Effective from session 2015-2016

BABU BANARASI DAS UNIVERSITY, LUCKNOW
School of Engineering
Department of Electrical Engineering
Master of Technology
[Full Time]
(Power System & Control)

Credit Summary Chart:

Credit Summary Chart						
Course Category	**Semester**				**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**		
GE	4	8			12	12.77
C	19	15	20	28	82	87.23
Total	**23**	**23**	**20**	**28**	**94**	**100**

Discipline wise Credit Summary Chart						
Course Category	**Semester**				**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**		
Basic Sciences	4	4			**8**	**8.51**
Humanities and Social Sciences					**0**	**0.00**
Engg. Sciences					**0**	**0.00**
Professional Subject Core	14	9			**23**	**24.47**
Professional Subject - Generic Elective	4	8			**12**	**12.77**
Professional Subject -Open Elective					**0**	**0.00**
GP + Project Work, Seminar and / or Internship in Industry or elsewhere.	1	2	20	28	**51**	**54.25**
Total	**23**	**23**	**20**	**28**	**94**	**100.00**

Master of Technology
[Part Time]
(Power System & Control)

Credit Summary Chart:

Credit Summary Chart								
Course Category	**Semester**						**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**	**V**	**VI**		
GE	0	4	4	4			12	12.77
C	13	9	6	6	20	28	82	87.23
Total	**13**	**13**	**10**	**10**	**20**	**28**	**94**	**100**

Discipline wise Credit Summary Chart								
Course Category	**Semester**						**Total Credits**	**Percentage**
	I	**II**	**III**	**IV**	**V**	**VI**		
Basic Sciences	4	4					**8**	**8.51**
Humanities, Social Sciences &Management							**0**	**0.00**
Engg. Sciences							**0**	**0.00**
Professional Subject Core	9	4	5	5			**23**	**24.47**
Professional Subject - General Elective		4	4	4			**12**	**12.77**
Professional Subject -Open Elective							**0**	**0.00**
GP + Project Work, Seminar and / or Internship in Industry or elsewhere.		1	1	1	20	28	**51**	**54.25**
Total	**13**	**13**	**10**	**10**	**20**	**28**	**94**	**100.00**

Master of Technology
[Full Time]
(Power System & Control)

Evaluation Scheme:

1st YEAR SEMESTER I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS2006	Applied Mathematics	3	1	0	40	60	**100**	**4**
C	MEE2101	Advanced Power System Analysis	3	1	0	40	60	**100**	**4**
C	MEE2102	Modeling and Simulation	3	1	0	40	60	**100**	**4**
C	MEE2103	Advanced Control System	3	1	0	40	60	**100**	**4**
GE		**Generic Elective I**	3	1	0	40	60	**100**	**4**
C	MEE2151	Power System Lab	0	0	2	40	60	**100**	**1**
C	MEE2152	Modeling and Simulation Lab	0	0	2	40	60	**100**	**1**
C	MEE2153	Seminar	0	0	2	100		**100**	**1**
Total			**15**	**5**	**6**	**380**	**420**	**800**	**23**

1st YEAR SEMESTER II									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MAS2004	Optimization Techniques	3	1	0	40	60	**100**	**4**
C	MEE2201	Application of AI in power & control	3	1	0	40	60	**100**	**4**
C	MEE2202	Economic operation & control of power System	3	1	0	40	60	**100**	**4**
GE		**GenericElective II**	3	1	0	40	60	**100**	**4**
GE		**GenericElective III**	3	1	0	40	60	**100**	**4**
C	MEE2251	Artificial IntelligenceLab	0	0	2	40	60	**100**	**1**
C	MEE2252	Mini Project	0	0	2	100		**100**	**1**
C	MEE2253	Research Methodology and Practices$	0	0	2	100		**100**	**1**
Total			**15**	**5**	**6**	**440**	**360**	**800**	**23**

$ The mission of the cource is to impart research skills to the skills to the begineers and help them to improve the quality of research. The student is expected to develop most appropriate methodoligies for their research studiesand then give a presenntation on researchoverview and its methodoligies. This may include various steps to conduct the research.

2nd YEAR SEMESTER III									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MEE2351	State of the Art Seminar*	-	-	-	200	-	**200**	**4**
C	MEE2352	Thesis-I#	-	-	-	400	-	**400**	**16**
Total			**-**	**-**	**-**	**600**	**-**	**600**	**20**

***The Student need to perform a literature survey, give a state of art presentation and will submit a synopsis clearly mentioning the problem statement. The presentation ans synopsis will be evaluated internally within two months of the start of the semester and result will be intimated to the student so as to proceed for the thesis-I.**

#The student will develop a workable model for the problem that has been proposed in synopsis.

2nd YEAR SEMESTER IV									
Course Category	Course Code	Code Title	Contact Hours			Evaluation Scheme			Credits
			L	T	P	CIA	ESE	Course Total	
C	MEE2451	Thesis-II##	-	-	-	200	800	**1000**	**28**
Total			**-**	**-**	**-**	**200**	**800**	**1000**	**28**

##This is in continuation with thesis-I. The required experimental/mathematical verification of the proposed model will be done in this semester.

