CURRICULUM
&
ACADEMIC REGULATIONS

POST-GRADUATE PROGRAMME

M.Tech. in Power Systems

(2020-2022)

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Department of Electrical & Electronics Engineering

VISION

The department will be an internationally recognized centre of excellence imparting quality education in electrical engineering for the benefit of academia, industry and society at large

MISSION

M1: Impart quality education in Electrical and Electronics Engineering through theory and its applications by dedicated and competent faculty

M2: Nurture creative thinking and competence leading to innovation and technological growth in the overall ambit of electrical engineering

M3: Strengthen industry-institute interaction to inculcate best engineering practices for sustainable development of thesociety

PROGRAM EDUCATIONAL OBJECTIVES

PEO1: Graduates will be competitive and have a successful career in electric power industry and other organizations.

PEO2: Graduates will excel as academicians and contribute to research and development.

PEO3: Graduates will demonstrate leadership qualities with professional standards for sustainable development of society.

PROGRAM OUTCOMES

Students graduating from M.Tech - Power systems of department of Electrical & Electronics Engineering shall have the ability to:

PO1: Independently carry out research/ investigation and development work to solve practical problems in the field of power systems engineering.

PO2: Write and present a substantial technical report/document.

PO3: Demonstrate a degree of mastery in the field of power systems engineering in a technologically changing scenario.

PO4: Demonstrate managerial and financial skills.

PO5: Demonstrate concern for the safety and environment for sustainable development of society.

LIST OF COURSES OFFERED AS PER CATEGORY

Core – Theory			MPS1E202	Wind & Solar Power Systems and Energy Storage	(3-0-0)3
AEM1C01	Applied Engineering Mathematics	(4-0-0)4	MPS1E203	Smart Grid-Technology and Applications	(3-0-0)3
MPS1CXX	Power System Protection	(4-2-0)5	MPS2E301	EHV AC Transmission	(3-0-0)3
MPS1CXX	Power System Analysis and Stability	(4-2-0)5	MPS2E302	Power Quality and Custom Power Devices	(3-0-0)3
MPS1C04	Power Electronic Converters and Applications	(3-2-0)4	MPS2E303	Photovoltaic System Engineering	(3-0-0)3
			MPS2E3XX	Cybersecurity in Power system	(3-0-0)
MPS1CRM	Research Methodology	(2-0-0)2	MPS2E404	Electric and Hybrid Vehicles	(3-0-0)3
MPS2C01	Economic Operation of Power Systems*	(4-2-0)5	MPS2E4XX	IoT for Smart Grids	(3-0-0)3
MPS2C05	Power System Dynamics and Control*	(4-0-0)4	MPS2E403	PLC & SCADA	(3-0-0)3
MPS2C06	Flexible AC Transmission Systems	(4-2-0)5	MPS2I01	Design and Analysis of Industrial Power System Protection	(2-0-0)2
MPS2C04	Electrical Power Distribution Automation and Control	(3-2-0)4	MPS3MXX	MOOC Elective (Department Specific/Management)	(3-0-0)3
			MPS3MXX	MOOC open Elective (from other departments)	(3-0-0)2
Core –Lab			**Project, Seminar, etc**		
MPS1L01	Power Systems Lab – I	(0-0-2)1	MPS3C02	Seminar / Paper Presentation	(0-0-0)1
MPS2L01	Power Systems Lab – II	(0-0-2)1	MPS3C03	Internship	(0-0-0)5
Electives			MPS3CXX	Project Phase-1	(0-0-0)8
MPS1E101	Restructured Power Systems	(3-0-0)3	MPS4C01	Project Phase-2	(0-0-0)15
MPS1E102	Integration of Distributed Generation in Power Systems	(3-0-0)3			
MPS1E103	Electrical Transients in Power Systems	(3-0-0)3			
MPS1E2XX	Digital Control Systems	(3-0-0)3			

SUGGESTED PLAN OF STUDY

Semester/ Sl.No.	I	II	III	IV
1	AEM1C01	MPS2C01	MPS3MXX	MPS4C01
2	MPS1CXX	MPS2C05	MPS3MXX	
3	MPS1CXX	MPS2C06	MPS3C02	
4	MPS1C04	MPS2C04	MPS3C03	
5	MPS1E1XX	MPS2E3XX	MPS3CXX	
6	MPS1E2XX	MPS2E4XX		
7	MPS1CRM	MPS2I01		
8	MPS1L01	MPS2L01		
Total Credits	**27**	**27**	**19**	**15**

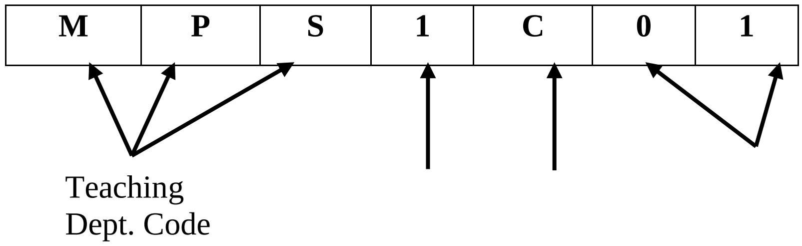
Table of total credits to be earned by a student

Degree Requirements:

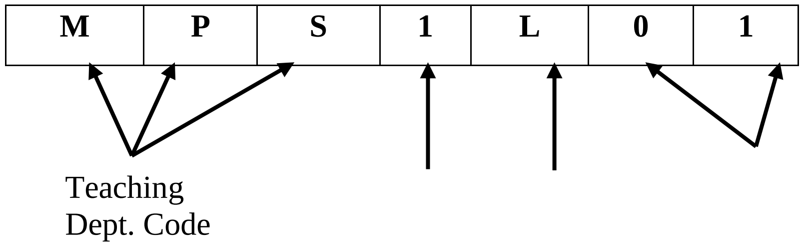
Category of courses	Minimum credits to be earned
	Regular Students
Subject of 1st to 4th Semester	
Basic science	04
Humanities and Social science core	05
Core	31
Dept. Elective	12
Industry Driven Elective	02
MOOC Elective (Department Specific/Management)	03
MOOC open Elective (from other departments)	02
Seminar/Paper Presentation, Internship, Project, Competency Training	29
Total Credits	**88**

COURSE NUMBERING SCHEME

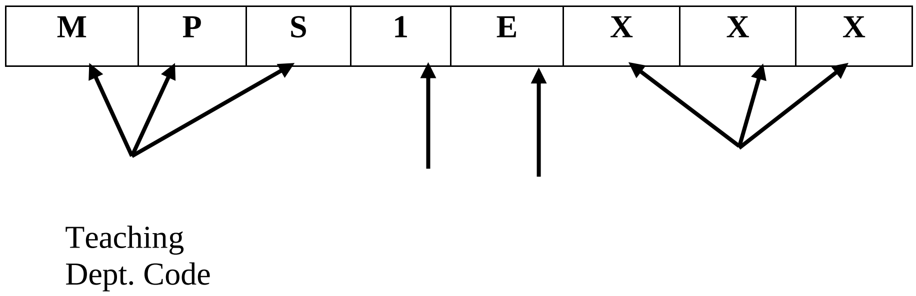
Core



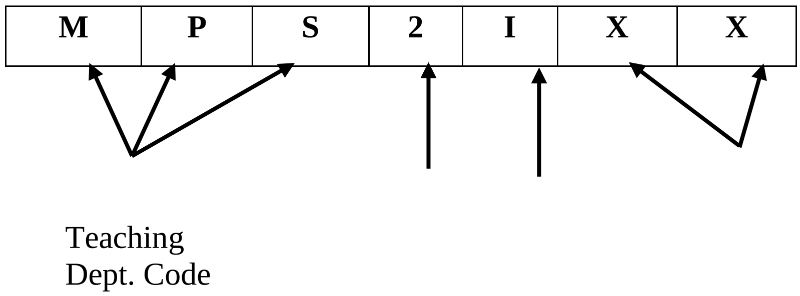
Lab



Elective



Industry Driven Elective



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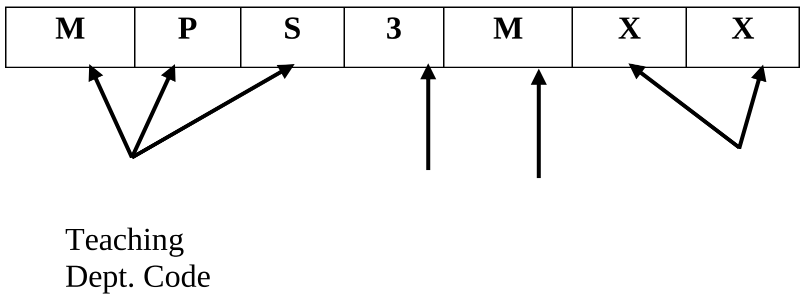

TABLE OF SCHEME AND EXAMINATION FROM 1ST TO 4TH SEMESTER

SCHEME OF TEACHING AND EXAMINATION
I SEMESTER

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	AEM1C01	Applied Engineering Mathematics	Mathematics	4	0	0	4
2	MPS1C05	Power System Protection	Electrical & Electronics Engg.	4	2	0	5
3	MPS1C06	Power System Analysis and Stability	Electrical & Electronics Engg.	4	2	0	5
4	MPS1C04	Power Electronic Converters and Applications	Electrical & Electronics Engg.	3	2	0	4
5	MPS1E1XX	Elective-1	Electrical & Electronics Engg.	3	0	0	3
6	MPS1E2XX	Elective-2	Electrical & Electronics Engg.	3	0	0	3
7	MPS1CRM	Research Methodology	Electrical & Electronics Engg.	2	0	0	2
8	MPS1L01	Power Systems Lab – I	Electrical & Electronics Engg.	0	0	2	1
Total				**31**			**27**

