Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE401**	**Title of the Course**	**Power system Protection**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To learn the basics of relays. • To get the knowledge of relay application. • To gain the knowledge of protection of Transmission line. • To study the different types of circuit breaker. • To gain the knowledge of protection of Alternator.						

Course Outcomes	
CO1	Learn the basics of relays
CO2	Acquire knowledge of relay application
CO3	Acquire knowledge of protection of Transmission line
CO4	Knowledge the different types of circuit breaker
CO5	Gain the knowledge of protection of Alternator

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to power system**	Introduction to protective system and its elements, Function of protective relaying, Protective zones, Primary and backup protection, Desirable qualities of protective relaying, Basic terminology. **Relays**: Electromagnetic, Attraction and induction type relays; Thermal relay; Gas actuated relay.	8	CO1
2	**Relay Applications and characteristics**	Amplitude and phase comparators, Over-current relays, Directional relays, Distance relays, Differential relays. **Static relays:** Comparison with electromagnetic relays, Classification and their description, Overcurrent relays, Directional relays, Distance relays, Differential relays	8	CO2
3	**Protection of Transmission line**	Time graded protection; Differential and distance protection of feeders; Choice between impedance, reactance and MHO relays; Elementary idea about carrier current protection of lines; Protection of bus; Auto reclosing, Pilot wire protection	8	CO3
4	**Breaking**	**Circuit Breaking:** Arc phenomenon, Properties of arc, Arc extinction theories, Recovery voltage and re-striking voltage, Current chopping, Resistance switching, Capacitance current interruption, Circuit breaker ratings. **Circuit breakers**: Need of circuit breakers; Types of circuit breakers; Operating modes; Principles of construction; Details of Air Blast, Bulk Oil, Minimum Oil, SF6, Vacuum Circuit Breakers, DC circuit breakers.	8	CO4
5	**Apparatus protection**	Types of faults on alternator, Stator and rotor protection, Negative sequence protection, Loss of excitation and overload protection, Types of faults on transformers, Percentage differential protection, Isolated neutral system, Grounded neutral system and selection of neutral grounding	8	CO5

Reference Books:

1. S. S. Rao, "Switchgear and Protection", Khanna Publishers, 13th Edition, 2008.
2. B. Ravindranath and M. Chander, "Power system Protection and Switchgear", Wiley Eastern Ltd., 5th Edison, 2015.
3. B. Ram and D. N. Vishwakarma, "Power System Protection and Switchgear", Tata McGraw Hill, 2nd Edition, 2011.
4. Y. G. Paithankar and S R Bhide, "Fundamentals of Power System Protection", Prentice Hall of India, 2004.
5. T.S.M. Rao, "Power System Protection: Static Relays with Microprocessor Applications", Tata McGraw Hill, 2nd edition, 1993.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3		1									1	2		2			
CO2	3	2		1									2	2	2			
CO3	3	2										1	2	2	2			
CO4	3	2		2								1	2	2	2			
CO5	3	1	2									1	2	2	2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE403**	**Title of the Course**	**ELECTRIC DRIVES**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• Describe the structure of Electric Drive systems and their role in various applications such as flexible production systems, energy conservation, renewable energy, transportation etc., making Electric Drives an enabling technology. • Analyze the operation of motor drives system to satisfy four-quadrant operation to meet mechanical load requirements. • Understand the basic principles of power electronics in drives using switch-mode converters and pulse width modulation to synthesize the voltages in dc and ac motor drives. • Describe the operation of induction machines in steady state that allows them to be controlled in induction-motor drives. Learn speed control of induction motor drives in an energy efficient manner using power electronics. • Learn the basic operation of stepper motors and switched-reluctance motor drives. • Realize an appreciation of power quality issues in powering electric drives.						

Course Outcomes	
CO1	**Conceptualize** fundamental elements of drive systems, **design** important elements of a drive system, **understand** the multi-quadrant operation and **analyze** it for different types of operation.
CO2	**Understand** and **evaluate** dynamics of motor-load combination, **Develop** the thermal model of a motor, **Analyze** steady state and transient state stability, **select** and **determine** the motor power rating for various duty cycles.
CO3	**Analyze** and **perform** the dynamics during starting and braking of DC and AC motor, **evaluate** energy loss and **implement** various methods to reduce it, **examine**, **develop** and **solve** various energy relations during starting and braking.
CO4	**Acquire** detailed knowledge of DC Shunt and Series motor operation using generalized machine theory, **Apply** the concepts of AC-DC and DC-DC Converters to evaluate and **enhance** the performance of steady and transient state operation, **Implement** speed control and current control loops of a DC Motor drive. **Understand** how DC Drives may pollute the power supply and **analyze** how to mitigate such pollution.
CO5	**Understand** the working of various phase controlled converters used in AC Drives**. Learn** the working principle and **design** details of frequency controlled converters used in induction motor drives. **Analyze** and **perform** the modeling and controlling CSI based drives.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Fundamentals of Electric Drives**	Electric drives and its parts, Advantages of electric drives, Classification of electric drives Speed torque conventions and multi-quadrant operations constant torque and constant power operation, Types of load torque: Components, Nature and Classification.	8	CO1
2	**Dynamics of Electric Drives**	Dynamics of motor-load combination; Steady state stability of Electric Drive; Transient stability of electric drive; Selection of motor power rating; Thermal model of motor for heating and cooling; Classes of motor duty; Determination of motor power rating for continuous duty, short time duty and intermittent duty; Load equalization.	8	CO2
3	**Electric Braking**	Purpose and types of electric braking; Braking of dc, three phase induction and synchronous motors; Dynamics during starting and braking of dc motors; Calculation of acceleration time and energy loss during starting of dc shunt and three phase induction motors; Methods of reducing energy loss during starting; Energy relations during braking, Dynamics during braking of ac motors.	8	CO3
4	**Power Electronic Control of DC Drives**	Single phase and three phase controlled converter fed separately excited dc motor drives (continuous conduction only); Dual converter fed separately excited dc motor drive; Rectifier control of dc series motor; Supply harmonics, power factor and ripples in motor current; Chopper control of separately excited dc motor and dc series motor.	8	CO4
5	**Power Electronic Control of AC Drives**	Three phase induction motor drive: Static voltage control scheme, Static frequency control scheme: VSI, CSI, and cyclo-converter based drives; Special drives: Switched reluctance motor, Brushless dc motor: Selection of motor for particular applications.	8	CO5