Generic Elective:

Course Code	Generic Elective-I
MEE2011	Deregulation of Power System
MEE2012	High Voltage D. C. Transmission system
MEE2013	Digital Signal Processing & its Applications
Course Code	**Generic Elective-II**
MEE2021	Flexible AC Transmission System (FACTS) Controllers
MEE2022	Advanced Power system Protection
MEE2023	Power Quality
MEE2024	Power System Dynamics and Control
Course Code	**Generic Elective-III**
MEE2031	Industrial Drives and Control
MEE2032	Robust and Adaptive Control
MEE2033	Intelligent Instrumentation

Legends:

L Number of Lecture Hours per week
T Number of Tutorial Hours per week
P Number of Practical Hours per week
CIA Continuous Internal Assessment
ESE End Semester Examination

Category of Courses:

F Foundation Course
C Core Course
GE Generic Elective
OE Open Elective

Master of Technology

[Part Time]
(Power System & Control)

Evaluation Scheme:

1st YEAR SEMESTER I									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS2006	Applied Mathematics	3	1	0	40	60	**100**	**4**
C	MEE2101	Advanced Power System Analysis	3	1	0	40	60	**100**	**4**
C	MEE2103	Advanced Control System	3	1	0	40	60	**100**	**4**
C	MEE2151	Power System Lab	0	0	2	40	60	**100**	**1**
Total			**9**	**3**	**2**	**160**	**240**	**400**	**13**

1st YEARSEMESTER II									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MAS2004	Optimization Techniques	3	1	0	40	60	**100**	**4**
C	MEE2202	Economic operation & control of power System	3	1	0	40	60	**100**	**4**
GE		**GenericElective II**	3	1	0	40	60	**100**	**4**
C	MEE2153	Seminar	0	0	2	100		**100**	**1**
Total			**9**	**3**	**2**	**220**	**180**	**400**	**13**

2nd YEAR SEMESTER III									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEE2102	Modeling and Simulation	3	1	0	40	60	**100**	**4**
GE		**GenericElective I**	3	1	0	40	60	**100**	**4**
C	MEE2152	Modeling and Simulation Lab	0	0	2	40	60	**100**	**1**
C	MEE2253	Research Methodology and Practices$	0	0	2	100		**100**	**1**
Total			**6**	**2**	**4**	**220**	**180**	**400**	**10**

$ The mission of the cource id to impart research skills to the skills to the begineers and help them to improve the quality of research. The student is expected to develop most appropriate methodoligies for their research studiesand then give a presenntation on researchoverview and its methodoligies. This may include various steps to conduct the research.

2nd YEAR SEMESTER IV									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEE2201	Application of AI in power & control	3	1	0	40	60	**100**	**4**
GE		**GenericElective III**	3	1	0	40	60	**100**	**4**
C	MEE2251	Artificial Intelligence Lab	0	0	2	40	60	**100**	**1**
C	MEE2252	Mini Project	0	0	2	100		**100**	**1**
Total			**6**	**2**	**4**	**220**	**180**	**400**	**10**

3rd YEAR SEMESTER V										
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEE2351	State of the Art Seminar*	-	-	-	200	-	**200**	**4**
C	MEE2352	Thesis-I#	-	-	-	400	-	**400**	**16**
Total			**-**	**-**	**-**	**600**	**-**	**600**	**20**

***The Student need to perform a literature survey, give a state of art presentation and will submit a synopsis clearly mentioning the problem statement. The presentation ans synopsis will be evaluated internally within two months of the start of the semester and result will be intimated to the student so as to proceed for the thesis-I.**

#The student will develop a workable model for the problem that has been proposed in synopsis.

3rd YEARSEMESTER VI									
Course Category	**Course Code**	**Code Title**	**Contact Hours**			**Evaluation Scheme**			**Credits**
			L	**T**	**P**	**CIA**	**ESE**	**Course Total**	
C	MEE2451	Thesis-II##	-	-	-	200	800	**1000**	**28**
Total			**-**	**-**	**-**	**200**	**800**	**1000**	**28**

##This is in continuation with thesis-I. The required experimental/mathematical verification of the proposed model will be done in this semester.

Generic Elective:

Course Code	GenericElective-I
MEE2011	Deregulation of Power System
MEE2012	High Voltage D. C. Transmission system
MEE2013	Digital Signal Processing & its Applications
Course Code	**Generic Elective-II**
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MEE2022	Advanced Power system Protection
MEE2023	Power Quality
MEE2024	Power System Dynamics and Control
Course Code	**Generic Elective-III**
MEE2031	Industrial Drives and Control
MEE2032	Robust and Adaptive Control
MEE2033	Intelligent Instrumentation

Legends:

L Number of Lecture Hours per week
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Category of Courses:

F Foundation Course
C Core Course
GE Generic Elective
OE Open Elective

Master of Technology
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SEMESTER – I

MEE2101ADVANCED POWER SYSTEM ANALYSIS

Course Objective:

1. To develop a strong foundation in the field advanced power system.
2. The subject gives the deep knowledge about advanced power system analysis.

Learning Outcome:

At the end of the course, student should be able:

1. Understand about advanced power system.
2. Logically explain the concepts of advanced power system analysis.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction to power system Analysis:** Single line diagram, Per unit system, Static modeling of power system components. **Fault Studies**:Analysis of balanced and unbalanced three phase faults, Fault **c**alculations, Short circuit faults, Open circuit faults.	30 Hours	1
II	**Transient Stability analysis:** Swing Equation, Equal area criterion, Multi-machine stability. **Small Signal Stability**: Modal Analysis, Participation Matrix, Design of Power System.	30 Hours	1
III	**Voltage Stability:** Sensitivity analysis, Real time voltage stability analysis methods. **Introduction to load flow problem:** Network admittance matrix formulation, Gauss Seidel method of load flow, Newton Raphson method, Decoupled and Fast decoupled Load flow, DC load flow, Distribution load flow.	30 Hours	1
IV	**Security Analysis:** Power system states, Power system security, Contingency analysis, Linear sensitivity factors, Generation shift distribution factor, Outage	30 Hours	1

	distribution factor. **Advanced topics in power system:** Introduction to Synchro-phasors and its applications in powers system monitoring & control.		

