UNIVERSITY OF MUMBAI

Syllabus Structure (R-2007)

at

B.E.(ELECTRICAL ENGINEERING)

Semester VII

Sr. No	Subjects	Scheme of Instructions, Periods per week (60 min)			Scheme of Evaluation					
					Paper		Term work	Practical and Oral	Oral	Total
		Lecture	Practical	Tutorial	Hours	Marks				
1	Electrical Machine Design	4	**	2	3	100	25	**	25	150
2	Power System Operation and Control	4	2	**	3	100	25	**	25	150
3	High Voltage DC Transmission	4	**	2	3	100	25	**	25	150
4	Control System- II	4	2	**	3	100	25	25	**	150
5	Elective-I	4	**	2	3	100	25	**	25	150
6	Project-I	**	4	**	**	**	25	**	25	50
Total		20	08	06		500	150	25	125	**800**

Elective - I:

1. High Voltage Engineering
2. Analysis and Design of Switched Mode Converters
3. Power System Dyanamics and Stability
4. Illumination Engineering

*One industrial Visit compulsory, its assessment should be included with the relevant subject's Term work

University of Mumbai			
Class:B.E.	**Branch: Electrical Engineering**	**Semester:** VII	
Subject: Electrical Machine Design (Abbreviated as EMD)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Practical and Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	03	150
Course Objective:- This course deals with the design of Electrical Machines as per ISI specifications emphasizing on the materials used along with the design of energy efficient motors and preparing the design drawings using AUTOCAD software.			

Module	Contents	Hours
1	**Introduction** : Introduction to machine design, Standardisation, Magnetic, electrical conducting and insulating materials used in machines.	06
2	**Design of single phase and three phase transformers** Output equation, Main Dimensions, Specific electric and magnetic loadings, Design of core, Selection of the type of winding, Design of LV and HV windings, Design of insulation ,Resistance and leakage reactance of the winding, Mechanical forces, No load current; Cooling of transformers – design of cooling tank and tubes/ radiators, IS:1180,IS:2026; design examples. Recent trends in transformer design.	16
3	**Design of three phase Induction motors**: Output equation, Choice of specific electric and magnetic loadings, Standard frames, Main dimensions, Design of stator and rotor windings, Stator and rotor slots, Design of stator core, air gap, Design of squirrel cage rotor, end rings, Design of wound rotor, Types of enclosures, calculation of leakage reactance, prediction of magnetizing current based on design data, Dispersion coefficient, Modifications of design of induction motors,IS325, IS1231; design examples.	20
4	**Energy efficient induction motors** Energy efficient induction motors and its design aspects (preliminary treatment only)	06

Term work:

1) The complete design of one Three phase transformer and one Three phase induction motor with standard frame size; Minimum four sheets(full imperial size) covering the diagrams of individual parts and the assembled views. At least one sheet should be using AUTOCAD. Design should be based on the Indian Standard Specifications.
2) A brief report should be prepared by each student on Design Aspects of Energy Efficient Induction Motor.

Practical Work (Design, drawing sheets, report on energy efficient IM):15 marks

Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. A.K. Sawhney, "Electrical Machine Design", Dhanpat Rai & Co
2. M.V.Deshpande, " Design and Testing of Electrical Machines", Wheeler & Co.
3. M.G.Say, "Performance & Design of AC Machines", Pitman
4. Indrajit Dasgupta, "Design of Transformers", TMH
5 B.E.Kushare, "Handbook on Energy Efficient Motors", International Copper Promotion Council (India)

Reference Book:

1. K.L.Narang, "Electrical engineering Drawing", Satya Prakashan, New Delhi
2. John C Andreas, "Energy efficient Electric motors: Selection and Applications", Marcel Dekker, New York
3. Howard E Jordan, "Energy Efficient Electric Motors and their Applications", Plennum Press, New York

University Of Mumbai		
Class:- BE	**Branch;- Electrical Engineering**	**Semester:**- VII
Subject: Power System Operation and Control (Abbreviated as PSOC)		

Periods Per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Practical and Oral	----	----
	Oral	----	25
	Term work	----	25
	Total	----	150

Course Objective: - The objective of the course is to bring together the many dimensions and discuss a number of engineering and economic aspects relating to power system operation and control.

Module	Contents	Hours
1	**Load Flow Studies.** Network model formulation, Y bus formation and singular matrix transformation. Load flow problem, Gauss Seidel (GS) methods., Newton Raphson methods (NR) (Polar, Rectangular form). , Decoupled, Fast Decoupled load flow and comparison. Concept of DC loads flow.	10
2	**Economic System Operation** Generator operating cost:- input-output , Heat rate and IFC curve, Constraints in operation, Coordinate equation, Exact coordinate equation, Bmn coefficients, transmission loss formula. Economic operation with limited fuel supply and shared generators, Economic exchange of power between the areas. Optimal unit commitment and reliability considerations	08
3	**Automatic Generation and control** Load frequency control problem, Thermal Governing system and transfer function. Steam Turbine and Power system transfer function, Isolated power system:- static and dynamic response , PI control and implementation. Two area load frequency control, static and dynamic response Frequency biased Tie line Bias control-implementation and effect. Implementation of AGC, AGC in restructured power system, under frequency load shedding, GRC, Dead band and its effect,	12

4	**Inter Change of Power and Energy** Multiple utility interchange transaction, Other types of transactions, Power Pool	04
5	**Power System Stability** Types of Stability Study, Dynamics of synchronous machine, Power angle equation, Node elimination technique, Simple Systems, Steady state stability, Transient stability, Equal area criteria and its applications, Numerical solution of swing equation, Modified Euler's method	10
6	**Power System Securities** System state classification, Security analysis, Contingency analysis, Sensitivity factors	04

Term Work

Term Work shall consist of minimum four programs or four Simulations based on above syllabus and four tutorials covering the entire syllabus carrying a weightage age of 10 marks and a test covering the entire syllabus carrying weightage of 15 marks.

- **Recommended Programs and Simulations**
    1. Y bus formation by singular matrix transformation
       Y bus formation by adding one element at a time
    2. Gauss Siedel Load flow
    3. Optimal loading of generator
    4. Transient stability of single machine.
    5. Simulation of LFC of Isolated power system under different conditions
    6. Simulation of LFC of Two Area power system under different conditions

Books Recommended:

Text Books

1. Kothari. D. P, Nagrath. I. J., Modern Power System Analysis, TMH Publication, Third Edition, 2008
2. Kothari. D. P, Nagrath. I. J., Power System Engineering, TMH Publication, Second Edition, 2008
3. George Kausic. Computer Aided Power System Analysis, Prentice Hall Publication.2008
4. Chakrabarti .A, Halder. S, Power System Analysis- Operation and Control, PHI, Second Edition 2008.
5. Allen. J. Wood., Bruce. F. Wollenberg., Power Generation operation and Control, Wiley India, Second Edition, 2007.
6. Prabha Kundur , Power System Stability and Control , TMH Publication,2008.

