M.Tech. Programme

in

POWER SYSTEMS

SYLLABUS

FOR

CREDIT BASED CURRICULUM

(Applicable for 2011 batch onwards)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI
The total minimum credits required for completing the M.Tech. Programme in Power Systems is 62

**SEMESTER – I**

<table>
<thead>
<tr>
<th>CODE</th>
<th>COURSE OF STUDY</th>
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**SEMESTER III**
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For the elective courses, a student may take a maximum of two courses from other Post Graduate programs.

### ELECTIVES

**Group I elective subjects recommended for 1st semester**

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Any one course from other department

**Group II elective subjects recommended for 2nd semester**

- EE612 Power Electronic Drives  
- EE614 Digital Controllers in Power Electronics Applications  
- EE616 Computer Networking  
- EE618 Electrical Distribution Systems  
- EE620 Fuzzy Systems

Or any one course from other department

**LIST OF RESERVE ELECTIVES**

From year to year, the departmental electives listed under group 1 & group 2 elective subjects may be replaced by suitable courses from the following list depending upon the interest of the majority of the students.

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M.Tech. Programme

in

POWER SYSTEMS

MA603 - OPTIMIZATION TECHNIQUES

Linear programming – formulation– Graphical and simplex methods-Big-M method-Two phase method-Dual simplex method-
Primal Dual problems.

Unconstrained one dimensional optimization techniques – Necessary and sufficient conditions – Unrestricted search methods-
Fibonacci and golden section method-Quadratic Interpolation methods, cubic interpolation and direct root methods.

Unconstrained n dimensional optimization techniques – direct search methods – Random search – pattern search and Rosen
brooch’s hill claiming method- Descent methods-Steepest descent, conjugate gradient, quasi -Newton method.

Constrained optimization Techniques- Necessary and sufficient conditions – Equality and inequality constraints-Kuhn-Tucker
conditions-Gradient projection method-cutting plane method- penalty function method .

Dynamic programming- principle of optimality- recursive equation approach-application to shortest route, cargo-loading,
allocation and production schedule problems.


EE602 – POWER SYSTEM OPERATION AND CONTROL


Automatic generation control -Review of LFC and Economic Dispatch control (EDC) using the three modes of control viz. Flat frequency – tie-line control and tie-line bias control – AGC implementation – AGC features - static and dynamic response of controlled two area system

MVAR control - Application of voltage regulator – synchronous condenser – transformer taps – static VAR compensators


EE603 – POWER CONVERSION TECHNIQUES

DC-DC converters-Buck converter, boost converter, buck-boost converter, averaged circuit modeling, input-output equations, ripple calculations, filter design

DC-AC inverters -Single phase VSI, Three phase VSI, Single phase CSI, Three phase CSI, voltage control and harmonic reduction in inverters-standard PWM techniques.

AC-DC converters- Uncontrolled (Diode rectifier), single and three phase fully controlled (SCR-line commutated) and semicontrolled converters, continuous current conduction, discontinuous current conduction, Reactive compensation, Harmonic compensation techniques.

AC-AC converters-single phase and three phase circuits employing Phase angle control, on-off control. AC choppers.

Loss calculations and thermal management: Device models for loss calculations, ratings, safe operating areas, data sheets, forward conduction loss, switching losses, heat sink design, snubber design drive and protection circuits, commutation circuits, Soft switching.


EE604 – HIGH VOLTAGE DC TRANSMISSION


Thyristor converter circuits -Analysis with and without overlap in converters - basic means of control- inverter operation of converters-power reversal-desired features of control-actual control characteristics

Basic methods of control-constant ignition angle control, Constant current control and constant extinction advance angle control – power control – high level controllers. Converter faults-misfire, arc through, commutation failure-D.C. Reactors-voltage and current oscillations-Circuit breakers, over voltage and over current protection.

Characteristic and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-active and passive filters. Reactive power control of converters.

Interaction between ac and dc systems- converter transformers-earth electrodes-Basics of VSC based HVDC transmission systems-Introduction to multiterminal HVDC systems and Hybrid HVDC systems - design of back to back thyristor converter system.


**EE06 - FLEXIBLE AC TRANSMISSION SYSTEMS**

Fundamentals of ac power transmission, transmission problems and needs, emergence of FACTS-FACTS control considerations, FACTS controllers.

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

Principles of static series compensation using GCSC, TCSC and TSSC, applications, Static Synchronous Series Compensator (SSSC).

Principles of operation-Steady state model and characteristics of a static voltage regulators and phase shifters- power circuit configurations.