Reference Books:

1. G.K. Dubey, "Fundamentals of Electric Drives", Narosa publishing House, Reprint 2017.
2. S.K. Pillai, "A First Course on Electric Drives", Wiley Eastern Limited, 2nd Edition, 1989.
3. M. Chilkin, "Electric Drives", Mir Publishers, Moscow,1st Edition, 2002.
4. Mohammed A. El-Sharkawi, "Fundamentals of Electric Drives", Thomson Asia, Pvt. Ltd. Singapore, 1st Edition, 2000.
5. N.K. De and Prashant K. Sen, "Electric Drives", Prentice Hall of India Ltd., 1st Edition,2006.
6. V. Subrahmanyam

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	1	1	2		1						2	2	1			
CO2	3	3	2	1	2							2	2	2	2			
CO3	3	3	2	2	2	2						1		2	2			
CO4	3	3	3	1	2	1		1			1		2		2			
CO5	3	3	3	2	2		1		1		1			1	2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE421**	**Title of the Course**	**ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEM**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• Knowledge and application of Theory of Break Down In Gaseous, Liquid and Solid dielectrics • Knowledge and application of Generation of High Voltage and Currents • Knowledge and application of Measurement of High Voltage and Currents • Knowledge and application of Over Voltage Phenomenon & Insulation Coordination • Knowledge and application of Non -Destructive Insulation Test Techniques						

Course Outcomes	
CO1	Understand and analyze the concept, design, technique, advancement and application of Break Down In Gases**,** electronegative gases, non-uniform field, vacuum, Liquid Dielectrics, pure liquid and commercial liquid, Solid Dielectric**,** solid dielectric in practice, composite dielectrics.
CO2	Understand and analyze the concept, design, technique, advancement and application of Generation of High direct Current Voltage, alternating voltages, impulse voltages, impulse currents and Tripping and control of impulse generators
CO3	Understand and analyze the concept, design, technique, advancement and application of Measurement of High direct Current Voltages; alternating & Impulse voltages, High direct, alternating & Impulse Currents and Cathode ray oscillographs for impulse voltage and current measurements
CO4	Understand and analyze the concept, design, technique, advancement and application of Lighting Phenomenon as natural cause for over voltage, Overvoltage due to switching surges and abnormal conditions and Principal of insulation coordination
CO5	Understand and analyze the concept, design, technique, advancement and application of Dynamic properties of dielectrics, Measurement of direct current resistivity, Measurement of dielectric constant and loss factor and Partial discharge measurements.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Break Down**	Break Down In Gases: Ionization processes, Townsend's criterion, Breakdown in electronegative gases, Time lags for breakdown, Streamer theory, Paschen's law, Breakdown in non- uniform field, Breakdown in vacuum. Break Down In Liquid Dielectrics: Classification of liquid dielectric, Characteristics of liquid dielectric, Breakdown in pure liquid and commercial liquid. Break Down In Solid Dielectric: Intrinsic breakdown, Electro-mechanical breakdown, Breakdown of solid dielectric in practice, Breakdown in composite dielectrics.	8	CO1
2	**Generation of High Voltage and Currents**	Generation of High direct Current Voltage, Generation of high alternating voltages, Generation of impulse voltages, Generation of impulse currents, Tripping and control of impulse generators	8	CO2
3	**Measurement of High Voltage and Currents**	Measurement of High direct Current Voltages; Measurement of High alternating & Impulse voltages; Measurement of High direct, alternating & Impulse Currents; Cathode ray oscillographs for impulse voltage and current measurements.	8	CO3
4	**Over Voltage Phenomenon & Insulation Coordination**	Lighting Phenomenon as natural cause for over voltage, Overvoltage due to switching surges and abnormal conditions, Principal of insulation coordination	8	CO4
5	**Non -Destructive Insulation Test Techniques**	Dynamic properties of dielectrics, Measurement of direct current resistively, Measurement of dielectric constant and loss factor, Partial discharge measurements.	8	CO5

Reference Books:

1. E. Kuffel, W.S. Zaengl and J. Kuffel, "High Voltage Engineering", CBS Publishers New Delhi, 2nd Edition, 2005.
2. M.S. Naidu & V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill, 5th edition, 2013.
3. C.L. Wadhwa, "High Voltage Engineering", New Age Internationals (P) Limited, 3rd Edition, 2010.
4. M. Khalifa, "High Voltage Engineering: Theory and Practice", Marcel Dekker, 1st edition, 1990.
5. Subir Ray, "An Introduction to High Voltage Engineering", Prentice Hall of India, 2nd edition, 2013.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	1	2	3							2	3	2	3			
CO2	3	3	1	2	3							2	3	2	3			
CO3	3	1	1	2	3							2	3	2	3			
CO4	3	1	1	2	3							2	3	2	3			
CO5	3	1	1	2	3							2	3	2	3			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE425**	**Title of the Course**	**EHVAC & EHVDC TRANSMISSION**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• Knowledge of ENVAC and EHVDC Transmission • Design of EHV using software • Knowledge of control circuits used in power transmission network						