Reference Books

1. Soman. S. A, Kharphade. S. A, and Subha Pandit Computer Methods for Large Power System Analysis, an Object Oriented Approach, Kluwer Academic Publisher New York 2001

2. Anderson P.M, Fouad A.A, Power System Control and Stability, Wiley Inter-Science, 2008 Edition

3. Kimbark E W, Power System Stability, Volume I, and III, Wiley Publication.

4. Jr W.D. Stevenson., G. J. Grainger. Elements of Power System. Mc-Graw-Hill, Publication.

5. Hadi Saadat, Power System Analysis**,** TMH Publication ,Second Edition, 2002

University of Mumbai			
Class:B.E.	**Branch: Electrical Engineering**	**Semester:** VII	
Subject: High Voltage DC Transmission (Abbreviated as HVDCT)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	--	
	Tutorial	02	
		Hours	**Marks**
Evaluation System	Theory	03	100
	Practical and Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	---	150
Course Objective:- High voltage dc power transmission is relatively a new technology. The invention of thyristor valves and related technological improvements made wide growth of HVDC system. The HVDC technology is still undergoing many changes due to continuing innovation directed at improving reliability and reducing cost of converters.			

Module	Contents	Hours
1	**HVDC System configuration and Components:** Classification of HVDC links, Components of HVDC transmission system, Comparison of AC and DC Transmission, Application of DC Transmission, Modern trends in DC Transmission, Ground Return- advantages and problems	06
2	**Converter Theory and Performance:** Valve characteristics, Detailed analysis of converter, Converter transformer rating, Multiple bridge converter , Numerical from converter circuit and multiple bridge converter	14
3	**Converter Faults:** Converter Faults types, DC line fault , AC system fault	6
4	**Protection:** Bypass valve,Protection against over-current and over-voltage	6
5	**Control of HVDC System:** Basic Principle of control, Control Implementation, starting stopping and Power flow reversal	6
6	**Converter Firing Control**: Converter Firing-Control System ,Control for Enhancement of AC system performance	4
7	**Harmonics and Filters:** AC side and DC side harmonics ,AC filter and DC filter	6

Term work:

Term work shall consist of at least six MATLAB simulation / assignments carrying weightage of 15 marks

A test covering the entire syllabus carrying weightage of 10 marks.

Text Books:

1. Prabha Kundur, Power system Stability & Control, Tata McGraw Hill Edition
2. Padiyar K.R., HVDC Transmission Systems, 1st Ed., Wiley Eastern Ltd., 1991
3. Kimabrk E.W., HVDC Transmission, 1st Ed., Wiley,1965

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VII	
Subject: Control System II (Abbreviated as CS II)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory Examination	03	100
	Practical and Oral	---	25
	Oral	---	--
	Term Work	---	25
	Total	---	150

Course Objective:- To study this course the basic knowledge of controller is necessary. This course gives the knowledge of classical method of controller design as well as modern control system design. Foundation of automation is also done through this course. The syllabus is industry oriented.

Module	Contents	Hours
1	Design via frequency response: transient and steady state compensation by gain, lag, lead, lag-lead compensator. (This topic will give idea of classical control. It should be explained by simple examples)	04
2	Design via state space: Introduction ,controller design,controllability,alternative approaches to controllers design, observer design, alternative approach to observer design, steady state errors for system in state space, steady state error design via integral control.	12
3	Digital Control System: Introduction,modeling, Z-transform,block diagram reduction,stability,steady state errors, transient response on z plane,cascade compensation via s-plane, implementing digital compensator.	12
4	PID Controllers: Introduction, industrial PID, issues in implementing an industrial PID controller, Integral windup and antiwindup circuits, P and D kicks, different form of industrial PID, Reverse acting controllers.	04
5	Programmable logic controller: Introduction to PLC, its components, different languages of PLC, relay ladder logic circuits, different addressing modes, relationship of data file addresses to I/O moduled,	06
6	Fundamental PLC programming: PLC program Execution, ladder diagram programming languages, relay logic instructions, timer, counters, data manupulation, arithmetic operation instructions,	04

7	Jump and loop instruction, Troubleshooting PLC, simple programs using above instructions., Advanced PLC programming and Troubleshooting	06

Term work:

Five Experiments in virtual lab using any simulation software and three experiments on PLC. The experiments should be based on Case Study.

Practical Work :15 marks

Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Suggested List of experiment to be performed in virtual laboratory:

1. Control system, find the preamplifier gain required for closed loop response of certain specified overshoot for step input.
2. Different compensators design for any system for some defined transient and steady state performance.
3. Design Of controllers for phase variables using pole placement. Antenna control: Stability design and Transient performance using frequency response.
4. To examine the open loop and closed loop frequency response and the effect of addition of poles and zeros
5. Using antenna azimuth position c
6. Design of controllers for the plants not represented in phase variable form.
7. Design of observer for plants in observer canonical form using pole placement.
8. Design of observer for plants not represented in observer canonical form.
9. Simulate the above designs
10. Determine the range of K for stability in digital control system.
11. Determination of Kp, Kv, Ka in digital control system
12. Plot of root locus in Z plan and calculation of transient response performance criteria.
13. Design a digital lead compensator using Tustin transformation
14. Conversion of antenna azimuth position control system in to a digital system. Gain design for given transient response
15. Study the performance of different PID controllers
16. Study of different modified form of controllers. Study of the P-kick and the D-kick
17. Comparison of series and parallel PID
18. Study of reverse acting controller
19. Automation using PLC for reversing contactor
20. Conveyor belt problem of process industry
21. Street light automation
22. Garage door and light automation
23. Counting automation in any manufacturing plant
24. Motor circuit control using PLC
25. Fan and light automation in cinema hall
26. Heating control using PLC

Experiments on automation are to be performed on PLC. All the instructions should be used in the programs.

