SAGI RAMA KRISHNAM RAJU ENGINEERING COLLEGE
(AUTONOMOUS)
(Affiliated to JNTUK, Kakinada), (Recognized by AICTE, New Delhi)
All UG Programmes are Accredited by NBA
CHINNA AMIRAM (P.O):: BHIMAVARAM :: W.G.Dt., A.P., INDIA :: PIN: 534 204
Estd:1980

ELECTRICAL & ELECTRONICS ENGINEERING
(Accredited by NBA)

SCHEME OF INSTRUCTION & EXAMINATION
(Regulation R19)

IV/IV B.TECH

I-SEMESTER

(With effect from **2019-2020**Admitted Batch onwards**)**

Course Code	Name of the Course	Category	Cr.	L	T	P	Internal Marks	External Marks	Total Marks
B19EE4101	Switchgear and Protection	PC	3	3	--	--	25	75	100
B19EE4102	Solar and Wind Energy Systems	PC	3	3	--	--	25	75	100
B19EE4103	Digital Signal Processing	PC	3	3	--	--	25	75	100
B19EE4104	Electric Vehicles	PC	3	3	--	--	25	75	100
#PE-IV	Professional Elective-IV	PE	3	3	--	--	25	75	100
B19EE4109	Electrical System Simulation Laboratory	PC	1.5	--	--	3	20	30	50
B19EE4110	Solar and Wind Energy Systems Laboratory	PC	1	--	--	2	20	30	50
B19EE4111	Smart Systems Laboratory (Skill development Program)	PR	1	--	--	2	--	50	50
B19EE4112	Project Work-I	PR	2	--	--	4	20	30	50
		TOTAL	**20.5**	**15**	**0**	**11**	**185**	**515**	**700**

	Course Code	Course
#PE-IV	B19EE4105	Computer Architecture and Organization
	B19EE4106	Power Quality
	B19EE4107	Soft Computing Techniques
	B19EE4108	MOOCS – IV

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4101	**PC**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

SWITCHGEAR AND PROTECTION

(For EEE)

Course Objectives: Students will learn

1.	About need for protection and basic principles of arc interruption.
2.	To know the principle of operation, constructional features and testing of circuit breakers.
3.	The principle of operation and different types of protective relays.
4.	The application of electromagnetic relays to power system devices & various devices used for overvoltage protection.
5.	The basics of static and numerical relaying and comparators

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Illustrate** the need for protection, rating of circuit breakers and **analyse** different voltages due to arc interruption.	K3, K4
2.	**Apply** the arc quenching methods and testing on various types of circuit breakers.	K3
3.	**Illustrate** the behaviour of different types of electromagnetic relays and **compute** the operating times by using time-current characteristics.	K3, K4
4.	**Apply** electromagnetic relays to alternator, transformer, feeder and busbar protection and **illustrate** the operation of various protection devices against over voltages.	K3
5.	**Illustrate** the principles of comparators, static and numerical relaying.	K3

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO PROTECTION & CIRCUIT BREAKERS:** Need for protective systems, Nature and causes of faults, Types and effects of faults, Essential qualities of protection, Switchgear Equipment-Isolating Switches. Formation of arc, Methods of arc extinction, Restriking voltage, Recovery voltage, Rate of Rise of Restriking Voltage (RRRV), Single frequency transients, Resistance switching, Current chopping, Ratings of circuit breakers.
UNIT-II (10 Hrs)	**TYPES OF CIRCUIT BREAKERS AND TESTING:** Principle of operation of circuit breakers, Classification of circuit breakers, Construction and working of Air Circuit Breakers, Air Blast Circuit Breakers, Minimum Oil Circuit Breaker (MOCB), Puffer type SF-6 Circuit Breakers and Vacuum Circuit Breakers, Auto reclosure, Testing procedure and Indirect testing of Circuit Breakers.
UNIT-III (10 Hrs)	**PROTECTIVE RELAYS**: Types of relays, Classification of protective Schemes, Primary and Back-up protection, Basic relay terminology. Time–Current characteristics, Calculation of relay operating time-Simple problems, Principle of operation & construction of induction type over current relay, Directional over-

	current relay, Differential relays (Current balanced protection) & percentage differential relays. Universal torque equation, Distance relays – Impedance, Reactance and Mho relays **[only basics].**
UNIT-IV (10 Hrs)	**APPARATUS PROTECTION:** Protection ofAlternators, Transformers, Single and parallel feeders, Bus-Bar, Lightning Arresters, Metal oxide Surge Arrester, Surge Absorber.
UNIT-V (10 Hrs)	**STATIC AND NUMERICAL RELAYING:** Introduction to Static relaying – Advantages and disadvantages of static relays, Basic Block Diagram Comparators: Phase comparator – Phase splitting type, Integrating type, Amplitude comparator – Rectifier Bridge type, Phase splitting type Numerical Protection: Block diagram of a typical numerical relay, Advantages and disadvantages of numerical relays, Block diagrams of Numerical over current, distance, differential relays

Text Books:	
1.	Power System Protection and Switchgear by Badri Ram and D. N. Vishwakarma, Tata McGraw-Hill Education, Second Edition, 2017.
2.	Principles of Power Systems by V. K Mehta and Rohit Mehta, S. Chand publications, Third edition, 2005.
Reference Books:	
1.	Protection and Switchgear by Bhavesh R. Bhalja R. P. Maheshwari Nilesh Chothani , Oxford University Press, Second Edition, 2018.
2.	A Course in Power Systems by J.B Gupta, S.K Kataria and Sons, 2013.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4102	PC	3	--	--	3	25	75	3 Hrs

SOLAR AND WIND ENERGY SYSTEMS

(For EEE)

