MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF ELECTRICAL ENGINEERING

Scheme & Syllabus
of
M. Tech. (Power Systems)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF ELECTRICAL ENGINEERING

M.Tech. Power Systems (Full Time)

Semester I

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EET-601	Power System Analysis	Program Core	Theory	3	2	1	0
2	EET-603	Advanced Power System Protection	Program Core	Theory	3	2	1	0
3	EET-605	Power Electronics	Program Core	Theory	3	2	1	0
4	EEP-601	Power System Lab	Program Core	Lab	3	0	0	6
5	PE (Odd)		Program Elective	Theory	3	2	1	0
6	PE (Odd)		Program Elective	Theory	3	2	1	0

Semester II

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EET-602	Power System Stability	Program Core	Theory	3	2	1	0
2	EET-604	Power System Optimization and Control	Program Core	Theory	3	2	1	0
3	PE (Even)		Program Elective	Theory	3	2	1	0
4	PE (Even)		Program Elective	Theory	3	2	1	0
5	PE (Even)		Program Elective	Theory	3	2	1	0
6	OE		Open Elective	Theory	3	2	1	0

Semester III

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EES-701	Seminar	Program Core	Seminar	3			
2	EED-701	Dissertation	Program Core	Dissertation	7			

Semester IV

S. No.	Course Code	Course Title	Course Category	Type	Credits	L	T	P
1	EED-702	Dissertation	Program Core	Dissertation	14			

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT OF ELECTRICAL ENGINEERING

M.Tech. Power Systems (Part Time)

Semester I

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	EET-601	Power System Analysis	Program Core	Theory	3	2	1	0
2	EET-603	Advanced Power System Protection	Program Core	Theory	3	2	1	0
3	EET-605	Power Electronics	Program Core	Theory	3	2	1	0

Semester II

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	EET-602	Power System Stability	Program Core	Theory	3	2	1	0
2	EET-604	Power System Optimization and Control	Program Core	Theory	3	2	1	0
3	PE (Even)		Program Elective	Theory	3	2	1	0

Semester III

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	PE (Odd)		Program Elective	Theory	3	2	1	0
2	PE (Odd)		Program Elective	Theory	3	2	1	0
3	EEP-601	Power System Lab	Program Core	Lab	3	0	0	6
4	EES-701	Seminar		Seminar	3			

Semester IV

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	PE (Even)		Program Elective	Theory	3	2	1	0
2	PE (Even)		Program Elective	Theory	3	2	1	0
3	OE		Open Elective	Theory	3	2	1	0

Semester V

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	EED-701	Dissertation	Program Core	Dissertation	7			

Semester VI

S. No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1	EED-702	Dissertation	Program Core	Dissertation	14			

Program Core

Course Code	Course Title	PRS	PRE	CWS	MTE	ETE
EET-601	Power System Analysis	-	-	20	30	50
EET-602	Power System Stability	-	-	20	30	50
EET-603	Advanced Power System Protection	-	-	20	30	50
EET-604	Power System Optimization and Control	-	-	20	30	50
EET-605	Power Electronics	-	-	20	30	50
EEP-601	Power System Lab	70	30	-	-	-
EES-701	Seminar	70	30	-	-	-
EED-701	Dissertation	-	-	-	30	70
EED-702	Dissertation	-	-	-	30	70

Program Elective-PE (Odd)

Course Code	Course Title	PRS	PRE	CWS	MTE	ETE
EET-611	HVDC Transmission	-	-	20	30	50
EET-613	Computer Methods in Power Systems	-	-	20	30	50
EET-615	Power System Transients and H.V. Engineering	-	-	20	30	50
EET-617	Power System Instrumentation	-	-	20	30	50
EET-619	EHV AC/DC Transmission System	-	-	20	30	50
EET-635	Electric Drives and their Control	-	-	20	30	50
EET-647	Modeling & Simulation of Power Electronic Systems	-	-	20	30	50

Program Elective –PE (Even)

Course Code	Course Title	PRS	PRE	CWS	MTE	ETE
EET-612	Flexible AC Transmission Systems	-	-	20	30	50
EET-614	Advanced Circuit Analysis and Design	-	-	20	30	50
EET-616	Integrated Energy Systems	-	-	20	30	50
EET-618	Power System Planning & Reliability	-	-	20	30	50
EET-620	Economics & Planning of Energy Systems	-	-	20	30	50
EET-622	Advances in Power Transmission & Distribution	-	-	20	30	50
EET-624	AI Application to Power Systems	-	-	20	30	50
EET-642	Modern Control Theory	-	-	20	30	50
EET-656	Excitation of Synchronous Machines and Their Control	-	-	20	30	50

Open Elective (OE): To be offered by other Programs and Departments/Centre

Course Code	Course Title	PRS	PRE	CWS	MTE	ETE
		-	-	20	30	50

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: Department of Electrical Engineering

Course Code: EET-601

Course Name: POWER SYSTEM ANALYSIS

Credits: 3 . L - 2 . T - 1 . P - 0 .