Text &Reference books:

1. 'Power System Analysis' by Grainger, J.J. and Stevenson, W.D., Tata McGraw hill, New Delhi.
2. 'Computer analysis of power systems' byArrillaga, J and Arnold, C.P.John Wiley and Sons.
3. 'Computer Techniques in Power System Analysis' by Pai, M.A. Tata McGraw hill.
4. 'Power system analysis' by Nagrath and Kotari.

MEE2102 MODELING AND SIMULATION

Course Objective:

This course provides an overview of models and simulations and of modeling and simulation techniques. Techniques include time-driven and event-driven dynamic models/simulations, Monte Carlo simulation, and decision simulation. The course addresses the role of modeling and simulation in the systems engineering process and provides methods for architecting and managing the development of complex models/simulations.

Learning Outcome:

At the end of the course, student should be able:

1. Understand the variety of different types of models and simulations and the different ways in which they are used.
2. Understand the role of modeling and simulation in the systems engineering process, how to manage the development of complex models and simulations, and how to use the systems engineering process to develop complex models and simulations
3. Understand key development factors associated with developing complex models and simulations, the factors that determine what level of detail is appropriate for a model/ simulation, and the evolution of a model/simulation.
4. Use MATLAB to develop and graph simple mathematical models of systems, translate these into simple dynamic time-driven simulations, discrete event simulations, and Monte Carlo simulations, and develop simple intelligent agents.
5. Develop a plan for the development of a distributed simulation, a design for a simple distributed simulation, and work as part of a team to develop, integrate, verify and validate prototype modules for a distributed simulation.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Definitions of Modeling and Simulation, Applications, Terminology & Components, Discrete vs. Continuous time, Process flow in simulation study, Review of Basic Probability and Statistics Terminology and Concepts, Useful Statistical Models, Distributions.	30 Hours	1
II	**Queuing models:** Characteristics, Performance Measures, Steady-State Behavior, Networks of Queues, Properties of Random Numbers, Generation of Pseudo-Random Numbers, Testing for Randomness, Pitfalls.	30 Hours	1
III	**Input Modeling:** Collecting Data, Identifying Distribution, Histograms, Parameter Estimation, Goodness-of-Fit Selecting Input Model without Data**,** Model Building, Verification, and Validation, Verification of Simulation Models, Calibration and Validation of Models.	30 Hours	1
IV	**Output Analysis:** Types of Simulations with Respect to Output Analysis,Stochastic Nature of Output Data, Measures of Performance Output Analysis for Termination Simulations, Output Analysis for Steady-State Simulations**,** Simulation Examples: Power Systems, Simulation Examples: Control Systems.	30 Hours	1

Text Books:

1. Averill M. Law, Simulation Modeling and Analysis
2. Bernard P. Zeigler , Herbert Praehofer , Tag Gon Kim ,Theory of Modeling and Simulation.

MEE2103 ADVANCEDCONTROL SYSTEM

Course Objective:

1. The course is designed to provide students with an understanding of linear system as well as non-linear system concepts.
2. Course emphasizes the state space approach and designing of pole placement and state observer design.
3. To check the stability of any autonomous system by using Lyapunov's approach.
4. To understand the concept of non-linear systems and describing functions.

Learning Outcome:

1. Analyze dynamics of a linear system by solving system model/equation or applying domain transformation.
2. Realize the structure of a discrete time system and model its action mathematically.
3. Examine a system for its stability, controllability and observability.
4. Examining the stability of an autonomous system with the help of Lyapunov's stability theory.
5. Understanding the concepts of non-linear control techniques.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**State Space Analysis:** Introduction, Concept of state, State Variable and State Model, State models for linear and continuous time systems, Solution of state and output equation, controllability and observability, Pole Placement, State observer Design of Control Systems.	30 Hours	1
II	**Analysis of Discrete System:**Discrete system and discrete time signals, State variable model and transfer-function model of discrete system, Conversion of state variable model to transfer function model and vice-versa.Modeling of sample hold circuit, solution of state difference equations.Steady state accuracy.Stability on the z plane and Jury stability criterion, bilinear transformation, Routh-Hurwitz criterion on rth planes.	30 Hours	1
III	**Stability Analysis:** Introduction**,** Stability in the sense of Lyapunov, Lyapunov's stability theorem, Lyapunov's instability theorems, Direct method of Lyapunov for the Linear and Nonlinear continuous time autonomous systems.	30 Hours	1

IV	**Nonlinear Control Techniques:** Introduction to nonlinear systems, Types of nonlinearities, Describing function, describing function analysis of nonlinear control systems, Sliding mode control, Feedback linearization methods.	30 Hours	1

Text &Reference Books:

1. 'Digital Control and State Variable Method' byM. Gopal.
2. 'Systems and Control' by S.H. Zak, Oxford Univ. Press.
3. 'Digital Control System' byB C Kuo.
4. 'Control System' by B.N.Sonkar, PHI.