Course Objectives: Students will learn

1.	About the solar geometry, operation of solar cell and Characteristics, equivalent circuit parameters.
2.	About the Series and Parallel connection of cells, Module design and its protection.
3.	About different Maximum Power Point Tracking (MPPT) techniques and selection of converters for particular PV application.
4.	The basics of wind energy systems and various techniques for the conversion of wind energy into electrical energy.
5.	About the wind generators and modelling of generators in different configurations of wind energy systems.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Apply** the fundamental principles to understand the solar geometry, operation of solar cell and **analyze** its Characteristics, equivalent circuit parameters.	K3, K4
2.	**Design** a PV Module and **analyze** series and parallel interconnection schemes.	K4
3.	**Apply** the MPPT techniques and **analyze** the Operating range of Buck, Boost and Buck-Boost converters.	K3, K4
4.	**Apply** the fundamental of wind energy systems to **illustrate** the wind turbine operation and control.	K3, K4
5.	**Illustrate** various configurations of wind energy conversion systems.	K3

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO SOLAR CELLS AND SOLAR RADIATION** Introduction, sun and the earth, the sun - earth movement, angle of sun rays on solar collector, Estimating and measurement of solar radiation- Solar cell - Generation of Photo voltage, Light generated current, I-V Characteristics. Limits of Cell Parameters - Short circuit current, Open circuit voltage, Fill factor and efficiency. Losses in Solar cell - Model of PV cell, Effect of Series & Shunt Resistance, Solar Radiation and Temperature on Efficiency - Simple problems - Recent trends in Solar Cell Technologies.
UNIT-II (10 Hrs)	**SOLAR PHOTOVOLTAIC MODULES DESIGN** Solar PV Modules from solar cells - Series and Parallel connection of cells – Mismatch in Cell/Module, Mismatch in series connection, Mismatch in Parallel connection, Design and structure of PV Modules-number of solar cells in a module, Wattage of Modules, PV Module Power output - I-V Equation of PV Modules- Ratings of PV Modules- I-V and Power curve of Module – Effect of Solar radiation and Temperature on PV Modules - Data sheet study - Simple problems.
UNIT-III	**SOLAR POWER CONVERSION WITH MPPT**

(10 Hrs)	Applications of Solar systems- Standalone mode- Grid connected mode [Elementary treatment only]. MPPT Concept- Concept of load line - Input Impedance of Buck converter, Boost converter and Buck-Boost Converter- Algorithms for MPPT- Perturb and Observe method, Incremental Conductance method.
UNIT-IV (10 Hrs)	**INTRODUCTION TO WIND ENERGY & WIND TURBINE:** Introduction, Basic Principles of Wind Energy Conversion-Nature of the wind, Power in the wind, Maximum Power, Forces on the Blades, Lift and drag, Site selection considerations, Basic Components of a WECS (Wind Energy Conversion System), Wind Energy Collectors- Horizontal Axial Machines, Vertical axis Machines, Number of Blades. Analysis of Aerodynamic Forces acting on the Blade, Power Characteristics of Wind Turbine, Aerodynamic Power Control: Yaw control, Passive Stall, Active Stall, and Pitch Control, Tip Speed Ratio.
UNIT-V (10 Hrs)	**WIND ENERGY CONVERSION SYSTEM CONFIGURATIONS (WECS)** Introduction, Fixed-Speed WECS, Variable-Speed Induction Generator WECS- Wound Rotor Induction Generator with External Rotor Resistance, Doubly Fed Induction Generator WECS with Reduced Capacity Power Converter, SCIG Wind Energy System with Full-Capacity Power Converters, Variable-Speed Synchronous Generator WECS- Configuration with Full-Capacity Back-to-Back Power Converters, Configuration with Diode Rectifier and DC - DC Converters, Configuration with Distributed Converters for Multi winding Generators.

Text Books:	
1.	"Solar Photovoltaics- fundamentals, Technologies and Applications", Chetan Singh Solanki, PHI learning private limited, 3rd edition, 2018.
2.	G. D. Rai, "Non-Conventional Energy Sources", 5th edition, Khanna Publishers, 2015.
3.	Bin Wu,Yongqiang Lang, Navid Zargari and Samir Kouro, "Power Conversion and Control of Wind Energy Systems ", IEEE Press, 2011.
Reference Books:	
1.	"Wind and Solar Power Systems", Mukund R. Patel, CRC Press, 1999.
2.	S.N Bhadra, S.Banerjee and D.Kastha, "Wind Electrical Systems", Oxford University Press, 1st Edition, 2005.
3.	https://archive.nptel.ac.in/courses/117108141

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4103	PC	3	--	--	3	25	75	3 Hrs

DIGITAL SIGNAL PROCESSING

(For EEE)

Course Objectives: Students will learn

1.	The basic concepts and techniques for processing signals.
2.	About the DTFT, DFT and convolution of sequences.
3.	About the FFT algorithms
4.	About design techniques for IIR digital filters
5.	About design techniques for FIR digital filters and finite word length effects in signal processing.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Apply** Sampling theorem to **analyze** the Discrete time signals, systems and realize digital filters.	K3, K4
2.	**Analyze** discrete signals in the frequency domain and **compute** the linear and circular convolutions of discrete sequences.	K4
3.	**Apply** FFT algorithms to find the DFT of Discrete sequence.	K3, K4
4.	**Design** the IIR filter by considering the given specifications.	K4
5.	**Design** the FIR filter by using window techniques and know the finite word length effects in FIR filter.	K4

SYLLABUS

UNIT-I (10 Hrs)	**DISCRETE - TIME SIGNALS AND SYSTEMS** Signal processing, Advantages,limitations and applications of DSP**.** Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate; Discrete time signals, Sequences; Linear Shift – Invariant Systems, Linear Constant Coefficient Difference Equations, System Function H (Z), Stability, Structure and Realization of Digital Filters.
UNIT-II (10 Hrs)	**DISCRETE TIME FOURIER TRANSFORM (DTFT) & DISCRETE FOURIER TRANSFORM (DFT):** DTFT and its properties Representation of Periodic Sequences, Properties of DFS, DFT and its Properties. Convolution Of Sequences, Long Duration Sequence Filtering.
UNIT-III (10 Hrs)	**FAST – FOURIER TRANSFORMS (FFT):** Radix – 2 Decimation – In – Time (DIT) and Decimation – In – Frequency (DIF) FFT Algorithms, Radix – 2 Inverse DIT- FFT, Radix – 2 Inverse DIF FFT.
UNIT-IV (10 Hrs)	**IIR DIGITAL FILTER DESIGN TECHNIQUES:** General Considerations in Digital Filter Design. IIR Filter Design-Bilinear Transformation Method, Impulse Invariance Technique. Design of IIR Filters from Analog Filters (Butterworth Approximation Only). Frequency Transformations.