Course Outcomes	
CO1	Knowledge of EHVDC and EHVAC transmission and conductors used in transmission
CO2	Knowledge of switching and their effects on transmission circuits
CO3	Knowledge of single and three phase converters and design of EHV lines
CO4	Knowledge of different converters used in EHV DC transmission
CO5	Knowledge of protection circuits

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to**	Need of EHV transmission, Standard transmission voltage, Comparison of EHV ac & dc transmission systems and their applications & limitations, Surface voltage gradients in conductor,Distribution of voltage gradients on sub-conductors, Mechanical considerations of transmission lines, Modern trends in EHV AC and DC transmission	8	CO1
2	**EHV AC Transmission**	Corona loss formula, Corona current, Audible noise – generation and characteristics, Corona pulses their generation and properties, Radio interference (RI) effects, Over voltage due to switching, Ferro resonance, Reduction of switching surges on EHV system, Principle of half wave transmission.	8	CO2
3	**Consideration for Design of EHV Lines**	Design factors under steady state limits, EHV line insulation design based upon transient over voltages, Effects of pollution on performance of EHV lines. **Converter Circuits:** 1-phase and 3-phase converters (properties and configurations), Cascade of converters	8	CO3
4	**EHV DC Transmission–I**	Types of dc links, converter station, Choice of converter configuration and pulse number, Effect of source inductance on operation of converters, Principle of dc link control, Converter controls characteristics, Firing angle control, Current and excitation angle control, Power control, Starting and stopping of dc link	8	CO4
5	**EHV DC Transmission–II**	Converter faults; Protection against over currents and over voltages; Smoothing reactors; Generation of harmonics; AC and DC filters; Multi Terminal DC systems (MTDC): Types, Control,protection and applications.	8	CO5

Reference Books:

1. R. D. Begamudre, "Extra High Voltage AC Transmission Engineering", Wiley Eastern, 3rdedition, 2006.
2. K. R. Padiyar, "HVDC Power Transmission Systems: Technology and System Reactions",New Age International, 2nd edition, 1983.
3. M. S. Naidu & V. Kamaraju, "High Voltage Engineering", Tata McGraw Hill, 3rd edition,2004.
4. M. H. Rashid, "Power Electronics: Circuits, Devices and Applications", Prentice Hall ofIndia, 4th edition, 2014.
5. S. Rao, "EHV AC and HVDC Transmission Engineering and Practice", Khanna Publisher,4th edition, 2011.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	2										2	3					
CO2	3	2										2	3	2	2			
CO3	2	3	2									2	2	3	2			
CO4	3	2	3									2	2	2				
CO5	3	2										2	3					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE427**	**Title of the Course**	**POWER SYSTEM DYNAMICS**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To understand the students about dynamics of Power systems. To develop ability for analysis of system stability and obtain the solution of transient problems. • To analyze the modeling of synchronous machine by applying fundamental law's. • To realize and examine the excitation systems and response the behavior of prime mover controllers in different system. • To recognize the concepts of dynamics of synchronous generator Connected to Infinite Bus by investigation in real time domain. • To execute the analysis of transient and voltage stability by various parameters and comparison with angle stability						

Course Outcomes	
CO1	Given a Power System Dynamics Problems, students shall be able to represent this in various conventional models, identify type of system, apply vector algebra, and formulate the expression in different System Model and solve using mathematical terms.
CO2	Given a Modeling of Synchronous Machine with sources, student shall be able to analyze System Simulation and evaluate the Steady State Performance using Equivalent Circuit of Synchronous Machine.
CO3	For a Excitation systems & Prime Mover Controllers, student shall be able to generate its analytical response by Standard Block Diagram and examine, analyze and evaluate the characteristics by State Equations and Load Modeling.
CO4	For a given System Model, students shall be able to identify its characteristics and for Stator Equation, select suitable design of application of Network Equation, develop various combination for System Simulation Small Signal Analysis with Block Diagram Representation for Single Machine System.
CO5	Given a Modeling and Analysis of Transient and Voltage Stability, student shall be able to define its Stability Evaluation, solve/ analyze, and modify energy functions for direct stability Evaluation.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Power System Dynamics Problems**	Introduction, General basic concept of Power System Stability, States of operation & System Security, System Dynamics Problems, Review of Classical Model, System Model, Analysis of Steady State Stability & Transient Stability	8	CO1
2	**Modelling of Synchronous Machine**	Introduction, System Simulation, Park's Transformation, Analysis of Steady State Performance, P.U. Quantities and Equivalent Circuit of Synchronous Machine.	8	CO2
3	**Excitation systems & Prime Mover Controllers**	Simplified Representation of Excitation Control, Excitation systems, Modelling, Standard Block Diagram, State Equations, Prime Mover Control System, Transmission Line & Load Modelling	8	CO3
4	**Dynamics of Synchronous Generator Connected to Infinite Bus**	System Model, Stator Equation, Rotor equations, Application of Model 1.1, Network Equation, Calculation of Initial Conditions, System Simulation Small Signal Analysis with Block Diagram Representation for Single Machine System, Synchronizing & Damping Torque Analysis, State Equation.	8	CO4
5	**Modelling and Analysis of Transient and Voltage Stability**	Simulation for Transient Stability Evaluation; Application of energy functions for direct stability evaluation; Voltage Stability: Introduction, Factors affecting voltage collapse, Analysis and comparison with angle stability.	8	CO5

Reference Books:

1. K. R. Padiyar, "Power System Dynamics: Stability & Control", BS Publications, 2nd edition, 2002
2. I. J. Nagrath and M. Gopal, **"**Control system engineering**",** Wiley Eastern Ltd, 3rd edition, 2000.
3. Benjamin C. Kuo, **"**Automatic Control system**",** Prentice Hall of India Pvt. Ltd, 8th edition, 2003.
4. Prabha Kundur, **"**Power System Stability and Control**"**, Tata McGraw Hill, 5th edition, 2014

