



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**IV Year – I SEMESTER**

S. No	Course Code	Subjects	Category	L	T	P	Credits
1		Switchgear & Protection	EE	3	--	--	3
2		OOPs through JAVA	ES	3	--	--	3
3		Renewable Energy Systems	EE	3	--	--	3
4		<b>Elective – II</b>	EL	3	--	--	3
5		<b>Elective - III</b>	EL	3	--	--	3
6		Linear & Digital IC Applications Laboratory	ES	--	--	2	1
7		Power Systems& Simulation Laboratory	EE	--	--	2	1
		Industrial Training /Skill Development Programmes / Research Project	Project	--	--	2	1
8		Project-I	Project			4	2
<b>Total Credits</b>				<b>15</b>	<b>0</b>	<b>10</b>	<b>20</b>

**IV Year – II SEMESTER**

S. No	Course Code	Subjects	Category	L	T	P	Credits
1		Power System Operation & Control	EE	3	--	--	3
2		<b>Open Elective - II</b>	OE	3	--	--	3
3		<b>Elective - IV</b>	EL	3	--	--	3
4		Project-II	Project	--	--	16	8
<b>Total Credits</b>				<b>09</b>		<b>16</b>	<b>17</b>

**BS – Basic Sciences**

**HS – Humanity Sciences**

**ES – Engineering Sciences**

**EE – Electrical Engineering**

**OE – Open Elective**

**EL – Elective**

**Proj- Project**

**MC–Mandatory Course**



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>POWER SYSTEM OPERATION AND CONTROL</b>					

**Preamble:**

This subject deals with Economic operation of Power Systems, Hydrothermal scheduling and modeling of turbines, generators and automatic controllers. It emphasizes on single area and two area load frequency control and reactive power control.

**Learning Objectives:**

- To understand optimal dispatch of generation with and without losses.
- To study the optimal scheduling of hydro thermal systems.
- To study the optimal unit commitment problem.
- To study the load frequency control for single area system with and without controllers
- .To study the load frequency control for two area system with and without controllers
- To understand the reactive power control and compensation of transmission lines.

**UNIT-I:**

**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:**

**Hydrothermal Scheduling & Unit Commitment**

Optimal scheduling of Hydrothermal System: Mathematical Formulation – Solution Technique. Optimal unit commitment problem – Need for unit commitment – Constraints in unit commitment – Cost function formulation – Solution methods – Priority ordering – Dynamic programming.

**UNIT-III:**

**Load Frequency Control-I**

Modeling of steam turbine – Generator – Mathematical modeling of speed governing system – Transfer function – 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.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**UNIT-IV:**

**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.

**UNIT-V:**

**Compensation in Power Systems**

Overview of Reactive Power control – Reactive Power compensation in transmission systems – Advantages and disadvantages of different types of compensating equipment for transmission systems – Load compensation – Specifications of load compensator – compensated transmission lines – Introduction of FACTS devices – Types of FACTS devices - Need of FACTS controllers.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- compute optimal scheduling of Generators.
- understand hydrothermal scheduling.
- understand the unit commitment problem.
- understand importance of the frequency.
- understand importance of PID controllers in single area and two area systems.
- understand reactive power control and compensation for transmission line.

**Text Books:**

1. Power Generation, Operation and Control by Allen J Wood, Bruce F WollenBerg 3<sup>rd</sup> Edition, Wiley Publication 2014.
2. Electric Energy systems Theory – by O.I.Elgerd, Tata McGraw–hill Publishing Company Ltd., Second edition.
2. Modern Power System Analysis – by I.J.Nagrath&D.P.Kothari Tata McGraw Hill Publishing Company Ltd, 2nd edition.

**Reference Books:**

1. Power System Analysis and Design by J.Duncan Glover and M.S.Sarma., Thompson, 3<sup>rd</sup>Edition.
3. Power System Analysis by Grainger and Stevenson, Tata McGraw Hill.
4. Power System Analysis by HadiSaadat – TMH Edition.
5. Power System stability & control, PrabhaKundur, TMH



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>MEASUREMENTS AND INSTRUMENTATION</b> (OPEN ELECTIVE-II)					

**Preamble:**

This course introduces the principle of operation of basic analog and digital measuring instruments for measurement of current, voltage, power, energy etc. Measurement of resistance, inductance and capacitance by using bridge circuits will be discussed in detail. It is expected that student will be thorough with various measuring techniques that are required for an electrical engineer.

**Learning Objectives:**

- To study the principle of operation and working of different types of instruments for measurement of Electrical Quantities.
- To study the working principle of operation of different types of instruments for measurement of power and power factor.
- To understand the principle of operation and working of various types of bridges for measurement of parameters –resistance, inductance, capacitance and frequency.
- To understand the principle of operation and working of transducers.
- To study the principle of operation and working of DVMS, Power analyser and applications of CRO.

**UNIT-I:**

**Analog Ammeter and Voltmeters**

Classification – deflecting, control and damping torques,– PMMC, Moving Iron type and Electrostatic instruments, Construction, Torque equation, advantages and disadvantages. Instrument transformers: Current Transformer and Potential Transformer-construction, theory, (Without derivation of ratio and phase angle error) - Numerical Problems.