MEE2151 POWER SYSTEM LAB

1. Formation of Y-BUS matrix using MATLAB coding.
2. MATLAB coding N-R Load flow in polar co-ordinates.
3. Load flow calculation using MATLAB and PST package.
4. Optimal power flow using PSAT.
5. Distribution loadflow.
6. Symmetrical and unsymmetrical fault studies.
7. Small signal stability analysis using MATLAB and PST package.
8. Transient stability analysis using MATLAB and PST package.
9. State Estimation using MATLAB program.
10. Power quality calculation using PSCAD/EMTDC.
11. Time-domain simulation in PSCAD for observing various power systemscenarios like power swing, voltage instability etc.

MEE2152 MODELLING AND SIMULATION LAB

1. Study of MATLAB toolboxes:
   i. Power system toolbox.
   ii. Control System toolbox.
   iii. Neural network toolbox.
   iv. Use of MATLAB functions block for linking m-file with Simulink model.
   v. Signal Processing toolbox.
   vi. Modeling of Wind Turbine and integration with Power System And utilization of the same in power/control applications

2. Simulating Power Quality events (sag swell, harmonics) in PSCAD/EMTDC.
3. Analysis of the power quality events in PSCAD/EMTDC interfaced with MATLAB.
4. M- file code generation and implementation for the power & control Applications.

SEMESTER - II

MEE2201APPLICATION OF AI IN POWER & CONTROL

Course Objective:

This course provides an overview of application of artificial Intelligence. Techniques include different applications of artificial Intelligence in power system and control.

Learning Outcome:

At the end of the course, student should be able:

1. Understand the variety of different types of application of artificial Intelligence.
2. Understand the role of different techniques in the field of artificial Intelligence in power system and control.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Introduction of soft computing, Soft computing vs. hard computing, Various types of soft computing techniques, Applications of soft computing, Introduction to Artificial Intelligence, Search Techniques knowledge representation issues.	30 Hours	1
II	**Fuzzy Logic:** Fuzzy set theory, Classical set theory, Crisp & Non-crisp set, Fuzzy set versus crisp set, crisp logic, fuzzy logic, Capturing uncertainty, Definition of fuzzy set, Graphic Interpretations, Fuzzy set -Small, Prime numbers, Universal space, Empty. **Fuzzy operations:**Inclusion, Equality, Comparability, Complement, Union, Intersection, introduction & features of membership functions.	30 Hours	1
III	**Neural Network:**Biological model, Information flow in neural cell, Artificial neuron, Functions, Equation, Elements, Single and Multi-layer Perceptrons.Structure and Function of a single neuron, Biological model, Information flow in neural cell, Characteristics and applications of ANN.	30 Hours	1
IV	**Genetic algorithm:**Fundamentals, basic concepts, working principle, Mechanics of Biological evolution; ArtificialEvolution and Search Optimization, Taxonomy of Evolution & Searchoptimization - Enumerative,Calculus-basedandGuided randomsearch techniques, Evolutionary algorithms (EAs), Definitions of ART and other types of learning; ART, Description, Model functions, Training, and Systems, encoding, fitness function.	30 Hours	1

	Associative Memory: Description of AM; Examples of Auto and Hetero AM. **Adaptive Resonance Theory:**Definitions of ART and other types of learning; ART, Description, Model functions, Training, and Systems.		

Text & Reference books:

1. 'Principles of Soft Computing' by S.N. Sivanandam& S.N. Deepa, Wiley Publications.
2. 'Artificial Intelligence' byRich E and Knight K TMH, New Delhi.
3. 'Neural Network fundamental with Graph' by Bose, TMH.

MEE2202 ECONOMICOPERATION AND CONTROL OF POWER SYSTEM

Course Objective:

This course provides an overview of economic operation and control of power system.

Learning Outcome:

At the end of the course, student should be able:

1. Understand the variety of different types of controls in power system.
2. Understand the role of economic operation in power system.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Mathematical preliminaries of Optimization:**Unconstrained and constrained optimization for functions of Single and multiple variables, Techniques to search for optimal solutions, Linear programming, Dynamic programming. **Economic dispatch of thermal units:**Economic load dispatch of thermal units including network Losses, Transmission line loss calculation using B-coefficients, Optimization techniques to find economic dispatch. **Unit commitment:** Need for unit commitment, Constraints in unit commitment problem, Application of dynamic programming for solving unit Commitment problem.	30 Hours	1

II	**Load Frequency & Control:**Overview of the load frequency control problem, Development of prime mover, generator, turbine and load Models, Isochronous generators, Speed regulation characteristics, Load sharing by parallel generators, Adjusting speed-droop characteristics, tie-line model, Interconnected power system, Automatic generation control, generation allocation.	30 Hours	1
III	**Reactive power dispatch and optimal power flow:** Reactive power dispatch, Classical method, Derivation of the exact loss formula for transmission lines, Optimal reactive power dispatch using linear programming, Methods of reactive power control, Optimal power flow, Problem formulation for various objectives, Security constrained optimal power flow, Multi-contingency voltage stability enhancement, Multi-objective optimal power flow.	30 Hours	1
IV	**State estimation:** Power system monitoring, EMS, SCADA, Function of state estimator, Maximum likelihood estimation, Formulation of the WLS state estimator, DC state estimation. **Load Dispatch Centre Functions:**Contingency Analysis Preventive, Emergency and Restorative Control. **Hydrothermal scheduling:**Special characteristics of the hydrothermal scheduling problem, Short-term and long-term scheduling, Formulation of the short-term scheduling problem.	30 Hours	1

Text &Reference books:

1. Nagrath and Kothari, Power system analysis.
2. A.J. Wood and B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons.

