III: ELECTRICAL AND MECHANICAL DESIGN OF TRANSMISSION LINE **12 Hrs**

Mechanical Design of Overhead Lines: Choice of line insulators, voltage distribution across insulators disc, string efficiency, methods of equalizing potential across insulator. Sag and tension calculations, Effect of ice and wind, Stringing chart, Sag template, Tower design, Spacing and clearance, Vibration damper **Electrical Design of Line:** Choice of voltage level, kW-km loading, choice of conductors, their spacing and current carrying capacity, consideration of corona discharge and corona loss. Sample case study for complete design of transmission line.

UNIT IV: DESIGN OF DISTRIBUTION SYSTEM AND SUB STATIONS **14 Hrs**

Radial, loop and grid type sub-transmission, distribution substation bus schemes, location and rating of substation, AC power supply scheme, advantage of higher transmission voltage, various supply schemes in distribution systems, voltage drop and power loss calculations in distribution systems, types of cables, economics of power supply considering economic choice of conductor size and voltage level. **Power station and substation grounding:** Objectives of grounding, definitions, tolerable limits of body currents, soil resistivity, measurement of soil resistivity, earth resistance, measurement of earth resistance, tolerable step and touch potential, actual step and touch potential, design of earthing grid.

TOTAL HOURS **52 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand basic schematic of power plant based on conventional energy sources and understand different terms to study economics of power generation
CO2 – Derive transmission line parameters with different configurations of transmission line
CO3 – Analyse the performance of short, medium and long transmission lines and compute its voltage regulation, power transfer capability, efficiency, compensation methods
CO4 – Perform electrical and mechanical design of transmission line
CO5 – Understand design of distribution supply systems
CO6 – Understand the design concepts of substations and its grounding practices

TEXT/REFERENCE BOOKS

1. Sivanagaraju and Satyanarayana, **"*Electrical Power Transmission and Distribution*", Pearson Education**
2. Glover, Sarma, Overbye, "***Power System Analysis and Design***", Cengage Publication.
3. M.V. Deshpande, "***Electrical Power Stations***", PHI Publications
4. V. K. Mehta, Rohit Mehta, ***"Principles of Power System",*** S Chand Publications.
5. Dr. S.L. Uppal and S. Rao, **"*Electrical Power Systems*", Khanna Publishers.**
6. Kothari &Nagrath***, "Power System Engineering,"*** Tata McGraw-Hill Education, 2008**.**
7. Hadi Saadat, **"Power System Analysis",**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, one from each unit, each carrying 10 marks 40 Marks

20EE206T					Linear Control Theory					
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 basic concepts of control theory and feedback systems.
2. To start thinking on the concepts of mathematical modelling and to model simple physical systems.
3. Introduce to concept of state, state space and state space models of a system
4. To teach students the characteristics of closed-loop control systems, including steady-state and transient response.
5. To understand and analyze the concepts of stability through time and frequency domain methods.

UNIT I: INTRODUCTION TO CONTROL SYSTEM **5 Hrs**

Definition, Open loop and closed loop systems, Examples, Components of control systems, Types of control systems, Concept of feedback, positive and negative feedback. Types of processes and its characteristics, linear, non-linear, time-varying, time-invariant, continuous, discrete process, lumped parameter, distributed parameter processes.

UNIT II: MATHEMATICAL MODELLING OF PHYSICAL SYSTEMS **15 Hrs**

First principle modelling, Modelling of physical systems such as electrical, mechanical, electro-mechanical systems, analogous systems, concept of transfer function, poles, zeroes, 'order' and 'type' of the system, computation of overall transfer function, block diagram reduction techniques, signal flow graphs, Introduction to state, state space and state variables, state space models, conversion of state space models to transfer function models, solution of state equation, Homogeneous and Non-homogeneous state equations, State transition matrix, concept of controllability and observability.