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2										2	3	1			
CO2	3	3	2	2	2								2	3	1			
CO3	3	3	1									2	2	3	1			
CO4	3	2	3	2	3					2	2		2	3				
CO5	3	3	3			2	1						2	3	1			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE431**	**Title of the Course**	**UTILIZATION OF ELECTRICAL ENERGY AND TRACTION**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To impart the detail knowledge of different types of Electrical Heating • To understand about Electrical Welding, Refrigeration and Air conditioning. • To study different definitions of Illuminations and its Laws • To understand types of Electric Traction, system of track electrification, Tractive effort. • Study of salient features of traction Drives. To impart knowledge of Diesel Electric Traction						

Course Outcomes	
CO1	**Conceptualize** fundamental elements of electrical heating, **designing** of different elements used in electrical heating, **understand** working and application of different type of furnaces.
CO2	**Understand** different types and working of electrical welding, **understand** different instrument used for electrical welding. **Acquire** detailed knowledge electro-deposition, laws of electrolysis and its application in different field.
CO3	**Acquire** knowledge of different Laws of Illuminations, **Develop** the designing skill for indoor and outdoor lighting system. **Understand** construction and operation of Refrigeration and air conditioner system, **Analyze** the electric circuit and **Learn** the maintenance of domestic refrigerator.
CO4	**Understand** operation, mechanism and types of track electrification used of a traction system. **Acquire** detailed knowledge of different terminology used in electric traction.
CO5	**Acquire** knowledge of different motor drives operation, **Analyze** starting, braking and of different type of motor drives used for traction **Apply** the concepts of AC-DC and DC-DC Converters for traction drives, **Implementation** of bridge transition speed control of a DC traction drive. **Understand** the concept of diesel electric traction.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Electric Heating**	Advantages and methods of electric heating, Resistance heating, Electric arc heating, Induction heating, Dielectric heating.	8	CO1
2	**Electric Welding**	Electric Arc Welding, Electric Resistance welding, Electronic welding control Electrolyte Process: Principles of electro-deposition, Laws of electrolysis, Applications of electrolysis	8	CO2
3	**Illumination**	Various definitions, Laws of illumination, Requirements of good lighting, Design of indoor lighting and outdoor lighting systems. Refrigeration and Air Conditioning: Refrigeration systems, Domestic refrigerator, Water cooler,Types of air conditioning, Window air conditioner	8	CO3
4	**Electric Traction I**	Types of electric traction; Systems of track electrification; Traction mechanics - Types of services, Speed time curve and its simplification, Average and schedule speeds; Tractive effort; Specific energy consumption; Mechanics of train movement; Coefficient of adhesion and its influence.	8	CO4
5	**Electric Traction II**	Salient features of traction drives, Series – parallel control of dc traction drives (Bridge transition) and energy saving Power Electronic control of dc and ac traction drives, Diesel electric traction	8	CO5

Reference Books:

1. H. Partab, “Art and Science of Electrical Energy”, Dhanpat Rai & Sons, 2014
2. G.K. Dubey, “Fundamentals of Electric Drives”, Narosa Publishing House, 2nd edition,2015.
3. H. Partab, “Modern Electric Traction”, Dhanpat Rai & Sons, 2013
4. C.L. Wadhwa, “ Generation, Distribution and Utilization of Electrical Energy”, New Age International Publications, 3rd edition, 2010
5. E. Open Shaw Taylor, “Utilization of Electric Energy”, Orient Longman, Reprint 2011.

e-Learning Source:

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3	1	2	2	2			2		1	2	2	3			
CO2	3	3	2	1	2	2	2			2		1	2	1	3			
CO3	3	3	3	3	3	3	3	2	3	3	1	2	2		2			
CO4	3	3	3	1	1	3		1		1		2	2	1	2			
CO5	3	3	2	2	1	2	1	1	1	2		3	2					

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE435**	**Title of the Course**	**HIGH VOLTAGE DC TRANSMISSION**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To introduce students with the concept of HVDC Transmission system. • To familiarize the students with the HVDC converters and their control system. • To expose the students to the harmonics and faults occur in the system and their prevention. • To Develop the knowledge of HVDC transmission and HVDC converters and the applicability and advantage of HVDC transmission over conventional AC transmission. • To Formulate and solve mathematical problems related to rectifier and inverter control methods and learn about different control schemes as well as starting and stopping of DC links • To Analyze the different harmonics generated by the converters and their variation with the change in firing angles. • To Develop harmonic models and use the knowledge of circuit theory to develop filters and assess the requirement and type of protection for the filters. • To Study and understand the nature of faults happening on both the AC and DC sides of the converters and formulate protection schemes for the same. • To Review the existing HVDC systems along with MTDC systems and their controls • To Recognize the need to follow the advancements in both the existing systems and HVDC systems and determine the most economic coexistence of both.						

Course Outcomes	
CO1	Choose intelligently AC and DC transmission systems for the dedicated application(s).
CO2	Identify the suitable two-level/multilevel configuration for high power converters.
CO3	Select the suitable protection method for various converter faults.
CO4	Decide the configuration for harmonic mitigation on both AC and DC sides.
CO5	Identify suitable reactive power compensation method and basics of MTDC system.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**General Aspects of HVDC Transmission**	Introduction to HVDC Transmission, Comparison of HVAC and HVDC systems (Economics of power transmission, Technical Performance and Reliability), Type of HVDC Transmission systems, Description of HVDC transmission system (Types of DC Links and Converter), Planning for HVDC transmission, Modern trends in HVDC technology	8	CO1
2	**Converters**	Simple rectifier circuits, Rectification circuits for HVDC transmission, HVDC converters (Line commutated and Voltage Source converters), Analysis of Graetz Bridge with and without overlap, Pulse number, 12 pulse firing schemes	8	CO2
3	**HVDC System Control**	HVDC system control (Principles of DC link control, Firing Angle Current and extinction angle control), Converter mal-operations, Commutation failure, Converter control characteristics, Power Control, Starting and stopping of converter bridge, Converter protection, DC Breakers.	8	CO3
4	**Reactive Power And Harmonics Control**	Reactive power requirements, Sources of Reactive Power, Smoothing reactor and DC Lines, Generation of Harmonics, Characteristic and Non-characteristic Harmonics, Troubles due to Harmonics, Harmonics Filters (AC Filters and DC Filters), Active Filters and Passive Filters	8	CO4
5	**Power Flow Analysis**	Interaction between AC and DC system, Power Flow in AC/DC Systems, DC system model, Basics of Multi-terminal DC (MTDC) system, Types of Multi-terminal DC (MTDC) system, Multi-In feed DC System	8	CO5

