Two Year M.Tech Course

Scheme of Instruction and Examination

(Effective from 2009-10)

M.Tech I SEMESTER **POWER ELECTRONICS**

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Electrical Machine Modelling	EMM	4	4	-	-	30	70	100
2. Solid State Power Converters - 1	SSPC -1	4	3	1	-	30	70	100
3. Solid State Power Converters - 2	SSPC-2	4	4	-	-	30	70	100
4. Digital Signal Processing	DSP	4	3	1	-	30	70	100
5. Elective - I		4	4	-	-	30	70	100
6. Elective - II		4	4	-	-	30	70	100
7. Simulation of Power Electronic systems Lab	SPELP	3	-	-	3	100	-	100
TOTAL		**27**	**22**	**2**	**3**	**280**	**420**	**700**

M.Tech II SEMESTER **POWER ELECTRONICS**

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Solid State DC Drives	SDCD	4	3	1	-	30	70	100
2. Solid State AC Drives	SACD	4	3	1	-	30	70	100
3. HVDC and FACTS	HVDCFACT	4	4	-	-	30	70	100
4. Dynamics of Electrical Machines	DEM	4	4	-	-	30	70	100
5. Elective-III		4	4	-	-	30	70	100
6. Elective-IV		4	4	-	-	30	70	100
7. Electrical Drives Lab	EDLP	3	-	-	3	100	-	100
8. Comprehensive Viva Voce	CV	3	-	-	-	-	100	100
TOTAL		**30**	**22**	**2**	**3**	**280**	**520**	**800**

M.Tech III & IV SEMESTERS **POWER ELECTRONICS**

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Seminar	SEM	3	-	-	-	100	-	100
2. Dissertation	DS	-	-	-	-	Satisfactory / Not Satisfactory		
TOTAL		**3**	**-**	**-**	**-**	**100**	**-**	**100**

M.Tech I SEMESTER (POWER ELECTRONICS) SCHEME - 2009

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Electrical Machine Modelling	EMM	4	4	-	-	30	70	100
2. Solid State Power Converters - 1	SSPC -1	4	3	1	-	30	70	100
3. Solid State Power Converters - 2	SSPC-2	4	4	-	-	30	70	100
4. Digital Signal Processing	DSP	4	3	1	-	30	70	100
5. Elective - I		4	4	-	-	30	70	100
6. Elective - II		4	4	-	-	30	70	100
7. Simulation of Power Electronic systems Lab	SPELP	3	-	-	3	100	-	100
TOTAL		**27**	**22**	**2**	**3**	**280**	**420**	**700**

List of Subjects under Elective – I

1. Digital Control Systems (DCS)
2. Reliability Engineering (RE)
3. Microprocessors and Microcontrollers(MPMC)

List of Subjects under Elective – II

1. Neural Networks and Fuzzy Logic (NNFL)
2. Programmable Logic Controllers and it's applications (PLC)
3. Power Electronics Systems design with ICs (PESD)

ELECTRICAL MACHINE MODELING (EMM)

(For I Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Basic Elements of generalized theory of machines, circuit models of synchronous, induction and dc machines – general expressions for voltage and torque.

Linear Transformations: Necessity in electrical machines – phase transformations, concepts of power invariance, MMF distributions in the air gap in the development of phase transformations – 3 phase to 2 phase – Parks transformations – symmetrical component transformations – space vector theory.

Reference Frame Theory: concept of reference frame – stationary reference frame – rotating reference frame synchronously rotating – rotor reference frame – commutator transformation – in phase variables – two axis variables – transformation matrices – transformations to a rotating reference frame.

Induction Machines: Matrix models in various reference frames – steady state and transient analysis – derivation of steady state equivalent circuit – torque equation – speed torque characteristics.

Synchronous Machines: Matrix module of synchronous motor in rotating reference frame – performance of synchronous motor – steady state and dynamic performance PM synchronous motor.

DC Machines: Mathematical Models of separately excited DC motor & DC series motor – steady state and dynamic performance.

Reference Books:

1. CV Jones "Unified Theory of Electrical Machines", Butterworths, 1967
2. Berbard Adkins, Ronald G Harley, "The general theory of alternating current machines, applications to practical problems", Chapman and Hall, 1978
3. P.C.Krause "Analysis of Electrical Machinery"
4. P.S.Bimbra "Generalized theory of Electrical Machines"
5. Mukhopadhyay A.K. "Matrix Analysis of Electrical Machines"

SOLID STATE POWER CONVERTERS – 1 (SSPC – 1)

(For I Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Switch Realization: single quadrant switches, current-bidirectional two quadrant switches, voltage- bidirectional two quadrant switches, four quadrant switches.

