SCHOOL OF ENGINEERING SWARNIM STARTUP & INNOVATION UNIVERSITY	
Course	Post Graduate in Electrical Engineering (Power System Engineering) (18 Seats)
Duration	2 Years
Aim	To introduce the students about fundamental concepts of power flow, protection. To familiarize the students with the construction of overhead lines and underground cables and give them an appreciation of the multidisciplinary nature of their design. To introduce the students to the concept of FACTS, and familiarize them with the basic design and principle of operation of HVDC systems.
Objectives	The main objective of the course is to create technically trained manpower readily available for recruitment to the power companies in the area of Transmission & Distribution of electrical power.
Course Outcome	Having successfully completed this module, you will be able to demonstrate knowledge and understanding of Fundamental concepts of power system stability, components of protection systems, the concept of protection zones, components used in earthing systems, basic structure of different lines and cables, types of HVDC links and their control, fundamentals of smart grids.

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

Applied Linear Algebra
SUBJECT CODE: _____
M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	-	5	5	30	20	70	30	150

Objectives: - To provide understating of various aspects of applied linear algebra, which are particularly valuable to electrical engineering field.

Prerequisites:- To lay a foundation for understanding in specialized areas of power system in electrical field.

Course outline:- Fundamental knowledge of basic and applied linear algebra.

Sr. No.	Course Contents	Number of Hours
1	Finite dimensional vector space, subspaces, linear independence, bases and dimension.	9
2	Algebra of transformations, range and null space of a linear transformation, matrix algebra, simultaneous equations.	9

3	Sum and intersection of subspaces, direct sum of invariant subspaces, Eigen values, characteristic vectors, Cayley-Hamilton theorem, minimal polynomial, Sylvester's interpolation method, various canonical form. Algebra of polynomial matrices, invariant.	**9**
4	Polynomial matrices, invariant polynomials, elementary divisors, Smith canonical form. Innerproduct spaces, Gram Schmidt orthogonalization, linear transformation and their adjoint, self adjoint, unitary and normal transformations, polar decomposition.	**9**
5	Some computational methods of linear algebra.	**9**
	TOTAL	**45**

Learning Outcomes:- After learning the course the students should be able to

1 Understand the vector spaces, transformation

2 Solve the engineering problems using linear algebra

3 Use the theorms and canonical forms

4 Use the computational methods for linear algebra

Teaching & Learning Methodology:- Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. Finkbeiner D.T. Introduction to Matrices and linear Transformation, D.B. Taraorewala's.1968

2. Hoffman, K and Kunze, R. linear Algebra, Prentice Hall of India. 1972.

3. Gantmocher F.R. The Theory of Matrices, Cheisea. 1960

4. Goult, R.J., Hoskin, R.P., Milner, J.A and Pratt, M.J.- Computational methods in Linear Algebra, Stanley Thomas Pub. Ltd. 1974

E-Resources:

1 http://nptel.ac.in

2 http://elearning.vtu.ac.in

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

COMPUTER METHODS IN POWER SYSTEM ANALYSIS

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	2	7	7	30	20	70	30	150

Objectives: - To provide understating of various aspects of Power system analysis, which are particularly valuable to electrical engineering field.

Prerequisites:- To lay a foundation for understanding in specialized areas of power system in electrical field.

Course outline:- Fundamental knowledge of Power system analysis .

Sr. No.	Course Contents	Number of Hours
1	**Network Formulation and Graph Theory:** Introduction, Network Equations, Graph Theory, Development of Network Matrices from Graph Theoretic Approach, Augment Cut-set Incidence Matrix Cut-set and Circuit Equations,	4

	Building Algorithm for the Bus Impedance Matrix Modification of ZBUS matrix due to changes in the primitive network	
2	**Load Flow Studies:** Introduction, Different techniques such as Gauss Saidal method, Newton Raphson method, De-Coupled method, Fast Decoupled method, Modified Fast Decoupled, Concept of Optimal Power Flow, Solution of Optimal power flow by Gradient method, Solution of Optimal power flow by Newton's method Linear Programming Methods, DC load flow, Continuation Power flow	**10**
3	**Power System Security:** Introduction, Factors Affecting Power System Security, Short Circuit Studies of a Large Power System Networks, Symmetrical Fault Analysis Using Bus Impedance Matrix, Algorithm for Formation of Bus Impedance Matrix, Contingency Analysis: Detection of Network Problems, Overview of security analysis, Linear Sensitivity Factors, Contingency Selection, Concentric Relaxation, Bounding	**10**
4	**Introduction to State Estimation in Power Systems:** Introduction, Power system state estimation, Maximum Likelihood Concept , Weighted Least Squares Estimation, Introduction, Matrix Formulation, State Estimation of an AC network, Development of Method, State Estimation by Orthogonal Decomposition, An Introduction to Advanced topics in state estimation, Detection and Identification of Bad measurements, Estimation of quantities not being measured, Network Observability and Pseudo measurements, Application of Power Systems State Estimation.	**10**
5	**Numerical Integration Techniques:** Numerical integration techniques: One step methods, Taylor series based methods, Forward -Euler's method, Runge-Kutta methods, Trapezoidal method, backward-Euler's method, Accuracy and error analysis, Numerical stability analysis, Stiff systems, Step-size selection, Differential algebraic systems, triangular factorization, Power system applications: Transient stability analysis	**8**
	TOTAL	**42**

