FACULTY OF ENGINEERING

Syllabus for the

M.E. Electrical (Power Electronics and Drives)

(w.e.f. 2011-2012)

Structure of M.E.(Electrical)- Power Electronics and Drives (2008 Course)
ELECTRICAL ENGINEERING BOARD,
University of Pune.

Semester I

Subject Code No.	Subject	Teaching Scheme		Examination Scheme				Total marks	Credits
		Lect	Pract	Paper	TW	Oral	PR		
503301	Modeling and Analysis of Electrical Machines	3	--	100	--	---	---	100	3
503302	Energy management and power quality in electrical drives	3	---	100	--	--	----	100	3
503303	Power Electronic devices and circuits	3	---	100	---	---	---	100	3
503304	Elective- I	3	---	100	---	---	----	100	3
503305	Elective- II	3	--	100	--	---	---	100	3
503306	Lab- Practice- I	---	6	--	50	---	--	50	3
503307	Seminar- I	---	4	--	50	--	---	50	2
	Total of First Term	15	10	500	100	--	--	600	20

Semester II

Subject Code No.	Subject	Teaching Scheme		Examination Scheme				Total marks	Credits
		Lect	Pract	Paper	TW	Oral	PR		
503308	Controlled Electrical drives	3	-	100	---	---	---	100	3
503309	Power electronic applications	3	-	100	---	-	-	100	3
503310	Design of Power electronic systems	3	-	100	----	-	-	100	3
503311	Elective- II	3	-	100	----	-	-	100	3
503312	Elective- IV (Open)	3	-	100	---	-	-	100	3
503313	Lab- Practice- II	---	6	--	50		-	50	3
503314	Seminar- II	---	4	---	50		-	50	2
	Total of Second Term	15	10	500	100	---	---	600	20

Semester III

Subject Code No.	Subject	Teaching Scheme		Examination Scheme			Total marks	Credits
		Lect	Pract	Paper	TW	Oral		
603301	Seminar- III	-	4	-	50	-	50	2
603302	Project stage- I	-	18	-	50	--	50	6
	Total of Third Term	--	22	--	100	--	100	08

Semester- IV

Subject Code No.	Subject	Teaching Scheme		Examination Scheme			Total marks	Credits
		Lect	Pract	Paper	TW	Oral		
603302	Project stage- II	---	18	---	150	50	200	12
	Total of Forth Term	---	18	---	150	50	200	12

Note:- The contact hours for the calculation of load of Teacher -
Seminar - 01Hr / Week / Student,
Project- 02Hr / Week / Student

· **Lab- Practice- I & Lab. Practice - II** will have minimum 10 experiments each.
· **Seminar III** will be based on the Project Work.
· The Term Work of Project stage II of semester IV should be assessed jointly by the pair of internal and external examiners, along with the oral examination of the same.

Elective- I

i) DSP and its applications in Electrical drives
ii) Data Acquisition and Signal conditioning
iii) Digital simulation of power electronic systems

Elective- II

i) FACTS and HVDC
ii) Harmonics and their mitigation

Elective- III

i) Automation in Industrial drives
ii) Computer Aided Design of Electrical Machines
iii) Microcontroller applications

Elective- IV

i) Artificial Intelligence in Electrical drives
ii) Special topics in Power electronics and drives
iii) Open*

503301: MODELLING AND ANALYSIS OF ELECTRICAL MACHINES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper: 100 Marks

Unit I: (7 Hrs)

Introduction to the theory of basic two pole machine applicable to DC machines, 3-ph induction machines and synchronous machine. Kron's primitive Machine. Need of modeling**, Intr**oduction to modeling of electrical machines, voltage and torque equations.

Unit II: (7 Hrs)

Concept of transformation: change of variables & m/c variables and transform variables for arbitrary reference frames. Application to D.C. machine for steady state and transient analysis, and equation of cross field commutator machine**.**

Unit III: (7 Hrs)

Polyphase Induction Machines: Voltage, torque equations , Equivalent circuit ,Steady state analysis, Dynamic performance during sudden changes in load torque and three phase fault at the machine terminals.

Unit IV: (7 Hrs)

Polyphase Synchronous Machine: Voltage and Torque Equations in stator, rotor and air-gap field reference frames . Transformation and Transformed Equations. Parks Transformation Voltage and power equation for salient and non salient alternator, their phasor diagrams, Simplified equations of a synchronous machine with two damper coils.

Unit V: (7 Hrs)

Dynamical Analysis of Interconnected Machines . Machine Interconnection Matrices . Transformation of Voltage and Torque Equations using Interconnection Matrix .
Large Signal Transient Analysis using Transformed Equations'. The DC Generator/DC Motor System . The Alternator /Synchronous Motor System .

Unit VI: (7 Hrs)

Linearized machine equations: Linearization of machine equations.
Small displacement stability: Eigen values, Eigen values of typical induction machine and synchronous machine, Transfer function formulation.

Text Books

1. Analysis of Electric Machinery - P.C.Krause
2. The General theory of Electrical Machines - B.Adkins
3**.** Generalised theory of Electrical m/c - P.S.Bhimbra

Reference Books:

1. The General theory of AC Machines - B.Adkins & R.G.Harley
2. Electro Mechanical Energy Conversion - White & Woodson
3.The Unified Theory of Electrical Machines - C.V. Jones, Butterworth, London.
4. Electrical Machine Dynamics Boldia & S.A. Nasar: The Macmillan Press Ltd.