UNIT-V (10 Hrs)	**FIR DIGITAL FILTER DESIGN:** Linear Phase FIR filters, Fourier Series Method, Design of FIR Filter Using Windows (Rectangular, Bartlett, Hamming & Hamming Windows). Effect of finite register length in FIR filter design. Comparison of IIR and FIR Filters.
Text Books:	
1.	Alan V. Oppenheim & Ronald W. Schafer: Digital Signal Processing 1st Edition published by Pearson Education.
2.	J. G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms And Applications", Prentice Hall, 1997.
Reference Books:	
1.	P. Ramesh Babu:Digital Signal Processing ,4th Edition ,Scitech Publications.
2.	A. Anand Kumar, "Digital Signal Processing:2nd Edition, PHI Publications, 2015.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4104	**PC**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

ELECTRIC VEHICLES

(For EEE)

Course Objectives: Students will learn

1.	The introductory concepts of EVs and dynamic modelling equations of EVs
2.	The various configurations of EVs and HEVs and power train components.
3.	Various Energy storage systems for EVs and understand their characteristics.
4.	The drive systems of EVs and their control
5.	About the charging technology in EVs.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Analyze** and understand dynamic modelling and design considerations of electrical vehicles.	K4
2.	**Illustrate** the architecture of electric vehicles and power train components.	K3, K4
3.	**Evaluate** battery performance parameters for EVs and understand other energy storage methods for EVs.	K4
4.	**Analyze** and understand the electric drives using power electronic converters for EVs.	K4
5.	**Illustrate** the EV charger infrastructure.	K3, K4

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO ELECTRIC VEHICLES AND MODELING** Introduction to Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), EV History, EV Advantages, Performance of EVs, Comparison of EV with Internal Combustion Engine vehicles, **Vehicle Mechanics and Dynamics modelling**-Roadway Fundamentals, Laws of Motion, Vehicle Load Forces, Vehicle Kinetics, Dynamics of Vehicle Motion, Propulsion Power, Force-Velocity Characteristics, Maximum Gradeability, Velocity and Acceleration for Constant Tractive Force on Level Road, General Acceleration for Nonconstant Tractive Force, Propulsion System Design, Design Considerations.
UNIT-II (10 Hrs)	**ARCHITECTURE OF EVs AND POWER TRAIN COMPONENTS** Architecture of EVs and HEVs – Plug-in Hybrid Electric Vehicles (PHEV), Fuel cell EV, Power train components of EVs - EV Transmission Configurations, Transmission Components, Ideal Gearbox: Steady State Model, and EV Motor Sizing, Standard Drive Cycles.
UNIT-III (10 Hrs)	**ENERGY STORAGE FOR EV** **Battery-** Battery Basics, Different types, Lead Acid Batteries and Lithium Batteries (Li-ion, Li-Polymer), Battery Parameters, Battery Power, Battery modelling, Battery Management system, Battery Pack Design, Lifetime and Sizing Considerations **Alternative Energy Sources**-Fuel cell, Super Capacitors, Ultra capacitors, Flywheel,

	Hydrogen Storage Systems
UNIT-IV (10 Hrs)	**ELECTRIC VEHICLE MOTOR DRIVES** Electric Drive Components of EV, Permanent Magnet Synchronous Motor (PMSM) Drive - PMSM motor operation, types, model, vector control, flux weakening, current and voltage controllers. Brushless DC (BLDC) Motor Drive - BLDC motor operation, model, control. Switched Reluctance Motor (SRM) Drive - SRM motor operation, configuration, SRM converters and controls.
UNIT-V (10 Hrs)	**EV CHARGING TECHNOLOGY** Overview of the EV battery charging system, Infrastructure Needed for Charging Electric Vehicles, Basic Requirements for Charging System, Charger Architectures, Charger Functions, EV Charging Standards, V2G and V2V technologies.

Text Books:	
1.	Iqbal Husain, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, Taylor & Francis Group, 2003.
2.	John G. Hayes and A. Goodarzi, “Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles” Wiley Publication, 1st edition, 2018.
Reference Books:	
1.	James Larmine, John Lowry, “Electric Vehicle Technology Explained” Wiley publication, 2nd edition.
2.	Y. Gao, S. Gay and A. Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press, 2005.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4105	**PE**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

COMPUTER ARCHITECTURE AND ORGANIZATION

(For EEE)

Course Objectives: Students will learn

1.	The concept of register transfer language and micro-operation.
2.	The structure of an instruction code and instruction cycle.
3.	The basic Central Processing unit (CPU) organization.
4.	About Memories and memory management.
5.	About peripheral interfacing and communication.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Acquire** the knowledge of register transfer language and micro-operations useful for the design of ALU.	K3
2.	**Illustrate** the instruction cycle, interrupt cycle, instruction formats, and the register and memory reference instructions.	K3
3.	**Illustrate** the CPU organization and micro program control.	K3
4.	**Explore** different memories and their organization.	K3
5.	**Illustrate** I/O interfacing and different modes of transfer.	K3

SYLLABUS

UNIT-I (10 Hrs)	**REGISTER TRANSFER AND MICRO OPERATIONS**: Register Transfer Language, Register Transfer, Bus and Memory Transfers, Arithmetic Micro operations – Binary Adder, Binary Adder- subtracter, Binary incrementor, Arithmetic circuit, Logic Micro operations, Shift Micro operations, Arithmetic Logic Shift Unit.
UNIT-II (10 Hrs)	**BASIC COMPUTER ORGANIZATION:** Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Register Reference instructions, Memory-Reference Instructions, Input-Output and Interrupt.
UNIT-III (10 Hrs)	**MICRO PROGRAMMED CONTROL:** Control Memory- Control word, Micro instruction, Micro program. Address Sequencing. **CENTRAL PROCESSING UNIT:** Introduction, General Register Organization, Stack Organization, Instruction Formats, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer (RISC)
UNIT-IV (10 Hrs)	**MEMORY ORGANIZATION:** Memory Hierarchy, Main memory, Auxiliary memory, Associate Memory, Cache Memory, and Virtual memory, Memory Management Hardware.