Elective - 1

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	MPS1E101	Restructured Power Systems	Electrical & Electronics Engg.	3	0	0	3
2	MPS1E102	Integration of Distributed Generation in Power Systems	Electrical & Electronics Engg.	3	0	0	3
3	MPS1E103	Electrical Transients in Power Systems	Electrical & Electronics Engg.	3	0	0	3

Elective – 2

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	MPS1E204	Digital Control Systems	Electrical & Electronics Engg.	3	0	0	3
2	MPS1E202	Wind & Solar Power Systems and Energy Storage	Electrical & Electronics Engg.	3	0	0	3
3	MPS1E203	Smart Grid-Technology and Applications	Electrical & Electronics Engg.	3	0	0	3

SCHEME OF TEACHING AND EXAMINATION
II SEMESTER

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	MPS2C01	Economic Operation of Power Systems*	Electrical & Electronics Engg.	4	2	0	5
2	MPS2C05	Power System Dynamics and Control*	Electrical & Electronics Engg.	4	0	0	4
3	MPS2C06	Flexible AC Transmission Systems	Electrical &ElectronicsEngg.	4	2	0	5
4	MPS2C04	Electrical Power Distribution Automation and Control	Electrical & Electronics Engg.	3	2	0	4
5	MPS2E3XX	Elective-3	Electrical & Electronics Engg.	3	0	0	3
6	MPS2E4XX	Elective-4	Electrical & Electronics Engg.	3	0	0	3
7	MPS2I01	Design and Analysis of Industrial Power System Protection**	Electrical & Electronics Engg.	2	0	0	2
8	MPS2L01	Power Systems Lab – II	Electrical & Electronics Engg.	0	0	2	1
Total					**31**		**27**

Elective – 3

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	MPS2E301	EHV AC Transmission	Electrical & Electronics Engg.	3	0	0	3
2	MPS2E302	Power Quality and Custom Power Devices	Electrical & Electronics Engg.	3	0	0	3
3	MPS2E303	Photovoltaic System Engineering	Electrical & Electronics Engg.	3	0	0	3
4	MPS2E305	Cybersecurity in the power sector	Electrical & Electronics Engg	3	0	0	3

Elective – 4

Sl.No.	Code	Subject	Dept./Board	Hrs/week			Credits
				L	T	P	
1	MPS2E404	Electric and Hybrid Vehicles	Electrical & Electronics Engg.	3	0	0	3
2	MPS2E304	IoT for Smart Grids	Electrical & Electronics Engg.	3	0	0	3
3	MPS2E403	PLC & SCADA	Electrical & Electronics Engg.	3	0	0	3

* Pre-requisite: Power System Analysis and Stability (MPS1CXX)
** Pre-requisite:Power System Protection

DEPARTMENT OF ELECTRICAL AND ELECTRONICSENGINEERING
SCHEME OF TEACHING AND EXAMINATION
III SEMESTER

Sl.No.	Subject Code	Subject	Dept./Board	L	T	P	Cr.
1	MPS3MXX	MOOC Elective (Department Specific/Management))	Electrical & Electronics Engg.	3	0	0	3
2	MPS3MXX	MOOC open Elective (from other departments)	Electrical & Electronics Engg.	2	0	0	2
3	MPS3C02	Seminar/Paper Presentation	Electrical & Electronics Engg.	0	0	0	1
4	MPS3C03	Internship	Electrical & Electronics Engg.	0	0	0	5
5	MPS3CXX	Project Phase-1	Electrical & Electronics Engg.	0	0	0	8
	Total Credits						**19**

Note:MOOC Electives will be decided on the availability courses during the corresponding academic year

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHEME OF TEACHING AND EXAMINATION
IV SEMESTER

Sl.No.	Subject Code	Subject	Dept./Board	L	T	P	Cr.
1	MPS4C01	Project Phase-2	Electrical & Electronics Engg.	0	0	0	15
	Total Credits						**15**

M.Tech.: Power Systems
(2020-2022)

Syllabus – I Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Applied Engineering Mathematics (4-0-0)

Sub Code	**: AEM1C01**	**CIE**	**: 50% Marks**
Hrs/Week	**: 4+0+0**	**SEE**	**: 50% Marks**
SEE Hrs	**: 03**	**Max.Marks**	**: 100 Marks**

Course outcomes :

On successful completion of the course the students will be able to:

1. Compute the extremals of functionals and solve standard variational problems.
2. Solve linear homogeneous partial differential equations with constant and variable coefficients.
3. Use optimization techniques to solve Linear and Non-Linear Programming problems.
4. Apply geometry of Lineartransformations and construct orthonormal basis of an inner product space.
5. Apply the method of least square to predict the best fitting curve for a given data and solve problems associated with discrete probability distribution.
6. Solve problems associated with discrete joint probability distribution, Markov chain using transition probability matrix and the concept of Queuing theory.

MODULE 1: Calculus of Variation: Variation of a function and a functional. Extremal of a functional, variation problems, Euler's equation, Standard variational problems including geodesics, minimal surface of revolution, Brachistochrone problems, Isoperimetric problems. Functionals of second order derivatives

SLE: hanging chain problem

9 Hours

MODULE 2: Partial Differential Equations: Solution of linear homogeneous PDE with constant and variable coefficients.

9 Hours

SLE: Cauchy's partial differential equation

MODULE 3: Optimization: Standard form of LPP, Simplex method, Big-M method, Duality, Non-Linear programming problems

9Hours

SLE: Degeneracy in simplex method

MODULE 4: Linear Algebra: Vectors & vector spaces. Linear transformations, Kernel, Range. Matrix of linear transformation, Inverse linear transformation. Inner product, Length/Norm. Orthogonality, orthogonal projections, orthogonal bases, Gram-Schmidt process.

9 Hours

SLE: Least square problems

MODULE 5 :Statistics and Probability – I: Curve fitting by the method of least squares: straight line, parabola and exponential curve $y = ae^{bx}$ – only problems. Probability: Random variables - discrete random variables, Binomial and Poisson distributions.

8 Hours

SLE: fitting of the curves $y = ax^b$ and $y = ab^x$

MODULE 6: Probability II: Joint probability distribution (Discrete), Markov chains – probability vector, stochastic matrix, transition probability matrix. Concept of queuing – M/M/1 and M/G/1 queuing system.

SLE: continuous joint probability distribution

8 Hours

Reference Books:

1) **Higher Engineering Mathematics** – Dr. B.S. Grewal, 42nd edition, Khanna publication.
2) **Advance Engineering Mathematics** – H. K. Dass, 17th edition, Chand publication.
3) **Higher Engineering Mathematics** – Dr. B.V. Ramana, 5th edition,Tata Mc Graw-Hill.
4) **Linear Algebra** – Larson &Falvo (Cengage learning), 6th edition.
5) **Probability, Statistics and Random Processes,** T Veerarajan-3rd Edition,Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.

Power system Protection (4-2-0)

Sub Code: MPS1C05 **CIE: 50% Marks**
Hours/Weeks: 4+2+0 **SEE: 50% Marks**
SEE Hrs: 3 **Max marks: 100**

Course Outcomes

On successful completion of the course, the students will be able to:

1. Explain and apply basic concepts of digital protection.
2. Discuss hardware considerations and relaying algorithms.
3. Explain principles of digital protection to Generator, Motor, Transmission lines, Bus bar and Transformers.
4. Explain protection schemes, testing and maintenance of digital relays.

MODULE 1: Introduction to Numerical Relay: Numerical relay, Comparison between electromechanical relays and numerical relay, Computer relay architecture and subsystems, Advantages and disadvantages of Numerical relay and Adaptive relaying.

06Hours

SLE: Study of protection philosophy and protection systems currently employed in India.

MODULE 2: Architectures of Programmable Devices : Microcontroller: 8051 architecture and real world interfacing, Introduction to advanced architecture, Processor and memory organization, Processor selection, Microcontroller selection.

Digital Signal Processor: Digital signal processing system, Major features of programmable digital signal processor, Basic architecture features, DSP computational building blocks, Bus architecture.

08 Hours

SLE: Memory selection

MODULE 3: Hardware Considerations: IC Elements and circuits for interfaces: Zero crossing detector, Phase shifter, Current to voltage converter, Precision rectifier.

Data Acquisition System: Signal conditioning, Aliasing, Sampling, Analog Interfacing. Analog Interfacing: Sample and Hold circuit, Analog Multiplexers, Analog to Digital Converters.

Filters: Digital Filters, Finite Impulse Response and Infinite Impulse Response Filters.

10 Hours

SLE: Digital to Analog Converters

MODULE 4: Relaying Algorithms: DC offset, Removal of DC offset. Digital relaying Algorithms: least square fitting algorithm, Mann-Morrison Technique, Discrete Fourier transform technique, Walsh-Hadamard Transform technique, Rationalized Haar Transform technique, Wavelet Transform technique.

09 Hours

SLE: Differential equation technique

MODULE 5: Protection schemes: Generator, Motor, Transmission line protection schemes.

Bus bar: Faults and Protection requirements. Transformer: CT Saturation, faults.

Power transformer algorithms: Current derived restraints, voltage based restraints, flux restraints, inrush current restraint. **09 Hours**

SLE: Bus bar arrangements

MODULE 6: Numerical Protection Schemes: Numerical differential protection, its applications to Transformer, Power transformer and Generator, Numerical Over current Protection, Numerical Directional Protection.