503302: ENERGY MANAGEMENT AND POWER QUALITY IN ELECTRICAL DRIVES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper: 100 Marks

Unit I: (7 Hrs)

Electric motors- Energy efficient controls and starting efficiency - Motor Efficiency and Load Analysis - Energy efficient /high efficient Motors - Case study; Load Matching and selection of motors**.**

Variable speed drives - Pumps and Fans - Efficient Control strategies - Optimal selection and sizing -Optimal operation and Storage; Case study

Unit II : **(**7 Hrs**)**

Transformer Loading / Efficiency analysis, Feeder / cable loss evaluation, case study. Reactive Power management-Capacitor Sizing - Degree of Compensation-Capacitor losses-Location-Placement-Maintenance .case study;

Peak Demand controls - Methodologies-Types of Industrial loads-Optimal Load scheduling-case study;

Lighting - Energy efficient light sources - Energy conservation in Lighting Schemes- Electronic ballast - Power quality issues - Luminaries, case study;

Unit III : (7 Hrs)

Cogeneration -Types and Schemes - Optimal operation of cogeneration plants - case study;

Electric loads of Air conditioning & Refrigeration-Energy conservation measures- Cool storage .Types-Optimal operation-case study; Electric water heating – Gysers - Solar Water Heaters - Power Consumption in Compressors, Energy conservation measures; Electrolytic Process;

Unit IV (7 Hrs)

Understanding Power quality, types of power quality disturbances, power quality indices, Causes and effects of power quality disturbances

Causes and effects of harmonics, converter configuration and their contribution to supply harmonics, other sources of harmonics

Unit V (7 Hrs)

Radio interference, supply standards, elimination / suppression of harmonics, classical solutions & their drawbacks, passive input filters, high power factor pre-regulator, switching control circuit, transformer connections.

Unit VI (7 Hrs)

Elimination / suppression of harmonics using active power filters – topologies, and their control methods, PWM converter as a voltage source active filter, current source active filter,

Electro-magnetic compatibility, constant frequency control, constant tolerance band control, variable tolerance band control, discontinuous current control.

MONITORING POWER QUALITY - Monitoring essentials, reliability indices, Power quality measuring equipment, Current industry trends, Fourier series, Fourier transform and wavelet transform

Text Books

1. M. H. J. Bollen, "Understanding Power Quality Problems, Voltage Sag & Interruptions", New York: IEEE Press, 2000, Series On Power Engineering
2. R. C. Dugan, Mark F. McGranghan, Surya Santoso, H. Wayne Beaty, "Electrical Power System Quality", 2nd Edition, McGraw Hill Pub.
3. J. Arrillaga, M. R. Watson, S. Chan, "Power System Quality Assessment", John Wiley and Sons
4. G. J. Heydt, "Electric Power Quality", Stars in a Circule Publications.
5. Enriques Acha, Manuel Madrigal, "Power System Harmonics: Computer Modeling & Analysis", John Wiley and Sons Ltd.
6. IEEE Std. 519-1992, IEEE recommended practices and requirements for harmonics control in electrical power system.

References Books:

1.Donald R. W., .Energy Efficiency Manual., Energy Institute Press

2. Partab H., 'Art and Science of Utilisation of Electrical Energy', Dhanpat Rai and Sons, New Delhi.

3.Tripathy S.C.,'Electric Energy Utilization And Conservation', Tata McGraw Hill.

4.Turner, Wayne C., .Energy Management Handbook., 2nd ed. Lilburn, GA: The Fairmont Press Inc., 1993.

UNESCAP-Guide Book on Promotion of Sustainable Energy Consumption (www.unescap.org/enrd/energy)

503303: POWER ELECTRONIC DEVICES AND CIRCUITS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit I INTRODUCTION (7 Hrs)

Thyristors, GTO, VI characteristics, Dynamic characteristics, ratings, protection, driving circuits. POWER MOSFET AND IGBT Basic structure, I-V and switching characteristics, operating limitation and safe operating area. Power ICs, New semiconductor materials.

Unit II SNUBBER CIRCUITS: (7 Hrs)

Types of Snubber circuits, need of Snubber circuit ,Turn-off Snubber, over voltage snubber, turn on snubber, Snubber for bridge circuit configurations, GTO Snubber circuit.
GATE AND BASIC DRIVE CIRCUITS Design Consideration, De-coupled drive circuits, Electrically isolated drive circuits, cascade connected drive circuits, Power device protection in drive circuits.

Unit III DC TO DC CONVERTERS (7 Hrs)

Buck, boost, buck-boost and cuk converter topologies- continuous and discontinuous modes of operation, Voltage and current commutated choppers, effect of source Inductance, Filter circuits, multiphase chopper.

Unit IV AC TO DC CONVERTERS (7 Hrs)

1-Φ, 3-Φ Fully controlled converters with RL, RLE loads, free wheeling diodes, Dual Converter, sequence control of converters - inverter operation, Effect of source inductance on commutation, Harmonic analysis of source current

Unit V INVERTER - GENERIC TOPOLOGY (7 Hrs)

General topology of single phase and three phase voltage source and Current source inverters, Configuration of single phase voltage source inverter: full bridge, Selection of switching frequency & switching device. Forced commutated bridge Inverter: McMurray Inverter, McMurray Bedford Inverter. Series Inverters

Unit VI OTHER CONVERTERS (7 Hrs)

Principle of phase control, single-phase bi-directional controllers with R, L and R-L loads, 3-phase controllers.
Principle of operation of single phase and three phase cycloconverters , Power circuits, gating signals-harmonics power factor.

