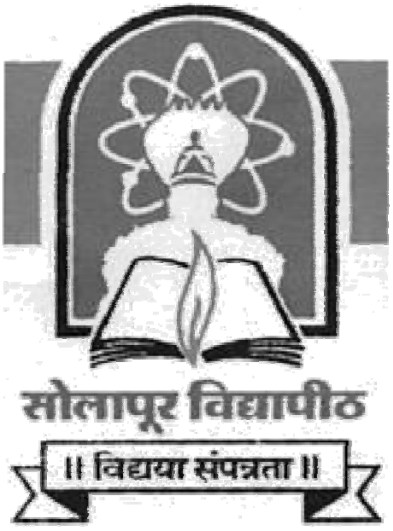

SOLAPUR UNIVERSITY, SOLAPUR

FACULTY OF ENGINEERING & TECHNOLOGY

ELECTRICAL ENGINEERING

Syllabus Structure for

M.E. (Electrical Engineering) w.e.f. Academic Year 2015-16

Choice Based Credit System Syllabus

CBCS structure of M.E Electrical Engineering W.E.F 2015-16
Semester I

Theory Course Name	HRS/Week			Credits	Examination Scheme			
	L	T	P		ISE	ESE	ICA	TOTAL
Power Electronics	3	-	-	3	30	70	-	100
Power System Dynamics and control	3	1	-	4	30	70	25	125
DC Drives	3	-	-	3	30	70	-	100
Control Engineering	3	-	-	3	30	70	-	100
Elective I	3	1	-	4	30	70	25	125
Sub total	**15**	**2**	**-**	**17**	**150**	**350**	**50**	**550**
Laboratory								
						ESE		
						POE	**OE**	
Power Electronics	-	-	2	1	-			25	25
DC Drives	-	-	2	1	-	-	-	25	25
Control Engineering	-	-	2	1	-	-	-	25	25
Seminar -I	-	-	4	2	-	-	-	50	50
Sub-Total	**-**		**10**	**5**	**-**	**-**		**125**	**125**
Grand Total	**15**	**2**	**10**	**22**	**150**	**350**		**175**	**675**

Note: Abbreviations: L- Lectures, P-Practicals, T- Tutorials, ISE –In Semester Exam, ESE- End semester Exam, ICA- Internal Continuous Assessment, ESE- University Examination (Theory/POE/OE Exam)

List of Elective for semester I

1. Extra High Voltage Transmission Systems
2. Renewable Energy Sources
3. Electric Traction

Note –

Seminar I shall be delivered on a topic related to student's broad area of interest for dissertation work. This should be selected in consultation with the supervisor after compiling the information from the latest literature. Student shall deliver seminar using modern presentation tools. A hard copy of the report (as per format specified by the department) shall be submitted to Department before delivering the seminar. A soft copy of the report must be submitted to the supervisor along with other details, if any.

SOLAPUR UNIVERSITY, SOLAPUR

FACULTY OF ENGINEERINIG & TECHNOLOGY

CBCS structure of M.E Electrical Engineering W.E.F 2015-16
Semester II

Theory Course Name	HRS/Week			Credits	Examination Scheme			
	L	T	P		ISE	ESE	ICA	TOTAL
Power Electronics Applications to Power system	3	-	-	3	30	70	-	100
Power Quality	3	1	-	4	30	70	25	125
A.C Drives	3	-	-	3	30	70	-	100
Advanced Control Engineering	3	-	-	3	30	70	-	100
Elective II	3	1	-	4	30	70	25	125
Sub total	**15**	**2**	**-**	**17**	**150**	**350**	**50**	**550**
Laboratory								
						ESE		
						POE	**OE**	
Power Electronics Applications to Power system	-	-	2	1	-	-	-	25	25
A.C Drives	-	-	2	1	-	-	-	25	25
Advanced Control Engineering	-	-	2	1	-	-	-	25	25
Seminar II	-	-	4	2	-	-	-	50	50
Sub-Total	**-**	**-**	**10**	**5**	**-**	**-**		**125**	**125**
Grand Total	**15**	**2**	**10**	**22**	**150**	**350**		**175**	**675**

Note: Abbreviations: L- Lectures, P-Practicals, T- Tutorials, ISE –In Semester Exam, ESE- End semester Exam, ICA- Internal Continuous Assessment, ESE- University Examination (Theory/POE/OE Exam)

List of Elective for semester II

1. Advanced Power System Protection
2. Analysis & Design of Switched Mode Converters
3. High Voltage DC Transmission

Note –

- Seminar II shall be delivered on a topic related to student's dissertation work& should be selected in consultation with the supervisor. Student shall deliver seminar using modern presentation tools. A hard copy of the report (as per format specified by the department) shall be submitted to Department before delivering the seminar. A soft copy of the report must be submitted to the advisor along with other details if any.
- Subjects may be added in the list of Elective I and II as per requirement.