**UNIT –II:**

**Analog Wattmeters and Power Factor Meters**

Electrodynamometer type wattmeter (LPF and UPF), Power factor meters: Dynamometer and M.I type (Single phase), construction, theory, torque equation, advantages and disadvantages - Numerical Problems.

**UNIT – III:**

**Measurements of Electrical parameters**

**DC Bridges:** Method of measuring low, medium and high resistance – Kelvin’s double bridge for measurement low resistance, Wheatstone bridge for measurement of medium resistance - Loss of charge method for measurement of high resistance, Megger – measurement of earth resistance - Numerical Problems.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**AC Bridges:** Measurement of inductance and quality factor, Maxwell's bridge, measurement of capacitance and loss angle, Desauty's bridge, Schering Bridge, Wien's bridge- Numerical Problems.

**UNIT – IV:**

**Transducers**

Classification, Resistive, Inductive and Capacitive Transducer, LVDT, Strain Gauge, Thermistors, Thermocouples, Piezo electric and Photo Diode Transducers, Digital shaft encoders, Hall effect sensors- Numerical Problems.

**UNIT – V:**

**Digital meters**

Digital voltmeter – Successive approximation DVM, – Digital frequency meter, Digital multimeter, Digital tachometer, Digital Energy Meter, LCRQ - Meter,

**Learning Outcomes:**

After the completion of the course the student should be able to:

- choose right type of instrument for measurement of ac and dc Electrical quantities.
- choose right type of instrument for measurement of power and power factor.
- select right type for measurement of R, L,C.
- understand the effectiveness of Transducer.
- understand Digital Meters.

**Text Books:**

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis, fifth Edition, Wheeler Publishing.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper, PHI, 5th Edition, 2002.

**Reference Books:**

1. Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai &Co.Publications.
2. Electrical and Electronic Measurements and instrumentation by R.K.Rajput, S.Chand.
3. Electrical Measurements by Buckingham and Price, Prentice – Hall
4. Electrical Measurements by Forest K. Harris. John Wiley and Sons
5. Electrical Measurements: Fundamentals, Concepts, Applications by Reissland, M.U, New Age International (P) Limited, Publishers.
6. Electrical and Electronic Measurements by G.K.Banerjee, PHI Learning Private Ltd, New Delhi–2012.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>FUNDAMENTALS OF UTILIZATION OF ELECTRICAL ENERGY (OPEN ELECTIVE -II)</b>					

**Preamble:**

In the modern society, every engineer is using electrical energy irrespective of their branch of specialization. To provide knowledge about the various electrical energy utilization technologies to non-electrical engineering students this course is developed. In this course, a detailed description about the various sources of electrical energy, illumination requirements and energy conservation, various techniques used for heating & welding applications, and brief description about the electric traction are presented. At the end of the course, an insight in to the importance, techniques, and testing of electrical equipment earthing is also presented.

**Learning Objectives:**

- To know various sources of electrical energy, methods used for generation of electrical energy.
- To study the various types of Illumination equipment, measurement of Illumination, Illumination techniques.
- To know the various technologies used for heating and welding applications using electrical energy.
- To know the various systems of traction, equipment used for traction.
- To understand the importance of earthing, earthing equipment and earthing measurement of electrical equipment.

**Unit-I:**

**Sources of Electrical Energy**

Conventional Sources: Schematic & description of components of thermal power plant - hydro electric power station and nuclear power plants.

Non-conventional sources: schematic and description of components - Solar power generation - Wind power generation – Tidal - Geo-Thermal - Bio energy - Fuel cells technology.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**Unit-II:**

**Illumination**

Introduction, source of light, term used in illumination - Lux meter - Discharge lamp - MV and SV lamps - types and design of light as flood light - LED light - shed lighting and domestic light - conservation of energy.

**Unit-III:**

**Heating and Welding**

Advantages of Electric heating - types of electric heating - Resistance Heating - properties of heating element - direct heating - indirect heating - Induction heating - Factors effecting heat – Characteristics – application - description of direct core - vertical core - indirect core and core less type of Induction heating - Dielectric heating – applications of dielectric heating. Advantages of heating – arc furnace – direct arc furnace – indirect arc furnace.

Welding: Introduction - Resistance welding – Spot welding – Projection welding – Seam welding – Butt welding – Arc welding – Metal arc welding – Helium arc welding – carbon arc welding – Hydrogen arc welding.

**Unit IV:**

**Traction**

Introduction – Advantages and disadvantages - systems of traction – classification – speed-time curve for different service – various factors affecting the energy consumption – components of electric locomotive (for collecting and discharging) – description of each component.

**Unit -V:**

**Grounding**

Introduction – earth and safety – nature of an electrode system – earth conductor sizes – design of earthing electrodes – earthing system – substation earthing mats – earthing practices – earth testing: methodology - earth tester and use

**Learning Outcomes:**

After the completion of the course the student should be able to:

- know the various sources of electrical energy and its generation technologies for conventional and non-conventional energy sources.
- know various types of illumination equipment, illumination measurement and illumination techniques.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

- learn about various methods used for electrical energy based heating and welding applications.
- know about the mechanisms, equipment and technology used in the electric traction.
- understand the importance of electrical earthing, earthing equipment and electrical earthing measurement methods.