Numerical Distance Protection: Impedance, Reactance, Mho and Offset Mho, Quadrilateral, and Distance relay reach, Testing of Digital relays. **10 Hours**

SLE: Maintenance aspects of Digital relays

Text Books:

1. Badriraam and Vishwakarma, "***Power System Protection and Switchgear***", 2^{nd} edition, TMH, 2011.

2.Arun G Phadke and James S Thorp, "***Computer Relaying for Power systems***", 2^{nd} edition, John Wiley and Sons, 2009

Reference Books:

1. S R Bhide, " ***Digital Power System Protection***", Prentice Hall of India, 2014.

2. Paithankar Y G and S R Bhide, "***Fundamentals of Power System Protection***", Prentice Hall of India, 2011.

Power System Analysis and Stability (4-2-0)

Sub Code:MPS1CXX **CIE: 50%Marks**
Hrs/week:4+2+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks :100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Apply the different Load Flow Techniques to given PowerSystems.
2. Analyze the symmetrical and unsymmetrical faults of a Power system.
3. Analyze transient stability and voltage stability of a Power system.
4. Explain the concept of state estimation and systemsecurity.

MODULE 1: Power Flow Methods: Introduction, Modeling of power system components, Review of load flow techniques, Forward - backward method, DC load flow method, AC- DC system power flow analysis- sequential and simultaneous solution algorithms, Sensitivity factors, ATC assessment, Sparsity directed optimal ordering schemes, Solution algorithms - LU factorization.

09 Hours

SLE: Bifactorization method.

MODULE 2: Analysis of Faulted Power System: Symmetrical and asymmetrical faults, Digital simulation techniques in fault analysis, Z bus method in contingency analysis, Contingency analysis of DC model, System reduction for contingency and fault studies.

08 Hours

SLE: Analysis of open circuit faults.

MODULE 3: Transient Stability: Introduction to transient stability, Numerical integration methods: Numerical stability of explicit integration methods, Implicit integration methods, RungeKutta method and trapezoidal method, Performance of protective relaying, Direct method of transient stability analysis, Energy function approach for stability studies.

09 Hours

SLE: Methods of improving transient stability.

MODULE 4: Voltage Stability: Definition and classification, Mechanism of voltage collapse, Analysis of voltage stability, Modeling of voltage collapse, Voltage security, Transient voltage stability, Power transfer at voltage stability limit, Maximum power angle at voltage stability limit, Relation between reactive power variation and system stability.

09 Hours

SLE: Loading limit of transmission system voltage.

MODULE 5: Voltage Stability Indicators: Introduction to voltage stability indicators, Fundamental indicators using PV and QV curves, Criterion of voltage stability, Direct indicator of voltage stability, Voltage stability index, Singular value decomposition. Expression for different indicators, voltage stability evaluation, effect of system reactance and power factor.

09 Hours

SLE: Relation with off nominal tap ratio.

MODULE 6: State Estimation and System Security: Introduction to state estimation, least squares estimation and weighted least squares estimation, State estimation in AC network, Detection and identification of bad measurements, Network observability and pseudo – measurements, Contingencyanalysis. Introduction to Real-Time Simulation Technologies and WAMS .

08 Hours

SLE: Contingency Selection.

Text Books:

1. J. Arrillaga,N. R. Watson, "***Computer modeling of electrical powersystems*****", W**iley Publisher, 2001.
2. PrabhaKundur, **"*Power System Stability and Control*",** Tata McGraw-Hilledition.

Reference books :

1. A.K. Mukhopadhyay, D.P. Kothari , A. Chakrabarti, **"*An Introduction to Reactive Power Control and Voltage Stability in Power Transmission Systems*",** PHI Publisher.
2. Allen J. Wood and Bruce F. Woollenberg, **"*Power Generation, Operation, and Control*",**2ndedition, John Wiley and Sons,INC**.**

Power Electronic Converters and Applications (3-2-0)

Sub Code: MPS1C04 | **CIE: 50%Marks**
Hrs/week: 3+2+0 | **SEE: 50%Marks**
SEE Hrs : 3 | **Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Describe the circuit topologies of Line commutated and SMPS Converters.
2. Analyze different types of Chopper and Inverters circuits.
3. Describe the operations of AC/DC/AC conversion technologies.
4. Describe the operations of DC/AC/DC conversion technologies.

MODULE 1: Line Commutated Converter: Functional circuit block of Line commutated converter, Direction of power flow-inverter operation , Phase controlled converter single and two quadrant operations, Converter for HVDC power link, Midpoint configuration- transformer connection, The bridge configuration-basic building blocks, Voltage and current ripples on dc side, Commutation and overlap.

08 Hours

SLE: Inversion mode.

MODULE 2: Choppers: Introduction, Voltage step down chopper, Voltage step up chopper**,** Two quadrant chopper, Multiphase choppers, problems.

08 Hours

SLE: Coupled reactor in multiphase choppers.

MODULE 3: Inverters: Full bridge configuration, Shaping of output voltage wave form- sinusoidal pulse width modulation (SPWM), Three phase inverter, Inverter operation with reverse power flow, Multilevel Inverters - types, Topology and operation.

08 Hours

SLE: SPWM with reverse voltage excursions.

MODULE 4: Switched Mode Power Supply: Functional circuit blocks of an OFF Line switcher, The front end rectifier, SMPS circuit topologies- Buck converter circuit configuration, working principle, Duty cycle constraint, Boost converter, Buck–boost converter, Cuk converter.

07 Hours

SLE: Resonant converter.

MODULE 5: AC/DC/AC Converters: Introduction, AC/DC/AC converters used in wind turbine systems, New AC/DC/AC converters, AC/DC/AC boost-type converters, Two-level AC/DC/AC ZSI.Three- level diode-clamped AC/DC/AC converter, Linking a wind turbine system to a utility network.

DC/AC/DC Converters: Review of traditional DC to DC converters, Chopper type DC/AC/DC converters, Switched capacitor DC/AC/DC converters- single stage, three stage and four stage .

08 Hours

SLE: Tapped transformer converters

Text Books:

1.JosephVithayathil, "***Power Electronics Devices and Circuits*",** 2nd edition**,** Tata- McGraw Hill,2010.

2. Fang Lin Luo Hong Ye "***Power Electronics Advanced Conversion Technologies*",** 1st edition, CRC Press Taylor & Francis Group, 2010.

Reference Books:

1.M.H.Rashid, "***Power Electronics Circuits, Devices & Applications*",**3rd edition, P.H.I. Pearson, New Delhi,2002.

2.FangLinLuo Hong Ye,"***Advanced DC/DC Converters*",** 1st edition, CRC Press Taylor & Francis Group, 2010.

Restructured Power Systems (3-0-0)

Sub Code :MPS1E101 **CIE: 50%Marks**
Hrs/week : 3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks :100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Understand and explain the need for restructured power system andeconomics.
2. Discuss and analyze transmission congestion and loss allocation in PowerSystem.
3. Evaluate LMP and explain the concept of FTR for a given powersystem.
4. Explain the generator bidding in powermarket.

MODULE 1: Introduction to Restructuring of Power Industry and Fundamentals of Economics: Introduction, Reasons for restructuring/deregulation of power industry, Understanding the restructuring process, Introduction to issues involved in deregulation, Reasons and objectives of deregulation of various power systems across the world.Consumer behavior, Supplier behavior, Market equilibrium, Short-run and Long-run costs, Various costs of production, Relationship between short-run and long-run average costs.

09 Hours

SLE: Perfectly competitive market.

MODULE 2: Transmission Congestion Management: Introduction, Classification of congestion management methods, Calculation of ATC, Non-market methods, Market based methods, Nodal pricing, Inter-zonal and Intra-zonal congestion management, Price area congestion management.

09 Hours

SLE: Capacity alleviation method.

MODULE 3: Pricing of transmission network usage and loss allocation: Introduction to transmission pricing, Principles of transmission pricing, Classification of transmission pricing methods, Rolled-in transmission pricing methods, Marginal transmission pricing paradigm, Composite pricing paradigm, Merits and de-merits of different paradigms, Debated issues in transmission pricing, Introduction to loss allocation, Classification of loss allocation methods.

09 Hours

SLE: Comparison between various methods.

MODULE 4: Locational Marginal Prices (LMP) and Financial Transmission Rights (FTR): Fundamentals of locational marginal pricing, Lossless DCOPF model for LMP calculation, Loss compensated DCOPF model for LMP calculation, ACOPF model for LMP calculation. Introduction to financial transmission rights, Risk hedging functionality of financial transmission rights,Simultaneous feasibility test and revenue adequacy, FTR issuanceprocess, Treatment of revenue shortfall, Secondary trading of FTRs, Flow gate rights, FTR and market power.

06 Hours

SLE: FTR and merchant transmission investment.

MODULE 5: Market power and generators bidding: Attributes of a perfectly competitive market, The firm's supply decision under perfect competition, Imperfect competition market power, Financial markets associated with electricity markets, Introduction to optimal bidding by a generator company.

06 Hours

SLE: Optimal bidding methods

Text Book:

1. Daniel Kirschen and GoranStrbac, **"*Fundamentals of Power System economics*",** John Wiley & Sons Ltd, 2004.

Reference Books:

1. Sally Hunt, **"*Making competition work in electricity*",** John Wiley & Sons, Inc.,2002.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H.J Bollen, **"*Operation of restructured power systems*"**, Kluwer Academic Pub.,2001.

Integration of Distributed Generation in Power Systems (3-0-0)

Sub Code: MPS1E102 **CIE: 50%Marks**
Hrs/week:3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks :100**

Course Outcomes:

On successful completion of the course, students will be able to:

1. Explain various non-conventional energy sources and methods of interfacing with grid.
2. Analyze the impact of distributed generation on general performance of power system.
3. Analyze the impact of distributed generation on over loading and losses, voltage magnitude variations and systemprotection.
4. Explain the influence of distributed generation on Power Quality and transmission systemoperation.

MODULE 1: Sources of Energy: Status and properties of wind power, Power distribution as a function of wind speed, Status and properties of solar power, Photo voltaic, Interfacing with grid.

08 Hours

SLE: Status and properties of combined heat and power.

MODULE 2: Impact of DG on Power System Performance, Overloading and Losses: Impact of distributed generation on power system performance, Hosting capacity approach, Power quality and design of distributed generation, increasing the hosting capacity.