Books Recommended:

Text books:

1. Norman Nise: Control System Engineering Wiley Students Edition , 4th edition,
2. Jacqueline Wilkie, Michael Johnson, Raza Katebi: Control Engineering an Introductory course: Palgrave Macmillan, 1st edition
3. Bartelt T., Industrial control Elctronics: Devices, System & Application, Delmar Thomson Learning, 1st Edition
4. I G Nagtath and M Gopal: Control System Engineering: Wiley Eastern Limited: 5th edition

Reference Books:

1. Curtis D Johnson, Process Control Instrumentation Technology: Pearson Education : 7th Edition
2. Dunning G., Introduction to Programmable Logic Controllers: Delmar Thomson Learning: 2nd Edition
3. G.F Franklin, Powel, Feedback control of Dynamic System: Pearson Higher education, ISBN 0130980412
4. JJD' Azzo, CH Houpis and S.N. Sheldon: Linear Control system Analysis and Design with MATLAB :Marshal Dekkar, ISBN 0824740386
5. Christopher T. Kilian:Modern Control Technology Components And System; Delmar Cenage learning; 3rd edition.

University Of Mumbai		
Class:- BE	**Branch:- Electrical Engineering**	**Semester:-** VII
Subject:- High Voltage Engineering (Abbreviated as HVE)		

Periods Per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	----	
		Hours	**Marks**
Evaluation System	Theory	04	100
	Practical and Oral	----	---
	Oral	----	25
	Term work	---	25
	Total	---	150

Course Objective: - The main objective is to know the fundamentals of high-voltage laboratory techniques, to provide an understanding of high-voltage phenomena, and to present the basic of high-voltage insulation design and testing together with the analytical and modern numerical tool available to high-voltage equipment designers.

Module	Contents	Hours
1	**Electrostatic Fields, their control and estimation** ▪ Electric field stress, its control and estimation ▪ Analysis of electrical field intensity in Homogenous Isotropic Single dielectric and multi dielectric system. ▪ Introduction to Numerical methods for the estimation of Electric Field Intensity.	06
2	**Conduction and breakdown in air and other gaseous dielectrics in electric fields.** ▪ Ionization processes, Townsend's current growth equation-Primary and secondary processes, Townsend's criterion for breakdown in electronegative gases. ▪ Paschen's law, Breakdown in non-uniform fields and corona discharges. ▪ Post-breakdown phenomenon and application. Practical considerations in using gas for insulation purposes..	09
3	**Conduction and breakdown in liquid dielectrics** ▪ Conduction and breakdown in pure liquids. ▪ Conduction and breakdown in commercial liquids.	04
4	**Breakdown in solid dielectrics** ▪ Intrinsic ,Electro-mechanical and Thermal breakdown. ▪ Breakdown of solid dielectrics in practice. ▪ Breakdown of composite insulation. ▪ Solid dielectrics used in practice. Application of insulating materials in electrical power apparatus ,	08

	electronic equipments.	
5	**Generation & Measurement of High voltage and Currents.** ▪ Generation of HV DC , HV AC and Impulse voltage. ▪ Generation of impulse currents. ▪ Tripping and control of impulse generators. Measurement of HV DC, HV AC and impulse voltage and currents.	07
6	**Testing and evaluation of dielectric materials and power apparatus.** ▪ Non-destructive testing of dielectric materials. ▪ DC resistivity measurement. ▪ Dielectric and loss factor measurement. ▪ Partial discharge measurement. ▪ Testing of insulators, bushing , isolators, circuit breakers, cable, transformers, high voltage motors , surge diverters. Radio interference measurement.	10
7	**High Voltage laboratory–design, planning and layout** ▪ Size and dimensions of the equipment and their layout. ▪ Earthing and its importance.	04

Term Work

At least 6 experiments/assignments and a report on visit to a high voltage laboratory covering the topics mentioned in the above syllabus.

Practical Work :15 marks

Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text books

1. Naidu M. S. and Kamraju V., high voltage engg. TMH publications second ed.,1995
2. Wadhwa C. L. ,High voltage engg ,Wiley Eastern ltd., first ed., 1994
3. Kuffel E. and Abdullah M. 'Introduction to High voltage engg, Pergamon, 1970.
4. Kuffel E. 'High voltage engg, Pergamon, 1984.

Reference Books

1) E. Kuffel, W. S. Zaengl and J. Kuffel High Voltage Engineering Fundamentals Second Edition Elsevier Publication
2) Dieter Kind and Kurt Feser High Voltage Test Techniques (SBA Electrical Engineering Series) by Shankars Book Agency Pvt. Ltd.

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VII	
Subject: Analysis & Design of Switched Mode Converters (Abbreviated as ADSMC)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	**Marks**
Evaluation System	Theory Examination	03	100
	Practical and Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	---	150
Objective:- To give an insight in to the design and fabrication of switched mode converters			

Module	Contents	Hours
1	**DC – DC Switched mode Converters** ▪ Review of Buck Converter, Boost Converter, Buck – Boost ,CUK & SEPIC converter ,Duty cycle derivation, Different conduction modes (CCM & DCM), Voltage and Current waveforms, Calculation of output voltage ripple, Problems.	14
2	**Resonant converters** ▪ Switch - mode inductive current switching, Zero Voltage & Zero Current switching , Resonant switch converters, Basic resonant circuit concepts, Resonant switch converters, ZCS and ZVS resonant switch converters , Comparison of ZCS and ZVS topologies.	06
3	**Switching DC power Supplies** ▪ Linear power supplies, Overview of switching power supplies, Switching losses ▪ Fly back and Forward Converters– duty cycle derivation, waveforms, comparison of converters, Problems	06
4	**Control Aspects** ▪ Voltage feed- forward PWM control, current mode control ,Power supply protection , Electrical isolation in the feedback loop, Designing to meet power supply specifications	04

5	**Converter Design** (for Buck, Boost , Flyback & Forward Converters only) ▪ Selection of output filter capacitor, Selection of energy storage inductor, Design of high frequency Inductor and high frequency transformer, Selection of switches . ▪ Snubber circuit design, Pulse width modulator circuit, Design of driver circuits, Necessity of EMI filter	14
6	**Thermal Model** ▪ Thermal resistance , Selection of Heat sinks , Simple heat sink calculations	02
7	**Applications** ▪ DC/DC converter as Power factor Corrector (active shaping of the line current) ▪ Offline computer power supply system, Uninterruptible ac power supplies, Space craft power supply etc	02

Theory Examination:

1. Question paper will comprise of total 7 questions, each of 20 marks.
2. Only 5 questions need to be solved.
3. Q.1 will be compulsory and based on the entire syllabus.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus

Term work:

Term work shall consist of three tutorials , two simulations and fabrication of a switched mode dc-dc converter. Practical Work :15 marks

Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of practical work and minimum passing in the term-work.