Course Type: Programme Core

Prerequisites: None

Course Contents:

Unbalanced Operation of 3-phase Induction Motors: Characteristics with application of unbalanced voltage to a balanced motor and with application of balanced voltage to a motor having unbalanced impedances in the rotor circuit.

Synchronous Machines: Short circuit currents and reactances of synchronous machine. Modelling of synchronous machine at no load and symmetrical load under steady state conditions, Sequence impedance of synchronous machines.

Representation of transformers: Fixed tap setting transformer, tap changing under load transformers, Phase shifting transformers, algorithms for formation of bus admittance and impedance matrices.

Load Flow Studies: Formulation of load flow problem. Gause-Siedel, Newton-Raphson and Fast Decoupled Algorithms.

Short circuit studies. Sparsity exploitation in power system studies. Static equivalents for power systems.

Introduction to power system security. System state classification, Security analysis, Contingency analysis. State estimation in power systems.

Recommended Readings:

1. Computer methods in power system analysis by Stagg and El-Abiad

2. Symmetrical components by C.F. Wagner and R.D. Evans.

3. Power system analysis by Nagrath and Kothari.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: Department of Electrical Engineering

Course Code: EET-602

Course Name: POWER SYSTEM STABILITY

Credits: 3 L - 2 T - 1 P - 0 .

Course Type: Programme Core

Prerequisites: None

Course Contents:

Modelling of cylindrical rotor salient pole synchronous machines, flux linkage equations, voltage equations, Park's transformation, various inductances and time constraints of synchronous machines, vector diagrams for steady state and transient conditions, power angle curves.

Dynamic models of synchronous machines, excitation system, turbines, governors, loads. Modelling of single machine-infinite bus system. Mathematical modelling of multi machine system. Dynamic and transient stability analysis of single machine and multi-machine systems.

Coherency. Power system stabilizer. Direct method of transient stability analysis: Transient energy function approach. Voltage stability, P-V curves, Q-V curves, sensitivity and continuation method.

Recommended Readings:

1. Power System Analysis By Stagg and El-biad

2. Power System Stability By Kimbark

3. Power Systems By Nagrath and Kothari

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: Department of Electrical Engineering

Course Code: **EET-603**

Course Name: **ADVANCED POWER SYSTEM PROTECTION**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Programme Core

Prerequisites: None

Course Contents:

Protective Current & Potential Transformers: Types, Rating, Accuracy, burden, Polarity, connections and Transient Response.

Review of Electromagnetic Relays, relay terminology, basic protection schemes, overcurrent and directional overcurrent relays, distance relays, differential relays. Relay Coordination,

Static Relays: Basic elements, Functional circuits, Generalised theory of two input comparators, Amplitude and Phase comparators, Realization of different relays using comparators. Types of static comparators.

Protection of transmission lines power transformers, alternators, induction motors. Bus zone protection. Protection of reactors and capacitors. Digital protection, Digital relaying algorithms

Recommended Readings:

1. Power System Protection & Switchgear By B. Ram, McGraw Hill

2. Power System Protection- Static Relays By T.S.M. Rao Tata McGraw Hill

3. Digital Protection- Protective Relaying from Electromechanical to Microprocessor By L. P. Singh, New Age International

4. Power System Protection By Patra Basu & Choudhary, Oxford & IBH

5. Protective Relay, Their Theory & Practices Vol. 1 By A.R.C. Warrington, Chapman & Hall UK

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-604**

Course Name: **POWER SYSTEM OPTIMIZATION AND CONTROL**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Programme Core

Prerequisites: None

Course Contents:

Optimal Power System Operation: Optimal Operation of generators on a bus bar, Optimal Unit Commitment, Constraints in unit commitment, spinning reserve, Thermal Unit Constraints, Other constraints, Hydro constraints, Must Run, Fuel constraints, Unit commitment Solution methods: Priority-List methods, Dynamic Programming solution. Backward DP Approach, Forward DP Approach, Restricted Search Ranges, Strategies.