Impact of distributed generation on over loading and losses, Overloading of Radial distribution network, Increasing the hosting capacity.

08 Hours

SLE: Hosting capacity approach for events.

MODULE 3: Impact of DG on Voltage Magnitude Variations: Impact of distributed generation, Voltage margin and hosting capacity, Voltage rise owing to distributed generation, Hosting capacity and measurements to determine hosting capacity, Estimating the hosting capacity without measurements, Increasing thehostingcapacity. **08Hours**

SLE: Numerical approach to voltage variations.

MODULE 4: Impact of DG on Protection: Impact of distributed generation, Over current protection, Upstream and downstream faults, Hosting capacity, Fuse – recloser coordination, Bus bar protection, Generator protection, General requirements, Non controlled island operation, Increasing the hostingcapacity.

08 Hours

SLE: Basic method of islanding detection.

MODULE 5: Impact of DG on Power Quality Disturbances and Transmission System Operation: Impact of DG on power quality disturbances, Fast voltage fluctuations, Voltage unbalanced, Introduction to low frequency harmonics, High frequency distortion and voltage dips, Increasing the hosting capacity.

Impact of distributed generation and transmission system operation, Fundamentals of transmission system operation, Increasing the hosting capacity.

07Hours

SLE: Balancing and reserve.

Text Book:

1.Math H. Bollen, **"*Integration of Distributed Generation in the Power System*"**, Willey IEEEPress.

Electrical Transients in Power Systems (3-0-0)

Sub Code:MPS1E103 **CIE: 50%Marks**
Hrs/week:3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks :100**

Course Outcomes:

On successful completion of the course, students will be able to:

1. Discuss the generation of switching transients.
2. Describe the transients in DC circuits, conversion equipments and static VAR controls.
3. Discuss the concept of Insulation coordination.
4. Analyze the lightning phenomenon and transient over voltage protection methods.

MODULE 1: Abnormal Switching Transients: Normal and abnormal switching transients, Current suppression, Capacitance switching, Other restriking phenomena, Transformer magnetizing inrush current, Ferro resonance**,** Worked examples. **08Hours**

SLE: Three phase capacitor switching.

MODULE 2: Transients in Direct Current Circuits, Conversion Equipment and Static Var Controls: Introduction, Interruption of direct current in low voltage circuits, Transients associated with HVDC circuit breakers, Delayed and periodic functions, Commutation transients – the current- limiting static circuit breaker, Commutation transients in conversion equipment, Worked examples.

08 Hours

SLE: Transient behavior of a transformer coil.

MODULE 3: Lightning: The Scope of the lightning problem, The physical phenomenon of lightning, Interaction between lightning and the power system, Computation of a specific lightning event, Thunderstorm tracking and other recent developments, Worked examples.

08 Hours

SLE: Induced Lightning Surges.

MODULE 4: Insulation Coordination: Some basic ideas about insulation coordination, The strength of insulation, The hierarchy of insulation coordination, Test voltage waveforms and transient ratings, Statistical approaches to insulation coordination**,** Worked examples.

08 Hours

SLE: Deterministic statistical approaches to insulation coordination.

MODULE 5: Protection of Systems and Equipment Against Transient Over voltages: Introduction, Protection of transmission lines against lightning, Lightning shielding of substations, Surge suppressors and lightning arresters, Application of surge arresters, Surge suppressors for direct current circuits,

Transient voltages and grounding practices, Protection of control circuits, Surge protection scheme for an industrial drive system, Worked examples. **07Hours**

SLE: Surge protection of rotating machines.

Text Books:

1. Allan Greenwood, **"*Electrical Transients in Power Systems*",** 2ndedition, Willey India Pvt. Ltd.,2010.
2. C.S Indulkar, D.P Kothari and K. Ramalingam, **"*Power System Transients-A Statistical Approach*"**, 2ndedition, PHI,2010.

Digital Control Systems (3-0-0)

Sub Code: MPS2E4XX — **CIE: 50%Marks**
Hrs/week: 3+0+0 — **SEE: 50%Marks**
SEE Hrs: 3 — **Max marks :100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Understand, analyze and apply knowledge of control engineering and mathematics in industrial problems
2. Analyze digital control systems using transform techniques
3. Analyze digital control systems using state-space methods.
4. Design, digital control systems using transform techniques and state-space methods
5. Analyze the concepts of nonlinear digital control systems.

MODULE 1: Introduction to digital control systems and Z-Transform Techniques: Introduction, Discrete time system representation, data conversion and quantization, sample and Hold devices, mathematical modeling of the sampling process, data reconstruction and filtering of sampled signals, zero-order hold, the first-order hold, aliasing and folding, choice of the sampling period – Z-transform, Inverse Z-transform, pulse transfer and z-transfer function, pulse transfer function of the ZOH, solution of difference equation, response of discrete-data control system.

08 Hours

SLE: Choice of the sampling period

MODULE 2: Analysis using Z- Transform Techniques: Comparison of time responses of continuous data and discrete data systems, steady state error analysis of digital control systems, correlation between time response and root locations in the s-plane and the z-plane, constant damping factor and constant damping ratio loci, dead beat response at the sampling instants, root loci for digital control systems, effect of adding poles and zeroes to the open-loop transfer function

08Hours

SLE: Practical issues with deadbeat response design

MODULE 3: Discrete state space model: State equations of discrete-data systems with sample and hold devices, state equations of digital systems with all digital elements, different state variable models, digital simulation and approximation, state transition equations, state diagrams of digital systems, Decomposition of discrete data transfer functions, Controllability and observability of discrete data systems, relation between observability, controllability and transfer functions, Controllability and observability versus sampling period.

08 Hours

SLE: Stability of discrete state space models

MODULE 4: Discrete state space model- Controller Design: Controller Design using Discrete-time state model, Pole placement design by state feedback, Full order and reduced order observer design, design of digital control systems with state feedback and dynamic output feedback, realization of state feedback by dynamic controllers. Introduction to Multivariable & Multi-input Multi-output (MIMO) Digital Control Systems

08 Hours

SLE: Set point tracking controller

MODULE 5: Nonlinear Digital control systems: Discretization of nonlinear systems, Extended linearization by input redefinition, input and state, Equilibrium of nonlinear discrete-time systems, Lyapunov stability theory, Lyapunov functions, Stability theorem, Rate of convergence, Lyapunov stability of linear systems, Lyapunov's linearization method, Instability theorems, Discrete-time nonlinear controller design

07 Hours

SLE: - Extended linearization using matching conditions

Text Books

1. Benjamin C. Kuo, "**Digital control systems",** Second edition (Indian), Oxford University Press, 2012.
2. Franklin, Powell, Workman, **"Digital Control of Dynamic Systems",** Pearson Education Third, 2006.
3. M. Gopal, "**Digital Control and State Variable Methods"**, Tata McGraw Hill Publication Limited, 2008.

References

1. Ogata,"**Discrete-time Control Systems"**, Prentice hall, Second edition, 2005.
2. M. Gopal, **"Digital Control Engineering",** New Age International,2006.
3. R. J. Vacaro, Digital Control "**A State Space Approach",** McGraw-Hill Higher Education, 1995

Wind &Solar Power Systems and Energy Storage (3-0-0)

Sub Code	**: MPS1E202**	**CIE: 50%Marks**
Hrs/week	**: 3+0+0**	**SEE: 50%Marks**
SEE Hrs	**: 3**	**Max marks :100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain the basic design aspects of wind and solar powersystems.
2. Discuss the issues related to grid connection of wind and solar powerSystems.
3. Explain the various energy storage schemes related to renewable energysystems.

MODULE 1: **Wind Power Systems**: System components, Turbine rating, Power v/sSpeed and TSR, Maximum energy capture, Maximum power operation, System-design trade-offs, System control requirements, BIS and IEC specifications and codes governing wind power systems.

07 Hours

SLE: Environmental aspects

MODULE 2: Electrical Generators and drives: Introduction to electrical generators, Doubly fed induction generator, Direct-driven generator, Generator drives, Speed control regions, Generator drives, Drive selection.

08 Hours

SLE: Cutout Speed Selection

MODULE 3: Photovoltaic Power Systems: Introduction to PV cell technologies, PV cell, Module and array, Equivalent electrical circuit, Open-circuit voltage and short-circuit current, Array design, Peak-power operation, Components, BIS and IEC specifications and Codes governing photovoltaic systems.

09 Hours

SLE: I-V and P-V curves

MODULE 4: Grid-Connected Systems: Interface requirements, Synchronizing with the grid, Operating limit, Energy storage and load scheduling, Utility resource planning tools, Wind farm–grid integration, BIS and IEC specifications and Codes governing grid-connected systems.

08 Hours

SLE: Grid stability issues

MODULE 5: Energy Storage: Types of battery, Equivalent electrical circuit, Performance characteristics, More on the lead-acid battery, Battery design, Battery charging, Charge regulators, Management, Flywheel, Superconducting magnet, Technologies compared, BIS specifications and codes governing lead acid and nickel cadmium batteries.

07 Hours

SLE: Compressed air as energy storage.

Text Book:

1. Mukund R. Patel, **"*Wind and Solar Power Systems*"**, 2ndedition, Taylor and Francis Group,2006.

E-resource link:

1. www.**bis**.org.in
2. www.**iec**.ch

Smart Grid-Technology and Applications (3-0-0)

Sub Code: MPS1E203 **CIE: 50%Marks**
Hrs/week: 3+0+ 0 **SEE: 50%Marks**
SEE Hrs: 3 **Max. Marks: 100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain the concept of smart grid and its realisation.
2. Discuss various concepts of dynamic energy management systems.
3. Describe interoperability, standards and cyber security.
4. Describe the characteristics of smart transmission and distribution grids
5. Discuss the interaction of smart grid with electric vehicles.

