

DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE.

Dr. Babasaheb Ambedkar Technological University
(Established as a University of Technology in the State of Maharashtra)
(Under Maharashtra Act No. XXIX of 2014)
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National Education Policy (NEP) 2020 for the session 2026-27

For

Final Year B. Tech. Electrical Engineering (11293)
(University Department)

With effect from the Academic Year 2026-2027

B. Tech. Electrical Engineering

A. Program Educational Objectives (PEOs)

Graduates will be able to–

1. To equip graduates with a strong foundation in engineering sciences and Electrical Engineering fundamentals to become effective collaborators, researchers and real-time problem solver with technical competencies.
2. Perceive the limitation and impact of engineering solutions in social, legal, environmental, economic and multidisciplinary contexts.
3. Excel in Industry/technical profession, higher studies, and entrepreneurship exhibiting global competitiveness.

B. Program Outcomes (POs)

Engineering Graduate 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 modelling 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 commitment to professional ethics and responsibilities and norms of 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, making 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.

C. Program Specific Outcomes (PSO)

Electrical Engineering graduates will specifically be able to do in their field.

1. Demonstrate the ability to apply fundamental knowledge of mathematics, science and engineering to identify, formulate, analyze, investigate, and design complex problems in the field of electrical engineering.
2. Demonstrate ability to apply the appropriate techniques and modern engineering tools to manage and solve complex electrical engineering projects, adapt in multidisciplinary environments, and engage in lifelong learning.
3. Able to propose & implement engineering solutions in the context of the environment, society, economy, and professional ethics and have good communication skills

B. Tech Final Year Electrical Engineering

SEMESTER VII

SEMESTER VII												
Sr. No.	Course Code	Course Title	Teaching Scheme			Marking Scheme			Total Marks	CR	Category	
			L	T	P	CA	MSE	ESE				
1	26UD1293PC701	Power System Operation & Control	3			20	20	60	100	3	PCC	
2	26UD1293PC702	High Voltage Engineering	3			20	20	60	100	3	PCC	
3	26UD1293PE703	Program Elective-IV	3			20	20	60	100	3	PEC	
4	26UD1293PCL704	Power System Operation & Control Lab			2	60		40	100	1	PCC	
5	26UD1293PCL705	High Voltage Engineering Lab			2	60		40	100	1	PCC	
6	26UDXXXXMD706	MDM Bucket*	2			20	20	60	100	3	MDM	
7	26UD1293VE707	Energy audit And Conservation	2			20	20	60	100	2	VSEC	
8	26UD1293PC708	Project-I			4	60		40	100	4	PCC	
Total			13	0	8				800	20		

NOTE: * Refer to Multidisciplinary Minor Bucket

Refer to Open Elective III Bucket *

BSC/ESC: Basic Science Course/ Engineering Science Course, **PCC:** Programme Core Course **PEC:** Programme Elective Course, **Multidisciplinary (OE):** Open Elective Other than particular programme, **VSEC:** Vocational and Skill Enhancement Course, **HSSM:** Humanities Social Science and Management, **IKS:** Indian Knowledge System, **HSSM- VEC:** Value Education Course, **CCA:** Co-curricular & Extracurricular Activities **NPTEL Course:** Online NPTEL Course

Program Elective-IV	
26UD1293PE703A	Electrical Drives
26UD1293PE703B	Special Purpose Electrical Machines
26UD1293PE703C	Lighting Design and Fundamentals

SEMESTER VIII

Sr. No.	Course Code	Course Title	Teaching Scheme			Marking Scheme			Total Marks	CR	Category
			L	T	P	CA	MSE	ESE			
1	26UD1293PC801	EHVAC And HVDC	3			20	20	60	100	3	PCC
2	26UD1293PC802	Advance Power System Protection	3			20	20	60	100	3	PCC
3	26DU1293PE803	Program Elective-V	2			20	20	60	100	2	PEC
4	26UD1293PC804	Internship/Project-II			12	60		40	100	12	PCC
5	26UDXXXXMD806	MDM Bucket*	2			60		40	100	2	PCC
Total			10		12				500	22	

NOTE: * Refer to Multidisciplinary Minor Bucket

Program Elective-V	
26DU1293PE803A	Digital Signal Processing
26DU1293PE803B	Advanced Control Systems
26DU1293PE803C	Advanced Power Electronics
26DU1293PE803D	Power Quality Improvements

Multidisciplinary minors Subjects

for the Electrical Engineering Department (MDM Subjects Electrical)

For other than Electrical engineering Student for Multidisciplinary minors Degree*

Semester	Category	Subject Code	Subject Name	Total Credit
SEM-III	Foundation Courses	25UD1293MD306	Electrical and Electronics Measurements	2
SEM-IV	Core Electrical Engineering Courses	25UD1293MD406	Electrical Machine	3
SEM-V	Core Electrical Engineering Courses	25DU1293MD506	Power System	3
SEM-VI	Core Electrical Engineering Courses	25DU1293MD606	Switchgear And Protection	3
SEM-VII	Electives/Specialization Courses	25UD1293MD706	High Voltage Engineering	2
SEM-VIII	Project/Research Work	25UD1293MD806	Project/Research Work	2
Total credits required to complete a Minor Degree in Electrical Engineering				15

Semester VII		
Power System Operation & Control		
Teaching Scheme Lectures Theory: 03 Hr / Week Credit:03	Examination Scheme Continuous Assessment : 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective:		
<ol style="list-style-type: none"> 1. To understand the importance of reactive power and explain different methods used for reactive power control and voltage regulation in power systems.. 2. To study the concept of power system stability, including steady-state, transient, and dynamic stability, and analyze system behaviour using the swing equation and equal area criterion. 3. To learn the working and requirements of excitation systems and understand their role in maintaining generator voltage, stability, and protection. 4. To explain the principles of load frequency control (LFC) in single-area and two-area power systems and understand the operation of speed governors. 5. To analyze the economic operation of power systems, including optimal load sharing, unit commitment, and transmission loss calculations for efficient and reliable power generation. 		
Course Outcome:		
After completion of this course, students will be able to:		
CO1. Explain the need for reactive power management and describe different methods of voltage control.		
CO2. Analyze power system stability problems including steady-state, transient, and dynamic stability using the swing equation and equal area criterion		
CO3. Describe the excitation system requirements, components, and types.		
CO4. Understand and analyze Load Frequency Control (LFC) for single-area and two-area systems, including speed governor action.		
CO5. Apply principles of economic operation of power systems to distribute load optimally, calculate transmission losses, and solve basic unit commitment.		
Unit	Contents	Hrs.
1	Excitation Systems: Excitation Systems: Excitation System requirements, Elements of an excitation system Types of excitation systems. Control and protective functions of Excitation systems	6
2	Power System Stability: The stability problem-Steady state stability, transient stability and Dynamic stability, Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step by step solution of swing equation-Factors affecting transient stability, Methods to improve steady state and Transient stability	6
3	Reactive Power Management: Necessity of reactive power control, production and absorption of reactive power, methods of voltage control, shunt reactors, series capacitors, shunt capacitors, synchronous condensers, Static VAR Systems.	6

4	<p>Economic Operation of Power System: Distribution of load between units within a plant, Economic division of load between units in a plant, transmission loss as function of plant generation, calculation of loss-coefficient, numerical Unit Commitment, Constraints on Economic operation of power system.</p>	7
5	<p>Load Frequency Control: Introduction, LFC control of a single-area system, Two-Area Load Frequency Control, Automatic voltage Control, Speed governing mechanism and modelling, Speed Governor Dead band and its effect on Automatic Generation Control</p>	7
	<p>References:</p> <ol style="list-style-type: none"> 1. P. Kundur, "Power System Stability and Control", McGraw-Hill, 1993. 2. I. J. Nagrath and D. P. Kothari, Modern Power System Analysis, TMH, 2003 3. A Chakrabarti and S. Halder, Power System Analysis: Operation and Control, PHI, 2006. 4. W. D. Stevenson, Elements of Power system analysis, Mcgraw Hill, Digitized on Dec., 2007. 5. C.L.Wadhwa, Electrical Power Systems, 3rd Edn, New Age International Publishing Co., 2001 6. T. K. Nagsarkar and M. S. Sukhija, Power System Analysis, Oxford University Press, 2007 7. Dr. K. Uma Rao "Power System: Operation & Control" Wiley, January 2012 	

