GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

BASICS OF ELECTRICAL ENGINEERING

SUBJECT CODE: 3110005

B.E. 1st Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	4	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

- Main objective of this course is to teach basic aspects of electrical engineering.
- This course gives idea about basic circuit solution methods, introduction to electrical machines and basics of domestic electrical installations.

Syllabus:

1	**DC Circuits:** Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff's current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.
2	**AC Circuits** Representation of sinusoidal waveforms, peak and RMS values, Phasor representation of AC quantities, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), Series and parallel resonance. Three phase balanced circuits, voltage and current relations in star and delta connections, Power measurement in three phase circuits.
3	**Transformers** Magnetic materials, BH characteristics. Construction and working principle of single phase and three phase transformers. Ideal and practical transformer.

	Auto-transformer and its applications**.**
4	**Electrical Machines** Generation of rotating magnetic fields. Construction and working of following machines: • Three-phase induction motor • Single-phase induction motor. • Separately excited DC motor. • Synchronous generators.
5	**Electrical Installations** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB. Types of Wires and Cables. Earthing – Types of earthing and its importance. Safety precautions for electrical appliances. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption. Basics of power factor improvement.

Course Outcomes:

CO-1:- Understand & apply Kirchoff's laws, network theorems, time domain analysis for RL & RC series circuit.

CO:-2 Understand and analyse phasor diagram and waveforms for purely resistive, purely inductive and purely capacitive as well as series and parallel R-L, R-C & R-L-C circuits and also circuit Resonance.

CO-3:- Understand concepts of Real, Reactive & apparent power and Power factor. Understand 3- phase supply and star and delta connection and their relationships. Power measurement by wattmeter

CO:-4 Understand construction & working principle of 1- phase and 3- phase transformers. Understand Ideal and practical transformer and auto-transformer and its applications as well.

CO:-5 Understand generation of rotating magnetic fields. Understand construction and working of 3-phase induction motor, 1-phase induction motor, DC motors& synchronous generators.

CO:-6 Understand LT Switchgear such as Switch Fuse Unit (SFU), MCB, ELCB, MCCB. Understand about wires, cables, earthing & its importance. Understand about types of batteries & its important Characteristics. Understand basic calculations for energy consumption & power factor improvement.

Program Specific Outcome (PSOs)

1. Apply design and development principles to develop software applications/products of varying complexity in emerging areas.

2. Ability to apply mathematical methodologies to solve computation task, model real world problem using appropriate data structure and suitable algorithm.

3. Ability to use current tools and techniques necessary for computing practices.

4. Ability to use knowledge in various domains to identify research gaps and provides innovative solution.

CO-PO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	1			1							2				
CO2	3	1			1							2		1	1	
CO3	3	1			1							2			1	
CO4	1		1									2				
CO5	2		1									1				
CO6	2		1			1						2				

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Basic knowledge about Ohm's and Kirchoff's laws will be gained by the students
CO1-PO2	1	Students will be able to identify, analyse and formulate problems in DC circuits domain.
CO1-PO5	1	Students use different measuring instruments to verify various laws related to electrical circuit.
CO1-PO12	2	Electrical laws will be useful to engage in independent and lifelong learning and gaining knowledge in any area of electrical engineering.
CO2-PO1	3	Students will gain basic knowledge about various series and parallel AC circuit.
CO2-PO2	1	Students will identify and analyse various problems related to AC circuits using principles of mathematics.
CO2-PO5	1	Students use different measuring instruments for practical performance of series and parallel AC circuit.
CO2-PO12	2	AC series & parallel circuits will be helpful to the students for technological change.

CO3-PO1	3	Students will gain basic knowledge about 3-phase power and its measurement techniques.
CO3-PO2	1	Students will identify, formulate and analyse various problems related to 3-phase power measurement using principles of mathematics.
CO3-PO5	1	Students use different measuring instruments for practical performance of 3-phase power measurement.
CO3-PO12	2	3-phase power measurement will be helpful to the students for lifelong learning.
CO4-PO1	1	Students will gain basic knowledge about 1-hase and 3-phase transformer along with auto transformer.
CO4-PO3	1	Students will be able to design that will meet the specified needs with appropriate consideration for the safety about 1-hase and 3-phase transformer along with auto transformer.
CO4-PO12	2	Study of 1-hase and 3-phase transformer along with auto transformer will be helpful to the students for lifelong learning.
CO5-PO1	2	Students will gain basic knowledge about construction and principles of DC & AC electrical machines.
CO5-PO3	1	Knowledge about DC & AC electrical machines will be useful for public health and safety.
CO5-PO12	1	Study of electrical machines such as DC machines, 1-phase AC & 3-phase AC machines will be helpful to the students for lifelong learning.
CO6-PO1	2	Students will gain basic knowledge about various protective devices and earthing system.
CO6-PO3	1	Knowledge about protective devices and earthing system will be highly useful for public health and safety.
CO6-PO6	1	Knowledge and application about various earthing system as well as protective devices will be useful for society in general.
CO6-PO12	2	Study of earthing, cables, batteries, switchgears will be helpful to the students for lifelong learning.

Mapping	Level	Justification
CO2-PSO2	1	Analysing phasor diagrams & waveforms of series & parallel circuits will be useful in enhancing ability to apply mathematical methodologies to solve computation task.
CO2-PSO3	1	Analysing phasor diagrams & waveforms of series & parallel circuits will be useful in enhancing ability to use current tools and techniques necessary for computing practices..
CO3-PSO3	1	Measurement of power and power factor and analysis thereafter will be useful in enhancing ability to use current tools and techniques necessary for computing practices.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

Electrical Workshop

SUBJECT CODE: 3110012

B.E. 1st Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
0	0	4	2	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

This course deals with basic introduction of system components of electrical systems, and provides hands on practice in assembling, interconnecting, testing, and repairing such system by making use of various tools used in electrical workshop.

Syllabus:

1	Measure voltage, current, frequency, phase difference, power, power factor for single and three-phase supply
2	Wire fan, tube light, two-way control (staircase wiring)
3	Wire MCB, ELCB for a given load circuit
4	Preparing the drawing for wiring a newly built room, without any electrical wiring along with a bill of materials with specifications; the room may be a class-room, an office, a shop, a clinic, a small workshop etc
5	Identify and rectify open circuit, and short circuit faults in PCB/System.
6	Solder and de-solder electronic components on different types of PCB
7	Identify various types of ports and connectors

Course Outcomes:

CO-1 Measure different electrical quantities.
CO-2 Understand the requirement and operation of safety devices.
CO-3 Select the appropriate tools and components required for specific operation.
CO-4 Wire and trouble shoot of house-hold appliances.

Program Specific Outcome (PSOs)

1. Apply design and development principles to develop software applications/products of varying complexity in emerging areas.
2. Ability to apply mathematical methodologies to solve computation task, model real world problem using appropriate data structure and suitable algorithm.
3. Ability to use current tools and techniques necessary for computing practices.
4. Ability to use knowledge in various domains to identify research gaps and provides innovative solution.

CO-PO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1					1											1
CO2						1		1								1
CO3					1						1					
CO4					1						1					

Mapping & Justification:

Mapping	Level	Justification
CO1-PO5	1	Applying knowledge of power tools to help in measurement of complex engineering quantities along with an understanding of the limitations.
CO2-PO6	1	Various safety measures during tools usage helps in assessing safety issues and the consequent responsibilities relevant to the professional engineering practice.
CO2-PO8	1	Safety measures while using the tools requires applying ethical principles and commit to professional ethics, responsibilities and norms of the engineering practice.
CO3-PO5	1	Applying knowledge of specific tools for specific operation help in prediction to complex engineering activities along with an understanding of the limitations.
CO3-PO11	1	Application of hand tools and power tools help in demonstrating knowledge and understanding of the engineering principles and apply these to one's own work
CO4-PO5	1	Applying knowledge of hand tools and power tools help in prediction to complex engineering activities along with an understanding of the limitations.
CO4-PO11	1	Application of hand tools and power tools help in demonstrating knowledge and understanding of the engineering principles and apply these to one's own work

Mapping	Level	Justification
CO1-PSO4	1	Different tools required for specific operation will enhance ability to use that knowledge in various areas to provide innovative solution.
CO2-PSO4	1	Various safety measures during tools usage will help enhance one's ability to use that to provide innovative solution.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

BASIC ELECTRONICS

SUBJECT CODE: 3110016

B.E. 2nd Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	4	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

- Analyze the general – and special-Purpose diode circuits.
- Design biasing circuits for BJT.
- Analyze BJT Circuits in small-signal domains.
- Analyze basic FET Circuits
- Verify the functionalities of basic digital gates and logic families

Syllabus:

1	**Diode theory and applications** Basic idea about forward bias, reverse bias and VI characteristics, ideal diode, second and third approximation, surface mount diodes, Zener diode, Testing of diode with multi-meter, half wave rectifier, full wave rectifier, bridge rectifier, RC and LC filters, Design of un-regulated DC power supply, Clipping circuit, Clamping circuit, voltage multiplier circuit, Reading datasheet of semiconductor diode.
2	**Bipolar junction transistors and its biasing** BJT operation, BJT voltages and currents, CE, CB and CC characteristics, DC load line and bias point, base bias, emitter feedback bias, collector feedback bias, voltage divider bias, Thermal stability, biasing BJT switching circuits, transistor power dissipation and switching time, Testing of bipolar junction transistor with multi-meter, Reading datasheet of BJT.
3	**Special purpose diodes and transistors** Light emitting diode (LED). Zener diode, Zener diode circuit for voltage regulation, Photo diode, Solar cell, PIN diode, Varactor, Schottky diode, Varistors, Tunnel diode, Seven Segment display, Sixteen segment display, Identify segments on pin using multi-meter, Dot-matrix LED display, Photo transistor, Opto-coupler, Reading datasheet of opto-electronics devices
4	**AC Analysis of BJT circuits and small signal amplifier** Coupling and bypass capacitors, AC load lines, Transistor models and parameters, Common emitter circuit analysis, common base circuit analysis, common collector circuit analysis, Comparison of CE, CB and CC circuits, Transistor as a switch

5	**Field effect transistors (FET) and its biasing** Junction field effect transistors(JFET), Comparison of BJT and FET, JFET characteristics, FET, Biasing in ohmic region and active region, Trans-conductance, amplification and switching, MOSFETs (D-type and E-type MOSFET), CMOS introduction, E-MOSFET amplifier. MOSFET testing, Reading datasheet for FET and MOSFET.
6	**Digital Circuits** Basic gates AND, OR,NOT, NAND, NOR, EX-OR, EX-NOR, Building AND, OR Gate with diodes, Digital logic families RTL, DTL, TTL, CMOS, Comparison of logic families

Course Outcomes:

CO-1 Analyze the general – and special-Purpose diode circuits.

CO-2 Design biasing circuits for BJT.

CO-3 Analyze BJT Circuits in small-signal domains
CO-4 Analyze basic FET Circuits
CO-5 Verify the functionalities of basic digital gates and logic families

Program Specific Outcome (PSOs)

1. Apply design and development principles to develop software applications/products of varying complexity in emerging areas.
2. Ability to apply mathematical methodologies to solve computation task, model real world problem using appropriate data structure and suitable algorithm.
3. Ability to use current tools and techniques necessary for computing practices.
4. Ability to use knowledge in various domains to identify research gaps and provides innovative solution.

CO-PO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	1				1		2		1				1			
CO2	1		1		1				1				1			
CO3	1		1		1				1				1			
CO4	1				1				1				1			
CO5	1				1				1				1	1		

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	1	Basic knowledge about general and special purpose diodes will be gained by the students
CO1-PO5	1	Students use different measuring instruments and tools to analyse various diode circuit.
CO1-PO7	2	Students will understand and analyse various diode circuit for the betterment of the environment.
CO1-PO9	1	Students will gain skills to work in group as well as individual by performing various practices related to different diode circuits.
CO2-PO1	1	Students will be able to apply knowledge of biasing for BJT in solving circuits which will lead to solution of complex engineering problems.
CO2-PO3	1	Students use understanding of biasing circuits for BJT which will lead to solutions of few of the societal, cultural and safety related problems.
CO2-PO5	1	Students use different measuring instruments and tools to analyse biasing circuits of BJT.
CO2-PO9	1	Students will gain skills to work in group as well as individual by performing various practices related to biasing circuits for BJT.
CO3-PO1	1	Students will be able to apply knowledge of BJT's application in analyzing circuits which will lead to solution of complex engineering problems.
CO3-PO3	1	Students use understanding of BJT circuits in small signal domain which will lead to solutions of few of the cultural, societal and safety related problems.
CO3-PO5	1	Students use different measuring instruments and tools to analyse BJT circuits in small signal domain.
CO3-PO9	1	Students will gain skills to work in group as well as individual by performing various practices related to BJT circuits in small signal domain.
CO4-PO1	1	Students will be able to apply knowledge of various FET circuits such as JFET, MOSFET in solving circuits which will lead to solution of complex engineering problems.
CO4-PO5	1	Students use different measuring instruments and tools to analyse circuits related to FET such as various JFET & MOSFET.
CO4-PO9	1	Students will gain skills to work in group as well as individual by performing various practices related to different JFET & MOSFET circuits.
CO5-PO1	1	Students will be able to apply knowledge of various logic gates in solving circuits which will lead to solution of complex engineering problems.
CO5-PO5	1	Students use different measuring instruments and tools to analyse functionalities of basic digital gates and logic families.
CO5-PO9	1	Students will gain skills to work in group as well as individual by performing various practices related to functionalities of basic

		digital gates and logic families.

Mapping	Level	Justification
CO1-PSO1	1	Students will apply knowledge of general and special purpose diodes which will lead to development of products of varying complexity.
CO2-PSO1	1	Students will apply understanding of designing biasing circuits for BJT diodes which will lead to development of products of varying complexity.
CO3-PSO1	1	Students will apply knowledge of BJT circuits in small signal domain which will lead to development of products of varying complexity.
CO4-PSO1	1	Students will apply understanding of various FET circuits which will lead to development of products of varying complexity.
CO5-PSO1	1	Students will apply understanding of functionalities of basic digital gates and logic families which will lead to development of products of varying complexity.
CO5-PSO2	1	Students will apply understanding of functionalities of basic digital gates and logic families to solve computational task and suitable algorithm.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09) / POWER ELECTRONICS (24)

ANALOG ELECTRONICS

SUBJECT CODE: 2130902

B.E. 3rd Semester

Type of Course: Engineering Science(ELECTRICAL)

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	Module 1. Diode and transistor: Common Emitter and Emitter follower analysis and comparison using hybrid equivalent circuit - Considerations in cascading transistor amplifiers- Class B and Class AB - Power amplifiers using BJTFET: Biasing a JFET and MOSFET - Small signal model - CS and CD amplifiers. Frequency response of BJT amplifiers. Concepts of negative and positive feedback – loop gain- advantages of negative feedback -Feedback Connection Types - Practical Feedback Circuits	6	10
2.	Module 2. Op amp basics and linear applications: Introduction Block diagram representation of a typical op-amp, Analysis op-amp ICC circuits, types, designations, packages, pin configurations and power supplies. Ideal op-amp, equivalent circuit, open loop op amp configurations of differential, inverting and non-inverting amplifiers, op amp feedback amplifier analysis, differential amplifier with one, two and three op amps.Op amp parameters - offset voltages and currents, bias current, drift, PSRR, CMRR, offset nulling methods.	12	30
3	Module 3. AC performance of O-amp: Bandwidth, slew rate and frequency response. Op-amp applications: DC and AC amplifiers, peaking, summing scaling and averaging amplifiers, instrumentation amplifier, differential input and differential, output amplifier, V to I and I to V converters, integrator, differentiator comparator, non-linear amplifier, phase shift oscillator, Wien voltage controlled oscillator, zero crossing detector, window	12	30

	detector, introduction to analog simulation		
	Module 4. Non linear IC applications using Opamp: Signal Generators: Square, triangle and ramp generator circuits using opamps - Effect of slew rate on waveform generation- monostable circuits- Principles of VCO circuits. Comparator Circuits: Zero Crossing Detector- Regenerative comparator circuits Active filters –Types- Characteristics- Frequency Response of different types of filters- Order and cut off frequency - Butterworth low pass filter –First order and second order filter design - Sallen and Key second order LP filter - - Butterworth high pass filters - Second order wide band and narrow band filters. Timer IC 555: Functional diagram- astable and monostable modes Phase locked loops: Principles – Building blocks of PLL-Lock and Capture ranges - Capture process - Study of NE565 - Applications of PLL - Frequency multiplication - FSK demodulator - FM demodulation. Three terminal regulator ICs: basic block schematic - 78 x x& 79 x x series - Adjustable output voltage regulator LM 317, LM 340 and LM 337 series power supply ICs. their use and basic design considerations for designing regulated power supplies.		

Reference Books

1.Robert T. Paynter, Introductory Electronic Devices and Circuits, Pearson Education
2.A. V. Boylestad and Nashelsky, Electronic Devices and Circuits, Prentice Hall of India
3.Ramakant A Gayakwad, Op- Amps and Linear Integrated Circuits, Prentice Hall of India
4.Schilling and Belove, Electronic Circuits, McGraw Hill
5.Theodore F. Bogart Jr., Electronic Devices and Circuits,
6.K. R. Botkar, Integrated Circuits, Khanna Publishers
7.Floyd, Fundamentals of Analog Circuits 2e, Pearson Education.

Course Outcomes:

After learning the course the students should be able to:

-Understand the different configurations of transistor and amplifiers.

-To test and design the circuits with op-amps and other electronics components for different applications.

-To test and design circuit using different ICs.

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PSOs (Electrical Engineering Department)

1. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.

2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.

3. Use technical expertise and suggest modifications in existing electrical systems.

Reference Books:

Robert T. Paynter, Introductory Electronic Devices and Circuits, Pearson Education
2. A. V. Boylestad and Nashelsky, Electronic Devices and Circuits, Prentice Hall of India
3. Ramakant A Gayakwad, Op- Amps and Linear Integrated Circuits, Prentice Hall of India
4. Schilling and Belove, Electronic Circuits, McGraw Hill
5. Theodore F. Bogart Jr., Electronic Devices and Circuits,
6. K. R. Botkar, Integrated Circuits, Khanna Publishers
7. Floyd, Fundamentals of Analog Circuits 2e, Pearson Education.

CO-PO-PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2														
CO 2	2		2		2									1	
CO 3			2		2										1

Mapping & Justification

Students will able to

Mapping	Level	Justification
CO1-PO1	2	Use fundamental knowledge transistor and op-amp in various engineering problem and find its solution..
CO2-PO1	2	This course will deliver fundamental knowledge about electronics components for different applications.
CO2-PO3	2	Fundamental design system components or processes that meet the specified needs with appropriate consideration for the public health and safety
CO2-PO5	2	Students use various latest open source tools and frameworks for performing their laboratory experiments. So, they will be acquainted with latest tools and techniques.
CO3-PO3	2	Students will be able to apply knowledge of different ICs for design an application.
CO3-PO5	2	Students will be able analyse different problem related to different op amp and ICs.
CO2-PSO2	1	Students will be able to apply fundamental op-amp and transistor design concepts for solving complicated electrical circuits and networks by using latest design and simulation tools. .
CO3-PSO2	1	Students will be able to apply fundamental different ICs design concepts for solving complicated electrical circuits and networks by using latest design and simulation tools. .

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09) /POWER ELECTRONICS (24)

DC MACHINE AND TRANSFORMER

SUBJECT CODE: 2130904

B.E. 3rd Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

After learning the course the students should be able to **:-**

CO-1 Understand working principle, performance, control and applications of DC Machines and Transformer.

CO-2 Carry out test and conduct performance experiments on DC machine and Transformer.

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CO-3 Identify, formulate and solve DC machine and Transformer related problems.

Syllabus:

1	Electromechanical Energy Conversion: Principle, Singly Excited Magnetic System and Doubly Excited Magnetic system. Physical concept of torque production; Electromagnetic torque and Reluctance torque. Concept of General terms pertaining to Rotating Machines: Electrical & Mechanical degree, Pole pitch, Coil, Generated EMF in full pitched coil, Generated EMF in a short pitched coil, EMF polygon, Distribution factor, Pitch factor. MMF produced by Distributed Windings, MMF of a coil, MMF of single phase distributed Winding, MMF waveform of Commutator machines.
2	D.C. Machines: Working principle, construction and methods of excitation. Armature Winding: Introduction of simplex lap and wave windings. DC generators: EMF equation – methods of excitation – separately and self-excited – shunt, series, compound - armature reaction – effects of armature reaction - demagnetizing & cross magnetizing ampere-turns – compensating windings – inter poles - commutation – methods to improve commutation - voltage build-up – no load characteristics – load characteristics – losses and efficiency - power flow diagram – parallel operation – applications of DC generators. D.C. Motors: Principle of operation – back EMF – classification – torque equation – losses and efficiency – power flow diagram – performance characteristics of shunt, series and compound motors – starting of DC motors – necessity and types of starters – design of starters – speed control – methods of speed control – solid state speed control (block diagram) – testing – Swinburne's test – Hopkinson's test – separation of losses – retardation test – field test of dc motors – application of DC motor.
3	Transformers: Principle, construction and operation of single phase transformers, phasor diagram, equivalent circuit, voltage regulation, losses and efficiency, Testing- Open & short circuit tests, Polarity test, Sumpner's test, Separation of hysteresis and eddy current losses, Autotransformers - Construction, Principle, Applications and Comparison with two winding

	transformer, Three phase Transformer: Construction, various types of connection and their comparative features, 3-phase transformer connections - Δ-Δ, Y-Y, Δ-Y, Y-Δ, V-V – vector groupings Yy0, Dd0, Yd1, Yd11, Dy1, Dy11, Scott connection – three winding transformer – tertiary winding – per unit impedance, Parallel operation of single phase and three phase transformers. Excitation phenomenon in transformers, Harmonics in single phase and three phase transformers, Tap changing Transformers - No load and on load tap changing of transformers, Cooling methods of transformers. Special Transformers: Potential transformer, Current transformer, Pulse transformer, Audio frequency transformer, Grounding transformer.

Reference Books:

1. Nagrath I J and Kothari D P, Electric Machines, Tata McGraw Hill
2. Ghosh, Electrical Machine, Pearson Education
3. P.S. Bhimbra, Electrical Machinery, Khanna Publishers
4. M G Say, Theory, Performance & Design of A.C. Machines, CBS Publishers.
6. Irving L. and Kosow, Electric Machinery and Transformers, Prentice-Hall of India
7. K. Murukesh Kumar, DC machines and Transformers, Vikas Publishing house Pvt Ltd.

Program Specific Outcome (PSOs)

1. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll. in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
3. Use technical expertise and suggest modifications in existing electrical systems.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		1								1		1	1
CO2	3	2		1									2	2	2
CO3	3	2	1	2										2	1

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students can be able to apply knowledge of engineering fundamentals to understand principles, performance and control of DC Machines and Transformer.
CO1-PO2	1	Students can be able to understand fundamental principles of DC Machines and Transformer by using principles of engineering science to analyse complex engineering problems.
CO1-PO4	1	Students can be able to gain research based knowledge about DC Machines and Transformer.
CO1-PO12	1	Students can be able to recognize the need of DC Machines and Transformer in life long learning.
CO2-PO1	3	Students can be able to apply knowledge of engineering fundamentals to carry out tests and conduct experiments on DC Machines and Transformer.
CO2-PO2	2	Students can be able to perform experiments and carry out tests on

		DC Machines and Transformer by using principles of engineering science and mathematics to analyse complex engineering Problems.
CO2-PO4	1	Students can be able to use research based knowledge and methods to perform experiments on v to provide valid conclusions.
CO3-PO1	3	Students can apply knowledge of DC Machines and Transformer to identify and solve the complex engineering problems.
CO3-PO2	2	Students can identify, formulate and solve DC Machines and Transformer problems using principles of engineering science.
CO3-PO3	1	Students can be able to design DC Machines and Transformer to meet the need of society.
CO3-PO4	2	Students can be able to use research based knowledge and methods to perform experiments on DC Machines and Transformer to provide valid conclusions.

Mapping	**Level**	**Justification**
CO1-PSO2	1	Students will gain knowledge DC Machines and Transformer which will help them in solving complicated electrical circuits.
CO1-PSO3	1	Students will be able to suggest modifications in existing electrical system by using fundamental knowledge DC Machines and Transformer.
CO2-PSO1	2	Students will be able to use electrical testing tools and equipments to carry out test and perform experiments on DC Machines and Transformer.
CO2-PSO2	2	Students will be able to use knowledge DC Machines and Transformer to carry out test and conduct experiments on DC Machines and Transformer.
CO2-PSO3	2	Students will be able to suggest modifications in existing electrical systems by performing experiments which will help them to derive conclusions.
CO3-PSO2	2	Students will be able to solve complicated electrical circuits consisting of DC Machines and Transformer by applying knowledge of various electrical machines.
CO3-PSO3	1	Students will be able to suggest modifications in existing electrical systems by solving DC Machines and Transformer related problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL & ELECTRONICS ENGINEERING (08) & ELECTRICAL ENGINEERING (09)

AC MACHINES

SUBJECT CODE: 2140906

B.E. 4th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Poly-phase Induction Motor:** Construction, Types of motor, Working principle, Rotating magnetic field. Operating parameters at different load, No-load & blocked rotor test, Equivalent circuit, Phasor diagram, Circle diagram, Efficiency and slip scale with the help of circle diagram, Effect of rotor resistance on performance of motor, Double cage motor and its equivalent circuit, Introduction to machine dynamics. Starters of poly-phase induction motor including soft starter, Methods of speed control of 3- phase motor, Schematic diagram and advantages of Variable Voltage Variable Frequency drive. Electrical transients in induction machine, Magnetic levitation : Principle, advantages and application of linear induction motor. Effect of harmonics, Harmonic torques, Cogging & Crawling, Effect of unbalanced voltages on performance of motor. Performance of motor with variable voltage and frequency. Testing of induction motor as per IS, Energy efficient motors.	**20**	**35**
2	**Induction Generator**, Principle of operation and application, Its load and p. f. control.	**2**	**5**
3	**Single phase A. C. motors:** Double field revolving theory, Starting & running performance of 1-phase induction Motor, Equivalent circuit of 1phase induction motor, Types of single phase motors, Principle and operation of split phase, Resistance start, Capacitor start and capacitor start & run induction motor, Shaded pole induction motor, Fractional horse power motors.	**6**	**10**

4	**Synchronous Machines:** Construction, Types, Applications, Working principle. Equation of induced emf with and without harmonics in MMF, pitch factor and distribution factor, MMF of distributed windings, Torque equation, Machine efficiency, Armature reaction and its compensation, Short circuit ratio, Effect of change in excitation, Effect of change in torque and speed, Voltage regulation, Determination of voltage regulation by Synchronous impedance method, MMF method, ZPF method and AIEE method, Synchronization : Importance and Methods of synchronization. Operating characteristic, Load angle and Power flow equations, Capability curves, Two reaction model of Salient pole machines, Parallel operation, Load sharing between parallel connected generators, Effect of unequal voltages & unequal percentage impedance, Governor characteristics, Introduction to single phase generators, Slip test for measurement of direct axis and quadrature axis reactance for salient pole machine, Sudden short circuit of Synchronous machine, Hunting of synchronous machines and its prevention.	**20**	**35**
5	**Synchronous Motor:** Methods of starting of synchronous motors, Different torques in Synchronous motor, Stability, Synchronous condenser, Synchronous phase modifiers, V-curves and O-curves of Synchronous motors, **Auto Synchronous Motor:** Construction, principle of operation, equivalent excitation current for various rotor connections, circle diagram.	**5**	**10**
6	**Commutator motors:** Construction and working principle of Schrage motor, Universal motor and Repulsion motor.	**3**	**5**

Reference Books:

1. Gupta J B, Electrical Machines, S K Kataria Publications
2. Theraja B L, Electrical Technology – Vol II, S Chand Publications
3. Nagrath I J and Kothari D P, Electric Machines, Tata McGraw Hill
4. Ghosh Samarjit, Electrical Machines, Pearson Education
5. Bhimbra P S, Electrical Machinery, Khanna Publishers
6. Say M G, Theory, Performance & Design of A.C. Machines, CBS Publishers.
7. Fitzgerald A.E and Kingsley, Electrical Machinery, Tata McGraw

Course Outcomes:

After learning the course the students should be able to:

1. Explain the construction, working principle, performance and applications of Poly-phase induction motor,
2. single phase motors, synchronous generator (Alternator), synchronous motor and commutator motors.
3. Perform experiments on above machines.
4. Describe the need of these machines in the society.
5. Identify, formulate and solve the numerical problems related to above machines

CO-PO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1			1							1		1	
CO2	3	1			1							1		1	
CO3	3	2			1				1	1		2	1	1	
CO4	1		1			1	1					1	1	1	
CO5	2	2										1		2	

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Detailed knowledge of poly phase Induction Motor will be gained by the students
CO1-PO2	1	Students will be able to identify, analyse and formulate problems on poly phase Induction Motor .
CO1-PO5	1	Students use the various techniques for control of poly phase Induction Motor.
CO1-PO12	1	Application of Polyphase I.M. will be useful in understanding need and lifelong learning in area of electrical engineering.
CO2-PO1	3	Students will gain detailed knowledge about single phase motors, synchronous generator (Alternator), synchronous motor and commutator motors.
CO2-PO2	1	Students will identify, formulate and analyse problems related to single phase motors, synchronous generator (Alternator), synchronous motor and commutator motors.
CO2-PO5	1	Students use the various techniques for control of single phase motors, synchronous generator (Alternator), synchronous motor and commutator motors.
CO2-PO12	2	Knowledge of Single phase motors and sunchronous machines will be helpful to the students for technological change.

CO3-PO1	3	Students will perform experiments on various a.c. machines to know its actual performance and to solve complex problems.
CO3-PO2	1	Students will identify, formulate and analyse various problems related to various a.c. machines by doing experiments on them.
CO3-PO5	1	Students use different methods for testing performance of 3-phase a.c. machines.
CO3-PO9	1	Performing experiments on machines will develop ability in students to work in teams or as a member or leader.
CO3-PO10	1	Students will be able to write effective reports and documents and presentations.
CO3-PO12	2	Practical knowledge of a.c. machines will be helpful to the students for lifelong learning and develop ability to engage independently.
CO4-PO1	1	Students will learn need of a.c. machines in the society.
CO4-PO3	1	Students will be able to design the solutions for electrical machines that will meet the specified needs with appropriate consideration for the society.
CO4-PO6	1	Students will be able to apply knowledge of ac machines for need of society.
CO4-PO7	1	Knowledge of need of ac machines in society and environment will give sustainable development.
CO4-PO12	1	Study of A.C. Machines will be helpful to the students for lifelong learning.
CO5-PO1	2	Students will identify, formulate and solve the numerical problems related to ac machines by gaining its detailed knowledge.
CO5-PO2	2	Knowledge about AC electrical machines will be useful for indentifying and solving complex problems and reaching conclusions.
CO5-PO12	1	Study of electrical machines 3-phase and single phase AC machines will be helpful to the students for lifelong learning.

Mapping	Level	Justification
CO1-PSO2	1	Knowledge of poly phase Induction Motor will be used to solve complicated electrical circuits and networks.
CO2-PSO2	1	Knowledge of single phase motors and synchronous machines will be useful in solving complicated electrical circuits.
CO3-PSO1	1	Practical knowledge of electrical machines will develop ability in students to use various testing tools and equipments in industry.

CO3-PSO2	1	Practical knowledge of electrical machines will be useful in solving complicated electrical circuits and networks.
CO4-PSO1	1	Students will be able to understand need of ac machines in industry.
CO4-PSO2	1	Knowledge of need of ac machines will be useful in electrical power system in solving electrical networks.
CO5-PSO2	2	Knowledge of ac machines will be useful in electrical power system in solving electrical networks.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

ELECTRICAL POWER GENERATION

SUBJECT CODE: 2140908

B.E. 4th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

1. Describe working and single line diagram different convention power plant like thermal nuclear, hydro, diseal, gas etc.
2. Compare various economic aspects of different types of Tariffs
3. Obtain I-V characteristics of Solar cell and Measure Solar isolation using Optical pyranometer
4. Identify and compare various components of Wind Energy Conversion system
5. Classify and compare various types of substation and different neutral Earthing

schemes Syllabus:

1	Introduction: Amount of generation of electric power from Conventional and non conventional sources of energy in Gujarat and India and some developed countries of the world.
2	Steam power station: Schematic arrangement, advantages and disadvantages, choice of site, efficiency of steam power station, Types of prime movers, characteristic, speed control & auxiliaries. Environmental aspects for selecting the sites and locations of thermal power stations
3	

	-conventional energy – seasonal variations and availability – sources and features □ Distributed energy systems and dispersed generation (DG)
9	Photovoltaic Power Conversion systems: asurement. 1. Heating 2. Cooling 3. Drying 4. Distillation 5. Power generation □ Solar Photovoltaic(SPV) systems 1. Operating principle 2. Photovoltaic cell concepts 3. Types of solar cells, fabrication of SPV cells 4. Cell, module, array (Series and parallel connections) 5. SPV system components and their characteristics, applications 6. Block diagram of general SPV system 7. Battery sizing and Array sizing lications of Solar Photovoltaic systems 1. Battery charging 2. Pumping 3. Lighting – thermal, Solar – PV) 1. Sizing residential systems 2. Batteries and Inverters □ Present Status of PV in India □ Governmental incentives, Numerical
10	Wind Power Conversion System**:** □ Introduction to wind energy □ basic principles of wind energy conversion □ forces on the blade – maximum power – wind data and (qualitative treatment only) energy estimation □ Basic components of wind energy conversion systems -HAWT, VAWT, Geared wind power plants (WPPs), direct-drive WPPs and Hybrid (semi-geared) WPPs □ Schemes of electric generation -fed (DFIG), wound rotor synchronous generator (WRSG), Permanent magnet synchronous generator (PMSG) of WECS. □ Site selection considerations. Numerical
11	Substation Classification of Substations, substation equipments, Specification and selection of equipments, Site selection of substation
12	Neutral Earthing: Introduction, isolated neutral, earth neutral systems-solid, resistance, reactance. Arc suppression coil, voltage transformer and earthing, transformer, earthing systems.

PROGRAM SPECIFIC OUTCOMES (PSOs)

- Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
- Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
- Use technical expertise and suggest modifications in existing electrical systems.

Reference Books:

1. A Text book of Power System Engineering, A Chakrabarti, M. L Soni, P. V. Gupta, U. S. Bhatnagar, Dhanpat Rai Publication
2. Renewable Energy Technologies, Solanki, Chetan S. , PHI Learning, New Delhi, 2011
3. Wind Power Technology, Earnest, Joshua, PHI Learning, New Delhi, 2013
4. Renewable Energy Sources for Sustainable Development, N.S. Rathore and N. L. Panwar, New India Publishing Agency, New Delhi
5. Wind Power in Power System, Thomas Ackermann, John Willey &Sons, 2005
6. Renewable Energy Resources, J. Twidell and T. Weir, E & F N Spon Ltd, London, 1999
7. Electric Power Generation: Transmission and Distribution, S. N. Singh, PHI Learning, New
8. Electrical Power, Dr. S.L. Uppal

CO-PO-PSO mapping:-

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	2	-	-	-	-	2	1	-	-	-	-	1	2	2	-
CO 2	2	1	1	-	-	2	-	-	-	-	-	-	-	1	-
CO 3	2	2	2	-	1	2	3	-	-	-	-	1	1	2	1
CO 4	2	2	2	-	1	2	3	-	-	-	-	1	1	1	1
CO 5	1	-	-	-	-	1		-	-	-	--	2	2	1	-

Mapping & Justification

Mapping	Level	Justification
CO1-PO1	2	Student will able to gain knowledge about working of diff-power station
CO1-PO6	2	Knowledge of various convention power plant will be helpful to the society
CO1-PO7	1	How convention power plant will affect the environment will be understood by student
CO1-PO12	1	Student will able to recognize the need of electricity generation
CO2-PO1	2	Student will able to compare various economical aspects
CO2-PO2	1	Student will able to identify different tariff to analysis complex engineering problem
CO2-PO3	1	Student will able to solve problem related to tariffs that meet the specified need s of society
CO2-PO6	2	Knowledge at tariff will help to apply responsibility relevant to the professional Engineering practice and society
CO3-PO1	2	Student will gain knowledge of solar pv system as an engineering specialization to the solution of engineering problem
CO3-PO2	2	Student will use principle of spv system in engineering science for researching substantiated conclusions
CO3-PO3	2	Student will able to design solar pv system components to society and environment
CO3-PO5	1	Student will use modern engineering and IT tools for designing pv cell
CO3-PO6	2	Knowledge of solar cell and optical pyrometer will helpful for society, legal and critical issues
CO3-PO7	3	For environment understanding of characteristic of solar cell and optical pyrometer to ful sustainable development
CO3-PO12	1	Student will able to recognize the need of solar cell broadest technological changes
CO4-PO1	2	Student will gain knowledge of wind energy conversion system as an engineering specialization to the solution of engineering problem
CO4-PO2	2	Student will use principle of wind energy conversion system in engineering science and researching substance classifying
CO4-PO3	2	Student will able to basic component of wind energy system for society
CO4-PO5	1	Student will able to design modern engineering and IT tools for designing various component of electric power generation
CO4-PO6	2	knowledge of scheme of electrical power generation will helpful for professional engineering practice and society
CO4-PO7	3	For environmental expect understanding of maximum power generation through wind energy helpful to fulfill the need for sustainable development
CO4-PO12	1	Student will able to recognize the need of energy generation through wind in broadest technical changes
CO5-PO1	1	Student gain knowledge about various types of substation
CO5-PO6	1	knowledge of ear thing scheme will be helpful for society and safety
CO5-PO12	2	Student will recognize the need of substation and ear thing scheme for life long earning in the broadest technical changes
CO1-POS1	2	Student will gain knowledge of various electrical testing tools for different power plant
CO1-POS2	2	Student will gain knowledge of various electrical machine used in different power plant
CO2-POS2	1	Student use knowledge of different tariff in electrical power system
CO3-POS1	1	Student will use different electrical equipments of solar pv system in industry

CO3-POS2	2	Student use simulation tools to design spv system in power system
CO3-POS3	1	Technical expatriation of spv system will be helpful to suggest modification in exciting electrical system
CO4-POS1	1	Student will use different electrical equipment of wind energy conversion system in industry
CO4-POS2	1	Student use simulation tools to design various components used in wind energy conversion system
CO4-POS3	1	Technical expatriation of wind energy conversion system will be helpful to suggest modification in exciting electrical system
CO5-POS1	2	Knowledge about use of electrical equipment of various power plant in industry in field of electrical engineering
CO5-POS2	1	Student will use knowledge of various electrical machine to develop different substation

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

CONTROL SYSTEM ENGINEERING

SUBJECT CODE: 2150909

B.E. 5th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

1. Apply systems theory to complex real world problems in order to obtain models that are expressed using differential equations, transfer functions, and state space equations
2. Predict system behavior based on the mathematical model of that system where the model may be expressed in time or frequency domain
3. Analyze the behavior of closed loop systems using tools such as root locus, Routh Hurwitz, Bode, Nyquist, and Matlab
4. Design controllers using classical PID methods, root locus methods, and frequency domain methods.
5. Devise a safe and effective method of investigating a system identification problem in the lab
6. Write a report that effectively communicates the results of an analysis or design.

Syllabus:

1	Introduction to Control Systems: Introduction, Brief History of Automatic Control, Examples of Control Systems, Engineering Design, Mechatronic Systems, The Future Evolution of Control Systems.
2	Mathematical Models of Systems: Differential Equations of Physical Systems, Linear Approximations of Physical Systems, The Laplace Transform, The Transfer Function of Linear Systems, Block Diagram Models, Signal-Flow Graph Models.
3	State Variable Models: The State Variables of a Dynamic System, The State Differential Equation, The Transfer Function from the State Equation, The Time Response and the State Transition Matrix.
4	Feedback Control System Characteristics: Error Signal Analysis, Sensitivity of Control Systems to Parameter Variations ,Disturbance Signals in a Feedback Control System, Control of the Transient Response, Steady-State Error, The Cost of Feedback
5	The Performance of Feedback Control Systems: Test Input Signals, Performance of Second-Order Systems, Effects of a Third Pole and a Zero on the Second-Order System Response, The s-Plane Root Location and the Transient Response, The Steady-State Error of Feedback Control Systems, Performance Indices, The Simplification of Linear Systems.
6	The Stability of Linear Feedback Systems: The Concept of Stability, The Routh-Hurwitz Stability Criterion, The Relative Stability of Feedback Control Systems

7	The Root Locus Method: The Root Locus Concept. The Root Locus Procedure, Parameter Design by the Root Locus Method, Sensitivity and the Root Locus, Three-Term (PID) Controllers.
8	Frequency Response Methods: Frequency Response Plots, Frequency Response Measurements, Performance Specifications in the Frequency Domain, Log Magnitude and Phase Diagrams.
9	Stability in the Frequency Domain: Mapping Contours in the s-Plane, The Nyquist Criterion, Relative Stability and the Nyquist Criterion, Time-Domain Performance Criteria in the Frequency Domain, System Bandwidth
10	The Design of Feedback Control Systems: Approaches to System Design**,** Cascade Compensation Networks, Phase-Lead Design Using the Bode Diagram, Phase-Lead Design Using the Root Locus, System Design Using Integration Networks, Phase-Lag Design Using the Root Locus, Phase-Lag Design Using the Bode Diagram,

PROGRAM SPECIFIC OUTCOMES (PSOs)

- Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
- Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
- Use technical expertise and suggest modifications in existing electrical systems.

Reference Books:

1. Modern Control System by Richarc C. Drof and Robert H. Bishop,11th Edition Person Int.
2. Modern Control Engineering by Katsuhiko Ogata, 4th Edition, Prentice Hall of India.
3. Automatic Control Systems by Benjamin C.Kuo, 8th Edition, Farid Golnaraghi, John Wiley & Sons.
4. Control Systems Engineering by Nagrath and Gopal New Age Publication
5. Feedback and Control Systems by Joseph J Distefano 2nd Edition TMH

CO-PO-PSO mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	3	2	2	-	1	-	-	-	-	-	-	-	-	2	-
CO 2	3	2	-	1	1	-	-	-	-	-	-	-	1	2	-
CO 3	3	3	2	-	1	-	-	-	-	-	-	-	1	2	-
CO 4	3	2	3	-	2	-	-	-	-	-	-	-	-	2	-
CO 5	3	2	3	1	2	-	-	-	-	-	-	-	2	2	-
CO 6	3	3	3	-	2	-	-	-	-	-	-	-	1	2	-

Mapping & Justification

Mapping	Level	Justification
CO1-PO1	3	Basic knowledge about control system and to obtain model using different techniques

CO1-PO2	2	Student will identify and analysis various problem related to time and frequency domain system
CO1-PO3	2	Student will able to design state-space models
CO1-PO5	1	Student use different matalab tools for performance of transfer functions and state-space models
CO1-PSO2	2	Student use simulation tools and design various model expressed by differential equations transfer functions.
CO2-PO1	3	Student will gain basic knowledge about time and frequency domain.
CO2-PO2	2	Student will identify and formulate various time and frequency domain specification
CO2-PO4	1	Student will gain knowledge to product system behaviour based on

		mathematical model system
CO2-PO5	1	Student use different technologies resources to obtain model time & frequency domain.
CO2-PSO1	1	Student will gain basic knowledge of various tools understanding of model expressed time domain.
CO2-PSO2	2	Student gain knowledge simulation tools in solving problems related to time & domain.
CO3-PO1	3	Student will gain basic knowledge about root-locus, R-H circuit board,nyquist and matlab.
CO3-PO2	3	Student will be able to identify analysis and behaviour of closed loop systems using different tools.
CO3-PO3	2	Student will design for complex engineering problems related to roots locus and bode plot.
O3-PO5	1	Student use different techniques for modelling of root locus bode,
CO5-PSO2	2	Student will gain knowledge about design and simulation tools to devise effective methods of investigation of system problems.
CO6-PO1	3	Student will gain basic knowledge about how to write a report that communicates the result of analysis of stability.
CO6-PO2	3	Student will able to analysis formulate and review the result of frequency & time domain method.
CO6-PO3	3	student will able to design phase-lag and head compensator using root locus and bode plot
CO6-PO5	2	Student will use different techniques to communicate the results of analysis root locus and bode plot.
CO6-PSO1	1	Student will able to use different matlab tools to analyses different compensator.
CO6-PSO2	2	Student will gain knowledge about simulation tools to design different faced back control system to write report.

Programme: Electrical Engineering	Degree: B.E.
Course Code: 2170908 Switchgear and protection	Semester: 7
Credits: 6	Contact hours: 4 (Theory) + 2 (Laboratory)

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	00	02	06	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	%Weighta
1	**Introduction to Protective Relaying and electromagnetic relays** Faults, Causes and Effects, Protective Zones, Primary and Backup Protection, Desirable Qualities and Terms of Protective Relaying, Basic Connection of Trip Circuit, Types of Relay Units, Relay Pick up, Reset or Drop out, Pick up/ Drop off Ratio, Construction and Working of Different Electromagnetic Relays [3]	3	4
2	**Over Current Protection of Transmission line** Introduction, Fuse, Thermal Relays, Over Current Relays, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Directional Over Current Relay, Limitations of O.C. Relays [1]	3	5

3	**Differential Protection** Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection[1]	2	4
4	**Transformer Protection** Types of Faults, Over Current Protection, Percentage Differential Protection, Inrush Phenomenon, High Resistance Ground Faults in Transformers, Inter-turn Faults, Incipient Faults, Over-fluxing Phenomenon[1]	4	7
5	**Distance Protection of Transmission line** Drawbacks of O.C. Protection, Introduction to Distance Protection, Types of Distance Relay, Impedance, Reactance, MHO Relay, Performance of Distance Relay During Normal Load and Power Swing, Effect of Arc Resistance on Reach of Distance Relays, Comparison of Distance Relays, Distance Protection of Transmission line, Reasons for Inaccuracy of Distance Relay Reach, Three Step Protection, Trip contact configuration, 3-step protection of double and fed lines. [1]	5	10
6	**Carrier aided protection of transmission lines** Need for carrier aided protection of transmission lines, various options for carrier, Coupling and trapping the carrier into the desired line section, single line to ground coupling, line to line coupling, unit type carrier aided directional comparison relaying, carrier aided distance scheme for acceleration of zone II, transfer trip or inter trip, permissive inter trip, acceleration of zone II, pre-acceleration of zone II, phase comparison relaying (unit scheme) [1]	5	10
7	**Generator protection** Various faults & abnormal operation conditions, stator & rotor faults, transverse differential protection, unbalanced loading, over speeding, loss of excitation, loss of prime mover [1]	5	10

8	**Induction motor protection** Various faults & abnormal operation conditions, starting of induction motor, protection of small & large induction motor. [2]	5	10
9	**Numerical protection** Introduction, block diagram of numerical relay, numerical over current protection, numerical transformer protection, numerical distance protection of transmission line [1]	5	10
10	**Theory of circuit Interruption**	3	5

	Introduction, Physics of arc phenomena, Maintenance of the arc, Losses from plasma, Essential properties of arc, Arc interruption theories. [4]		
11	**Circuit Constant in Relation to Circuit Breaking** Introduction, Circuit breaker rating, Circuit constants & circuit conditions Re-striking voltage transient Characteristics of re-striking voltage, Interaction between the breaker & circuit, Current chopping, duties of switchgear.[4]	4	5
12	**Theory & Practice of Conventional Circuit Breaker and modern circuit breakers** Automatic switch, Air-break circuit breakers, Oil circuit breakers, Single and multi break Construction, Air-blast circuit breaker, Performance of circuit breakers and system requirements, Modification of circuit breaker duty by shunt resistors, Power factor correction by series resistance, Comparative merits of different types of conventional circuit breakers, Modern trends, Vacuum circuit breakers, Sulphur hexafluoride (SF_6) circuit breakers D.C. circuit breaker, auto-reclosing - definitions & features, 3-Phase versus 1-Phase auto-reclosing [4]	8	15
13	**Protective current transformer and potential transformer** Magnetization curve of CT, Difference between measurement & protective CT, CT errors, calculation of CT accuracy, selection of CT, CT requirements for differential protection, specifications of CT, specifications of PT, CVT. **[2]**	4	5

Course Outcome:

After learning the course the students should be able to:

1. Explain the purposes of protection, in relation to major types of apparatus, protection principle, dangers and criteria.
2. Choose and justify a suitable protection system for a specified application.
3. Analyze and compare specified protection systems
4. Compare merits of various principles, relay hardware and interrupting devices.

5. Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application

Program Specific Outcome (PSOs)

1. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
3. Use technical expertise and suggest modifications in existing electrical systems.

PO:

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CO-PO mapping

	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2											2		
CO2	3	3													
CO3	2	3	3												3
CO4	3			3										2	
CO5	3					2									

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students will be able to apply knowledge of different apparatus protection schemes for solution of complex engineering in protection system.
CO2-PO1	3	Students will be to apply knowledge of mathematics,science and engineering for selection of a specified application protection schemes.
CO3-PO1	2	Students will apply knowledge to compare specified protection systems.
CO4-PO1	3	Comparison of various interrupting devices will be done by applying engineering knowledge.
CO5-PO1	3	Students will be able to applying engineering knowledge for selection of circuit breaker for a given application.
CO1-PO2	2	Students will be able to analyse problems of different apparatus protection schemes.
CO2-PO2	3	Students will analyse various problems for selection of a specified application protection schemes.
CO3-PO2	3	Students will analyse problems and compare specified protection systems.
CO4-PO4	3	Students will investigate complex problems for comparison of various interrupting devices.
CO3-PO3	3	Students will design and Analyze to compare specified protection systems

CO5-PO6	2	Students will Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application keeping in mind safety relevent to engineering practice.
CO3-PSO3	3	Students will use technical expertise for analysis of specified protection systems.
CO1-PSO1	2	Students will use various electrical testing tools and equipments in industry to select various apparatus protection schemes.
CO4-PSO2	2	Student will compare various relays and interrupting devices by applying knowledge of various electrical machines and power systems.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

POWER ELECTRONICS-1

SUBJECT CODE: 2150903

B.E. 5th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Outcome:

1. Explain and plot the construction and characteristics of Power semiconductor devices and fundamental of thyristors and its family.
2. Analyze, operate and design ac-to-dc converters.
3. Analyze, operate and design dc-to-dc converters.
4. Apply the knowledge of power electronic converter for speed control of DC motors.

Syllabus:

1	**Power Semiconductor Devices:** Construction and Characteristics of Power diodes, Power Transistors, Uni Junction transistors (UJT), Programmable UJT, Power MOSFET, Insulated Gate Bipolar transistors(IGBTs), Static Induction Transistors. **Thyristors and family :** SCR, DIACs, TRIACs, Light Activated SCRs (LASCRs), Reverse Conducting Thyristor(RCT), Asymmetrical SCR (ASCR), Gate turn-off Thyristors (GTOs), Integrated Gate-Commutated Thyristors (IGCTs), MOS controlled Thyristors (MCTs), Power Integrated circuits (PICs), Intelligent Modules, etc.
2	**Thyristor Fundamentals:** Construction, working, two transistor analogy, Static & dynamic characteristics, Gatecharacteristics, Turn on & turn off methods (Commutation methods), Ratings, Series &Parallel operations. **Thyristor Protections:** Cooling and Heat sinks, Thermal Modelling, di/dt and dv/dt protection, Design of SnubberCircuit, Over Voltage and Over Current protections, Gate protections, Electro

	MagneticInterference(EMI) and Shielding. **Thyristor firing (gate drive) circuits:** Gate circuit requirements, Isolation of gate and base drives using Pulse transformer and Opto-couplers, Gate drive circuits like: Resistance trigger, R-C trigger, DIAC trigger, UJT based trigger, Programmable UJT trigger, IC based advancetrigger, Microprocessor based trigger circuit
3	**Phase Controlled (AC to DC) Converters:** Review of half-wave and full-wave diode rectifier (with RL load); **Principle of phase controlled converter operation;** Operation of 1-phase half wave converter with R, RL and RLE load; Significance of free-wheeling diode ;1-phase full wave converter : Center-tapped and Bridge Configuration; Operation and analysis with R,RL, RLE load; Analysis; Gating Requirements; Conversion (Rectification) and Inversion mode of operation; Operation and analysis of 1-phase Semi-converter/ Half-controlled converter: Asymmetric and Symmetric Configurations; **3-phase converters** : Operation of half wave converter; Full wave fully controlled converters: Analysis and operation with different type of loads; Rectification and Inversion Mode; Semi-controlled converter; Dual Converter: Principle and operation; 1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation Effect of source and load inductances, Power factor improvement techniques, Applications of AC-DC converters
4	**DC to DC Converters** The chopper, Basic principle of DC chopper, Classification of DC choppers, Control strategies, Basic DC-DC converter (switch regulator) topologies : Principle, operation and analysis for Step-down (Buck), Step-up (Boost), Step up/down (Buck-Boost), Continuous conduction and Discontinuous conduction operation, Chopper configurations: Voltage Commutated, Current Commutated, Load Commutated Chopper Multi-phase chopper, Application of DC to DC converters
5	**DC Drives with phase controlled converters:** Basic characteristics of DC motors, Two zone operation, Four quadrant operation (Operating modes), Principles of DC motor speed control Single phase separately excited drives: Half Wave converter, Semi-converter and Fully Controlled converter based drives; Braking operation of separately excited drive,Single phase Series DC motor drive: Semi-converter and Fully Controlled coverter based drives 3-phase separately excited drives: Half Wave converter, Semi-converter and Fully Controlled converter based drives;
6	**DC drives with dc-dc converters** Principle of power control (motoring control) of separately excited and series motor with DC-DC Converter; Steady-state analysis Principle of Regenerative Braking; Chopper configuration for Regenerative braking; Analysis for minimum and maximum speed for Regenerative Braking; Combined regenerative and rheostatic brake control; Two and four quadrant DC-DC converter drives

Reference Books:

1. M D Singh and K B Khanchandani, “Power electronics”, TMH, New Delhi, 2nded., 2007.

2. Muhammad H. Rashid, “Power Electronics -Circuits, Devices and Applications”, Prentice Hall of India, 3rd ed., 2003.
3. Vedam Subramanyam, “Power Electronics –Devices, Converters and Applications”, New Age International Publishers Pvt. Ltd., Bangalore, 2nded. 2006.
4. P.S. Bimbhra, “Power Electronics”, Khanna Publishers, New Delhi, 2012..
5. Ned Mohan, Undeland and Robbins, “Power Electronics –Converters, Applications and Design”, John Willey & sons, Inc., 3rd ed., 2003.
6. V.R.Moorthi, “Power Electronics”, Oxford University press, 2005.
7. G..K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, “Thyristorised Power Controllers”, New Age International Ltd. Publishers, 1986 (Reprint 2008).
8. P.T. Krein, “Elementsof Power Electronics”, Oxford University Press, 1998.
9. G..K. Dubey, “ Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, 2nded. 2001.

PROGRAM SPECIFIC OUTCOMES (PSOs)

4. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.

5. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.

6. Use technical expertise and suggest modifications in existing electrical systems.

CO-PO-PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3		2										2		
CO2	3	2			2								2	2	
CO3	3		2		2		2						2	2	
CO4	3		2		2							3	2	2	

Mapping & Justification

Mapping	Level	Justification
CO1-PO1	3	Basic fundamental knowledge of Thyristros and its family member such as IGBT, MOSFET, GTO, TRIAC, and DIAC etc. will be gained by students.
CO1-PO3	2	Concepts learned in this subject will be useful to design and development of different gate triggering circuits for converters.
CO2-PO1	3	This course will deliver fundamental knowledge about AC to DC converters.
CO2-PO3	2	Concepts learned in this subject will be useful to design and

		development of different AC to DC converters and its application.
CO2-PO5	2	Students use various converters circuits for performing laboratory experiments. So, they will be acquainted with latest tools and measurement techniques.
CO3-PO1	3	This course will deliver fundamental knowledge about DC to DC converters.
CO3-PO3	2	Concepts learned in this subject will be useful to design and development of different DC to DC converters and its application.
CO3-PO5	2	Students use various converters circuits for performing laboratory experiments. So, they will be acquainted with latest tools and measurement techniques.
CO3-PO7	2	Knowledge of Control strategies of DC chopper will help students to design renewable based energy electricity generation to reduce global warming as well as to develop sustainable environment.
CO4-PO1	3	This course will deliver fundamental knowledge about DC Drives application to control various parameters of DC motors.
CO4-PO3	2	Concepts learned in this subject will be useful to design and development of DC motors and its application.
CO4-PO5	2	Students use various DC drives circuits for performing laboratory experiments. So, they will be acquainted with latest tools, its control circuits and measurement techniques.
CO4-PO12	3	Students will be able to apply this knowledge in lifelong problem in the domain of DC drives.
CO1-PSO1	2	Students will be able to apply fundamental knowledge of power electronics in industry as well as in higher studies.
CO2-PSO1	2	Students will be able to apply fundamental knowledge of AC to DC converters in industry as well as in higher studies.
CO3-PSO1	2	Students will be able to apply fundamental knowledge of DC to DC converters in industry as well as in higher studies.
CO4-PSO1	2	Students will be able to apply fundamental knowledge of power electronics in industry as well as in higher studies.
CO2-PSO2	2	Students will be able to design AC to DC converters for various applications.
CO3-PSO2	2	Students will be able to design DC to DC converters for various applications.
CO4-PSO2	2	Students will be able to design DC motor drives for various applications.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

Control of Electric Drive

SUBJECT CODE: 2160913

B.E. 6th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

After learning the course the students should be able to **:-**

CO-1 Understand working principle, performance, control and applications of DC Machines and Transformer.

CO-2 Carry out test and conduct performance experiments on DC machine and Transformer.

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CO-3 Identify, formulate and solve DC machine and Transformer related problems.

Syllabus:

1	Electromechanical Energy Conversion: Principle, Singly Excited Magnetic System and Doubly Excited Magnetic system. Physical concept of torque production; Electromagnetic torque and Reluctance torque. Concept of General terms pertaining to Rotating Machines: Electrical & Mechanical degree, Pole pitch, Coil, Generated EMF in full pitched coil, Generated EMF in a short pitched coil, EMF polygon, Distribution factor, Pitch factor. MMF produced by Distributed Windings, MMF of a coil, MMF of single phase distributed Winding, MMF waveform of Commutator machines.
2	D.C. Machines: Working principle, construction and methods of excitation. Armature Winding: Introduction of simplex lap and wave windings. DC generators: EMF equation – methods of excitation – separately and self-excited – shunt, series, compound - armature reaction – effects of armature reaction - demagnetizing & cross magnetizing ampere-turns – compensating windings – inter poles - commutation – methods to improve commutation - voltage build-up – no load characteristics – load characteristics – losses and efficiency - power flow diagram – parallel operation – applications of DC generators. D.C. Motors: Principle of operation – back EMF – classification – torque equation – losses and efficiency – power flow diagram – performance characteristics of shunt, series and compound motors – starting of DC motors – necessity and types of starters – design of starters – speed control – methods of speed control – solid state speed control (block diagram) – testing – Swinburne's test – Hopkinson's test – separation of losses – retardation test – field test of dc motors – application of DC motor.

3	Transformers: Principle, construction and operation of single phase transformers, phasor diagram, equivalent circuit, voltage regulation, losses and efficiency, Testing- Open & short circuit tests, Polarity test, Sumpner's test, Separation of hysteresis and eddy current losses, Autotransformers - Construction, Principle, Applications and Comparison with two winding transformer, Three phase Transformer: Construction, various types of connection and their comparative features, 3-phase transformer connections - Δ-Δ, Y-Y, Δ-Y, Y-Δ, V-V – vector groupings Yy0, Dd0, Yd1, Yd11, Dy1, Dy11, Scott connection – three winding transformer – tertiary winding – per unit impedance, Parallel operation of single phase and three phase transformers. Excitation phenomenon in transformers, Harmonics in single phase and three phase transformers, Tap changing Transformers - No load and on load tap changing of transformers, Cooling methods of transformers. Special Transformers: Potential transformer, Current transformer, Pulse transformer, Audio frequency transformer, Grounding transformer.

Reference Books:

1. Nagrath I J and Kothari D P, Electric Machines, Tata McGraw Hill
2. Ghosh, Electrical Machine, Pearson Education
3. P.S. Bhimbra, Electrical Machinery, Khanna Publishers
4. M G Say, Theory, Performance & Design of A.C. Machines, CBS Publishers.
6. Irving L. and Kosow, Electric Machinery and Transformers, Prentice-Hall of India
7. K. Murukesh Kumar, DC machines and Transformers, Vikas Publishing house Pvt Ltd.

Program Specific Outcome (PSOs)

1. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll. in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
3. Use technical expertise and suggest modifications in existing electrical systems.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		1								1		1	1
CO2	3	2		1									2	2	2
CO3	3	2	1	2										2	1

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students can be able to apply knowledge of engineering fundamentals to understand principles, performance and control of DC Machines and Transformer.

CO1-PO2	1	Students can be able to understand fundamental principles of DC Machines and Transformer by using principles of engineering science to analyse complex engineering problems.
CO1-PO4	1	Students can be able to gain research based knowledge about DC Machines and Transformer.
CO1-PO12	1	Students can be able to recognize the need of DC Machines and Transformer in life long learning.
CO2-PO1	3	Students can be able to apply knowledge of engineering fundamentals to carry out tests and conduct experiments on DC Machines and Transformer.
CO2-PO2	2	Students can be able to perform experiments and carry out tests on DC Machines and Transformer by using principles of engineering science and mathematics to analyse complex engineering Problems.
CO2-PO4	1	Students can be able to use research based knowledge and methods to perform experiments on v to provide valid conclusions.
CO3-PO1	3	Students can apply knowledge of DC Machines and Transformer to identify and solve the complex engineering problems.
CO3-PO2	2	Students can identify, formulate and solve DC Machines and Transformer problems using principles of engineering science.
CO3-PO3	1	Students can be able to design DC Machines and Transformer to meet the need of society.
CO3-PO4	2	Students can be able to use research based knowledge and methods to perform experiments on DC Machines and Transformer to provide valid conclusions.

Mapping	**Level**	**Justification**
CO1-PSO2	1	Students will gain knowledge DC Machines and Transformer which will help them in solving complicated electrical circuits.
CO1-PSO3	1	Students will be able to suggest modifications in existing electrical system by using fundamental knowledge DC Machines and Transformer.
CO2-PSO1	2	Students will be able to use electrical testing tools and equipments to carry out test and perform experiments on DC Machines and Transformer.
CO2-PSO2	2	Students will be able to use knowledge DC Machines and Transformer to carry out test and conduct experiments on DC Machines and Transformer.
CO2-PSO3	2	Students will be able to suggest modifications in existing electrical systems by performing experiments which will help them to derive conclusions.
CO3-PSO2	2	Students will be able to solve complicated electrical circuits consisting of DC Machines and Transformer by applying knowledge of various electrical machines.
CO3-PSO3	1	Students will be able to suggest modifications in existing electrical systems by solving DC Machines and Transformer related problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

HIGH VOLTAGE ENGINEERING

SUBJECT CODE: 2160904

B.E. 6th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Syllabus:

1	**Electrostatic fields and field stress control** :Electrical field distribution and breakdown strength of insulating materials - fields in homogeneous, isotropic materials - fields in multi-dielectric, isotropic materials - numerical method: Finite Element Method (FEM), charge simulation method (CSM)
2	**Electrical breakdown in gases**: Gases as insulating media - ionization and decay processes, Townsend first ionization coefficient, photoionization, ionization by interaction of metastable with atoms, thermal ionization, deionization by recombination, deionization by attachment–negative ion formation, examples - cathode processes – secondary effects, photoelectric emission, electron emission by positive ion and excited atom impact, thermionic emission, field emission, Townsend second ionization coefficient, secondary electron emission by photon impact, examples - transition from non-self-sustained discharges to breakdown, the Townsend mechanism, examples - the streamer or 'kanal' mechanism of spark, examples - the sparking voltage–Paschen's law, penning effect, the breakdown field strength, breakdown in non-uniform fields- partial breakdown, corona discharges,
3	**Breakdown in liquid and solid dielectrics:** Liquid as insulators, breakdown in liquids - electronic breakdown, suspended solid particle mechanism, cavity breakdown, examples - static electrification in power transformers, transformer oil filtration, transformer oil test, alternative liquid insulations like vegetable oils, esters and silicon oils - breakdown in solids, intrinsic breakdown, streamer breakdown, electromechanical breakdown, edge breakdown and treeing, thermal breakdown, erosion breakdown, tracking - breakdown of solid dielectrics in practice, partial discharges in solid insulation, solid dielectrics used in practice
4	**Generation of high voltages :**Generation of high direct voltages, half and full wave rectifier circuits, voltage multiplier circuits, Van de Graff generators, electrostatic generators, examples - generation of alternating voltages, testing transformers, cascaded transformers, resonant transformers, examples - impulse voltages, Standard lightning and switching surge and associated parameters and their corrections, impulse voltage generator

	circuits, Marx circuit, operation, design and construction of impulse generators, examples - impulse current generator - control systems
5	**Measurement of high voltages :**High direct voltage measurement, peak voltage measurements by spark gaps, sphere gaps, reference measuring systems, uniform field gaps, rod gaps, factors affecting sphere gap measurements, examples - electrostatic voltmeters - ammeter in series with high ohmic resistors and high ohmic resistor voltage dividers - generating voltmeters and field sensors - the measurement of peak voltages, the Chubb–Fortescue method, high- voltage capacitors for measuring circuits - voltage dividing systems and impulse voltage measurements, digital recorders, errors inherent in digital recorders
6	**Over voltages, testing procedures and insulation coordination :**The lightning mechanism, energy in lightning, nature of danger - laboratory high-voltage testing procedures and statistical treatment of results, examples - insulation coordination, insulation level, statistical approach to insulation coordination, correlation between insulation and protection levels - modern power systems protection devices, M O A – metal oxide arresters
7	**Non-destructive insulation test techniques :**Measurement of d.c. resistivity - dielectric loss and capacitance measurements, the Schering bridge, current comparator bridges, Tan Delta measurement, null detectors - partial-discharge (PD) measurements, the basic PD test circuit, PD currents, PD measuring systems within the PD test circuit, measuring systems for apparent charge, sources and reduction of disturbances, other PD quantities, calibration of PD detectors in a complete test circuit, digital PD instruments
8	**High voltage testing:**Testing of insulators and bushings, testing of isolators and circuit breakers Testing of cables, testing of transformers - testing of surge diverters - radio interference measurements - design, planning an layout of high voltage laboratory

Course Outcome: After learning the course the students should be able to

1. Understand the basic generation and measurement of High voltage and High current for testing purposes
2. Comprehend Breakdown phenomenon in air, solid and liquid insulation
3. Test high voltage electrical Equipment with various testing devices.

PROGRAM SPECIFIC OUTCOMES (PSOs)

7. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
8. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
9. Use technical expertise and suggest modifications in existing electrical systems.

Reference Books:

1. Kuffel, E., Zaengl W.S., Kuffel J., “High Voltage Engineering: Fundamentals” Butterworth- Heinmann (A division of Reed Educational & Profession Publishing Limited), 2nd Edition, 2000.
2. Naidu M. S. and Kamaraju V., “High Voltage Engineering”, fourth Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2009.
3. Rakosh Das Begamudre, “High Voltage Engineering, Problems and Solutions”, New Age International Publishers, New Delhi, 2010.
4. Dieter Kind, Kurt Feser, “High Voltage Test Techniques”, Reed educational and professional publishing ltd. (Indian edition), New Delhi-2001
5. M. Khalifa, "High Voltage Engineering-Theory and Practice", Marcel Dekker, Inc. New York and Basel,1990.
6. Hugh M. Ryan, “High Voltage Engineering and Testing”, 2nd edition, The Institution of Electrical Engineers, London, United Kingdom, 2001.
7. Wadhwa C.L., "High Voltage Engineering", third edition, New Age publishers, New Delhi, 2010.

CO-PO-PSO mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	1		2											2	
CO 2															
CO 3															
CO 4															

Mapping & Justification

Mapping	Level	Justification
CO1-PO1	3	Basic knowledge of image processing and video processing algorithms will be gained by students.
CO1-PO3	1	Concepts learned in this subject will be useful to design and develop image processing system.
CO2-PO1	3	This course will deliver fundamental knowledge about image transformation and enhancement techniques.
CO2-PO2	2	Students will be able analyse different problem related to segmentation and enhancement of image/video.
CO2-PO3	2	Basic concepts of Image processing will enable students to develop solutions for different image processing problems

CO2-PO5	3	Students use various latest open source tools and frameworks for performing their laboratory experiments. So, they will be acquainted with latest tools and techniques.
CO3-PO2	2	Knowledge about algorithms with time complexity is delivered.
CO3-PO12	2	Students will be able to apply these knowledge in life long problem in the domain of image and video processing.
CO4-PO2	2	Students will be able analyse different problem related to compress of image/video.
CO1-PSO2	2	Students will be able to apply mathematical concepts in image enhancement and segmentation.
CO2-PSO3	2	The current tools used for processing images with less amount of processing time.
CO3-PSO2	2	Students will be able to apply mathematical concepts in image/video compression and decompression.
CO4-PSO1	1	Students will be able to design and develop real-world image processing / video processing applications.
CO4-PSO4	2	Student will be able to find out limitation of traditional approaches and investigate the research gap by analysing the strength and weakness of different open ended problem.

Programme: Electrical Engineering	Degree: B.E.
Course Code: 2180910 **Energy conservation and audit**	Semester: 8
Credits: 5	Contact hours: 3 (Theory) + 2 (Laboratory)

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Syllabus:

Sr. No.	Content	Total Hrs.	% Wtg.
1.	**Energy Audit Methodology and recent trends.** General Philosophy, need of Energy Audit and Management, EC Act, Definition and Objective of Energy Management, General Principles of Energy Management. Energy Management Skills, Energy Management Strategy. Economics of implementation of energy optimization projects, it's constraints, barriers and limitations, Financial Analysis: Simple Payback, IRR, NPV, Discounted Cashflow; Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits. Guidelines for writing energy audit report, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities.	**11**	**25-30%**
2.	**Electrical Distribution and Utilization:** Electrical Systems, Transformers loss reductions, parallel operations, T & D losses, P.F. improvements, Demand Side	**11**	**25-30%**

	management (DSM), Load Management, Harmonics & its improvements, Energy efficient motors and Soft starters, Automatic power factor Controllers, Variable speed drivers, Electronic Lighting ballasts for Lighting, LED Lighting, Trends and Approaches. Study of 4 to 6 cases of Electrical Energy audit and management (Power factor improvement, Electric motors, Fans and blowers, Cooling Towers, Industrial/Commercial Lighting system, etc.)		
3.	**Thermal Systems:** Boilers- performance evaluation, Loss analysis, Water treatment and its impact on boiler losses, integration of different systems in boiler operation. Advances in boiler technologies, FBC and PFBC boilers, Heat recovery Boilers- it's limitations and constraints. Furnaces- Types and classifications, applications, economics and quality aspects, heat distributions, draft controls, waste heat recovering options, Furnaces refractory- types and sections. Thermic Fluid heaters, need and applications, Heat recovery and its limitations. Insulators- Hot and Cold applications, Economic thickness of insulation, Heat saving and application criteria. Steam Utilization Properties, steam distribution and losses, steam trapping, Condensate, Flash steam recovery.	**10**	**20-25%**
4.	**System Audit of Mechanical Utilities:** Pumps, types and application, unit's assessment, improvement option, parallel and series operating pump performance. Energy Saving in Pumps & Pumping Systems. Bloomers (Blowers) types & application, its performance assessment, series & parallel operation applications & advantages. Energy Saving in Blowers Compressors, types & applications, specific power consumption, compressed air system,& economic of system changes. Energy Saving in Compressors & Compressed Air Systems Cooling towers, its types and performance assessment & limitations, water loss in cooling tower. Energy Saving in Cooling Towers .Study of 4 to 6 cases of Energy Audit & Management in Industries (Boilers, Steam System, Furnaces, Insulation and Refractory, Refrigeration and Air conditioning, Cogeneration, Waste Heat recovery etc.)Study of Energy Audit reports for various Industries and Organizations	**10**	**20-25%**

Course Outcome: After learning the course the students should be able to,

1. Identify and assess the energy conservation/saving opportunities in different electric system
2. Identify and assess energy conservation opportunities in thermal system
3. Demonstrate skills required for energy audit and management.
4. Prepare energy flow diagrams and energy audit report
5. Suggest cost-effective measures towards improving energy efficient and energy conservation.

Program Specific Outcome (PSOs)

2. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
3. Use technical expertise and suggest modifications in existing electrical systems.

PO:

Engineering Graduates will be able to:

13. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

14. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

15. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

16. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

17. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

18. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

19. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

20. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

21. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

22. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

23. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

24. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CO-PO mapping

	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2	3				2								2
CO2	1	3		2			2								2
CO3	2	2				2							2		
CO4	2		3	1		2								2	
CO5	3	2	2	2											3

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students will be able to identify various energy conservation opportunities by applying knowledge of mathematics and engineering to complex electrical engineering systems.
CO5-PO1	3	Students will use knowledge of mathematics and engineering design concepts for finding cost effective measures of improving energy efficient conservation systems.
CO2-PO1	2	Students use different engineering specialization for identifying energy conservation opportunities in thermal system.
CO3-PO1	2	Various energy management and audit skills will be demonstrated by analysing various energy systems.

CO1-PO2	2	Students will be able to identify various problem and do analysis of Different electric system.
CO2-PO2	3	Students will identify complex engineering problem and do analysis for energy conservation opportunities in thermal systems.
CO5-PO2	2	Various cost effective problem analysis will be done by students using principles of mathematics and engineering sciences for energy conservation.
CO4-PO3	3	Students will be able to conduct investigations of complex problems for preparing various energy flow diagrams.
CO5-PO3	2	Students will be identify various cost effective measures for various complex problems resulting in energy conservations.
CO2-PO4	2	Students will conduct investigations of complex problems in thermal systems.
CO4-PO4	1	Students will use research based knowledge for identifying complex problems and prepare energy flow diagram and report for energy conservation.
CO5-PO4	2	Students will identify complex problems and conclude various cost effective measures for improving energy conservation.
CO3-PO6	2	The students will demonstrate skills required for energy audit and management with respect to society by applying relevant to the professional engineering practice.
CO4-PO1	2	Student will apply engineering knowledge to prepare energy flow diagrams and energy audit reports.
CO3-PO2	2	Students will analyse various problems to demonstrate skills for energy management.
CO1-PO3	2	Students will design solutions for energy conservation in various electric systems.
CO4-PO6	2	Students will prepare energy audit reports for assesing in benefit of society by conserving electrical energy.
CO1-PO7	2	Students will identify various energy saving opportunities in context with environmental sustainability.
CO2-PO7	2	Students will assess energy conservation opportunity in thermal system in context with environmental sustainability.
CO1-PSO3	2	Students will identify energy conservation methods by using technical expertise of the concept taught.
CO2-PSO3	2	Students will identify energy management skills of thermal system by technical expertise.
CO3-PSO1	3	Students will use various tools for demonstrating skills required to perform energy audit in any electrical system.
CO5-PSO3	3	Students will use technical expertise of electrical system and Suggest cost-effective measures towards improving energy efficient and energy conservation
CO4-PS02	2	Student will prepare energy flow diagram using knowledge of various electrical machines and electrical power system.

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL (09)

POWER QUALITY AND MANAGEMENT

SUBJECT CODE: 2180911

B.E. 8th Semester

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Course Objectives:

After learning the course the students should be able to **:-**

1. Understand the major power quality problems.
2. Use equipment that are required to measure the quality of power
3. Apply and analyze/compare techniques available to mitigate power quality problems.

Syllabus:

1	**Introduction to Power Quality:** Definition of power Quality, power quality terminology, power quality issues, Susceptibility Criteria, Responsibility of supplier and users of elect power, Standards
2	**Power Frequency Disturbance:** Common power frequency disturbances, voltage sags, cures of low frequency disturbances, voltage tolerance
3	**Electrical Transients:** Transient system model, Examples of models & response, Types and causes of transients, Examples of transient wave forms
4	**Harmonics:** Definition , number, odd and even harmonics, causes of harmonics, Individual & total distortion, Harmonics signatures, Effect of harmonics, Guide lines for harmonic voltage & current limitation, Harmonic current mitigation
5	**Grounding & Bonding:** Introduction, National electric code grounding requirements, Essentials of grounding system, Ground electrodes, Earth resistance tests, Earth ground grid system, Power Ground system, Signal reference ground, Signal reference ground methods, Single and multi-point grounding, Ground loops
6	**Power Factor:** Introduction, Active and Reactive power, Displacement and true power factor, power factor improvement, correction, penalty, voltage rise due to capacitance, application of synchronous condensers and static VAR compensators
7	**Electromagnetic Interference:** Electric and magnetic fields, Electromagnetic interference terminology, Power frequency fields, High frequency interference, EMI Mitigation, Cable shielding to minimize EMI, Health concerns of EMI
8	**Power Quality Measurement:** Power quality measurement devices, power quality measurements, Number of test locations, Test duration, Instrument set-up, Instrument set up guidelines.
9	**Distributed Generation and Power Quality:** Resurgence of DG, DG technologies, Interface to the utility system, Power quality issues, Operating conflicts,

Reference Books:

1. Power Quality by C.Sankaran, CRC publication

2. Electrical Power Systems Quality by Roger C.Dugan , TMH publication

3. Harmonics and Power Systems by Francisco C. De La Rosa, CRC Publication

Program Specific Outcome (PSOs)

4. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll. in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
5. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
6. Use technical expertise and suggest modifications in existing electrical systems.

CO-PO-PSO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3			1			1							1	
CO2	3	1		1	2							1	1	1	
CO3	3	2		2	2		1					1	2	2	1

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students can be able to apply knowledge of engineering specialization to understand Power Quality problems.
CO1-PO4	1	Students can be able to use knowledge of Power Quality problems to analyse and interpretation of data to provide valid conclusion.
CO1-PO7	1	Fundamental knowledge of power quality will helps students to develop sustainable environment by using renewable energy based generation (solar ,wind etc.)
CO2-PO1	3	Students can be able to apply knowledge of use of equipments to measure quality of power.
CO2-PO2	1	Students can be able to identify the use of equipments that are required to measure quality of power.
CO2-PO4	1	Students can be able to use knowledge of equipments required to measure the quality of power.
CO2-PO5	2	Students can be able to apply different techniques to use equipments which measure power quality for prediction and modelling of complex engineering activities.
CO2-PO12	1	Students can be able to recognize need for equipments required to measure power quality.
CO3-PO1	3	Students can be able to apply knowledge of mathematics, science, engineering fundamentals and specialization to analyze techniques available to mitigate power quality problems.
CO3-PO2	2	Students can be able to identify and analyze different techniques to mitigate power quality problems.
CO3-PO4	2	Students can be able to use research based knowledge and methods to analyze techniques to mitigate power quality problems.
CO3-PO5	2	Students can be able to select and apply modern engineering tools for modelling of power quality issues mitigation techniques.

CO3-PO7	1	Fundamental knowledge of mitigation techniques of power quality issues will helps students to develop sustainable environment by using renewable energy based generation (solar ,wind etc.)
CO3-PO12	1	Students can be able to recognize the need for techniques to mitigate power quality problems.

Mapping	**Level**	**Justification**
CO1-PSO2	1	Students will be able to use knowledge of power quality issues in electrical power system.
CO2-PSO1	1	Students will be able to use knowledge of equipments to measure power quality which will help them in industry.
CO2-PSO2	1	Students will be able to use equipments to measure power quality in solving complicated electrical circuits by using simulation tools.
CO3-PSO1	2	Students will be able to apply various techniques available to mitigate power quality problems in the field of electrical engineering.
CO3-PSO2	2	Students will be able to analyze techniques to mitigate power quality problems by using latest design and simulation tools.
CO3-PSO3	1	Students will be able to use technical expertise in analysis of techniques available to mitigate power quality problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: ELECTRICAL ENGINEERING

SUBJECT NAME: POWER SYSTEM PLANNING AND DESIGN

SUBJECT CODE: 2180903

B.E. 8th SEMESTER

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weight
1.	**Transmission lines design :** Requirements of transmission lines, selection of voltage for high-voltage transmission lines, choice of conductors, spacing of conductors, corona, insulators, specifications of transmission lines,	10	20 %

	surge- impedance loading of transmission lines, electrical design of transmission lines, main considerations in the mechanical design of transmission lines, sag-tension relation, stringing of transmission lines, towers Design of EHV transmission lines : transmission of electric power at extra-high voltage, design considerations of EHV lines, selection and spacing of conductors, corona, radio and television interference, insulation co-ordination, towers**[1]**		
2.	**Design of distribution systems :** Development of a distribution plan, transmission and distribution systems, types of distribution systems arrangements, primary distribution design, secondary distribution design,	**8**	**20 %**

	distribution substations, calculation of distributor sizes: voltage drops, voltage regulation, Lamp flicker**[1]**		
3.	**Design of power system :** Introduction, selection of sizes and location of generating stations, selection and specifications of transmission lines, sizes and location of substations, interconnection**[1]**	**5**	**8 %**
4.	**Power System Earthing :**Objectives, definitions, tolerable limits of body currents, soil resistivity, earth resistance, tolerable step and, actual step and touch voltage, design of earthing grid, concrete encased electrodes, tower footing resistance, measurement of earth resistance R, measurement of soil resistivity, impulse behavior of earthing system.**[2]**	**5**	**15 %**
5.	**Insulation Co-ordination:** Introduction, definitions, determination of line insulation, B.I.L and insulation levels of sub-station equipment, lightning arrester selection, power system overvoltages, tentative selection of arrestor voltage ratings, selection of arrestor discharge currents, arrestor discharge voltage, establishment of impulse voltage level of equipment, protective margin, establishment of separation limits, location of lightening arrestor**[3]**	**5**	**15 %**
6.	**Power system improvement:** Introduction, methods of power system improvement, power system improvement scheme, determination of the voltage regulation and losses in a power system, shifting of distribution transformer centre, financial aspects of the power system improvement scheme**[1]**	**4**	**10 %**
7.	**Power system planning:**Introduction, methods of power system planning, forecasting load and energy requirements, generation planning, transmission system planning, distribution system planning, reliability of electrical power systems, methods of measuring power system reliability**[1]**	**5**	**12 %**

Reference Books:

1. Electrical Power System Design – M. V. Deshpande, TMH publication

2. Electrical Power System Design – B. R. Gupta, S. CHAND

3. A course in Electrical Power- Soni, Gupta and Bhatnagar, DhanpatRai& Sons
8. Substation Design – Satnam& Gupta, DhanpatRai andCo.

9. Electrical Power System Planning – A. S. Pabla, TMHpublication

Course Outcome:

After learning the course the students should be able to:

6. Design transmission line (electrical and mechanical aspects)
7. Design primary and secondary distribution.
8. Selection of sizes and location of generating stations, substations.
9. Explain the basic concepts of power system earthing and measurement of earthing resistance.
10. Explain the basic concepts of insulation co-ordination.
11. Explain the basic concepts of generation planning, transmission planning and distribution planning.

CO-PO-PSO mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	2		3	2		1									2
CO 2	2		3	2		1									2
CO 3	1			1											1
CO 4	3		1												1
CO 5	3		2	1									1		
CO 6	2	1				2									1

Mapping & Justification:

Mapping	Level	Justification

CO1-PO1	2	Basic knowledge of Design of transmission line will be gained by students.
CO1-PO3	3	Concepts learned in this subject will be useful to design transmission line.
CO1-PO4	2	Students will be able to analyse different problems related to transmission line design.
CO1-PO6	1	Students will be able to design transmission line by considering safety and legal issues.
CO2-PO1	2	This course will deliver fundamental knowledge about design of primary and secondary distribution.
CO2-PO3	3	Concepts learned in this subject will be useful to design primary and secondary distribution.
CO2-PO4	2	Students will be able to analyse different problems related to design of primary and secondary distribution.
CO2-PO6	1	Students will be able to design primary and secondary distribution by considering safety and legal issues.
CO3-PO1	1	Knowledge about selection of sizes and location of generating stations and substations is delivered.
CO3-PO4	1	Students will be able to analyse different problems related to sizes and location of generating stations and substations.
CO4-PO1	3	Basic knowledge of power system earthing and measurement of earthing resistance will be gained by students.
CO4-PO3	1	Concepts learned in this subject will be useful to design earthing grid in substation.
CO5-PO1	3	Basic knowledge of insulation co-ordination will be gained by students.
CO5-PO3	2	Concepts learned in this subject will be useful to select insulating material required for power apparatus.
CO5-PO4	1	Students will be able to analyse different problems related to insulation co-ordination between equipment to be protected and protecting device.
CO6-PO1	2	Basic knowledge of generation planning, transmission planning and distribution planning will be gained by students.
CO6-PO2	1	Students will be able to identify various problems in generation planning, transmission planning and distribution planning and

		rectify it.
CO6-PO6	2	Students will be able to do generation planning, transmission planning and distribution planning by considering safety and legal issues.
CO1-PSO3	2	Student will use technical expertise and suggest modifications in existing transmission systems.
CO2-PSO3	2	Student will use technical expertise and suggest modifications in existing distribution systems.
CO3-PSO3	1	Student will use technical expertise and suggest modifications in existing substation.
CO4-PSO3	1	Student will use technical expertise and suggest modifications in existing earthing system of power station.
CO5-PSO1	1	Student will be able to do research and innovation in the field of insulation co-ordination.
CO6-PSO3	1	Student will use technical expertise in generation planning, transmission planning and distribution planning.

Programme: Electrical Engineering	Degree: B.E.
Course Code: 2170908 Switchgear and protection	Semester: 7
Credits: 6	Contact hours: 4 (Theory) + 2 (Laboratory)

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	00	02	06	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	%Weighta
1	**Introduction to Protective Relaying and electromagnetic relays** Faults, Causes and Effects, Protective Zones, Primary and Backup Protection, Desirable Qualities and Terms of Protective Relaying, Basic Connection of Trip Circuit, Types of Relay Units, Relay Pick up, Reset or Drop out, Pick up/ Drop off Ratio, Construction and Working of Different Electromagnetic Relays [3]	3	4
2	**Over Current Protection of Transmission line** Introduction, Fuse, Thermal Relays, Over Current Relays, Application of Definite Time & IDMT O.C. Relays for Protection of Feeder, Directional Over Current Relay, Limitations of O.C. Relays [1]	3	5

3	**Differential Protection** Simple Differential Protection, Zone of Protection and Actual Behavior of Simple Differential Protection, Percentage Differential Protection, Earth Leakage Protection[1]	2	4
4	**Transformer Protection** Types of Faults, Over Current Protection, Percentage Differential Protection, Inrush Phenomenon, High Resistance Ground Faults in Transformers, Inter-turn Faults, Incipient Faults, Over-fluxing Phenomenon[1]	4	7
5	**Distance Protection of Transmission line** Drawbacks of O.C. Protection, Introduction to Distance Protection, Types of Distance Relay, Impedance, Reactance, MHO Relay, Performance of Distance Relay During Normal Load and Power Swing, Effect of Arc Resistance on Reach of Distance Relays, Comparison of Distance Relays, Distance Protection of Transmission line, Reasons for Inaccuracy of Distance Relay Reach, Three Step Protection, Trip contact configuration, 3-step protection of double and fed lines. [1]	5	10
6	**Carrier aided protection of transmission lines** Need for carrier aided protection of transmission lines, various options for carrier, Coupling and trapping the carrier into the desired line section, single line to ground coupling, line to line coupling, unit type carrier aided directional comparison relaying, carrier aided distance scheme for acceleration of zone II, transfer trip or inter trip, permissive inter trip, acceleration of zone II, pre-acceleration of zone II, phase comparison relaying (unit scheme) [1]	5	10
7	**Generator protection** Various faults & abnormal operation conditions, stator & rotor faults, transverse differential protection, unbalanced loading, over speeding, loss of excitation, loss of prime mover [1]	5	10

8	**Induction motor protection** Various faults & abnormal operation conditions, starting of induction motor, protection of small & large induction motor. [2]	5	10
9	**Numerical protection** Introduction, block diagram of numerical relay, numerical over current protection, numerical transformer protection, numerical distance protection of transmission line [1]	5	10
10	**Theory of circuit Interruption**	3	5
	Introduction, Physics of arc phenomena, Maintenance of the arc, Losses from plasma, Essential properties of arc, Arc interruption theories. [4]		
11	**Circuit Constant in Relation to Circuit Breaking** Introduction, Circuit breaker rating, Circuit constants & circuit conditions Re-striking voltage transient Characteristics of re-striking voltage, Interaction between the breaker & circuit, Current chopping, duties of switchgear.[4]	4	5
12	**Theory & Practice of Conventional Circuit Breaker and modern circuit breakers** Automatic switch, Air-break circuit breakers, Oil circuit breakers, Single and multi break Construction, Air-blast circuit breaker, Performance of circuit breakers and system requirements, Modification of circuit breaker duty by shunt resistors, Power factor correction by series resistance, Comparative merits of different types of conventional circuit breakers, Modern trends, Vacuum circuit breakers, Sulphur hexafluoride (SF_6) circuit breakers D.C. circuit breaker, auto-reclosing - definitions & features, 3-Phase versus 1-Phase auto-reclosing [4]	8	15

13	**Protective current transformer and potential transformer** Magnetization curve of CT, Difference between measurement & protective CT, CT errors, calculation of CT accuracy, selection of CT, CT requirements for differential protection, specifications of CT, specifications of PT, CVT. **[2]**	4	5

Course Outcome:

After learning the course the students should be able to:

6. Explain the purposes of protection, in relation to major types of apparatus, protection principle, dangers and criteria.
7. Choose and justify a suitable protection system for a specified application.
8. Analyze and compare specified protection systems
9. Compare merits of various principles, relay hardware and interrupting devices.
10. Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application

Program Specific Outcome (PSOs)

3. Use various electrical testing tools and equipments in industry, be an Entrepreneur, Enroll in post-graduate courses, Pursue Research and Innovation in the field of Electrical Engineering.
2. Use knowledge of various electrical machines and electrical power system in solving complicated electrical circuits and networks by using latest design and simulation tools.
3. Use technical expertise and suggest modifications in existing electrical systems.

PO:

Engineering Graduates will be able to:

25. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
26. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
27. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

28. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

29. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

30. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

31. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

32. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

33. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

34. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

35. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

36. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CO-PO mapping

	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2											2		
CO2	3	3													
CO3	2	3	3												3
CO4	3			3										2	
CO5	3					2									

Mapping & Justification:

Mapping	Level	Justification
CO1-PO1	3	Students will be able to apply knowledge of different apparatus protection schemes for solution of complex engineering in protection system.
CO2-PO1	3	Students will be to apply knowledge of mathematics,science and engineering for selection of a specified application protection schemes.
CO3-PO1	2	Students will apply knowledge to compare specified protection systems.
CO4-PO1	3	Comparison of various interrupting devices will be done by applying engineering knowledge.
CO5-PO1	3	Students will be able to applying engineering knowledge for selection of circuit breaker for a given application.
CO1-PO2	2	Students will be able to analyse problems of different apparatus protection schemes.
CO2-PO2	3	Students will analyse various problems for selection of a specified application protection schemes.
CO3-PO2	3	Students will analyse problems and compare specified protection systems.
CO4-PO4	3	Students will investigate complex problems for comparison of various interrupting devices.
CO3-PO3	3	Students will design and Analyze to compare specified protection systems
CO5-PO6	2	Students will Compare the different type of circuit breakers performance based on which selection of circuit breaker can be made for a given application keeping in mind safety relevent to engineering practice.
CO3-PSO3	3	Students will use technical expertise for analysis of specified protection systems.
CO1-PSO1	2	Students will use various electrical testing tools and equipments in industry to select various apparatus protection schemes.
CO4-PSO2	2	Student will compare various relays and interrupting devices by applying knowledge of various electrical machines and power systems.