MODULE 1: Introduction to smart grid: Background and history of smart Grid evolution, Definition and characteristics of smart grid, Benefits of smart grid , Smart Grid vision and its realisation, Motives behind developing the Smart Grid concept, Examples of Smart Grid projects/initiatives, The Smart Grid basic infrastructure.

08 Hours

SLE: Comparison between Smart Grid and conventional electrical networks

MODULE 2: Dynamic Energy Systems Concept: Smart energy efficient end use devices,Smart distributed energy resources, Advanced whole building control systems, Integrated communications architecture, Energy management, Role of technology in demand response, Current limitations to dynamic energy management, Distributed energy resources, Overview of a dynamic energy management, Key characteristics of smart devices, Key characteristics of advanced whole building control systems.

08 Hours

SLE: Key characteristics of dynamic energy management system

MODULE 3: Interoperability Standards and Cyber Security: Introduction to Interoperability, Analogy between the interoperability of a digitally based device and human interoperability, Type and characteristics of interoperability standards for Smart Grid Electrical power industry standards development organizations (SDOs) and key interoperability standards: IEEE, ANSI, NIST, NERC, W3C., Smart Grid communication system infrastructure, Cyber security of power systems: Smart Grid cyber-security challenges, Communication-based attacks, Emerging Smart Grid cyber-security technologies, Smart Grid cyber-security standards.

09 Hours

SLE: Mitigation approach to cyber security risks.

MODULE 4: Smart Transmission and Distribution Grids: Smart distribution networks versus conventional distribution networks, Basic building blocks of a smart distribution network, Introduction to smart transmission grid, Challenges and requirements of future STG, Characteristics of smart transmission network, Characteristics of a smart substation. IEEE C 37.118 and series standards communications in smart grid.

08 Hours

SLE: IEC 61850 substation architecture

MODULE 5: Smart Grid Interaction with Electric Vehicles: Types of electric drive vehicle, Characteristics of energy storage devices/systems, Types, characteristics and benefits of EES systems, Types of EV charging systems, smart charging in smart grid, Load management of EVs using Smart-Grid technologies.

06 Hours

SLE: Components related to EV-Smart-Grid integration

Text Books:

1. Salman K. Salman, ***"Introduction to the Smart Grid Concepts, Technologies and Evolution",*** The Institution of Engineering and Technology, London, United Kingdom, 2017.
2. Clark W Gellings, **"*The Smart Grid, Enabling Energy Efficiency and Demand SideResponse*"**, CRC Press, 2009.

Research Methodology (2-0-0)

Sub Code: MPS1CRM **CIE: 50%Marks**
Hrs/week:2+0+0 **SEE: 50%Marks**
SEE Hrs:2 **Max marks :50**

Course outcomes

After studying this course, students will be able to:

1. Understand the basic framework of research process, research design and techniques
2. Understand the processes of quantitative data collection, analysis, interpretation and presentation
3. Understand the components of scholarly writing and ethical issues in research

MODULE-1

Overview of research: Introduction to research, Objectives and motivations for research, Significance of research, Research Methods v/s Methodology, Types of research, Quantitative Research Methods, Variables, Conjecture, Hypothesis. Research Process, Steps in research process, Criteria of good Research, Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources -Reviews, - web as a source - searching the web - Identifying gap areas from literature review, Development of working hypothesis.

Research problem-definition, selection and formulation of a research problem selection, criteria of a good research problem**.** Introduction to research design, Characteristics of good research design.

8 Hours

SLE : Developing a research plan, Department/program specific research problem discussions

MODULE-2

Data collection, processing and analysis: Sources of data, collection of data, Primary and secondary Data, Collection of Data through various methods, Measurement and scaling, Sources of error in measurement. Modeling, Mathematical Models for research

Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Probability and Non Probability sampling- types and criteria for selection, Probability, Probability Distributions, Hypothesis Testing, Level of Significance and Confidence Interval, Type I and Type II errors, t-test, z-test, ANOVA, Correlation, Regression Analysis.

9 Hours

SLE : Measures of central Tendency (Mean, medium, Mode), Measures of dispersion (range, mean deviation, standard deviation) Graphical representation of Data.

MODULE-3

Report writing and ethics in Research: Writing Research Report: Format and style. Review of related literature its implications at various stages of research. (Formulation of research problem, hypothesis, interpretation and discussion of results. Major findings, Conclusions and suggestions.) Layout of a Research Paper, Research proposal, Citation of references, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, effective technical presentation in seminars/workshops/symposiums

Significance of ethical conduct in research, Ethical issues related to publishing, Plagiarism. Software for detection of Plagiarism.

9Hours

SLE: Intellectual property rights, importance and protection, copyrights, patents, Impact factor of Journals

Text books:

1. Chawla, Deepak &Sondhi, Neena (2011) **"Research methodology: Concepts and Cases" ,**Vikas Publishing House Pvt. Ltd. Delhi.
2. Kothari, C.R., (2014), "**Research Methodology",**New Age International second revised edition

Reference books:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002)."**An Introduction to Research Methodology",** RBSA Publishers.
2. Sinha S.C. and Dhiman AK, (2002)."**Research Methodology",**Ess, Publications
3. Fink A, (2009). "**Conducting Research Literature Reviews: From the Internet to Paper"** Sage Publications

Power Systems Lab - I (0-0-2)

Sub Code: MPS1L01 **CIE: 50% Marks**
Hrs/Week: 0+0+2 **SET: 50% Marks**
Max Marks: 50

Course Outcomes

On successful completion of the course, the students will be able to:

1. Perform Steady state analysis of power systems.
2. Perform Transient analysis of power systems.
3. Execute relaying algorithmsand Test power system protection schemes

List of Experiments:

1. To perform power flow studies of 5 Bus system with HVDC transmission line.
2. To carry out short circuit studies on a given power system.
4. To determine voltage stability indicator and investigation of voltage stability of power system.
5. To carryout Contingency analysis on a power system.
6. To perform State Estimation and bad data detection for a given power system
7. Simulation of Relaying Algorithms for numerical protection
8. To test and analyze Feeder protection schemes
9. To test and analyzeMotor protection schemes
10. To test and analyze Generator protection schemes

M.Tech.: Power systems

(2020-2022)

Syllabus – II Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Economic Operation of Power Systems (4-2-0)

Pre-requisite: Power System Analysis and Stability (Sub Code:MPS1CXX)

Sub Code :MPS2C01	**CIE: 50%Marks**
Hrs/week :4+2+0	**SEE: 50%Marks**
SEE Hrs:3	**Max marks :100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Solve economic dispatch and unit commitment in Thermal PowerPlant.
2. Formulate and evaluate the economic dispatch Hydro - Thermal PowerPlant.
3. Analyze single area and two area load frequency control of power system.
4. Apply optimization techniques to solve optimal power flowproblem.
5. Explain the concept of interchange of power andenergy.

MODULE 1: Economic Dispatch - I: Introduction to economic aspects, Load curve, Load forecasting. Introduction to economic load dispatch, Characteristics of hydro and thermal units, Economic load dispatch problem neglecting transmission losses and generation limits, Economic load dispatch problem with generation limits, Economic load dispatch problem with piecewise linear cost functions,Problems.

08 Hours

SLE: Base Point and participation Factors

MODULE 2: Economic Dispatch – II and Optimal Unit Commitment (OUC) of Thermal Units: Derivation of transmission line loss expressions, Economic load dispatch with transmission network losses, Introduction to OUC, Constraints in OUC, Priority list method and dynamic programming for UC, Problems.

08 Hours

SLE: Optimal Unit Commitment (OUC) considering start up cost for thermal units

MODULE 3: Hydrothermal Coordination: Introduction, Hydroelectric plant models, Composite generation production cost function, Long-range hydro-scheduling, Short- range hydro-scheduling, Short-term hydro-scheduling: a gradient approach, Hydro- units in series (hydraulically coupled), Pumped-storage hydro plants, Dynamic- programming solution to the hydrothermal schedulingproblems.

10 Hours

SLE: Hydrothermal scheduling using linear programming

MODULE 4: Load Frequency Control : Single area block diagram representation, Single area – steady state and dynamic analysis, Static load frequency curves, Integral control, Response of a two – area system for uncontrolled and controlled case with block diagram, Dynamic state variablemodel.

08 Hours

SLE: Area control error

MODULE 5: Optimal Power Flow: Introduction, Solution of the optimal power flow – Gradient method, Newton's method, Linear sensitivity analysis, Linear programming methods, Security-constrained optimal power flow. **09 Hours**

SLE: Bus incremental cost

MODULE 6: Interchange of Power and Energy: Introduction, Economy interchange between interconnected utilities, Inter utility economy energy evaluation, Interchange evaluation with unit commitment, Multiple-utility interchange transactions, Other types of interchange- capacity interchange, Diversity interchange, Energy banking, Emergency power interchange, Inadvertent power exchange, Power pools - the energy-broker system, Allocating pool savings, Transmission effects and issues-transfer limitations, Wheeling, Rates for transmission services in multiparty utility transactions, Someobservations.

09 Hours

SLE: Transactions involving nonutility parties

Text Books:

1. Allen J. Wood and Bruce F. Woollenberg, "***Power Generation, Operation, and Control***", 2nd edition, John Wiley and Sons,INC**.**
2. S. Sivanagaraju, G. Sreenivasan, "***Power System Operation and Control***", Pearson Publisher.

Power System Dynamics and Control (4-0-0)

Pre-requisite: Power System Analysis and Stability (Sub Code:MPS1CXX)

Sub Code : MPS2C05 **CIE : 50% Marks**
Hrs/week : 4 +0+0 **SEE : 50% Marks**
SEE Hrs : 3 Hrs **Max marks : 100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Explain the concepts of power system security and stability.
2. Construct the models of synchronous machine and other power system components for the study of system dynamics.
3. Investigate small signal stability of a synchronous generator connected to an infinite bus and explain the structure and design aspects of PSS

MODULE 1: Introduction to the power system stability problem: Rotor angle stability, Voltage stability and voltage collapse, Mid-term and long-term stability, Classification of stability problems, States of operation and system security, Review of classical methods, Swing equation, Some mathematical preliminaries, Analysis of steady state stability.