Brief survey of Power Semiconductor devices: Power diodes, MOSFET, BJT, IGBT, SCR, GTO, IGCT.

Line Commutated Converters:
1-ϕ Full wave bridge converters with R, RL and RLE load with and without freewheeling diode. 3ϕ full wave bridge converters with R, RL and RLE load. Effect of source inductance, discontinuous conduction, input harmonics, output ripples, reactive power consideration, input power factor.

Dual Converters:
Ideal dual converter, practical dual converter, dual converter with and without circulating current operation, comparison between non-circulating and circulating current mode.

DC-DC switched mode power conversion:
Introduction, control of dc-dc converters, step-down (buck) converter, step-up (boost) converter, buck-boost converter, cuk dc-dc converter.

Resonant Converters:
Introduction, classification of resonant converters, basic concepts of series and parallel resonant circuits, zero current switching (ZCS) and zero voltage switching (ZVS) resonant switch converters.

Reference Books:

1. Rashid M.H. " Power Electronics, Circuits, Devices and Applications"
2. Joseph Vithiyadil, "Fundamentals of power electronics"
3. Ned Mohan, "Power Electronics"
4. R.W. Erickson, " Fundamentals of power electronics"
5. Vedam Subrahmanyam "Power Electronics"
6. B.K.Bose "Modern Power Electronics & AC Drives"
7. Singh & Kanchandani "Power Electronics"
8. P.C. Sen, "Power electronics"

SOLID STATE POWER CONVERTERS – 2 (SSPC – 2)

(For I Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Pulse width modulated Inverters:

3-ϕ bridge inverters (VSI) with 120^O and 180^O mode of conduction with R and R-L load, sinusoidal PWM, selective harmonic elimination method, third harmonic injection method, Space vector PWM, harmonic reduction. 3-ϕ bridge Current Source Inverters (CSI).

AC-AC converters:

1ϕ and 3ϕ cycloconverters, output voltage equation, reduction of harmonics in output voltage, effect of source inductance, load and line harmonics, line displacement power factor (DPF), control of cycloconverters, DPF improvement methods, high frequency cycloconverters, 3-phase dual converter as a cycloconverter, advantages and disadvantages.

1-ϕ half and full voltage controllers with R and RL loads, 3ϕ voltage controllers, AC voltage controller with PWM control, effect of source and load inductance, sequence control of voltage controllers.

Principle and operation of three-phase basic Matrix converter.

Multi level inverters:

Multi level concept, classification of multi level inverters, principle of operation and features of diode clamped multi level inverters and flying capacitor multi level inverters.

Reference Books:

1. Rashid M.H. " Power Electronics, Circuits, Devices and Applications"
2. Dr.B.S.Bimbra "Power Electronics"
3. Vedam Subrahmanyam "Power Electronics"
4. B.K.Bose "Modern Power Electronics & AC Drives"
5. Singh & Kanchandani "Power Electronics".
6. G.K. Dubey, et.al, "Thristorized power controllers"
7. T.A. Lipo and G. Holmes, "Pulse width modulation for power conversion"

DIGITAL SIGNAL PROCESSING (DSP)

(For I Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Discrete Time Signals and Systems:
Discrete time signals and sequences, linear shift, invariant systems, stability and causality, linear constant, coefficient of difference equations, frequency domain representation of discrete time systems and signals, properties of fourier transform of discrete sequence, sampling of continuous time signals.

Z-Transforms:
Z-transform and inverse Z-transforms, theorems and properties, systems function, sampling the Z-transform.

Discrete Fourier Transform (DFT):
Fourier representation of frequency domain sequences, discrete fourier transform(DFT), properties of DFT, Inverse DFT (IDFT).

Fast Fourier Transform:
Introduction, Radix-2, Radix-4, Split-Radix FFT algorithms, applications of FFT algorithms.

Implementation of Discrete-Time Systems: Structures of FIR systems, Structures of IIR systems.

Design of Filters: Design of FIR filters, Design of IIR filters.