TEXT BOOKS:

1.Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Second Edition, New Delhi, 1995.
2.“Power Electronics: Converters, Design and Applications”, Ned Mohan, Undeland, Robbins. John Wiley & Sons, 2004.
3.“Modern Power Electronics and AC drives”, B.K.Bose, Peasron Education Inc., 2002.
4.“Power Electronics”, M.H.Rashid, Prentice Hall,2004.

References:

1.“Fundamentals of Power Electronics”, 2nd Edition, Robert W.Erickson, Dragan Maksimovic, Kulwer Academic Publishers, 2001
2.G.K. Dubey et al, " Thyristorised Power Controllers ", New Age International Pvt. Ltd., New Delhi, 1996.
3.M. Ramamoorthy, " Introduction to thyristors & and their application " East-west Press, 1977.

503304: (Elective I)

i] DIGITAL SIGNAL PROCESSING AND ITS APPLICATIONS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1: (7 Hrs)

OVERVIEW - Concept of frequency in continuous and discrete time signals, A-D Conversion process, Sampling Theorem, Introduction and classification of discrete time signals and systems, Analysis of discrete linear time-invariant (LTI) systems, convolution and correlation of discrete time signals, implementation of discrete time systems.

Unit 2: (7 Hrs)

Z-TRANSFORM Z-Transform and inverse z-transform, rational z-transform, Analysis of Linear Time Invariant (LTI) systems in z-domain.
FREQUENCY ANALYSIS OF SIGNALS AND SYSTEM Frequency analysis of continuous and discrete time signals, Fourier series and Fourier Transform for discrete and continuous periodic and non periodic signals.

Unit 3: (7 Hrs)

DISCRETE FOURIER TRANSFORM - Frequency domain sampling, Discrete Fourier Transform (DFT), Linear filtering methods based on DFT, Frequency analysis of signals using DFT, Fast Fourier Transform (FFT), FFT algorithms(Radix2, DIF, DIT, FFT), Methods and Applications of FFT algorithms**.**

Unit 4: (7 Hrs)

DIGITAL FILTER DESIGN - Realisation of FIR and IIR filters using direct form, cascade form, parallel form, lattice and ladder structure. Digital filter, filter design using rectangular window, hamming, hanning, Kaiser window, Infinite Impulse Filter (IIR), finite Impulse filters (FIR) ,

Unit 5: (7 Hrs)

MULTIRATE SIGNAL PROCESSING: Decimation and Interpolation, Sample rate conversion by Integer and Non-Integer factors.

Unit 6: (7 Hrs)

DSP PROCESSOR: Architecture and instruction set of TMS 320C 54X and examples.
APPLICATIONS TO ELECTRIC SYSTEMS: Harmonic analysis, PWM and firing pulse generation, static and Digital Relays, Digital signal conditioning and algorithms for digital protection. Transmission line protection, Transformer protection.

Text Books

1. Proakis J.G. and Manolakis D.G., Digital Signal Processing, PHI New Delhi.

2. Rabiner C.R. and Gold B., Theory and Applications of Digital Signal Processing, PHI New Delhi.
3. Oppenhein A.V. and Schafer R. W., Digital Signal Processing. PHI New Delhi.
4. Litan – Digital signal preossesing. Elsevier Publications

Reference Books

1. Helmut U., Wilibald W. and Andrzey W., "Protection techniques in Electrical Engg. Systems, Marcel Dekker Inc., New York.
2. Antonion A., Digital Filters: Analysis, Design and Application, PHI New Delhi.

503304 (Elective I)

ii] DATA ACQUISITION AND SIGNAL CONDITIONING

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1: Transducers & Signal Conditioning (7 Hrs)

Data Acquisition Systems (DAS)- Introduction . Objectives of DAS . Block Diagram Description of DAS- General configurations - Single and multichannel DAS-Transducers for the measurement of motion, force, pressure, flow, level, dc and ac voltages and currents (CTs, PTs for supply frequency as well as high frequency, Hall Effect Current Sensors, High Voltage Sensors , Opto-sensors, Rogowski Coil etc.)

Unit 2 Signal Conditioning: (7 Hrs)

Requirements - Instrumentation amplifiers: Basic characteristics . Chopped and Modulated DC Amplifiers -Isolation amplifiers - Opto couplers - Buffer amplifiers .Noise Reduction Techniques in Signal Conditioning- Transmitters .Optical Fiber Based Signal Transmission-Piezoelectric Couplers- Intelligent transmitters.

Unit 3 : Filtering and Sampling (7 Hrs)

Need for Prefiltering-First and second order filters - classification and types of filters - Low - pass, High-pass, Band-pass and Band-rejection and All Pass: Butterworth, Bessel, Chebyshev and Elliptic filters . Opamp RC Circuits for Second Order Sections-Design of Higher Order Filters using second order sections using Butterworth Approximation-Narrow Bandpass and Notch Filters and their application in DAS. Sample and Hold Amplifiers

Unit 4: Signal Conversion and Transmission (7 Hrs)

Analog-to-Digital Converters (ADC)-Multiplexers and demultiplexers - Digital multiplexer . A/D Conversion. Conversion Processes , Speed, Quantization Errors . Successive Approximation ADC . Dual Slope ADC. Flash ADC . Digital-to-Analog Conversion(DAC) . Techniques, Speed, Conversion Errors, Post Filtering- Weighted Resistor, R-2R, Weighted Current type of DACs-Multiplying Type DAC-Bipolar DACs- Data transmission systems-Schmitt Trigger-Pulse code formats- Modulation techniques and systems-Telemetry systems.