UNIT III: TIME RESPONSE ANALYSIS **05 Hrs**

System dynamics, Standard test signals, Step, Impulse, Ramp, Parabolic, Sinusoidal signals, Transient and steady state response of first and second order systems, Time response specifications, Steady state error, Concept of dominant poles for higher order systems.

UNIT IV: STABILITY ANALYSIS OF CONTROL SYSTEMS **15 Hrs**

Notations of stability, Asymptotic and BIBO stability, Necessary conditions for stability, Routh-Hurwitz stability criterion, Relative stability, Introduction to root locus, definition, rules to construct root locus, Stability analysis and control system design using root locus, Introduction to frequency response, Frequency response specifications, Stability analysis using Bode plots, Polar and Nyquist plots.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Understand the basic concepts of control theory and feedback control systems.
CO2 – Apply the first principle laws to model (Mathematically) the simple physical processes.
CO3 – Analyze the time response of continuous systems.
CO4 – Evaluate the stability of control systems using Routh array test and Evans root locus technique.
CO5 – Analyze the performance characteristics and stability of a control system using frequency response methods.
CO6 – Understand the concept of state, state variables and state space modelling

TEXT/REFERENCE BOOKS

1. I.J. Nagrath and M.Gopal, **Control system Engineering**, New Age International Limited.
2. Katsuhiko Ogata, Modern **Control Engineering**, PHI Learning Pvt. Ltd., New Delhi.
3. Gene F. Frankline, J. David Powell, Abbas Emami-Naeini, **Feedback Control of Dynamic Systems**, Pearson Education Inc.
4. I.J. Nagrath and M. Gopal,**Systems Modelling and Analysis**, Tata McGraw-Hill Publishing Company Limited.
5. Norman N. Nise, **Control system engineering**, Wiley International Edition.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

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

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

20EE206P					Control 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 make the students acquainted with the use of computational software such as MATLAB and its programming.
2. Students will able to perform simulation exercise on control theory using Simulink environment.
3. Students will be able to identify model parameters using open loop experimental runs.
4. To study stability analysis using time and frequency response methods using MATLAB.
5. To do transient and steady state response analysis of processes for standard test signals.

LIST OF EXPERIMENTS

1. Introduction to MATLAB (Mathematical Computational & Simulation Software) - Applications in Control Theory.
2. To study mathematical modelling of Electrical Systems & Simulate using MATLAB.
3. To study mathematical modelling of Mechanical Systems & Simulate using MATLAB.
4. Transient response analysis of first order systems (Simulation Exercise using MATLAB).
5. Transient response analysis of second order systems (Simulation Exercise using MATLAB).
6. To solve ordinary differential equations (state space models) using solvers in MATLAB.
7. To solve ordinary differential equations (state space models) using Simulink in MATLAB.
8. To study transient and steady state response of liquid level system using open loop experimental runs and verify them using open loop simulations.
9. To find time constant and steady state gain of Single Board Heater System (SBHS).
10. To study stability analysis using Root Locus (verifying using MATLAB).
11. To study stability analysis using Bode Plots (verifying using MATLAB).
12. To check controllability and observability of the system using state space models (verifying using MATLAB).

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the use of various commands and functions used in control theory using MATLAB Computational Software.

CO2 – Analyze the transfer function and differential equation models (state space models) using MATLAB simulation environment.

CO3 – Perform hands-on experiments to analyze the dynamics of the system.

CO4 – Evaluate the stability of a system using Root Locus and Bode plots in MATLAB environment.

CO5 – Analyze the time response of continuous systems using MATLAB simulation environment.

CO6 – Model the process using time response data.

