M. Tech. DEGREE
POWER SYSTEMS

SYLLABUS FOR
CREDIT BASED CURRICULUM
(2009-2010)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015, INDIA.
M. Tech. (POWER SYSTEMS)

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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<td>MA603</td>
<td>Optimization Techniques</td>
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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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<td>EE627</td>
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Any one course from other department

Group II elective subjects recommended for 2nd semester

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Any one course from other department

G-Global Elective

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.

<table>
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<tr>
<th>CODE</th>
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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.


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.


EE601 - ADVANCED POWER SYSTEM ANALYSIS


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

Single-Phase and Three-Phase AC to DC converters- half controlled configurations-operating domains of three phase full converters and semi-converters. Operation of 12-pulse converter.

Single phase and Three phase inverters, Voltage source and Current source inverters, multi-stepped inverters.

AC to AC voltage regulators , continuous and discrete configurations , single phase and three phase circuits , introduction to DC to DC voltage regulators –Step down and Step up configuration.

Reactive power and harmonic considerations and analysis in the context of converters and inverters.

Pulse Width Modulation Techniques in converters and inverters: Sinusoidal PWM, selected harmonic elimination, Bus clamping PWM, space vector based PWM.


**EE604 – HIGH VOLTAGE DC TRANSMISSION**

General aspects - HVAC and HVDC links – comparison – economic, technical performance reliability-limitation-properties of thyristor converter circuits - choice of best circuit for HVDC converters

Thyristor converter circuits - Analysis with overlap in converters - basic means of control-power reversal-desired features of control-actual control characteristics

Inverters- power control – commutation failure – D.C Reactors – voltage and current oscillations- Circuit breakers, over voltage protection

Characteristic and uncharacteristic harmonics-troubles due to harmonics-harmonic filters-converter charts of direct current and voltage-active and reactive power.

Interaction between ac and de systems- converter transformers-earth electrodes - design of back to back thyristor converter system.


**EE605 POWER SYSTEM STABILITY**


EE606 - 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.


EE608 - POWER SYSTEM SIMULATION LABORATORY

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

EE614 - 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.


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.


EE615G – ANALYSIS AND DESIGN OF ARTIFICIAL NEURAL NETWORKS

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.


EE616G – 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


EE618- ELECTRICAL DISTRIBUTION SYSTEMS


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- 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.


EE620 - RENEWABLE POWER GENERATION SOURCES

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


EE621 – POWER SYSTEM PLANNING AND RELIABILITY


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.


EE622- ADVANCED POWER SYSTEM PROTECTION

General philosophy of protection-Characteristic function of protective relays-basic relay elements and relay terminology-basic construction of static relays-non-critical switching circuits.


Bus protection, Techniques applicable for line protection – long EHV line protection Backup remote local and Breaker failure

Placement of reactors in power system- Transformer tap changing – Protection of boosters-capacitors in an interconnected power system.


EE623-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.


EE624 - FUZZY SYSTEMS

Different faces of imprecision – inexactness, Ambiguity, Undecidability, Fuzziness and certainty, Probability and fuzzy logic, Intelligent systems.
Fuzzy sets and crisp sets - Intersections of Fuzzy sets, Union of Fuzzy sets, the complement of Fuzzy sets.
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.


EE625 POWER QUALITY

Electric power quality phenomena - IEC and IEEE definitions - power quality disturbances - voltage fluctuations-transients-unbalance-waveform distortion-power frequency variations.
Voltage variations, Voltage sags and short interruptions – flicker-longer duration variations -
resources – range and impact on sensitive circuits-standards – solutions and mitigations –
equipment and techniques.

Transients – origin and classifications – capacitor switching transient – lightning-load

Harmonics – sources – definitions & standards – impacts - calculation and simulation –
harmonic power flow - mitigation and control techniques – filtering – passive and active.

Power Quality conditioners – shunt and series compensators-DStatcom-Dynamic voltage
restorer-unified power quality conditioners-case studies.

1994.

2 Bollen, M.H.J., ‘Understanding Power Quality Problems: Voltage sags and


EE626 DIGITAL CONTROLLERS IN POWER ELECTRONICS APPLICATIONS

Introduction to the C2xx DSP core and code generation, The components of the C2xx DSP
core, Mapping external devices to the C2xx core , peripherals and Peripheral Interface ,
System configuration registers , Memory , Types of Physical Memory , memory Addressing
Modes , Assembly Programming using C2xx DSP, Instruction Set, Software Tools.

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

1. Hamid.A.Toliyat and Steven G.Campbell “ DSP Based Electro Mechanical Motion
Control “ CRC Press New York , 2004

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
EE627 DIGITAL SIGNAL PROCESSING & APPLICATIONS


Classification of filter design - Design of IIR filters – Bilinear transformation technique – Impulse invariance method – Step invariance method.

FIR filter design – Fourier series method - Window function technique - Finite Word Length Effects.

Introduction to Multirate Signal Processing - Decimation - Interpolation - Case Studies on Speech Coding, Transform Coding – DSP based measurement system.


EE653 – INDUSTRIAL CONTROL ELECTRONICS

Review of switching regulators and switch mode power supplies-Uninterrupted power supplies- solid state circuit breakers – programmable logic controllers

Analog Controllers - Proportional controllers, Proportional – Integral controllers, PID controllers, Feed forward control

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 , Applications of opto isolation, interrupter modules and photo sensors – Fibre optics – Bar code equipment, application of barcode in industry.


EE654 - POWER ELECTRONIC DRIVES


Conventional methods of D.C. 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.


EE655 – SYSTEM THEORY

State space modeling of physical systems – determining of STM – controllability and observability of time invariant linear system

Different techniques of linearising non-linear systems – Describing functions for various types of non-linearities – describing function analysis of non linear control systems

Method of constructing phase – trajectories– phase plane analysis of linear and non-linear systems – Bang-bang system

Different methods of constructing Liapunov functions for linear and non-linear continuous systems – stability analysis

Pole placement technique by state feedback for linear SISO time, invariant system – Theory of high-gain feedback-advantages – Pole placement technique along with high-gain feedback control.


EE656–MICRO CONTROLLERS APPLICATIONS IN POWER CONVERTERS

Evolution of micro-controllers – comparison between micro processor and micro controllers- Micro-controller development systems; 8051, 8096 and PIC Series Microcontrollers - architecture - hardware description.
Addressing modes – Terminology, Linear addressing, segmented addressing and stack addressing.

Instruction set- arithmetic operations, logical operations, data transfer operations, control transfer operations.

Interrupt structure and Timers; Assembly language programming – C program structure, data acquisition.

Typical applications in the control of power electronic converters for power supplies and electric motor drives.