Unit 5 : Digital Signal Transmission And Interfacing (7 Hrs)

DAS Boards-Introduction. Study of a representative DAS Board-Interfacing Issues with DAS Boards, I/O vs Memory Addressing, Software Drivers, Virtual Instruments, Modular Programming Techniques for Robust Systems, Bus standard for communication between instruments - GPIB (IEEE-488bus) - RS-232C- USB-4-to-20mA current loop serial communication systems. Communication via parallel port . Interrupt-based Data Acquisition.

Unit 6 (7 Hrs)

Software Design Strategies-Hardware Vs Software Interrupts-Foreground/ background Programming Techniques- Limitations of Polling . Circular Queues

Text Books

1.Ernest O Doeblin., "Measurement Systems: Application and Design", McGraw Hill (Int. edition) 1990, ISBN 0-07-100697-4
2.George C.Barney, "Intelligent Instrumentation", Prentice Hall of India Pvt Ltd., New Delhi, 1988.
3.Ibrahim, K.E., "Instruments and Automatic Test Equipment", Longman Scientific & Technical Group Ltd., UK, 1988.
4.John Uffrenbeck, "The 80x86 Family ,Design, Programming, And Interfacing", Pearson Education , Asia,

Reference Books

1. Bates Paul, "Practical digital and Data Communications with LSI", Prentice Hall of India, 1987.
2. G.B. Clayton, .Operational Amplifiers.,Butterworth &Co,

3. A.K Ray et. Al ,.Advanced Microprocessors and Peripherals., Tata McGrawHill,
4. Oliver Cage, .Electronic Measurements and Instrumentation., McGraw-Hill, (Int. edition) 1975, ISBN 0-07-085544-7

503304(Elective I)
iii] DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)

Principles of Modeling Power Semiconductor Devices – Macro models versus Micro models - Thyristor model - Semiconductor Device modelled as Resistance, Resistance-Inductance and Inductance-Resistance-Capacitance combination - Modelling of Electrical Machines - Modelling of Control Circuits for Power Electronic Switches.

Unit 2 (7 Hrs)

Computer Formulation of Equations for Power Electronic Systems - Review of Graph Theory as applied to Electrical Networks - Systematic method of Formulating State Equations - Computer Solution of State Equations - Explicit Integration method - Implicit Integration method.

Unit 3 (7 Hrs)

Circuit Analysis using Software , A/D - Simulation Overview - Creating and Preparing a Circuit for Simulation - Simulating a Circuit with software, A/D - Displaying Simulation Results - A/D Analyses - Simple Multi-run Analyses - Statistical Analyses - Simulation Examples of Power Electronic systems.

Unit 4 (7 Hrs)

Preparing a Schematic for Simulation - Creating Symbols - Creating - Models - Analog Behavioral Modeling - Setting Up and Running analyses - Viewing Results - Examples of Power Electronic Systems**.**

Unit 5 (7 Hrs)

Design Creation and Simulation with any simulation software - Placing the Parts - Editing the Symbol - Properties - Wiring the Schematic - Modifying Wire Attributes - Performing a Transient and DC Analysis - Placing Probes in the Design - Performing AC Analysis and Invoking

Unit 6 (7 Hrs)

Design of single phase half wave controlled rectifier and full wave controlled rectifier, Design of three phase full wave controlled rectifier. The closed-loop response of the output Voltage for the diode rectifier–boost converter. Using any simulation software.

Text Books

1. V.Rajagopalan: Computer Aided Analysis of Power Electronic Systems - Marcel Dekker, Inc.
2. MicroSim PSpice A/D and Basics+: Circuit Analysis Software, User's Guide, MicroSim Corporation.
3. MicroSim Schematics: Schematic Capture Software, User's Guide, MicroSim Corporation.
4. Multisim user Guide

Reference Books

1. Muhammad H. Rashid , SPICE for Power Electronics and Electric Power 2nd Edition, CRC press

503305(Elective II)
i] FACTS and HVDC

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit I : Introduction (7Hrs)

Basic concepts of reactive power compensation, Types of compensation, Static VAR compensators, Resonance damper, Thyristor controlled series capacitor (TCSC) , Static condenser, Phase angle regulator, and other controllers.

Unit II: Series Compensation Technique (7 Hrs)

Sub-Synchronous resonance, Tensional interaction, Modeling and control of Thyristorised controlled series compensators. Static VAR Compensation - Basic concepts, Thyristor controlled reactor (TCR), Thyristors switched reactor (TSR), Thyristor switched capacitor (TSC), saturated reactor (SR) , and fixed capacitor (FC)

Unit III: Facts Controllers & STATCOM (7 Hrs)

Variable structure FACTS controllers for Power system transient stability, Non-linear variable-structure control, Unified power flow, Unified Power Flow Control - Introduction, Implementation of power flow control using conventional thyristors, concept, Implementation of unified power flow controller. Basics of STATCOM, its applications.

Unit IV: DC Power Transmission Technology (7 Hrs)

Introduction-comparison of AC and DC transmission-application of DC transmission-description of DC transmission system-planning for HVDC transmission-modern trends in DC transmission, Different configuration of HVDC scheme.