**Text Books:**

1. Electrical Power Systems(Generation, Transmission, Distribution, Protection and Utilization of Electrical Energy) – Dr. S.L.Uppal and Prof. Sunil S.Rao – Khanna Publisher, 15<sup>th</sup> edition, 1987.
2. Electric Power Distribution – A S Pabla – McGrawHill.

**Reference Books:**

1. Generation Distribution and Utilization of Electrical Energy – C.L.Wadhwa- New Age International Publishers- revised third edition.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>CONCEPTS OF POWER SYSTEM ENGINEERING</b> (OPEN ELECTIVE-II)					

**Preamble:**

This course introduces the basic concepts and overall view and basic knowledge regarding the power system engineering. The Course is giving the concepts of power generation, power transmission and distribution. It also covers protection, economics and power factor improvement concepts. This subject is very much useful to gain knowledge in the power systems.

**Learning Objectives:**

- To understand the types of power plants.
- To understand the concepts of transmission and distribution
- To gain the knowledge of protection and grounding
- To know the economic aspects of electrical energy.
- To learn the importance of power factor improvement and voltage control.

**UNIT-I:**

**Power Generation Concepts & Types**

Generation and sources of Energy – Generating stations: Schematic arrangements of Steam Power Plant – Hydro Power Plant - Nuclear Power Plant – Gas Power Plants working principle and Schematic diagram approach only– Comparison between Power Plants.

**UNIT-II:**

**Transmission and Distribution Concepts**

Types of Conductors Materials - Constants of Transmission Line – Classification of Overhead Transmission Lines – Performance of Single Phase Short Transmission Lines – Simple Problems – Basic concept of Sub Station.

Distribution Systems – Connection Schemes of Distribution Systems – Structure of Cables – Differences between Overhead & Underground systems.

**UNIT – III:**

**Protection and Grounding**

List of Faults – Basic concepts of fuse - Circuit Breakers – Relays – SF<sub>6</sub> Circuit Breakers – Vacuum Circuit Breakers – Operation of Lightning Arrester – Grounding and its advantages - Methods of Neutral Grounding: Resistance, Reactance and Resonant Grounding – Numerical Problems.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**UNIT-IV:**

**Economic Aspects**

Definitions of Load - Load & Load Duration Curves - Load Factor - Demand Factor – Utilization Factor - Loss Factor – Types of Tariff - Cost of Electrical Energy – Expression for Cost of Electrical Energy – Numerical Problems.

**UNIT-V:**

**Power Factor Improvement and Voltage Control**

Power Factor – Effects and Causes of low Power Factor – Power Triangle – Shunt & Series Capacitor Compensation - Numerical Problems – Need of Voltage Control – Types of Voltage regulating Devices.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- gain knowledge on types of power plants.
- learn about transmission and distribution concepts.
- understand protection and grounding methods.
- learn the economic aspects of electrical energy.
- understand the power factor improvement and voltage control.

**Text Books:**

1. Principles of Power System by V.K.Mehata, Rohit Mehata, S.Chand Publishers.

**Reference Books:**

1. Electrical Power Systems by C.L.Wadwa, New Age International Publishers.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>BASICS OF CONTROL SYSTEMS</b> (OPEN ELECTIVE-II)					

**Preamble :**

This course introduces the basic principles of control systems for analyzing LTI systems and investigate their stability.

**Learning Objectives:**

- To learn the mathematical modeling of physical systems and to use block diagram algebra and signal flow graph to determine overall transfer function
- To analyze the time response of first and second order systems and improvement of performance by proportional plus derivative and proportional plus integral controllers
- To investigate the stability of closed loop systems using Routh-Hurwitz criterion and analysis by root locus method.
- To present the Frequency Response approaches for the analysis of linear time invariant (LTI) systems using Bode plots.
- Ability to formulate state models and analyze the systems. To learn the concepts of Controllability and Observability.

**UNIT – I:**

**Mathematical modeling of control systems**

Classification of control systems, open loop and closed loop control systems and their differences, transfer function of linear system, differential equations of electrical networks, translational and rotational mechanical systems, transfer function of DC servo motor – AC servo motor – block diagram algebra – representation by signal flow graph – reduction using Mason's gain formula, Feedback characteristics.

**UNIT-II:**

**Time response analysis**

Standard test signals – time response of first and second order systems – time domain specifications, steady state errors and error constants, P, PI, PID Controllers.

**UNIT-III:**

**Stability and rootlocus technique**

The concept of stability – Routh-Hurwitz – limitations of Routh-Hurwitz criterion, Root locus concept – construction of root loci (simple problems).



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**UNIT-IV:**

**Frequency response analysis**

Introduction to frequency domain specifications – Polar Plot - Bode diagrams – transfer function from the Bode diagram – phase margin and gain margin – stability analysis from Bode plots.

**UNIT-IV:**

**State space analysis of LTI systems**

Concepts of state, state variables and state model, state space representation of transfer function, diagonalization, solving the time invariant state equations, State Transition Matrix and its Properties, concepts of controllability and observability.