Reference Books:

1. Padiyar K.R., "HVDC transmission system", Wiley Eastern Ltd., New Delhi, Second Edition, 2015.
2. Arrilaga J., "High voltage direct current transmission", Peter Pereginver Ltd. London, U.K., 1998.
3. Kim Bark E.W., "Direct current transmission – Vol.1", Wiley Inter Science, New York, 1971.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	2								2	2	1		1			
CO2	3	3	2	2	2							2	2	2				
CO3	3	3	1									1	2	2				
CO4	3	2	3	2	3					2	2	3	1	2	1			
CO5	3	3	3			2	1				2	3	1					

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE437**	**Title of the Course**	**ELECTRICAL DISTRIBUTION SYSTEM & AUTOMATION**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives							

Course Outcomes	
CO1	Knowledge of energy losses, OHTL and UG lines
CO2	Analyze and modelling of distribution system
CO3	Design of distribution system
CO4	Protection analysis of distribution system
CO5	Knowledge of automation systems and sensors

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Industrial and commercial distribution system**	Energy Loss in distribution system, System ground for safety and- protection, Comparison of overhead lines and underground cable system	8	CO1
2	**Network model**	Power flow, short circuit and calculations, Distribution system reliability analysis, Reliability concepts, Markov model, Distribution network reliability, Reliability performance	8	CO2
3	**Distribution system expansion planning**	Load characteristics, Load forecasting, Design concepts, Optimal location of sub-station, Design of radial lines, Solution technique	8	CO3
4	**System protection**	Requirement; Fuses and section analyzers; Over current, under voltage and under frequency protection; Co-ordination of protective device	8	CO4
5	**Industrial Automation and Control**	Introduction to Industrial Automation and Control Architecture of Industrial Automation Systems, Introduction to sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level.	8	CO5

Reference Books:

1. Pabla. A.S., “Electrical Power Distribution, System”, Tata McGraw Hill, 1981.
2. Tuvar Goner, "Electrical Power Distribution System”, McGraw Hill, 1986.
3. Johnson C.D., "Process control instrumentation technology", Prentice-Hall, New Delhi,2006
4. Kalsi H.S., “Electronic Instrumentation”, McGraw Hill, 3rd edition, New Delhi, 2010

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2									2	3		2			
CO2	2	3	3										2	3				
CO3	3	2	3									3	3	3	3			
CO4	3	2	2									3	3					
CO5	3											3	3					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE439**	**Title of the Course**	**HIGH POWER SEMICONDUCTOR DEVICES**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• Knowledge of latest semiconductor switches • Apply knowledge of thyristors in hardware based models						

Course Outcomes	
CO1	To understand the construction and working of power switches like diode, transistor, IGBT and their practical applications in industries.
CO2	Analysis of different types thyristors their practical implementation. To understand the different methods to turn it on and their blocking characteristics.
CO3	To understand the structure and operation of MOSFET, Silicon IGBT, Silicon carbide IGBT and its practical application in electrical devices for industries.
CO4	To understand the operation and structure of VMOS and DMOS and its practical application in electrical devices for industries.
CO5	To understand the operation and structure of silicon MCT, BRT, EST, Gallium Nitride devices and its practical application in electrical devices for industries.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Power Switching Waveforms, High Voltage Power Device Structures, Breakdown Model for Silicon, High Voltage Applications	8	CO1
2	**SCR**	Operation & structure of Silicon Thyristors, Silicon Carbide Thyristors & Silicon GTO, Blocking characteristics	8	CO2
3	**Power Bipolar Transistors**	Operation and structure of Silicon IGBT, SiC Planar MOSFET Structures and Silicon Carbide IGBT	8	CO3
4	**Power MOS Devices**	Operation and structure of V MOS and DMOS, Heat Transfer in Power MOS devices, Device packaging	8	CO4
5	**High Voltage Devices**	Operation and structure of silicon MCT,silicon BRT,silicon EST,Gallium nitride devices	8	CO5

Reference Books:

1. B. Jayant Baliga, "Fundamentals of Power Semiconductor Devices", 3rd edition, Springer, 2008
2. B. Jayant Baliga, "Advanced High Voltage Power Device Concepts", 1st edition, Springer, 2011
3. Robert Perret, "Power Electronics Semiconductor Devices", 1st edition, Wiley, 2009
4. Tadahiro Ohmi, Andre A. Jaecklin, "Power Semiconductor Devices & Circuits", 1st edition,Springer, 1992
5. Josef Lutz, Heinrich Schlangenotto, Uwe Scheuermann, Rik De Doncker, "SemiconductorPower Devices", Springer, 1st edition, 2011

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	1	1	1	1	2	2	1					3	2	1			
CO2	3	2	3	2	2	3	1	1	1				3	1	2			
CO3	3	2	3	2	2	2	2	1	1		1	2	3	2	2			
CO4	3	2	3	2	3	2	2	1	1		3	2	3	2	2			
CO5	3	2	3	2	3	2	2		1		3	2	3	2	2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE441**	**Title of the Course**	**FLEXIBLE AC TRANSMISSION SYSTEMS**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To familiarize power engineers about the Flexible AC Transmission devices and their applications in power systems with respect to active/reactive power control.						