Learning Outcomes:- After learning the course the students should be able to

1. Recent techniques and computer application for modeling of practical and large interconnected power system networks using programming languages.

2. Recent methodologies for simulation and analysis of power system networks like real and reactive power flows and optimal scheduling.

3. Effect of outage of any important component of power system on the operation and reliability of power systems.

4. Algorithm required to find out parameters for monitoring and control of power system in real time from actual measurement data.
5. Computer Algorithms used to solve algebro-differential pertaining to power system to assess the stability performance of power systems.

Teaching & Learning Methodology:-

Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. Computer-Aided Power Systems Analysis (2nd Edition), George Kusic, CRC Press – Indian Edition
2. Power Generation Operation & Control, John Wiley & Sons, Inc, 1996- A. J. Wood and B. F. Wollenberg
3. Power System Analysis By stevenson and grainger TATA McgrowHill
4. AC-DC Power System Analysis, IEE London UK, 1998- Jos Arrillaga and Bruce Smith
5. Power System Analysis, Tata Mcgraw Hill, New Delhi, 1999- Hadi Sadat.
6. Computational methods for Electric Power Systems, CRC press- Mariesa Crow
7. Computer Methods in Power System Analysis, Glenn Stagg and El-abiad, McGraw-Hill

List of Experiments:

1. Formation of network matrices using any programming language.

2. Develop the program for power flow analysis using Gauss iterative method .

3. Develop the program for power flow analysis using GS method.

4. Develop the program for power flow analysis using NR method.

5. Develop the program for gain matrix (H) in state estimation.

6. Develop the program for power flow analysis using FDLF method.

7. Develop the program for WLSE method for DC networks .

8. Develop the program for bad data detection and elimination.

9. Develop the program for gain matrix (H) in state estimation.

10. Develop the program for stability assessment of SMIB.

11. Develop the program for solution of swing equation using various method of solution of differential equation

12. Develop the program for solution of integro-differential equation.

E-Resources:

1 http://nptel.ac.in

2 http://elearning.vtu.ac.in

3. Computers with software like MATLAB, SciLAB, C, C++, and it is preferable to have some software packages like MiPower , ETAP, PSCAD.

4. Pdf class notes, presentations and video lectures available at nptel.ac.in related to above topics.

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

POWER ELECTRONICS

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	2	7	7	30	20	70	30	150

Objectives: - To provide understating of various aspects of Power Electronics, which are particularly valuable to electrical engineering field.

Prerequisites:- To lay a foundation for understanding in specialized areas of power Electronics in electrical field.

Course outline:- Fundamental knowledge of Power Electronics .

Sr. No.	Course Contents	Number of Hours
1	Semiconductor Devices Review of Semiconductor devices like Power BJT, SCR, MOSFET, IGBT, GTO, MCT; Static and dynamic characteristics of these devices; Single quadrant, Two quadrant and bid-directional switches.	4
	Switching Voltage Regulators Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage	8

2	regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, , Push-pull converter, C'uk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator.	
3	Design of Magnetic Components Design of power transformer; high frequency transformers for flyback, forward, half-bridge – full bridge and push pull converters; Design of inductors for various converter topologies; Design of current transformers; Different types of core materials.	**8**
4	Line Commutated Converters Single phase and three phase half wave and full wave, 1-phase and 3- phase half controlled and fully controlled converters, Analysis with R & RL load, Performance parameters for converters,, Operation in continuous and dis-continuous mode, Operation in conversion and inversion mode, Effect of source inductance, Power factor 8 15 improvement techniques, Dual Converters	**8**
5	Classification; Review of line commutated inverters, Concept of Unipolar and Bipolar PWM, Sine-triangular PWM, Space Vector Pulse Width Modulation, Other PWM techniques, Harmonic reduction techniques, Current Source Inverters, Impedance source inverters, Voltage Source Inverters.	**9**
6	Gate and Base drive circuits Preliminary design considerations; DC coupled drive circuits with unipolar and bipolar outputs; Importance of isolation in driver circuits; Electrically isolated drive circuits; Some commonly available driver chips (based on boot-strap capacitor); Cascode connected drive circuits; Thyristor drive circuits; Protection in driver circuits; Blanking circuits for bridge inverters	**5**
7	Three phase AC voltage controllers and Cycloconverters AC voltage controllers: Review of On-off and phase control; Single phase full wave controllers and their analysis with resistive loads; Three phase full wave controllers, Analysis with R-load, Three phase bi-directional delta-connected controllers Cycloconverters: single-phase to single-phase cycloconverter, 3-phase to 1-phase cyclo-converter, 3-phase to 3-phase cycloconverter circuits; circulating current operation; non-circulating current operation; mean output voltage and harmonics in supply current waveform	**8**
	TOTAL	**50**