Reference Books:

1. Alan V Oppenheim and Ronald W Schafer "Digital signal Processing"
2. John G Proakis et.al. "Digital Signal Processing, Principles, algorithms and applications"
3. Andrew Antonio "Digital filters"
4. William D Stanley "Digital Signal Processing"
5. Johney R Johnson "Introduction to digital signal processing"

List of Subjects under Elective – I

1. **Digital Control Systems (DCS)**
2. **Reliability Engineering (RE)**
3. **Microprocessors and Microcontrollers(MPMC)**

DIGITAL CONTROL SYSTEMS (DCS)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Introduction:
Block diagram of typical digital control system, advantages of sampling in control systems, examples of discrete data and digital control systems, reconstruction of sampled signals, ZOH.

Z-Transform:
Definition and evaluation of Z-transforms, mapping between s-plane and z-plane, inverse Z-transform, theorems of Z-transforms, limitation of Z-transform, pulse transfer function, pulse transfer function of ZOH, relation between G(s) and G(z), signal flow graph method applied to digital systems.

State Space Analysis:
State space modeling of digital systems with sample and hold, state transition equation of digital time in variant systems, solution of time in variant discrete state equation by the Z-transformation, transfer function from the state model, eigen values, eigen vectors and diagonalisation of the A-matrix, Jordan canonical form, computation of state transition matrix,
Stability: Definition of stability, stability tests, the second method of Liapunov.

Time Domain Analysis:
Comparison of time responses of continuous data and digital control systems, correlation between time response and root locus in the s-plane and z-plane, root loci for digital control systems, steady state error analysis of digital control systems.

Controllability and Observability:
Theorems on controllability, theorems on Observability (time invariant systems), relation between controllability, observability and transfer function, controllability and observability VS sampling period.

Design:
Digital PID controller, pole placement through state feedback.

Reference Books:

1. B.C.Kuo “Digital Control Systems”
2. M.Gopal “Digital Control Systems”
3. Ogata, “Digital Control Systems”

RELIABILITY ENGINEERING (RE)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Elements of probability theory:
Probability Distributions: Random variables density and distribution functions. Mathematical expectation, Binominal distribution, poisson
Distribution, normal distribution, exponential distribution, weibull distribution.

Definition of Reliability, significance of the terms appearing in the definition, Component reliability, Hazarad rate, derivation of the reliability function in terms of the hazarad rate, Hazardmodels.

Failure:
causes of failures, types of failures(early failures, chance failures and wear-our failures), modes of failure, Batch tub curve, Effect of preventive maintenance, Measures of reliability, mean time of failure and mean time between failures.

Reliability logic diagrams (reliability block diagrams):
Classification of engineering systems: series, parallel, series-parallel, parallel-series and non-series-parallel configurations. Expressions for the reliability of the basic configurations.

Reliability evaluation on Non-series parallel configurations:
Minimal tie-set, minimal cut-set and decomposition methods. Deduction of the minimal cut-sets from the minimal path sets.

Discrete Markov Chains:
General modeling concepts, stochastic transitional probability matrix, time dependent probability evaluation and limiting state probability evaluation. Absorbing states.

Continuous Markov Process:
Modeling concepts, state space diagrams, stochastic Transitional Probability Matrix, Evaluating limiting state Probabilities. Reliability evaluation of repairable systems.

Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutsets/failure mode approach.

Text Books:
1. “REALIBILITY EVALUATION OF ENGINEERING SYSTEMS”, Roy Billinton and Ronald N Allan, plenum press.

MICROPROCESSORS AND MICROCONTROLLERS(MPMC)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

8086 CPU architecture, segmented memory, addressing modes, basic 8086 configuration, minimum mode, maximum mode, system bus timing, interrupt priority management.

8086 instruction set, assembler directives, assembly language programming.

8086 applications:
D/A converter interfacing, A/D converter interfacing, microcomputer based industrial process control system, microcomputer based temperature controller, stepper motor interfacing.
Architectural advances of intel microprocessor series 80386 to Pentium processors.

8051 Microcontroller:
Architecture and memory organization, addressing modes, instruction formats, CPU timings, interrupt structure and interrupt priorities, post structures and operations, accessing internal and external memories, timer/counter functions and different modes of operation.

Programming and peripheral interface to microcontrollers: simple programs using memory interface, I/O interface and serial interface.

8051 applications:
Interfacing a real time clock, interrupt base controlling, traffic signal controller and elevator simulator.