High Voltage Engineering		
Teaching Scheme Lectures Theory: 03 Hr / Week Credit:03	Examination Scheme Continuous Assessment : 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objectives:		
<ol style="list-style-type: none"> 1. To introduce the fundamentals of high voltage engineering and explain electric field stresses, surge voltages, and methods used for estimation and control of electric stress in power systems.. 2. To study conduction and breakdown mechanisms in gases, including ionization processes, Townsend theory, corona discharge, and the behavior of gases under uniform and non-uniform electric fields. 3. To understand breakdown phenomena in dielectric materials, such as liquids and solids, and analyze different breakdown theories and insulation practices used in electrical equipment. 4. To explain the causes and effects of over-voltages, particularly due to lightning and switching operations. 5. To learn the generation and measurement of high voltages and currents, including DC, AC, impulse voltages, and impulse currents. 		
Course Outcome:		
After completion of this course, students will be able to:		
CO1. Explain electric field stresses in high-voltage equipment and analyze surge voltages, their distribution, and methods used for electric stress control.		
CO2. Describe the mechanisms of conduction and breakdown in gases, including ionization processes, Townsend theory, corona discharge, and the effect of non-uniform electric fields.		
CO3. Analyze breakdown phenomena in liquid and solid dielectric materials, and evaluate the properties and applications of insulating materials.		
CO4. Explain the causes and effects of overvoltage's due to lightning, switching surges, and system faults, and apply insulation coordination.		
CO5. Demonstrate knowledge of generation and measurement techniques of high DC, AC.		
Unit	Contents	Hrs.
1	Introduction to High Voltage Engineering: Electric Field Stresses, Poisson's equation, Estimation and Control of Electric Stress, Surge Voltages, their distribution and control.	3
2	Conduction & breakdown in gases: Gases as insulation media, ionization processes, Townsend's current growth equation, current growth in presence of secondary processes, Townsend's criterion for breakdown in electronegative gases, time lags for breakdown, Streamers theory, Panchen's law, breakdown in non-uniform fields and corona discharge, corona under positive & negative polarities, glow & arc discharge, considerations in using gases for insulation purpose	7

3	<p>Breakdown in Dielectric Materials:</p> <p>Conduction & breakdown in liquid dielectrics: Pure and commercial liquids, breakdown in pure and commercial liquids, theories of breakdown in liquids. Breakdown in solid dielectrics: Intrinsic, electromechanical& thermal breakdown, chemical, electrochemical deterioration, treeing, tracking, internal discharges, breakdown in composite insulation, properties of solid insulators & other materials used in practice. Insulating materials: In power transformers, rotating machines, circuit breakers, cables, power capacitors & other equipment</p>	7
4	<p>Over voltage due to lightening phenomenon:</p> <p>Natural causes for over voltages – Lightning phenomenon, Overvoltage due to switching surges, system faults and other abnormal conditions, propagation of lightning voltage & current waves on transmission lines, reflection & transmission of traveling wave at junction, system control of over voltage due to switching protection of transmission lines against over voltage. Insulation co-ordination, surge diverters, equipment insulation level & co-ordination of substations</p>	7
5	<p>Generation & Measurement of high voltages & currents:</p> <p>Generation of a) high d.c voltage b) power frequency high alternating voltage c) high frequency a.c. d) impulse voltages Standard impulse waves shapes and it's equation, multistage impulse generator, Marx circuit, generation of switching surges, tripping & control of impulse generators, generation of impulse currents. Measurement of High Direct Current voltages, Abraham Voltmeter Measurement of High Voltages alternating and impulse, Measurement of High Currents-direct, alternating and Impulse, Oscilloscope for impulse voltage and current measurements</p>	7
	<p>Text Books:</p> <ol style="list-style-type: none"> 1. Kamaraju V. & Naidu M. S., 'High Voltage Engineering', Tata-McGraw Hill , 6th Edition 2020 2. C. L. Wadhwa, "High Voltage Engineering", New Age International Pvt. Ltd, 4th Edition, 2020 <p>Reference Books:</p> <ol style="list-style-type: none"> 1. High Voltage Engineering: Fundamentals by E.Kuffel, W.S.Zaengl, J.Kuffel by Elsevier, 2nd Edition, 2000 2. High Voltage Insulation Engineering by Ravindra Arora, Wolfgang Mosch, New Age International (P) Limited, 2022. 3. High Voltage Engineering, Theory and Practice by Mazen Abdel Salam, Hussein Anis, Ahdan El-Morshedy, Roshdy Radwan, Marcel Dekker, 2nd Edition 2000 	

Program Elective-IV		
(A) Electrical Drives		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	Examination Scheme Continuous Assessment : 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objectives: <ol style="list-style-type: none"> 1. Students will be able to understand the dynamics of drive system. 2. Students will be able to use various methods of speed control of AC and DC Drive. 3. Students will have the ability to analyze the drive system 4. Students will be able to select proficiently and the proper drive system for application. 5. Students will be able to have basic knowledge of recent advancement in Electric Drive. 		
Course Outcome: <p>CO1. Analyze the dynamics of Electrical Drives system.</p> <p>CO2. Use various control techniques for controlling the speed of AC and DC motors.</p> <p>CO3. Analyze the AC and DC drives.</p> <p>CO4. To Select/recommend the appropriate Drive according to the particular applications.</p> <p>CO5. State the recent technology of AC and DC drive</p>		
Unit	Contents	Hrs.
1	INTRODUCTION Advantages of Electrical Drives, Parts of Electrical drive, Choice of Electric drives Dynamics of Electrical drives: fundamental torque equations, Multiquadrant operation, nature and classification of load torques, steady state stability, concept of load equalization in drives	7
2	CONTROL OF ELECTRICAL DRIVES Modes of operation: Steady state, Acceleration, Deceleration, Drive classification. Closed loop control of drives : Current limit control, torque control, speed control, position control, Control of multi motor drives, speed sensing, current sensing, Classes of motor duty & criteria for selection of motor	6
3	DC MOTOR DRIVES Review of basic characteristics of DC motors, Single phase drives: Single phase half wave converter drives, semi converter drives, Full converter drives, Dual converter drives. Three phase drives : Three phase half wave drives, semi-converter drives, full converter drives, dual converter drives DC-DC converter drives: Principle of Rheostatic and regenerative braking control, combined control, two and four quadrant DC-DC converter fed drives. Introduction to closed loop control of DC drives.	6

4	<p>INDUCTION MOTOR DRIVES</p> <p>Review of starting, braking and speed control of three phase induction motors, Stator voltage control, Rotor voltage control, frequency control, Voltage and frequency control, Current control, Closed loop control of Induction motors, Principle of Scalar and Vector control of Induction motor, Mult quadrant operation of induction motor drives fed from Voltage Source Inverters. Static rotor resistance control method, static slip power recovery control-Static Scherbius drive and Static Kramer drive.</p>	6
5	<p>SYNCHRONOUS MOTOR DRIVES</p> <p>Review of starting, pull in and braking of Synchronous motor, Static variable frequency control for Synchronous motors, Load commutated inverter fed Synchronous motor drive, Introduction to closed loop control of Load commutated inverter fed Synchronous motor drive.</p>	6
	<p>Reference Books:</p> <ol style="list-style-type: none"> 1. Dubey G. K., “Fundamentals of Electrical Drives”, Narosa Publishing house, 2nd Edition, 2001 2. De N. K., Sen P. K., “Electric Drives”, Prentice Hall of India, 1999 3. Vedam Subramanyam, “Electrical Drives and Control”, TMH Publications, 2nd Edition, 2011 	

Program Elective-IV		
(B) Special Purpose Electrical Machines		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: <ol style="list-style-type: none"> 1. To learn the unique internal designs of reluctance, stepper, and permanent magnet motors. 2. To understand how these motors generate torque using magnetism and electronic switching. 3. To derive EMF and torque equations and study speed-torque characteristics. 4. To learn how power electronic converters and drive circuits are used to run these motors. 5. To understand how microprocessors and computers are used for high-precision motor control. 		
Course Outcome: After completion of this course, students will be able to: <ol style="list-style-type: none"> CO1. Explain the constructional features, operating principles, and performance characteristics of Synchronous Reluctance and Vernier motors using phasor diagrams. CO2. Analyze the theory of torque prediction, perform linear and non-linear analysis, and evaluate the drive circuits for variable reluctance and hybrid stepping motors. CO3. Evaluate the torque prediction, power controllers, and modern microprocessor-based control strategies of Switched Reluctance Motors. CO4. Formulate the EMF and torque equations, and analyze the magnetic circuits, power controllers, and motor characteristics of Permanent Magnet Brushless D.C. Motors. CO5. Analyze the phasor diagrams, volt-ampere requirements, torque-speed characteristics, and microprocessor-based control schemes of Permanent Magnet Synchronous Motors. 		
Unit	Contents	Hrs.
1	SYNCHRONOUS RELUCTANCE MOTORS: Constructional features, Types – Axial and radial air gap motors – Operating principle – Reluctance – Phasor diagram - Characteristics – Vernier motor.	7
2	STEPPING MOTORS: Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor – Single and multi-stack configurations – Theory of torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits.	6
3	SWITCHED RELUCTANCE MOTORS: Constructional features – Principle of operation – Torque prediction – Power controllers – Nonlinear analysis – Microprocessor based control - Characteristics – Computer control.	6

4	<p>PERMANENT MAGNET BRUSHLESS D.C. MOTORS: Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations – Power controllers – Motor characteristics and control</p>	6
5	<p>PERMANENT MAGNET SYNCHRONOUS MOTORS: Principle of operation – EMF and torque equations – Reactance – Phasor diagram – Power controllers - Converter - Volt-ampere requirements – Torque speed characteristics - Microprocessor based control.</p>	6
<p>Text Books</p> <ol style="list-style-type: none"> 1. K. Venkataratnam, Special Electrical Machines, Universities Press (India) Private Limited, 2008. 2. T. Kenjo, Stepping Motors and Their Microprocessor Controls, Clarendon Press London, 1984 3. E.G. Janardanan, Special electrical machines, PHI learning Private Limited, Delhi, 2014. <p>Reference Books</p> <ol style="list-style-type: none"> 01. R.Krishnan, Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application, CRC Press, New York, 2001. 02. T. Kenjo and S. Nagamori, Permanent Magnet and Brushless DC Motors, Clarendon Press, London, 1988. 03. T.J.E.Miller, Brushless Permanent-Magnet and Reluctance Motor Drives, Oxford University Press, 1989. 04. R.Srinivasan, Special Electrical Machines, Lakshmi Publications, 2013. 		

Program Elective-IV		
(C) Lighting Design and Fundamentals		
Teaching Scheme Practical: 3 Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective:		
<ol style="list-style-type: none"> 1. To provide a fundamental understanding of light, vision, and the units of measurement for Lighting Design. 2. To familiarize students with the construction, working, and characteristics of various modern light sources. 3. To teach the design principles for interior and exterior lighting systems (Street, Flood, and Industrial lighting). 4. To introduce the concept of energy-efficient lighting and modern control systems (Dimmers, Ballasts, and Sensors). 5. To familiarize students with essential accessories like ballasts, ignitors, and modern smart lighting control systems. 		
Course Outcome:		
After completion of this course, students will be able to:		
CO1: Apply principles of physics and optics to solve complex lighting problems.		
CO2: Design energy-efficient lighting layouts for various environments.		
CO3: Select lighting technologies that reduce carbon footprint and energy consumption.		
CO4: Keep pace with rapid advancements in LED and smart lighting technologies.		
CO5: Analyze polar curves and photometric data to determine the light distribution of various luminaires.		
1	Fundamentals of Light and Vision : Nature of Light: Radiation, wavelength, and frequency, Photometric Quantities: Luminous flux, Luminous intensity, Illumination (Lux), Luminance (Brightness), and their units, Inverse Square Law and Lambert's Cosine Law, Human Vision: Structure of the eye, photopic and scotopic vision, color response, and visual acuity, Glare: Types of glare and its effects on human performance.	8
2	Light Sources and Accessories: Incandescent Lamps: Filament materials, gas-filled lamps, and halogen lamps, Discharge Lamps: Low and high-pressure sodium vapor lamps, Mercury vapor lamps, and Metal halide lamps, Fluorescent Lamps: Working, starters, and ballast (Choke) types, Modern Sources: LED (Light Emitting Diodes) construction, driver circuits, and OLEDs, Comparison of efficacy, life, and color rendering index (CRI) of various lamps.	7
3	Illumination Control and Photometry: Photometry: Measurement of light, Photometers (Lummer-Brodhun, Integrating sphere), Polar Curves: Type A, B, and C curves; calculation of mean spherical candle power (MSCP), Control Devices: Magnetic and Electronic ballasts, Ignitors, Dimmers (TRIAC based), Automatic Control:	7

	Day-light sensors, occupancy sensors, and DALI (Digital Addressable Lighting Interface).	
4	Interior Lighting Design: Lighting Schemes: Direct, indirect, and semi-direct lighting, Design Calculations: Lumen method (Utilization Factor, Maintenance Factor, Space-to-Height ratio), Applications: Design requirements for residential, office, industrial, and hospital lighting, Point-by-point method for illumination calculation.	6
5	Exterior and Special Lighting: Street Lighting: Principles, beam distribution, and layout design, Flood Lighting: Projector types, waste light factor, and calculation of floodlights required, Special Applications: Stage/Studio lighting, sports stadium lighting, and aviation/transport lighting, Energy Audit of Lighting Systems: Energy Conservation Building Code (ECBC) norms.	6
	Text Books: 1. H. S. Mamak , " <i>Advertising and Illumination</i> ", KHANNA Publishers. 2004 2. J. B. Gupta , " <i>Utilization of Electric Power & Electric Traction</i> ", S. K. Kataria & Sons. 10th Edition, 2012 3. C. L. Wadhwa , " <i>Generation, Distribution and Utilization of Electrical Energy</i> ", New Age International. 3rd Edition, 2015 Reference Books: 1. N. V. Suryanarayana, " <i>Utilization of Electric Power</i> ", Wiley Eastern. 1st Edition, 2005 2. Jack L. Lindsey, " <i>Applied Illumination Engineering</i> ", The Fairmont Press. 3rd Edition, 2015 3. IES Lighting Handbook, Illuminating Engineering Society of North America (Standard Reference). 10th Edition, 2011	

Power System Operation & Control Lab		
Teaching Scheme Practical: 02 Hr / Week Credit:01		Examination Scheme Continuous Assessment: 60Marks End Sem Exam: 40 Marks
Unit	Contents	Hrs.
1	To study the necessity of reactive power control in power systems and its effect on voltage profile.	2
2	To analyze the production and absorption of reactive power in generators, transmission lines, and loads.	2
3	To study voltage control using shunt capacitors in a power system.	2
4	To study the working and performance of synchronous condenser for reactive power compensation.	2
5	To study Static VAR Systems (SVC / STATCOM) and analyze their role in reactive power control and voltage stability.	
6	To study different types of power system stability such as steady-state, transient, and dynamic stability.	2
7	To derive and study the swing equation of a synchronous machine.	2
8	To analyze transient stability of a power system using the Equal Area Criterion.	2
9	To study excitation system requirements, components, and types of excitation systems.	2
10	To study two-area Load Frequency Control and analyze tie-line power flow.	2

High Voltage Engineering Lab		
Teaching Scheme Practical: 02 Hr / Week Credit:01		Examination Scheme Continuous Assessment:60Marks End Sem Exam: 40 Marks
Unit	Contents	Hrs.
1	To understand the use and importance of a Faraday Cage in high voltage laboratories.	2
2	To study the standard layout and safety arrangements of a high voltage laboratory.	2
3	To perform a one-minute DC high voltage withstand test on electrical equipment up to 10 kV.	2
4	To study how the breakdown voltage of liquid insulation changes with electrode gap length.	2
5	To find the breakdown strength of composite dielectric insulating material.	2
6	To study the construction and working of an impulse voltage generator.	2
7	To conduct a DC high voltage test on cables, safety gloves, and safety shoes as per IS standards up to 2.25 kV.	2
8	To study the working of a horn gap arrangement used for surge protection.	2
9	To measure the corona inception and extinction voltages using audible and visual methods.	2
10	To study the formation of tracking and treeing on polymeric insulating materials.	2
11	To study the effect of extra high voltage electric fields on humans, animals, and plants.	2

Energy audit And Conservation		
Teaching Scheme Practical: 03 Hr / Week Credit:03	Examination Scheme Continuous Assessment:20Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: <ol style="list-style-type: none"> 1. To learn about global warming and the role of renewable energy. 2. To understand the Energy Conservation Act and how to conduct an audit. 3. To study energy saving in boilers, ACs, and cooling towers. 4. To learn how to save power in motors, lighting, and power factor control. 5. To learn how to calculate if an energy project is profitable. 		
Course Outcome: After completion of this course, students will be able to: CO1: Explain how carbon emissions and protocols affect the planet. CO2: To perform step-by-step energy audits for industries. CO3: Calculate boiler efficiency and identify waste heat recovery. CO4: Reduce electricity costs using APFC panels and load management. CO5: Calculate ROI and Payback Periods for new projects.		
Unit	Contents	Hrs.
1	SOURCES OF ENERGY: Energy resources, Stored & running resources, Environmental Concerns – Global Warning, Depletion of Ozone layer, Kyoto Protocol, UNFCCC, CDM, Carbon Emissions, Role of Renewable Energy Sources	6
2	ENERGY CONSERVATION ACT, POLICY FRAMEWORK: Energy Conservation Act 2001, Designated Consumers, Energy Policy, BEE and its role in Energy Conservation, Energy Audit – Need, Types, Methodology, Steps involved in Energy Audit, Energy Costs and Benchmarking, Measurements for Energy Audit, Energy Management Duties and Responsibilities.	6
3	THERMAL MECHANICAL SYSTEMS: Boiler Efficiency by direct and indirect methods, Energy efficiency opportunities in boilers, HVAC, and refrigeration systems, compressed air systems, pumps, cooling towers, fans and blowers, Cogeneration – Need and Principle, Prime movers for cogeneration, Waste heat recovery systems – Recuperators, economizer heat recovery boilers.	7
4	ELECTRICAL SYSTEMS: Utilities: Energy conservation in generation, transmission, distribution & utilization, Electrical billing, load management, maximum demand control, APFC Panel, PF improvement and benefits, Energy Efficient motors and starter, lightning systems, Electronic Ballast	6

5	<p>INVESTMENT APPRAISAL AND ECONOMIC ANALYSIS: Planning, Implementation & monitoring of energy conservation project, Time Value of money, Financial Investment – Simple payback period, ROI (Return on Investment), Net Present value, Internal rate of return, profitability index. All calculations and numerical interpretation.</p>	7
	<p>Text Books:</p> <ol style="list-style-type: none"> 1. “Industrial Energy Conservation” Charles M Gottschalk ,John Willey and Sons 2. “Energy Management” Paul O Callaghan, Tata Mc Grawhill 3. “Energy Technology” – S Rao and B Parulekar , Khanna Publisher, 3rd Edition, 2015 4. “Energy Management Handbook” – Wayne C Turner, 8th Edition, 2013 5. B. L. Singhal & Amit L. Nehete, "<i>Energy Audit and Management</i>", Techknowledge Publications, Nehete, 1st Edition,2025 <p>Reference Books:</p> <ol style="list-style-type: none"> 1. L. Ashok Kumar & Gokul Ganesan, "Energy Audit and Management: Concepts, Methodologies, and Case Studies", CRC Press. 1st Edition,2024 2. C. B. Smith, "Energy Management Principles", Pergamon Press. 3. Albert Thumann & Terry Niehus, "Handbook of Energy Audits", Fairmont Press.2020 	

Semester VIII		
EHVAC And HVDC		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objectives: <ol style="list-style-type: none"> To provide a comprehensive comparison between EHVAC and HVDC systems, highlighting their necessity and economic viability for long-distance power transfer. To study the behavior of line parameters at extra high voltages, specifically focusing on surface voltage gradients and bundled conductors. To analyze the corona effects, including power loss, radio interference (RI), and audible noise (AN) in EHV systems. To explain the operation and control strategies of Graetz bridge converters (rectifier and inverter modes) and their power reversal characteristics. To introduce the concepts of harmonics in HVDC systems and the role of FACTS devices in improving AC/DC system stability. 		
Course Outcome: After completion of this course, students will be able to: <p>CO1. Apply mathematical models to calculate EHV line parameters and converter characteristics.</p> <p>CO2. Analyze the impacts of corona and harmonics on power system performance and environment.</p> <p>CO3. Design basic compensation schemes and harmonic filters for AC and DC systems.</p> <p>CO4. Understand the integration of power electronic controllers (FACTS/HVDC) in modern grids.</p> <p>CO5. Evaluate the efficiency of high voltage transmission in reducing global carbon emissions and energy losses.</p>		
Unit	Contents	Hrs.
1	Introduction and Line Parameters: Necessity of EHVAC and HVDC transmission; Advantages and problems, Standard transmission voltages in India and the world, Line parameters: Resistance and Inductance of bundled conductors, Properties of bundled conductors (spacing, radius, and configurations), Calculation of surface voltage gradient on conductors.	8
2	Corona and Electrostatic Fields: Corona: Basic phenomena, corona loss formulae, and charge-voltage (q-V) diagrams. Factors affecting corona: Audible noise (AN) and Radio interference (RI) — measurement and computation. Electrostatic field of EHV lines: Effect on humans, animals, and plants. Insulation coordination and shielding of transmission lines.	6
3	Reactive Power Control and Compensation: Reactive power planning and control in EHVAC systems, Voltage profile of loaded and unloaded extra-long lines, Compensation: Principles of series and shunt compensation, Sub-synchronous resonance (SSR) in series capacitor compensated lines, Introduction to FACTS controllers (SVC, STATCOM, TCSC).	7
4	HVDC Systems and Converters: Types of HVDC links (Monopolar, Bipolar, Homopolar) and their components, Analysis of Graetz Bridge: 6-pulse and 12-pulse converter configurations, Converter characteristics: Rectifier and Inverter operation, voltage and current	6

	equations, Equivalent circuit representation and power reversal in DC links.	
5	<p>HVDC Control, Harmonics, and Protection: HVDC Control: Constant Current (CC), Constant Ignition Angle (CIA), and Constant Extinction Angle (CEA) control, Harmonics in HVDC: Characteristic and uncharacteristic harmonics; Design of AC and DC filters. Converter faults: Commutation failure and bypass action. DC Circuit Breakers and overvoltage protection in converter stations.</p>	6
	<p>Text Books:</p> <ol style="list-style-type: none"> 1. R. D. Begamudre, "Extra High Voltage AC Transmission Engineering", New Age International. (Standard for EHVAC). 2nd Edition, 2011 2. K. R. Padiyar, "HVDC Power Transmission Systems: Technology and System Interactions", New Age International. (The primary text for HVDC), 2nd Edition, 2011. 3. S. Rao, "EHV-AC, HVDC Transmission & Distribution Engineering", Khanna Publishers, 2013. <p>Reference Books:</p> <ol style="list-style-type: none"> 1. J. Arrillaga, "High Voltage Direct Current Transmission", IEE Power Engineering Series, 2nd Edition, 1998. 2. E. W. Kimbark, "Direct Current Transmission", Wiley Interscience., 1st Edition, 1971 3. V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill, 4th Edition, 2019 	

Advance Power System Protection		
Teaching Scheme Lectures Theory: 03Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: 1. To understand the transition from analog to digital and numerical protection algorithms. 2. To learn advanced protection schemes for large Generators, Transformers, and Busbars. 3. To study the theory of distance relaying and how to compensate for errors in long transmission lines. 4. To learn mathematical techniques like Fourier Transforms used for fault detection in digital relays. 5. To introduce modern concepts like PMUs (Phasor Measurement Units) and SCADA integration.		
Course Outcome: After completion of this course, students will be able to: CO1. Apply digital signal processing knowledge to analyze fault signals in power systems. CO2. Design coordination schemes for complex radial and mesh networks. CO3. Evaluate the performance of relays under dynamic conditions like power swings or frequency changes. CO4. Use modern simulation tools (like MATLAB/ETAP) to test protective relay logic. CO5. Understand the impact of communication protocols (IEC 61850) on substation reliability.		
Unit	Contents	Hrs.
1	Numerical Protection Fundamentals: Introduction to Numerical Relays: Block diagram and Advantages over conventional relays. Sampling Theorem: Anti-aliasing filters, Sample and Hold circuits. Analog to Digital Conversion (ADC) techniques. Introduction to Digital Filtering and Windows.	6
2.	Digital Relaying Algorithms: Mathematical basis for Protective Relaying. Fault Sensing Algorithms: Discrete Fourier Transform (DFT), Least Square Fit, and Walsh Function. Differential equation-based algorithms for line protection. Algorithm for R-X locus calculation during faults.	6
3	Advanced Apparatus Protection: Generator Protection: Modern schemes for 100% Stator earth fault, inter-turn faults, and out-of-step protection. Transformer Protection: Digital differential protection, Harmonic restraint, and Inrush current detection techniques. Busbar Protection: High-speed biased differential protection and breaker failure schemes.	8
	Advanced Line Protection: Distance Relaying: Mho, Offset-Mho, and Quadrilateral characteristics.	

4	Effects of Arc Resistance, Power Swings, and Load Encroachment on distance relays. Carrier-aided protection: Directional comparison and Phase comparison schemes. Auto-reclosing: Single-phase and three-phase auto-reclosing logic.	6
5	<p>Modern Trends in Protection:</p> <p>Wide Area Measurement Systems (WAMS): Role of Phasor Measurement Units (PMUs). Adaptive Relaying: Concepts and applications in changing grid topologies. Protection of Microgrids and Renewable Energy Sources (Solar/Wind). IEC 61850 Standard: Introduction to Substation Automation and GOOSE messaging.</p>	6
	<p>Textbooks:</p> <ol style="list-style-type: none"> 1. Y. G. Paithankar & S. R. Bhide, "Fundamentals of Power System Protection", PHI Learning. (Best for conceptual clarity), 2nd Edition, 2010. 2. Badri Ram & D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill, 2nd Edition, 2011 3. T.S. Madhava Rao, "Digital Power System Protection", Tata McGraw Hill, 2nd Edition, 1998. <p>Reference:</p> <ol style="list-style-type: none"> 1. A. G. Phadke & J. S. Thorp, "Computer Relaying for Power Systems", John Wiley & Sons. (Advanced/Research level), 2nd Edition, 2009. 2. B. Ram, "Power System Protection and Switchgear", Khanna Publishers, 2nd Edition, 2011. 3. P.M. Anderson, "Power System Protection", IEEE Press. 1999 	

Program Elective-V		
(A)Digital Signal Processing		
Teaching Scheme Lectures Theory: 02Hr / Week Credit:02	Examination Scheme Continuous Assessment: 20 MarksMid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: <ol style="list-style-type: none"> 1. To understand the basic elements of DSP systems and differentiate between continuous-time, discrete-time, and digital signals. 2. To learn the physics of Analog-to-Digital conversion, specifically the Sampling Theorem and Quantization errors. 3. To study how Linear Time-Invariant (LTI) systems respond to signals using techniques like Convolution Sum and Difference Equations. 4. To apply the Z-Transform for analyzing system stability and solving linear constant-coefficient difference equations. 5. To understand the Discrete Fourier Transform (DFT) and its properties for sampling and reconstructing signals in the frequency domain. 		
Course Outcome: After completion of this course, students will be able to: CO1. Represent signals, systems and digital processing of analog signals. CO2. Represent discrete time signals, systems and analysis of Discrete-Time Linear Time Invariant Systems. CO3. Apply digital signal processing techniques to analyze discrete time signals in time domain. CO4. Apply digital signal processing techniques to analyze discrete time signals in frequency domain. CO5. Design different filter structure and Validate system functionality and evaluate results.		
Unit	Contents	Hrs.
1	Introduction to Digital Signal Processing: Overview: Basic elements of DSP systems; advantages of digital over analog processing. Signal Classification: Multichannel/multidimensional, continuous vs. discrete, deterministic vs. random signals. Frequency Concepts: Continuous-time vs. discrete-time sinusoidal signals and complex exponentials. A/D and D/A Conversion: The Sampling Theorem; quantization of continuous-amplitude signals; coding of quantized samples.	4
2	Discrete-Time Signals and Systems: Signals: Elementary signals, classification, and basic signal manipulations. Systems: Input-output descriptions, block diagram representations, and interconnection of systems. LTI Systems Analysis: Impulse response and the convolution sum; properties of convolution; stability and causality. Difference Equations: Recursive and non-recursive systems; solving linear constant-coefficient difference equations.	4

3	<p>Z-Transform and System Analysis: Z-Transform: Definition, region of convergence (ROC), and properties. System Functions: Poles and zeros; pole location and time-domain behavior. Inverse Z-Transform: Techniques including partial-fraction expansion, power series, and contour integration. Applications: Decomposition of rational z-transforms; one-sided z-transforms and solving difference equations.</p>	5
4	<p>Frequency Analysis of Signals: Discrete-Time Fourier Transform (DTFT): Analysis of discrete-time signals. Properties: Symmetry properties, Fourier transform theorems, and frequency-domain characteristics.</p>	5
5	<p>Discrete Fourier Transform (DFT): Fundamentals: Frequency-domain sampling and signal reconstruction. DFT Properties: Linearity, symmetry, and periodicity. Convolution: Multiplication of DFTs and circular convolution. Applications: Relationship between DFT and other transforms; practical utility in frequency analysis.</p>	5
	<p>Reference Books: 1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing". 4th Edition, 2006 2. Shalivahanan, Vallavaraj and Gnanapriya, "Digital Signal Processing" 2nd Edition, 2018</p> <p>Text Books: 1. N.G.Palan, "Digital Signal Processing" 2008 2. Ramesh Babu, "Digital Signal Processing" 2014 3. Alon V. Oppenheim, "Digital Signal Processing", PHI Pub. 2nd Edition, 2013 Reprint 4. S.K.Mitra, "Digital Signal Processing", TMH Pub. 4th Edition, 2011.</p>	

Program Elective-V		
(B) Advanced Control Systems		
Teaching Scheme Lectures Theory: 02Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: 1. To introduce advanced control system design techniques beyond classical methods. 2. To develop understanding of nonlinear systems and their analysis. 3. To study discrete-time (digital) control systems. 4. To apply state-space methods for controller and observer design. 5. To introduce modern control concepts such as optimal and robust control.		
Course Outcome: After completion of this course, students will be able to: CO1. Analyze nonlinear control systems using phase plane and describing function methods. CO2. Design controllers using state-space techniques (pole placement, observers). CO3. Analyze and design discrete-time control systems using Z-transform. CO4. Apply optimal control techniques to engineering systems. CO5. Understand robustness and advanced stability concepts.		
Unit	Contents	Hrs.
1	Nonlinear Control Systems: Introduction to nonlinear systems, Types of nonlinearities (dead zone, saturation, backlash), Phase plane analysis, Construction of phase trajectories, Stability of nonlinear systems, Limit cycles, Describing function analysis	5
2	State Space Design: Review of state-space representation, State transition matrix (brief revision), Controllability and Observability (Kalman test), Pole placement technique, State feedback controller design, Observer design (Luenberger observer), Separation principle	6
3	Discrete-Time Control Systems: Introduction to digital control systems, Sampling and data reconstruction, Z-transform and inverse Z-transform, Pulse transfer function, Stability analysis in Z-domain, Jury stability criterion, Design using digital controllers.	6
4	Optimal Control: Introduction to optimal control problem, Performance index, Calculus of variations (basic idea), Linear Quadratic Regulator (LQR), Riccati equation, Introduction to optimal state feedback control	6
5	Robust and Advanced Control: Concept of robustness, Sensitivity and complementary sensitivity, Gain margin and phase margin (review), Robust stability, Introduction to H-infinity control (basic idea), Introduction to adaptive control (concept only)	6
Reference Books: 1. Gopal M., "Control System", Prentice Hall of India. 4th Edition, 2012		

	<ol style="list-style-type: none"> 2. Kuo B. C., “Automatic Control System”, Prentice Hall of India. 9th Edition, 2014 3. Nagarath I. J. and Gopal M., “Control System Engineering”, Willey Eastern. 5th Edition, 2007 4. Modern Control Systems by Richard C. Dorf and Robert H. Bishop (Pearson) 13th Edition, 2016 5. Control Systems Engineering by Norman S. Nise (Wiley), 8th Edition, 2019 6. Automatic Control Systems by Benjamin C. Kuo and Farid Golnaraghi (Wiley), 9th Edition, 2014. 7. Feedback Control of Dynamic Systems by Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini (Pearson), 8th Edition, 2019 <p>Text Books:</p> <ol style="list-style-type: none"> 1. Ogata K., “Modem Control Engineering”, Prentice Hall of India. 5th Edition, 2010 2. Norman S. Nice, “Control System Engineering”, Wiley. 8th Edition, 2019 3. Smarajit Ghosh, “Control Systems Theory & Applications”, Pearson. 2012 	
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Program Elective-V		
(C) Advanced Power Electronics		
Teaching Scheme Lectures Theory: 02 Hr / Week Credit:03	Examination Scheme Continuous Assessment: 20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective:		
<ol style="list-style-type: none"> 1. To introduce advanced power semiconductor devices including wide band gap (SiC, GaN) technologies and intelligent power modules. 2. To introduce advanced power semiconductor devices including wide band gap (SiC, GaN) technologies and intelligent power modules. 3. To study multilevel inverter topologies, advanced PWM techniques, and their applications in high-power systems. 4. To study multilevel inverter topologies, advanced PWM techniques, and their applications in high-power systems. 5. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems. 		
Course Outcome:		
After completion of this course, students will be able to:		
CO1. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems.		
CO2. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems.		
CO3. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems.		
CO4. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems.		
CO5. To introduce modeling, simulation, and digital control techniques for advanced power electronic systems.		
Unit	Contents	Hrs.
1	Advanced Power Semiconductor Devices & Switching: Review of MOSFETs, IGBTs (brief) , Wide band gap devices: SiC and GaN devices, Switching characteristics and losses, Hard switching vs soft switching, Snubber circuits (advanced design), Gate driver design for high-frequency operation, Thermal management and heat sinks	7
2	High-Frequency DC-DC Converters: Limitations of conventional converters, Isolated DC-DC converters: Flyback converter, Forward converter, Push-pull converter, Half-bridge and Full-bridge converters, Design considerations (transformer, switching frequency), Continuous and discontinuous conduction modes, Applications in SMPS	7
3	Resonant Converters & Soft Switching: Need for soft switching, Resonant converters: Series resonant converter, Parallel resonant converter, LLC resonant converter, Zero Voltage Switching (ZVS), Zero Current Switching (ZCS), Quasi-resonant converters, Performance comparison with hard-switched converters	7

4	<p>Multilevel Inverters & Advanced PWM Techniques: Introduction to multilevel inverters, Types: Diode clamped (NPC), Flying capacitor, Cascaded H-bridge, Advantages and applications Advanced PWM techniques: Space Vector PWM (SVPWM), Selective Harmonic Elimination (SHE), Harmonic analysis and reduction</p>	7
5	<p>Applications & Digital Control of Power Electronics: Power electronics in renewable energy: Solar PV systems (MPPT techniques), Wind energy systems, Grid-connected converters, Electric vehicle (EV) power converters, Introduction to digital control: DSP and microcontroller-based control, PWM generation using digital controllers, Basics of real-time control implementation</p>	7
	<p>Reference Books:</p> <ol style="list-style-type: none"> 1. "Power Electronics" - B.K. Bose, Academic Press (for advanced devices and applications) 1st Edition, 2009 2. "Modern Power Electronics and AC Drives" - B.K. Bose, Pearson (for motor drives integration) 1st Edition, 2002 3. "Flexible AC Transmission Systems (FACTS)" - N.G. Hingorani, L. Gyugyi, Wiley (for power quality and transmission applications) 1st Edition, 2000 4. "Power Electronic Systems: Theory and Design" - Jai P. Agrawal, Pearson, 1st Edition, 2001 5. "High-Power Converters and AC Drives" - Bin Wu, Wiley (for multilevel converters and high-power applications), 2nd Edition, 2017 	

Program Elective-V		
(D) Power Quality Improvements		
Teaching Scheme Lectures Theory: 02Hr /Week Credit:03	Examination Scheme Continuous Assessment :20 Marks Mid-Sem Exam: 20 Marks End Sem Exam: 60 Marks	
Course Objective: 1. To understand various power quality issues and their causes in electrical systems. 2. To analyze voltage and current disturbances such as harmonics, sag, swell, and transients. 3. To study measurement and monitoring techniques of power quality. 4. To explore mitigation techniques using passive and active filters. 5. To introduce custom power devices and modern solutions for power quality improvement.		
Course Outcome: After completion of this course, students will be able to: CO1. Identify and classify different power quality disturbances. CO2. Analyze harmonics and their impact on power systems. CO3. Evaluate power quality using standard indices and measurement techniques. CO4. Design mitigation techniques using filters and compensators. CO5. Apply custom power devices for improving power quality in practical systems.		
Unit	Contents	Hrs.
1	Introduction to Power Quality: Definition and importance of power quality, IEEE standards on power quality (IEEE 519 overview), Types of disturbances: Voltage sag, swell, interruption, Transients (impulsive and oscillatory), Flicker, noise Causes of power quality problems (industrial loads, power electronics, faults), Impact on equipment and system performance	6
2	Harmonics Analysis: Concept of harmonics and waveform distortion, Fourier analysis of non-sinusoidal waveforms, Harmonic sources (nonlinear loads, converters), Harmonic indices: THD, distortion factor, Effects of harmonics on equipment (transformers, motors, capacitors), Harmonic standards and limits	5
3	Measurement and Monitoring of Power Quality: Power quality monitoring instruments, Measurement of voltage, current, harmonics, and flicker, Data acquisition systems, Power quality indices, Smart meters and real-time monitoring, Introduction to signal processing techniques for PQ analysis	5
4	Power Quality Improvement Techniques: Passive filters: single-tuned, high-pass filters, Active power filters (APF): Shunt APF, Series APF, Hybrid filters, Principle of operation and control strategies, Reactive power compensation Power factor improvement techniques	6