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

20EE207T					Synchronous and DC Machines					
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 basic principles, working, construction, classification and operating characteristics of rotating machines such as Synchronous and DC machines
2. To evaluate and analyse the performance of Synchronous and DC machines
3. To enable students to identify and solve the related problems in Synchronous and DC machines
4. To impart sound knowledge about the different applications of Synchronous and DC machines

UNIT I: THREE PHASE SYNCHRONOUS GENERATOR **18 Hrs**

Construction, Types, Operating Principle, Terms Related to AC Armature Winding, Pitch & Distribution Factors, Generated EMF, Effect of Harmonics on Induced EMF, Operation on Load – Standalone operation of an Alternator, Phasor Diagrams, Power Output Equation, Armature Reaction, SCR of an Alternator, Voltage Regulation, Determination of Voltage Regulation by Direct Loading, Synchronous Impedance, MMF & ZPF Methods, Two Reaction Theory, Condition of Parallel Operation, Synchronizing of Alternators & Methods of Synchronization, House Diagram, Operation of two or more machines, load sharing, Operation on Infinite Bus, F-P, Q-V Characteristics, Effect of change in excitation, Effect of change in prime mover speed, Slip Test, Hunting of Synchronous Machines & Its Prevention, Capability Curves, Short Circuit Transients, Short Circuit on Generator, Constant Flux Linkage Theorem, Mathematical Solution of series RL circuit, Transient, Sub-transient, Steady state
Single Phase Generator Short Circuit, Testing and Trouble Shooting of Three Phase Alternator

UNIT II: THREE PHASE SYNCHRONOUS MOTOR **06 Hrs**

Construction, Operating Principle, Phasor Diagrams, Starting Methods, Effect of Varying Field Current at Different Loads, V-Curves, Hunting & Damping, Synchronous Condenser, Power Developed by Synchronous Motor.

UNIT III: DC GENERATOR **10 Hrs**

Principle & Construction of a DC Machine, Types of DC Generators, DC Machine Armature Winding, Characteristics of DC Generators, EMF Equation, Voltage Build-Up in a Shunt Generator, Critical Resistance & Speed, Losses in DC Machine, Power Stages & Efficiency, Armature Reaction & its Effects, Inter Poles & Compensating Winding, Commutation & Methods to Improve Commutation, Applications.

UNIT IV: DC MOTOR **06 Hrs**

Working Principle, Back EMF, Voltage & Power Equations, Types, and Torque of a DC Motor, Power Stages, Efficiency, Performance Characteristics, Necessity of Starter, Three & Four Point Starters, Speed Control of DC Motors, Applications, **Efficiency and Testing of DC Machines:** Methods of Testing, Brake Test, Swinburne's Test, Hopkinson's Test, Field Test, Retardation Test, and Trouble Shooting of DC Machines.

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Understand the construction, principle of operation and working of different kind of rotating machines
CO2 – Understand operation and performance of three phase alternator in isolated & grid connected mode
CO3 – Calculate the voltage regulation of alternator by different methods
CO4 – Appraise the purpose for parallel operation of generators and learn the process of synchronization
CO5 – Analyze the performance of DC machines by various tests
CO6 – Compare the different methods of starting and speed control of DC motors

TEXT/REFERENCE BOOKS

1. B.L. Theraja & A.K. Theraja, **A Text Book of Electrical Technology Volume II-AC & DC Machines**, S. Chand & Co.
2. J.B.Gupta, **Theory and performance of electrical machines**, Katson Publication, S.K.Kataria& Sons.
3. Ashfaq Hussain, **Electric Machines**, DhanpatRaiand Co.
4. P. S. Bimbhra, **Electrical Machinery**, Khanna Publishers
5. M. G. Say, **Alternating Current Machines**, Pitman and Sons
6. J. G. Jamnani, **Electrical Machines**, Mahajan Publishing House.

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, 3 form unit I and 1 form unit III, each carrying 10 marks 40 Marks

20EE207P					Synchronous and DC Machines 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 of construction and working of rotating electrical machines
2. To determine the performance characteristics of rotating electrical machines by different tests
3. To determine the voltage regulation of alternator by different methods
4. To learn the synchronization procedure for alternators

List of Experiments:

1. To determine the voltage regulation of an alternator by direct loading method.
2. To determine the voltage regulation of an alternator by synchronous impedance method.
3. To determine the voltage regulation of an alternator by MMF method.
4. To determine the voltage regulation of an alternator by Z.P.F. method.
5. Synchronization of two 3-phase alternators with common bus bars by various methods.
6. To plot `V' curve of three phase synchronous motor.
7. To determine direct and quadrature axis reactance of a salient pole alternator by slip test.
8. To understand the construction and operation of DC machine by working cut section.
9. To obtain the efficiency and load characteristics of a DC shunt motor by direct load test.
10. To determine external and internal characteristics of a DC shunt generator.
11. To determine external and internal characteristics of a DC series generator.
12. To determine external and internal characteristics of a DC compound generator.
13. To control speed of a DC shunt motor by armature control and field control methods.
14. To find the efficiency of a DC machine by Swinburne's test.
15. To perform Hopkinson's Test on a pair of two identical DC machines to find the efficiency of each machine.
16. To perform Field test on a pair of two identical DC series machines to find the efficiency

COURSE OUTCOMES

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

CO1 – Demonstrate construction, working and operating of rotating machines such as Synchronous and DC machines
CO2 – Analyze the performance parameters and characteristics of DC machines
CO3 – Measure and compare the voltage regulation of Alternator by different method
CO4 – Understand the speed control of DC motors
CO5 – Understand the parallel operation of Alternators
CO6 – Verify and Analyze the performance characteristics of rotating machines by conducting different tests.

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

20EE208T					Microprocessors and Microcontrollers					
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 get familiar with microprocessors and microcontrollers and their role in designing embedded systems.
2. To understand the architecture, assembly programming and timing diagram for a microprocessor and microcontroller
3. To write basic programs in C to explore the functionalities of microcontrollers for real-world applications

UNIT I:FUNDAMENTALS OF MICROPROCESSORS **10 Hrs**

Introduction to Microprocessors:8-bit microprocessor and microcontroller architecture, Comparison of 8-bit, 16-bit and 32-bit microcontrollers, Definition, classification and examples of Embedded systems

Internal architecture of Intel 8085 microprocessor: Block diagram, Registers, Internal Bus Organization, Functional details of pins, Registers, ALU

UNIT II:8085 MICROPROCESSOR **10 Hrs**

Memory Interfacing: Interfacing external RAM and ROM, Bus System, Control signals, Address / Data bus multiplexing and de-multiplexing.

Assembly language programming: 8085 instruction set: Instructions, Classifications, Addressing modes, Decision Making, Looping, Stack and Subroutines etc. and Programming examples. Timing Diagrams of various instructions, Interrupts.

UNIT III:8051 MICROCONTROLLER **10 Hrs**

Introduction to 8051 microcontroller: Introduction, Architecture of 8051 Microcontroller, 8051 microcontroller hardware, Pin diagram of 8051, input/output pins, ports and circuits. Internal RAM and ROM, SFR's

On-board Peripherals: GPIO, Timers and Counters, Interrupt, Serial data communication (UART)

UNIT IV:8051 C PROGRAMMING **10 Hrs**

Basics of C programming, programming examples for GPIO, Timers, Round-robin with interrupts, PWM, LCD, UART

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 – Understand microprocessor & microcontroller and their applications
CO2 – Learn the architecture, assembly language programming and timing diagram for a microprocessor & microcontroller
CO3 – Understand structure of embedded C programming
CO4 – Explore the functionalities of microcontrollers for real-time applications
CO5 – Illustrate the functionalities of different peripherals and their interfacing with microprocessor
CO6 – Develop the embedded solution for real time applications

TEXT/REFERENCE BOOKS

1. Ramesh S. Gaonkar, "**Microprocessor Architecture, Programming, and Applications with the 8085**", Penram International.
2. David E. Simon, "**An Embedded Software Primer**", Addison-Wesley Professional
3. William Kleitz, "**Microprocessor and Microcontroller fundamentals: The 8085 and 8051 Hardware and Software**"
4. Douglas V. Hall , "**Microprocessors, Interfacing and Peripherals**", Tata McGraw Hill,
5. Ajoy Ray, K Bhurchandi, "**Advanced Microprocessors and Peripherals**", Tata McGraw Hill
6. Muhammad Ali Mazidi, Janice GillispieMazidi and RolinMcKinley, "**The 8051 Microcontroller and Embedded Systems Using Assembly and C**", Pearson Education.
7. K. J Ayala, D. V. Gadre, "**The 8051 Microcontroller and Embedded Systems using Assembly and C**", Cengage Learning, India Edition.