09 Hours

SLE: Analysis of transient stability

MODULE 2: Modeling of Synchronous Machine:Flux linkage equations, Voltage and torque equations, Park's transformation, Transformation of flux, Stator voltage equations and rotor equations, Transformation of torque equations, Choice of constants, Analysis of steady state performance, Per unit quantities, Equivalent circuits of synchronous machine.

09 Hours

SLE: Determination of synchronous machine reactances

MODULE 3: Modeling of Excitation Systems and Prime Mover Controllers:Excitation system requirements, Elements of excitation systems, Types of excitation systems, Excitation system modeling, Standard block diagrams, System representation by state equations, Inclusion of limits, Modeling of turbines and speed-governing systems.

09 Hours

SLE: Excitation system control and protective circuits

MODULE 4: Modeling of Transmission Lines and Loads : Transmission line model, Transformation to D-Q components, Steady state equations, Transformation using α-β variables, Modeling of static and dynamic loads.

08 Hours

SLE: Modeling of SVC

MODULE 5:Dynamics of a Synchronous Generator connected to Infinite bus:System model, Synchronous machine model, Application of model 1.1,Calculation of initial conditions, Consideration of other machine models, System simulation.

SLE:. Inclusion of SVC model **08 Hours**

MODULE 6 : Analysis of Small Signal Stability and Power System Stabilizer: Small signal analysis with block diagram representation of SMIB systems with generators represented by classical and 1.0 models, Synchronizing and damping torque analysis, Basic concepts in applying PSS, Control signals, Structure and tuning of PSS.

SLE: Nonlinear oscillations- Hopf bifurcation **09 Hours**

Text Book:

1. K.R. Padiyar,**"*Power System Dynamics Control and Stability*",** Second Edition, B S Publications.
2. K N Shubanga "***Power System Analysis : A Dynamic Perspective "****Pearson publications, 2018*

Reference Books:

1. PrabhaKundur ,**"*Power System Stability and Control*"**, Tata McGraw – Hill edition.
2. Chakrabarti, Abhijit ***"Power System Dynamics And Simulation"***PHI learning pvt ltd ,2013

Flexible AC Transmission Systems (4-2-0)

Sub Code :MPS2C06 **CIE: 50%Marks**
Hrs/week :4+2+0 **SEE: 50%Marks**
SEE Hrs: 3 **Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Analyze the behavior of uncompensated AC transmissionsystem.
2. Analyze series and shunt compensated system with fixed compensators and FACTS controllers.
3. Explain the structure and functions of combinedcompensators.

MODULE 1: Uncompensated AC transmission system: Fundamental requirements in AC power transmission, Fundamental transmission line equation, Surge impedance & natural loading, Analysis of uncompensated AC lines - radial & symmetrical line on No-load & load, Transmission interconnections, Flow of power in AC system, Loading capability limitations,

09 Hours

SLE: Relative importance of controllable parameters.

MODULE 2: Types of compensation & fixed series compensation: Basic types of line compensation, Uniformly distributed fixed compensation, Objectives of series compensation, Compensation by a series capacitor connected at the midpoint of the line, Protective gear and reinsertion schemes.

08 Hours

SLE: Varistor protective scheme.

MODULE 3: Introduction to FACTS controllers and controlled series compensation: Basic types of FACTS controllers, Benefits from FACTS technology, Basic concepts of controlled series compensation, Operation of TCSC, Analysis of TCSC, GCSC, Applications of TCSC, Introduction to SSSC, Operation of SSSC & the control of power flow.

09 Hours

SLE: Applications of SSSC.

MODULE 4: Fixed shunt compensation and SVC: Objectives of shunt compensation, Compensation by a shunt capacitor connected at the midpoint of the line, SVC – objectives, Control characteristics, Analysis, Configuration, Applications.

09Hours

SLE: SVC controller.

MODULE 5: STATCOM: Introduction to STATCOM, Basic operating principle, Control characteristics and simplified analysis of 3-phase 6 pulse STATCOM, Applications.

08 Hours

SLE: Comparison between STATCOM & SVC.

MODULE 6: UPFC: Introduction to UPFC, Operation of UPFC connected at sending end, midpoint & receiving end, Control of UPFC, Interline power flow controller.

09 Hours

SLE: Applications of UPFC.

Text Books:

1. Narain. G. Hingorani& Laszlo Gyugyi, **"*Understanding Facts*"**, IEEE Press,2000.
2. K. R. Padiyar, **"*FACTS Controllers in Power Transmission & Distribution*"**, New Age International Publishers, 1st edition,2007.

Reference book :

1.T.J.E. Miller, **"*Reactive Power Control in Electric Systems*"**, A Wiley IntersciencePublication,1982.

Electrical Power Distribution Automation and Control(3-2-0)

Sub Code :MPS2C04 **CIE: 50%Marks**
Hrs/week :3+2+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Discuss the control and management in the Distribution Automation.
2. Model the Distribution system components.
3. Discuss the Feeder and Substation Automation& the communication technologies
4. Analyze the performance of distribution system

MODULE 1: Power delivery system control and Automation: Introduction, Power delivery systems, Control hierarchy, Distribution Automation concepts, Basic architectures and implementation strategies for distribution automation**.**

07 Hours

SLE: Different levels of automation preparedness.

MODULE 2: Central control and Management: Operations environment of distribution networks, Evolution and functions of Distribution management systems, Basics of real time control system (SCADA), Outage management, Decision support applications, Database structures and interfaces.

07 Hours

SLE: Data model standards.

MODULE 3: Computational Techniques for Distribution System: Introduction, Equipment modeling: Distribution transformer, Photovoltaic systems. Component modeling: Line model, Shunt capacitor model, Switch model and load models, Distribution power flow methods, Problems.

08 Hours

SLE: Composite load model.

MODULE 4: Distribution Automation and Control Function: State and trends substation automation, Demand side management, Feeder automation -voltage/var control, Fault detection, Trouble calls, Restoration functions, Reconfiguration, Power quality assessments.

08Hours

SLE: Demand response.

MODULE 5: Performance of Distribution system: Faults on distribution networks, Performance and basic reliability calculations, Improving the performance without automation, Improving the reliability of underground and overhead network –design methods, Improving the performance with automation, Performance as function of network complexity factor.

Communication system for control and automation: Introduction, Wire communication, Wireless communications, Distribution automation communications- protocols, Architecture, User interface, Requirements of dimensioning the communication channel.

09 Hours

SLE: Power theft

Text Books:

1. James Northcote-green and Robert wilson, **"*Control and automation of Electrical Power Distribution Systems*"**, 1st edition, CRC Press Taylor and Francis group,2013.
2. James A. Momoh, **"*Electrical Power Distribution, automation, protection and control*"**, 1st edition, CRC Press Taylor and Francis group, 2009.

Reference Book:

1. William H. Kersting, **"*Distribution System Modeling and Analysis*"**, 3rd edition, CRC Press, 2001.

EHV AC Transmission (3-0-0)

Sub Code :MPS2E301 **CIE: 50%Marks**
Hrs/week :3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Understand the effect of corona and its assessment.
2. Gain knowledge on performance characteristics of EHV cables and principles of Lightning Protection.
3. Explain the method of voltage control and SSR phenomenon.
4. Gain knowledge of standard wave shapes and generator circuit for EHV testing.

MODULE 1 : Corona Effects : Power loss and Audible Noise (AN), Corona loss formulae charge voltage diagram, Generation, characteristics, Limits and measurements of AN, Relation between 1-phase and 3-phase AN levels, Radio Interference (RI),Corona pulses generation, Properties, Limits, Frequency spectrum, Modes of propagation and excitation functions, Examples.

07 Hours

SLE: Measurement of RI.

MODULE 2: Lightning and lightning protection : Lightning strokes mechanism, Lightning strokes to lines, General principles of lightning protection problem, Tower footing resistance, Probability of occurrence of lightning stroke current, Lighting arrester and protective characteristics, Dynamic voltage rise arrester rating.

08 Hours

SLE: Insulation coordination based on lightning.

MODULE 3: Extra High voltage cable Transmission: Electrical characteristics of EHV cables**,** Properties of EHV cables, Breakdown and withstand electrical stress in solid insulation design basis, Test on cable characteristics and surge performance of cable system.

08 Hours

SLE: Gas insulated EHV Lines

MODULE 4 : Voltage Control: Power circle diagram and its use, Voltage control using synchronous condensers, Cascade connection of shunt and series compensation, Sub- Synchronous Resonance (SSR) in series capacitor compensated lines, Static VAR compensating system.

08 Hours

SLE: SSR counter measures.

MODULE 5: EHV Testing and laboratory equipment: Standard specification, Standard wave shape, Properties of double exponential wave shapes, Procedure for calculating α, Wave shaping circuits-principle and theory, Impulse voltage generator-practical circuits, Generation of switching surges for transformer testing.

08 Hours

SLE: Generation of impulse current.

Text Books:

1. Rakosh Das Begamudre, "***EHV AC Transmission Engineering***", 3^{rd}edition, New Age International publishersLtd.,2009.
2. S.Rao, "***EHV-AC, HVDC Transmission & Distribution Engineering***", 3^{rd}edition,Khanna publishers New Delhi**,** 2008.

Power Quality and Custom Power Devices (3-0-0)

Sub Code:MPS2E302 **CIE: 50%Marks**
Hrs/week:3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Analyze the power quality problems and conventional mitigation techniques.
2. Describe the custom power devices.
3. Understand the principles of shunt and series compensation for power quality enhancement.
4. Describe different structures and control of UPQC.