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

1. Load flow studies.
2. Short circuit studies.
3. Transient stability studies.
4. Simulation of IGBT inverters.
5. Simulation of thyristor converters.
6. Economic Load Dispatch with thermal power plants.
7. Economic Load Dispatch with Hydro thermal power plants.
8. Simulation of Facts controllers
10. Load forecasting and unit commitment.

Software ETAP/ MiPOWER / MATLAB / LABVIEW will be used.
**ELECTIVES**

**EE611 – INDUSTRIAL CONTROL ELECTRONICS**

Review of switching regulators and switch mode power supplies-Uninterrupted power supplies- OFF-LINE AND ON-LINE TOPOLOGIES-Analysis of UPS topologies-solid state circuit breakers-solid-state tap-changing of transformer

Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, derivative overrun, integral windup-cascaded control-Feedforward control-Digital control schemes- control algorithms-programmable logic controllers

Signal conditioners-Instrumentation amplifiers – voltage to current, current to voltage, voltage to frequency, frequency to voltage converters ; Isolation circuits – cabling; magnetic and electro static shielding and grounding.

Opto-Electronic devices and control , electronic circuits for photo-electric switches-output signals for photo-electric controls; Applications of opto-isolation, interrupter modules and photo sensors – Fiber optics – Bar code equipment, application of barcode in industry.

Stepper motors – types, operation, control and applications; servo motors- types, operation, control and applications – servo motor controllers – servo amplifiers – linear motor applications-selection of servo motor.


EE612 - POWER ELECTRONIC DRIVES


Conventional methods of DC motor speed control, single phase and three phase converter fed D.C motor drive. Power factor improvement techniques, four quadrant operation.

Chopper fed drives, input filter design. Step-up chopper for photovoltaic systems. Braking and speed reversal of DC motor drives using choppers, multiphase choppers.


Speed control of synchronous motors, field oriented control, load commutated inverter drives, switched reluctance motors and permanent magnet motor drives.

EE613- SYSTEM THEORY

Introduction to state space modeling, modeling of physical systems. Solution to vector differential equations and state transition matrix.

Controllability and Observability definitions and Kalman rank conditions. Detectability and Stabilizability, Kalman decomposition.

Introduction to nonlinear systems. Phase plane analysis of nonlinear system using linear approximation. Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behavior near singular points.

Stability of nonlinear systems. Lyapunov direct and indirect methods. Input to state stability. Various methods to check the stability of nonlinear systems.

State feedback controller design using pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design.

EE614 DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS


Pin Multiplexing (MUX) and General Purpose I/O Overview, Multiplexing and General Purpose I/O Control Registers. Introduction to Interrupts, Interrupt Hierarchy, Interrupt Control Registers, Initializing and Servicing Interrupts in Software.

ADC Overview, Operation of the ADC in the DSP, Overview of the Event manager (EV), Event Manager Interrupts, General Purpose (GP) Timers, Compare Units, Capture Units And Quadrature Enclosed Pulse (QEP) Circuitry, General Event Manager Information

Introduction to Field Programmable Gate Arrays – CPLD Vs FPGA – Types of FPGA, Xilinx XC3000 series, Configurable logic Blocks (CLB), Input/Output Block (IOB) – Programmable Interconnect Point (PIP) – Xilinx 4000 series – HDL programming – overview of Spartan 3E and Virtex II pro FPGA boards– case study.

Controlled Rectifier, Switched Mode Power Converters, PWM Inverters, DC motor control, Induction Motor Control

2. XC 3000 series datasheets (version 3.1). Xilinx,Inc.,USA, 1998
3. XC 4000 series datasheets (version 1.6). Xilinx,Inc.,USA, 1999
4. Wayne Wolf,” FPGA based system design “, Prentice hall, 2004
Pattern classification – Learning and generalisation-structure of neural networks – ADA line and Mada line-perceptrons.


Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis, Self organizing maps.

Applications of neural algorithms and systems -Character recognition networks, Neural network control application, connectionist expert systems for medical diagnosis.

EE616 COMPUTER NETWORKING


Data link layer - design issues, Data link protocols. Medium access sub layer - channel allocations, Multiple Access protocols, IEEE protocols.

Network layer - Design issues, routing algorithms, congestion control algorithms, QoS, Transport layer- Design issues, Connection management.

Application layer – DNs, Electronic mail, World Wide Web, multimedia, Cryptography,

Internet transport protocols - TCP and UDP


Discrete-Time Signals- Shannon’s sampling theorem- Difference equation description- characteristics of digital filters and time
domain analysis- properties of discrete time system (linearity, time-variance, convolution)- BIBO stability- Z-transformation and
their application in solving difference equations- Relationship between Laplace and Z-transforms.

Discrete Time Fourier Transform (DTFT) and Discrete Fourier Transform (DFT)- Periodic convolution- Direct evaluation of
DFT, FFT algorithms decimation in time and frequency, Relationship between Fourier and Z-transforms.

Direct form I&II- cascade- parallel and ladder realizations. Filter Function Approximations and Transformations-Review of
approximations of ideal analog filter response- Butterworth filter- Chebyshev Type I & II-Frequency transformation in analog
domain- frequency transformation in digital domain.

Design based on analog filter approximations- Impulse invariance Method- Matched Z-transformation-Bilinear transformation-
comparison of FIR and IIR filters.

Symmetric and antisymmetric FIR filters- design of linear phase FIR filters using windows and frequency – sampling methods-
design of optimum equiripple linear phase FIR filters. Introduction to Multirate signal processing-Introduction to STFT and WT.

   India, 2006.

Distribution system, reliability analysis – reliability concepts – Markov model – distribution network reliability – reliability performance-

Distribution system expansion -planning – load characteristics – load forecasting – design concepts – optimal location of sub station – design of radial lines – solution technique.

Voltage control – Application of shunt capacitance for loss reduction – Harmonics in the system – static VAR systems –loss reduction and voltage improvement.

System protection – requirement – fuses and section analyzers-over current. Under voltage and under frequency protection – coordination of protective device.

EE619 - DIGITAL SYSTEM DESIGN

Review of sequential circuits, Mealy & Moore Models, Analysis & Synthesis of Synchronous sequential circuits

Digital system design Hierarchy, ASM charts, Hardware description language, Control logic Design Reduction of state tables, State Assignments.

Analysis and synthesis of Asynchronous sequential circuits, critical and non-critical races, Essential Hazard

Combinational and sequential circuit design with PLD’s, Introduction to CPLD’s & FPGA’s.

Fault classes and models – Stuck at faults, Bridging faults, Transition and Intermittent faults. Fault Diagnosis of combination circuits by conventional methods- Path sensitization technique, Boolean different method and Kohavi algorithm.

1. Digital principles and design – Donald D.Givone
3. Digital circuits and logic design – Samuel C.Lee, PHI.
4. Logic Design Theory – N.N.Biswas, PHI.
EE620 - FUZZY SYSTEMS


Fuzzy sets and crisp sets - Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets

Fuzzy reasoning - Linguistic variables, Fuzzy propositions, Fuzzy compositional rules of inference- Methods of decompositions, defuzzification

Methodology of fuzzy design - Direct & Indirect methods with single and multiple experts, Adaptive fuzzy control, Rule base design using dynamic response.

Fuzzy logic applications to engineering, Fuzzy decision making, Neuro-Fuzzy systems, Fuzzy Genetic Algorithms.

RESERVE ELECTIVES

EE621 - TRANSIENT OVER VOLTAGES IN POWER SYSTEMS

Transients in electric power systems – Internal and external causes of over voltages-- Lightning strokes – Mathematical model to represent lightning, Travelling waves in transmission lines – Circuits with distributed constants – Wave equations – Reflection and refraction of travelling waves – Travelling waves at different line terminations.

Switching transients – double frequency transients – abnormal switching transients – Transients in switching a three phase reactor-three phase capacitor.

voltage distribution in transformer winding – voltage surges-transformers – generators and motors, Transient parameter values for transformers, reactors, generators and transmission lines.

Basic ideas about protection – surge diverters-surge absorbers- protection of lines and stations Modern lighting arrestors, Insulation coordination, Protection of alternators and industrial drive systems.

Generation of high AC and DC-impulse voltages, currents-measurement using sphere gaps-peak voltimeters-potential dividers and CRO.

EE622- STOCHASTIC MODELS AND APPLICATIONS

Probability Spaces- Discrete probability distributions, Continuous probability densities, Conditional probability, distribution and densities. Distribution functions, Multiple random variables and joint distributions.

Expectations, moments, Characteristic functions and moments generating functions, sequence of random variables and Convergence Concepts.

Law of large numbers – Discrete and continuous random variables; Central limit theorem – Bernoulli trials, Discrete and continuous independent trials.


Poisson processes – Exponential distribution and applications; Birth-death processes and applications.

Basic characteristics of sunlight – solar energy resource – photovoltaic cell-characteristics – equivalent circuit – photo voltaic for battery charging.

Wind source – wind statistics - energy in the wind – aerodynamics - rotor types – forces developed by blades-Aerodynamic models – braking systems – tower - control and monitoring system – power performance


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

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

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

EE625- ADVANCED POWER SYSTEM PROTECTION

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

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

Bus bar protection, line protection, distance protection–long EHV line protection, Power line carrier protection.

Reactor protection–Protection of boosters-capacitors in an interconnected power system.

Digital signal processing –digital filtering in protection relays- numeric protection –testing digital filtering in protection relays –

EE626 - MODELING AND ANALYSIS OF ELECTRICAL MACHINES

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

Basic Concepts of Rotating Machines - Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames


Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self controlled operation; Analysis of Switch Reluctance Motors.

EE627 POWER QUALITY

Electric power quality phenomena- IEC and IEEE definitions - power quality disturbances- voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations.


Use of microcontrollers for pulse generation in power converters—overview of zero crossing detectors—typical firing/gate—drive circuits—firing/gate pulses for typical single phase and three phase power converters—PIC16F876 microcontroller device overview—pin diagrams.

PIC16F876 microcontroller memory organization—special function registers—I/O ports—timers—capture/compare/PWM modules (CCP)


Introduction to MPLAB IDE and PICSTART plus—device programming using MPLAB and PICSTART plus—generation of firing/gating pulses for typical power converters.

8051 microcontroller—architecture—addressing modes—I/O ports—instruction sets—simple assembly language programming.

**EE629 POWER SYSTEM RESTRUCTURING**


Operational and planning activities of a Genco - Electricity Pricing and Forecasting -Price Based Unit Commitment Design - Security Constrained Unit Commitment design. - Ancillary Services for Restructuring- Automatic Generation Control (AGC).

Introduction-Components of restructured system-Transmission pricing in Open-access system-Open transmission system operation; Congestion management in Open-access transmission systems- FACTS in congestion management - Open-access Coordination Strategies; Power Wheeling-Transmission Cost Allocation Methods

Open Access Distribution - Changes in Distribution Operations- The Development of Competition – Maintaining Distribution Planning

Power Market Development – Electricity Act, 2003 - Key issues and solution; Developing power exchanges suited to the Indian market - Challenges and synergies in the use of IT in power- Competition- Indian power market- Indian energy exchange- Indian power exchange- Infrastructure model for power exchanges- Congestion Management-Day Ahead Market- Online power trading.

EE630 COMPUTER RELAYING AND WIDE AREA MEASUREMENT SYSTEMS

Introduction to computer relaying- Historical background- Expected benefits- computer relay architecture-Analog to digital converters- Anti-aliasing filters- Substation computer hierarchy- Fourier series-Exponential fourier series- Sine and cosine fourier series- Phasor.

Mathematical basis for protective relaying algorithms-Walsh functions- Fourier transforms- discrete fourier transform- Random processes- Filtering of random processes- Kalman filtering- Digital filters-Windows and windowing- Linear phase
Approximation- filter synthesis- Wavelets- Elements of artificial intelligence.

Phasor Measurement Unit- Introduction- Phasor representation of sinusoids- Fourier series and Fourier transform and DFT Phasor representation- Phasor Estimation of Nominal Frequency-Signals- Formulas for updating phasors -Nonrecursive updates- Recursive updates- Frequency Estimation

Phasor Measurement Units and Phasor Data Concentrators- A generic PMU- The global positioning system- Hierarchy for phasor measurement systems- Functional requirements of PMUs and PDCs- Transient Response of Phasor Measurement Units-of instrument transformers- filters- During electromagnetic transients- Transient response during power swings

Phasor Measurement Applications-State Estimation- History- Operator’s load flow- weighted least square least square- Linear weighted least squares; Nonlinear weighted least squares- Static state estimation- State estimation with Phasors measurements-linear state estimation. Adaptive protection- Differential and distance protection of transmission lines- Adaptive protection-
Adaptive out-of-step protection.

DSK

DSP Development system: Introduction to DSP- Example of DSP system A to D signal conversion- DSP Support tools- code composer studio- compiler- assembler and linker- input and output with the DSK

Architecture of C6x Processor: Introduction TMS321 C6x architecture- functional units- fetch and execute packets- pipe lining- registers- Liner and circular addressing modes

Instruction of C6x Processor: Instruction set assembly directives- liner assembly- ASM statement within C- timers- interrupts- multi channel buffering serial ports- direct memory access- memory consideration- fixed and floating points format- code improvement and constraints. Fast Fourier Transform: Introduction- DIT FFT algorithm with Radix 2- DIF FFT algorithm with Radix 2- inverse fast Fourier transform- fast convolution- programming example using C language


DSP/BIOS and RTDX using MATLAB & Lab View: Introduction to DSP/BIOS- RTDX using MATLAB provide interface between PC and DSK- RTDX using Lab VIEW provide interface between PC and DSK.

1. *Digital signal processing and applications C6713 and C6416 DSK by Rulph Chassaing- Wiely publication, 2005.*
3. *DSP applications using C and the TMS320c6x DSK by Rulph Chassaing- Wiely publication, 2002.*