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Solapur University, Solapur

M.E Electrical Semester-I

POWER ELECTRONICS

Teaching Scheme
Hrs/Week
Hrs/Week

Examination Scheme Theory: - 3
Theory Credits – 3.0 **Practical: - 2**
Practical Credit – 1.0

SECTION- I

Unit 1 Introduction & Structure of Power Electronics: (03 Hrs)

Overview of application of Power Electronics to :

1) Motor control with emphasis on Traction and Industrial Process control

2) Power Supplies - Revolution in Personal Computers SMPS

3) Power Transmission

4) Power extraction from non-conventional energy sources

5) Automotive electronics

6) High energy physics

Stages of evolution of Power Electronics

Structural difference of power electronics from low power analog electronics

Unit 2 Power Electronic Devices: (09 Hrs)

Device structure, Static characteristic, dynamic characteristic of Power Diode, Diac, Triac, GTO, Transistor, MOSFET, IGBT

Turn on and Turn off process of above devices, different relevant ratings.

Structure of power modules and smart switches

Unit 3 Diode rectifiers & its Applications: (08 Hrs)

Analysis of following diode rectifier configurations

1) Single phase Half wave with R load

2) Single phase Half wave with R-L load

3) Single phase Full bridge rectifier with dc link capacitive filter, issue of harmonics

4) Three phase Full bridge rectifier with dc link capacitive filter, issue of harmonics

Review of Diode rectifiers Applications in Power Supplies, Front end converter for ac motor drives, battery charger

SECTION- II

Unit 4 AC to DC controlled converters: (08 Hrs)

1) Single phase half controlled converter:

Operating principle, input displacement factor, modes of operation in the V-I plane.

2) Single phase fully controlled converter:

i) Principle of operation: Issue of line commutation

ii) Continuous mode of conduction: expression for average output voltage

iii) Modes of operation in the voltage-current plane

iv) discontinuous mode of conduction

v) analysis with R-L-E load, significance of R-L-E load

vi) operation as an inverter: constraints for line commutation

vii) Dual converter: motivation, Simultaneous and non-simultaneous control

vii) input displacement factor, distortion factor, harmonics

viii) Effect of source inductance

ix) Requirement of snubber

3) Three phase half wave ac to dc converter

Principle of operation, derivation of output voltage, issue of dc magnetization of the input transformer.

4) Three phase fully controlled ac to dc converter

Principle of operation, Derivation of average output voltage, Derivation of displacement factor, Inverter mode of operation, Constraints of commutation in inverter mode, Effect of source inductance.

Limitation of Line commutated converters, Single phase unity power factor converter, Principle of switched power conversion, Bi-directional Power converters.

Unit 5 DC- DC Power Converters: (04 Hrs)

Limitations of Linear Power supplies, switched Power supplies (Buck, Buck-Boost, Boost, Cuk, Fly-back and Forward Converters), Transfer function for these converters.

Unit 6 DC- AC Power Converters: (04 Hrs)

Principle of operation of Inverters, relationship between output voltage & frequency, types of inverter: voltage source inverter and current source inverter, single phase Half bridge & full bridge configurations, three phase six step operation, PWM techniques , harmonics elimination techniques, voltage source inverter, current source inverter.

Unit 7 Ac –Ac Power Converters: (04Hrs)

Introduction, bidirectional A.C voltage regulator with R load & RL load, three phase A.C voltage regulator, three phases A.C voltage regulator feeding star connected load

Reference Books:

1. M.H.Rashid , "Power Electronic: Circuits ,Devices and Applications", Pentis hall of india, IIIrd Edition (2004).
2. Ned Mohan, "Power Electronics, Applications & Design": John Willey & Sons, IIIrd Edition (2002).
3. Cyril Laneder, "Power Electronics", McGRAW Hill Co, IIIrd Edition (1993).
4. B.K.Bose, "Modern Power Electronics & AC Drives, Pearson Education Inc., 2002.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur
M.E Electrical Semester-I

POWER SYSTEM DYNAMICS & CONTROL

Teaching Scheme
Hrs/Week
Hr/Week

Examination Scheme Theory: - 3
Theory Credits – 3.0 **Tutorial: - 1**
Tutorial Credit – 1.0

SECTION- I

Unit 1 Introduction to Power System Stability: (04 Hrs)

Structure of Power System, Synchronous grids, Stability Problems faced by Power Systems, impact on Power System Operation and Control.

Unit 2 Analysis of Dynamical Systems: (10 Hrs)

Concept of Equilibrium, Small and Large Disturbance Stability, Example: Single Machine Infinite Bus System, Analysis of Dynamical systems, Linear time invariant Systems, Analysis using Numerical Integration Techniques, Issues in Modeling: Slow and Fast Transients, Stiff Systems.