MODULE 1: Analysis and Conventional Mitigation Methods: Power quality terms and definitions, Analysis of power outages, Analysis of unbalance, Analysis of distortion, Analysis of voltage sag, Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem and harmonic reduction.

09 Hours

SLE: Voltage sag reduction

MODULE 2: Custom Power Devices: Utility-customer interface, Custom power devices, Network reconfiguring devices, Solid state current limiter, Solid state breaker, Issues in limiting and switching operations, Solid state transfer switch, Sag/swell detection algorithms.

08 Hours

SLE: Custom power park

MODULE 3: Realization and Control of DSTATCOM: DSTATCOM structure, Control of DSTATCOM connected to a stiff source, DSTATCOM connected to weak supply point, DSTATCOM current control through phasors when both load and source are unbalanced, DSTATCOM in voltage control mode.

08 Hours

SLE: DSTATCOM current control when both load and source are unbalanced and distorted.

MODULE 4: Series Compensation of Power Distribution System: Rectifier supported DVR, DC capacitor supported DVR, DVR structure, Voltage restoration, Series active filter.

08 Hours

SLE: State feedback control of DVR.

MODULE 5: **Unified Power Quality Conditioner:** UPQC configurations, Right-shunt UPQC characteristics, Left-shunt UPQC characteristics, Structure and control of right-shunt UPQC, Structure of left-shunt UPQC.

06 Hours

SLE: Control of left-shunt UPQC

Text Books:

1. ArindamGhosh, Gerard Ledwich, Kluwer, "***Power Quality Enhancement Using Custom Power Devices***", 1st edition, Academic Publishers,2002.
2. Math H J Bollen, **"*Understanding Power Quality Problems - Voltage Sags and Interruptions*"**, 1st edition, Wiley India,2011.

Photovoltaic System Engineering (3-0-0)

Sub Code: MPS2E303 **CIE: 50%Marks**

Hrs/week : 3+0+0 **SEE: 50%Marks**

SEE Hrs : 3 **Max marks : 100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Analyze and design grid connected and standalone PV systems.
2. Design a battery system for grid connected PV systems.
3. Investigate the economics and environmental concerns associated with PV systems.
4. Describe the manufacturing technology of solar cells.

MODULE 1: Grid-Connected Utility-Interactive Photovoltaic System: Introduction, Applicable codes and standards, Design considerations for straight grid-connected PV systems, Design of a system based on desired annual system performance, Design of a system based upon available roof space, Design of a micro inverter-based system, Design of a nominal 20KW system that feeds a three-phase distribution panel.

08 Hours

SLE: Design of PV system.

MODULE 2: Battery-Backup Grid-Connected Photovoltaic Systems: Introduction, Battery-backup design basics, A single inverter 120V battery-backup system based on standby loads, A 120/240V battery-backup system based on available roof space, An 18-KW battery-backup system using inverters in parallel, AC-coupled battery-backup system.

08 Hours

SLE: Battery connection.

MODULE 3:Stand-Alone Photovoltaic Systems: Introduction, The simplest configuration: module and fan, A PV-powered water pumping system, , A PV-powered parking lot lighting system, A portable highway advisory sign, A critical need refrigeration system, A PV-powered mountain cabin, A hybrid-powered, Off-grid residence.

08 Hours

SLE: A cathodic protection system.

MODULE 4: Economics and Environmental Consideration: Introduction, Life-cycle costing, Borrowing money, Externalities, Environmental impact of PV systems.

08 Hours

SLE: Payback analysis.

MODULE 5: Manufacturing Technology of Silicon Solar Cells: Introduction, Extraction and purification of silicon, Crystal growth and preparation of wafers, Typical manufacturing process for silicon cells, Advanced manufacturing processes, Construction of modules

07 Hours

SLE: Energy invested in the production of photovoltaic modules.

Text Books:

1. Roger Messenger, Amir Abtahi, **"*Photovoltaic Systems Engineering*",** 4th edition**, CRC Press**, Taylor & Francis Group**,** 2017.

2. Eduardo Lorenzo, **"*Solar Electricity: Engineering of Photovoltaic Systems*",** Progensa, 1994.

Cybersecurity in Power system (3-0-0)

Sub Code:MPS2E3XX | **CIE: 50% Marks**
Hrs/Week: 03 | **SEE: 50% Marks**
SEE Hrs: 03 | **Max.: 100 Marks**

Course outcomes:

On successful completion of the course the students will be able to:

1. Discuss the importance of cybersecurity in power systems.
2. Apply the cybersecurity standards for electricity sector.
3. Analyze the cost of cyber security management and controls.

MODULE 1:Introduction: Transformation, Dependence on the ICT, Cybersecurity, Priority Critical Infrastructure.State of Cybersecurity in the Electricity Sector: Introduction, Vulnerabilities, Threats, Challenges, Initiatives**.**

09 Hours

SLE: Future Directions

MODULE 2:Cybersecurity Standards Applicable to the Electricity Sector: Introduction, Literature Search, Literature Analysis, Standards Selection and Evaluation Criteria, Results, Most Relevant Standards, Standards Implementation and Awareness.

06 Hours

SLE: Standards Limitations

MODULE 3: A Systematic Approach to Cybersecurity Management: Introduction, Cybersecurity Management Approaches in Standards, The Systematic Approach to Cybersecurity Management in the Electricity Sector.

09 Hours

SLE: Cybersecurity Assessment, Monitoring and Improvement.

MODULE 4: **Cost of Cybersecurity Management**: Introduction, Economic Studies, Organisation Management Studies, CostBenefit Analysis, Cost Calculators, Costing Metrics, CAsPeA. Cybersecurity Assessment: Introduction, Security Assessment Methods for the Electricity Sector, Cybersecurity Test beds for Power Systems, JRC Cybersecurity Assessment Method, Laboratory Infrastructure.

08 Hours

SLE: MAlSim

MODULE 5: Cybersecurity Controls: Introduction, Standard Technical Solutions, Information Sharing Platform on Cybersecurity Incidents for the Energy Sector.

07 Hours

SLE: Situation Awareness Network.

Text book:

1. RafalLeszczyna "**Cybersecurity in the Electricity Sector"**, Springer, 2019

Electric and Hybrid Vehicles (3-0-0)

Sub Code:MPS2E404 **CIE: 50% Marks**
Hrs/Week: 03 **SEE: 50% Marks**
SEE Hrs: 03 **Max.: 100 Marks**

Course outcomes:

On successful completion of the course the students will be able to:

1. To understand the basics of Electric and hybrid vehicles.
2. To analyze different Electric and Hybrid electric Drive train topologies.
3. To analyze different Drive system, and energy storage systems.
4. To size the electric and hybrid electric drive trains
5. To identify different energy management strategies.

MODULE 1: Introduction to Electric Vehicles: Basic Components of Electric and Hybrid Electric vehicles, History of Electric Vehicles, EV Advantages: Efficiency Comparison, Pollution Comparison, Capital and Operating Cost Comparison and U.S. Dependence on Foreign Oil
Vehicle Dynamics: Mathematical Model of vehicle to describe vehicle performance, Torque vs Speed characteristics of Electric vehicle and ICE vehicle, Performance of Electric Vehicles, Importance of gear in vehicles.

09 Hours

SLE: EV Market

MODULE 2: **Electric Drive-trains:** Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.
Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.

06 Hours

SLE: Plug-in Hybrid Electric Vehicles

MODULE 3: Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives.
Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis.

09 Hours

SLE: Hybridization of different energy storage devices.

MODULE 4:Vehicle Drive-train: EV Transmission Configurations, Transmission Components, Ideal Gearbox: Steady State Model, EV Motor Sizing. Hybrid Drivetrains: Sizing of Components, Rated Vehicle Velocity, Initial Acceleration, Maximum Velocity, Maximum Gradability
Vehicle Communication: Importance of Electronic Control System, Automotive Vehicle Networks, Communication Protocol: CAN, TT CAN and Flexray Communication.

08 Hours

SLE: Applications of Communication Protocol

MODULE 5: Energy Management Strategies: Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies.

07 Hours

SLE: Challenges of energy management strategies.

Text books:

1. Iqbal Hussein, "**Electric and Hybrid Vehicles**: Design Fundamentals", CRC Press, 2003.

2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, "**Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design**", CRC Press, 2004.

Reference book :

1. James Larminie, John Lowry, "**Electric Vehicle Technology Explained**", Wiley, 2003.

IoT for Smart Grids (3-0-0)

Sub Code:MPS2E4XX **CIE: 50% Marks**
Hrs/Week: 03 **SEE: 50% Marks**
SEE Hrs: 03 **Max.: 100 Marks**

Course outcomes:

On successful completion of the course the students will be able to:

1. Discuss the concepts, organizational implementation and challenges of Internet of Things.
2. Explain the fundamental components for realizing IoT platforms targeting the smart-grid domain.
3. Explain various applications of IoT in Smart grid and Smart cities.

MODULE 1: Introduction to IoT: Introduction, Definition of IoT, Proposed architecture and Reference Models, Enabling technologies, challenges.

Organizational Implementation and Management Challenges in the Internet of things: Introduction, IoT in Organizations, Managing IoT Systems.

06 Hours

SLE: Building the Blocks of IoT.

MODULE 2: The Smart-Grid Concept: Introduction**,** Actors in the Smart-grid Environment: Grid operator, Grid users, Energy market place, Technology providers, Influencers. Challenges of Smart-grid: Inadequacies in Grid Infra Structure, Cyber Security, Storage Concern, Data Management, Communication Issues.

Edge Computing for Smart Grid: An Overview on Architectures and Solutions: Introduction, IoT Applications, Requirement and Architecture, Information processing in Smart-Grid, Edge Computing in Internet of Things, Edge Computing Model for Smart Grid, A Use-Case for Home Appliance Management.