Reference Books:

1. Liu, Gibson "Microcomputer Systems: the 8086/8088 Family"
2. Douglas V Hall "Microprocessors interfacing"
3. Kenneth j Ayala "The 8051 microcontroller"
4. Daniel Tabak "Advanced Microprocessors and interfacing"
5. Barry B Brey "The intel microprocessor 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium proprocessor architecture, programming and interfacing" (PHI 4th edition)

List of Subjects under Elective – II

1. **Neural Networks and Fuzzy Logic (NNFL)**
2. **Programmable Logic Controllers and it's applications (PLC)**
3. **Power Electronics Systems design with ICs (PESD)**

NEURAL NETWORKS AND FUZZY LOGIC (NNFL)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Biological Neural Network:
Organisation of human brain, Neuron functions-cell body, Dendrites Axon, Cell membrance, computers and human brains.
Artificial Neural Networks: Characteristics, single layer and multi-layer Artificial Neural Networks, Training: objective, supervised and unsupervised training, overview.
Perceptrons: perceptron representation, learning, training algorithm.

Multilayer feed forward Network:
Counters propagation Networks: Introduction, Network structure, Normal operation, training the Kohonen and Grossberg layers, full counter propagation network, applications, generalized Delta rule.

Associative Memories:
Hopfield Networks: Recurrent network configurations, applications.
Bi-directional Associative Memories: BAM structure, retrieving a stored association, encoding the associations, Memory capability, continuous, adaptive and competitive BAM.
Adaptive Resonance Theory: ART architecture and implementation training example, characteristics, self organizing maps (som).

Classical & Fuzzy Sets:
Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

Fuzzy Logic System Components:
Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, defuzzification methods.

Reference Books:

1. Fuzzy Set theory and its applications – H.J.Zimmerman – Allied Publishers
2. Neural Computing, theory and practice – Philip D. Wasserman – Van Nostrand Reinhold.
3. Fuzzy sets, uncertainty and information - George I Klir and Tina A. Folger _ PHI
4. Neural Networks and Fuzzy Systems - Bart Kosko. – PHI
5. Fundamentals of Neural Networks, Architectures, Algorithms and Applications – Laurene Fausett - PHI, Englewood Cliffs.
6. Fuzzy Logic with Engg. Applications – Timothy Toss- TMH

PROGRAMMABLE LOGIC CONTROLLERS AND THEIR APPLICATIONS (PLC)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week — Sessional Marks: 30
University Exam: 3 Hrs. — University Marks: 70

PLC Basics:
PLC system, I/O modules and interfacing, CPU processor, programming equipment, programming formats, construction of PLC ladder diagrams, devices connected to I/O modules.

PLC programming:
Input instructions, outputs, operational procedures, programming examples using contacts and coils. Drill press operation.

Digital logic gates, programming in the Boolean algebra system, conversion examples. Ladder diagrams for process control: Ladder diagrams & sequence listings, ladder diagram construction and flow chart for spray process system.

PLC Registers:
Characteristics of Registers, Module addressing, holding registers, input registers, output registers.

PLC Functions:
Timer functions & Industrial applications, counters counter function industrial applications, Arithmetic functions, Number comparison functions, number conversion functions.

Data Handling functions:
SKIP, Master control Relay, Jump, Move, FIFO, FAL, ONS, CLR & Sweep functions and their applications.

Bit pattern and changing a bit shift register, sequence functions and applications, controlling of two axis & three axis Robots with PLC, Matrix functions.

Analog PLC operation:
Analog modules & systems, Analog modules & systems, Analog signal processing, multi bit data processing, analog output application examples, PID principles, position indicator with PID control, PID modules, PID tuning, PID functions.

Reference Books:

1. Programmable Logic Controllers – Principle and Applications by John W. Webb & Ronald A.Riss, Fifth Edition, PHI
2. Programmable Logic Controllers – Programming Method and Applications by JR. Hackworth & F.D Hackworth Jr. – Pearson, 2004.

POWER ELECTRONICS SYSTEMS DESIGN WITH ICs (PESD)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Introduction, measurement techniques for voltage, current, power, power factor in Thyristorised AC & DC Circuits, other measurement and recording of waveforms.

Sensing of current, voltage, power in Thyristorised circuits, sensing of speed.

Study of different PWM ICs.

Concepts of digital logic circuits, Design of combinational and sequential circuits, PLL A/D & D/A converters, 555 timer, op-amps.

Implementation of gating, PLCs developing a microprocessor based system.