Unit V:. Analysis of HVDC Converters (7 Hrs)

Pulse number-choice of converter configuration-simplified analysis of Graetz circuit converter bridge characteristics – characteristics of a twelve pulse converter, Different faults occurred in converter, Protection against overvoltage, over current.

Unit VI :. HVDC System Control (7 Hrs)

General principles of DC link control-converter control characteristics –system control hierarchy – firing angle control-current and extinction angle control-starting and stopping of DC link – power control-higher level controllers – telecommunication requirements. Harmonics and Filters: Introduction-generation of harmonics-design of AC filters-DC filters-carrier frequency and RI noise

Text Books –

1. Barain G. Hingorani, “Understanding Facts”, IEEE Press, New York 2000
2. Yong Hua Sung and Allan T. John (ed), “Flexible AC Transmission System (FACTS)”, The Institution of Electrical Engineering, London 1999.
3. Kimbark E.X., “Direct Current Transmission”, Vol. I, Wiley Interscience, New York, 1971

References –

1. Narin G.Hingorani, "Flexible AC Transmission", IEEE Spectrum, April 1993, pp 40-45.
2. Narin G. Hingorani, "High Power Electronics and Flexible AC Transmission Systems", IEEE Power Engineering Review, 1998.
3. Narin G.Hingorani, "Power Electronics in Electric Utilities: Role of Power Electronics in future power systems", Proc. of IEEE, Vol.76, no.4, April 1988.
4. Einar V.Larsen, Juan J. Sanchez-Gasca, Joe H.Chow, "Concepts for design of FACTS Controllers to damp power swings", IEEE Trans On Power Systems, Vol.10, No.2, May 1995.
5. Gyugyi L., "Unified power flow control concept for flexible AC transmission", IEEE Proc-C Vol.139, No.4, July 1992.
6 Padiyar, K.R., HVDC Power transmission system, Wiley Eastern Limited, New Delhi, 1990.
Edward Wilson Kimbark, Direct Current Transmission, Vol.1, Wiley Interscience, New York, London, Sydney, 1971.
7.Rakosh Das Begamudre, Extra high voltage AC transmission engineering Wiley Eastern Ltd., New Delhi, 1990.

503305(Elective II)
ii] HARMONICS AND THEIR MITIGATION

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)
OVERVIEW Sources of pollution and regulations, various power quality problems, transmission problems and needs.

Unit 2 (7 Hrs)
HARMONICS Effects-within the power system, Interference with communication Harmonic measurements, Harmonic elimination, Harmonic distortion due to various sources

Unit 3 (7 Hrs)
Effects of harmonic distortion, THD calculation, and Harmonic filter design Active and Passive Filters.

Unit 4 (7 Hrs)
MONITORING POWER QUALITY Monitoring essentials, reliability indices, Power quality measuring equipment, Current industry trends, Fourier series, Fourier transform and wavelet transform.

Unit 5 (7 Hrs)
SERIES AND SHUNT COMPENSATION Fundamental of series compensation, principle of operation, TCSC operation in power system, SSSC: principle of operation, Shunt SVC principles, configuration & control, STATCOM, Modelling and applications of series and shunt compensating devices**.**

Unit 6 (7 Hrs)
PHASE SHIFTER Principle of operation, steady state model of static phase shifter, operating characteristics of SPS, power current configuration of SPS application

Text Books

1. Understanding power quality problems, voltage sag and interruptions - M. H. J. Bollen IEEE press, 2000, series on power engineering.
2. Electrical power system quality - Pogei C. Dugan, Mark F. McGranghan, Surya santoso, H. Wayne Beaty, second edition, McGraw Hill Pub.
3. Power system harmonics: Computer modeling and analysis- Enriques Acha, Manuel Madrigal, John wiley and sons ltd.
4.Power System Harmonics – J. Arrillaga & N. Watson

Reference Books

1. Power system quality assessment - J. Arrillaga, M.R. Watson, S. Chan, John Wiley and sons.
2. Electric power quality - G. J. Heydt.

503306: Laboratory Practice – I

Teaching Scheme	*Examination Scheme*
Lab Practice: 6 Hrs/Week	Term Work: 50 Marks

Students should perform at least ten experiments under Lab. Practice – I covering the subjects taught during semester - I

503307: Seminar – I

Teaching Scheme	*Examination Scheme*
Seminar: 4 Hrs/Week	Term Work: 50 Marks

Each student is required to deliver a seminar in first semester on state of art of the topic of his/her own choice. The topic of the seminar should be out of the syllabus and relevant to the latest trends in Power Electronics and Drives. The student is expected to submit the seminar report in standard format approved by the University of Pune.

503308: CONTROLLED ELECTRICAL DRIVES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit I : Converter Fed DC Drives (7 Hrs)

General analysis of Single phase and three phase semi converter and full converter fed drives - separately excited and series motor drives - Evaluation of performance parameters - Dual converter fed drives**.**

Unit II: Chopper Fed DC Drives (7 Hrs)

Single quadrant chopper controlled drives - evaluation of performance parameters for separately excited and series motor drives - Two quadrant and four quadrant chopper controlled drives.

Unit III : Induction Motor Drives (7 Hrs)

Stator control: Stator voltage control of 3 phase induction motors, effect of voltage variation on motor performance by ac voltage controllers - Variable frequency square wave VSI drives - Twelve step inverters for induction motors - PWM drives - CSI drives.
Rotor control: Static rotor resistance control - DC equivalent circuit - Torque equation - slip power recovery- static Kramer drive - AC equivalent circuit - Torque expression**.**

Unit IV : Vector Control of Induction Motors (7 Hrs)

Principle of vector control - rotor flux - oriented control, stator - flux oriented control, Magnetizing flux - oriented control of induction machines.