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

20EE208P					Microprocessors and Microcontrollers 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 8085 architecture and programming assembly language.
2. To introduce basic concepts of interfacing memory and peripheral devices to microprocessor.
3. To introduce 8051 microcontroller.
4. To write basic programs in C to explore the functionalities of microcontrollers for real-world applications

List of Experiments:

1. Tabulate Instruction Set for 8085 microprocessors
2. Write a program to move a data block starting at Memory Location X to Location Y without overlap. X, Y and block length are to be specified
3. Write a program to move a data block starting at Memory Location X to Location Y with overlap. X, Y and block length are to be specified
4. Write a program to perform an addition of two 8 bit numbers stored at locations X and Y.
5. Write a program to perform subtraction of two 8 bit numbers stored at location X and Y.
6. Find the product of two unsigned binary numbers stored at location X and X+1
7. Write a program division of two Binary Numbers stored at location X and X+1. Display the quotient in address field and remainder in data field
8. Write a program to find the smallest of N one byte numbers. Value of N is stored at location X and the numbers from location X+1. Display the smallest number in the data field and its address in the address field
9. Write a program to display a MOD N binary up counter and down counter. Display the count in address/data field. Generate a 0.5 sec delay between the counts. If clock frequency is 3 MHz
10. Configure ports A, B, C in the output mode in 8155 without timer operation and observe the output with the help of LEDs
11. Configure ports A, B, C in the input mode in 8155 with the help of LEDs without timer operation and observe the output.
12. Configure ports A, B, C in the output mode in 8255 without timer operation and observe the output with the help of LEDs
13. Configure ports A, B, C in the input mode in 8255 with the help of LEDs without timer operation and observe the output
14. Configure ports A, B, C in the output mode in 8255 without timer operation and code for getting square signal & observe the output with the help of LEDs
15. Stepper motor Interfacing/Speed Control & Direction Control using 8085 and 8051
16. Write the Embedded C Program and Assembly Program to Display "EMBEDDED LAB" on LCD and compare Output of both program and draw the conclusion
17. Write the Embedded C Program and Assembly Program for Wave Drive Stepper Motor System. And observe the output in the Proteus
18. Write the Embedded C Program and Assembly Program for Half Wave Drive Stepper Motor System. And observe the output in the Proteus.

COURSE OUTCOMES

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

CO1 – Understand the internal architecture of 8085 microprocessor and 8051 microcontroller thoroughly.
CO2 – program assembly language codes for 8085 microprocessor and 8051 microcontroller.
CO3 – apply C language based coding on different problems involving 8051 microcontrollers
CO4 – understand the interfacing of 8085 microprocessor and 8051 microcontroller with different peripherals
CO5 – understand the application of basic concepts of 8085 microprocessor and 8051 microcontroller related to timers, counters, interrupts.
CO6 – engage the students in formulating practical solutions from the theoretical knowledge gained into electrical engineering domain applications

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

20IF201T					Industry 4.0					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To interpret the core elements and basic technologies of Industry 4.0
2. To understand how the core elements and technologies of Industry 4.0 are interconnected
3. To develop a holistic approach to improve processes and products with Industry 4.0

UNIT I: INDUSTRY 4.0 – CONCEPTS & TERMINOLOGIES **08 Hrs.**

Industry 4.0, Smart business model, Technology road-map, Sensing & actuation, Communication, Internet of things (IoT), Cyber Physical Systems and Next Generation Sensors, Visualization, Cloud Computing.