Learning Outcomes:- After learning the course the students should be able to

1. Analyze the characteristics of Power electronics devices and to determine the suitable device for a particular application
2. Analyze, design and operate DC-DC converters, phase controlled converters, inverters and AC-AC converters.
3. Design inductors and transformers for power electronic converters
4. Design of driver, protection and control circuits for power electronic devices
5. Design the schemes for reduction or elimination of harmonics.

Teaching & Learning Methodology:-

Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2003.
3. P.C.Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2012.
4. L. Umanand and S. Bhat, "Design of Magnetic Components for Switched Mode Power Converters", New Age International Ltd., New Delhi, 2001.
5. G.K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Ltd. Publishers, 1986 (Reprint 2008).
6. R.W. Erickson, D. Maksimovic, "Fundamentals of Power Electronics", Kluwer Academic Publisher, 2nd ed., 2001.
7. P.T. Krein, "Elements of Power Electronics", Oxford University Press, 1998.
8. B. Jayant Baliga, "Fundamentals of Power Semiconductor Devices", Thomson, 2008.
9. Joseph Vithayathil , "Principles of Power Electronics", Tata Mc-Graw Hill, 2010.

10. William Shepherd, Li Zhang, “Power Converter Circuits”, Marcell Dekker, New York, 2005.

11. http://nptel.iitm.ac.in/coursecontents_elec.php

E-Resources:

http://nptel.iitm.ac.in/coursecontents_elec.php

ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007.

List of Experiments:

1. To study the static/dynamic characteristics of power electronics devices
2. Design of an inductor for a DC-DC converter configuration.
3. Design of a transformer for an isolated DC-DC converter configuration.
4. Design of gate/base driver circuits for power electronic converter
5 To study the closed loop control scheme for dc-dc converters.
6. To study the performance of various single-phase ac-dc converters with different types of loads.
7. To study the performance of various three-phase ac-dc converters with different types of loads
8. To evaluate the performance of unipolar and bipolar pulse width modulation technique.
9. To compare the performance of various PWM techniques for three phase bridge inverter.
10 Write a code to determine the switching positions of the single phase bridge inverter so that the output voltage waveform is free from 3rd, 5th and 7th harmonics.
11 Speed control of 3-phase induction motor using 3-phase inverter
12 To study the performance of 3-phase ac voltage controller(s) with R and RL load.
13 To study the performance of 1-phase and 3-phase cycloconverter circuit(s).

Major Equipments:

Power Electronic Converters, Oscilloscopes (preferably DSO), Current Probe, Circuit Simulation Tools like MATLAB, PSIM or open source software to simulate power electronic converter circuits, and other basic equipment like meters, loads, motors etc.

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

RESEARCH SKILLS

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
1	2	0	3	3	0	20	0	80	100

Objectives: - This is not a subject on Communication or English language. This subject is designed for conducting and presenting research in engineering. Hence it is recommended that the subject be taught by teachers who have done research in the relevant engineering discipline.

Prerequisites :- Knowledge of access to referred journals;

Course outline:- NA

Assessment: It is essential to explain the concepts of research to the students, hence the scheme shows theory hours. However the assessment shall be done only through Practical presentation by the students before a review committee.

To the Student:

The purpose of this subject is to orient the students to the scientific methodology of research and presenting their research. Research constitutes primarily, literature review, giving critical comments on the literature reviewed and identifying the gap, problem formulation, modelling in either an analytical or experimental set up, validating the model and solving the problem you set for yourself.

At the end, student should be able to present and defend the solution he/she has found, in a simple and easy manner. Communicating the research outcomes, is an art wherein, you do not want to either undermine or over emphasise the content, within the short time limit given for such presentations. The balance of critical technicality and overall outcomes is the key to an effective presentation. The content and articulation should be such as to convey in a unified manner, the gist of your work.

To the Teacher:

It is envisaged that the teacher from the engineering research fraternity, will discuss each topic, through case studies of actual 5 papers from the best referred international journals, related to the particular discipline of engineering. Theory classes will be used to demonstrate each concept in Module 1,2 and 3. Whereas, each topic taught in class is to be practiced in tutorials, Module 4 is to be demonstrated through mock review of presentation by student by the rest of the class in the tutorial hours.