Course Outcomes	
CO1	Understand the importance of controllable parameters and benefits of FACTS controllers.
CO2	Know the significance of shunt, series compensation and role of FACTS devices on system control.
CO3	Analyze the functional operation and control of GCSC, TSSC and TCSC.
CO4	Describe the principles, operation and control of UPFC and IPFC.
CO5	Knowledge of UPFC and IPFC

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction to FACTS**	Challenges and needs, Power Flow in AC transmission line, Power flow control, Description and definition of Flexible AC Transmission Systems (FACTS) controllers, Static power converter structures.	8	CO1
2	**Power Semiconductor devices**	Types of power semiconductor devices, Voltage-sourced and Current-sourced converters, Converter output and harmonic control, Power converter control issues, Reactive power compensation.	8	CO2
3	**Shunt Compensation**	Static VAR compensator (SVC), Static Synchronous Compensator (STATCOM), Thyristor controlled Reactor (TCR) and Thyristor switched Reactor (TSR) Operation and control, Configurations and applications	8	CO3
4	**Series Compensation:**	Thyristor Controlled Series Capacitor (TCSC), Static Synchronous Series Compensator (SSSC), Operation and control, Configurations and applications. Voltage and Phase angle regulators: Thyristor controlled voltage regulators (TCVRs) and Thyristor controlled phase angle regulators (TCPARs) operation and control.	8	CO4
5	**Shunt-Series compensation**	Unified power flow controller (UPFC), Power flow studies with FACTS controllers, Operational constraints, Interline Power flow Controller (IPFC), Operation and control.	8	CO5

Reference Books:

1. Narain G. Hingorani, " Understanding FACTS", Wiley IEEE PRESS, Reprint 2015.
2. K.R. Padiyar, "FACTS Controllers in Transmission & Distribution", 3rd edition 2017.
3. V. K. Sood, "HVDC and FACTS Controllers: Applications of Static Converters in Power Systems", 2004.
4. Enrique Acha, C.R. Feurte, Esquivel, "Modelling and Simulation in Power Networks", Wiley-India edition, 2004.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	3	3		1				2	1			2	2	2			
CO2	3	3	3	1			3		3	1	3		2	2	2			
CO3	3	3	3	1					3	1	3	1	2	2	2			
CO4	3	3	3	1					3	1		1	2	2	2			
CO5													2	2	2			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE443**	**Title of the Course**	**SPECIAL ELECTRICAL MACHINES**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• Knowledge of slip power recovery scheme • To get knowledge of constructional features of special machines such as single-phase synchronous motor and ac servomotor. • To attain knowledge of working of stepper motor and switched reluctance motor and their drive circuits • To study about different types of magnets and their application in different machines • To have the knowledge of working and application of linear induction motor and universal motor.						

Course Outcomes	
CO1	Evaluate the performance special induction motors and slip power recovery schemes
CO2	Analyze the performance of single-phase synchronous motor and ac servomotor
CO3	Evaluate the performance of drive circuit of stepper motors
CO4	Knowledge of permanent magnet machines
CO5	Knowledge of linear induction motor and universal motor used for special applications

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Poly-phase AC Machines**	Construction and performance of double cage and deep bar three phase induction motors, E.m.f. injection in rotor circuit of slip ring induction motor, Concept of constant torque and constant power controls, Static slip power recovery control schemes (constant torque and constant power).	8	CO1
2	**Single phase synchronous motor**:	Construction, Operating principle and characteristics of reluctance and hysteresis motors. Two Phase AC Servomotors: Construction, Torque-speed characteristics, Performance and applications.	8	CO2
3	**Stepper Motors:**	Principle of operation; Variable reluctance, Permanent magnet and Hybrid stepper motors; Characteristics, drive circuits and applications. Switched Reluctance Motors: Construction, Principle of operation, Torque production, Modes of operation, Drive circuits.	8	CO3
4	**Permanent Magnet Machines**	Types of permanent magnets and their magnetization characteristics, Demagnetizing effect, Permanent magnet dc motors, Sinusoidal PM ac motors, Brushless dc motors and their important features and applications, PCB motors, Introduction to permanent magnet generators.	8	CO4
5	**Single Phase Commutator Motors**:	Construction, Principle of operation; Characteristics of universal and repulsion motors; Linear Induction Motors: Construction, Principle of operation, Linear force and applications.	8	CO5

Reference Books:

1. P.S. Bimbhra "Generalized Theory of Electrical Machines", Khanna Publishers Limited, 5th Edition, 4th Reprint, New Delhi, 2000
2. P.C. Sen, "Principles of Electrical Machines and Power Electronics", John Wiley & Sons, 2nd edition, 2001.
3. G.K. Dubey, "Fundamentals of Electric Drives", Narosa Publishing House, 2nd edition, reprint 2017.
4. Cyril G. Veinott, "Fractional and Sub-fractional horse power electric motors", McGraw Hill International, 1986
5. M.G. Say, " Alternating current Machines", Pitman & Sons, 4th edition, 1976

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	2	2	1								1	2	2	2			
CO2	3	2										1	3	2	2			
CO3	3	3	2	2								1	3	2	1			
CO4	3	2										1	2	1	2			
CO5	3	1										1	3	1	1			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE445**	**Title of the Course**	**ELECTRICAL SYSTEM & SUBSTATION DESIGN**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To develop knowledge of general aspects of electrical system design • Having Knowledge of Medium and HV installations • Having knowledge of installation of transformers, Switchgears and protective devices • To get knowledge of Design of illumination systems • To get the knowledge of different types of substation, Substation equipment and its function.						