UNIT II: SMART WORLD & SUSTAINABLE ENVIRONMENT **08 Hrs.**

Sensors and their integration, Renewable Energy System, Hybrid Energy System, Smart Grid, Smart Metering, Communication Protocols, 5G Technology, Smart Agriculture, Smart Infrastructure, Physiological Sensors, Human Machine Interface.

UNIT III: SMART MANUFACTURING **08 Hrs.**

Automation Systems, Additive Manufacturing, Micro-Electro-Mechanical Systems (MEMS), Smart Factories and Interconnection, Advanced Robotics – Autonomous and Swarm, Self-Propelled Vehicles, Drones–Unmanned Aerial Vehicle (UAV), 3d Printing, Spacecrafts.

UNIT IV: TRANSFORMING TECHNOLOGIES IN BIOENGINEERING **08 Hrs.**

Establishment of Smart Biotechnology Factory, Artificial Intelligence in Bioprocess Technology, 3D Bio Printing for Tissue Engineering, Simulation Tools, RSM and Box Model, Cyber Physical System based Telemedicine, Real Time Biosensors, Bio nanotechnology, biofuel.

Total Hours 32 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the core elements and basic technologies for Industry 4.0
CO2 – Apply the different computational techniques and algorithms for realizing Industry 4.0
CO3 – Transform the traditional business approach by integrating the data and intelligence
CO4 – Develop the traditional industries with intelligent and automated machines
CO5 – Utilize data and intelligence for the development of Smart World
CO6 – Understand the concept, significance and means to achieve sustainable development

TEXT/REFERENCE BOOKS

1. Ustundag Alp, and EmreCevikcan, Industry 4.0: Managing the Digital Transformation, Springer,First Edition, 2018
2. Kaushik Kumar, DivyaZindani, and J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0., CRC Press, Taylor & Francis First Edition, 2019.
3. Antonella Petrillo, Raffaele Cioffi, and Fabio De Felice, Digital Transformation in Smart Manufacturing., IntechOpen Publisher, First Edition, 2018.
4. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama and N. Jenkins, Smart Grid: Technology and Applications, John Wiley and Sons Ltd., First Edition, 2012
5. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, First Edition, 2016
6. Ibrahim Garbie, Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0, Springer, First Edition, 2016

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

20IF201P					Industry 4.0 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 comprehend the concept and significance of Industry 4.0
2. To understand core elements and technologies of Industry 4.0 through simulation and experimental studies
3. To explore different software packages and hardware elements involved in realization of Industry 4.0

List of Experiments

1. Basic computations using Python programming.
2. Use simulations to understand the performance/behavior of a system by (i) creating a computational environment that mimics the real world, (ii) generating (synthetic) or loading data from sources, and (iii) testing the hypothesis
3. Introduction to MATLAB programming and SIMULINK
4. 3D printing of Airfoil through rapid prototyping 3D printer
5. Dynamic simulation of drone (unmanned air vehicle) through MATLAB/SIMULINK
6. ANSYS simulation of bending of a beam in an earthquake resist-building
7. Introduction to Arduino Embedded platform.
8. Design of line follower autonomous vehicle.
9. Design of smart meter for recording the electricity consumption
10. Design of smart lighting with the help of proximity sensors.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the concept of Industry 4.0 and its significance
CO2 – Understand the resource requirements for the implementation of Industry 4.0
CO3 – Learn the Simulation Packages for Industry 4.0
CO4 – Explore the concept of Smart Infrastructure through simulation studies
CO5 – Inspect embedded platform applications for Industry 4.0
CO6 – Synthesise the solution for the given Industry 4.0 related problem

END SEMESTER LABORATORY EXAMINATION PATTERN

Max. Marks: 100

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

TP210					Industrial Orientation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	2	--	--	--	--	--	100	100

COURSE OBJECTIVES

1. To introduce students to the working environment of the industry
2. To understand the different departments involved in an industry for developing a product or offering a service
3. To learn about the significance of the theoretical knowledge being imparted in the lecture sessions in working of an industry

Students are required to visit industries to observe the working of an industry. The students will have the opportunity to understand various industrial processes, departments involved and manufacturing process. Moreover, the students will get an opportunity to see the theoretical knowledge acquired being put into practice in industry.

COURSE OUTCOMES

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

CO1 – Understand the working of industry
CO2 – Acquire knowledge about the different departments involved in the functioning of an industry
CO3 – Learn about the products being developed or services being offered by the industry
CO4 – Understand the safety procedures followed by industry while working on shop floor
CO5 – Learn how the theoretical knowledge is utilized for product development or for services being offered
CO6 – Acquire the necessary skills for technical report writing

END SEMESTER EXAMINATION PATTERN

Max. Marks: 100

End semester examination and Viva-voce 100 marks

20EE209T					Energy and Water Nexus					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the significance of water and energy efficiency.
2. To gather knowledge about interdependency of energy and water use.
3. To identify the processes requiring energy for water use and water for energy generation.

UNIT I:INTRODUCTION TO ENERGY-WATER NEXUS **08 Hrs**

What is Energy-Water nexus?, Energy-Water flow diagram, Unsustainable and sustainable development, Energy and water challenges, Need for integrating energy and water, Population, Hunger and Millennium Development Goals (MDGs), UN sustainable development goals (SDGs), Climate change and its impact, Electricity consumption in the water sector by process, Societal aspects: rural livelihood scenario, urban scenario,

UNIT II:ENERGY FOR WATER: ENERGY USE FOR WATER DEMAND **10 Hrs**

Energy and its measurement, Drivers of water demand, Characteristics and Properties of Water: Abundance, Thermal Properties, Phase Transitions, Other Properties, Regional and Temporal Variability in Water Accessibility, Linkages between the Fuels Life Cycle and Water Quality. Energy consumption for drinking water supply and wastewater treatments, Energy for ground-water pumping, Energy for desalination, Energy pricing and costs

UNIT III:WATER FOR ENERGY: WATER USE FOR ELECTRICITY GENERATION **13 Hrs**

Drivers of energy demand, Sectoral energy demand: domestic, commercial, industrial, agricultural

fossil-fuel based power generation processes: Coal fuel cycle, Thermoelectric Cooling, Oil and Natural gas, Nuclear power,

renewable power sources: Geothermal, Hydroelectricity, Solar thermal power generation, solar photovoltaic, wind energy

Transportation Fuels Production: Water Life Cycle Management in Fossil Fuels Production, Water Consumption Intensity for Fuels Production, Water Pricing and Costs

UNIT IV: CASE STUDIES AND FUTURISTIC INNOVATIONS **09 Hrs**

Case studies, Circular economy, Challenges and opportunities, Data, Modelling, and Analysis, thinking to enhance energy-water nexus thinking, Sector-Specific Water-Energy Landscape for Decision Making, Challenges and opportunities

TOTAL HOURS 40 Hrs

COURSE OUTCOMES

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

CO1 - Examine the concept of Water and Energy usage.
CO2 - Analyse behaviour of energy consumption for water demand.
CO3 - Analyse behaviour of water usage for energy demand.
CO4 - Understand the concept of interlinkage of Energy and Water.
CO5 - Gather knowledge through national case studies.
CO6 - Gather knowledge through international case studies.

TEXT/REFERENCE BOOKS

1. Ernest J. Moniz (2014), "**The Water-Energy Nexus: Challenges and Opportunities**", U.S. Department of Energy.
2. Gleick, P. H. (1994). "**Water and Energy**." Annual Review of Energy and the Environment, 19(1), 267–299.
3. Khatavkar, P., & Mays, L. W. (2017 a) "**Model for the Real-Time Operation of Water Distribution Systems under Limited Power Availability**". In World Environmental and Water Resources Congress 2017 (pp. 171–183).
4. Khatavkar, P., & Mays, L. W. (2017). Testing an Optimization/Simulation Model for the Real-Time Operations of Water Distribution Systems under Limited Power Availability. In Congress on Technical Advancement 2017 (pp. 1–9).

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