Reference Books:

1. G K Dubey "Thyristorised power controllers"
2. J R Gibson "Electronic Logic Circuits"
3. Data Book "National semiconductor"
4. Data Book I & II "Motorola-Linear Ics"
5. Unitrode Applications data book

Simulation of Power Electronic systems Lab (SPELP)

(For I Sem M. Tech)

1. Develop a simulink model for a three-phase induction motor using stationary reference frame.

2. Develop a simulink model for a three-phase induction motor using synchronously rotating reference frame.

3. Develop a simulink model for sinusoidal pulse width modulation algorithm for three-phase voltage source inverter. Study the same at various switching frequencies and at various modulation indices.

4. Develop a simulink model for space vector pulse width modulation (SVPWM) algorithm for three-phase voltage source inverter. Study the same at various switching frequencies and at various modulation indices.

5. Develop a simulation model for pulse width modulated diode clamped three-level inverter and compare the same with two-level inverter. (Carrier comparison approach only).

6. PSIM simulation of four quadrant chopper with R and R-L loads.

7. PSIM simulation of single phase dual converter with R and R-L loads.

8. PSIM simulation of three-phase AC voltage controller with R and R-L loads.

9. PSIM simulation of single phase full controlled rectifier with R and R-L loads

10. PSIM simulation of three-phase full controlled rectifier with R and R-L loads

Note: A minimum of eight experiments should be conducted

M.Tech II SEMESTER (POWER ELECTRONICS) SCHEME - 2009

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Solid State DC Drives	SDCD	4	3	1	-	30	70	100
2. Solid State AC Drives	SACD	4	3	1	-	30	70	100
3. HVDC and FACTS	HVDCFACT	4	4	-	-	30	70	100
4. Dynamics of Electrical Machines	DEM	4	4	-	-	30	70	100
5. Elective-III		4	4	-	-	30	70	100
6. Elective-IV		4	4	-	-	30	70	100
7. Electrical Drives Lab	EDLP	3	-	-	3	100	-	100
8. Comprehensive Viva Voce	CV	3	-	-	-	-	100	100
TOTAL		**30**	**22**	**2**	**3**	**280**	**520**	**800**

List of Subjects under Elective – III

1. Solid State Relays and Static VAR Compensation (SRVC)
2. Industrial Applications of Power Electronics (IAPE)
3. Power Quality (PQ)

List of Subjects under Elective – IV

1. Energy Conversion Systems (ECS)
2. Analysis of SCR controlled machines (ASCM)
3. Microcomputer Control of Elective Drives (MCED)

Note: Any one of the subject is offered under each elective

M.Tech III & IV SEMESTERS (POWER ELECTRONICS) SCHEME - 2009

Name of the Subject	Abbreviation	Credits	Hrs/Week			Evaluation (marks)		
			Lectures	Tutorial	Practical	Internal	External	Total
1. Seminar	SEM	3	-	-	-	100	-	100
2. Dissertation	DS	-	-	-	-	Satisfactory / Not Satisfactory		
TOTAL		**3**	**-**	**-**	**-**	**100**	**-**	**100**

SOLID STATE DC DRIVES (SDCD)

(For II Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Review of Conventional DC Drives:
Review of conventional DC Drives, Steady state speed torque relation of DC motor, methods of speed control, electrical braking for both series and separately excited DC motors, Multi quadrant operation of separately excited DC motor with regenerative braking, Models and transfer function of series and separately excited DC motor.

Rectifier Control of DC Drives:
Introduction, types, 1ϕ half controlled and fully controlled converters and 3ϕ half controlled and fully controlled converters connected to separately excited and series motor, continuous and discontinuous modes of operation, dual converter fed DC drives, comparison of semi-converter with full converter, reversible DC drives.

Chopper Controlled dc drives:
Introduction, types, Type A and Type B chopper fed drives, chopper fed separately excited and series motor drives, motoring operation, regenerative operation and braking operation, multi-quadrant drives, closed loop control of dc drives, effect of saturation in series motor.

Closed loop operation of DC Drives:
Speed controlled drive system, current control loop, pulse width modulated current controller, hysteresis current controller, modeling and design of current controller.

Reference Books:

1. S B Dewan, Slemon, Straughen "Power Semiconductor Drives"
2. Subrahmanyam V "Electric Drives – Concepts and Applications"
3. V Subrahmanyam "Thyristor Control of Electric Drives"
4. PC Sen "Thyristor DC Drives"
5. G K Dubey "Power Semiconductor Drives"
6. R. Krishnan, "Electric motor drives: concepts and applications"

SOLID STATE AC DRIVES (SACD)

(For II Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Review of Conventional AC Drives:
Review of conventional AC Drives, speed-torque and slip-torque relations of Induction Motor and Synchronous Motor.