MEE2251ARTIFICIAL INTELLIGENCE LAB

1. Study and utilizing of MATLAB toolboxes for power & control applications in ANN.
2. Study and utilizing of MATLAB toolboxes for power & control applications in Fuzzy model for classification/regression analysis
3. Study and utilizing of MATLAB toolboxes for power & control applications in Genetic Algorithm (GA) for optimization.
4. Study of example through MATLAB based on:
   i. ANN.
   ii. Fuzzy.
   iii. GA.
5. Developing programs for non-conventional optimization methods including Bacteria Forging, Particle Swarm Optimization.
6. Developing M-programs for ANN, Fuzzy Logic, and GA.

GENERIC ELECTIVE-I

MEE2011DEREGULATIONOF POWER SYSTEM

Course Objective:

1. The subject gives the knowledge about deregulation of power system.
2. To give the students a fair knowledge in deregulation field.

Learning Outcome:

At the end of the course, student should be able:

1. To analyze the Restructuring Models and Trading Arrangements and System Operator (SO).
2. To analyze in detail and understand about Different Models of Deregulation, Operation and control.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Fundamentals of Deregulation:** Motivations for Restructuring the Power Industry,Restructuring Process-Unbundling & Privatization, Wholesale and Retail Competition MarketEntities.	30 Hours	1
II	**Restructuring Models and Trading Arrangements:** Components and Models ofRestructuredElectricity Markets. **System Operator (SO):** Functions and Responsibilities, TradingArrangements (Pool, Bilateral & Multilateral), Open Access to the transmission system.	30 Hours	1
III	**Different Models of Deregulation:**UK Model,California Model**,** Australian and New Zeeland Models**,** Deregulation in Asia including India.	30 Hours	1
IV	**Operation and control:** Old vs New, Bidding strategies, Forward and future Market,Market Power, Available Transfer Capability, Congestion Management, AncillaryServices.	30 Hours	1

Text &References Books:

1. ‘Power System Restructuring: Engineering andEconomics’ by M. Ilic, F. Galiana and L Fink, Kluwer Academic Publishers.
2. ‘Restructured Electrical Power Systems’ by M. Shahidehpour and M. Alomoush, Volatility, Marcel Dekker Inc.

3. L.L. Lie, Power System Restructuring and Deregulation, John Wiley & Sons, UK.
4. K. Bhattacharya, M.H.J. Bollen and J.E. Daalder, Operation of RestructuredPower Systems, Kluwer Academic Publishers, USA.
5. L. Philipson and H.L. Willis, "Understanding Electric Utilities and Deregulation", Marcel Dekker Inc.

MEE2012 HIGH VOLTAGE DC TRANSMISSION SYSTEM

Course Objective:

1. The subject gives the knowledge about high voltage DC.
2. To give the students a fair knowledge in the field of DC transmission.

Learning Outcome:

At the end of the course, student should be able:

1. To analyze the Phase controlled rectifiers&HVDC Control and Protection.
2. To analyze in detail and understand about harmonic analysis&recent Scenarios:

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Review of power electronic components: Thyristor, MOSFET, IGBT,comparison between HVAC and HVDC. **Transmission schemes:** Monopolar, bipolar, back to back, Multiterminal.	30 Hours	1
II	**Phase controlled rectifiers:** Thyristorised phase controlled rectifiers and dual converters, Operating principle, Characteristics, Control circuits, Commutation, End effect of source inductance.	30 Hours	1
III	**HVDC Control and Protection**: Alpha minimum characteristics, Constant current characteristic at rectifier, Constant extinction angle characteristics at rectifier, Alpha minimum at inverter, Current margin, Active power control, Current control amplifier (CCA), Commutation failure prevention control, Equidistant firing control.	30 Hours	1

IV	**Harmonic analysis**: Harmonic analyzer, THD, Distortion factor (DF), Ripple factor, and Reactive power requirement. **Filtering:** Active and passive, AC-DC system interaction. **Recent Scenarios**: HVDC schemes in India and worldwide, Research topics related to HVDC controls	30 Hours	1

Text &References Books:

1. Direct current transmission, volume 1 Edward Wilson Kimbark.
2. High voltage direct current transmission J. Arrillaga.
3. ‘HVDC power transmission system’ by K.R. Padiyar.
4. ‘HVDC and FACTS controller’ by V.K.Sood.

MEE2013 DIGITAL SIGNAL PROCESSING & ITS APPLICATIONS

Course Objective:

1. To develop a strong foundation in the field of digital signal processing.
2. The subject gives the knowledge about applications of digital signal processing.

Learning Outcome:

At the end of the course, student should be able:

1. Understand about digital signal processing.
2. May able to apply concept of signal processing.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Basic elements of digital signal Processing: Concept of frequency incontinuous time and discrete time signals, Sampling theorem, discrete time signals, discrete time systems, Analysis of Linear time invariant systems, Z transform, Convolution and correlation.	30 Hours	1
II	**Introduction to DFT**: Efficient computation of DFT , Properties of DFT , FFT algorithms Radix-2 and Radix-4 FFT algorithms , Decimation in Time, Decimation in Frequency algorithms, Use of FFT	30 Hours	1

	algorithms in Linear Filtering and correlation, STFT, Introduction to Wavelet Transform- CWT and DWT		
III	**Structure of IIR**: System Design of Discrete time IIR filter from continuous time filter, IIR filter design by Impulse Invariance, Bilinear transformation, Approximation derivatives, Design of IIR filter in the Frequency domain. **Symmetric & Anti-symteric FIR filters:** Linear phase filter, Windowing technique, Rectangular, Kaiser Windows, and Frequency sampling techniques, Structure for FIR, systems.	30 Hours	1
IV	**Quantization noise** : derivation for quantization noise power , Fixed point and binary floating point number representation , comparison , over flow error , truncation error, co-efficient quantization error , limit cycle oscillation , signal scaling , analytical, model of sample and hold operations. **Recent Research topics-** Measurement, Estimation techniques.	30 Hours	1