Reliability Considerations, Patton's Security Function, Security constrained Optimal Unit Commitment, Start-up considerations, Optimal Generation Scheduling, Representation of Transmission Loss by B-coefficients, Derivation of Transmission Loss formula. Representation of Transmission Loss by Power Flow equations, Optimal Load Flow solution. Optimal Scheduling of Hydrothermal System.

Automatic generation and Voltage Control: Introduction Load Frequency Control, Turbine Speed Governing System, Model of Speed governing system. Turbine Model, Generator Load Model, Block diagram representation of Load Frequency Control. Control Area, Load frequency control and Economic Dispatch Control, Two-area load frequency control, Optimal Load Frequency Control (two- area), Automatic Voltage Control, Introduction to Digital LF Controllers, Decentralized Control.

Recommended Readings:

1. Wood, A.J. and B.F. Wollenberg, Power Generation Operation and Control, John Wiley & Sons, Third Edition, 2013.
2. P. Kundur, Power system stability and control, McGraw-Hill, 1994.
3. A. Chakrabati and S. Halder, Power System Analysis Operation and Control, PHI, 2011
4. Jizhong Zhu, Optimization of Power System Operation, John Wiley & Sons, 2009.
5. D.P.Kothari and I.J.Nagrath, Modern Power System Analysis, Fourth Edition, TMH, 2011
6. Dhillon, Kothari, Power System Optimization, PHI.
7. O.E. Elgerd: Electric Energy Systems Theory, TMH Publishing Company.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-605**

Course Name: **POWER ELECTRONICS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Programme Core

Prerequisites: None

Course Contents:

Solid State Power Semi-conducting Devices: Review of the thyristors, traic, GTO, transistor MOSFET and other modem power devices (IGBT, SIT, SITCH, MCT), characteristics ratings, commutation methods, protection and requirement of firing circuits.

Phase Controlled Converters: Single and three-phase controlled converters, power factor improvement techniques. Dual Converter mode of operation, Firing Circuits.

Choppers: Review of choppers, commutation circuits, firing circuits. Introduction to multiquardant and multi-phase choppers.

Inverters and Cyclo-converters (Frequency Conversion): Line commutated, voltage source, and current source inverters; Commutation techniques, Voltage control and harmonic reduction techniques. PWM rectifiers and inverters. Single phase and three phases cyclo-converters. Power Electronics Controller for Wind Energy Electric Conversion Systems, Photo Voltaic Arrays, energy Saving in AC and DC Drives.

Power Factor Improvements, Extinction Angle, Symmetrical Angle. PWM Control and Sinusoidal PWM Control power techniques.

Recommended Readings:

1. Muhammad H. Rashid, Power Electronics: Circuits, Devices, and Applications, Pearson Education.
2. P. C. Sen, Power Electronics, Tata McGraw-Hill.
3. Mohan, Undeland, Robbins, Power Electronics: Converters, applications and design, Wiley
4. Robert W Erikson, Fundamentals of Power Electronics, Kluwer Academic Press.
5. M Ramamoorthy , Thyristors and their Applications , East West Press.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-611**

Course Name: **HVDC TRANSMISSION**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Rectification: The 3-phase Bridge rectifier or Graetz circuit, Inversion, Kinds of D.C links, Paralleled and Series connection of thyristors, Power flow in HVDC transmission system. Converter Station: Major components of a converter station-converter unit, filters, reactive power source. Ground return and ground electrode.

Basic principles of DC link control: Converter control characteristics, firing angle control and extinction angle control. Parallel operation of D.C. link with A.C. transmission line.

Introduction to Multiterminal HVDC Systems and HVDC Circuit Breakers, Comparison between AC and DC transmissions, break even distance for overhead transmission lines and underground cables. Application of HVDC transmission.

Recommended Readings:

1. K.R. Padiyar, HVDC Power Transmission System, Wiley Estern Limited.

2. E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-612**

Course Name: **FLEXIBLE AC TRANSMISSION SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Conventional reactive power compensation, Theory of Power Transmission Control, Basic principle of FACTS (Flexible AC Transmission System), Principle of Static VAr compensation (SVC). Basic Principle of Thyristor Controlled Series Compensation (TCSC) Basic series and shunt FACTS devices. Advance new generation FACTS devices, Control and coordination of FACTS devices, Locations of FACTS Devices.