Speed control of Induction Motor:
Speed control of 3 phase Induction Motor using stator voltage control method using AC Voltage Controllers, stator frequency control method using Cycloconverters, stator V/F control method using Voltage Source Inverters (VSI), stator current control method using current source inverters (CSI), dynamic and regenerative braking of VSI and CSI fed Induction Motor Drives.
Speed control of 3 phase induction motor using static rotor resistance control method, slip power recovery schemes, static Kramer method, static Scherbius method.
Speed control of 3 phase induction motor by vector control methods: Basic concepts of Direct and Indirect methods of vector control.
Speed control of induction motor by Direct Torque Control (DTC).

Speed control of Synchronous motor:
Self control and separately control of synchronous motors, VSI and CSI fed synchronous motors, margin angle control, cycloconverter fed synchronous motor, speed control and performance of synchronous motor using a variable frequency supply with DC link inverter.

Variable Reluctance Motor drives:
Torque production in the variable reluctance motor drives, drive characteristics and control principles, current control variable reluctance motor drives.

Brushless DC motor Drives:
Three-phase full wave brushless dc motor, sinusoidal type of brushless dc motor, current controlled brushless DC motor drive.

Reference Books:

1. S B Dewan, Slemon, Straughen “Power Semiconductor Drives”
2. B K Bose “Modern Power Electronics and AC Drives”
3. V Subrahmanyam “Thyristor Control of Electric Drives”
4. Murphy JMD, Turnbull FG “Thyristor control of AC motor”
5. G K Dubey “Power Semiconductor Drives”
6. Peter Vas, “Sensorless vector and direct torque control”

HVDC AND FACTS (HVDC FACT)

(For II Sem. M.Tech)

Lectures/Tutorials: 4 Periods/week — Sessional Marks: 30
University Exam: 3 Hrs. — University Marks: 70

Basic concepts: Economics and terminal equipment of HVDC transmission systems – Types of HVDC links – Apparatus required for HVDC systems – Comparison of AC and DC Transmission – Application of DC Transmission System – Planning and Modern trends in D.C.Transmission.

HVDC Converters: choice of converter configurations -Analysis of Graetz circuit – characteristics of 6-pulse and 12-pulse converters – principle of DC link control – converter control characteristics – firing angle control – current and extinction angle control – effect of source inductance on the systems – converter faults.

Power flow analysis in AC/DC systems; Modelling of DC Links – solution of DC load flow – P.U.system for d.c quantities. Converter faults & protection: converter faults – protection against over currents & over voltages in converter station – surge arresters – smoothing reactors – DC breakers – Effects of proximity of AC & DC transmission lines.

FACTS concept and General System considerations: Transmission Interconnections- Flow of power in an AC system- What limits the loading capability- power flow and dynamic stability considerations of a transmission interconnection – relative importance of controllable parameters- basic types of FACTS controllers- Brief description and definitions of FACTS controllers.

Static Shunt and Series Compensation: Objectives of shunt compensation – Mid point voltage Regulation for Line segmentation – end line voltage support to prevent voltage Instability – Improvement of Transient Stability – power Oscillation Damping – Objectives of series compensation – Concept of series capacitive compensation – voltage stability - Improvement of Transient Stability – power oscillation Damping – sub synchronous Oscillation Damping

Reference:

1. K R Padiyar “HVDC Power Transmission Systems”
2. E W Kimbark “Direct Current Transmission”
3. J Arrillaga “High Voltage Direct Current Transmission”
4. N G Hingorani and L Guygi “Understanding FACTS Devices”
5. G K Dubey et al “Thyristorised Power Controllers”

DYANMICS OF ELECTRICAL MACHINES (DEM)

(For II Sem. M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Basic Machine Theory:
Electromechanical Analogy – Magnetic Saturation – Rotating field theory - Operation of Inductor motor - equivalent circuit – Steady state equations of d.c.machines – operation of synchronous motor – Power angle characteristics.

Electro dynamical equations and their solutions:
Spring and plunger system – Rotational motion – mutually coupled coils – Lagrange's equation - Application of Lagrange's equation - solution of Electro dynamical equations.

Dynamics of D.C. Machines:
Separately excited d.c.generators – steady state analysis – transient analysis – Separately excited d.c.motors – steady state analysis – transient analysis – interconnection of machines – Ward Leonard systems of speed control.

Induction Machine Dynamics:
Induction machine dynamics during starting and braking – accelerating time – Induction machine dynamics during normal operation – Equation for dynamic response of the induction motor.