UNIT-V (10 Hrs)	**INPUT/OUTPUT ORGANIZATION:** Peripheral Devices, I/O interface, Asynchronous data transfer, Modes of transfer, priority Interrupt, Direct memory access, Input-Output Processor (IOP), Serial Communication.
Text Books:	
1.	Computer System Architecture, M. Morris Mano, Prentice Hall of India Pvt. Ltd., Third Edition, Sept. 2008.
2.	Carl Hamacher, ZvonksVranesic, SafeaZaky (2002), Computer Organization, 5th edition, McGraw Hill, New Delhi, India.
Reference Books:	
1.	Computer Architecture and Organization, William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, Sixth Edition, 2003
2.	Computer Organization and Architecture, V. Raja Ramam, T. Radha Krishnan. PHI Pvt. Ltd., Eastern Economy Edition, Fourth Printing, July 2011

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4106	**PE**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

POWER QUALITY

(For EEE)

Course Objectives: Students will learn

1.	The significance of power quality and power quality parameters.
2.	About transient over voltages and protection against transient voltages.
3.	About harmonics, their effects and minimization techniques.
4.	About long duration voltage variations and their regulation.
5.	Various power quality issue mitigation techniques in distribution systems.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Acquire** the knowledge of power quality issues and power quality parameters.	K3
2.	**Illustrate** the sources of transient over voltages and protection techniques.	K3
3.	**Analyze** filters for controlling harmonic distortion.	K4
4.	**Analyze** long duration voltage variations and regulation of voltage variations.	K4
5.	**Explore** power quality aspects and protection in distributed generation.	K3

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION** Overview of Power Quality - Concern about the Power Quality - General Classes of Power Quality Problems – Transients -Long-Duration Voltage Variations - Short-Duration Voltage Variations - Voltage Unbalance - Waveform Distortion - Voltage fluctuation - Power Frequency Variations - Voltage Sags and Interruptions -Sources of Sags and Interruptions – Nonlinear loads.
UNIT-II (10 Hrs)	**TRANSIENT OVER VOLTAGES** Source of Transient Over Voltages - Principles of Over Voltage Protection - Devices for Over Voltage Protection - Utility Capacitor Switching Transients - Utility Lightning Protection – Load Switching Transient Problems
UNIT-III (10 Hrs)	**HARMONIC DISTORTION AND SOLUTIONS** Voltage vs. Current Distortion - Harmonics vs. Transients - Power System Quantities Under Non-sinusoidal Conditions - Harmonic Indices – Sources of harmonics - Effects of Harmonic Distortion - Devices for Controlling Harmonic Distortion - Harmonic Filter Design -Control of Harmonics using Passive Filters - Standards on Harmonics.
UNIT-IV (10 Hrs)	**LONG DURATION VOLTAGE VARIATIONS** Principles of Regulating the Voltage - Devices for Voltage Regulation - Utility Voltage Regulator Application - Capacitor for Voltage Regulation - End-user Capacitor Application, Regulating Utility Voltage with Distributed Resources.

UNIT-V (10 Hrs)	**DISTRIBUTED GENERATION AND POWER QUALITY** Resurgence of Distributed Generation - DG Technologies - Interface to the Utility System Power Quality Issues - Operating Conflicts - DG on Low Voltage Distribution Networks - Interconnection standards.
Text Books:	
1.	Electrical Power Systems Quality, Dugan R C, Mc Granaghan M F, Santoso S, and Beaty H W, Third Edition, McGraw-Hill, 2012
2.	Bhim Singh, Ambrish Chandra, Kamal Al-Haddad, “Power Quality Problems and Mitigation Techniques” Wiley Publications, 2015.
Reference Books:	
1.	Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J, First Edition, IEEE Press; 2000.
2.	Power Quality Enhancement Using Custom Power Devices – Power Electronics and Power Systems, Gerard Ledwich, ArindamGhosh, Kluwer Academic Publishers, 1st ed,2002.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4107	PE	3	--	--	3	25	75	3 Hrs

SOFT COMPUTING TECHNIQUES

(For EEE)

Course Objectives: Students will learn

1.	The Need for Soft Computing Techniques in Engineering.
2.	About Fuzzy Logic and applications to Electrical Engineering problems.
3.	About Neural Networks to Various Forecasting Problems of Electrical Engineering
4.	About Genetic Algorithm to Find Optimal Solutions of Engineering Problems
5.	About Particle Swarm Optimization Algorithm to Find Optimal Solutions of Engineering Problems

Course Outcomes: Students will be able to

Sl. No	Outcomes	Knowledge Level
1.	**Examine** the Feasibility of Applying Soft Computing Techniques.	K3
2.	**Apply** Fuzzy Logic to **Design** Intelligent Controllers for Electrical Systems	K3, K4
3.	**Apply** Artificial Neural Networks to **Identify** Engineering Prediction Models	K3, K4
4.	**Apply** Genetic Algorithm to **Identify** Optimal Solutions of Engineering Problems	K3, K4
5.	**Apply** Particle Swarm Optimization to **Identify** Optimal Solutions of Engineering Problems	K3, K4

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO SOFT COMPUTING** Introduction to Soft Computing (SC), Artificial Intelligence (AI), Historical Background, Applications of Soft Computing and AI, Conventional Rule-based Systems versus Expert Systems and Knowledge-based Systems. Significance of Soft Computing-Linear Regression (LR) Mathematical Model with ‘N’ Data Points, Identification of LR Model with SC Techniques, Role of Soft Computing and AI in Engineering, Merits and Demerits of SC.
UNIT-II (10 Hrs)	**FUZZY LOGIC SYSTEM (FLS)** Introduction to Fuzzy, Historical Background of Fuzzy logic, Crisp Sets- Operations, Properties and Relations, Fuzzy Sets- Membership Functions, Basic Operations, Properties and Fuzzy Relations, Fuzzy System-Fuzzy Quantifiers, Fuzzy Inference and Defuzzification Methods, Fuzzy Rule-based Systems (IF-THEN), Application of Fuzzy Logic System for Basic Electrical DC Motor Control Problem.
UNIT-III (10 Hrs)	**ARTIFICIAL NEURAL NETWORKS (ANN)** Introduction to ANN, Biological Neural Networks, Framework of ANN-Terminology, Notation, Processing Units, Connections, Activation Functions and Output Rules. McCulloch-Pitts Neuron Model, Single Layer Neural Networks-Perceptron and ADALINE, Multilayer Neural Networks, Recurrent Neural Networks (Elementary Structures), Learning Methods-Back Propagation Algorithm, Application of ANN for Electrical Load Forecasting Problem