08 Hours

SLE: Current Art in Edge Computing and Smart Grid.

MODULE 3: Communication Protocols for the IoT-Based Smart Grid: Introduction, IoT Application types, IoT based Smart-Grid review, Current IoT Based Smart Grid Technology Enablers.

Smart Grid Hardware Security: Introduction, Smart Grid Architecture Patterns, Hardware Device Authentication, Confidentiality of Power Usage, Integrity of Data, Software and Hardware.

08 Hours

SLE: Future and Enabling Technologies for IoT based Smart Grid.

MODULE 4: Solar Energy Forecasting in the Era of IoT Enabled Smart Grids: Introduction, The Future Role of Forecasting, Summary of Solar Forecasting Methods, Example of a Detailed, Short-Term Forecasting Method.

Intelligence in IoT-enabled Smart Cities: Energy Consumption monitoring in IoT based smart cities, Smart homes in the crowd of IoT based cities, Smart meters for the smart city's grid, Intelligent parking solutions in IoT based smart cities.

09 Hours

SLE: Smart Office

MODULE 5: The Internet of Things in Electric Distribution Networks: Introduction, Current Control and Communication Provision in DNOs, AuRA-NMS-Based Electric IoT Architecture, Communication Standards, Protocols, and Requirements of Electric IoT.

Satellite-Based Internet of Things Infrastructure for Management of Large-Scale Electric Distribution Networks: Introduction, Distributed Control Approach for Smart Distribution Grid, LEO Network Characteristics and Modeling, Communication Performance Assessment.

08 Hours

SLE: Communication Infrastructure Requirements

Text books:

1. Qusay F. Hassan, Atta urRehman Khan, Sajjad A. Madani**"Internet of Things: Challenges, Advances, and Applications"** 1st Edition, CRC Press, Taylor and Francis group,2019.
2. Kostas Siozios , DimitriosAnagnostos, DimitriosSoudris, Elias Kosmatopoulos, **"IoT for Smart Grids: Design Challenges and Paradigms",** Springer, 2019

Reference books

1. Fadi Al-Turjman, **"Intelligence in IoT-enabled Smart Cities",** 1st Edition, CRC Press 2018
2. IEEE journal publications.

PLC & SCADA (3-0-0)

Sub Code :MPS2E403	**CIE: 50%Marks**
Hrs/week :3+0+0	**SEE: 50%Marks**
SEE Hrs:3	**Max marks:100**

Course Outcomes

On successful completion of the course, students will be able to:

1. Describe architecture and hardware of PLC.
2. Explain the interface for a variety of input and output devices for PLC.
3. Use programming constructs for ladder diagram, Instruction list, Sequential function charts (SFC) and Structured text.
4. Application of SCADA to Power System operation and management.

MODULE 1: Introduction to PLC: Programming logic controller hardware and internal architecture, PLC systems basic configuration and development, Desktop and PC configurated system, I/O devices, Mechanical switches, Proximity switches, Photoelectric sensors and switches, Temperature sensors, Position sensors, Pressure sensors and smart sensors.

08 Hours

SLE: Interface of encoder device to PLC.

MODULE 2: Output devices: Relay, Directional control valves, Control of single and double acting cylinder control, Conveyors control, I/O processing-signal conditioning, Remote connections, Networks, Processing inputs, Programming features.

08 Hours

SLE: Serial and parallel communication standards.

MODULE 3: Programming methods: Ladder programming, Ladder diagrams, Logic functions, latching multiple outputs, Entering programs, Function blocks, Programming with examples, Instruction List(IL), Sequential Function Charts(SFC), Structured text example with programs.

08 Hours

SLE: Implementation of different programming languages to practical systems.

MODULE 4: Extended Programming methods: Ladder program development examples with jump and call subroutines, Timers, Programming timers, Off-delay timers, Pulse timers, counters, Forms of counter, Up and down counting, Timer with counters, Programming with examples.

08 Hours

SLE: Sequencers.

MODULE 5: SCADA in Power Systems: SCADA basic functions, SCADA application functions, Advantages of SCADA in power systems, Power system field, Flow of data from the field to the SCADA control center.

07 Hours

SLE: Smart devices for substation automation.

Text Books:

1. W. Bolton, **"Programmable Logic Controllers"**, Elsevier Publication, Oxford UK.
2. Mini S Thomas, John Douglas McDonald, " Power system SCADA and smart grid" CRC Press, 2015.

Reference Books:

1. E.A Paar,**"*Programmable Controllers-An Engineers Guide*"**, Newness publication.
2. Johnson Curties, **" *Process Control Instrumentation Technology*"**, 8^{th}edition, Prentice hall of India.

Design and Analysis of Industrial Power System Protection(2-0-0)

Pre-requisite: Course on power system protection(Sub Code:MPS1CXX)

Sub Code :MPS2I01	**CIE: 50%Marks**
Hrs/week :2+0+0	**SEE: 50%Marks**
SEE Hrs:2	**Max marks:50**

Course Outcomes

On successful completion of the course, students will be able to:

1. Familiar with Types of relays, protection schemes, computer applications, fault calculation used in an industrial power system
2. Apply the protection schemes to design and solve the industrial power system protection problem.
3. Familiar with special protection needs, disturbance file analysis, post-mortem analysis following a disturbance.

MODULE 1 : Typical industrial system SLD, Power flow and fault analysis of the industrial system to establish the base case, Stability study to compute the critical clearing time, Impact of large motor starting, Impact of loss of generation and loss of grid.

09 Hours

SLE: Electromagnetic transient analysis for the industrial system

MODULE 2: Understanding the protection diagram of the industrial system, Relay setting calculation for feeder protection, motor protection, generator protection, transformer protection, line protection, bus bar protection, Application of frequency based relays.

09 Hours

SLE: Grid islanding relay settings.

MODULE3: Protection system simulation, COMTRADE file format, Tripping analysis, Adaptive relaying.

08 Hours

SLE: Special protection schemes

Reference:

1. Lecture and tutorial notes by the Industry offering the course and Journal publications.

Power Systems Lab - II (0-0-2)

Sub Code : MPS2L01 **CIE: 50% Marks**
Hrs/Week : 0+0+2 **SET: 50% Marks**
Max Marks: 50

Course Outcomes:

On successful completion of the course, the students will be able to:

1. Perform studies on Economic dispatch of thermal and hydro units
2. Simulate load frequency control.
3. Perform studies on optimal power flow
4. Model and evaluate performance of SMIB systems with PSS.
5. Simulate voltage control methods in distribution system.

<u>List of Experiments:</u>

1. To perform Economic dispatch and Unit commitment of thermal units.
2. To perform Economic dispatch of hydro – thermal units.
3. To simulate single area and two area systems for load frequency control.
4. To perform optimal power flow for a given power system.
5. To study the effect of StaticVar Compensator connected at the load bus using hardware simulator.
6. To model a SMIB system with synchronous generator represented by classical model and obtain the system response for a step increase in Tm by 5%.
7. To model a SMIB system (with synchronous generator represented by classical model) with a STATCOM damping controller and to evaluate its response for a step increase in T_m by 5%.
8. To model a SMIB system with synchronous generator (represented by 1.0 model) and obtain response for the following conditions:
   (a) Step increase in V_{ref}orTm by 5%
   (b) 3-phase short circuit at generator terminals.
9. Design a PSS for the system described in experiment no 5 and evaluate its performance for the following conditions:
   (a) Step increase in V_{ref}orTm by 5%
   b)3-phase short circuit at generator terminals.
10. To simulate voltage/var control methods in distribution system.

M.Tech.: Power systems

(2020-2022)

Syllabus – III Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

MOOC Elective (Department Specific/Management) (3-0-0)

Sub Code :MPS3MXX **CIE: 50%Marks**
Hrs/week :3+0+0 **SEE: 50%Marks**
SEE Hrs:3 **Max marks:100**

MOOC open Elective(from other departments)(2-0-0)

Sub Code :MPS3MXX **CIE: 50%Marks**
Hrs/week :2+0+0 **SEE: 50%Marks**
SEE Hrs:2 **Max marks:50**

Seminar/ Paper Presentation (1 Credit)

Sub Code : MPS3C02 **Max marks: 50**

Course Outcomes:

On successful completion of the course, students will be able to:

1: Identify the topic of relevance within the discipline.

2: Understand the study material in depth.

3: Inculcate ethical practices.

4: Present and document the study.

5: Acquire knowledge by introspection.

Internship (5 Credits)

Sub Code :MPS3C03 **Max marks:50**

Course Outcomes:

On successful completion of the course, students will be able to:

1: Gain field experience in the relevant discipline.

2: Connect the theory with practice.

3: Present and document the training experience.

4: Acquire knowledge by introspection.

Project Phase – 1(8 Credits)

Sub Code:MPS3CXX **Max marks:100**

Course Outcomes:

On successful completion of the course, students will be able to:

1: Identify the topic of relevance within the discipline

2: Carry out literature survey

3: Formulate the problem, Identifythe objectives and develop solution methodology

4: Inculcate ethical practices.

5: Present and document the preliminary project work.

6: Acquire knowledge by introspection.

M.Tech.: Power systems

(2020-2022)

Syllabus – IV Semester

Department of Electrical and Electronics Engineering

The National Institute of Engineering

Mysuru-570 008

Project Phase - 2(15 Credits)

Sub Code:MPS4C01 **CIE:50Marks**
Max marks:250 **SEE: 200Marks**

Course Outcomes:

On successful completion of the course, students will be able to:

1: Implement solution methodology.

2: Judiciously execute the project schedule.

3: Harness the modern tools.

4: Analyze, interpret the results and establish the scope for future work.

5: Identify and execute economically feasible projects of social relevance.

6: Present and document the project work.

7: Acquire knowledge by introspection.