Synchronous Machine Dynamics:
Electromechanical equation – motor operation – generator operation – small oscillations – general equations for small oscillations – representation of the oscillation equations in state variable form.

Reference:

1. Sen Gupta D.P.and J.W. "Electrical Machine Dynamics", Macmillan press Ltd.,1980
2. Bimbhra P.S."Generalized Theory of Electrical Machines",Khanna Publishers 2002

List of Subjects under Elective – III

1. **Solid State Relays and Static VAR Compensation (SRVC)**
2. **Industrial Applications of Power Electronics (IAPE)**
3. **Power Quality (PQ)**

SOLID STATE RELAYS AND STATIC VAR COMPENSATION (SRVC)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Comparators and static relay characteristics:
Relays as comparators, amplitude and phase comparison schemes, general equation for comparators, coincidence circuits, phase splitting methods, hall effect comparators, operating principles, use of level detectors, time delay circuits, filters, thyristors, triggering circuits and dc power supplies, spike diverters and suppressors

Static relay hardware:
Operating principles, static time current relays, directional units based on phase and amplitude comparison, differential relays, distance relays and their characteristics, comparison of characteristics with induction relays, linear segmental couplers

Relay response:
Principles on the Rx diagram, convention for superposing relay and system characteristics, power swings, loss of synchronism and its effect on distance relays

Relay coordination and static VAR compensation:
Static VAR compensation techniques, types of SVC, variable impedance type SVC, current source type SVC, their merits and utility to the power systems

Relay coordination of over current relays, distance relay coordination on power systems

Reference Books:

1. Russel Mason “The art and sciences of protective relaying”
2. T J E Miller “Reactive power control in electric systems”
3. K R Padiyar “Power system dynamics, stability & control”

INDUSTRIAL APPLICATIONS OF POWER ELECTRONICS(IAPE)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Industrial Heating:
Advantages and methods of electric heating, types and applications of electric heating equipment, induction heating, dielectric heating.

Industrial Welding:
Physical description of wheel welding system, sequence of operations, sequence initiation, interval triggering and gating circuit, interval stepping circuit, interval time counter, heat-cool counter, weld power circuit.

Electric Traction:
Traction motors, requirement of traction motors, tractioning series motor, ac traction using 1 phase and 3 phase ac motors, linear motors, control of dc traction motor, controllers, energy saving with series parallel starting, collection of series parallel control, multiple unit control. Solid state converter controlled drives, 25KV ac traction using semi converter. controlled dc motors, dc traction using choppers, traction using poly phase ac motors, types of diesel electric traction.

Drives for specific applications:
Introduction, drives and motors for textile mills, steel rolling mills, cranes and hoist drives, cement mills, sugar mills, machines tools, paper mills, coal mines, centrifugal mills, turbo compressors.

Other Applications:
Electro chemical application, static excitation system for alternators, static circuit breaker, over voltage protection, simple battery charger, automatic battery charger, SCR current limiting circuit breaker, fan regulator using TRIAC.

Reference Books:

1. Maloney Timothy J "Industrial Solid State Electronics"
2. Ned Mohan "Power Electronics: converters, applications and design"
3. Mithal "Industrial Electronics"
4. S K Battacharya, S chattarjee "Industrial Electronics and Control"
5. Harish C Rai "Industrial Applications"
6. H Partab "Utilising Electrical Energy"
7. Vedam Subrahmanyam, "Electrical drives, concepts and applications'
8. Richard N Criwder, "Electric Drives and their controls", Clorendon, Oxford 1995.

POWER QUALITY (PQ)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week — Sessional Marks: 30
University Exam: 3 Hrs. — University Marks: 70

Introduction:
Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonica, over voltages, spikes, voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring.

Long Interruptions:
Interruptions – Definition – Difference between failure, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the interruptions frequency – Limits for the interruption duration - costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Short Interruptions:
Short interruptions – definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

Voltage sag – characterization – single phase:
Voltage sag – definition, causes of voltage sag, voltage sag magnitude, and monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, and voltage sag duration.

Voltage sag – characterization – Three phase:
Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

PQ considerations in Industrial Power Systems:
Voltage sag - equipment behavior of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

Mitigation of Interruptions and Voltage Sags:
Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Power Quality and EMC Standards:
Introduction to standardization, IEC Electromagnetic compatibility standards, European voltage characteristics standards, PQ surveys.

Reference Books:

1. Math H J Bollen, "Understanding Power Quality problems" IEEE Press.
2. Dugan, "Introduction to Power Quality" TMH Publishers

List of Subjects under Elective – IV

1. **Energy Conversion Systems (ECS)**
2. **Analysis of SCR controlled machines (ASCM)**
3. **Microcomputer Control of Elective Drives (MCED)**

ENERGY CONVERSION SYSTEM (ECS)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Photo voltaic power generation, spectral distribution of energy in solar radiation, solar cell configurations, voltage developed by solar cell, photo current and load current practical solar cell performance, commercial photo voltaic systems, test specifications for pv systems, applications of super conduction materials in electrical equipment systems.

Principles of MHD power generation, ideal MHD generator performance, practical MHD generator, MHD technology.

Wind Energy conversion:
Power from wind, properties of air and wind, types of wind Turbines, operating characteristics.

Tides and tidal power stations, modes of operation, tidal project examples, turbines and generators for tidal power generation. Wave energy conversion: properties of waves and power content, vertex motion of Waves, device applications. Types of ocean thermal energy conversion systems Applications of OTEC systems examples

Miscellaneous energy conversion systems:
Coal gasification and liquefaction, biomass conversion, geothermal energy, thermo electric energy conversion, principles of EMF generation, description of fuel cells

Co-generation and energy storage, combined cycle co-generation, energy storage. Global energy position and environmental effects: energy units, global energy position.

Types of fuel cells, H_2-O_2 Fuel cells, Application of fuel cells - Batteries, Description of batteries, Battery application for large power.

Environmental effects of energy conversion systems, pollution from coal and preventive measures steam stations and pollution, pollution free energy systems.

TEXT BOOKS:

1. "Energy conversion systems" by Rakosh das Begamudre, New age international publisher, New Delhi – 2000.
2. "Renewable Energy Resources" by John Twidella dn Tony Weir, 2nd edition, Fspon & Co.

ANALYSIS OF SCR CONTROLLED MACHINES (ASCM)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week — Sessional Marks: 30
University Exam: 3 Hrs. — University Marks: 70

Introduction – Analysis of DC motors fed from AC to DC converters, DC Choppers.

Analysis of Induction Motors: Matrix Methods and state space techniques for the analysis of VSI and CSI fed motors.

Analysis of Induction motors fed from 3 phase voltage controller, analysis of commutation process of a CSI fed induction motor.

Analysis of induction motor with static converter cascade in the rotor.

Analysis of commutation of CSI feeding a 3 phase synchronous motor.

Analysis of PM motor.

Reference Books:

1. Vedam Subrahmanyam, “Thyristor control of Electric Drives”
2. Pillai, “A first course in Electric Drives”

MICROCOMPUTER CONTROL OF ELECTRIC DRIVES (MCED)

(Elective for M.Tech.)

Lectures/Tutorials: 4 Periods/week | Sessional Marks: 30
University Exam: 3 Hrs. | University Marks: 70

Introduction to Micro Computer control of electric drive, review of microprocessors in industrial motor drive systems.

Microprocessor control of converter fed DC motor drives, performance analysis of microprocessor based control system applied to adjustable speed motor drives.

Microprocessor control of induction motors, microprocessor based vector control system for induction motor drives, microprocessor based optimal efficiency drive of an induction motor.

Microprocessor control of current fed and voltage fed synchronous motor drives.

Microprocessor control for sensorless brushless motors, microprocessor control of switched reluctance motors, microprocessor control of stepper motors.

Reference Books:

1. B K Bose "Microcomputer control of power electronics & drives"
2. B K Bose "Modern power electronics & AC Drives
3. S B Dewan, G R Solemon "Power semiconductor drives"
4. Leonard W "Control of electrical drives"
5. V Subrahmanyam "Thyristor control of Electric Drives

Electrical Drives Lab (EDLP)

(For II Sem M.Tech)

1. DSP based V/f controlled induction motor drive.
2. Verification of SPWM and SVPWM methods using DSP kit
3. Verification of SPWM and SVPWM methods using dSPACE kit
4. Microcontroller based speed control of separately excited DC motor.
5. DSP based speed control of PMDC motor drive
6. Static Kramer drive
7. Static rotor resistance control of SRIM using chopper.
8. DSP based speed control of BLDC motor drive
9. Speed control of induction motor using three-phase AC voltage controllers.
10. Four-quadrant chopper fed DC motor drive.

Note: A minimum of eight experiments should be conducted