**Learning Outcome:**

After the completion of the course the student should be able to:

- derive the transfer function of physical systems and determination of overall transfer function using block diagram algebra and signal flow graphs.
- determine time response specifications of second order systems and to determine error constants.
- analyze absolute and relative stability of LTI systems using Routh's stability criterion and the root locus method.
- analyze the stability of LTI systems using frequency response methods.
- represent physical systems as state models and determine the response. Understanding the concepts of controllability and observability.

**Text Books:**

1. Modern Control Engineering by Kotsuhiko Ogata, Prentice Hall of India.
2. Automatic control systems by Benjamin C.Kuo, Prentice Hall of India, 2<sup>nd</sup> Edition.

**Reference Books:**

5. Control Systems principles and design by M.Gopal, Tata Mc Graw Hill education Pvt Ltd., 4<sup>th</sup> Edition.
6. Control Systems by Manik Dhanesh N, Cengage publications.
3. Control Systems Engineering by I.J.Nagarath and M.Gopal, Newage International Publications, 5<sup>th</sup> Edition.
4. Control Systems Engineering by S.Palani, Tata Mc Graw Hill Publications.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year – II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ENERGY AUDIT (OPEN ELECTIVE-II)</b>					

**Preamble:**

This is an open elective course developed to cater the current needs of the industry. This course covers topics in energy conservation. It also covers energy efficient lighting system. The student will learn power factor improvement techniques, energy efficiency in HVAC systems. In addition the economic aspects such as payback period calculations, life cycle costing analysis is covered in this course.

**Learning Objectives:**

- To understand energy efficiency, scope, conservation and technologies.
- To design energy efficient lighting systems.
- To estimate/calculate power factor of systems and propose suitable compensation techniques.
- To understand energy conservation in HVAC systems.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

**Unit-I:**

**Energy sources**

Energy consumption – world energy reserves – prices – alternative sources – power – energy policies – choice of fuels.

**Energy Auditing**

Energy conservation schemes: Short term - Medium term - Long term energy conservation schemes – Industrial energy use - Energy index – Cost index .

Representation of energy consumption: Pie charts - Sankey diagrams – Load Profile.

Energy auditing: General Auditing, Detailed Energy Audit.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**Unit–II:**

**Heat Transfer Theory**

Heat – Heat content – Rate of heat transfer – Heat transfer coefficient - Conduction – Convection and radiation. Thermal insulation & its importance - space heating – HVAC system – Heating of Buildings – District heating – Factors & affecting the choice of district heating.

**Unit–III:**

**Energy Efficient Instruments**

Digital Energy Meter – Data loggers – Thermo couples – Pyranometer – Lux meters – Tong testers – Power analyzers – Power factor – effects with non-linear loads – effect of harmonics on power factor – Power Factor Improvement – Capacitor rating - Effects of power factor improvements - Electric lighting – Types of lighting – Luminaries – Energy efficient lighting.

**Unit–IV**

**Economic Aspects**

Costing Techniques – cost factors – break-even charts – sources of capital and hire charges - capital recovery – depreciation – budgeting and standard costing – charging energy – cash flow diagrams and activity charts.

**Unit–V**

**Financial Analysis**

Financial appraisal and profitability : investment decision- methods of investment appraisal- discounted cash flow – summary of investment appraisal techniques – Cost optimization – optimization with one variable – optimization with more than one variable.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- explain energy efficiency, conservation and various technologies.
- design energy efficient lighting systems.
- calculate power factor of systems and propose suitable compensation techniques.
- explain energy conservation in HVAC systems.
- calculate life cycle costing analysis and return on investment on energy efficient technologies.

**Text Books:**

1. Energy management by W.R. Murphy & G. McKay Butter worth, Elsevier publications. 2012
2. Hand Book of Energy Audit by Sonal Desai- Tata McGraw hill



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**Reference Books:**

1. Electric Energy Utilization and Conservation by S C Tripathy, Tata McGraw hill publishing company Ltd. New Delhi.
2. Energy management by Paul o' Callaghan, Mc-Graw Hill Book company-1<sup>st</sup> edition, 1998.
3. Energy management hand book by W.C.Turner, John wiley and sons.
4. Energy management and conservation –k v Sharma and pvenkateshaiah-I K International Publishing House pvt.ltd,2011.
5. Industrial Energy Management Systems by Arry C. White, Philip S. Schmidt, David R. Brown, Hemisphere Publishing Corporation, New York, 1994.
6. Fundamentals of Energy Engineering by Albert Thumann, Prentice Hall Inc, Englewood Cliffs, New Jersey, 1984.
7. Economic Analysis of Demand Side Programs and Projects - California Standard Practise Manual, June 2002 – Free download available online



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>ELECTRICAL DISTRIBUTION SYSTEMS (ELECTIVE-IV)</b>					

**Preamble:**

This subject deals with the general concept of distribution system, substations and feeders as well as discusses distribution system analysis, protection and coordination, voltage control and power factor improvement.

**Learning Objectives**

- To study different factors of Distribution system.
- To study and design the substations and distribution systems.
- To study the concepts of voltage drop and power loss.
- To study the distribution system protection and its coordination.
- To study the effect of compensation for power factor improvement.
- To study the effect of voltage control on distribution system.