Text & Reference Books:

1. 'Digital Signal Processing Principles,Algorithms and Application' by John G Proakis and Dimtris G Manolakis, PHI/Pearson.
2. 'Discrete Time SignalProcessing' by Alan V Oppenheim, Ronald W Schafer and John R Buck, PHI/Pearson Education.
3. 'Introduction to Digital Signal Processing' byJohnyR.Johnson,Prentice Hall of India/Pearson Education.

GENERIC ELECTIVE-II

MEE2021FLEXIBLE AC TRANSMISSION SYSTEM (FACTS) CONTROLLERS

Course Objective:

1. The subject gives the knowledge about FACTS.
2. To give the students a fair knowledge FACTS controllers.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the need for FACTS.
2. To learn shunt and series compensation techniques.
3. To learn about controlled voltage and face angle regulator.
4. To learn the concept of unified power flow controller.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction**:The concept of flexible AC transmission, reactive power control inelectrical power transmission lines, uncompensated transmission line, series and shunt compensation. Overview of FACTS devices , Static Var Compensator (SVC) , Thyristor Switched Series capacitor (TCSC), Unified Power Flow controller (UPFC) , Integrated Power Flow Controller (IPFC).	30 Hours	1
II	**Static Var Compensator and application (SVC):** Voltage control by SVC, advantagesof slope in dynamic characteristics, influence of SVC on system voltage. Applications, enhancement of transient stability, steady state power transfer, enhancement of power system damping prevention of voltage instability.	30 Hours	1
III	**Thyristor Controlled Series Capacitor (TCSC) and applications:** Operation of theTCSC, different modes of operation, modeling of TCSC, variable reactance model,modeling for stability studies. Applications, improvement of the system stability, limit, enhancement of system damping, voltage collapse prevention.	30 Hours	1
IV	**Emerging FACTS controllers:** Static Synchronous, Compensator (STATCOM), operating principle, V-I characteristics, Unified Power Flow Controller (UPFC),	30 Hours	1

	Principle of operation - modes of operation, applications, modeling of UPFC for, power flow studies. **Coordination of FACT controller:** FACTs Controller interactions – SVC–SVC, interaction - co-ordination of multiple controllers using linear control techniques, Quantitative treatment of control coordination.		

Text & Reference books:

1. 'Thyristor – Based Facts Controllers forElectrical Transmission Systems' by MohMohan Mathur, R., Rajiv. K. Varma, an Mathur, R., Rajiv. K. Varma, IEEE press and John Wiley & Sons.
2. 'Flexible AC Transmission System' by A.T.John,Institution of Electrical and Electronic Engineers (IEEE).
3. 'Understanding FACTS Concepts andTechnology of Flexible AC Transmission System' byNarainG.Hingorani, Laszio. Gyugyl, Standard Publishers, Delhi.

MEE2022ADVANCED POWER SYSTEM PROTECTION

Course Objective:

1. The subject gives the knowledge about advanced protection in power system.
2. To give the students a fair knowledge power system protection.

Learning Outcome:

At the end of the course, student should be able:

1. To understand the need for protection.
2. To learn **fundamentals of protection.**
3. To learn about **numerical relaying**& t**ypes of relays.**
4. To learn the concept of **adaptive protection.**

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Fundamentals of Protection:**Protective Relaying - Qualities of relaying – Definitions, Codes- Standards; Characteristic Functions, Classification, Analog-digital- numerical.Fundamental principles of over-current protection in feeder and motor.Fundamental principles of distance relaying protection in transmission lines-zones of protection, out-of step protection.Fundamental principles of differential protection and application to transformer, bus bar and	30 Hours	1

	generator armature winding protection.Role of instrument transformers in protection, Relay co-ordination in transmission system.		
II	**Numerical Relaying**: Introduction to Numerical relaying.DSP fundamentals like aliasing, sampling theorem.Discrete Fourier Transform and application to current and voltage phasor estimation.Basic elements of digital protection, Signal conditioning- conversion subsystems**,** Relay units-sequence networks-fault sensing data processing units, FFT and Wavelet based algorithms: least square and differential equation based algorithms, Travelling wave protection schemes.	30 Hours	1
III	**Types of Relays:** Relay Schematics and Analysis-Over Current Relay, Instantaneous/Inverse Time – IDMT, Characteristics; Directional Relays**,** Differential Relays, Restraining Characteristics, Distance Relays: Types- Characteristics.	30 Hours	1
IV	**Adaptive Protection:**Need of Adaptive Protection in the system, Techniques for adaptive strategies in distance protection, synchrophasor based adaptive protection schemes, Protection schemes, SCADA based protection systems- FTA**,** Testing of Relays.	30 Hours	1

Text & Reference books:

1. A T John and A K Salman- Digital protection for power systems-IEE powerseries-15, Peter Peregrines Ltd, UK.
2. C.R. Mason, The art and science of protective relaying, John Wiley &sons.
3. Gerhard Ziegler-Numerical distance protection, Siemens.
4. A.R.Warrington, Protective Relays, Vol .1&2, Chapman and Hall.
5. T.S.MadhavRao, Power system protection static relays with microprocessorapplications, Tata McGraw Hill Publication.