UNIT-IV (10 Hrs)	**GENETIC ALGORITHMS (GA)** Introduction to GA, Prerequisites-Objective Function, Constraints and Solution Search Space, Genetic Algorithm (GA)- Historical Background of GA, Working Principle, Encoding, Fitness Function, Reproduction, Crossover, Mutation and Convergence Criteria. Solution of Single Variable Unconstrained Problems using GA (Problems with Hand Calculations)
UNIT-V (10 Hrs)	**PARTICLE SWARM OPTIMIZATION (PSO)** Introduction to PSO, Population Search-based Algorithms-Overview, Terminology, Common Parameters of PSO-Population Size and Iterations, Control Parameters of PSO-Acceleration Coefficients and Inertia Weight. Updating Mechanisms of PSO, Convergence Criteria of PSO, Solution of Single Variable Unconstrained Problems using PSO (Problems with Hand Calculations)
Text Books:	
1.	Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Pai – PHI Publication, 2003
2.	Soft Computing with MATLAB Programming-N.P. Padhy, S.P. Simon. Oxford University Press, 2015.
Reference Books:	
1.	Introduction to Neural Networks using MATLAB 6.0 - S.N. Sivanandam, S. Sumathi, S.N. Deepa, TMH, 2006
2.	Intelligent Systems-Modelling, Optimization and Control, Yung C.Shin, C. Xu, CRC Press, 2008.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4109	**PC**	**--**	**--**	**3**	**1.5**	**20**	**30**	**3 Hrs**

ELECTRICAL SYSTEM SIMULATION LABORATORY

(For EEE)

Course Objectives: Student will learn

1.	To write MATLAB programs for Y-bus formation, load flow, Economic Load Dispatch.
2.	To write MATLAB programs for obtaining Symmetrical components and fault analysis.
3.	To make SIMULINK models for solving swing equation and load frequency control of single area system
4.	About SIMULINK models for Rectifier, Inverter, Chopper, AC Voltage controller & Cycloconverter.
5.	About the functioning of PF correction & Effect of shading in PV array using PSCAD software.

Course Outcomes: Studentswill be able to

Sl.No	Outcome	Knowledge Level
1.	**Compute** the Y-bus and solve GS load flow, Economic Load Dispatch using MATLAB Programming.	**K4**
2.	**Compute** the symmetrical components and LG, LLG fault currents using MATLAB Programming / SIMULINK.	**K4**
3.	**Construct** the model of swing equation for assessing transient stability, load frequency control of single area system using MATLAB/ SIMULINK software.	**K4**
4.	**Construct** the simulation models to **illustrate** the operation of Rectifier, Inverter, Chopper, AC Voltage controller and Cycloconverter using MATLAB/SIMULINK software	**K4**
5.	**Construct** the EMTP models to **illustrate** the functioning of PF correction & Effect of shading in PV array using PSCAD and ETAP softwares.	**K4**

LIST OF EXPERIMENTS / PROGRAMS

1	Y-bus formation by direct inspection method
2	Power flow solution by Gauss-seidel method using MATLAB
3	Economic load dispatch
4	Symmetrical components
5	LG & LLG Fault analysis
6	Transient stability using swing curve
7	Single Phase controlled & uncontrolled rectifier fed R & RL load
8	Three-phase SPWM (phase-shift) inverter with R load
9	DC-DC Boost converter (Chopper)
10	Single phase AC voltage controller with R & RL load
11	PF improvement of a lagging load using PSCAD software.
12	Effect of shading a single module in aphotovoltaic array using PSCAD software.
ADD ON EXPERIMENTS	
13	Power flow solution by Gauss-seidel method using ETAP software
14	Automatic generation control in a Single area isolated power system
15	Single phase bridge type cycloconverter with R-Load

Reference Books:

1.	Power System Analysis Haadi Saadat IInd edition, McGraw-Hill College1998
2.	Power Electronics by Dr. P. S Bimbra, Khanna Publications, 3rd edition, reprint 2021

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4110	PC	--	--	2	1	20	30	3 Hrs

SOLAR AND WIND ENERGY SYSTEMS LABORATORY

(For EEE)

Course Objectives: Students will learn

1.	About Photovoltaic (PV) panels and connections and characteristics of a PV Module.
2.	About Partial shading effect and its mitigation principles.
3.	About PV Off-Grid and ON-Grid mode configurations.
4.	To estimate required number of PV panels and their connections.
5.	Performance of wind turbine at various wind speed and load conditions

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Plot** and **analyse** the performance Characteristics of a PV Module	K4
2.	**Illustrate** partial shading effect on PV Modules and its mitigation.	K4
3.	**Analyse** the Standalone and Grid connected PV systems.	K4
4.	**Estimate** the required number of PV panels and configuration for a given load.	K5
5.	**Illustrate** the performance of wind turbine at various wind speed and load	K4

LIST OF EXPERIMENTS / PROGRAMS

1.	Plot the I-V and P-V Characteristics for a given PV Module at various Irradiance levels
2.	Plot the I-V and P-V characteristics for Series, Parallel and series-parallel connection of PV Panels
3.	Performance of PV modules under partially shaded conditions and its mitigation
4.	Effect of tilt angle on PV module performance
5.	Static reconfiguration of PV modules under partial shading.
6.	Off-Grid mode of PV connection
7.	On-Grid mode of PV connection
8.	Estimation and Design of PV modules for a given load.
9.	Effect of Air Velocity on the output of a Wind Turbine
10.	Effect of Load on the output of a Wind Turbine
	Add-On Experiment
11.	Study of Street light connection
12.	Maximum Power Output from a wind turbine

