Scheme & Syllabus of M. Tech. (Power Systems)
MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF ELECTRICAL ENGINEERING

Proposed structure of new scheme as per R &R manual of PG Programmes
in Power Systems

M. Tech. Programme Structure for Full Time

<table>
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<th>Semester</th>
<th>Courses</th>
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M.Tech. Programme Structure for Part Time

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### Programme Core

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EES-701 Seminar  
EED-702 Dissertation  
EED-703 Dissertation

### Professional Elective (PE-1 to PE-4)

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### Professional Elective (PE-5 & PE-6): To be offered by other Programs and Departments

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DETAILED SYLLABUS

PROGRAMME CORE

EET-601: POWER SYSTEM ANALYSIS  
Credit: 3 (2 1 0)

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.


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

Text Books/Reference Material:

1. Computer methods in power system analysis by Stagg and El-Abiad
3. Power system analysis by Nagrath and Kothari.

EET-602: POWER SYSTEM STABILITY  
Credit: 3 (2 1 0)

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.


**Text Books/Reference Material:**

1. Power System Analysis By Stagg and El-biad
2. Power System Stability By Kimbark
3. Power Systems By Nagrath and Kothari

**EET-603: ADVANCED POWER SYSTEM PROTECTION**

Credit: 3 (2 1 0)

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,


**Text Books/Reference Material:**

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

**EET-604: POWER ELECTRONICS**

Credit: 3 (2 1 0)

Solid State Power Semi-conducting Devices: Review of the thyristors, traic, GTO, transistor MOSFET and other modern 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.

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.

**Text Books/Reference Material:**

3. Mohan, Undeland, Robbins, Power Electronics: Converters, applications and design, Wiley

**EET-605: POWER SYSTEM OPTIMIZATION AND CONTROL**  
Credit: 3 (2 1 0)


PROFESSIONAL ELECTIVE

EET-610: EHV AC TRANSMISSION Credit: 3 (2 1 0)

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.


Text Books/Reference Material:


EET-611: COMPUTER METHODS IN POWER SYSTEMS Credit: 3 (2 1 0)

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


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

**Text Books/Reference Material:**

2. Computer Techniques in Power System Analysis by M Pai (Author), Chatterjee (Author), 2017

**EET-612: POWER SYSTEM PLANNING & RELIABILITY**


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


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

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

Text Books/Reference Material:


EET-613: POWER SYSTEM TRANSIENTS AND HIGH VOLTAGE ENGINEERING  
Credit: 3 (2 1 0)

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.

Text Books/Reference Material:

2. Fundamentals of High-Voltage Engineering by Ravindra Arora (Author), Bharat Singh Rajpurohit
3. High Voltage Engineering, by C L Wadhwa (Author) New Age International Publication
4. High Voltage Engineering Fundamentals, by E Kuffel (Author), W.S. Zaengl, J. Kuffel
5. High Voltage Engineering, by M Naidu (Author), V. Kamaraju (Author)
EET-614: ECONOMICS & PLANNING OF ENERGY SYSTEMS       Credit: 3 (2 1 0)
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.

Text Books/Reference Material:
    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

EET-615: FLEXIBLE AC TRANSMISSION SYSTEM       Credit: 3 (2 1 0)
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.

Text Books/Reference Material:
EET-616: INTEGRATED ENERGY SYSTEMS  
Credit: 3 (2 1 0)


Text Books/Reference Material:


EET-617: ADVANCED CIRCUIT ANALYSIS & DESIGN  
Credit: 3 (2 1 0)


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:


Attenuators and Equalizers: Symmetrical Bridge-Tand lattice attenuators, asymmetrical T and □ 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.


Text Books/Reference Material:

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

EET-618: MODERN CONTROL THEORY        Credit: 3 (2 1 0)


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.
Text Books/Reference Material:

1. Modern Control Theory, 3rd Edition by William L Brogan
2. Modern Control System Theory, by Madan Gopal (Author), New Edge publications

EET-619 POWER SYSTEM INSTRUMENTATION   Credit: 3 (2 1 0)

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.