Recommended Readings:

1. Understanding FACTS , N.G.Hingorani and L. Gyugyi, IEEE Press 2001
2. FACTS: Modelling and Control, X.P. Zhang, Cristian Rehlanz, Bikash Pal, Springer Publications.
3. FACTS, Y.H. Song, A Johns, IET Publications.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-613**

Course Name: **COMPUTER METHODS IN POWER SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Three-Phase Networks: Introduction, Three-phase network elements, Three-phase balanced network elements. Transformation Matrices, Three-phase unbalanced network elements, incidence and network matrices for three-phase networks. Algorithm for formation of threephase bus-

impedance matrix. Modification of the three-phase bus impedance matrix for changes in the network.

Short Circuit Studies: Short circuit calculations using Bus Impedance matrix, Short circuit calculations for balanced three- phase network using Bus Impedance matrix, Short circuit calculations using Loop Impedance matrix.

Sensitivity Analysis and Optimal Load Flow: Classification of System variables, Sensitivity Analysis-Sensitivity Matrix, Development of Gx and Gu, Optimal Load Flow, Optimisation Technique, Gradient method. Formulation of Optimal Load-flow Problem and its Solutions, Consideration of Inequality Constraints. Comparison with Classic Economic Dispatch Method. Security Concept and Contingency Evaluation: Operating States of a Power System, Concept of security Monitoring. Techniques for Contingency Evaluation DC Load Flow, Fast Decoupled Load-flow, Preventive and corrective Measures.

Load Forecasting & State Estimation: Estimation of average, periodic, stochastic components of load, basic idea of state estimation of power system.

Recommended Readings:

1. Computer Methods in Power System Analysis by G.W. Stagg, A.H. El-Abiad
2. Computer Techniques in Power System Analysis by M Pai, Chatterjee,2017
3. Computer Modelling of Electrical Power Systems, Second Edition, J Arrillaga N R Watson

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-614**

Course Name: **ADVANCED CIRCUIT ANALYSIS & DESIGN**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Network Topology: Network geometry, incidence matrix, tie-set matrix and loop currents, cutset matrix, and node pair potentials. Properties of cut-set and tie-set matrices, f–cutset Analysis, f-circuit Analysis, Node-pair Analysis. Duality, planner and non-planner networks. Branch parameters matrices. Kirchhoff's equilibrium equations on loop basic. Equilibrium equations on the node basis.

Network Functions: Network functions, evaluation of network function from (1) a given magnitude (2) a given angle and (3) a given real part; integral relationship between real and imaginary parts.

Elements of Realizability: Driving point functions, Brune's positive real functions, properties of positive real functions. Testing driving point functions an application of the maximum modulus theorem, properties of hurwitz polynomials, the computation of residues, even & odd functions, Sturm's theorem, An alternative test for positive real character. Driving point synthesis with LC elements: Elementary synthesis operations, LC Network Syunthesis. RC and RL Networks:

Properties of RC network functions, foster form of RC networks, faster form of RL networks. The Caur form of RC and RL networks, RLC one Terminal-Pairs: Minimum positive real functions. Brune’s method of RLC synthesis.

Attenuators and Equalizers: Symmetrical Bridge-Tand lattice attenuators, asymmetrical T and π attenuators. Equalizer configuration, four terminal equalizers, full -series, shunt and bridge-T and lattice equalizers.

Active RC filters: Realisable approximation to Ideal filter, constant time delay & Thompson filter, frequency transformation, Active RC filter, Multi amplifier Biquad realization. Fixed capacitor filter.

Computer Application: Network solution by matrix Inversion- Gauss Elimination Method, Computer Programme for plotting transient response, Computer Programme for finding roots of polynomial equations.

Recommended Readings:

1. Network Analysis and Synthesis by A.K. Chakraborty and S P Ghosh

2. Advanced Circuit Analysis and Design by H. Michael Thomas (Author),2014

3. Electronic Circuit Analysis and Design, by William H. Hayt (Author), G.W. Neudeck (Author), W.H. Hayt Jr. (Author),1989

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: Department of Electrical Engineering

Course Code: **EET-615**

Course Name: **POWER SYSTEM TRANSIENTS AND H.V. ENGINEERING**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Wave terminology, development of wave equations, terminal problems, lattice diagrams. Origin and nature of power system surges, wave shapes, attenuation, effect of shielding by ground wires and masts, tower footing-resistance. Traveling waves, multi-velocity waves, methods of measuring tower footing resistance, voltages across insulator strings. Dynamic overvoltages during surges and system faults, system recovery voltage characteristics.