**UNIT – I:**

**General Concepts**

Introduction to distribution systems - Distribution system losses – Coincidence factor – Contribution factor loss factor – Numerical Problems – Load Modeling and Characteristics – Relationship between the load factor and loss factor – Classification and characteristics of loads (Residential, commercial, Agricultural and Industrial).

**UNIT – II:**

**Substations**

Location of substations: Rating of distribution substation – Service area with ‘n’ primary feeders – Benefits and methods of optimal location of substations..

**Distribution Feeders**

Design Considerations of distribution feeders: Radial and loop types of primary feeders – Voltage levels – Feeder loading – Basic design practice of the secondary distribution system.

**UNIT – III:**

**System Analysis**

Voltage drop and power-loss calculations: Derivation for voltage drop and power loss in lines – Uniformly distributed loads and non-uniformly distributed loads – Numerical problems - Three phase balanced primary lines.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**UNIT – IV:**

**Protection, Coordination & Automation**

Objectives of distribution system protection – Time current characteristics – Protective devices: Principle of operation of fuses – Circuit reclosures – Line sectionalizers and circuit breakers, Modulated case circuit breakers, Earth leakage circuit breakers – Protection schemes of parallel & Ringmain feeders.

Coordination of protective devices: General coordination procedure – Various types of coordinated operation of protective devices - Residual Current Circuit Breaker

Automation: Block diagram approach of SCADA.

**UNIT – V:**

**Compensation for Power Factor Improvement**

Capacitive compensation for power factor control – Different types of power capacitors – shunt and series capacitors – Effect of shunt capacitors (Fixed and switched) – Power factor correction – Capacitor allocation – Economic justification – Procedure to determine the best capacitor location – Numerical problems.

**Voltage Control**

Voltage Control: Equipment for voltage control – Effect of series capacitors – Effect of AVB/AVR – Line drop compensation – Numerical problems.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- understand various factors of distribution system.
- design the substation and feeders.
- determine the voltage drop and power loss
- understand the protection and its coordination.
- understand the effect of compensation for p.f improvement.
- understand the effect of voltage control.

**Text Book:**

1. “Electric Power Distribution system, Engineering” – by TuranGonen, McGraw–hill Book Company.

**Reference Books:**

1. Electrical Distribution Systems by Dale R.Patrick and Stephen W.Fardo, CRC press
2. Electric Power Distribution – by A.S. Pabla, Tata McGraw–hill Publishing company, 4<sup>th</sup> edition, 1997.
3. Electrical Power Distribution Systems by V.Kamaraju, Right Publishers.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

IV Year –II SEMESTER	L	T	P	C
	3	0	0	3
<b>HVAC &amp; DC TRANSMISSION</b> (ELECTIVE-IV)				

**Preamble:**

With the increasing power generation in the country and long distance power transmission, it is necessary that power should be transmitted at extra and ultra high voltage. The topics dealt in this subject relate to phenomena associated with transmission line at higher voltages, equipments generating high voltage and power control strategy.

**Learning Objectives**

- To understand the phenomena associated with transmission line, operating at extra high voltages. The unit gives detail analysis of several phenomena viz. electrostatic field, charges, voltage gradient and conductor configuration.
- The objective is to discuss phenomena of corona, losses, audible noise, radio interference and measurement of these quantities.
- To understand the phenomena of HVDC, HVDC equipment comparison with AC and the latest state of art in HVDC transmission.
- To understand method of conversion of AC to DC, performance of various level of pulse conversion and control characteristics of conversion. It also provides knowledge of effect of source inductance as well as method of power control.
- To understand the requirements of reactive power control and filtering technique in HVDC system.
- To understand the harmonics in AC side of power line in a HVDC system and design of filters for various levels of pulse conversion.

**Unit – I:**

**Introduction of EHV AC transmission**

Necessity of EHV AC transmission – Advantages and problems– Power handling capacity and line losses– Mechanical considerations – Resistance of conductors –Electrostatics – Field of sphere gap – Field of line charges and properties – Charge ~ potential relations for multi-conductors – Surface voltage gradient on conductors – Bundle spacing and bundle radius– Examples – Distribution of voltage gradient on sub conductors of bundle – Examples.

**Unit – II:**

**Corona effects**

Power loss and audible noise (AN) – Corona loss formulae – Charge voltage diagram – Generation – Characteristics – Limits and measurements of AN – Relation between 1-phase and 3-phase AN levels – Examples – Radio interference (RI) – Corona pulses generation –



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

### **COURSE STRUCTURE-R19**

Properties and limits – Frequency spectrum – Modes of propagation – Excitation function – Measurement of RI, RIV and excitation functions – Examples.

#### **UNIT – III:**

##### **Basic Concepts of DC Transmission**

Economics & Terminal equipment of HVDC transmission systems: Types of HVDC Links – Apparatus required for HVDC Systems – Comparison of AC & DC transmission – Application of DC Transmission System – Planning & Modern trends in DC transmission.

#### **UNIT – IV:**

##### **Analysis of HVDC Converters and System Control**

Choice of Converter configuration – Analysis of Graetz – Characteristics of 6 Pulse & 12 Pulse converters – Cases of two 3 phase converters in star – Star mode and their performance – Principal of DC Link Control – Converters Control Characteristics – Firing angle control – Current and extinction angle control – Effect of source inductance on the system – Starting and stopping of DC link – Power Control.