Reference Books:

1.	Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications" PHI Publication, 3rd edition.
2.	Mukund R. Patel "Wind and Solar Power Systems", CRC Press, 1999.
3.	https://archive.nptel.ac.in/courses/117108141

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4111	**PR**	**--**	**--**	**2**	**1**	**--**	**50**	**3 Hrs**

SMART SYSTEMS LABORATORY

(For EEE)

Course Objectives: Students will learn

1.	About Arduino / Node MCU boards and their applications.
2.	About the operation of various sensors and actuators using Arduino / Node MCU
3.	To interface display devices with Arduino / Node MCU.
4.	About wireless communication technologies.
5.	About automation principles using IOT devices.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Demonstrate** Arduino and Node MCU usage and applications.	K3
2.	**Interface** display devices with Arduino / Node MCU	K4
3.	**Interface** various sensors to Processor boards.	K4
4.	**Apply** Bluetooth and Cloud technology for wireless communication.	K3
5.	**Develop** automation of a system using IoT devices.	K4

LIST OF EXPERIMENTS / PROGRAMS

1.	Familiarization with Arduino, Node MCU and perform necessary software installation.
2.	Interfacing of 7 Segment Display/LCD Display with Arduino board.
3.	Interfacing Analog Input and Digital Output boards with Arduino board.
4.	Interfacing Ultrasonic and PIR sensors with Arduino board.
5.	Program to interface LED/Buzzer with Arduino to turn ON LED.
6.	Program to interface Push button/Digital sensor (IR/LDR) with Arduino to turn ON LED.
7.	Program to interface sensors with Arduino to display temperature and humidity.
8.	Program to interface a smartphone with Arduino to turn LED ON/OFF using Bluetooth.
9.	Smart Energy Monitoring.
10.	Cloud based control of motor using MQTT protocol.

Reference Books:

1.	Massimo Banzi, "Getting Started with Arduino", First Edition, February 2009, O'Reilly Media, Inc
2.	Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1 st Edition, VPT, 2014.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4112	PR	--	--	4	2	20	30	3 Hrs.

PROJECT WORK - I
(For EEE)

Course Objectives: Students will learn

1	To survey and study the published literature on the selected problem
2	The existing methodologies related to their selected problem
3	To identify the objective from gaps present in literature.
4	The necessity of tools and components in order to initiate their project.
5	To write report and deliver presentation orally regarding their project works.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1	**Identify** a problem through literature survey/area/case studies	K3
2	**Analyze** the existing methodologies to indentify the research gaps.	K4
3	**Identify** the objectives from the gaps and propose solution for solving objective	K4
4	**Identify** the required tools & components to initiate the project/process at the laboratory level.	K4
5	**Write** a detailed report, and also present the merits & demerits between existing and proposed solution orally.	K6

*The object of Project Work I is to enable the student to take up investigative study in the broad field of Electrical and Electronics Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or a group of students, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work.

The assignment to normally include:

a) Survey and study of published literature on the assigned topic.
b) Working out a preliminary approach to the problem relating to the assigned topic.
c) Conducting preliminary Analysis/Modeling/Simulation/Experiment/Design/ Feasibility.
d) Preparing a written report on the study conducted for presentation to the department.
e) Final Seminar, as oral Presentation before a departmental committee.

ELECTRICAL & ELECTRONICS ENGINEERING
(Accredited by NBA)

SCHEME OF INSTRUCTION & EXAMINATION
(Regulation R19)
IV/IV B.TECH
II-SEMESTER
(With effect from **2019-2020**Admitted Batch onwards**)**

Course Code	Name of the Course	Category	Cr.	L	T	P	Internal Marks	External Marks	Total Marks
B19EE4201	Power System Operation and Control	PC	3	3	--	--	25	75	100
#PE-V	Professional Elective-V	PE	3	3	--	--	25	75	100
#OE-II	Open Elective-II	OE	3	3	--	--	25	75	100
B19EE4206	Project Phase -II	PR	8	--	--	16	60	90	150
		TOTAL	**17**	**9**	**--**	**16**	**135**	**315**	**450**

	Course Code	Course
#PE-V	B19EE4202	High Voltage Engineering
	B19EE4203	Power Electronics for Renewable Energy
	B19EE4204	HVDC Transmission
	B19EE4205	MOOCS - V
#OE-II	Student has to study one Open Elective offered by CE or CSE or ECE or IT or ME or S&H from the list enclose	

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4201	**PC**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

POWER SYSTEM OPERATION AND CONTROL

(For EEE)

Course Objectives: Students will Learn

1.	About optimal dispatch of generation with and without losses
2.	About optimal scheduling of hydro thermal systems and unit commitment.
3.	The load frequency control for single area system with and without controllers
4.	The load frequency control for two area system with Tie-line bias, Economic dispatch control, automatic voltage control, generator constraints and governor dead band.
5.	About stability enhancement methods, preventive and emergency control.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Compute** the economic load scheduling for Thermal power plants.	K3
2.	**Illustrate** the concepts of hydro thermal systems and unit commitment.	K3
3.	**Analyze** the frequency deviations of a single area power system.	K4
4.	**Analyze** the Load frequency control of a Two area system with tie-line bias and illustrate the concepts of automatic voltage control, generator constraints and governor dead band.	K3, K4
5.	**Apply** the knowledge of engineering fundamentals to assess the stability enhancement methods and preventive & emergency control.	K3