Methods of neutral grounding and their effect on system behaviour. Insulation coordination, requirement in surge protection of lines and equipment.

Impulse generator development. Impulse testing technique. Power frequency H.V. transformers, cascade connection. H.V.D.C. generators, tests with power frequency and d.c. voltages. Large current generating and measurement techniques. Partial discharge testing. High voltage and high current testing of power equipment. Field investigations. Magnetic links their calibration and mounting, klydenographs, potential dividers and cathodes ray oscillograph.

Recommended Readings:

1. R. D. Begamudre, “Extra High Voltage AC Transmission Engineering” Wiley Eastern.
2. Fundamentals of High-Voltage Engineering by Ravindra Arora, Bharat Singh Rajpurohit
3. High Voltage Engineering, by C L Wadhwa, New Age International Publication
4. High Voltage Engineering Fundamentals, by E Kuffel, W.S. Zaengl, J. Kuffel
5. High Voltage Engineering, by M Naidu, V. Kamaraju

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-616**

Course Name: **INTEGRATED ENERGY SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Pattern of fuel consumption: Agricultural, domestic, industrial and community needs. Projection of Energy Demands, substitution of conventional sources by alternative sources and more efficient modern technologies. Potential of Solar, Wind, Biogas, Natural Gas, Forest produce, Tidal, Geothermal, Minihydro and other modern applications. Hybrid and Integrated Energy Systems. Total Energy concept and Waste heat utilization.

Recommended Readings:

1. S P Sukhatme, J K Nayak: Solar Energy, McGraw Hill.

2. D P Kothari and D K Sharma: Energy Engg.,S Chand & Co.

3. G D Rai: Non-Conventional Energy Sources, Khanna Publishers

4. R D Begamudre: Energy Conversion Systems, New Age

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-617**

Course Name: **POWER SYSTEM INSTRUMENTATION**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Control of voltage, frequency and tie-line power flows, Q-v and P-f control loops. Mechanism of real and reactive power control. Net interchange tie-line bias control. Optimal, sub-optimal and decentralised controllers. Discrete mode AGC. Time-error and inadvertent interchange correction techniques. Online computer control. Distributed digital control. Data acquisition systems. Emergency control, preventive control, system wide optimization, Introduction to PMUs and their placement. SCADA.

Recommended Readings:

1. Power System Engineering, by D.P. Kothari, I.J.Nagrath (Author)
2. Electrical Instrumentation by U.A. Bakshi, A.V. Bakshi, K.A. Bakshi, Technical Publication Pune.
3. C. L. Wadhawa “Electrical Power System” 6th edition, New Age International Publication Delhi.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: Department of Electrical Engineering

Course Code: **EET-618**

Course Name: **POWER SYSTEM PLANNING & RELIABILITY**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Load forecasting: Classification and characteristics of loads. Approaches to load forecasting. Forecasting methodology. Energy forecasting.

Basic Reliability Concepts: General reliability function, Markov Chains and processes and their applications, simple series and parallel system models.

Static Generating Capacity Reliability Evaluation: Outage definitions, loss of load probability methods, loss of energy probability method. Frequency and duration methods, load forecasting uncertainty.

Spinning Generating Capacity Reliability Evaluation: Spinning capacity evaluation, load forecast uncertainty.

Transmission System Reliability Evaluation: Average interruption rate method. The frequency and duration method. Stormy and normal weather effects.

Inter-connected Systems Generating Capacity Reliability Evaluation: Introduction, The loss of toad approach.

Reliability evaluation in two and more than two interconnected systems. Interconnection benefits.