#### **UNIT-V:**

##### **Reactive Power Control in HVDC and Filters**

Reactive Power Requirements in steady state – Conventional control strategies – Alternate control strategies sources of reactive power – AC Filters – Shunt capacitors – Synchronous condensers.

Generation of Harmonics – Characteristics harmonics – Calculation of AC Harmonics – Non-Characteristics harmonics – Adverse effects of harmonics – Calculation of voltage & current harmonics – Effect of Pulse number on harmonics. Types of AC filters, Design of Single tuned filters – Design of High pass filters.

#### **Learning Outcomes:**

After the completion of the course the student should be able to:

- acquaint with HV transmission system with regard to power handling capacity, losses, conductor resistance and electrostatic field associate with HV. Further knowledge is gained in area of bundle conductor system to improve electrical and mechanical performance.
- develop ability for determining corona, radio interference, audible noise generation and frequency spectrum for single and three phase transmission lines.
- acquire knowledge in transmission of HVDC power with regard to terminal equipments, type of HVDC connectivity and planning of HVDC system.
- develop knowledge with regard to choice of pulse conversion, control characteristic, firing angle control and effect of source impedance.
- develop knowledge of reactive power requirements of conventional control, filters and reactive power compensation in AC. side of HVDC system.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

- calculate voltage and current harmonics, and design of filters for six and twelve pulse conversion.

**Text Books:**

1. HVDC Power Transmission Systems: Technology and system Interactions – by K.R.Padiyar, New Age International (P) Limited, and Publishers.
2. Direct Current Transmission – by E.W.Kimbark, John Wiley & Sons.
3. EHVAC Transmission Engineering by R. D. Begamudre, New Age International (p) Ltd.

**Reference Books:**

1. EHVAC and HVDC Transmission Engineering and Practice – S.Rao.
2. Power Transmission by Direct Current – by E.Uhlmann, B.S.Publications
3. HVDC Transmission – J.Arrillaga.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>FLEXIBLE ALTERNATING CURRENT TRANSMISSION SYSTEMS (ELECTIVE-IV)</b>					

**Preamble:**

Flexible Alternating Current Transmission System controllers have become a part of modern power system. It is important for the student to understand the principle of operation of series and shunt compensators by using power electronics. As the heart of many power electronic controllers is a voltage source converter (VSC), the student should be acquainted with the operation and control of VSC. Two modern power electronic controllers are also introduced.

**Learning Objectives:**

- To learn the basics of power flow control in transmission lines using FACTS controllers
- To explain operation and control of voltage source converter.
- To understand compensation methods to improve stability and reduce power oscillations of a power system.
- To learn the method of shunt compensation using static VAR compensators.
- To learn the methods of compensation using series compensators
- To explain operation of Unified Power Flow Controller (UPFC).

**Unit–I:**

**Introduction to FACTS**

Power flow in an AC System – Loading capability limits – Dynamic stability considerations – Importance of controllable parameters – Basic types of FACTS controllers – Benefits from FACTS controllers – Requirements and characteristics of high power devices – Voltage and current rating – Losses and speed of switching – Parameter trade-off devices.

**Unit–II:**

**Voltage source and Current source converters**

Concept of voltage source converter (VSC) – Single phase full wave bridge converter – Square wave voltage harmonics for a single-phase bridge converter – Three-phase full wave bridge converter – Transformer connections for 12, 24 and 48 pulse operation, concept of Current Source Converter (CSC), Three-phase current source converter – Comparison of current source converter with voltage source converter.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

### **COURSE STRUCTURE-R19**

**Unit–III:**

**Shunt Compensators**

Objectives of shunt compensation – Mid–point voltage regulation for line segmentation – End of line voltage support to prevent voltage instability – Improvement of transient stability – Power oscillation damping – variable Impedance type VAR generator - Thyristor Switched/Controlled Reactor (TSR/TCR) – Thyristor Switched Capacitor(TSC) – Fixed Capacitor–Thyristor Controlled Reactor (FC-TCR), Thyristor Switched Capacitor and Thyristor Controlled Reactor (TSC–TCR), Switching Converter type VAR generator – principle of operation - Comparison of SVC and STATCOM.

**Unit IV:**

**Series Compensators**

Static series compensators: Concept of series capacitive compensation – Improvement of transient stability – Power oscillation damping – Functional requirements. GTO thyristor controlled Series Capacitor (GSC) – Thyristor Switched Series Capacitor (TSSC) and Thyristor Controlled Series Capacitor (TCSC) - Switching Converter type Series Compensation.

**Unit–V:**

**Combined Controllers**

Voltage and Phase Angle Regulator - TCVR and TCPAR – Switched Converter Based Voltage-Phase Angle Regulator - Schematic and basic operating principles of Unified Power Flow Controller (UPFC), Interline Power Flow Controller (IPFC) - Application on transmission lines.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- understand power flow control in transmission lines using FACTS controllers.
- explain operation and control of voltage source converter.
- analyze compensation methods to improve stability and reduce power oscillations in the transmission lines.
- explain the method of shunt compensation using static VAR compensators.
- understand the methods of compensations using series compensators.
- explain operation of Unified Power Flow Controller (UPFC).