Unit 3 Modeling of a Synchronous Machine: (08 Hrs)

Physical Characteristics, Rotor Position Dependent model, D-Q Transformation, Steady State behavior of Synchronous Machine, Model with Standard Parameters, Short Circuit Transient Analysis of a Synchronous Machine, Synchronous Machine Connected to Infinite Bus.

SECTION- II

Unit 4 Modeling of Excitation and Prime Mover Systems: (06Hrs)

Physical Characteristics and Models, Control system components, Excitation System Controllers, Prime Mover Control Systems.

Unit 5 Modeling of Transmission Lines and Loads: (08 Hrs)

Transmission Line Physical Characteristics, Transmission Line Modeling, Load Models - induction machine model, Other Subsystems - HVDC, protection systems.

Unit 6 Stability Issues in Interconnected Power Systems: (08 Hrs)

Single Machine Infinite Bus System, Multi-machine Systems, stability of Relative Motion, Frequency Stability: Centre of Inertia Motion, Concept of Load Sharing: Governors, single Machine Load Bus System: Voltage Stability, Torsional Oscillations.

Reference Book:

1. K.R.Padiyar, Power System Dynamics, Stability & Control, 2nd Edition, B.S. Publications, Hyderabad, 2002.
2. P.Kundur, Power System Stability and Control, McGraw Hill Inc, New York, 1995.
3. P.Sauer & M.A.Pai, Power System Dynamics & Stability, Prentice Hall, 1997.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur

M.E Electrical Semester-I

DC DRIVES

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Practical: - 2**
Hrs/Week **Practical Credit –** 1.0

SECTION- I

Unit 1 Introduction: (04 Hrs)

Definition of drive, Evolution of drive, present definition of drive, electric drive, Advantages of electric drive, power modulator, Important considerations for drives.

Unit 2 Dynamics of Electric Drives: (08Hrs)

Motor load interaction, Dynamic torque, solution of the torque equation, modes of the drive operation, basic types of loads: Passive load & active load, requirement of braking, advantages of electric braking, Stability of the equilibrium point, examples for investigating stability of the equilibrium points, Variable speed curves, Significance & Benefits of variable speed curves in relation to some typical loads, Characteristics of some typical loads, Condition for linear motion of the car, electric traction: diesel electric traction & diesel electric locomotive, torque speed characteristic of hoist

Unit 3 DC motor control characteristics: **(08 Hrs)**

Advantages; disadvantages, Speed torque characteristics: compensated DC machine, Feedback between electrical & mechanical world, speed control of separately excited DC motor: armature resistance control, Combined armature voltage & field control method, efficiency of combined armature voltage & field control method, constant torque mode, constant power mode, Dynamic braking with self excitation, plugging , Speed control of DC series motor, Braking in DC series motor, Regenerative Braking, Dynamic Braking, plugging, Dynamics involved four quadrant drive

SECTION- II

Unit 4 Convertor Control: (08 Hrs)

Fully controlled bridge (two quadrant converter), Discontinuous mode of conduction, Starting of the converter fed DC motor, Regenerative braking of a converter fed DC motor drive in motoring mode, Inverting mode operation of operation & continuous mode operation, Inverting mode of operation & discontinuous mode, T-ω characteristic of a converter fed DC motor, Steady state T-ω characteristic of converter fed DC in continuous mode of conduction, Complete torque speed characteristics, Discontinuous mode of operation

Unit 5 Control of DC drive: (06 Hrs)

3-phase converter fed DC motor drive: motoring mode & Regenerative mode

Dual converter operation in Non – simultaneous mode for motoring and regeneration

Dual converter operation in simultaneous mode

Dc to Dc converter fed Dc motor drive,

Step down DC to Dc converter: class-A chopper, class-B chopper, Class-C chopper, Class –D chopper, Class-E chopper for dynamic braking

Unit 6 Torque control drive and Speed control drive: (06 Hrs)

Torque control drive and Speed control drive,Closed loop control of a dual converter fed drive, speed control drive having wide Range of speed

Reference Books:

1. Gobal K.Dubey, "Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, 2001.

2. P.C Sen "Thyristor DC Drives", John wiely and sons, New York, 1981

3. Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education (Singapore), New Delhi, 2003.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur
M.E Electrical Semester-I
CONTROL ENGINEERING

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Practical: - 2**
Hrs/Week **Practical Credit –** 1.0

SECTION- I

Unit 1 Introduction to control problem: (04Hrs)

Industrial Control examples, different kinds of control systems, history of feedback, transfer function models of mechanical, electrical, thermal & hydraulic systems

Unit 2 Models of industrial control devices & systems: (08Hrs)

Control hardware and their models: potentiometers, synchros, LVDT, dc and ac servomotors, tachogenerators, electro hydraulic valves, hydraulic servomotors, electro pneumatic valves, pneumatic actuators.

Unit 3 Basic characteristics of feedback control systems: (08Hrs)

Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness, Basic modes of feedback control: proportional, integral and derivative. Feed-forward and multi-loop control configurations, stability concept, relative stability, Routh stability criterion.

SECTION- II

Unit 4 Time-response analysis: (04Hrs)

Time response of second-order systems, steady-state errors and error constants, Performance specifications in time-domain, Root locus method of design. Lead and lag compensation

Unit 5 Frequency-response analysis: (10Hrs)

Relationship between time & frequency response, Polar plots, Bode's plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion, Performance specifications in frequency-domain, Frequency-domain methods of design, Compensation & their realization in time & frequency domain. Lead and Lag compensation.

Unit 6 State variable Analysis: (06Hrs)

Concepts of state, state variable, state model, state models for linear continuous time functions, diagonalization of transfer function, solution of state equations, concept of controllability & observability.

Reference Books:

1. Gopal. M., “Control Systems: Principles and Design”, Tata McGraw-Hill, 1997.
2. Kuo, B.C., “Automatic Control System”, Prentice Hall, sixth edition, 1993.
3. Ogata, K., “Modern Control Engineering”, Prentice Hall, second edition, 1991.
4. Nagrath & Gopal, “Modern Control Engineering”, New Ages International.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur

M.E. Electrical Semester-I

EXTRA HIGH VOLTAGE TRANSMISSION SYSTEMS

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Tutorial: - 1**
Hr/Week **Tutorial Credit –** 1.0

SECTION-I

Unit 1 Introduction to EHV AC Transmission: (04 Hrs)

Basic aspects of AC power transmission, standard transmission voltages, average values of line parameters, power handling capacity and line loss, mechanical consideration in line performance.

Unit 2 Calculation of line and ground parameters: (08 Hrs)

Resistance of conductors, temeraute rise of conductors and current carrying capacity, properties of bundled conductors, inductance of EHV line configuration, line capacitance calculation, sequence inductance and capacitances, line parameters for modes of propagation, resistance and inductance of ground return.

Unit 3 Voltage gradients and corona effects (08 Hrs)

Charge potential relations for multi conductor line, surface voltage gradient on conductors, gradient factors and their use, distribution of voltage gradient on sub conductors of bundle.

I^2R loss and corona loss, corona loss formulae, charge voltage (q-v) diagram and corona loss, attenuation of travelling waves due to corona loss.

SECTION-II

Unit 4 Theory of travelling waves and standing waves: (08 Hrs)

Travelling Waves and Standing Waves at Power Frequency, Differential Equations and Solutions for General Case, Standing Waves and Natural Frequencies, Open-Ended Line: Double-Exponential Response, Open-Ended Line: Response to Sinusoidal Excitation, Line Energization with Trapped-Charge Voltage, reflection and refraction of travelling waves

Unit 5 Lightning and lightning protection: (08 Hrs)

Lightning stroke to lines, lightning stroke mechanism, general principles of the lightning protection problem, tower footing resistance, lightning arresters and protective characteristics, dynamic voltage rise and arrester rating, operating characteristics of lightning arresters, insulation coordination based on lightning.

Unit 6 Power frequency voltage control and over voltages (04 Hrs)

Generalized constants, the power circle diagram and its use, voltage control using synchronous condensers, cascade connection of components-shunt and series compensation.

Reference Books:

1. A. Chakrabarti, D.P.Kothari, A.K. Mukhopdadhyay ,"Performance, operation & control of EHV power transmission system ," Wheeler publications

2. Rakosh Das Begamudre, "Extra high-voltage A.C. transmission Engineering," New Age International Pvt. Ltd.

3. S. Rao, "EHVAC & HVDC Transmission Engineering & Practice ," Khanna Publications.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur
M.E Electrical Semester-I
RENEWABLE ENERGY SOURCES

Teaching Scheme
Hrs/Week
Hr/Week

Examination Scheme Theory: - 3
Theory Credits – 3.0 **Tutorial: - 1**
Tutorial Credit – 1.0

SECTION- I

Unit 1 Introduction: (04Hrs)

Worlds Production and reserves of commercial energy sources, India's Production and reserves, energy alternatives The Solar Option, The Nuclear Option, Tar sands and Oil Shale, Tidal Energy, Geothermal Energy.

Unit 2 Solar Energy: **(08Hrs)**

Solar energy alternatives, solar radiation, availability, measurement and estimation, solar thermal conversion devices and storage applications, Liquid flat plate collector, Solar air heater, concentric collectors, thermal energy storage, solar pond, Solar Photovoltaic conversion, basics of technology,
applications, BOS components of solar PV systems.

Unit 3 Wind Energy: (08 Hrs)

History of wind energy, Wind machine types, classification, and parameters, general concepts of airfoils and aerodynamics, Analysis of wind flow, measurement of wind speed, Power in wind, performance calculations of wind turbine.

SECTION- II

Unit 4 Fuel Cell: (08 Hrs)

Introduction to fuel cell, principle of operation of fuel cell, stack configuration, Fuel cell Performance, Polymer electrolyte fuel cell, alkaline fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, solid oxide fuel cells, components of fuel cell, thermodynamics of fuel cell, Fuel cell systems, applications.

Unit 5 Biogas Plants : (06 Hrs)

Biomass- Biomass as a source of energy, introduction, energy plantation, methods of obtaining energy from biomass, photosynthesis, biomass gasification, factors affecting bio-digestion, classification of biogas plants, thermal gasification of biomass, pyrolysis

Unit 6 Other Sources : **(06 Hrs)** Tide- Basic principle of tide power, components of tidal power plant, operation methods of utilization of tidal energy, estimation of single basin systems and double cycle systems, Ocean Thermal Electric Conversion (OTEC)- Introduction, open cycle OTEC systems, closed cycle OTEC systems.

Reference Books:

1. S. P Sukhatme "Solar Energy- Principle of Thermal collector and storage", second edition, TMH publication.

2. J. A. Duffie and W. A. Beckman, "Solar Engineering of Thermal Processes", second edition, John Wiley, New York, 1991.

3. J.F. Manwell, J.G. McGowan, "Wind Energy Explained, theory design and applications" Wiley publication.

4. G D Rai, "Non Conventional Energy Sources", Khanna Publications

5. Leo J.M.J. Blomen and michael N. Mugerwa, "Fuel Cell System", New York, Plenum Press, 1993.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur

M.E Electrical Semester-I

ELECTRIC TRACTION

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Tutorial: - 1**
Hr/Week **Tutorial Credit –** 1.0

SECTION- I

Unit 1 Electric Traction- Principle and History: (04Hrs)

Systems of traction, Indian Scenario, Electric traction 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.

Unit 2 Mechanics of train movement: **(08Hrs)**

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

Unit 3 Adhesion, types of suspension and mechanism of torque transmission: (08Hrs)

Adhesion & Coefficient of adhesion, Suspension and mechanism of torque transmission, Concept of Weight Transfer & Effect of unsprung mass and wheel diameter.

SECTION- II

Unit 4 Traction Motor: (05 Hrs)

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.

Unit 5 Electric Traction Sub-Systems (Overhead Equipment): (05 Hrs)

Overhead Equipment (OHE), Sectionalizing, Bonding of Rails and Masts, Materials Employed in OHE.

Unit 6 Railway Signaling: **(10 Hrs)**

Block Section Concept, Track Circuits, Interlocking Principle, Train speed and signaling, Solid state, Interlocking, automatic Warning Systems, CAB signaling, Signaling level crossing. 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.

Reference 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. Gopal K Dubey ,"Fundamentals of Electric Drives" , Narosa Publishing.

4. Partab, "Modern Electric Traction" , Dhanpat Rai & Sons

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur

M.E Electrical Semester-II

POWER ELECTRONICS APPLICATIONS TO POWER SYSTEM

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Practical: - 2**
Hrs/Week **Practical Credit –** 1.0

Section-I

Unit 1 FACTS concepts and electrical power system overview: (03Hrs)

Introduction-brief discussions on Transmission line theory, use of Voltage source inverter (VSI) for reactive power support, mid-point series and shunt compensation and HVDC.

Discussion on voltage profile at the point of common coupling (PCC),

Unit 2 Load Balancing: (04Hrs)

Need for load compensation, load balancing using passive elements. Limitations of load balancing using passive elements, Use of VSI as a Var generator, indirect current controlled synchronous link converter Var Compensator (SLCVC).

Various PWM techniques: Harmonic Elimination and space vector PWM techniques - Theory and implementation issues.

Unit 3 Voltage Source Converters: (13Hrs)

Discussion on bi-directional power flow in VSI, Use of VSI as active filter cum Var generator, Current controlled SLCVC, Strategy-1: Sensing the compensator current, Strategy-2: Sensing the source current, Use of two VSIs, one as Var generator and another as active filter. Limitations of 2-level VSI, Discussion on the need for the change in power circuit configuration of 2-level VSI for high power application.

Introduction to multi-level inverters. Principle of operation of 3-level and 4-level diode clamped multi-level inverters. Space vector representation of 3-level VSI, voltage control of 3-level inverter.

Instantaneous reactive power theory, expression for active and reactive powers in terms of d-q components. Reactive power compensator using instantaneous reactive power theory, stationary to rotating frame transformation. Reference wave generation (hardware method), harmonic oscillator, Phase locked loop (PLL) Introduction on one cycle control, discussion on one cycle controlled Var generator and active filter.

Section - II

Unit 4 Shunt Compensation: (05Hrs)

Introduction, methods of Var generation: Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor-Thyristor controlled reactor (FC-TCR), STATCOM.

Unit 5 Series Compensation: (05Hrs)

Introduction, comparison between series and shunt compensation. Various Equipment: GTO Controlled Series Capacitor (GCSC), Comparison of TCR and GCSC, Thyristor Switched Series Capacitor (TSSC), Thyristor Controlled Series Capacitor (TCSC). Static Synchronous Series Compensator (SSSC), modes of operation, Voltage regulator and Phase Angle Regulator (PAR).

Multi functional FACTS controller: Unified Power Flow Controller (UPFC), control capabilities of UPFC, 2-port representation of UPFC.

Unit 6 HVDC: (10 Hrs)

Introduction, various possible HVDC configurations, unipolar and bipolar links, components of HVDC system: Converter, transformer, smoothing reactor, harmonic filter. Reactive power support, operation of 6-pulse controlled rectifier in inverting mode of operation. Effect of source inductance, equivalent circuit representation of 6-pulse converter considering effect of source inductance. Operation of 12- pulse converter.

Control of HVDC system, Rectifier and inverter characteristics, mode stabilization, current control, voltage dependent current order limit, combined rectifier-inverter characteristics, valve blocking and by-passing, limitations HVDC system using line commutated converters, modern HVDC system - HVDC light.

Reference Books:

1. T. J. E. Miller "Reactive power control in Electrical system," John Wiley & Sons, New York, 1982.
2. K. R. Padiyar "FACTS CONTROLLERS in Power Transmission & Distribution," New Age International (P) Ltd.," 2007.
3. K. R. Padiyar "HVDC POWER TRANSMISSION SYSTEMS Technology and System Interactions," New Age International (P) Ltd.," 1990.
4. Hingorani N. G "Understanding FACTS Concepts & Technology of FACTS Systems," IEEE PRESS, 2000.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

Solapur University, Solapur

M.E Electrical Semester-II

POWER QUALITY

Teaching Scheme
Hrs/Week
Hr/Week

Examination Scheme Theory: - 3
Theory Credits – 3.0 **Tutorial: - 1**
Tutorial Credit – 1.0

SECTION- I

Unit 1 Introduction: (04 Hrs)

Power quality-voltage quality-overview of power quality phenomena, classification of power quality issues.

Unit 2 Power quality measures and standards: (10 Hrs)

THD-TIF-DIN-C-message weights-flicker factor-transient phenomena occurrence of power quality problems-power acceptability curves-IEEE guides, standards and recommended practices.

Unit 3 Harmonics: (06 Hrs)

Harmonic distortion- voltage v/s current distortion-harmonics v/s transients individual and total harmonic distortion-RMS value of a harmonic waveform power and power factor under sinusoidal and non-sinusoidal conditions-triplex harmonics.

SECTION- II

Unit 4 Harmonic introducing devices and their effects: (10 Hrs)

SMPS-Three phase power converters-arcing devices- saturable devices, harmonic distortion of fluorescent lamps- power quality problems created by drives and its impact on machines-effect of power system harmonics on power system equipment and loads.

Unit 5 Power factor improvement: (10 Hrs)

Passive Compensation- Passive Filtering- harmonic filter design- active filters shunt active filters- Generation of reference current using instantaneous PQ theory- Other methods for generation of reference current- methods of implementation- Basic schematic and working of series active filter- unified power quality conditioner.

Reference Books:

1. Roger C. Dugan, Mark F. McGranaghan and H.Wayne Beaty, “Electrical Power System Quality,” MC Graw Hill

2. G.T.Heydt , “Electric Power Quality,” Stars in a Circle Publications

3. J. Arrillaga, N.R.Watson and S.Chen, “ Power System Quality Assessment,” John Wiley & Sons

4. IEEE-519: 1992, IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

5. Math H.J.Bollen, “Understanding Power Quality Problems, Voltage Sag and Interruptions ” Wiley-IEEE Press

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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सोलापूर विद्यापीठ
॥ विद्यया संपन्नता ॥

Solapur University, Solapur

M.E Electrical Semester-II

AC DRIVES

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Practical: - 2**
Hrs/Week **Practical Credit –** 1.0

SECTION- I

Unit 1 Introduction to Induction Motor Drives: (06 Hrs)

Advantages, Comparison of DC motor drive & induction motor drive, rotating magnetic field
Torque production, Equivalent circuit, Variable terminal voltage control, variable frequency control, V/F controlled induction motor drive

Unit 2 Characteristics of IM drives: (06Hrs)

Characteristic of E/f controlled drive, approximate efficiency of V/F controlled drive, Characteristic of V/f controlled drive above rated frequency, torque - power capabilities in induction motor, Control of V/F controlled drive-open loop control, close loop control, closed loop slip controlled drive

Unit 3 VSI and CSI Fed Induction Motor Control: **(08 Hrs)**

Voltage fed inverter, Configuration of the power circuit- dynamic braking, Current fed induction motor drive, Nature of T-N characteristics, structure of CSI drive, Speed control of wound rotor/field induction motor, basic wound field IM drive, Static scherbius drive,

SECTION- II

Unit 4 Synchronous Motor Drives: **(06 Hrs)**

Significance of synchronous machine drives, Analysis, speed control, load commutation, True synchronous mode of operation, Rotor position encoder, Self controlled drive for synchronous motor for frequency below and above rated values, Advantages & disadvantages

Unit 5 Switched Relutance Motor control: (06 Hrs)

Voltage equation, torque equation, inductance profile, primitrive inverter, diagram of elementary torque production, L/Φ/I diagram, control strategy for SRM, determination of θ

Unit 6 Vector control of Induction Motor: (08 Hrs)

Introduction, advantages of vector control over scalar control, types of Vector control: Direct and Indirect vector control, Dynamic modeling of vector control

Three phase to two phase stationary reference frame (abc to α-β) transformation, Two phase stationary reference frame to two phase general rotating reference frame (α-β to d-q) transformation, Separation of real and imaginary component from d-q frame equations, Separation of d-q components for stator and rotor equation, Development of d-q axis dynamic equivalent circuits for an Induction Motor, Torque calculation for induction motor

implementation of equivalent current control model of induction motor, current controlled equivalent model of induction motor, implementation of vector control using current control induction motor model

Reference Books:

1. Gobal K.Dubey, "Fundamentals of Electrical Drives", Narosal Publishing House, New Delhi, 2001.

2. Bimal K.Bose "Modern Power Electronics and AC Drives", Pearson Education (Singapore) Pte. Ltd., New Delhi, 2003.

3. Murphy J.M.D and Turnbull, "Power electronic Control of AC Motors", Pergamon Press, Oxford.

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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Solapur University, Solapur
M.E Electrical Semester-II
ADVANCED CONTROL ENGINEERING

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Practical: - 2**
Hrs/Week **Practical Credit –** 1.0

SECTION- I

Unit 1 Introduction: (04 Hrs)

Introduction, Control structures and performance description of a control system, Time and frequency domain performance measures

Unit 2 Model Based Controller Design: (06 Hrs)

PID controller & its variants, model based controller design, Design of PI &PID controller for SISO system, , Design of PI &PID controller for TITO processes, Limitations of PID controllers, PID-P controller for Two Input Two Output(TITO) system, Effects of measurement noise and load

Unit 3 Frequency Domain Based Identification: (10 Hrs)

Identification of dynamic models of plants, Relay control system, equivalent gain of the relay, Off-line tuning of PID controller and on-line tuning of PID controller

SECTION- II

Unit 4 State space based identification (06 Hrs)

State space based identification, Relay control based identification of system, State space analysis of systems, State space equations, Identification of simple systems-general expression & model parameters.

Unit 5 Time-Domain Based Identification: (10 Hrs)

Identification of FOPDT model- general expression & model parameters, Identification of second order plus dead time model, Identification of SOPDT model- general expression & model parameters, Steady state gain from asymmetrical relay test- analytical expression & model parameters, Identification of SOPDT model with pole multiplicity, Existence of limit cycle for unstable system, Identification procedures, Identification of underdamped systems, Off-line identification of TITO systems, On-line identification of TITO systems, Review of time domain based identification

Unit 6 DF Based Identification: **(04 Hrs)**

DF based analytical expressions for on-line identification, Model parameter accuracy and sensitivity, Improved identification using Fourier series and wavelet transform, Reviews of DF based identification.

Reference Books:

1. S. Majhi, Advanced Control Theory-Relay Feedback Approach, Cengage Asia/India Pvt.Ltd, 2009.
2. A. Johnson and H. Moradi, New Identifications and Design Methods, Springer - Verlag, 2005.
3. Norman S. Nise, Control Systems Engineering, John Wiley & Sons, 2008

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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॥ विद्यया संपन्नता ॥

Solapur University, Solapur
M.E Electrical Semester-II
ADVANCED POWER SYSTEM PROTECTION

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Tutorial: - 2**
Hrs/Week **Tutorial Credit –** 1.0

SECTION- I

Unit 1 Introduction: (04 Hrs)

Power system Protection, Prevention and control of system failure, Protective system design consideration, Definitions used in System Protection, System disturbances.

Unit 2 Protection Measurements and Controls: (08 Hrs)

Graphic symbols and device connections, Typical relay connections, Circuit Breaker Control circuits, Instrument Transformers-Selection, Types and Connections, Relay control configurations, Optical Communications.

Unit 3 Protective Device Characteristics & Relay Logic: (08 Hrs)

Relay characteristics, Power circuit breakers, Automatic circuit reclosers and line sectionalizers, Circuit switches and digital fault recorders.

Analog relay logic, Digital relay logic, Hybrid relay logic, Relays as comparators.

SECTION- II

Unit 4 Protection against Abnormal frequency: (06 Hrs)

Computation of available fault current, System equivalent for protection studies, Compensation theorem, Compensation application in fault studies, Abnormal frequency operation, effects of frequency on generator, frequency effects on the turbine, a system frequency response module, off normal frequency protection, under frequency protection.

Unit 5 Protective schemes for stability enhancement: (06 Hrs)

Review of stability fundamentals, System transient behavior, Automatic reclosing, Loss of synchronism protection, Special protection schemes.

Unit 6 HVDC Protection Sub synchronous resonance Protection: (08 Hrs)

A general working principle of line, Philosophy of HVDC protection, AC side protection, DC side protection, Special HVDC protection.

SSR overview, SSR system counter measures, SSR unit counter measures.

Reference Books:

1. Anderson PM, "Power system protection," McGraw-hill, 1999.
2. Mason CR, "The art and science of protective relaying," John Wiley & sons
3. Badriram &Vishwakarma, "Power system protection and SWG," Mcgraw Hill
4. Madhava Rao T S, " Power system protection with static relays and Microprocessor application," McGraw hill
5. Chapman & Hall, "Electrical Power System Protection"
6. J. Lewis Blackburn & T.J. Domin, "Protective Relaying Principles & Applications"

Term work: *Minimum six Laboratory assignments based on above curriculum are required to be submitted.*

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॥ विद्यया संपन्नता ॥

Solapur University, Solapur
M.E Electrical Semester-II
ANALYSIS & DESIGN OF SWITCHED MODE CONVERTERS

Teaching Scheme **Examination Scheme Theory: - 3**
Hrs/Week **Theory Credits** – 3.0 **Tutorial: - 1**
Hr/Week **Tutorial Credit –** 1.0

SECTION- I

Unit 1 DC – DC Switched mode Converters: (08 Hrs)

Review of Buck Converter, Boost Converter, Buck – Boost , Duty cycle derivation, Different conduction modes (CCM & DCM), Voltage and Current waveforms, Calculation of output voltage ripple, Problems.

Unit 2 Resonant converters: (06 Hrs)

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.

Unit 3 Switching DC power Supplies: (06 Hrs)

Linear power supplies, Overview of switching power supplies, Switching losses, Fly back and Forward Converters– duty cycle derivation, waveforms, comparison of converters, Problems.

SECTION- II

Unit 4 Control Aspects: (08 Hrs)

Voltage feed- forward PWM control, current mode control, Power supply protection, Electrical isolation in the feedback loop, designing to meet power supply specifications

Unit 5 Converter Design (for Buck, Boost , Flyback & Forward Converters only)**: (12 Hrs)**

Selection of output filter capacitor, Selection of energy storage inductor, Design of high frequency Inductor and high frequency transformer, Selection of switches.

Reference 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

4) M.H.Rashid, “Power Electronics”, Prentice-Hall of India

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Solapur University, Solapur
M.E Electrical Semester-II
HIGH VOLTAGE DC TRANSMISSION

Teaching Scheme
Hrs/Week
Hr/Week

Examination Scheme Theory: - 3
Theory Credits – 3.0 **Tutorial: - 1**
Tutorial Credit – 1.0

SECTION- I

Unit 1 Introduction: (05 Hrs)

Evolution of HVDC Transmission, Comparison of HVAC and HVDC systems, Type of HVDC Transmission systems, Components of HVDC transmission systems.

Unit 2 HVDC converters: (10 Hrs)

Analysis of simple rectifier circuits, Required features of rectification circuits for HVDC transmission, Analysis of HVDC converter, Different modes of converter operation, Output voltage waveforms and DC voltage in rectification, Output voltage waveforms and DC in inverter operation, Thyristor voltages, Equivalent electrical circuit.

Unit 3 Control Aspects: (05 Hrs)

HVDC system control features, Control Modes, Control Schemes, Control comparisons

SECTION- II

Unit 4 faults & protection: (06 Hrs)

Converter mal-operations, Commutation failure, Starting and shutting down the converter bridge, Converter protection.

Unit 5 Harmonic Analysis: (06 Hrs)

Smoothing reactor and DC Lines, reactive power requirements, harmonic analysis, filter design.

Unit 6 AC-DC System: (08 Hrs)

Component Models for the Analysis of AC-DC Systems, Power flow analysis of AC-DC systems, Transient stability analysis, Dynamic stability analysis.

Multi-terminal HVDC system, advances in HVDC transmission, HVDC system application in wind power generation.

Reference Books

1. KR Padiyar, "*HVDC Power Transmission Systems*", Willey Eastern Limited, Second edition.
2. J. Arrillaga, "*High Voltage Direct current Transmission*", Peter Peregrinus Ltd, UK.
3. EW Kimbark, "*Direct Current Transmission*", Wiley-Interscience, New York.
4. S.N. Singh, "*Electric Power Generation, Transmission and Distribution*, PHI, New Delhi 2nd edition, 2008.

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