Recommended Readings:

1. J. Endrenyi, “Reliability modelling in Electric Power System”, John Wiley, 1980.
2. David Elmakias, “New Computational Methods in Power System Reliability”, Springer-Verlag, 2008.
3. Ali Chowdhury, Don Koval, “Power Distribution System Reliability: Practical Methods and
4. Applications”, Wiley-IEEE Press, 2009.
5. Richard E. Brown, “Electric Power Distribution Reliability”, CRC Press, 2002.
6. R. L. Sullivan, “Power System Planning”, Heber Hill, 1987.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-619**

Course Name: **EHV AC/DC TRANSMISSION SYSTEM**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Bulk power transmission over long distance, need for EHV transmission problems of EHV transmission, Power Handling capacity and surge impedance loading. Current carrying capacity of conductor. Choice of economic voltage, standard transmission voltages.

Bundled Conductors: Properties of bundled conductors, geometric mean radius of bundle, inductance and capacitance, Voltage gradients of conductors, maximum surface voltage gradients of bundled conductors, maximum surface electric fields for bundled and single conductor lines. Electrostatic fields of EHV lines. Effect of E.S. field on Humans, Animals and Plants.

Series and Shunt compensation: Effect of series capacitors, location of series capacitors. Subsynchronous resonance in series-capacitor compensated lines and counter measures. Shunt compensation - Variation of no load receiving end voltage, Static VAR Systems: TCR-FC, TCR, TSC-TCR and MSC-TCR Schemes.

Recommended Readings:

1. C. L. Wadhawa “Electrical Power System” 6th edition, New Age International Publication Delhi.
2. B. R. Gupta “Power Systems Analysis & Design” S. Chand & Company Pvt.
3. R. D. Begamudre, “Extra High Voltage AC Transmission Engineering” Wiley Eastern.
4. Sanjay Kumar Sharma, EHV-AC, HVDC Transmission and Distribution Engineering, S K Kataria& Sons, First Edition, 2013
5. S. Rao, “EHV-AC and H.V.D.C. Transmission Engineering Practice”, Khanna publishers, 1990.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-620**

Course Name: **ECONOMICS & PLANNING OF ENERGY SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

System Economics: Basic concepts, National accounting framework. Criteria for economic growth. Model types and philosophy. Production functions. Input-output economics, macroeconomic growth models. "Econometric" models, policy options and budgetary Implication, some illustrations of economic research for identifying demand functions, supply functions, cost functions, production functions, utility functions and Engel curves. Dynamic models of the economy and "Simple" theory of business fluctuations. Multiple linear and non-linear regression analysis, energy per unit monetary value of consumer needs and services. Energy efficiency, Cost-benefit risk analysis. Environmental repercussions and the economic structure. Conflict between energy consumption and pollution. Systems Design and quantitative economic policy with particular references to energy. Econometric in the context of multiple objectives, conflicting goals and decisions under uncertainty.

Recommended Readings:

1. R. L. Sullivan, “Power System Planning”, Heber Hill, 1987.
2. David Elmakias, “New Computational Methods in Power System Reliability”, Springer-Verlag, 2008.
3. Reliability and Risk Evaluation of Wind Integrated Power Systems (Reliable and Sustainable Electric Power and Energy Systems Management) by Roy Billinton, Rajesh Karki, Springer

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-622**

Course Name: **ADVANCES IN POWER TRANSMISSION & DISTRIBUTION**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Basic theory of line compensation. FACTS devices, The FACTS optimisation problem. Transient and dynamic stability enhancement using FACTS components. Concepts of modern grid.

Introduction to distribution automation, Layout of substations and feeders, Optimum siting and sizing of substations Distribution system load flow, configuration of distribution system, optimum capacitor placement. Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system monitoring and control: SCADA, Concept of modern distribution systems.

Recommended Readings:

1. Rakesh Das Begmudre, Extra High Voltage AC Transmission Engineering, Wiley Estern Limited.
2. K.R. Padiyar, HVDC Power Transmission System, Wiley Eastern Limited.
3. E.W. Kimbark. EHV-AC and HVDC Transmission Engineering & Practice, Khanna Publishers.
4. Math H. J. Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions, Wiley- IEEE Press.
5. Flexible Ac Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication
6. Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, Narain G. Hingorani, Laszlo Gyugyi .

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-624**

Course Name: **AI APPLICATION TO POWER SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Introduction to AI: Definition, Applications, Components of an AI program; production system.

Problem Characteristics. Overview of searching techniques. Knowledge representation: Knowledge representation issues; and overview. Representing knowledge using rules; procedural versus declarative knowledge. Logic programming, forward versus backward reasoning, matching. Control knowledge.

Statistical Reasoning: Probability and Daye's theorem. Certainty factor and rule based systems. Baysian Networks, Dampster Shafer theorem. Semantic nets and frames, Scripts. Examples of knowledge based systems.