Unit V : Special Drives (7 Hrs)

Synchronous Motor Drives: Scalar control - True synchronous and self modes - Vector control - Permanent magnet machine control - Switched reluctance motor and stepper motor drives.

Unit VI : Closed Loop Control: (7 Hrs)

Motor transfer function - P, PI, and PID controllers - Current control - Design procedure - Phase locked loop (PLL) control - Microcomputer control.

Text Books

1. Sen, P.C.,"Thyristor DC Drives", John Wiley & sons, New York, 1981
2. Pillai, S.K.,"Analysis of Thyristor Power Conditioned Motors", University Press, 1992.
3. Gopal K.Dubey, ”Fundamentals of Electric Drives", Narosa Publications, 1995.
4. Bimal K.Bose, "Power Electronics and variable Frequency Drives - Technology and Application", IEEE Press, 1997.

Reference Books

1. Peter Vas, "Vector control of Ac machines", Oxford University Press, 1990.
2. Bose, B.K.et.al."Microcomputer control of power electronics and drives", IEEE Press, 1987.
3. Leonard, W,"Control of Electric Drives", Springer Verlag, 1985.
4.R.Krishnan ,”Electric motor drives: Modelling , Analysis and Control”.PH ,1998

503309: POWER ELECTRONIC APPLICATIONS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)
Applications in automobile-Starter electronics, hybrid vehicle system, regenerative braking, electric two wheeler system. Battery chargers

Unit 2 (7 Hrs)
Application in railway system- DC electric locomotive, AC-DC electric locomotive, AC-AC electric locomotive,

Unit 3 (7 Hrs)
Regenerative braking system. AC coach air conditioning system, Railway Signaling system

unit 4 (7 Hrs)
EHV / HV substation system, uninterrupted supply system. Active filter system

Unit 5 (7 Hrs)
Non conventional energy system-Solar system – dc dc converters, battery chargers, inverter system, Wind turbine station – excitation system.

Unit 6 (7 Hrs)
Switch Mode Power Supplies , resonant converters – ZVS, ZCS, Series loaded resonant inverter, Static Reactive Power compensation

Text Book:
1) Electric Traction by A.T.Dover
2) Modern Electric Traction by Prakash.
3) Thyristorised Power Controllers by G.K.Dubey, Dorodla, Joshi& Sinha

Reference Books:

1)Otmar Kilgenstein : Switched Mode Power Supplies in Practice. John Wiley and Sons.

2)Keith H Billings : Handbook of Switched Mode Power Supplies. McGraw Hill Publishing Company.

503310: DESIGN OF POWER ELECTRONIC SYSTEMS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)

Modeling of basic power electronic circuits and Electric drives

Modeling of 1-ϕ, 3-ϕ rectifiers, DC-DC converters and Inverters using MATLAB/SIMULINK Dynamic modeling of DC and AC machines using SIMULINK/ SCI LAB - Basic concepts

Unit 2 (7 Hrs)

Modeling of SMPS

DC transformer model, State Space Averaging and Linearization. AC Small Signal Approximation. Voltage Mode control of SMPS. Transfer Function. General control law considerations. Source to State Transfer Function. Source to Output Transfer Function-stability. Loop Compensation. Switching function approach for modeling of power electronic circuits

Unit 3 (7 Hrs)

Thermal design and modeling

Heat sink design and selection of heat sink

Unit 4 (7 Hrs)

Magnetic component design – Magnetic materials and cores, Copper windings, Thermal considerations, special inductor design and procedure, power and converter transformer design procedure and K-factor transformer design, inductor, magnetic shielding design.

Unit 5 (7 Hrs)

Design of soft starters, design of converters, design of inverters

Unit 6 (7 Hrs)

Design of complete converter inverter system model

Text Books

1.“Advanced Electrical Drives- Analysis, control and modeling using SIMULINK”, Ned Mohan, MNPERE-2001.
2.“Modern Power Electronics and AC drives”, B.K.Bose, Peasron Education Inc., 2002.

3.“Electric Motor Drives- Modeling, Analysis and Control”, R.Krishnan, Prentice Hall Inc., 2001.

Reference Books

1.“Fundamentals of Power Electronics”, 2nd Edition, Robert W.Erickson, Dragan Maksimovic, Kulwer Academic Publishers, 2001

2.“Pulse width modulation for power converters- principles and practice”, D.Grahame Holmes, Thomas A.Lipo, IEEE series on Power Engineering- 2003

503311(Elective III)
i] AUTOMATION IN INDUSTRIAL DRIVES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)

INTRODUCTION Definition, Types of loads, steady state & transient stability of Drive, state of art of power electronics and drives, selection of motor rating.

Unit 2 (7 Hrs)

D.C. DRIVES Review of braking and speed control of D.C. motors, multi-quadrant operation, loss minimization in adjustable speed drives. Mathematical modeling of dc drives, stability analysis, modern control techniques: variable structure, adaptive control.

Unit 3 (7 Hrs)

INDUCTION MOTOR DRIVES Review of braking and speed control of induction motors. constant V/F, constant air gap flux, controlled voltage, controlled current and controlled slip operation. Mathematical modeling of induction motor drives, transient response and stability analysis, Introduction to cycloconverter fed induction motor drive.