Course Outcomes	
CO1	Understands the general aspects of electrical system design
CO2	Selection of main distribution board; Sub distribution board; MCCB, ELCB, MCB and cables for sub circuits
CO3	Understand installation of transformers, Switchgears and protective devices
CO4	Knowledge of Design of illumination systems
CO5	Knowledge of types of substation, substation equipment and its function.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**General Aspects**	National Electric Code (NEC) - scope and safety aspects applicable to low and medium (domestic)voltage installations, Electric services in buildings, Classification of voltages, Standards and specifications, IE Rules, IS Codes, General aspects of the design of electrical installations for domestic buildings – connected load calculation.	8	CO1
2	**Distribution board**	Selection of main distribution board; Sub distribution board; MCCB, ELCB, MCB and cables forsub circuits; Pre-commissioning tests of domestic installations; Medium and HV installations –Selection of cables, Guidelines for cable installation & installation of induction motors.	8	CO2
3	**Transformers**	Selection and installation of transformers, Switchgears and protective devices; Design of indoor and outdoor 11 KV substation up to 630 KVA: Design of Earthing system - Pipe, plate and mat earthing; Lightning arresters; Metering and protection; HT and LT breaker control panels; Selection of standby generator, installation and its protection.	8	CO3
4	**Illumination systems**	Design of illumination systems – Yard lighting, Street lighting and Flood lighting; Design and layout of installation for recreational or assembly buildings and high rise building; Design of Electrical system related to fire fighting, lifts and escalators.	8	CO4
5	**Substation**	Types of Substation, Substation equipment and its function, Bus bar arrangement, Single busbar systems and duplicate bus-bar systems, Capacitor bank, Earthing practices, Substation automation.	8	CO5

Reference Books:

1. M.K.Giridharan, “Electrical System Design”. I.K. International Pvt. Ltd., 2011.
2. Raina & Bhattacharya, “Electrical Design Estimating and Costing”. New Age International,1st Edition, 1991.
3. Bureau of Indian Standards publications, “National Electric Code”, 1986.
4. S.N. Singh, “Electric Power Generation, Transmission & Distribution”, PHI, 2015

1. M.K.Giridharan, “Electrical System Design”. I.K. International Pvt. Ltd., 2011.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	3	2		1								1	3		2			
CO2	3	2					1					1		2				
CO3	3	1										2		3				
CO4	3	2										1		3				
CO5	3	2					1					1	2					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE447**	**Title of the Course**	**ELECTRIC VEHICLES**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	**3**	**1**	**0**	**4**
Pre-Requisite	1. Basic Electrical Engg. 2.Electromechanical Energy Conversion I and II 3.Power Electronics	**Co-requisite**	None				
Course Objectives	• Knowledge of different types of electric vehicles • Knowledge of different types of converters used in electric vehicles • Knowledge of current sensors and speed sensors used in electric vehicles • Knowledge of charge controllers and batteries used in electric vehicles • To identify different types of electric vehicles on the basis of performance						

Course Outcomes	
CO1	Knowledge of different electric vehicles and their environmental impact
CO2	Knowledge of different types of converters used in electric vehicles
CO3	Knowledge of current sensors and speed sensors used in electric vehicles
CO4	Knowledge of charge controllers and batteries used in electric vehicles
CO5	Identify different types of electric vehicles

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction of Electric Vehicles**	Introduction, Types of electric vehicles, History of Electrical Vehicles (EV), Configurations of Electric Vehicles, Relative merits and their limitations, Applications, Environmental impact.	8	CO1
2	**Converters**	Introduction and working of semiconductor power diode, Thyristors and MOSFET. Power electronic converters: DC-DC and DC-AC converters for electric and hybrid vehicles.	8	CO2
3	**Motors & Sensors: EV motors**	PMDC, Series motors, Induction Motors, Switched reluctance motor. Sensors: Hall Effect sensors, optical encoders, current and speed sensing, closed loop speed control of vehicle.	8	CO3
4	**Battery and Charge Controllers: Battery**	Basic, Type, Parameters, Capacity, Discharge Rate, State of Charge, Depth of Discharge, Characteristics, Properties of Batteries. Charge Controllers: Purpose, Working and Limitations.	8	CO4
5	**Electric Vehicles: Hybrid Electric Vehicles**	Types, Performance Parameters, Advantages and Disadvantages, Limitations. Electric Cars: Emerging Trend, Hybrid Cars, Acceleration and Speed Characteristics, Fuel Cell Vehicles: Fundamentals, Advance Hybrid Electric Vehicles	8	CO5

Reference Books:

1. James Larminie, "Electric Vehicle Technology Explained", John Wiley & Sons, 2003.

2.Mehrdad Ehsani, Yimin Gao, Ali Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles Fundamentals", CRC Press, 2010.

3.Sandeep Dharmeja, " Electric Vehicle Battery System", Newnes, 2011

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO4	PSO5	PSO6	PSO7
CO1	2						3					1	2	2	2			
CO2	3					2						1	3	3	2			
CO3		3	2									1	3	2	2			
CO4	3	1										2	2	3	2			
CO5					1		3					2	2	3	2			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2022-23							
Course Code	**EE449**	**Title of the Course**	**ENERGY CONSERVATION AND ENERGY AUDIT**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	**7th**	3	1	0	4
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To Give the basic knowledge of the energy management. • To make aware the students about Lighting System. • To provide the knowledge of decentralized energy supply to agriculture, industry, commercial and household sector. • Assessment of transmission and distribution efficiency, Energy conservation in buildings.						

Course Outcomes	
CO1	Student understands the basic concept of energy, limitations faced in the energy conservation, and classification & importance of energy auditing.
CO2	Ability to understand the concepts of energy audit and produce the knowledge of energy conservation in boiler and steam based systems.
CO3	After completion of the subject, the understanding of the factors affecting the energy conservation and design consideration would be clear.
CO4	For a given refrigeration and air conditioning system, students shall be able to identify its characteristics. Select suitable design of application with various combination for System.
CO5	For a given Energy management system, student shall be able to define its process, different types of control strategies, and compensators.