Pattern Recognition: Introduction, automatic pattern recognition scheme. Design Concepts, Methodologies, Concepts of Classifier, concept of feature selection. Feature selection based on means and covariances. Statistical classifier design algorithms; increment-correction and LMSE algorithms. Applications.

Artificial Neural Networks: Biological Neuron, Neural Net, use of neural 'nets, applications, Perception, idea of single layer and multilayer neural nets, back propagation, Hopfield nets, supervised and unsupervised learning.

Expert Systems: Introduction. Study of some popular expert systems, Expert System building tools and Shells, Design of Expert Systems.

Recommended Readings:

1. Artificial Intelligence Techniques in Power Systems (Energy Engineering), by Kevin Warwick, Arthur Ekwue, Rag Aggarwal,1997
2. AI Application Areas in Power Systems, Iraj Dabbaghchi, American Electric Power Richard D. Christie, Gary W. Rosenwald, and Chen-Ching Liu, University of Washington

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-635**

Course Name: **ELECTRIC DRIVES AND THEIR CONTROL**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Characteristics of Electric Motors: Characteristics of DC motors, 3-phase Induction motors and Synchronous motors. Starting and Breaking of Electric motors. Status of DC and AC Drives.

Dynamics of Electric Drives: Parts of electric drives electric motors, power modulators, sources, control unit, and mechanical system. Fundamental torque equations. Multiquadrant operation. Equivalent values of drive parameters-loads with rotational motion and translational motion, components of load torque, nature and classification of load torques. Dynamic conditions of a drive system. Energy loss in transient operations, load equalization.

Motor Power Rating: Power losses of motors, heating and cooling of electric motors. Thermal model of motor for heating and cooling, classes of motor duty, Determination of motor rating, continuous duty, short time duty and intermittent periodic duty. Equivalent current, torque and power for fluctuating and inter- mittent loads.

Control of electric Drives: Modes of operation. Closed-loop control of drives. Current-limit control. Closed-loop torque, and speed control. Closed-loop control of multi motor drives. Speed and current sensing. Phase-locked-loop control.

DC Motor Drives: Starting, Braking, and speed control Transient Analysis of separately excited motor with armature and field control, energy losses during transient operation. Phase controlled converter DC drives, dual-converter control of DC drive, power factor, supply harmonics and ripple in motor current. Chopper control DC drives. Source Current harmonics.

3-Phase Induction Motor Drives: Starting, Breaking and Transient Analysis. Calculation of energy losses. Speed Control, Staler Voltage control. Variable Frequency control from voltage and current sources, Slip power recovery-Static Scherbius and Cramer Drives.

Synchronous Motor Drives: Starting, Pull in and Braking of Synchronous motor. Speed control variable frequency control, cycloconverter control.

Brushless DC Motor, Linear Induction Motor, Stepper Motor and Switched Reluctance Motor Drives: Important Features and applications.

Energy Conservation in Electrical Drives: Losses in electrical drive system. Measures for energy conservation in electric drives. Use of efficient motor. Energy efficient operation of drives.

Improvement of power factor and quality of supply.

Recommended Readings:

1. Fundamental of Electrical Drives, G.K. Dubey, New Age International Publication.
2. Electric Drives, Vedam Subrahmanyam, TMH
3. A first course on Electrical Drives, S.K. Pillai, , New Age International Publication.
4. Electric motor Drives, R. Krishnan, Pearson Education.
5. Modern power Electronics and AC drives, Bimal K Bose, PHI

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-642**

Course Name: **MODERN CONTROL THEORY**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Discrete Time Systems and the Z-Transform Method: Sampled Data Control Systems, Digital Controller, Sample & Hold Operation, Frequency consideration in Sampling and Reconstruction. Z-transformation, Solution of Differential & State Equations by 'Z' Transform Method, The Inverse Z-Transform, Pulse Transfer Function and Stability in Z-plane.

Transform Design of Digital Controls & State Space Concepts: Design Specifications, Design on the 'W'-plane, 'W plane & 'Z' plane. The CAYLEY HAMILTON Theorem, Concepts of

Controllability & Observability. Stochastic Optimal State Estimation & Stochastic Processes. Stability: Generalized Stability Creterion (d-partition technique), Pole Assignment method, LIAPUNOV's method, LURE's transformation, POPOV's criterion.