Unit 4 (7 Hrs)

SYNCHRONOUS MOTOR DRIVES Adjustable frequency operation, voltage fed drive, current fed self-controlled drive.

Unit 5 (7 Hrs)

AUTOMATION USING DRIVES Introduction, various components of automation, different sensors used in automation, PLC introduction and ladder programming,

Unit 6 (7 Hrs)

Industrial application of automation, sensor less vector control and DTC drive, recent trends in automation and case studies.

Text Books

1. Dubey G.K., Power Semiconductor Controlled Drive, Prentice Hall, New Jersey
2. Sen P.C., Thyristor Controlled DC Drives, Wiley, New York
3. Murphy J.M.D. and Turnbull F.G.,"Power Electronics Control of AC Motors", Franklin Book Co.

Referance Books

1. Bose B.K., "Power Electronics and AC Drives" Prentice Hall, New Jersey
2. Bose B.K. "Power Electronics and Variable Frequency Drives-Technology and applications ", IEEE Press

503311(Elective III)
ii] COMPUTER AIDED DESIGN OF ELECTRICAL MACHINES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit I : Introduction (7 Hrs)

Conventional design procedures -Limitations -Need for field analysis based design.

Unit II : Mathematical formulation of Field problems (7 Hrs)

Development of torque/force -Electromagnetic Field Equations -Magnetic Vector/Scalar potential -Electrical Vector/Scalar potential.

Unit III : (7 Hrs)
Stored energy in field problems –Inductances -Laplace and Poisson's Equations -Energy functional- Principle of energy conversion.

Unit IV : Philosophy of FEM (7 Hrs)

Mathematical Models -Differential/Integral equations -Finite Difference method -Finite Element Method -Energy minimization -Variational method -2D Field problems - Discretisation- Shape functions -Stiffness matrix -Solution techniques.

Unit V : CAD Packages (7 Hrs)

Elements of a CAD System -Preprocessing -Modelling -Meshing -Material properties - Boundary Conditions -Setting up solution –Post processing**.**

Unit VI : Design Applications (7 Hrs)

Design of Solenoid Actuator -Induction Motor -Switched Reluctance Motor –Synchronous Machines.

Text books

1.Silvester and Ferrari, “Finite Elements for Electrical Engineers” Cambridge University press, 1983
2.S.R.H.Hoole, Computer- Aided, Analysis and Design of Electromagnetic Devices,Elsevier, New York, Amsterdam, London, 1989.
3.D.A. Lowther and P.P.Silvester, Computer Aided Design in Magnetics, Springer Verlag, New York, 1956.

References

1.S.J.Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London,1995.
2.C. W. Trowbridge, "An Introduction to Computer Aided Electromagnetic Analysis"' Vector Field Ltd.
3.User Manuals of MAGNET, MAXWELL & ANSYS. Software Packages.

503311(Elective III)
iii] MICRO-CONTROLLERS APPLICATIONS

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)

Role of micro-controllers and its comparison with microprocessors.

Overview of micro-controllers, Architecture of micro-controllers 8051 and Program memory and data memory – Parallel ports – AD and DA converters – Reset circuitry – Watch dog timers – Power down considerations.

Unit 2 (7 Hrs)

Programming Techniques

Overview of programming framework: register structure- Addressing modes – Instruction set – Assembly Language programming – Handling complexity in Assembly language coding**.**

Unit 3 (7 Hrs)

Software building blocks: Queues, Tables and Strings, State machines, Macros and assembler directives. C/c++ programming for 8051

Unit 4 (7 Hrs)

Analog output Interfacing

Solenoids- Relay control and clamping, pick/hold heaters, LED, LCD, DAC, actuators.

Motors- i) Stepper motors- bipolar and unipolar operation, half-stepping and micro-stepping, driving steppers, motor drive ICs

ii) DC motors- driving dc motors, BLDC motor & its driving, DC motor controller.

Unit 5 Designing with peripheral resources and external HW (7 Hrs)

Designing with Timers, High Speed Input, High speed Output, PWM module, ADC for Power electronics control circuit using INTEL 8051
Interfacing external hardware like Driver ICs, sensors and actuators.

Unit 6 (7 Hrs)

Case studies

Case study of 8051 based systems like Numerical protection relays, Intelligent Transformer, Intelligent Switchgear, High efficiency Induction Motors, Electronic speed governors, Auto synchronizing unit.

Text Books

1.”The 8051 Microcontroller and Embedded systems”,M.A.Mazidi and J.G.Mazidi . Pearson Education publishers.
2. .”The 8051 Microcontroller” , I.Scott Mackenzie and Raphael C.W.Phan.Forth edition, Pearson Education publishers.
3.” Embedded system design using The 8051 Microcontroller Family” , Satish Shah. Benison Education publisher

References

1.”The 8051 Microcontroller and Embedded systems using Assembly language and C”, Kenneth.j.Ayela and D.V.Gadre. Cengage Learning publisher
2..” Embedded system design using C8051”, Han-Way Huang. Cengage Learning publisher
3] Stuart R. Ball, "Analog Interfacing to Embedded Microprocessor Systems”, Newnes Publication 2004.

503312(Elective IV)
i] ARTIFICIAL INTELLIGENCE IN ELECTRICAL DRIVES

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper : 100 Marks

Unit 1 (7 Hrs)

ARTIFICIAL INTELLIGENT BASED SYSTEMS

Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller.