Books Recommended:

Text Books

1) Mohan N. Undeland . T & Robbins W., "Power Electronics Converters , Application and Design" John Wiley, 3rd edition , 2002
2) Umanand L., Bhat S.R., "Design of magnetic components for switched Mode Power converters" , Wiley Eastern Ltd.,1992
3) Robert. W. Erickson, D. Maksimovic "Fundamentals of Power Electronics", Springer International Edition, 2005

Reference books

1) Krein P.T "Elements of Power Electronics" ,Oxford University Press
2) M.H.Rashid, "Power Electronics", Prentice-Hall of India

University Of Mumbai			
Class:- BE	**Branch;- Electrical Engineering**	**Semester:-** VII	
Subject: Power System Dynamics and Stability (Abbreviated as PSDS)			
Periods Per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	00	
		Hours	**Marks**
Evaluation System	Theory	04	100
	Practical and Oral	----	---
	Oral	----	25
	Term work	---	25
	Total	---	150
Course Objective: - The objective of the course is to study the system dynamics which has a Significant bearing on integrality of the system following major disturbances.			

Module	Contents	Hours
1	**Synchronous Machine Modeling And Representation** Basic equations of synchronous machine, dqo transformation, Per unit- voltage- flux- torque- power equations and reactance, Equivalent circuit d-q axis, Voltage current flux linkage relation- phasor representation- rotor angle-steady state equivalent circuit Three phase short circuit, Magnetic saturation and representation Simplifications for large scale studies, Constant flux linkage model	14
2	**Excitation System** Excitation system requirement Elements of excitation system Types of excitation system Dynamic performance measures Control and protective functions Basic elements of different types of excitation system	10
3	**Small Signal Stability (SSS)** Fundamental concept of stability of dynamic system, Eigen properties of state matrix, SSS of single machine infinite bus system, Effect of AVR on synchronizing and damping torque, Power system stabilizer, SSS of multi-machine system,	12

	Special techniques to analyze large system, Characteristics of SSS, SSS Enhancement.	
4	**Voltage Stability** Basic concepts, Voltage collapse, Voltage stability analysis, Prevention of voltage collapse	12

Term Work

Term Work shall consist of minimum four, computer programs or four Simulations, and four tutorials covering the entire syllabus carrying a weightage of 10 marks and a test covering the entire syllabus carrying weightage of 15 marks.

Recommended Computer Simulations

- Demonstration of the Three-Phase Programmable Source, Sequence Analyzer, and abc_dq0 transformation blocks.
- Synchronous generator powered by hydraulic turbine with excitation and governor systems.
- Torque amplification study: IEEE second benchmark on sub synchronous resonance (case 1A)
- Performance of Three PSS for Inter area Oscillations.
- Transient stability of a two-machine transmission system with Power System Stabilizers (PSS) and Static Var Compensator (SVC).

Text Books

1. Prabha Kundur , Power System Stability and Control , TMH Publication,2008
2. Padiyar K R, Power System Dynamics- Stability and Control, BSP Publication.

Reference Books

3. Kimbark E W, Power System Stability, Volume I, III, Wiley publication.
4. Jr W.D. Stevenson., G. J. Grainger. Elements of Power System. Mc-Graw-Hill Publication.
5. Anderson P.M, Fouad A.A, Power System Control and Stability, Wiley Inter-Science, 2008 Edition
6. Saur P W, Pai M A, Power System Dynamics and Stability, Pearson Education Asia
7. Pai, Sen Gupat, Padiyar, Small Signal Analysis of Power System, Narosa Publication, 2007 Edition.

University of Mumbai			
Class: B.E.	**Branch:** Electrical Engineering	**Semester:** VII	
Subject: Illumination Engineering (Abbreviated as I.E.)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	02	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory Examination	03	100
	Practical and Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	---	150
Course Objective:- To get detailed insight into illumination system components, its controls and design aspects in order to know the requirements of proper and energy efficient lighting.			

Module	Contents	Hours
1	**Light, Sight, Color and Photometry** Electromagnetic radiation, Laws of illumination, illumination entities. Photopic and Scotopic vision of human eye. Radiometric and photometric standards, Choice of right detector, detector specification-construction, details of luminous flux, luminance, illuminance and luminous intensity measuring meters. Photometric measurement procedure-preparation of test report. Spectral power distribution data– assessment of lamp efficacy, Color temperature, Colorimetry-Different color specification systems and their limitations. Measurement of CRI, CRI of radiation due to multiple sources, Glare	06
2	**Lamps and Luminaries** Lamp development, construction and characteristics: Incandescent lamp, Discharge lamps: fluorescent lamps, CFL, mercury vapor, sodium vapor, metal halide and induction lamp. LED and its application in lighting. Lamp testing procedures. Light field, Optical control methods, Advanced techniques of using reflection, refraction, polarization, interference, diffraction, diffusion and absorption in optical control. Materials used for Luminaire manufacturing. Control gear: ballast, standard and electronic type Basics of Mechanical, thermal and electrical design of luminaire. Luminaire photometry, Luminaire testing procedures. Introduction to Luminaire for hazardous area application	10

3	**Interior Lighting Design & Calculation** Objectives, quality and quantity of lighting. Lamp /Luminaire selection and placement, design considerations and calculation. Glare Consideration and control. Principal of lighting design- Indoor lighting design by lumen method, by point by point method. Designing problems and solution and designing documentation for: applications like residential, offices, educational institute, industries, religious buildings, art galleries/museums, retail stores, indoor sports centers, eating outlets etc. Applicable IS standards	16
4	**Exterior Lighting Design & Calculation** Exterior lighting system- Road lighting system, Utility area lighting, Sports lighting, Decorative flood lighting. Design Consideration for Emergency lighting. Applicable IS standards	10
5	**Lighting Monitoring and Control** Lighting control strategies, techniques & equipment, sensors and timers, Impact of lighting control, protocols for lighting control	02
6	**Day lighting Design and Analysis** Daylight availability data and analysis. Lighting integration- daylighting / electric lighting integration. Daylight control and distribution	02
7	**Energy Efficient lighting and Lighting Design software tools** Designing techniques for achieving energy efficiency, Concept of Lighting power density, Software design tools for interior lighting, road lighting, flood lighting. Advantages and limitations	02

Term Work:

1: Four lab experiments based on study of lamps and luminaries operation and construction parameters measurements
2: Group study report on observation and analysis of existing lighting installation (at least 4) at following areas commercial/ non commercial, industries/offices, indoor/outdoor, sports center etc.
3: Minimum two designs on interior and exterior lighting based on specific applications. Design calculation and computer aided design

The distribution of the Term Work shall be as follows,

Practical Work (experiments, visit reports and design problems) : 15 Marks
Tests : 10 Marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work

Books Recommended:

Text Books:

1. "Designing with light: Lighting Handbook", Anil Valia;Lighting System 2002
2. "Lamps and Lighting", M.A. Cayless and A.M. Marsden; Edward Arnold

3. “Interior Lighting for Designers”, Gary Gorden, ;John Wiley & Sons Inc.