Microprocessor Based Control Systems: Digital Quantization, Positional Control System, Temperature Control System, Stepper Motor Drive circuits and Control of a Manipulator Arm.

Optimization: Time Optimal System (without proof of control law), Calculation of Switching Trajectories for second order systems. Optimal Control System based on Quadratic performance Indices (proof through Liapunov's function), Basic concepts of Model Reference Control System and Adaptive System.

Pontryagin's maximum principle, constrained and unconstrained input, Dynamic Programming optimality principle, Discrete and Continuous Dynamic Programming.

Recommended Readings:

1. Modern Control Theory, 3rd Edition by William L Brogan
2. Modern Control System Theory, by Madan Gopal (Author), New Edge publications
3. Modern control theory By U.A.Bakshi, M.V.Bakshi , Technical Publications Pune

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-647**

Course Name: **MODELING & SIMULATION OF POWER ELECTRONIC SYSTEMS**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Modelling of Power Electronic Converters: Modelling of semiconductor devices, Switch realization– single quadrant and two quadrant switches, switching losses

Review of DC-DC converters: Steady-state analysis of converter in continuous and discontinuous modes (CCM & DCM), and estimation of converter efficiency, Development of circuit model for simulating dynamic operating conditions in CCM & DCM, Feedback control for converters

Controller design Dynamic Modelling of Electrical Machines: Modelling of DC machines, Modelling of three phase Induction machine, Reference frame theory – ARF, RRF, SYRF, SRF,

equations of transformation, voltage equations, torque equations, analysis of steady-state operation, acceleration characteristics, effect of loading and operation with non-sinusoidal voltages

Choice of simulators: Power Electronic Circuit simulation using PSPICE, Analysis of Dynamic behaviour of Electrical Machines using MATLAB/SIMULINK.

Recommended Readings:

1. R.W. Erickson, Dragan Maksimovic, Fundamentals of Power Electronics (2 e), Springer, 2005.
2. P.C. Krause, O. Wasynczuk, S.D. Sudhoff, Analysis of Electrical Machinery & Derive Systems (2e), Wiley Student Edition, 2002.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre: **Department of Electrical Engineering**

Course Code: **EET-656**

Course Name: **EXCITATION OF SYNCHRONOUS MACHINES AND THEIR CONTROL**

Credits: **3 L - 2 T - 1 P - 0 .**

Course Type: Professional Elective

Prerequisites: None

Course Contents:

Excitation Systems: Principal Controls of a generating unit. Arrangement of excitation components, voltage response-ratio. Excitation specifications. Ceiling voltage, time constant and response of excitation systems. Requirements of excitation systems: Classification of excitation systems.

D.C. Excitation Systems: configuration of DC excitation system with main and pilot exciters.

Amplidyne and magnetic amplifier. Automatic voltage regulator with magnetic amplifier and Amplidyne. Limitation and problems of DC excitation systems. Improvement in DC excitation system.

AC Shunt Excitation Systems (Static Rectifier Excitation Systems): Static thyristor rectifier schemes. Transient Response during fault condition. Use of booster transformer. Application for shunt excitation systems.

AC Separately Excitation Systems. (Alternator- Rectifier Excitation System): Scheme of alternator-rectifier excitation system with (i) diode rectifier and (ii) thyristor rectifier. Comparison and Application of these schemes. Harmful effects of static excitation systems or system machine components, means of prevention.

Brushless Excitation Systems: Brush-slip ring problem. Scheme of Brushless excitation system with rotating diode. Control, protection and monitoring of Brushless excitation system.

Introduction to brushless excitation system with rotating thyristors.

Introduction to Superconducting Exciter.

Automatic Voltage Regulator (AVR): Solid state automatic voltage regulator scheme. Auto and manual follow-up. Thyristor converter and AVR protection. Introduction to Digital AVR.

Excitation Control: Introduction to power stabilizing signal-speed, frequency and power signals. Rotor current limiter, MVAR limiter. Effect of excitation on generator power limits, Dynamic and Transient stabilities.

Recommended Readings:

1. Steam Turbine Generator Excitation System and Application by Li Ji Cheng.
2. Steam Turbine Generator Excitation System Modernization by Schaefer R C, Basler Electric Co; Highland, IL, USA
3. Published literature on all types of excitation systems for Synchronous Generators in AIEE and IEEE, USA.