MEE2023POWER QUALITY

Course Objective:

1. To study the various issues affecting Power Quality.
2. To learn about production, monitoring and suppression.

Learning Outcome:

At the end of the course, student should be able:

1. To study the production of voltages sags, interruptions and harmonics and methods of control.
2. To study various methods of power quality monitoring.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction**: Overview and definition of power quality (PQ), Sources of pollution, International power quality standards and regulations. **Power quality issues:** rapid voltage fluctuations voltage unbalance, voltage dips and voltage swells, short duration outages, sources of power quality events, solution at end user level- isolation transformer, Voltage regulator, static UPS, rotary UPS, active series compensator.	30 Hours	1
II	**Power system harmonics**: Harmonics analysis, harmonic sources- static converters, Transformer magnetization and nonlinearities, Rotating machines, arc furnaces, florescent lighting Effects of harmonics on Transformers, AC motors, Cables, protection devices, passive and active filtering	30 Hours	1
III	**Harmonic effects and measurement**: **I**nterference within the power system, interference with communication, harmonic measurement, power quality analyzer, transient disturbance analyzer, wiring and grounding tester, flicker meter	30 Hours	1
IV	**Power quality indices:** Distortion factor, THD, ripple factor, Custom power devices: voltage regulation using DSTATCOM, sensitive load protection using DVR, UPQC.	30 Hours	1

Text & Reference books:

1. Understanding power quality problems: voltage sags and interruptionsMathH. J. Bollen.
2. Power quality enhancement using custom power devices-ArindamGhosh,Gerard Ledwich.
3. Understanding FACTS: concept and Technology of Flexible AC TransmissionSystems- NARAIN G. HINGORANI, LASZLO GYUGYI.

MEE2024 POWER SYSTEM DYNAMICS AND CONTROL

Course Objective:

1. To study the dynamic control.
2. To learn about power system dynamic control.

Learning Outcome:

At the end of the course, student should be able:

1. To study the transient stability & frequency control.
2. To study various small signal stability & voltage stability.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Frequency control:**Modelling of Synchronous Machine, Modelling of load, network and excitation system, Modelling of turbine and governing system, Mathematical Modelling of Multi Machine System, Automatic Generation Control of Single Area and Multi AreaSystems, Static and Dynamic Response of AGC Loops.	30 Hours	1
II	**Transient Stability Problem:**Equal area criterion and its application to transientstability studies under common disturbances including short, Circuits, Critical clearingangle and critical clearing time, Numerical solution of swing equation by step-by-stepMethod, Multi machine Transient Stability, Numerical methods for solution of differential equations, Modified Euler Method, Runge – Kutta fourth order method, Factors affecting steady state and transient stabilities, Methods of improving steady state, dynamic and transient Stabilities, Series capacitor compensation of lines, Excitation control, Power stabilizing signals.	30 Hours	1
III	**Small Signal Stability:**Power System Model for Low Frequency Oscillation Studies, Rotor angular measurement, synchrophasormeasurement, Eigen value Analysis, Improvement of System Damping with Supplementary ExcitationControl, Standard models for PSS representation- Introduction to SubSynchronous Resonance.	30 Hours	1
IV	**Voltage Stability Problem:** Real and Reactive Power Flow in Long TransmissionLines, Effect Of ULTC And	30	1

	Load Characteristics On Voltage Stability, Voltage Stability Limit, Voltage Stability Assessment Using PV Curves, System Modelling-Static and Dynamic Analysis-VoltageCollapse Proximity Indices, Voltage Stability Improvement Methods.	Hours	

Text & Reference books:

1. P. Kundur, "Power System Stability and Control", McGraw-Hill.
2. P.M Anderson and A.A Fouad, "Power System Control and Stability", IowaState University Press, Ames, Iowa.
3. Elgerd O.I, "Electric Energy System Theory - an Introduction" - Tata McGrawHill.
4. Allen J.Wood and Bruce .F. Woolenberg, "Power Generation Operation and Control", John Wiley &sons, New York.
5. Mahalanabis A.K., Kothari. D.P. and Ahson.S.I., "Computer Aided Power System Analysis and Control", Tata McGraw Hill publishing Ltd.

GENERIC ELECTIVE-III

MEE2031INDUSTRIAL DRIVES AND CONTROL

Course Objective:

1. To study the industrial drives.
2. To learn about drives and control.

Learning Outcome:

At the end of the course, student should be able:

1. To study dcmotor drives, inverter PWM techniques.
2. To study ac motor drives.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Classification of Electric Drives, Requirements of Electric Drives, SomeApplicationsConverters and control: Phase controlled converters, AC to DC converters, Types,Four quadrant operations.	30 Hours	1
II	**DC motor drives:** Speed-torque characteristics DC shunt, PMDC and series motors,Dynamic model, Speed and position control methods	30 Hours	1
III	**Inverters and PWM techniques**: voltage source inverters, current source inverters,PWM techniques, sine-triangle comparison, harmonic elimination, hysteresis currentcontrollers, space vector PWM.	30 Hours	1
IV	**AC motor drives:** d-q model of induction motor, constant flux speed controlstructure, vector control model, vector control structure.	30 Hours	1

Text Books/References:

1. Power Electronics and Drives – Ned Mohan.
2. Power electronics circuits devices and application –M H Rashid
3. Power semiconductor drives- G. K. Dubey
4. NPTEL lecture series on line available

MEE2032 ROBUST AND ADAPTIVE CONTROL

Course Objective:

1. To understands the concept of robust and adaptive control along with the structure of the same.
2. Analyzing the stability of linear as well as non-linear systems. To study stability of non-linear systems also.
3. To study the uncertainties present in the system and analysis of robustness.
4. To study the different adaptive control strategies and their robustness.