Reference Book:

1. “IESNA lighting Handbook”, Illuminating Engineering Society of North America 9th edition 2000
2. “Simplified Design for Building Lighting”, M.Schiler; John Wiley & Sons Inc
2. IS 3646 : Part I : 1992, *Code of practice for interior illumination*

UNIVERSITY OF MUMBAI

Syllabus Structure (R-2007)

at

B.E.(ELECTRICAL ENGINEERING)

Semester VIII

Sr. No	Subjects	Scheme of Instructions, Periods per week (60 min)			Scheme of Evaluation					
		Lecture	Practical	Tutorial	Paper		Term work	Practical and Oral	Oral	Total
					Hours	Marks				
1	Design, Management and Auditing of Electrical System	4	2	**	3	100	25	**	25	150
2	Drives and Control	4	2	**	3	100	25	25	**	150
3	Power System Planning and Reliability	4	**	2	3	100	25	**	25	150
4	Elective-II	4	**	2	3	100	25	**	25	150
5	Project-II	**	8	**	**	**	50	**	50	100
Total		16	12	4		400	150	25	125	700

Elective - II:

1.Power Quality
2. Electric Traction
3.Flexible AC Transmission Systems
4. Digital Signal Processors Applications in Power Systems

University of Mumbai			
Class:B.E.	**Branch: Electrical Engineering**	**Semester:** VIII	
Subject: Design, Management and Auditing of Electrical System (Abbreviated as DMAES)			
Periods per Week (Each 60 min)	Lecture	**04**	
	Practical	**02**	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory Examination	**03**	**100**
	Practical and Oral	**---**	**---**
	Oral	**---**	**25**
	Term Work	**---**	**25**
	Total	---	**150**
Course Objective:- To get conceptual understanding of design of electrical systems, their management and auditing procedures.			

Module	Contents	Hours
1	**Introduction** Types of electrical Projects, types of electrical systems, review of components of electrical system Different plans/ drawings in electrical system design, single line diagram in detail, Introduction to Energy Conservation Act 2001, Basics of tendering and estimation, Review of Economic and financial analysis techniques: time value of money, Simple payback, IRR.	04
2	**Design of Power Distribution System** Different types of distribution systems and selection criteria, Temporary and permanent power supply, Electrical load: size, LF, DF, future estimates, Substation equipments options, Design considerations in: Transformer selection, sizing and specifications. IS standards applicable in above designs.	08
3	**Design of Switchgear Protection and Auxiliary system** Selection of HT/LT switchgears, Metering, Switchboards and MCC, Protection systems, co-ordination and discrimination; Cables: selection and sizing, cable installation and management systems, bus-bars; Basics of Selection of emergency/backup supplies, UPS, DG set, Batteries; Preliminary design of interior lighting system. IS standards applicable in above designs.	10
4	**Monitoring and Management of Electrical Systems** Energy Monitoring and Targeting: Defining monitoring & targeting, Elements of monitoring& targeting, Energy analysis techniques for	12

	energy optimization. Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses, Introduction to Energy Efficient Technologies in Electrical Systems: Maximum Demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls, Energy saving potential of each technology. SCADA, Energy Management System (EMS) and Building Management System (BMS) systems	
5	**Energy Audit** Definition, Energy audit-need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments: Audit of installations comprising following with respect to their electrical energy usage: Electric motors, HVAC systems , Fan and blowers systems, Compressed air systems Pumps, DG sets, Lighting installations etc. Evaluation of energy conservation opportunities. Energy conservation in buildings, Economic and non economic aspects of energy conservation in electrical systems	12
6	**Use of Renewable and Green building Concept** Impact of renewable energy sources in electrical system design, Concept of green building and its accreditation	02

Term work:

1: Design based on following case studies with complete design calculation and diagrams/ drawings/ layouts (at least three)

i) Power distribution network: Substation design
ii) Lighting installation
iii) Cable selection
iv) Switchgear and protection system design
v) Emergency / backup system design
vi) Power factor Improvement system

2: Preliminary Audit report on observation and analysis of existing electrical installation (at least two)

3. Three Assignments / case studies based on module 1 and 4

The distribution of the Term Work shall be as follows,

Practical Work : 15 Marks
Tests : 10 Marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. "Handbook of Electrical Installation Practice" , By Geofry Stokes, Blackwell Science
2. "Designing with light: Lighting Handbook", By Anil Valia, Lighting System
3. "Energy Management Handbook", By W.C. Turner, John Wiley and Sons
4. "Handbook on Energy Audits and Management", edited by Amit Kumar Tyagi, Tata Energy Research Institute (TERI).

Reference Book:

1. " Energy Auditing Made Simple", By P.Balasubramanian ,Seperation Engineers (P) Limited
2. "Energy Management Principles", By C.B.Smith, Pergamon Press
3. "Energy Conservation Guidebook", Dale R. Patrick, Stephen Fardo, Ray E. Richardson, Fairmont Press
4. "Handbook of Energy Audits", By Albert Thumann,William J. Younger, Terry Niehus, CRC Press

Websites:

1. ***www.energymanagertraining.com***
2. ***www.bee-india.nic.in***

UNIVERSITY OF MUMBAI			
CLASS B.E	**Branch : Electrical Engineering**	**Sem VIII**	
Subject : Drives and control (abbreviated as DC)			
Periods per week(Each 60 min)	Lecture	**4**	
	Practical	**2**	
	Tutorial	**--**	
		Hours	**Marks**
Evaluation System	Theory	**3**	**100**
	Practical and oral	**---**	**25**
	Oral	**---**	**--**
	Term work	**---**	**25**
	Total	**---**	**150**

Course Objectives: This course is designed to understand fundamentals of electric drives and their control through knowledge of electrical machines and power electronics. The scope of this course covers basics, dynamics, selection, braking, and control of AC DC drives. Students' are expected to learn more by studying application of drives in industry.

Module	Contents	Hours
1	**Electrical Drives** Introduction, Advantages of Electrical Drives, Parts of Electrical Drives, Choice of Electrical Drives, Status of DC and AC Drives	3
2	**Dynamics of Electrical Drives** Fundamental torque equations, Speed torque conventions and multi quadrant operation, Equivalent values of drive parameter, Measurement of moment of inertia, Components of load torques, Nature and classification of load torques, Calculation of Time and Energy-Loss in transient operations, Steady state stability, Load equalization	7
3	**Selection of Motor Power Rating** Thermal Model of motor for heating and cooling, Classes of motor rating, Determination of motor ratting	5
4	**Control of Electrical Drives** Modes of operation, Speed control drive classification, Closed loop control of drives	4
5	**DC Drives** Speed torque relations for shunt, Series and separately excited motors, Starting, Braking – Regenerative, Dynamic, Plugging, Speed control- Armature voltage, Field flux, Armature resistance, Methods of voltage Control – Ward Leonard scheme, Controlled rectifiers, Controlled rectifier fed DC drives(separately excited only)- Single phase fully-controlled rectifier, Single phase half controlled rectifier, three phase fully-controlled rectifier, three phase half-controlled rectifier, dual converter control, Chopper Control – Motoring and braking of separately excited and series motor.	12
6	**AC Drives** Induction Motor drives, Review of speed-torque relations, Review of Starting methods Braking- Regenerative, Plugging, Ac dynamic	12

	braking, Speed Control- stator voltage control, variable frequency control form voltage source, Vector Control (Elementary treatment only), Introduction to Synchronous Motor variable speed drives.	
7	**Special Motor drives** Stepper Motor drives- Types, Torque Vs Stepping rate characteristics, Drive circuits, Introduction to Brushless DC drives, Introduction to Switched reluctance drives	5

Term work:
Term work will consist of at least 6 experiments /assignments performed, properly recorded and graded, which will carry weightage of 15 marks and the test will carry weightage of 10 marks.

List of Practicals.

1. Simulation of electrical drive.
2. Simulation of Starting of D. C. Motor (soft start)
3. Dynamic Braking of D. C. motor.
4. Plugging of D. C. Motor / Plugging while lowering the load.
5. Regenerative braking of D. C. motor. (by making V< Eb for high inertia load.)
6. DC or AC dynamic braking of 3 phase induction motor.
7. Plugging of Induction Motor.
8. Single Phase full wave controlled D. C. motor drive
9. Chopper drive.
10. V/F control of Induction Motor using PWM inverter.
11. Measurement of moment of inertia by retardation test.
12. Study of Stepper Motor Drive.

Books Recommended:

Text books:

1. Dubey G.K, fundamentals of electrical drives, Narosa .
2...Subrahmanyam .V. Electrical Drives: concepts and applications TMH
3. Krishnan R , Electric motor drives: modeling, analysis and control PHI
4. Pillai s.k A first course on electrical drives, willey eastern ph

Reference books:

1. Bose B.K Modern Power electronics and AC Drives, Pearson Education Asia
2. Rashid M.H, Power electronics: circuits, Devices and Applications, PHI

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VIII	
Subject: Power System Planning and Reliability (Abbreviated as PSPR)			
Periods per Week (Each 60 min)	Lecture	04	
	Practical	--	
	Tutorial	02	
		Hours	**Marks**
Evaluation System	Theory Examination	03	100
	Practical and Oral	---	---
	Oral	---	25
	Term Work	---	25
	Total	---	150
Course Objective:- To understand the different power system planning/forecasting techniques and reliability evaluation in terms of basic reliability indices.			

Module	Contents	Hours
1	**Load Forecasting:** Introduction, Classification of Load, Load Growth Characteristics, Peak Load Forecasting, Extrapolation and Co-Relation methods of load Forecasting, Energy Forecasting, Reactive Load Forecasting, and Impact of weather and Factors affecting load Forecasting, Annual, Monthly and Total Forecasting.	8
2	**System Planning:** Introduction to system planning, Its Objectives & Factors affecting to System Planning, Short, Medium and Long Term Planning, Reactive Power Planning.	8
3	**Generation and Transmission planning:** Objectives of generation planning, Factors affecting Generation Planning, Sources of Generation. Objectives of transmission planning Network Reconfiguration,	6
4	**Fundamentals of Power system Reliability** Concepts, Terms and Definitions, **o**utage, failure rate, and outage rate availability, unavailability, Reliability models, Morkov process Reliability function, Mean time to failure, Hazard Rate Function, Bathtub Curve	05
5	**Reliability of Systems** Serial Configuration, Parallel Configuration, Combined Series – Parallel Systems, System Structure Faction, Minimal Cuts and Minimal Paths	06

6	**Generating Capacity: Basic probability methods and Frequency & Duration method**: Introduction, , Generation system model, capacity outage probability table, recursive algorithm, Evaluation of: loss of load indices, Loss of load expectation, Loss of energy	06
7	**Operating Reserve:** General concept, PJM method, Modified PJM method, Security function approach	06
8	**Composite generation and transmission system:** Data requirement, system and load point indices, Impact of component outage on the system reliability, application to simple system	06

Term Work:

The term work will consist of at least Six Simulations/Computer Programs/Assignments
The distribution of the Term Work shall be as follows,
Practical Work (Computer Program/simulations) : 15 Marks
Tests : 10 Marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work

Books Recommended:

Text Books:

1. Roy Billinton and Ronald N Allan, 'Reliability Evaluation of Power System', Plenum, Press, 1984
2. Power System Planning - R.L. Sullivan, Tata McGraw Hill Publishing Company

Reference Book:

3. Roy Billinton and Ronald N Allan 'Reliability Assessment of Large Electric Power Systems', Kluwer academic publishers, 1988
4. Modern Power System Planning – X. Wang and J.R. McDonald, McGraw Hill

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VIII	
Subject: Power Quality (Abbreviated as PQ)			
Periods per Week (Each 60 min)	Lecture	**04**	
	Practical	**02**	
	Tutorial	---	
		Hours	Marks
Evaluation System	Theory	**03**	**100**
	Practical and Oral	**---**	**---**
	Oral	**---**	**25**
	Term Work	**---**	**25**
	Total	---	**150**
Objective:- To get awareness about latest and future problems in power system due to nonlinear load and its solution.			

Module	Contents	Hours
1	**Introduction** Overview of Power Quality- Power Quality- Voltage Quality- Disturbances-Unbalance-Distortion-Voltage Fluctuations-Flicker-Quality Assessment	04
2	**Power Quality Indices & standards** Classification of power Quality phenomena-Disturbances-Waveform distortion - Voltage unbalance-voltage fluctuation & flicker	04
3	**Non-linear Loads in Power system (Only short notes)** CFL lamps- HVDC Transmission-HVDC Light-Static Var Compensator (SVC)-Thyristor Controlled Series Compensator (TCSC)-Static Compensator (STATCOM)-Static Synchronous Series Compensator (SSSC)-Unified Power Flow Controller (UPFC)- Distributed Generators	06
4	**Non-sinusoidal waveforms under steady state** Fourier Analysis of Repetitive waveforms-Line Current Distortion-Power and Power Factor	04
5	**Effects of harmonics** Rotating Machines – Transformers – Cables – Capacitors – Harmonic resonance – Voltage Notching – EMI (Electromagnetic Interference) – Overloading of Neutral – Protective relays and Meters – Circuit Breakers and fuses – Telephone Influence Factor	08

6	**Harmonic mitigation** Mitigation of harmonics- Passive filters(no design)- Limitation of passive filters- Active filters-shunt connection, series connection and hybrid connection	08
7	**Load Compensation Using DSTATCOM** Compensating Single-Phase Loads-Ideal Three-Phase Shunt Compensator Structure-Generating Reference Currents Using Instantaneous PQ Theory (with problems)	08

Term work:

Term Work will consist of four **assignments**, minimum one **simulation** and one **seminar** on power quality from IEEE Journal Paper

Laboratory work (Tutorial, simulation and seminar) :15 marks
Test (at least one) :10 marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Suggested List of Simulations:

1. Simulation on any power electronic devices(as given in module 3.) connected to power system and see how it affects the shape of current and voltage
2. Connect passive filter to the same load and see how it affects power factor and THD
3. Connect active filter to the same load and see its effect on shape of input current

Books Recommended:

Text Books:

1. " Power System Quality Assessment", J. Arrillaga, N.R.Watson, S.Chen
2. "Power Quality Enhancement Using Custom Devices" Arindam Ghosh, Gerard Ledwich
3. "Power Electronics" Ned Mohan, Undeland, Robbins, John Wiley Publication
4. "Power System Analysis- Short Circuit Load Flow and Harmonics" J.C.Das.
5. " Understanding Power Quality Problems,Voltage Sag and Interruptions " Math H.J.Bollen

Reference Book:

1. "Power System Harmonics" Jos Arrillaga, Neville R Watson
2. "Electric Power Quality" , G.T.Heydt
3. "Electric Power Systems and Quality" , Roger C. Dugan,Mark F. McGranaghan, H.Wayne Beaty
4. "IEEE-519 Standard"

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VIII	
Subject: Electric Traction (Abbreviated as E.T.)			
Periods per Week (Each 60 min)	Lecture	**04**	
	Practical	--	
	Tutorial	**02**	
		Hours	Marks
Evaluation System	Theory	**03**	**100**
	Practical and Oral	**---**	**---**
	Oral	**---**	**25**
	Term Work	**---**	**25**
	Total	---	**150**
Course Objective:- To impart the knowledge on electric traction as it is one of the most important application of Electrical Engineering.			

Module	Contents	Hours
1	**Electric Traction- Principle and History** • Systems of traction.,The Indian Scenario, vis-à-vis Electric traction. • Present day State of art. • Electric traction as a Viable Transport Strategy for the 21st century. • Advantages of Electric Traction over other systems of traction. • Choice of traction system - Diesel- Electric or Electric.	02
2	**Mechanics of train movement** • Speed - time curve for train movement. • Requirement of tractive effort and T-N curve of a typical train load. • Specific energy consumption. & Factors affecting SEC.	07
3	**Adhesion, types of suspension and mechanism of torque transmission** • Adhesion & Coefficient of adhesion, • Suspension and mechanism of torque transmission, • Concept of Weight Transfer & Effect of unsprung mass and wheel diameter	07
4	**Traction Motor** • Type of traction motor best suited for traction duties. • Available motor characteristics and their suitability for traction duties. • Optimization of design and construction features for improved power to weight ratio.	05
5	**Traction motor drives - Principles and gear** • Power Factor and Harmonics • Tractive Effort and Drive Ratings • Important Features of Traction Drives	10

	• Conventional DC and AC Traction drives • Semiconductor Converter Controlled Drives • DC Traction using Chopper Controlled Drives • Poly phase AC motors for Traction Motors • DC /AC Traction employing Polyphase motors • Diesel Electric Traction • Traction control of DC locomotives and EMU's • Traction control system of AC locomotives • Control gear • PWM control of induction motors • Power & Auxiliary circuit equipment (Other than traction motors)	
6	**Protection of electric locomotive equipment and circuits (Safety considerations and monitoring)** • Broad strategy for protection • Surge protection • Overload protection of main power circuits • Earth fault protection of power of auxiliary circuits • Protection from over-voltage and under-voltage • Differential protection of traction circuits • Protection against high and low air pressure in the compressed air circuit. • Temperature monitoring. • Protection of transformer by Bucholz relay • Protection against accidental contact with HT equipment • Protection against fires.	`
7	**Electric Traction Sub-Systems (Overhead Equipment)** • Overhead Equipment (OHE) • Sectionalizing • Bonding of Rails AND Masts • Materials Employed in OHE	05
8	**Railway Signalling** : • Block Section Concept,Track Circuits • Interlocking Principle • Train speed and signalling • Solid state Interlocking • Automatic Warning Systems • CAB signaling • Signaling level crossing	04
9	**Electric Traction Sub-Systems (Power Supply Installations)** • Lay out design of 137/25 KV Traction Substation/ Protection • Booster Transformers and Return Conductor. • Salient 2x25 kv AC System/ SCADA .	03

Termwork

Termwork shall consist of at least six experiments/assignments carrying weightage of 15 marks and a test covering the entire syllabus carrying weightage of 10 marks.

Text Books:

1. Upadhayay J. & Mahindra S.N., *Electric Traction,* Allied Publishers Ltd., 1st Ed.
2. Rao P.S., *Principle of 25 KV Overhead Equipments.*R.(Nasik) Printpack Pvt Ltd,, 1st Ed,
3. Fundamentals of Electric Drives , Gopal K Dubey, Narosa Publishing.
4. Modern Electric Traction, Partab, Dhanpat Rai & Sons

Websites

www.irieen.com (Indian Railways Institute of Electrical Engineering, Nasik Road)
www.wr.railnet.gov.in/bctweb/ELECTRICAL.htm
www.scrailway.gov.in

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**		**Semester: VIII**
Subject: Flexible AC Transmission Systems (Abbreviated as FACTS)			
Periods per Week	Lecture	**04**	
	Practical	---	
(Each 60 min)	Tutorial	**02**	
		Hours	Marks
Evaluation System	Theory Examination	**3**	**100**
	Practical and Oral	**--**	**--**
	Oral	**--**	**25**
	Term Work	**--**	**25**
	Total	--	**150**
Course Objective:- To develop the ability among students for problem formulation and finding solution and also, it open up wide area in research.			

Module	Contents	Hours
1.	**FACTS Concepts and General System Considerations:** Transmission Interconnections- Flow of Power in 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- Benefits from FACTS Technology	4
2.	**Load Compensation:**Reactive Power (VAR) Compensation for isolated loads - Power factor correction-Voltage Regulation-V-Q characteristics for an inductive load-System load line-Effect of characteristics of VAR compensators in terms of short circuit levels-Load balancing in 3-phase loads with parallel compensation	8
3.	**Transmission Line:** Wave equation-Standing Waves-surge impedance and SIL-Voltage and current profile along unloaded line-Ferranti effect-Effect of loading on reactive power requirement-Compensated transmission line-Uniformly distributed fixed compensation-Effect of distributed compensation on line charging reactive power	12
4.	**Voltage Control:** Tap changing transformers-Booster transformers -Static voltage regulators-Thyristorised series voltage injection	4
5.	**Types of compensators:** Passive and active compensators-Shunt reactor/ capacitor compensators-Single-Multiple-Mid-point-Static compensators-Control schemes and characteristics of FC-TCR-TCR-TSC-TSC and other combinations	10
6.	**Dynamic compensation:** Introduction-Effect on stability of a power system	2
7.	**Unified Power Flow Controller (UPFC):** Basic relationships for power flow control-Synchronous Voltage sources-Implementation of synchronous voltage source-Shunt compensation by synchronous voltage source-Reactive power compensation scheme-Series compensation by synchronous voltage source-Reactive series compensation-Unified power flow concept	8

Term work:

Term Work will consist of Eight **Tutorials/Simulations**

Laboratory work (Tutorial/ simulation) :15 marks

Test (at least one) :10 marks

Books Recommended:

Text Books:

1. Miller T.J.E..,Reactive power control in Electric Systems , Wiley Europe, 1st Ed.1983.
2. Hingorani N.G.. & Gyugi L., Understanding FACTS : Concepts and Technology of Flexible AC Transmission Systems, Wiley-IEEE Press, 1st 1999

University of Mumbai			
Class: B.E.	**Branch: Electrical Engineering**	**Semester:** VIII	
Subject: Digital Signal Processors Applications in Power Systems (Abbreviated as DSPAPS)			
Periods per Week (Each 60 min)	Lecture	**04**	
	Practical	**02**	
	Tutorial	**---**	
		Hours	Marks
Evaluation System	Theory Examination	**03**	**100**
	Practical and Oral	**---**	**---**
	Oral	**---**	**25**
	Term Work	**---**	**25**
	Total	---	**150**
Course Objective:- To get awareness about DSP hardware implementation for control and signal processing applications in the field of power systems			

Module	Contents	Hours
1	**Introduction:**Review of microprocessor, microcontroller and digital signal processors architecture, Fixed and floating-point processors and microcontrollers: TMS320 series family	04
2	**Number Representations in DSP processors:** Number formats and operations: Fixed point 16 bit Numbers representations of signed integers and fraction, Q-15 numbers and its operations. Floating Point Numbers. Assemblers and assembly language programming, Binary file formats, COFF file structure for TMS320 processor.	08
3	**DSP Architecture and programming:** Architectural details of TMS320VC33 and TMS320F2407 Memory map, interrupts and addressing mode, programming with assembly language and C compiler	08
4	**Power Electronics applications in Power systems:** Review of power electronics applications: Control applications, Active filtering, Static VAR Compensator, Electric Drives, Hardware in Loop simulations. Implementing power electronics control on digital systems. Issues of harmonics and unbalanced currents in power systems, Harmonic Extraction of current components, Implementation of Active filters in DSP under balanced and unbalanced conditions: reference frame transformation, harmonic oscillator, 3ϕ phase lock loop, oscillator synchronization	20
5	**Integration Methods for Real Time DSP implementation:** Review of numerical integration: Euler's implicit and explicit method, Heun Method, Trapezoidal Method. Implementation of low pass filter.	04

6	**Control Applications of DSP processor:** Generation of PWM signals, sine PWM, ADC interface; basics of implementation of converter control for renewable energy sources: Solar, wind and Fuel cell systems	04

Term work:

1. Implementation of following in DSP architecture: (Any Six)
    a. Number operations on fixed point / floating point processor
    b. Implementation of calculation of any mathematical series like exponential, logarithm etc.
    c. Implementation of Harmonic oscillator
    d. Implementation of Low pass filter
    e. Implementation of reference frame transformation
    f. Generation of PWM signals
    g. Generation of Sine PWM Signals
    h. Converter control application with DSP

2. Minimum two assignments/ tutorials based on theoretical part of the syllabus

The distribution of the Term Work shall be as follows,
Practical Work : 15 Marks
Tests : 10 Marks

The final certification and acceptance of term-work ensures the satisfactory performance of laboratory work and minimum passing in the term-work.

Books Recommended:

Text Books:

1. "Power Electronics, Converters, Applications & Design", N.Mohan, T.M.Undeland, W.P Robbins, Wiley India Pvt.Ltd.

2. "Modern Power Electronics and AC Drives", B. K Bose, Perason Education

3. "Understanding FACTS", N. G. Hingorani, & Laszlo Gyugyi, IEEE press

4. "Digital signal Processing: A practical Approach", E. C. Ifeachor & B. W. Jervice, Pearson Education

Reference Book:

1. "Numerical Methods for scientific and Engineering Computation", M. K. Jain, S.R.K. Iyengar & R. K. Jain, New Age International Publications
2. "Digital Signal Processing: Principle, Algorithm, & Applications", J.G. Proakis & D. G. Manolokis, Pearson Education
3. TMS320VC33 processor datasheet
4. TMS320F2407 processor datasheet
5. TMS320VC33 Starter Kit manual
6. TMS320F2407 Starter Kit manual