Unit 2 (7 Hrs)

ARTIFICIAL INTELLIGENCE: Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic

FUZZY LOGIC: Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

Unit 3 (7 Hrs)

ARTIFICIAL NEURAL NETWORK: Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

Unit 4 (7 Hrs)

EVOLUTIONARY TECHNIQUES: Introduction and concepts of genetic algorithms and evolutionary programming

Unit 5 (7 Hrs)

HYBRID SYSTEMS: Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems

Unit 6 (7 Hrs)

VLSI IMPLEMENTATION OF NEURAL NETWORKS Analog and digital techniques – hybrid systems – special purpose VLSI chips- neuro-fuzzy control system.

Text Books

Rajasekaran S. and Pai G.A.V., "Neural Networks, Fuzzy Logic And Genetic Algorithm Synthesis and applications?, PHI New Delhi.

2. Lin C. and Lee G., "Neural Fuzzy Systems", Prentice Hall International Inc.

Reference Books

1. Goldberg D.E. Genetic Algorithms in Search Optimization & Machine **,** Addition Wesley Co., New York.

2. Kosko B., "Neural Networks & Fuzzy Systems A dynamical systems approach to machine intelligence, Prentice Hall of India.

503312(Elective IV)

ii] SPECIAL TOPICS IN POWER ELECTRONICS AND DRIVES.

Teaching Scheme	Examination Scheme
3 Hours / Week	Paper: 100 Marks

Unit I (7 Hrs)

Three Phase Square Wave /Stepped Wave Inverters. Three Phase SPWM Inverters. Effect of Blanking Time on Inverter Output Voltage. Selective Harmonic Elimination Method.

Unit II (7 Hrs)

Current Regulated Inverter -Current Regulated PWM Voltage Source Inverters. Hysteresis Control - Areas of application of Current Regulated VSI. Switched Mode Rectifier - Operation of Single/Three Phase Bridges in Rectifier Mode. Control Principles.

Unit III (7 Hrs)

Power Factor Control - Shunt Reactive Power Compensators. Switched Capacitors. Static Reactor Compensators based on thyristors. Static Reactive VAR Generators using PWM Current Regulated VSI.

Unit IV

Active Power Filtering. Harmonic Generation by PE Equipment. Harmonic Pollution Standards. PWM Current Regulated VSI based implementation of a Single Phase Active Power Filter.

Unit V (7 Hrs)

Sensorless Vector control of Induction motor drives, Adaptive control of IM drives-self tuning control, model referencing adaptive control(MRAC),sliding mode control(SMC),Space –Phasor model

Unit V I (7 Hrs)

Sensorless control of Synchronous motor drives, Cycloconverter fed Synchronous motors.

Text Books

1. Ned Mohan et al, Power Electronics, John Wiley and Sons, 1989.
2. Rashid .Power Electronics, Prentice Hall India,1993
3. G.K.Dubey et.al , Thyristorised Power Controllers, Wiley Eastern Ltd, 2001.
4. G.K. Dubey & C.R. Kasaravada, Power Electronics & Drives, Tata McGraw Hill, 1993.
5. B. K Bose, Modern Power Electronics and AC Drives, Pearson Education (Asia), 1992.

Reference Books

1. Dewan & Straughen, Power Semiconductor Circuits, John Wiley & Sons, 1984.
2. IETE Press Book, Power Electronics., Tata McGraw Hill
3. Cyril W Lander, Power Electronics,1993

503312(Elective IV)
(iii): Open Elective

Teaching Scheme	Examination Scheme
Theory: 3 Hrs/Week	Paper: 100 Marks

Candidate will have option for any one of the elective subject from the exiting Pune University PG programmers, either from the same Board or from any other Board, with the consent of his guide.

503313: Laboratory Practice – II

Teaching Scheme	*Examination Scheme*
Lab Practice: 6 Hrs/Week	Term Work: 50 Marks

Students should perform at least ten experiments under Lab. Practice – II covering the subjects taught during semester – II.

503314: Seminar – II

Teaching Scheme	*Examination Scheme*
Seminar: 4 Hrs/Week	Term Work: 50 Marks

The student is required to deliver a seminar in second semester on the topic relevant to latest trends in Power Electronics and Drives preferably on the topic of his/her dissertation. The student is expected to submit the seminar report in standard format approved by the University of Pune.

603301 : Seminar– III

Teaching Scheme	*Examination Scheme*
Seminar: 4 Hrs/Week	Term Work: 50 Marks

The Term Work will consist of a report prepared by every student on a seminar topic on Advancement in Technology related to the selected dissertation topic or closely related to dissertation and oral presentation. The student is expected to submit the seminar report in standard format approved by the University.

603302 : Project Stage – I

Teaching Scheme	*Examination Scheme*
Project: 2 Hrs/Week/student	Term Work: 50 Marks

Project Stage – I is the integral part of the dissertation project. The project should be based on the knowledge acquired by the student during the coursework and should contribute to the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems in an area where the student like to acquire specialized skills.

The student should present the progress of the project. It will consist of problem statement, literature survey; project overview and scheme of implementation (block diagram, PERT chart, etc.)

603302 : Project Stage – II

Teaching Scheme	*Examination Scheme*
Project: 2 Hrs/Week/student	Term Work: 150 Marks Oral: 50 Marks

The Project Stage-II will be evaluated on the basis of –

1. Understanding of the problem statement.
2. Physical inspection of the project in case of hardware project.
3. Project Report
4. Oral examination

Term-work will be assessed jointly by a pair of internal and external examiners along with the oral examination of the same.