

Master of Science in Energy and Power Systems

Curriculum of the Program:

Semester 1		
Sr. No	Course Name	Credit Hours
1	Core 1	3
2	Core 2	3
3	Core 3	3
Semester 2		
1	Core 4	3
2	Elective-1	3
3	Elective-2	3
Semester 3		
1	MS Research Work /Elective-5	3
2	Elective-3	3
Semester 4		
1	MS Thesis /Elective-6	3
2	Elective-4	3

University Requirement: SS-821 Research Methodology 2 Non-credit hour course.

Core Courses:

- ECE-821 Advanced Power System Transmission and Distribution
- ECE-822 Advanced Power System Analysis
- ECE-823 Advanced Power System Operation and Control
- ECE-827 Energy Resources
- ECE-898 MS Research Work
- ECE-899 MS Thesis

Elective courses:

- ECE-801 Applied Machine Learning for Power System
- ECE-844 Power System Stability and Control
- ECE-832 Smart Grids - Active Networks and Microgrids
- ECE-828 Battery Energy Storages in Smart Grids
- ECE-818 Seasonal Energy Storage and Conversion Technologies
- ECE-803 Modeling and Simulation of Energy Systems
- ECE-831 Smart Grid Communication
- ECE-825 Distributed Energy Generation Systems
- ECE-845 Control and Simulation Principles of Converter Systems and Drives
- ECE-829 Energy Policy
- ECE-817 Power Electronics for Electric Vehicles
- ECE-826 Energy Management
- ECE-812 Power Electronic Application in Smart Grids
- ECE-824 Advanced Power System Protection

Course Outline:

Core Courses

ADVANCE POWER SYSTEM TRANSMISSION DISTRIBUTION		Cr.Hrs: 3
<ol style="list-style-type: none">1. Introduction to Power systems, main parts of Power system, Description, Discussion of each part, Design aspects of Power systems and Production of Loads.2. Load Forecasting, Types of Loads in the Power System, Load factor, Demand Factor and Numerical examples.3. Transmission of Power, Types of Transmission.4. DC and AC Transmission, Advantages and Disadvantages5. Various Systems of Transmission of Power6. Economics of Transmission System7. Annual cost of Energy wasted8. Requirement of satisfactory Power Supply9. Resistance of Transmission line10. Inductance of Transmission line11. Showing of Midterm papers12. Mathematical derivation of equations13. Derivation of equation of log14. According to service15. Discussion of Bus Bars16. Types of Insulators		
Recommended Books	<ol style="list-style-type: none">1. "Principle of Power System" by RK MEHTA and VK MEHTA 20052. "ELECTRICAL POWER GENERATION, TRANSMISSION AND DISTRIBUTION" By Leonard L.Griggs. 2012	

ENERGY RESOURCES		Cr.Hrs 3
<ol style="list-style-type: none">1. Introduction, Degradable and Renewable Sources2. Solar thermal Use, Concentrating and Non-Concentrating Collectors and their manufacturing and composition, advantages, and disadvantages3. Solar thermal uses and different applications, direct and indirect systems gain4. PV, extraction of silicon, manufacturing of silicon wafer, mono and polycrystalline, manufacturing of solar cell5. Fabrication of PV panel from PV cells, manufacturing, and composition, PWM and MPPT controllers6. Optimal sizing of PV system for a controller7. Solar system designing8. Solar system designing9. Energy storage devices, batteries, their characteristics, different types, Project presentation10. Hydroelectric generation, Project presentation11. Hydroelectric generation, Project presentation12. Wind generation, Project presentation13. Wind generation, Project presentation14. Geothermal energy sources, Project presentation15. Tidal and ocean energy source		

Recommended Books	Energy Resources and System by Tushar K. Ghosh, Mark A. Prelas, Springer 2011 Energy resources by Andrew L. Simon 2013
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Power System Operation and Control		Cr.Hrs 3
<p>LOAD FREQUENCY CONTROL: Basics of speed governing mechanism and modeling – speed - load characteristics – load sharing between two synchronous machines in parallel. Control area concept. Load Frequency Control of a single area system. Static and dynamic analysis of uncontrolled and controlled cases. Integration of economic dispatch control with LFC. Two - area system – modeling - static analysis of uncontrolled case - tie line with frequency bias control of two-area system - state variable model.</p> <p>REACTIVE POWER VOLTAGE CONTROL: Basics of reactive power control, Excitation systems – modelling. Static and dynamic analysis: stability compensation generation and absorption of reactive power. Methods of voltage control – tap changing transformer. System level control using generator voltage magnitude setting. Tap setting of OLTC transformer. MVAR injection of switched capacitors to maintain acceptable voltage profile and to minimize transmission loss. ECONOMIC OPERATION OF POWER SYSTEMS: Statement of economic dispatch problem – cost of generation-Incremental cost curve - co-ordination equations without loss and with loss, solution by direct method and λ-iteration method. Economic Aspects of Power Generation: Load curve, load duration and integrated load duration curves – load demand, diversity, capacity, utilization and plant use factors - NumericalProblems. UNIT COMMITMENT: Statement of Unit Commitment problem – constraints, spinning reserve, thermal unit constraints, hydro constraints, fuel constraints and other constraints. Solution methods – Priority list methods - forward dynamic programming approach. Numerical problems on priority-list method using full- load average production cost and Forward DP method.</p>		
Recommended Books	<ul style="list-style-type: none"> • Chakrabarti & Haldar, “Power System Analysis: Operation and Control”, Prentice Hall of India, 2004 Edition. • C.L.Wadhwa, ‘Power System Analysis’, New Age International- 6th Edition, 2010, • Robert Miller, James Malinowski, ‘Power System Operation’, Tata McGraw Hill Publishing Company Ltd, New Delhi, 3E, JUN-09. • P. Kundur, Neal J. Balu, ‘Power System Stability & Control’, IEEE, 1998. <p>5. Power System Analysis by Hadi Saadat – TMH Edition.</p>	

ADVANCED POWER SYSTEM ANALYSIS		Cr.Hrs 3
<ol style="list-style-type: none"> 1. Introduction to electric power system, review of phasors and three phase power 2. Models for transformers, generators, and loads 3. Per unit system of calculations: Selection of base and change in base of per unit quantities, node equations, one-line diagram 4. Per unit system of calculations: Problem Solution 5. Bus admittance matrix: Importance and formulation 6. Bus admittance matrix: Problem solution 7. Load Flow Analysis: Importance, Static load flow equations, Gauss Seidel Method 8. Load Flow Analysis: Application of Gauss Seidel Method for load flow studies 9. Load Flow Analysis: Problem Solution using GS method 10. Load Flow Analysis: Newton Raphson Method, Application of Newton Raphson Method for Load Flow Studies 11. Load Flow Analysis: Problem Solution using NR method 12. Introduction to faults in power system, Type of Faults, Symmetrical/ Balanced faults 13. Methods for the analysis of Symmetrical Fault: First order method 14. Methods for the analysis of Symmetrical Fault: Bus Impedance Matrix method 15. Symmetrical Components: Introduction and mathematical computation 16. Unbalanced fault analysis: L-G, L-L, L-L-G faults 		
Recommended books:	Elements of Power System Analysis By: W. D. Stevenson Jr. 2016 Electric Power Transmission and Distribution: S. Sivanagaraju (2nd Edition) 2018 Power System Analysis By B. Hadi Soddatt (Latest Edition) 2002	

Elective Courses:

Applied Machine Learning (Power System)		Cr. Hrs 3
<p>Study Block 1 - Statistical Methods The topic includes basic statistical tools for data analysis and pre-processing of data. In addition, distance-based methods such as Nearest Neighbour and other non supervised learning techniques are covered.</p> <p>Study Block 2 - Artificial Neural Networks The topic covers design and optimisation of learning in ANN single and multilayer networks. Methods for optimisation and learning such as Kohonen feature maps are also included. In addition, methods for structured search in problem spaces are covered in this study block.</p> <p>Study Block 3 - Decision Trees Analysis of problems and design of Decision Trees for classification and regression is covered in this study block. Methods for optimal splitting and validation are included.</p>		
Recommended Book	Applied Machine Learning M.Gopal, McGraw-Hill Education, 2018	

Power Electronic Application in Smart Grids		Cr.Hrs 3
<ol style="list-style-type: none"> 1. Transition from Traditional Electrical Grid to Smart Grid 2. Grid Automation and Control 3. Distributed Generation System 4. Energy Storage System 5. Power Electronic Converters, Inverters, and Filters 6. Hybrid AC/DC Microgrid 7. Role of Electric Vehicles in Smart Grid 8. Renewable Energy Systems 9. High Voltage DC (HVDC) Transmission System 10. Distribution Management System in Smart Grid, including: <ol style="list-style-type: none"> i. Customer Information System ii. Outage Management System 11. Environmental Impact of Power Electronics and Smart Grid 12. Brief introduction to power electronics 13. Different topologies of power electronics converter (AC/DC, DC/DC converter interfaces of distributed energy resources) 14. Power electronic applications and power quality (grid side filters of inverters/converters and their design), PQC – Power quality conditioners, charging of electric vehicles and effect of power quality, FACTS, SVC, STATCOM 15. Wind turbine systems 16. PV system 17. Battery energy storage system 18. Visiting lecturer from industry 19. DC, hybrid AC/DC distribution/Microgrid 20. Power electronics based solid-state transformers for future smart grids, or power electronics-based circuit-breakers e.g., for future microgrids 		
Recommended Books	Power Electronics in Renewable Energy Systems and Smart Grid: Technology and Applications, Bimal K. Bose, ISBN: 978-1-119-51562-3, Wiley-IEEE Press, 2019	

Power System Stability and Control		Cr. Hrs 3
<p>General background and overview of power system stability issues (angle and voltage stability, transient, midterm and long-term stability)</p> <ul style="list-style-type: none"> ● Synchronous machine theory and modelling ● Machine representation in stability studies ● AC transmission components ● Power system loads ● Excitation systems ● Prime movers and energy supply systems ● HVDC ● Control of active power and reactive power 		

	<ul style="list-style-type: none"> • Small-signal stability • Transient stability • Methods for improving stability
Recommended Books	Power System Stability and Control", Prabha Kundur, McGraw-Hill, 1994

Smart Grid Active Networks and Microgrid		Cr. Hrs 3
<p>Smart grids; Intelligent Distribution Networks; Renewable Energy; Distributed Generation; DG Integration; Solar; Wind; Energy Storage Technologies; Chemical, Mechanical and Electrical Energy Storage; Demand Side Management; Load Management; Demand Side Response; Conservation Voltage Reduction; Demand Pricing; Time of Use; Real Time Pricing; Peak Time Pricing; FDIR; Reactive Power Optimisation; Volt-Var Optimisation; Distribution Automation; Advanced Asset Management; Electric Vehicles; Smart Meters; Advanced Measuring Infrastructure; Distribution Management Systems; Smart Grid ICT; Common Information Model; Cyber-Security; Wide Area Measurement Systems; Smart Grid Communications; SCADA; SG costs; Markets; Ancillary Markets; Smart Grid Standards; Substation Automation; Stakeholders and Benefits;</p>		
Recommended Books	<p>CW Gellings, "The Smart Grid, Enabling Energy Efficiency and Demand Side Response"- CRC Press, 2009. J Ekanayake, K. Liyanage, J.Wu, A. Yokoyama, N. Jenkins, "Smart Grid: Technology and Applications"- Wiley, 2012. James Momoh, "Smart Grid: Fundamentals of Design and Analysis"- Wiley, IEEE Press, 2012. The Smart Grid: Adapting the Power System to New Challenges, Bollen, Math H J, Morgan & Morgan Publishers, 2011</p>	

Battery Energy Storages in Smart Grids		Cr.Hrs 3
<p>NEW MARKETS FOR ON-GRID BATTERY ENERGY STORAGE DECENTRALISED BATTERY ENERGY STORAGE FOR GRID MANAGEMENT Battery Energy Storage in a smartening Electricity sector Services and Functions of Battery Energy Storage for Grid Operators BATTERY ENERGY STORAGE FOR HOMES AND BUILDINGS Battery Energy Storage at a customer level Functions of BES in End-user applications OVERVIEW OF BATTERY TECHNOLOGIES 1. Lead-based batteries 2. Lithium-based batteries 3. Nickel-based batteries 4. Sodium-based batteries Application of Energy Storage for Fast Regulation Service in Energy Market Impact of Energy Storage on Cascade Mitigation in Multi-Energy Systems</p>		

Recommended Books	Energy Storage for Smart Grids Planning and Operation for Renewable and Variable Energy Resources (VERs) Authors: Pengwei Du Ning Lu, 2014
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Modelling and Simulation of Energy Systems		Cr. Hrs 3
<ol style="list-style-type: none"> 1. Complex Systems in the Context of Energy 2. Modelling and Simulation of Complex Systems 3. Multi Agent Systems 4. Energy-related issues 5. Types of modelling systems 6. Energy flow-paths and weather boundary conditions 7. Response function method 8. Numerical method – buildings 9. Numerical method - energy supply systems 10. Short- and long-wave radiation 11. Electrical Energy Systems Modelling 12. Analytical Modelling of Energy System 13. Energy Demand Models 14. Energy Supply Models 		
Recommended Books	<ol style="list-style-type: none"> 1. J A Clarke, Energy Simulation in Building Design (2nd Edn), Butterworth-Heinemann, ISBN 0 7506 5082, 2002, 2. Modelling and Simulation of Energy Systems, by Thomas A Adam, 2019 3. Modelling and Simulation of Electrical Energy Systems By Enrique Alberto Kremers 2013 	

Energy Policy	Cr. Hrs 3
<p>Overview: the state of energy and the symbiosis between energy, policy, technology, and the economy</p> <p>GLOBAL ENERGY POLICY OVERVIEW</p> <p>Uncertainty and impact: environmental, political, cultural</p> <p>Electricity Markets</p> <p>Electricity production: Policy and Economics</p> <p>Liquid Fuels for transportation</p> <p>Alternative Energy for transportation</p> <p>Economics/Policy of Renewables I – technical and policy challenges of incorporating renewables</p> <p>Economics/Policy of Renewables II – impact of renewables policy on climate change</p> <p>The policy of energy efficiency</p> <p>International Emissions and Environmental Negotiations</p> <p>The reality of policymaking and the future of energy policy</p>	

Recommended Books	The Handbook of Global Energy Policy, Andreas Goldthau (Editor) ISBN: 978-0-470-67264-8, 2016
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Power Electronics for Electric Vehicles		Cr. Hrs 3
<p>Introduction</p> <ul style="list-style-type: none"> • Transportation electrification <p>Electric drivetrain system overview</p> <ul style="list-style-type: none"> • Architectures of hybrid (HEV), plug-in hybrid (PHEV) and electric vehicles (EV) • Vehicle dynamics, MATLAB/Simulink modeling • System design considerations, rating and sizing of electric drivetrain components <p>Analysis, modeling, simulations, and design of electric drivetrain components</p> <ul style="list-style-type: none"> • Battery systems, battery management electronics • Bidirectional DC-DC converters • Inverters and motor drives • Chargers 		
Recommended Books	<ul style="list-style-type: none"> • R W Erickson and D Maksimovic, “Fundamentals of Power Electronics”, Springer, 2nd Edition, 2001. • NedMohan, Undeland and Riobbins, “Power Electronics – Concepts, applications and Design”, John Wiley and Sons, Singapore, 2000 • Philip T. Krein, “Elements of Power Electronics” Oxford University Press -2004 	

Energy Management and Conservation		Cr. Hrs 3
<p>Value of energy management</p> <p>Energy management careers and certifications</p> <p>Developing Energy Management and Auditing Programs</p> <p>Electric theory, systems and measurements</p> <p>Energy Costs and Bill Analysis</p> <p>Economic Analysis,</p> <p>Lightning,</p> <p>Electric Motors and Mechanical Loads</p> <p>Compressed Air and Process Systems</p>		
Recommended Books	<ul style="list-style-type: none"> • Guide to Energy Management, 7th Edition, Barney L. Capehart, Ph.D., CEM, Wayne C. Turner, Ph.D., PE, CEM, William J. Kennedy, Ph.D., 2013 • The Dranetz Field Handbook for Electrical Energy Management, Dranetz Technologies, Inc. 1992. • Energy Management Handbook, 4th Edition, Wayne C. • Turner Plant Engineers and Managers Guide to Energy Conservation, 10th Edition, Albert Thumann, PE, CEM, Scott Dunning, Ph.D. PE, CEM 	

Research Methodology		Non-credit
<p>Introduction to Research. Objectives of Research. Importance of Research Methodology in Research Study. Types of Research. Steps in Conducting Research. What is Literature Review? Why need for Literature Review. Types of Literature Review. Systematic. Literature Review Protocol. Problem Statement and Problem formulation. Criteria for selecting a problem. Identifying Types of variables in Research. Types of hypothesis. Identifying Target Population. Types of Sampling. Sampling Techniques. Quantitative Research Methods. Scientific Methods. Design of Quantitative Surveys. Techniques to Conduct Quantitative Methods. Introduction to Qualitative Research. Qualitative Research Methods. Data Analysis and Theory in Qualitative Research Articles. Introduction to Mixed Methods Research. Design of Mixed Methods Research. Evaluation of Mixed Methods Research. Case Study. How to Conduct a Case Study. Case Study Protocol. Importance and Benefits of Case Study. Types of Statistical Tests to Conduct Data Analysis. Data Analysis Tools. Introduction to SPSS. Hands on Practice of SPSS. How to Define variables in SPSS. How to Record Collected Data in SPSS. Types of Tests via SPSS including Regression. Correlation. Cross tabulation and others. How to write Good Research Proposal. Contents of Thesis. Important Elements of Research Thesis.</p>		
Recommended Books	<p>Book: Research design: Qualitative, quantitative and mixed methods approaches, Creswell, 2017</p>	

Distributed Energy Generation Systems		Cr.Hrs 3
<ul style="list-style-type: none"> • Introduction to power. What is power generation transmission and Distribution? Need of Power system • Some important definition. Load Factor, Load Forecasting, method of Load Forecasting • Convection Source of energy • Boiler, Type of Boiler • Boiler Performance • Problem in steam turbine • Gas turbine • Hydro electric energy • Type of system • Classification of hydel turbine • Classification of Impulse Turbine • Efficiency of turbines • Handling of Nuclear waste • Nuclear Power & Environment • Introduction to renewable energy • Geothermal Energy 		
<p>Recommended Book</p>	<p>Power generation transmission and distribution by DP Kothari, 3rd Edition 2019</p>	