SYLLABUS

UNIT-I (10 Hrs)	**ECONOMIC OPERATION OF POWER SYSTEMS** Optimal operation of Generators in Thermal power stations, Heat rate curve, Cost Curve, Incremental fuel and Production costs, Input–output characteristics, Optimum generation allocation with line losses neglected, Optimum generation allocation including the effect of transmission line losses, Loss Coefficients, General transmission line loss formula.
UNIT-II (10 Hrs)	**HYDROTHERMAL SCHEDULING** Optimal scheduling of Hydrothermal System: Mathematical formulation – Solution of hydrothermal scheduling problem. **UNIT COMMITMENT** Need for unit commitment, Constraints in unit commitment, Cost function formulation, Solution methods, Priority ordering, Dynamic programming.
UNIT-III (10 Hrs)	**LOAD FREQUENCY CONTROL-I** Mathematical modeling of speed governing system, Transfer function, Turbine Modeling, Necessity of keeping frequency constant, Definitions of Control area, Single area control system, Block diagram representation of an isolated power system, Steady state analysis, Dynamic response, Uncontrolled case. Proportional plus Integral control of single area and its

	block diagram representation – Steady state response.
UNIT-IV (10 Hrs)	**LOAD FREQUENCY CONTROL-II** Block diagram development of Load Frequency Control of two area system uncontrolled case and controlled case. Tie-line bias control. Load Frequency Control and Economic dispatch control. Automatic voltage control, Load frequency control with generation rate constraints, Speed Governor dead band and its effects on AGC.
UNIT-V (10 Hrs)	**PREVENTIVE AND EMERGENCY CONTROL:** Concepts of Preventive and Emergency Control, Coherent Area Dynamics, Stability Enhancement Methods, Long Term Frequency Dynamics, Average System Frequency, Centre of Inertia.

Text Books:

1.	Modern Power System Analysis - by I.J.Nagrath&D.P.Kothari, Tata McGraw-Hill Publishing Company ltd, 2nd edition.
2.	Electrical Energy Systems Theory - by O.I.Elgerd, Tata McGraw-Hill Publishing Company Ltd, 2nd edition.

Reference Books:

1.	Power Generation, Operation and Control - by A.J. Wood and B.F.Wollenberg,John Wiley& sons Inc. 1984.
2.	Power System Analysis by HadiSadat, Third Edition, Tata McGraw Hill publication.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4202	**PE**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

HIGH VOLTAGE ENGINEERING

(For EEE)

Course Objectives: Students will learn

1.	About various types of over voltages in power systems, electric field distribution and computation in different configuration of electrode systems.
2.	To understand HV breakdown phenomena in gases, liquids and solid dielectrics.
3.	About the generation of HV DC, AC and Impulse voltages and currents.
4.	Different methods of measuring HV AC, DC and Impulse voltages and currents
5.	About the HV testing apparatus and industrial applications.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Apply** the knowledge of over voltages, electric stress and field configuration to compute electric fields.	K3
2.	**Explore** the breakdown behaviour of solid, liquid and gaseous dielectric materials.	K3
3.	**Illustrate** the generation of High AC, DC & Impulse voltages and currents.	K3
4.	**Apply** different methods to measure High AC, DC & Impulse voltages and currents.	K3
5.	**Analyse** the different electrical apparatus used in HV engineering and industrial applications.	K4

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO HIGH VOLTAGE ENGINEERING** Electric Field Stresses – Uniform and non–uniform field configuration of electrodes – Estimation and control of electric Stress – Numerical methods for electric field computation. Over voltages in power systems: Causes of over voltages and its effects on power system – Lightning, switching surges and other abnormal conditions, Corona and its effects
UNIT-II (10 Hrs)	**BREAK DOWN PHENOMENON FOR UNIFORM FIELDS IN GASEOUS, LIQUID AND SOLID INSULATION** Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases – Paschen's law – Liquid as Insulator – Pure and commercial liquids – Breakdown in pure and commercial liquid – Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown –Breakdown of solid dielectrics in practice.
UNIT-III (10 Hrs)	**GENERATION OF HIGH VOLTAGES AND HIGH CURRENTS** Generation of High DC voltages: Rectifiers, voltage multipliers, Van de graf generators: generation of high impulse voltages: single and multistage Marx circuits- generation of high

	AC voltages: cascaded transformers, resonant transformers and tesla coils. Generation of high impulse currents – triggering and control of impulse generators.
UNIT-IV (10 Hrs)	**MEASUREMENT OF HIGH VOLTAGES AND HIGH CURRENTS** High resistance with series ammeter – dividers, resistance, capacitance and Mixed dividers – peak voltmeter, Generating voltmeters – capacitance voltage transformers, Electrostatic voltmeters – sphere gaps, measurement of high current – resistive shunts, Rogowski coil.
UNIT-V (10 Hrs)	**HIGH VOLTAGE ELECTRICAL APPARATUS** Measurement of DC resistivity – Measurement of dielectric constant and loss factor – Partial discharge measurements. Industrial Applications to High Voltage Engineering Electro Static applications – Electro static precipitator, Electro static separator, Electro static coating, pulsed power engineering.

Text Books:

1.	M S Naidu and V Kamaraju, “High Voltage Engineering”, Tata McGraw Hill, 3rd Edition, 2004.
2.	C L Wadhwa, “High Voltage Engineering”, New Age Publications, 3rd Edition, 2012.

Reference Books:

1.	E Kuffel and W S Zaengl, “High Voltage Engineering Fundamentals”, Pergamon Press, Oxford, London, 1986.
2.	E Kuffel and M Abdullah, “High Voltage Engineering”, Pergamon Press, Oxford, 1970.

Course Code	Category	L	T	P	C	I.M	E.M
B19EE4203	PE	3	--	--	3	25	75

POWER ELECTRONICS FOR RENEWABLE ENERGY

(For EEE)

Course Objectives: Students will learn

1.	The importance of renewable energy and their interconnections
2.	The Power electronic topologies in PV systems and the importance of MPPT
3.	The Power electronics usage for wind power
4.	The fundamentals of Small Hydroelectric systems and their operation using Power Electronics.
5.	The basic configurations of power conversion system for Fuel cells

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Apply** the fundamentals of physics to understand the principles of renewable power generation and their interconnections.	K3
2.	**Apply** the Power Electronics to enhance the performance of the PV system.	K3
3.	**Illustrate** different wind generations and their interconnection to grid	K3
4.	**Illustrate** different topologies of small hydroelectric systems and their operation.	K3
5.	**Apply** the concepts of Power electronics to fuel cell systems.	K3

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION TO RENEWABLE ENERGY:** Introduction, Energy and Power, Renewable Energy Generation systems, Photovoltaic systems, Wind Energy systems, Hydro power systems, Fuel Cells, Renewable Energy sources Interconnection, Attributes of power electronics for renewable energy systems.
UNIT-II (10 Hrs)	**PHOTOVOLTAIC POWER ELECTRONICS:** PV basics, PV modules and strings, Mismatch losses, PV system configurations- Module, String and Central Inverters, Power electronic topologies and associated control techniques in Standalone and Grid connected systems, MPPT operation with Buck, Boost and Buck-Boost converters.
UNIT-III (10 Hrs)	**WIND POWER GENERATION:** Wind Energy Basics, Wind turbines, Wind generators, Power Electronics for Wind power, Back-to-Back PWM VSI for DFIG Turbines, Back-to-Back PWM VSI for Full Converter.
UNIT-IV (10 Hrs)	**SMALL HYDROELECTRIC SYSTEMS:** Hydro power basics, Operation of PMSG, Types of PMSG, Topologies for Hydro power connection, Power Electronic Controls for Three-Phase Generators Operating in Single-Phase Mode.

UNIT-V (10 Hrs)	**FUEL CELL SYSTEMS:** Fuel Cell Basics, Power Electronic Converter for Fuel Cell, Basic configurations of power conversion system (PCS) for FC, DC-DC converters high gain Boost converters, Bidirectional converters, difference between isolated and non-isolated converters, Fly back converter.

Text Books:

1.	Power electronics for renewable and Distributed Energy Systems - Sudipta Chakraborty- Springer, 2013.
2.	Power Electronics: Circuits Devices and Applications – M.H. Rashid, Prentice Hall of India, 4 th edition.

Reference Books:

1.	Solar Photovoltaics, Fundamentals, Technologies and Applications, Chetan Singh Solanki, Third Edition
2.	Fundamentals and Applications of Renewable Energy by Mehmet Kanoglu , Yunus A. Cengel , John M. Cimbala.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4204	**PE**	**3**	**--**	**--**	**3**	**25**	**75**	**3 Hrs**

HVDC TRANSMISSION

(For EEE)

Course Objectives: Students will learn

1.	The concept of HVDC Transmission system.
2.	About Voltage Source Converter (VSC) based HVDC system.
3.	About the control aspects of HVDC system.
4.	About the Harmonics Generation and Suppression in HVDC system.
5.	About the Multi Terminal HVDC systems and their operation.

Course Outcomes: Students will be able to

Sl.No	Outcome	Knowledge Level
1.	**Compare** the HVDC transmission and conventional AC transmission.	K3
2.	**Explore** the VSC with respect to Graetz converter with and without overlap.	K3
3.	**Describe** various methods of controlling HVDC systems	K3
4.	**Examine** the generation of harmonic and necessity of filters in HVDC systems.	K3
5.	**Compare** the existing HVDC systems with MTDC systems.	K3

SYLLABUS

UNIT-I (10 Hrs)	**INTRODUCTION:** Types of HVDC systems, Equipment required for HVDC systems, Comparison of AC & DC Transmission, Limitations and Reliability of HVDC Systems. HVDC-VSC Transmission System.
UNIT-II (10 Hrs)	**HVDC - VOLTAGE SOURCE CONVERTERS** Principle & Operation, 6- Pulse Graetz Converter, Analysis of Graetz circuit with and without overlap, Complete Characteristics of Converter as Rectifier and Inverter, Comparison between Classical HVDC and HVDC-VSC.
UNIT-III (10 Hrs)	**CONTROL OF HVDC SYSTEMS** Principles of DC link control, Converter control characteristics, System control hierarchy, firing angle control, Current and extinction angle control, Starting and stopping of DC link.
UNIT-IV (10 Hrs)	**HARMONICS IN HVDC SYSTEMS:** Generation, Characteristic & Non-Characteristic Harmonics, Suppression using AC and DC Filters.
UNIT-V (10 Hrs)	**MULTI - TERMINAL HVDC SYSTEMS:** Types of MTDC Systems, parallel operation aspects of MTDC systems, Control of power

	in MTDC, Applications of MTDC, Study of VSC-MTDC Systems.
Text Books:	
1.	"K. R. Padiyar", HVDC Power Transmission Systems: Technology and system Interactions, New Age International (P) Limited, and Publishers, 1990.
2.	"S K Kamakshaiah, V Kamaraju", HVDC Transmission, TMH Publishers, 2011.
Reference Books:	
1.	"Jos Arrillaga", HVDC Transmission, The institution of electrical engineers, IEE power & energy series 29, 2nd edition 1998.
2.	"E. Uhlmann", Power Transmission by Direct Current, B. S. Publications, 2009.

Course Code	Category	L	T	P	C	I.M	E.M	Exam
B19EE4206	PR	--	--	16	8	60	90	3 Hrs.

PROJECT WORK - II

(For EEE)

Course Objectives: Students will learn

1	To work in self & teams to overcome the issues related to electrical engineering.
2	To undertake problem formulation and its solutions.
3	To design, build and test a system with hardware /software.
4	To develop a prototype/model of the project work.
5	To prepare documentation in standard format and communicate technical concepts

Course Outcomes: Students are able to

Sl.No	Outcome	Knowledge Level
1	**Demonstrate** a sound technical knowledge of their selected project topic as individual and team in extension to phase-I project.	K3
2	**Investigate** the selected problem in depth and propose solution.	K4
3	**Design** solutions to complex electrical engineering problems utilizing software/hardware approach.	K5
4	**Develop** the project within the available resources, in stipulated time and with ethical values & social responsibility.	K5
5	**Write** the documentation in standard format and communicate orally in a professional manner enhancing self-study and lifelong learning abilities.	K6

*The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under Project Work I, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership.

The assignment to normally include:

a) In depth study of the topic assigned in light of Report prepared under Project Work I.
b) Review and finalization of the approach to the problem relating to the assigned topic.
c) Preparing an Action Plan for conducting the investigation, including team work.
d) Detailed Analysis/ Modeling/Simulation/Design/Problem Solving/Experiment as needed.
e) Final development of product/process, testing, results, conclusions and future directions.
f) Preparing a paper for Conference presentation/publication in Journals, if possible.
g) Preparing a dissertation in the standard format for being evaluated by the department.