5	<p>Custom Power Devices and Advanced Solutions:</p> <p>Introduction to custom power devices, Distribution STATCOM (D-STATCOM), Dynamic Voltage Restorer (DVR), Unified Power Quality Conditioner (UPQC), Application in distribution systems, Role of power electronics in smart grids, Case studies of industrial power quality improvement</p>	6
	<p>References:</p> <ol style="list-style-type: none"> 1. Power Quality C. Sankaran CRC Press, 1st Edition, 2001 2. Electrical Power Systems Quality Roger C. Dugan, Mark F. McGranaghan, Surya Santoso, H. Wayne Beaty McGraw-Hill, 3rd Edition, 2012 3. Power Quality: Problems and Mitigation Techniques Bhim Singh, Ambrish Chandra, Kamal Al-Haddad Wiley, 1st Edition, 2014 4. Power System Harmonics J. Arrillaga, N.R. Watson Wiley, 2nd Edition, 2003 5. Understanding Power Quality Problems: Voltage Sags and Interruptions Math H. J. Bollen Wiley–IEEE Press, 1st Edition, 2000 	

Department of Electrical Engineering

Credit Framework under Four-Years UG Engineering

Programme with Multiple Entry and Multiple Exit options:

- The Four-year Bachelor’s Multidisciplinary Engineering Degree Programme allows the students to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per their choices and the feasibility of exploring learning from different institutions.
- The minimum and maximum credit structure for different levels under the Four-year Bachelor’s Multidisciplinary Engineering UG Programme with multiple entry and multiple exit options are as given below:

Credit Framework

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
4.5	One Year UG Certificate in Engg./ Tech.	40	44	2	1
5.0	Two Years UG Diploma in Engg./ Tech.	80	88	4	2
5.5	Three Years Bachelor’s Degree in Vocation (B. Voc.) or B. Sc. (Engg./ Tech.)	120	132	6	3
	4-Years Bachelor’s degree				

- There are multiple exit options at each level. Student will be given a specific Qualification mentioned in the table depending on the level at which he/she decide to have an exit. Ex. If a student decides to exit after completion of two years (level 5.0) of the program, he will be given a Diploma in Engineering with specific exit condition mentioned in the syllabus of the specific branch. He/she can rejoin the program with the multiple entry option at the level next where he/she chose to exit previously. (Student can join at level 5.5 if successfully completed level 5.0 previously at the time of exit).
- Minimum credit requirements of each level are mentioned in the credit framework table.
- There are 4 distinct options available at level 6.0.
- First one is basic level 6.0 option where minimum 160-maximum 176 credits are mandatory which can be completed as per the Semester-wise Credit distribution structure mentioned in the table given below.

Here, the Bachelor’s Engineering Degree in chosen Engg./ Tech. Discipline with multidisciplinary minor (min.160-max.176 Credits) i.e. **“B. Tech in Electronics and Telecommunication Engineering with Computer Engineering”** (160-176 credits)

enables students to take up five-six or required additional courses of 14 credits in the discipline other than Electronics and Telecommunication Engineering distributed over semesters III to VIII. Here in the case of “**B. Tech in Electronics and Telecommunication Engineering with Computer Engineering**” (160-176 credits) student is supposed to take up 50% or more courses to complete the 50% or more credits (from assigned 14 credits) from **Computer Engineering minor bucket**. The remaining courses to complete the assigned 14 credits can be covered from other discipline’s minor buckets.

- Remaining three level 6.0 options are the advanced options where the student is given an opportunity to get extra qualification by earning some extra credits (18-20 extra credits). These three options are given below:

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	(B.E./ B.Tech. or Equivalent) in Engg./ Tech. with Multidisciplinary Minor	160	176	8	4
6.0	4-Years Bachelor’s degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Honors and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor’s degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Honors with Research and Multidisciplinary Minor	180	194	8	4
6.0	4-Years Bachelor’s degree (B.E./ B.Tech. or Equivalent) in Engg./ Tech.- Major Engg. Discipline with Double Minors (Multidisciplinary and Specialization Minors)	180	194	8	4

- Level 6.0: The **Bachelor’s Engineering Degree with Honours** in chosen Major Engg./ Tech. Discipline i.e. in Electronics and Telecommunication Engineering with Honours with Multidisciplinary Minor (180-194 credits) enables students of Electronics and Telecommunication Engineering to take up five-six additional courses of 18 to 20 credits in the Electronics and Telecommunication Engineering discipline distributed over semesters III to VIII. The decision regarding the mechanism of distribution of these 18-20 credits over semesters III to VIII, which are over and above the min.160-max.176 Credits prescribed for the duration of four years will be taken by Academic Authorities of University. **Student must have CGPA equal to or greater than 7.5 at the end of second semester to go for this option.**
- Level 6.0: The **Bachelor’s Engineering Degree with Research** in i.e. in Electronics and Telecommunication Engineering with Research with Multidisciplinary Minor (180-194 credits) enables students of Electronics and Telecommunication Engineering to take up a research project of 18 to 20 credits in the Electronics and Telecommunication Engineering discipline distributed over semesters VII to VIII. **Student must have CGPA equal to or greater than 7.5 at the end of sixth semester to go for this option.**
- Level 6.0: The **Bachelor’s Engineering Degree in chosen Engg./ Tech. Discipline with Double Minor** (Multidisciplinary and Specialization Minor, 180-194 credits), i.e. “**B. Tech in Electronics and Telecommunication Engineering with *other selected discipline in Engineering (as MDM) with Specialization Minor in Computer Engineering***” (180-194 credits) enables students to take up five-six additional courses of 14 credits in the discipline other than Electronics and Telecommunication Engineering(for completion of multidisciplinary minor) and 18 to 20 extra credits in the **Computer Engineering discipline** distributed over semesters III to VIII. Here, the ***other selected discipline in Engineering should be different from Specialization Minor i.e. Computer Engineering***. This enables students to take up five-six or required additional courses of 18 to 20 credits in the **Computer Engineering** discipline distributed over semesters III to VIII, which are over and above the min.160-max.176 Credits. The decision regarding the mechanism of distribution of these 18-20 credits over semesters III to VIII, prescribed for the duration of four years will be taken by Academic Authorities of University. **Student must have CGPA equal to or greater than 7.5 at the end of second semester to go for this option.**
- Students need to follow the Semester-wise Credit distribution structure for Four Year UG Engineering Program as prescribed in the table given above.
- There are seven vertical categories with specific credits distributed in specific semesters.
- Student can choose a Program Elective Course (PEC) in that specific semester from the given subjects.
- Multidisciplinary courses (MDM) and Open Elective (OE) courses can be chosen from the MDM and OE Buckets depending on students choice. Completion of total credits given in the last column of the table for each vertical is mandatory.
- Students can complete 40% of the courses through online platforms like NPTEL/SWAYAM. The NPTEL SWAYAM course content should be at least 80% similar to the course content in the syllabus

Semester-wise Credit distribution structure for Four Year UG Engineering

Program - One Major, One Minor

Semester		I	II	III	IV	V	VI	VII	VIII	Total Credits
Basic Science Course	BSC/ESC	06-08	08-10		--	--	--	--	--	14-18
Engineering Science Course		10-08	06-04		--	--	--	--	--	16-12
Programme Core Course (PCC)	Program Courses	--	02	08-10	08-10	10-12	08-10	04-06	04-06	44-56
Programme Elective Course (PEC)		--	--	--	--	04	08	02	06	20
Multidisciplinary Minor (MD M)	Multidisciplinary Courses		-	02	02	04	02	02	02	14
Open Elective (OE) Other than a particular program		--	--	04	02	02	--	--	--	08
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	02	02	--	02	--	02	--	--	08
Ability Enhancement Course (AEC -01, AEC-02)	Humanities Social Science and Management (HSSM)	02	--	--	02	--	--	--	--	04
Entrepreneurship/Economics/Management Courses		--		02	02	--	--	--	--	04
Indian Knowledge System (IKS)			02		--	--	--	--	--	02
Value Education Course (VEC)		--	--	02	02	--	--	--	--	04
Research Methodology	Experiential Learning Courses	--	--	--	--	--	--		04	04
Comm. Engg. Project (CEP)/Field Project (FP)		--	--	02	--	--	--	-	-	02
Project		--	--	--	--	--	--		04	04
Internship/ OJT		--	---			--	--	12	-	12
Co-curricular Courses (CC)	Liberal Learning Courses	02	02		--	--	--	--	-	04
Total Credits (Major)		20-22	20-22	20-22	20-22	20-22	20-22	20-22	20-22	160-176

General Rules and Regulations

1. The normal duration of the course leading to B.Tech degree will be EIGHT semesters.
2. The normal duration of the course leading to M.Tech. degree will be FOUR semesters.
3. Each academic year shall be divided into 2 semesters, each of 20 weeks duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least 90 Teaching Days, with at least 40 hours of teaching contact periods in a five to six days session per week. The semester that is typically from Mid-July to November is called the ODD SEMESTER, and the one that is from January to Mid-May is called the EVEN SEMESTER. Academic Session may be

scheduled for the Summer Session/Semester as well. For 1st year B. Tech and M. Tech the schedule will be decided as per the admission schedule declared by Government of Maharashtra.

4. The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), and announced at least TWO weeks before the Closing Date of the previous Semester.

5. The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra-curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

Registration:

1. Lower and Upper Limits for Course Credits Registered in a Semester, by a Full- Time Student of a UG/PG Programme:

A full time student of a particular UG/PG programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that UG/PG programme as stipulated in the specific Regulations pertaining to that UG/PG programme.

2. Mandatory Pre-Registration for higher semesters: In order to facilitate proper planning of the academic activities of a semester, it is essential for the every institute to inform to Dean (Academics) and COE regarding details of total no. of electives offered (Course-wise) along with the number of students opted for the same. This information should be submitted within two weeks from the date of commencement of the semester as per academic calendar.
3. PhD students can register for any of PG/PhD courses and the corresponding rules of evaluation will apply.
4. Under Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the DUGC/DPGC is convinced of the level of the academic achievement and the potential in a student.

Course Pre-Requisites:

1. In order to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior earned credits in, some specified courses.
2. Students who do not register on the day announced for the purpose may be permitted LATE REGISTRATION up to the notified day in academic calendar on payment of late fee.
3. REGISTRATION IN ABSENTIA will be allowed only in exceptional cases with the approval of the Dean (Academic) / Principal.
4. A student will be permitted to register in the next semester only if he fulfills the following conditions:
 - i) Satisfied all the Academic Requirements to continue with the programme of Studies without termination
 - ii) Cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters;
 - iii) Paid all required advance payments of the Institute and hostel for the current semester;
 - iv) Not been debarred from registering on any specific ground by the Institute.

Evaluation System:

1. Absolute grading system based on absolute marks as indicated below will be implemented from academic year 2023-24, from I year B. Tech.

Percentage of marks	Letter Grade	Grade Point
91-100	EX	10.0
86-90	AA	9.0
81-85	AB	8.5
76-80	BB	8.0
71-75	BC	7.5
66-70	CC	7.0
61-65	CD	6.5
56-60	DD	6.0
51-55	DE	5.5
40-50	EE	5.0
<40	EF	0.0

2. Class is awarded based on CGPA of all eighth semester of B.Tech Program.

CGPA for pass is minimum 5.0	
CGPA upto <5.50	Pass class
CGPA ≥ 5.50 & <6.00	Second Class
CGPA ≥ 6.00 & <7.5	First Class
CGPA >7.50	Distinction
[Percentage of Marks =CGPA*10.0]	

3. A total of 100 Marks for each theory course are distributed as follows:

Mid Semester Exam (MSE) Marks	20
Continuous Assessment Marks	20
End Semester Examination(ESE)Marks	60

4. A total of 100 Marks for each practical course are distributed as follows

1.	Continuous Assessment Marks	40
2.	End Semester Examination (ESE)Marks	60

- It is mandatory for every student of B. Tech to score a minimum of 40 marks out of 100, M. Tech to score a minimum of 45 marks out of 100 with a minimum of 20 marks out of 60 marks in End Semester Examination for theory course.
- This will be implemented from the first year of B. Tech starting from Academic Year 2023-24

5. Description of Grades

EX Grade: An 'EX' grade stands for outstanding achievement.

EE Grade: The 'EE' grade stands for minimum passing grade.

The students may appear for the remedial examination for the subjects he/she failed for the current semester of admission only and his/her performance will be awarded with EE grade only.

If any of the students remain absent for the regular examination due to genuine reason and the same will be verified and tested by the Dean (Academics) or committee constituted by the University Authority.

FF Grade: The 'FF' grade denotes very poor performance, i.e. failure in a course due to poor performance. The students who have been awarded 'FF' grade in a course in any semester must repeat the subject in next semester.

6. Evaluation of Performance

a. Semester Grade Point Average (SGPA)

The performance of a student in a semester is indicated by Semester Grade Point Average (SGPA) which is a weighted average of the grade points obtained in all the courses taken by the student in the semester and scaled to a maximum of 10. (SGPI is to be calculated up to two decimal places). A Semester Grade Point Average (SGPA) will be computed for each semester as follows:

$$SGPA = \frac{[\sum_{i=1}^n c_i g_i]}{[\sum_{i=1}^n c_i]}$$

Where

'n' is the number of subjects for the semester,

'c_i' is the number of credits allotted to a particular subject, and

'g_i' is the grade-points awarded to the student for the subject based on his performance as per the above table.

SGPA will be rounded off to the second place of decimal and recorded as such.

b. Cumulative Grade Point Average (CGPA):

An up to date assessment of the overall performance of a student from the time he entered the Institute is obtained by calculating Cumulative Grade Point Average (CGPA) of a student. The CGPA is weighted average of the grade points obtained in all the courses registered by the student since s/he entered the Institute. CGPA is also calculated at the end of every semester (upto two decimal places). Starting from the first semester at the end of each semester (S), a Cumulative Grade Point Average (CGPA) will be computed as follows:

$$CGPA = \frac{[\sum_{i=1}^m c_i g_i]}{[\sum_{i=1}^m c_i]}$$

Where,

'm' is the total number of subjects from the first semester onwards up to and including the semester S,

'c_i' is the number of credits allotted to a particular subject, and

'gi' is the grade-points awarded to the student for the subject based on his/her performance as per the above table.

CGPA will be rounded off to the second place of decimal and recorded as such.

7. Attendance Requirements:

- a. All students must attend every lecture, tutorial and practical classes.
- b. To account for approved leave of absence (eg. representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted. If the student failed to maintain 75% attendance, he/she will be detained for appearing the successive examination. The Dean (Academics)/ Principal is permitted to give 10% concession for the genuine reasons as such the case may be. In any case the student will not be permitted for appearing the examination if the attendance is less than 65%.
- c. The course instructor handling a course must finalize the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.
- d. The attendance records are to be maintained by the course instructor and he shall show it to the student, if and when required.

8. Transfer of Credits:

The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges/Swayam Courses by students during their study period at DBATU may count towards the credit requirements for the award of degree. The guidelines for such transfer of credits are as follows:

- a. 20 % of the total credit will be considered for respective calculations.
- b. Credits transferred will be considered for overall credits requirements of the programme.
- c. Credits transfer can be considered only for the course at same level i.e UG, PG etc.
- d. A student must provide all details (original or attested authentic copies) such as course contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. He shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned Board of Studies before giving approval. The Board of Studies will then decide the number of equivalent credits the student will get for such course(s) in DBATU. The complete details will then be forwarded to Dean for approval.
- e. A student has to get minimum passing grades/ marks for such courses for which the credits transfers are to be made.
- f. Credits transfers availed by a student shall be properly recorded on academic record(s) of the student.
- g. In exceptional cases, the students may opt for higher credits than the prescribed.