**Text Books:**

1. “Understanding FACTS” N.G.Hingorani and L.Guygi, IEEE Press.Indian Edition is available:—Standard Publications, 2001.

**Reference Books:**

1. “Flexible ac transmission system (FACTS)” Edited by Yong Hue Song and Allan T Johns, Institution of Electrical Engineers, London.
2. Thyristor-based FACTS Controllers for Electrical Transmission Systems, by R.MohanMathur and Rajiv k.Varma, Wiley.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>POWER QUALITY (ELECTIVE-IV)</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Preamble:**

Power quality is a major problem for utilities and customers. Customers using sensitive critical loads need quality power for proper operation of the electrical equipment. It is important for the student to learn the power quality issues and improvement measures provided by the utility companies. This course covers the topics on voltage and current imperfections, harmonics, voltage regulation, power factor improvement, distributed generation, power quality monitoring and measurement equipment.

**Learning Objectives:**

- To learn different types of power quality phenomena.
- To identify sources for voltage sag, voltage swell, interruptions, transients, long duration over voltages and harmonics in a power system.
- To describe power quality terms and study power quality standards.
- To learn the principle of voltage regulation and power factor improvement methods.
- To explain the relationship between distributed generation and power quality.
- To understand the power quality monitoring concepts and the usage of measuring instruments.

**Unit–I:**

**Introduction**

Overview of power quality – Concern about the power quality – General classes of power quality and voltage quality problems – Transients – Long–duration voltage variations – Short–duration voltage variations – Voltage unbalance – Waveform distortion – Voltage fluctuation – Power frequency variations.

**Unit–II:**

**Voltage imperfections in power systems**

Power quality terms – Voltage sags – Voltage swells and interruptions – Sources of voltage sag, swell and interruptions – Nonlinear loads – IEEE and IEC standards. Source of transient over voltages – Principles of over voltage protection – Devices for over voltage protection – Utility capacitor switching transients.

**Unit–III:**

**Voltage Regulation and power factor improvement:**

Principles of regulating the voltage – Device for voltage regulation – Utility voltage



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

### **COURSE STRUCTURE-R19**

regulator application – Capacitor for voltage regulation – End-user capacitor application – Regulating utility voltage with distributed resources – Flicker – Power factor penalty – Static VAR compensations for power factor improvement.

#### **Unit– IV:**

##### **Harmonic distortion and solutions**

Voltage distortion vs. Current distortion – Harmonics vs. Transients – Harmonic indices – Sources of harmonics – Effect of harmonic distortion – Impact of capacitors, transformers, motors and meters – Point of common coupling – Passive and active filtering – Numerical problems.

#### **Unit–V:**

##### **Distributed Generation and Power Quality Monitoring**

Resurgence of distributed generation – DG technologies – Interface to the utility system – Power quality issues and operating conflicts.

Power quality monitoring and considerations – Historical perspective of Power quality measuring instruments – Power quality measurement equipment – Assessment of Power quality measuring data.

#### **Learning Outcomes:**

After the completion of the course the student should be able to:

- differentiate between different types of power quality problems.
- explain the sources of voltage sag, voltage swell, interruptions, transients, long duration over voltages and harmonics in a power system.
- analyze power quality terms and power quality standards.
- explain the principle of voltage regulation and power factor improvement methods.
- demonstrate the relationship between distributed generation and power quality.
- explain the power quality monitoring concepts and the usage of measuring instruments.

#### **Textbooks:**

1. Electrical Power Systems Quality, Dugan R C, Mc Granaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw–Hill, 2012, 3<sup>rd</sup> edition.
2. Electric power quality problems –M.H.J.Bollen IEEE series-Wiley India publications,2011.

#### **Reference Books:**

1. Power Quality Primer, Kennedy B W, First Edition, Mc Graw–Hill, 2000.
2. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M HJ, First Edition, IEEE Press; 2000.
3. Power System Harmonics, Arrillaga J and Watson N R, Second Edition, John Wiley & Sons, 2003.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

4. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula,  
Van Nostrand Reinhold, New York.
5. Power Quality c.shankaran, CRC Press, 2001
6. Harmonics and Power Systems –Franciso C.DE LA Rosa–CRC Press (Taylor & Francis)
7. Power Quality in Power systems and Electrical Machines–EwaldF.fuchs,  
Mohammad A.S. Masoum–Elsevier.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>SMART GRID (ELECTIVE-IV)</b>					

**Preamble:**

Basic knowledge on smart concept communication protocols, renewable energy systems and electronic circuits.

**Learning Objectives:**

- To understand concept of smart grid and developments on smart grid.
- To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc.
- To have knowledge on smart substations, feeder automation and application for monitoring and protection.
- To have knowledge on micro grids and distributed energy systems.
- To know power quality aspects in smart grid.

**Unit-I:**

**Introduction to Smart Grid**

Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self Healing Grid, Present development & International policies on Smart Grid. Case study of Smart Grid.

**Unit-II:**

**Smart Grid Technologies: Part 1**

Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers.

**Unit-III:**

**Smart Grid Technologies: Part 2**

Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU).



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**Unit-IV:**

**Micro grids and Distributed Energy Resources**

Concept of micro grid, need & applications of microgrid, formation of microgrid, Issues of interconnection, protection & control of microgrid. Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuelcells, microturbines, Captive power plants, Integration of renewable energy sources.

**Unit-V:**

**Power Quality Management in Smart Grid**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

**Information and Communication Technology for Smart Grid**

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN).

**Course Outcomes:**

After the completion of the course the student should be able to:

- understand smart grids and analyse the smart grid policies and developments in smart grids.
- develop concepts of smart grid technologies in hybrid electrical vehicles etc.
- understand smart substations, feeder automation, GIS etc.
- analyse micro grids and distributed generation systems.
- analyse the effect of power quality in smart grid and to understand latest developments in ICT for smart grid.

**Text Books:**

1. Ali Keyhani, Mohammad N. Marwali, Min Dai “Integration of Green and Renewable Energy in Electric Power Systems”, Wiley
2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press
3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley
4. Jean Claude Sabonnadière, NouredineHadjsaïd, “Smart Grids”, Wiley Blackwell 19
5. Peter S. Fox Penner, “Smart Power: Climate Changes, the Smart Grid, and the Future of Electric Utilities”, Island Press; 1 edition 8 Jun 2010



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

6. S. Chowdhury, S. P. Chowdhury, P. Crossley, “Microgrids and Active Distribution Networks.” Institution of Engineering and Technology, 30 Jun 2009
7. Stuart Borlase, “Smart Grids (Power Engineering)”, CRC Press.

**Reference Books:**

1. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
2. James Northcote, Green, Robert G. Wilson “Control and Automation of Electric Power Distribution Systems (Power Engineering)”, CRC Press
3. MladenKezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer
4. R. C. Dugan, Mark F. McGranhan, Surya Santoso, H. Wayne Beaty, “Electrical Power System Quality”, 2nd Edition, McGraw Hill Publication
5. Yang Xiao, “Communication and Networking in Smart Grids”, CRC Press



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>	<b>SPECIAL ELECTRICAL MACHINES (ELECTIVE - IV)</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Preamble:**

This is an advanced course on electrical machines. Students will be exposed to various special machines which are gaining importance in industry. This course covers topics related to principles, performance and applications of these special machines including switched reluctance motors, stepper motors, permanent magnet dc motors and linear motors.

**Learning Objective:**

- To explain theory of operation and control of switched reluctance motor.
- To explain the performance and control of stepper motors, and their applications.
- To describe the operation and characteristics of permanent magnet dc motor.
- To distinguish between brush dc motor and brush less dc motor.
- To explain the theory of travelling magnetic field and applications of linear motors.

**Unit I:**

**Permanent magnet materials and PMDC motors**

Introduction-classification of permanent magnet materials used in electrical machines-minor hysteresis loop and recoil line-Stator frames of conventional dc machines-Development of electronically commutated dc motor from conventional dc motor-Permanent-magnet materials and characteristics-B-H loop and demagnetization characteristics-high temperature effects-reversible losses-Irreversible losses-Mechanical properties, handling and magnetization-Application of permanent magnets in motors-power density-operating temperature range-severity of operation duty.

**Unit II:**

**Stepper Motors**

Principle of operation of Stepper Motor – Constructional details - Classification of stepper motors – Different configuration for switching the phase windings - Control circuits for stepper motors – Open loop and closed loop control of two phase hybrid stepping motor.

**Unit III:**

**Switched Reluctance Motors**

Construction and Principle of operation of Switched Reluctance Motor – Comparison of conventional and switched reluctance motors – Design of stator and rotor pole arcs – Torque producing principle and torque expression – Different converter configurations for SRM – Drive and power circuits for SRM – Position sensing of rotor – Applications of SRM.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

**Unit IV:**

**Permanent Magnet Brushless DC Motor**

Principle of operation of BLDC motor - Types of constructions - Surface mounted and interior type permanent magnet DC Motors - Torque and EMF equations for Square wave & Sine wave for PMLDC Motor – Torque - Speed characteristics of Square wave & Sine wave for PMLDC Motor - Merits & demerits of Square wave & Sine wave for PMLDC Motor - Performance and efficiency – Applications.

**Unit V:**

**Linear Induction Motors (LIM)**

Construction– principle of operation–Double sided LIM from rotating type Induction Motor – Schematic of LIM drive for traction – Development of one sided LIM with back iron- equivalent circuit of LIM.

**Learning Outcomes:**

After the completion of the course the student should be able to:

- distinguish between brush dc motor and brush less dc motor.
- explain the performance and control of stepper motors, and their applications.
- explain theory of operation and control of switched reluctance motor.
- explain the theory of travelling magnetic field and applications of linear motors.
- understand the significance of electrical motors for traction drives.

**Text Books:**

1. Brushless Permanent magnet and reluctance motor drives, Clarendon press, T.J.E. Miller, 1989, Oxford.
2. Special electrical Machines, K.VenkataRatnam, University press, 2009, New Delhi.



**JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY: KAKINADA**  
**KAKINADA – 533 003, Andhra Pradesh, India**  
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**COURSE STRUCTURE-R19**

<b>IV Year –II SEMESTER</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>0</b>	<b>0</b>	<b>16</b>	<b>8</b>
<b>PROJECT-II</b>					