Unit No.	**Title of the Unit**	**Content of Unit**	**Contact Hrs.**	**Mapped CO**
1	**Introduction**	Energy Scenario, Role of Energy Managers in Industries, Energy monitoring, Auditing & targeting, Economics of various Energy Conservation schemes, Total Energy Systems	8	CO1
2	**Energy Audit**	Energy Audit, Types of energy audit, Identification of energy conservation opportunities, Various Energy Conservation Measures in Steam Losses in Boiler, Energy Conservation in Steam Systems –Case studies.	8	CO2
3	**Energy conservation**	Classification of energy conservation measures, Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressor energy consumption & energy saving potentials, Design consideration.	8	CO3
4	**Refrigeration & Air conditioning**	Heat load estimation, Components of Heating ventilation and air conditioning (HVAC) system, Energy conservation opportunities in HVAC system-Case studies, Energy Efficiency in Lighting-Case studies.	8	CO4
5	**Energy management & process**	Organizational background desired for energy management motivation; Detailed process of M&T; Thermostats; Boiler controls- proportional, differential and integral control; Optimizers; Compensators.	8	CO5

Reference Books:

1. Eastop T.D. & Croft D.R., "Energy Efficiency for Engineers and Technologists", Logman Scientific & Technical, ISBN-0-582-03184, 1990.
2. Reay D.A., "Industrial Energy Conservation", Pergamon Press, 1st edition,1977.
3. Kothari D. P., Nagrath I. J., "Power System Engineering", Tata McGraw-Hill Co., 2nd Ed., 2008.
4. Singh S., Rathore U., "Energy Management", S. K. Kataria & sons, 2nd edition, 2017.

e-Learning Source:

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)																	
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	1	2	3	1					1			1	2	1	2			
CO2	1	3	3	1		1	2	1		1		1	3	1	3			
CO3	1	3	2	2		1	2	1		1		1	2	1	2			
CO4	1	3	2	3		1	2	1		1		1	2	3	2			
CO5	1	2	3	2		1	2	1		1		1	2	1	2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE 402**	**Title of the Course**	**Power system protection lab**	**L**	**T**	**P**	**C**
Year	**4th**	**Semester**	7th	**0**	**0**	**2**	**1**
Pre-Requisite		**Co-requisite**					
Course Objectives	• To understand and experiment with operation of relays. • To understand and experiment with operational characteristics of relays. • To understand and experiment with impedance calculation of transformer. • To understand and experiment with voltage ratio test of Transformer.						

Course Outcomes	
CO1	Adopt, perform, analyze and implement the operational characteristic of under and over voltage relays.
CO2	Adopt, perform, analyze and implement the operational characteristic of IDMT and earth fault relays.
CO3	Adopt, perform, analyze and implement the operational characteristic of differential and thermal relays.
CO4	Adopt, perform, analyze and implement the to study and calculate impedance and transformation ratio of the given transformer.

Exp. No.	**Content of Experiment**	**Contact Hrs.**	**Mapped CO**
1	Operational characteristic of under voltage relay.	2	1
2	Operational characteristics of over voltage relay.	2	1
3	Operational characteristic of IDMT relay.	2	2
4	Operational characteristic of earth fault relay.	2	2
5	Operational characteristic of differential relay.	2	3
6	Operational characteristic of thermal relay.	2	3
7	To study and calculate impedance of the given transformer.	2	4
8	To study and calculate voltage ratio test of the given transformer.	2	4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)															
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	1	2	3							2	2	2		3
CO2	3	3	1	2	3							2	2			3
CO3	3	1	1		3							2	2			3
CO4	3	1	1		3							2	2			3

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Integral University, Lucknow

Effective from Session: 2018-19							
Course Code	**EE404**	**Title of the Course**	**Electric Drive Lab**	**L**	**T**	**P**	**C**
Year	**IV**	**Semester**	VII	**0**	**0**	**2**	**1**
Pre-Requisite		**Co-requisite**	EE403				
Course Objectives	• To impart knowledge on Performance of the fundamental control practices associated with AC and DC machines (starting, reversing, braking, plugging, etc.) using power electronics. • To evaluate the use of microcontroller-based analysis tools to review the major classes of machines and their physical basis for operation.						

Course Outcomes	
CO1	Identify relevant information to supplement to the Electric Drives (EE403) course.
CO2	Set up control strategies to synthesize the voltages in dc and ac motor drives.
CO3	Develop testing and experimental procedures applying basic knowledge in electrical circuit analysis, electrical machines, power electronics, and microprocessors.
CO4	Combine the use of microcontroller-based tools relevant to electrical Drives with practical laboratory experimentation.

Exp. No.	**Content of Experiment**	**Contact Hrs.**	**Mapped CO**
1	To study the single phase half controlled bridge convertor.	2	1,3
2	To study the single phase fully controlled bridge convertor.	2	1,3
3	To study control of 3-phase induction motor using v/f control.	2	1,2
4	To study the dc motor speed controller.	2	1,2
5	To study MOSFET based chopper motor controller.	2	1,4
6	To study micro controller based speed control of 1-phase induction motor by voltage control.	2	1,2,4
7	To study the micro controller based single phase dual converter.	2	1,3,4
8	To study the micro controller based 3-phase fully controlled bridge converter.	2	1,3,4

	Course Articulation Matrix: (Mapping of COs with POs and PSOs)															
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2				1				2	3	2		
CO2	1	3		2	3								3		2	
CO3	2	1	3	2			2		2	1		2		2	1	
CO4	1			1		2					2	2	2		1	

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation