M.TECH. SCHEME & SYLLABUS
(POWER SYSTEM)
W.E.F. 2019-20

DEPARTMENT OF ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, KURUKSHETRA

M.TECH. ELECTRICAL ENGINEERING
POWER SYSTEM
M.TECH. SCHEME (W.E.F. ACADEMIC SESSION 2019-20)

Semester I

Course. No.	Course	L	T	P	Credits
MEE2C01	Advanced Power System Analysis	3	-	-	3
MEE2C03	Power System Stability & Control	3	-	-	3
MEE2C05	Power System Operation & Economics	3	-	-	3
	Elective-I	3	-	-	3
	Elective-II	3	-	-	3
	Elective-III	3	-	-	3
MEE2L01	Advanced Power System Lab	-	-	4	2
Total		**18**	**-**	**4**	**20**
Total contact hours		**22**			

Semester II

Course. No.	Course	L	T	P	Credits
MEE2C02	Electrical Distribution System Analysis	3	-	-	3
MEE2C04	Advanced Relaying & Protection	3	-	-	3
MEE2C06	Smart Grid Technology	3	-	-	3
	Elective-IV	3	-	-	3
	Elective-V	3	-	-	3
	Elective-VI (Departmental/Open)	3	-	-	3
MEE2L02	Programming & Simulation Lab	-	-	3	1
MEE2S02	Seminar	-	-	1	1
	Total	**18**	**-**	**4**	**20**
	Total contact hours	**22**			

Summer Academic Activity

Sr. No.	Course	L	T	P	Credits
MEE2I01#	Practical/Industrial Training/Short Term Course/Internship	-	-	-	-
	Total	**-**	**-**	**-**	**-**

 # Activity will be decided and evaluated by Supervisor of Student

Semester III

Sr. No.	Course	L	T	P	Credits
MEE2D01*	Dissertation Part-I	-	-	28	14
	Total	**-**	**-**	**-**	**14**

Semester IV

Sr. No.	Course	L	T	P	Credits
MEE2D02*	Dissertation Part-II	-	-	28	14
	Total	**-**	**-**	**-**	**14**

* **Evaluation will be done as per Institute norms**

The total credits are 68

List of Electives to be offered by the Department in Even & Odd Semester

Odd Semester

Course. No.	Course Name
MEE2E31	EHVAC Transmission
MEE2E33	Power System Deregulation and Pricing
MEE2E35	Transients in Power System
MEE2E37/ MEE2O71	Energy Auditing & Management*
MEE2E39	Design & Testing of High Voltage Apparatus
MEE2E41/ MEE2O73	Solar Energy in Power Systems*
MEE3C03	Power Conversion Techniques
MEE1C01	Linear System Theory
MEE1E31	Intelligent Control
MEE1E41	Digital Signal Processing
MEE1E47	Introduction to Machine Learning

Even Semester

Course. No.	Course Name
MEE2E32	Flexible AC Transmission Systems
MEE2E34	Power System Automation
MEE2E36/ MEE2O72	Distributed Generation & Micro-Grids*
MEE2E38	Power System Planning and Optimization
MEE2E40	Distribution System Planning and Automation
MEE2E42	State Estimation & Security Analysis
MEE2E44	HVDC Transmission
MEE3C02	Power Quality
MEE3C04	PLC & Microprocessor
MEE3C06	Electric Vehicles
MEE3E36	Wind Energy Conversion Systems
MEE3E40	Power converters for Renewable Energy Systems

*Subjects are open electives with a condition that pre-requisite of the subject is previously studied by the student

Course Code	:	MEE2C01
Course Title	:	Advanced Power System Analysis
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Power System Analysis, Matrix Algebra, Electric Machines and Network Analysis

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. To construct models of power system components and apply them
CO2. To solve ac and dc load flow for single and three phase systems
CO3. To analyse the faults in the power system networks
CO4. To apply the concepts of optimization in power system
CO5. To explain the concept of state estimation in power system and the role of statistics in state estimation.

CONTENTS:

Network modelling –Incidence matrix method, Method of successive elimination, Triangular factorization – Sparse matrix Incidence and network matrices – introduction – graphs – incidence matrices formation – Ybus by singular transformation
Load flow analysis - Newton Raphson method, Fast Decoupled method, AC-DC load flow – Single and three phase methods – Sequential solution techniques and extension to multiple and multi-terminal DC systems.
Fault Studies -Analysis of balanced and unbalanced three phase faults – fault calculations – Short circuit faults – open circuit faults. System optimization - strategy for two generator systems – generalized strategies – effect of transmission losses - Sensitivity of the objective function - Formulation of optimal power flow-solution by Gradient Method-Newton's method.
Contingency Analysis: Importance of contingency analysis - addition / removal of one line - construction of a column of bus impedance matrix from the bus admittance matrix - calculation of new bus voltages due to addition / removal of one line - calculation of new bus voltages due to addition / removal of two lines.
Fundamentals of State Estimation – method of least squares – statistics – errors – estimates – test for bad data – structure and formation of Hessian matrix – power system state estimation.

REFERENCE BOOKS:

1. Grainger, J.J. and Stevenson, W.D. 'Power System Analysis' Tata McGraw hill, New Delhi, 2003.
2. Hadi Saadat, 'Power System Analysis', Tata McGraw hill, New Delhi, 2002.
3. Arrillaga, J and Arnold, C.P., 'Computer analysis of power systems' John Wiley and Sons, New York, 1997.
4. Pai, M.A., 'Computer Techniques in Power System Analysis', Tata McGraw Hill, New Delhi, 2006
5. Stagg G. Ward, El–Abiad: Computer methods in power system analysis, McGraw Hill ISE, 1986.

Course Code	:	MEE2C03
Course Title	:	Power System Stability & Control
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Numerical Methods , Electrical Machines, Power System Analysis

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the basic modelling and stability considerations of power system

CO2. Appraise and analyse the small signal stability and the effects of excitation systems on small signal stability

CO3. Investigate transient stability issues of single and multiple synchronous machines in power systems

CO4. Evaluate the various aspects of voltage stability in power systems

CO5. Interpret different schemes for improving transient stability and voltage stability.

CONTENTS:

Power system stability considerations – definitions-classification of stability - rotor angle and voltage stability - synchronous machine – Modelling - load modelling concepts - modelling of excitation systems - modelling of prime movers.

Transient stability - swing equation-equal area criterion - solution of swing equation-Numerical methods - Euler method-Runge - Kutte method - critical clearing time and angle - effect of excitation system and governors-Multimachine stability – extended equal area criterion - transient energy function approach.

Small signal stability – state space representation – Eigen values - modal matrices - small signal stability of single machine infinite bus system – effect of field circuit dynamics - effect of excitation system-small signal stability of multi machine system.

Voltage stability – generation aspects - transmission system aspects – load aspects – PV curve – QV curve – PQ curve – analysis with static loads – loadability limit - sensitivity analysis - continuation power flow analysis - instability mechanisms – examples.

Methods of improving stability – transient stability enhancement – high speed fault clearing – steam turbine fast valving - high speed excitation systems - small signal stability enhancement - power system stabilizers – voltage stability enhancement – reactive power control.

REFERENCE BOOKS:

1. Kundur, P., 'Power System Stability and Control', McGraw-Hill Intl. Editions, 1994.
2. Van Cutsem, T. and Vournas, C., 'Voltage Stability of Electric Power Systems', Kluwer Academic Publishers, 1998.
3. Abhijit Chakrabarti, D.P. Kothari, A.K. Mukhopadhyay and Abhinandan De, 'An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems', PHI Learning Private Ltd., 2010.
4. R. Ramanujam, 'Power System Dynamics: Analysis and Simulation', PHI Learning Private Ltd., 2009.
5. P. M. Anderson and A. A. Fouad, "Power System Control and Stability, Wiley Interscience, John Wiley & Sons.
6. K.R. Padiyar: Power System Dynamics Stability and Control, BS Publications, 2nd edition, 2002

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2C05
Course Title	:	Power System Operation & Economics
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Numerical Methods, Power System Analysis, Optimization theory

COURSE OBJECTIVES:

CO1. To understand the concepts of economic dispatch for thermal generation units
CO2. To coordinate the scheduling of hydro and thermal systems
CO3. To apply various techniques for solution of unit commitment problem
CO4. To model the control of generation units in single and multi-area systems
CO5. To investigate the application of ANN and meta-heuristic techniques to economic dispatch.

CONTENTS:

Economic dispatch problem and methods of solutions – Economic importance – Characteristics of steam units.
Economic dispatch of Thermal Units and methods of solutions – problem considering and neglecting transmission losses.
Iterative and non–iterative methods of solutions – economic dispatch using dynamic programming.
Unit Commitment – Definition – Constraints in Unit Commitment–Unit Commitment solution methods – Priority–List Methods – Dynamic Programming Solution.
Economic dispatch versus Unit Commitment – constraints in thermal and hydro–units – hydrothermal coordination.
Long range and short–range hydro–scheduling – dynamic programming solution to hydro–thermal scheduling.
Control of generation – models of power system elements – single area and multi area block diagrams – generation control with PID controllers – implementation of Automatic Generation control (AGC) – AGC features.
Economic dispatch using ANN and meta- heuristic techniques.

REFERENCE BOOKS:

1. Allen J. Wood & B.F. Woolenberg: Power Generation, Operation and Control, Wiley India Pvt. Ltd., 2nd edition, 2006.
2. O. I. Elgerd, Electric Energy Systems Theory: An Introduction, TMH.
3. Jizhong Zhu, Optimization of Power System Operation, IEEE – Wiley.
4. R. H. Miller, J. H. Maliwski, Power System Operation, TMH.
5. James Momoh, Electric Power System Application of Optimization, CRC Press.

Course Code	:	MEE2E31
Course Title	:	EHVAC Transmission
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	High Voltage Engineering

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand issues of concern with EHVAC transmission

CO2. Identify and calculate the various parameters of EHV line for modelling

CO3. Assess the effects of corona and methods to limit the audible noise

CO4. Estimate the over–voltages in EHV AC systems and mitigation techniques.

CO5. Analysis of compensation schemes and Design case studies of EHVAC systems

CONTENTS:

Introduction to EHV AC Transmission

Calculations of line and ground parameters: Properties of bundled conductors – inductance and capacitance calculations – line parameters for modes of propagation – resistance and inductance of ground returns – equivalent circuit of line model.

Corona: Corona – corona loss formula factors affecting corona. Audible noise – its characteristics – limits for audio noise – relation between single phase and 3–phase AN levels – radio interference – limits for radio interference fields – CIGRE formula.

Over Voltage in EHV Systems: Switching surges – causes of switching surge over voltages – recovery voltage – restriking transients – over voltages caused by interruption of low inductance currents – line energization transients

Ferro–resonance over voltages – lightning over voltages– insulation coordination – design example.

Theory of reactive power/voltage control: Theory of steady state reactive power control in transmission system – uncompensated transmission lines – fundamental transmission line equation – surge impedance loading – uncompensated line on open circuit / under load. Passive shunt compensation – control of open circuit voltage with shunt reactors – voltage control with switched shunt compensation – Midpoint shunt reactor or capacitor. Series compensation – objectives and limitations symmetrical line with mid–point series capacitance and shunt reactor

Design and Construction aspects of EHVAC Systems

REFERENCE BOOKS:

1. R. D. Begamudre: Extra High Voltage Ac Transmission Engineering, PHI (pub) 1991.
2. T.J.E.Miller : Reactive Power Control in Electric Systems, John Wiley & Sons, 1986
3. Turan Gonen: Electric Power Transmission System Engineering Analysis and Design, McGraw Hill (Pub) .
4. A Chakraborti, D.P. Kothari and A.K. Mukhopadyay: Performance, Operation and Control of EHV Power Transmission Systems, T.M.H, 1999.
5. AP Sakis Meliopoulos: Power System Grounding and transients, 1988.

Course Code	:	MEE2E33
Course Title	:	Power Systems Deregulation & Pricing
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Power System Analysis, Power System Transmission and distribution.

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to
CO1. To explain the deregulated electricity market models functioning around the world.
CO2. To understand the operational and planning activities in power generation.
CO3. To solve transmission pricing and understand strategies in congestion management.
CO4. To study the development of competition in electricity distribution companies.
CO5. To outline the salient features of Indian Electricity Act and the formation and operation of Indian power exchanges.

CONTENTS:
Introduction: Market Models – Entities – Key issues in regulated and deregulated power markets; Market equilibrium- Market clearing price- Electricity markets around the world Key entities- Gencos – Discoms–Independent system operator (ISO) – power exchange.
Restructuring models: Models based on Trading – Models based on transactions – Hybrid model – market operations – market power – standard cost.
Power system operation in competitive environment: Introduction – operational planning activities of ISO – the ISO in pool markets – the ISO in bilateral markets – operational planning activities of a Genco. Transmission pricing: Cost Components – Postage Stamp method – Megawatt Mile method – Contract Path Method. Congestion pricing – Preventive and corrective measure – management of inter zonal/intra zonal congestion.
OASIS: Open Access Same–time Information System – structure of oasis – pooling of information – transfer capability on OASIS.
Definitions transfer capability issues: ATC calculations – methodologies to calculate ATC.
Congestion management in Open-access transmission systems- FACTS in congestion management -Electricity Pricing: Introduction – electricity price volatility electricity price indexes – challenges to electricity pricing – construction of forward price curves –price forecasting Ancillary services management: Introduction – reactive power as an ancillary service – a review – synchronous generators as ancillary service providers.
Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges.

REFERENCE BOOKS:
1. K. Bhattacharya, M. H.J. Bollen and J. E. Daalder: Operation of Restructured Power Systems, Springer Publishers, 2001.
2. L. L. Lai, 'Power System Restructuring and Deregulation', John Wiley & Sons Ltd., 2001.
3. M. Shahidehpour, H. Yamin, 'Market operations in Electric power systems', John Wiley & son ltd., 2002.
4. L. Philipson, H. L. Willis, 'Understanding Electric Utilities and Deregulation' Taylor & Francis, 2006.
5. M. Shahidehpour, M. Alomoush, 'Restructured Electrical Power Systems', Marcel Dekker, Inc., 2001.

Course Code	:	MEE2E35
Course Title	:	Transients in Power System
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Power System Analysis

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Recognize and construct different circuits representing lightning and travelling waves.
CO2. Analyse various switching transients in power systems.
CO3. Appraise voltage surges and distribution of surges in different electrical machines.
CO4. Understand schemes of surge protection of high voltage equipment.
CO5. Modelling and analysis power apparatuses under transient conditions.

CONTENTS:

Transients in electric power systems – Internal and external causes of over voltages – Lightning strokes – Mathematical model to represent lightning,
Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations – Bewley–Lattice diagram – switching operations of transmission lines
Switching transients – double frequency transients – abnormal switching transients – Transients in switching a three phase reactor - three phase capacitor
Voltage distribution in transformer winding – voltage surges-transformers – generators and motors Transient parameter values for transformers, reactors, generators and transmission lines
Basic ideas about protection – surge diverters-surge absorbers - protection of lines and stations Modern lighting arrestors - Insulation coordination - Protection of alternators and industrial drive systems– Effect of grounding practices.
Modelling of power apparatus under transient conditions: Modelling of transformers – Generators – Motors – Overhead lines and cables – case studies.

REFERENCE BOOKS:

1. A. Greenwood, ‘Electrical transients in power systems’, Wiley Interscience, 1991.
2. Bewley, L.V., ‘Travelling waves on Transmission systems’, Dover publications, New York, 1963.
3. Gallaghar, P.J. and Pearman, A.J., 'High voltage measurement, Testing and Design', John Wiley and sons, New York, 2001.
4. Harold A Peterson: Transient in Power Systems, McGraw Hill, 1966.
5. Kuffel and Abdullah: High Voltage Engineering, PHI, 2000.
6. Rakesh D. Begamudre: EHV AC Transmission Engineering, PHI, 2006.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E37/ MEE2O71
Course Title	:	Energy Auditing & Management
Number of Credits	:	3
Course Type	:	Elective/ Open Elective
Pre-requisite	:	Electrical Machines, Transmission and Distribution of Electrical Energy, utilization of electrical energy

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the basics of Energy auditing and Energy management
CO2. Employ energy management strategies for electric machines and cogeneration
CO3. Employ energy management strategies in lighting systems
CO4. Devise energy management strategies for metering and instrumentation
CO5. Analyse and justify the economics of different energy management strategies

CONTENTS:

Basics of Energy – Need for energy management – energy accounting- energy monitoring, targeting and reporting-energy audit process
Energy management for electric motors – Transformer and reactors-capacitors and synchronous machines, energy management by cogeneration –forms of cogeneration – feasibility of cogeneration – electrical interconnection
Energy management in lighting systems – task and the working space - light sources – ballasts – lighting controls – optimizing lighting energy – power factor and effect of harmonics, lighting and energy standards Metering for energy management – units of measure - utility meters – demand meters – paralleling of current transformers – instrument transformer burdens – multitasking solid state meters, metering location vs requirements, metering techniques and practical examples
Economic analysis – economic models- time value of money - utility rate structures – cost of electricity – loss evaluation, load management – demand control techniques – utility monitoring and control system – HVAC and energy management – economic justification

REFERENCE BOOKS:

1. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, 'Guide to Energy Management', 5th Edition, The Fairmont Press, Inc., 2006
2. Amit K. Tyagi, 'Handbook on Energy Audits and Management', The Energy and Resources Institute, 2003
3. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E39
Course Title	:	Design & Testing of High Voltage Apparatus
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Design a compact and economical insulation structure for high voltage equipment.
CO2. Estimate electric field intensity of various electrode configurations for high voltage power equipment.
CO3. Understand the testing methods of High Voltage Equipment
CO4. Understand the methods to diagnose the partial discharge activity in a power equipment
CO5. To familiarize with basics of Power System Grounding

CONTENTS:

History of high voltage engineering – Overhead lines – Towers and supports – conductors – dampers – foundations – Insulator design. Components of insulated power cable – design features Testing – diagnostics. Types of bushings – Bushing design – Bushing applications – Testing – maintenance and diagnosis. HV Power transformer–Insulation design concepts – winding short circuit forces and testing. Methods of generation of high direct voltages – alternating voltages and impulse voltages – insulation coordination – Test conditions. Introduction – Measuring system – Amplitude measurement of direct voltage – alternating voltage – impulse current measurement of time parameters – optical fiber based monitoring of high voltage power equipment.
Power System Grounding: Analysis of simple grounding systems – body currents due to touch and step voltages – grounding system safety assessment – Basic design of grounding – Mitigation of touch and step voltages – Design example of substation grounding.
Application to High Voltage

REFERENCES:

1. H.M. Ryan: High Voltage Engineering & Testing, IEE Press
2. Ravindra Arora & Wolfgang Mosch: High voltage Insulation Engineering, New Age International Publishers, 2011.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E41/ MEE2O73
Course Title	:	Solar Energy in Power Systems
Number of Credits	:	3
Course Type	:	Elective/ Open Elective
Pre-requisite	:	

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the concept of solar energy conversion system.
CO2. Distinguish grid connected issues and measures to mitigate it.
CO3. Select the appropriate inverters, converters, batteries and Balance of systems
CO4. Identify the grid interfacing requirements
CO5. Analyse detail operation of power system with solar energy systems

CONTENTS:

Solar energy conversion systems: Photovoltaic Energy Conversion: Solar radiation and measurement - solar cells and their characteristics -PV arrays - Electrical storage with batteries - Switching devices for solar energy conversion Grid connection Issues - Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing. PV Applications: Standalone inverters - Charge controllers - Water pumping, audio visual equipment, street lighting - analysis of PV systems.

Operation of power system with solar energy systems: Interface requirement – synchronizing with grid – operating limit – energy storage and load scheduling – utility resource planning – electrical performance – voltage, current and power efficiency – component design for maximum efficiency – static bus impedance and voltage regulation – quality of power – renewable capacity limit – Plant economy.

REFERENCES:

1. Chetan Singh Solanki, SOLAR PHOTOVOLTAICS: Fundamentals, Technologies and Applications 2/e 2nd Edition, PHI, 2009.
2. Sundaravadivelu S., Suresh R Norman , Solar Photovoltaic Power Systems: Principles, Design and Applications Hardcover – Import, 12 Apr 2018.
3. Rao. S. & Parulekar, “Energy Technology”, Khanna publishers, Fourth edition, 2005.
4. Rai, G.D., “Non- conventional resources of energy”, Khanna publishers, Fourth edition, 2010.
5. Bansal N K, Kleeman and Meliss, “Renewable energy sources and conversion Techniques”, Tata McGraw hill, 1990.
6. B.H. Khan, “Non-Conventional Energy Resources”, Tata McGraw Hills, Second edition, 2009.

Course Code	:	MEE2L01
Course Title	:	Advanced Power System Lab
Number of Credits	:	2
Course Type	:	Lab
Pre-requisite	:	

COURSE OBJECTIVES:

Upon completion of the Lab course, the students will be able to

CO1. Study breakdown of Air using AC/DC test set with different geometries.
CO2. Generate and analyse the generated impulse waves.
CO3. Understand application of Buchholz Relay
CO4. Understand model of lines and analyse the compensation of transmission line
CO5. Apply different protective schemes to power system elements

CONTENTS:

List of Practical:

Rotor 1

1. To Study Breakdown of Air Using 100 kV AC Test Set Using:
   - Sphere – Sphere Gap
   - Sphere – Plane Gap
   - Point – Plane Gap
2. Generation of HVDC with the Help of 140 KV, DC Set-Up.
3. To Generate and Measure Positive & Negative Lightning Impulse Voltage Waveforms Using 280 KV, 2-Stage, and 1.96 KJ Impulse Test Set.
4. To Generation of Switching Wave Positive & Negative with the Help of Two-Stage, 280 KV Impulse Generator.
5. To Detect Low Oil Level Inside Transformer Using Buchholz Relay.

Rotor 2:

6. To Perform Various Test On Transmission Line Model to Determine the Following:
   - ABCD Parameters
   - Efficiency at Various Loads
   - Compensation of Transmission Line
7. To Plot Trip Time Characteristics of Microprocessor Based Over/Under Voltage Relay.
8. To Plot Trip Time Characteristics of Numerical Based Percentage Biased 3-ϕ Differential Relay.
9. A. To Observe Trip Time of Microcontroller Based Over/Under Frequency Relay.
   B. To Observe Trip Time of Microcontroller Based Reverse Power Relay
10. To study the Negative phase sequence protection scheme on testing kit.

Second Semester

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2C02
Course Title	:	Electrical Distribution System Analysis
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Transmission and Distribution of Electrical Energy, Power System Analysis

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand types of distribution systems, components and substation schemes.
CO2. Analyse voltage drop and power loss calculations
CO3. Carry out voltage control analysis of electrical distribution systems.
CO4. Understand distributed generation in distribution systems
CO5. Perform load flow analysis and analysis with Distributed generation.

CONTENTS:

Types of Distribution Systems: Industrial and commercial distribution systems – Energy losses in distribution system, comparison of O/H lines and underground cable system. Network model –power flow and loss calculations, Introduction to Power Quality issues

Distribution Transformers: Types – Three phase and single phase transformers – connections – Dry type and self-protected type transformers – regulation and efficiency.

Sub Transmission Lines and Distribution Sub–Stations: Distribution substations –Bus schemes –description and comparison of switching schemes Substation location and rating.

Primary Systems: Types of feeders – voltage levels – radial type feeders.

Voltage Drop and Power Loss Calculations: Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks.

Voltage Control in Distribution Systems: Effects of series and shunt capacitors – justification for capacitors – Procedure to determine optimum capacitor size and location. Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems – loss reduction and voltage improvement.

Distribution System Protection: Basic definitions – types of over current protection devices. Objective of distribution system protection, system ground for safety and protection

Distributed Generation in Distribution System: Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, – Siting and sizing of DGs – optimal placement of DG sources in distribution systems and Power flow analysis with DGs.

Reference Books:

1. Pabla, A.S., 'Electrical Power Distribution System', 5th edition, Tata McGraw hill, 2011.
2. Turan Gonen, 'Electrical Power Distribution System Engineering', McGraw hill, 2008.
3. Sterling, M.J.H., 'Power System Control', Peter Peregrinus, 1986.
4. H. Lee Willis, Walter G. Scott,'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2C04
Course Title	:	Advanced Relaying & Protection
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Basic knowledge on short circuit analysis, digital system and signal processing.

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Describe the characteristics of various relays

CO2. Develop the digital circuit based protection for alternator and transformer

CO3. Knowledgeable about various schemes of protection for busbar, transmission line, capacitor and boosters.

CO4. Understand the concepts related to digital signal processing

CO5. Familiarize with functioning o PMUs and wide area measurement systems.

CONTENTS:

General philosophy of protection - Classification and Characteristic function of various protective relays basic relay elements and relay terminology - Development of relaying scheme

Digital Protection of power system apparatus – protection of generators – Transformer protection – Application and connection of transformer differential relays – transformer over current protection

Bus bar protection - line protection - distance protection–long EHV line protection - Power line carrier Protection Reactor protection – Protection of boosters - capacitors in an interconnected power system

Digital signal processing – digital filtering in protection relays - numeric protection – testing Digital filtering in protection relays – digital data transmission – relay hardware – relay algorithms - Concepts of coordination of relays.

Phasor Measurement Units

Introduction to Phasor measurement units (PMUS), global positioning system (GPS), Functional requirements of PMUs and PDCs, phasor estimation of nominal frequency inputs, PMU Applications Wide Area Measurement Systems (WAMS), Case studies on Industrial Switchgear

Reference Books:

1. Lewis Blackburn, J., ‘Protective Relaying – Principles and Applications’, Marcel Dekkar, INC, New York, 2006.
2. The Electricity Training Association, ‘Power System Protection Vol1-4’, The IEE, U.K., 2005.
3. C. Russeil Mason, ‘The art and Science of Protective Relaying’, GE Publishers, 1962.
4. T. Johns and S. K. Salman, ‘Digital Protection for Power Systems’, Peter Peregrinus Ltd., 1997.
5. Arun G Padkye and James S Thorp, ‘Computer Relaying for Power Systems’, John Wiley publications, 2nd Edition, 2009.
6. P M Anderson, ‘Power System Protection’, IEE Press, 2012.
7. A.G. Phadke, J.S. Thorp, ‘Synchronized Phasor Measurements and Their Applications’, Springer Publications, 2008.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2C06
Course Title	:	Smart Grid Technology
Number of Credits	:	3
Course Type	:	Core
Pre-requisite	:	Fundamentals of Power Distribution Systems

COURSE OBJECTIVES:

CO1. To get acquainted with the concepts of smart grid components.
CO2. To understand the components of energy management system.
CO3. To describe the various functions of distribution management system
CO4. To apply the various techniques of communication, computer networking and cyber security for smart metering systems.
CO5. To analyse application of smart grid technology in power system through case studies.

CONTENTS:

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid –Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers.
Energy Management System (EMS) - Smart substations - Substation Automation - Feeder Automation, SCADA, Smart switchgear – Remote Terminal Unit – Intelligent Electronic Devices – Protocols, Phasor Measurement Unit – Wide area monitoring, protection and control, Smart integration of energy resources – Renewable, intermittent power sources – Energy Storage.
Distribution Management System (DMS) – Volt / VAR control – Fault Detection, Isolation and Service Restoration, Network Reconfiguration, Outage management System, Customer Information System, Geographical Information System, Effect of Plug in Hybrid Electric Vehicles.
Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.
Elements of communication, networking and interfacing – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.
Applications of smart grid to power systems and case study

REFERENCES:

1. James Momoh, “Smart Grid: Fundamentals of design and analysis”, John Wiley & sons Inc, IEEE press 2012.
2. Stuart Borlase ‘Smart Grid: Infrastructure, Technology and Solutions’, CRC Press 2012.
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, ‘Smart Grid: Technology and Applications’, Wiley, 2012.
4. Mini S. Thomas, John D McDonald, ‘Power System SCADA and Smart Grids’, CRC Press, 2015
5. Kenneth C. Budka, Jayant G. Deshpande, Marina Thottan, ‘Communication Networks for Smart Grids’, Springer, 2014.

6. Fereidoon P. Sioshansi, “Smart Grid: Integrating Renewable, Distributed & Efficient Energy”, Academic Press, 2012.
7. Clark W. Gellings, “The smart grid: Enabling energy efficiency and demand response”, Fairmont Press Inc, 2009.

Course Code	:	MEE2E32
Course Title	:	Flexible AC Transmission systems
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Power System Analysis, Power Conversion techniques or equivalent

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the concepts of ac power transmission - problems and needs of Active & Passive Compensation

CO2. Identify in conventional power system where the installation of FACTS controllers or Devices becomes vital.

CO3. Analyse the performance of a conventional transmission system and apply the principles of reactive power compensation for improvement.

CO4. Illustrate the modes of operation of thyristor based and voltage source converter based FACTs controllers and explains the capabilities and modelling aspects.

CO5. Analyse different series, shunt or combined series-shunt FACTs controllers and compute the performance when installed in a given transmission system.

CONTENTS:

Fundamentals of ac power transmission - transmission problems and needs of Active & Passive Compensation - emergence of FACTS - FACTS control considerations - FACTS controllers, Classification of FACTs Controller and Voltage Source Converter

Principles of shunt compensation – Variable Impedance type & switching converter type - Static Synchronous Compensator (STATCOM) configuration - characteristics and control

Principles of static series compensation using TCSC- Static Synchronous Series Compensator (SSSC)

Principles of operation - Steady state model and characteristics of a static voltage regulators and phase shifters

UPFC - Principles of operation and characteristics - independent active and reactive power flow control - comparison of UPFC with the controlled series compensators and phase shifters

Load flow studies of Power System with FACTs Devices

Reference Books:

1. Song, Y.H. and Allan T. Johns, 'Flexible AC Transmission Systems (FACTS)', Institution of Electrical Engineers Press, London, 1999.
2. Hingorani, L. Gyugyi, 'Concepts and Technology of Flexible AC Transmission System', IEEE Press New York, 2000 ISBN –078033 4588.
3. Mohan Mathur R. and Rajiv K. Varma, 'Thyristor - based FACTS controllers for Electrical transmission systems', IEEE press, Wiley Inter science, 2002.
4. Padiyar K.R., 'FACTS controllers for Transmission and Distribution systems' New Age International Publishers, 1st Edition, 2007.
5. Enrique Acha, Claudio R. Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho 'FACTS –Modeling and simulation in Power Networks' John Wiley & Sons, 2002.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E34
Course Title	:	Power System Automation
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Basic Knowledge of Transmission & Distribution systems and Measuring Instruments

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the concepts of power system automation and SCADA systems
CO2. Understand the components and building blocks of SCADA systems.
CO3. Comprehend the RTU, IED and other components of automation systems
CO4. Analyse the Master station software and hardware configurations
CO5. Case studies of an interoperable powers automation system.

CONTENTS:

Evolution of Automation systems, History of Power System Automation, Supervisory Control and Data Acquisition(SCADA) Systems, Components of SCADA systems, SCADA Applications, SCADA in power systems, SCADA basic functions, SCADA application functions in Generation, Transmission and Distribution.

Advantages of SCADA in Power Systems, The Power system 'Field', Types of data & signals in the Power system, Flow of Data from the field to the SCADA Control center. Building blocks of SCADA systems, Classification of SCADA systems.

Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication, Logic, Termination and Test/HMI Subsystems, Power supplies, Advanced RTU Functionalities.

Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED functional block diagram, The hardware and software architecture of IED, IED Communication subsystem, IED advanced functionalities, Typical IEDs, Data Concentrators and Merging Units, SCADA Communication Systems.

Master Station, Master station software and hardware configurations, Server systems in the master station, Small, medium and large master station configurations, Global Positioning Systems, Master station performance, Human Machine Interface (HMI), HMI components, Software functionalities, Situational awareness, Case studies in SCADA.

Reference Books:

1. 1. Mini S. Thomas, John D McDonald, Power Systems SCADA and Smart Grid, CRC Press, Taylor and Francis .
2. 2. Electric Power Substation Engineering John D. Mc Donald CRC Press, Taylor and Francis
3. 3. Control and Automation of Electrical Power Distribution systems, James Northcote-Green, R Wilson, CRC Press, Taylor and Francis.
4. 4. Electric Power Distribution, Automation, Protection and Control, James Momoh, CRC press, Taylor and Francis.
5. General Electric Global Research Center, Niskayuna, New York.

Course Code	:	MEE2E36/ MEE2O72
Course Title	:	Distributed Generation & Micro-Grids
Number of Credits	:	3
Course Type	:	Elective/ Open Elective
Pre-requisite	:	The students must have a basic knowledge in Power System Analysis and Distribution Systems

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand the current scenario of Distributed Generation and the need to implement DG sources

CO2. Associate different types of micro-grids and Investigate the different types of interfaces for Grid integration of DGs.

CO3. Evaluate the various impacts of DGs on system performance and analysis of stability

CO4. Appraise and evaluate the reactive power and voltage control of DGs and various control aspects upon transmission and distribution systems.

CO5. Analyse the islanding schemes and protection related issues in micro-grids.

Contents:

Distributed Generation (DG): Need for distributed generation, renewable sources in distributed generation, current scenario in distributed generation, planning of DGs – Siting and sizing of DGs, optimal placement of DG sources in distribution systems.

Grid integration of DGs- Requirements for grid interconnection, limits on operational parameters, different types of interfaces - Inverter based DGs and rotating machine based interfaces, aggregation of multiple DG units, Energy storage elements- Batteries, ultra-capacitors, flywheels, Technical impacts of DGs – Transmission systems, Distribution systems, Impact of DGs on protective relaying, Impact of DGs on transient and dynamic stability of existing distribution systems.

Economic and control aspects of DGs- Market facts, issues and challenges, limitations of DGs, Voltage control techniques, Reactive power control, Harmonics, Power quality issues, Steady-state and Dynamic analysis, Different types of restoration systems.

Microgrids: Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids, modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques.

Reference Books:

1. *H. Lee Willis, Walter G. Scott,'Distributed Power Generation – Planning and Evaluation', Marcel Decker Press, 2000.*

2. *M. Godoy Simoes, Felix A. Farret, 'Renewable Energy Systems – Design and Analysis with Induction*
3. *Generators', CRC press.*
4. *Robert Lasseter, Paolo Piagi, 'Micro-grid: A Conceptual Solution', PESC 2004, June 2004.*
5. *F. Katiraei, M.R. Iravani, 'Transients of a Micro-Grid System with Multiple Distributed Energy Resources', International Conference on Power Systems Transients (IPST'05) in Montreal, Canada on June 19-23, 2005.*
6. *Z. Ye, R. Walling, N. Miller, P. Du, K. Nelson 'Facility Microgrids', Subcontract report, May 2005,*
7. *General Electric Global Research Center, Niskayuna, New York.*

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E38
Course Title	:	Power System Planning and Optimization
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Power system analysis, Power system transmission and distribution, Matrices, Probability and Calculus

COURSE OBJECTIVES:

Upon completion of the course, the students will be able

CO1. To explain the characteristics of loads, concepts of load forecasting and its types for power system planning

CO2. To comprehend the significance of reliability in power system, various methods and tools used for reliability analysis.

CO3. To describe the concepts of reliability in generation and transmission system, and system interconnection.

CO4. To discriminate the different modes of system failure and to explain various approaches to assess power system failure.

CO5. To understand and apply different optimization techniques to solve power system problems

CONTENTS:

Objectives of planning – Long and short term planning - Load forecasting – characteristics of loads –methodology of forecasting – energy forecasting – peak demand forecasting – total forecasting – annual and monthly peak demand forecasting.

Reliability concepts – exponential distributions – meantime to failure – series and parallel system –MARKOV process – recursive technique.

Generator system reliability analysis – probability models for generators unit and loads – reliability analysis of isolated and interconnected system – generator system cost analysis – corporate model – energy transfer and off peak loading

Transmission system reliability model analysis – average interruption rate - LOLP method – frequency and duration method.

Two plant single load system - two plant two load system - load forecasting uncertainly interconnections benefits

Introduction to system modes of failure – the loss of load approach – frequency & duration approach –spare value assessment – multiple bridge equivalents.

Optimization Techniques: Fundamentals of optimization techniques, evolutionary computation, GA, PSO, advanced optimization methods, multi-objective optimization, Applications to power system problems,

Reference Books:

1. Sullivan, R.L., 'Power System Planning', Heber Hill, 1987.
2. Roy Billington, 'Power System Reliability Evaluation', Gordan& Breach Scain Publishers, 1990.
3. Eodrenyi, J., 'Reliability modelling in Electric Power System' John Wiley, 1980.
4. D.P. Kothari and J.S. Dhillon, "Power System Optimization", 2nd Edition, PHI learning private limited, 2010.

5. Kalyanmoy Deb, “Multi objective optimization using Evolutionary Algorithms”, John Wiley and Sons, 2008. 3. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice hall of India first edition, 1988.
6. Electric Power System Planning: Issues, Algorithms and Solutions, by Hossein Seifi and Mohammad Sadegh Sepasian, Springer, 2011.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E40
Course Title	:	Distribution System Planning and Automation
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Basic knowledge in circuit analysis, control systems, power system and power electronic devices and circuits.

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand and distinguish characteristics of distribution systems from transmission systems

CO2. Design, analyse and evaluate distribution system design based on forecasted data

CO3. Design and evaluate a distribution system for a given geographical service area from alternate design alternatives.

CO4. Familiarize with basic architecture of Distribution automation system

CO5. Know about Communication protocols for Distribution systems

CONTENTS:

Power Computational Techniques in Distribution Systems: Complex power concept, per unit system, power loss calculation, voltage regulation techniques, components modeling, power flow methods.

Distribution Automation and control functions: Demand side management, voltage/var control, fault detection, trouble calls, restoration functions, Reconfiguration, optimization techniques.

Distribution System Planning: Planning and forecasting techniques – Present and future – Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy.

Distribution System Automation**:** Reforms in power sector –Intelligent systems in distribution automation, Methods of improvement –Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions –Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards, Distribution system management, Integrated sub–station metering system, automatic meter reading, cost benefit analysis.

REFERENCES:

1. Turan Gonen: Electric Power Distribution Engg., Mc-Graw Hill, 1986.
2. James A Momoh: Electric Power Distribution, Automation, Protection and Control, CRC press, Taylor and Francis.
3. A. S. PABLA: Electric Power Distribution, TMH, 2000.
4. H Lee Willis, "Distributed Power Generation Planning and Evaluation", CRC Press, 2000.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E42
Course Title	:	State Estimation & Security Analysis
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Computer Methods in Power System

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Understand and Develop mathematical models for analysis of linear and non–linear State Estimation of Power System.

CO2. Identify the strategic locations for measurements, Detection, Identification and measurements, Observability of power systems

CO3. Analyse the linear and non–linear State Estimation methods and Contingency studies

CO4. Select and identify the algorithms for State Estimation and Contingency Evaluation

CO5. Understand real time control, energy control centres and SCADA applications

CONTENTS:

State Estimation of Power Systems: Introduction to State Estimation (SE) in Power Systems: Maximum likelihood Weighted Least Square Estimation – Weighted Least Square (WLS) SE. SE of AC networks: Types of measurements – Linear WLS–SE theory – DC Load flow based WLS–SE – Linearized model of WLS–SE of Non–linear AC power systems – Sequential and non–sequential methods to process measurements – typical results of SE on an Ac network. Types of SE. Detection and Identification of bad measurements – Network Observability and Pseudo–measurements – observability by graphical technique and triangularisation approach – Optimal meter placement – Application of Power System S.E.

Security Analysis of Power System: Concept of security – Security analysis and monitoring – factors affecting Power System Security – Contingency Analysis for Generator and Line Outages by Fast Decoupled Inverse Lemma–based approach – Network Sensitivity factors. Contingency selection. Computer control of Power Systems: Need for Real – Time and Computer control of Power Systems – operating states of a Power System – Supervisory Control and Data Acquisition system (SCADA) – implementation considerations – energy control centres – software requirements for implementing the above functions.

REFERENCES:

1. Allen J. Wood and Bruce Woolenberg: Power System Generation, Operation and Control, John Wiley and Sons, 1996.
2. John J. Grainger and William D Stevenson Jr.: Power System Analysis, McGraw Hill ISE, 1994.
3. IEEE Proc. July 1974, Special Issue on Computer Control of Power Systems.

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2E44
Course Title	:	HVDC Transmission
Number of Credits	:	3
Course Type	:	Elective
Pre-requisite	:	Basic knowledge in circuit analysis, control systems, power system and power electronic devices and circuits.

COURSE OBJECTIVES:

Upon completion of the course, the students will be able to

CO1. Appraise the need of HVDC technology for bulk power transmission and choose appropriate type of HVDC link and converter

CO2. Analyse the operation of Graetz circuit as rectifier and inverter without and with overlap.

CO3. Evaluate the operation and efficacy of different controllers and analyse the different faults in HVDC systems

CO4. Discriminate and evaluate the issues related with harmonics, reactive power control and protection of HVDC system.

CO5. Recognize and appraise the recent trends in HVDC transmission systems.

CONTENTS:

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, Types of HVDC links - monopolar, bipolar and homopolar links, Components of HVDC transmission system Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit without and with overlap.

Output voltage waveforms and DC voltage in both rectifier and inverter operation, Equivalent circuit of HVDC link

Basic means of HVDC system control, desired features, power reversal, Basic controllers – constant ignition angle, constant current and constant extinction/ advance angle control, power control, high level controllers. Converter maloperations - misfire, arc through, commutation failure Harmonics in HVDC system - Characteristic and uncharacteristic harmonics - troubles due to harmonics – harmonic filters - active and passive filters - Reactive power control of converters, Protection issues in HVDC, over voltage and over current protection, voltage and current oscillations, DC reactor design, DC

Circuit breakers

Recent trends in HVDC transmission-CCC based HVDC system, VSC based HVDC system, – Multiterminal HVDC systems and HVDC system applications in wind power generation, Interaction between AC and DC systems

REFERENCES:

1. Kimbark, E.W., 'Direct Current Transmission-vol.1', Wiley Inter science, New York, 1971.
2. Padiyar, K.R., 'HVDC transmission systems', Wiley Eastern Ltd., 2010.
3. Kamakshaiah, S and Kamaraju, V, 'HVDC Transmission', 1st Edition, Tata McGraw Hill Education (India), New Delhi 2011.
4. Arrilaga, J., 'High Voltage Direct Current Transmission', 2nd Edition, Institution of Engineering and Technology, London, 1998.
5. Vijay K. Sood, 'HVDC and FACTS Controllers', Kluwer Academic Publishers, New York, 2004.

Course Code	:	MEE2L02
Course Title	:	Programming & Simulation Lab
Number of Credits	:	1
Course Type	:	Lab
Pre-requisite	:	

COURSE OBJECTIVES:
Upon completion of the Lab course, the students will be able to
CO1: Understand MATLAB software and its Applications
CO2: Develop MATLAB code for Load flow analysis
CO3: Apply SIMULINK models for designing load frequency control schemes
CO4: Understand different softwares in Power Systems lab and their Applications
CO5: Analysis of Power systems problems with applications of softwares

CONTENTS:

List of Practicals:

1. Write a MATLAB code for determining Ybus using different techniques
2. Develop MATLAB code for N-R method of load flow analysis
3. Develop MATLAB codes for other load flow techniques and compare
4. Develop MATLAB code for study of fault analysis in power systems network.
5. Design in SIMULINK a multi area power system network for load frequency control and application of PSS
6. Design in SIMULINK a multi area power system network for load frequency control using different controllers and compare the performance.
7. Apply different softwares for analysing power system problems
8. Application of GAMS software for solving economic load dispatch without and with consideration of loss in the network.
9. Application of GAMS software for solving Unit Commitment problem in Power Systems

Second Semester

Course Code	:	MEE2S02
Course Title	:	Seminar
Number of Credits	:	1
Course Type	:	Core

Course Outcomes: At the end of the course, student will be able to:

CO1 Identify and chose appropriate area of interest.

CO2 Assimilate literature on technical articles of specified topic of relevance

CO3 Understand the articles and prepare text and illustrations respecting intellectual property right.

CO4 Write technical report.

CO5 Present a technical talk on the chosen topic

Suggested Rubrics:

1. Background Content
2. Methods
3. Presentation material
4. Illustrations (Graphs, figures, tables, flowcharts etc)
5. Presentation skills
6. Report writing on Seminar
7. Time management
8. Response to Audience Queries
9. Personality, Preparedness and Gestures

Achievements to be judged on four levels: Below Average, Average, Good and Outstanding.

Third Semester

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2D01
Course Title	:	Dissertation Part-I
Number of Credits	:	14
Course Type	:	Dissertation

Course Outcomes

Course Outcomes: At the end of the course, student will be able to:

CO1. Define Research plan based on industry and social issues.
CO2. Develop a detailed study methodology based on critical literature survey.
CO3. Carryout theoretical study/experimental analysis
CO4. Prepare presentation of the work carried out
CO5. Understand issues related in terms of environment, society and ethics in research and publications.

Learning Resources: 1. Journal and conference papers from reputed publishers such as IEEE, Elsevier, and Wiley.

2. Research Articles / Reports available on Internet.

Suggested Rubrics:

- Selection of Dissertation topic with objectives
- Identification of methodology to be adopted
- Complete Literature survey in proposed area
- Proposed design/setting up / simulation environment for experiment.
- Benchmarks used / Assumptions made
- Sample Simulation results towards preparedness for dissertation
- Documentation of report towards preparedness for dissertation work

Achievements to be judged on four levels: Below Average, Average, Good and Outstanding

Fourth Semester

MASTER OF TECHNOLOGY (ELECTRICAL ENGINEERING)
POWER SYSTEM W.E.F. 2019-20

Course Code	:	MEE2D02
Course Title	:	Dissertation Part-II
Number of Credits	:	14
Course Type	:	Dissertation

Select a topic for his / her dissertation, based on his/her interest and the available facilities at the commencement of dissertation work.
Students are required to submit a dissertation report on the research work carried out by him/her

Course Outcomes: At the end of the course, student will be able to:

CO1 Expand on the defined Research Problem statement
CO2 Formulate the objectives and plan experimental / theoretical study
CO3 Conduct experimental /analytical studies
CO4 Analyze Data, develop models and offer solutions
CO5 Write the dissertation and papers following ethics in research and publications

Learning Resources:
1. Journal and conference papers from reputed publishers such as IEEE, Elsevier, and Wiley.
2. Research Articles / Reports available on Internet.

Suggested Rubrics:

- Apparent and concise objectives
- Evident methodology articulated using technical terms indicating all steps and tools
- Cites substantial current and good quality literature
- The clarity in design/setting up of experiment.
- Benchmarks used / Assumptions made
- Interpretation of results and justification thereof and validity of the results presented
- Documentation of the work

Achievements to be judged on four levels: Below Average, Average, Good and Outstanding