Text Books/Reference Material:

1. Power System Engineering, by D.P. Kothari, I.J.Nagrath (Author)

EET-620: ADVANCED THEORY AND ANALYSIS OF AC MACHINES   Credit: 3 (2 1 0)


Text Books/Reference Material:

5. The General Theory of Alternating Current Machines Application to Practical Problems Authors: Adkins, Bernard, Harley, Ronald G.

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 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.


Introduction to brushless excitation system with rotating thyristors.

Introduction to Superconducting Exciter.


Text Books/Reference Material:

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.

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.


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.


Improvement of power factor and quality of supply.
Text Books/Reference Material:
2. Electric Drives, Vedam Subrahmanyam, TMH
4. Electric motor Drives, R. Krishnan, Pearson Education.
5. Modern power Electronics and AC drives, Bimal K Bose, PHI

EET-624: AI APPLICATIONS TO POWER SYSTEMS       Credit: 3 (2 1 0)
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.

Bayesian 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.

and Shells, Design of Expert Systems.

Text Books/Reference Material:
1. Artificial Intelligence Techniques in Power Systems (Energy Engineering), by Kevin Warwick (Editor),
   Arthur Ekwue (Editor), Rag Aggarwal (Editor), 1997
2. Artificial Intelligence Techniques in Power Systems Edited by Kevin Warwick, Arthur Ekwue, Rag
   Aggarwal
3. AI Application Areas in Power Systems, Iraj Dabbaghchi, American Electric Power Richard D.
   Christie, Gary W. Rosenwald, and Chen-Ching Liu, University of Washington
EET-625: HVDC TRANSMISSION  
Credit: 3 (2 1 0)  
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.  

Text Books/Reference Material:  

EET-634: ADVANCES IN POWER TRANSMISSION & DISTRIBUTION  
Credit: 3 (2 1 0)  

Text Books/Reference Material:  
5. Flexible Ac Transmission Systems, Yong-Hua Song, Allan T. Johns, IEE publication  
EET-635: APPLICATIONS OF POWER ELECTRONICS IN POWER SYSTEMS
Credit: 3 (2 1 0)

Steady state and dynamic problems in AC systems: Flexible AC transmission systems (FACTS), Principles of series and shunt compensation, Description of static var compensators (SVC), Thyristor Controlled series compensators (TCSC), Static phase shifters (SPS), Static condenser (STATCON), Static synchronous series compensator (SSSC) and Unified power flow controller (UPFC),

Modelling and Analysis of FACTS controllers: Control strategies to improve system stability, Power Quality problems in distribution systems

Harmonics: Harmonics creating loads, modelling, harmonic propagation, Series and parallel resonances, harmonic power flow, Mitigation of harmonics, filters, passive filters, Active filters, shunt, series hybrid filters, voltage sags & swells, voltage flicker, Mitigation of power quality problems using power electronic conditioners, IEEE standards, HVDC Converters and their characteristics, Control of the converters (CC and CEA), Parallel and series operation of converters.

Text Books/Reference Material:


EET-636: MODELLING & SIMULATION OF POWER ELECTRONIC SYSTEMS
Credit: 3 (2 1 0)

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.

Text Books/Reference Material:


EET-638: POWER SYSTEM QUALITY Credit: 3 (2 1 0)

Power quality: concepts and definition, Power quality and voltage quality, Power quality standards, General classes of power quality problems, CBEMA and ITI Curves, Power quality terms, Power frequency variations

Long-duration voltage variations, Short-duration voltage variations, Voltage imbalance, Waveform distortion, Voltage sags and interruptions, sources of sags and interruptions Estimating voltage sag performance, Sensitivity of Equipments to voltage sag.

Transients: origin and classifications, capacitor switching transient, lightning-load switching, impact on users, protection, mitigation.

Power system harmonics: harmonics, inter-harmonics, sub-harmonics, Difference between harmonics and transients, voltage and current distortion, harmonic indexes, sources of harmonic distortion, effects of harmonic distortion, mitigation and control techniques, harmonic filters.

Power quality conditioners: shunt and series compensators, DSTATCOM-Dynamic voltage restorer, unified power quality conditioners-case studies

Text Books/Reference Material:

3. C. Sankaran, “Power Quality” CRC Press