Learning Outcome:

1. Concept of robust and adaptive control along with the structure of the same. Also the performance objectives and design constraints or the control engineers.
2. Lyapunov stability theory for continuous as well as discrete time system and stability for varying time system also.
3. Different uncertainties present in the system and analysis of robustness.
4. Different adaptive control strategies and their robustness.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Introduction:** Overview of classical control, Introduction of robust control and Adaptive control schemes, Features of robust control, Relationship between Non- Adaptive, robust and Adaptive Control, Performance objectives and design constraints for the control engineers.	30 Hours	1
II	**Analysis Tools (Lyapunov's stability theory**): Definition for continuous-time systems, Definition for discrete-time systems, Lyapunov stability theorems, Lyapunov's second method for stability, Stability for linear state space models, Stability for systems with inputs, Barbalat's lemma and stability of time-varying system.	30 Hours	1
III	**Introduction to Robust Control System:** Robust control system and system sensitivity, Analysis of robustness, Systems with uncertain parameters, types of uncertainties: additive and multiplicative with examples, Design of robust control systems using worse case polynomial and Routh-Hurwitz criteria.	30 Hours	1

IV	**Types of Adaptive Control strategies**: Introduction, Gain Scheduling Regulators, Self-Tuning Regulators, Model Reference Adaptive Control-Robustness of adaptive systems to disturbance and measurement noise-Parameter convergence: persistent excitation- Parameter projection, e-modification, sigma-modification-Adaptive control in the presence of input saturation-Adaptive backstepping-Overview of adaptive output feedback control theory, L1 adaptive control: transient performance and robustness- Norms and gains for signals and systems-Small-gain theorem-Achievable performance: Reference system and guaranteed performance bounds-Design system and decoupled performance bounds- State feedback architecture-Output feedback architecture-Unknown high-frequency gain-Output feedback for non SPR reference systems.	30 Hours	1

Text/Reference Books:

1. S.H. Zak, Systems and Control, Oxford Univ. Press, 2003.
2. H.K. Khalil, Nonlinear Systems, Prentice Hall, N.J., 2002.
3. Kemin Zhou, Essentials of Robust Control, Prentice Hall.
4. Feng Lin, Robust Control Design, John Wiley & Sons, Ltd.

MEE2033 INTELLIGENT INSTRUMENTATION

Course Objective:

1. To understand the concept of current trends in the instrumentation engineering.
2. To understand LabVIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. To understand the different Transducers, sensors and data acquisition in the instrumentation engineering.
4. To understand the structure and working of PC hardware and instrumentation busses.

Learning Outcome:

1. Concept of current trends in the instrumentation engineering.
2. Lab-VIEW, Virtual Instruments (VIs) and sub VIs created on this platform.
3. Different Transducers, sensors and data acquisition in the instrumentation engineering.
4. Structure and working of PC hardware and instrumentation busses.

Course Contents:

Module	Course Topics	Total Hours	Credits
I	**Virtual Instrumentation:** Introduction to instrumentation and intelligent instrumentation, Software based instruments, Introduction to data flow & graphical programming techniques, Evolution of Virtual Instrumentation. **Virtual Instrumentation**: Definition, Architecture, Advantage of VI techniques, Presentation, Control and Functional Integration, VIs and sub Vis, Loops and charts, arrays, clusters and graphs, case and sequence structure, formula nodes, string and file I/O, Code Interface Nodes and DLL link.	30 Hours	1
II	**Transducers:** Introduction to transducers, Electro mechanical transducers, Resistance, Inductance, Capacitive and Piezoelectric transducers, Thermoelectric and Photoelectric transducers, Analog and digital transducers including semiconductor and optical type, Application to measurement of temperature, Pressure, Flow, Displacement and other non-electrical quantities.	30 Hours	1
III	**Sensors and Data Acquisition:** Sensors,Introduction, Type of sensors, Sensor Standards and Protocols, Sensor Performance Characteristics, Intelligent Sensors. **Data Acquisition:** Introduction to data acquisition system, A/D and D/A converters, Sample and hold circuit, MUX and DEMUX, Signal transmission, Introduction to DAQ cards.	30 Hours	1
IV	**PC Hardware Review and Instrumentation Buses:** Introduction, Structure, Timing and interrupts, DMA, operating system, ISA, PCI, USB and PCMCIA Buses, IEEE488.1 & 488.2 serial, Interfacing-RS 232C, RS422, RS423, RS485, USB, VXI, SCXI, PXI.	30 Hours	1

Reference/Text Books:

1. G. C. Barney, “Intelligent Instrumentation”, Prentice Hall, 1995.
2. Virtual Instrumentation using LABVIEW, J.John, S Gupta.
3. LabVIEW based Advanced Instrumentation Systems, S. Sumathi and P. Surekha.
4. Lisa, K. Wells & Jeffery Travis, “Lab VIEW For every one”, Prentice Hall, 1997.