Tutorials:

Tutorials are to be utilized for demonstration of literature review and a unique problem identified by each student. Student should search at least 5 papers from referred journals, read, critique, identify gaps, identify problem statement, write paper, prepare powerpoint and finally present the mock Research Topic. Please note that this course demonstrates the concepts for conducting good research. Hence the topic identified here is not the final Research Topic for the dissertation.

End Semester Assessment:

Assessment will be through presentations by students on Impact factor, H Index, Citation Index, of Authors and Papers reviewed, Literature Review of 5 major papers, Research Gap and Referencing in Standard format.

ESE Marks Allocation out of 80:

Topic of Presentation reflects Research Gap (5)	Quality of Source of Literature (20)	Quality of Content of Literature Presented (30)	Research Gap Identified (10)	Standard Format of Referencing (5)	Presentation Skills (10)	Total (80)
* Minimum 40 required for Passing						

Sr. No.	Course Contents	Number of Hours

1	**Starting Research and Literature Review :-** • **Find what is expected of the you** Identify specific requirements for evaluation/review and what constitutes completion of your work • **Decide which sources you will need** Differentiate between journals, conferences, books, magazines and their quality and Understand how to establish their quality and authenticity • **Finding Information** How to conduct effective searches How to find relevant papers related to your area of research How to capture critical information • **Identify main ideas in scholarly literature** Understand and identify the bias, theoretical position and evidence produced • **Write notes to organize your ideas** Compare ideas and concepts from different papers • **References** Understand the importance of distinguishing your work from others work and acknowledging such references. Learn international standards of referencing	**5**
2.	**Identify Problem and Methods to Solve it** • **Analyse the question** Identify key areas in your field Determine the nature and extension of papers that you should read • **Identify the gaps** Learn to Critique existing knowledge and how to find the gap • **Formulate the Problem Statement** Understand what should be the key aspects of your problem statement Examples of effective and ineffective Titles • **Validation** Identify problem and experimental/theoretical data for comparison with your model Learn how to extrapolate/scale data for validation Find what is acceptable level of error and justification there of	**5**
3	**Writing your Assignment** • **Structure your assignment** Identify the key features of any written work • **Build your argument** Recognise the importance of emphasizing your point Distinguish between your point and the evidence available Acknowledge the evidence • **Review and finalize your work** Know and follow the Process of reviewing and proof reading your work	**3**

	Use feedback to improve your work	
4	**Delivering Your Presentation** • **Check the logistics of your presentation** Identify the key message of your presentation Understand the expectations and what will be the key review points • **Develop the structure of your presentation** Understand the key components of an oral presentation Know the usual structure of a good presentation • **Putting together the support material** Identify all the material you need to carry as supporting material • **Get feedback on oral presentation** Get your presentation reviewed : prepare a set of questions such as "Am I audible?", "Am I too fast?", "Am I reading too much from the slides?" etc, to get feedback Use the feedback to improve your technique • **Prepare for delivery of your Oral presentation** Rehearse and time your presentation Prepare to answer questions from the audience: Fundamental concepts should be spoken from memory as reviewer will be looking for evidence of your thorough understanding. Read more than the content you are presenting; keep sources ready on hand for reference;	**1**
	TOTAL	**14**

Learning Outcomes:- After learning the course the students should be able to

1. Conduct a quality literature review and find the research gap.
2. Identify an original and relevant problem and identify methods to find its solution
3. Validate the model
4. Present and defend the solution obtained in an effective manner in written or spoken form.

E-Resources:

- http://www.elsevier.com/online-tools/scopus
- http://computationalengineering.mit.edu/research/methodology
- https://www.ieee.org/index.html
- http://www.asce.org/
- http://www.asme.org/
- Research Methodology: Methods and Techniques, by C.R. Kothari, Newage Publishers•

List of Assignments:

1. What do you understand by Impact factor and H factor. Identify 5 good research papers based on I and H factor.
2. Write critical review of each paper and summary of strength and gaps of above referred papers.
3. Demonstrate how you have identified the Research Gap. Write what is existing knowledge in literature review and what can be further researched.
4. Write briefly on how the Problem statement is identified.
5. Describe the various methods for validating the research problem from the papers referred.
6. Describe the key features of a Research Paper. Write a paper on the Literature Review conducted.
7. Presentation of Problem formulation and Literature Review

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

INSTRUMENTATION

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	2	7	7	30	20	70	30	150

Objectives: - NA.

Prerequisites :- NA

Course outline:- NA

Sr. No.	Course Contents	Number of Hours
1	**DATA ACQUISITION SYSTEMS**: Overview of A/D converter, types and characteristics – Sampling , Errors. Objective – Building blocks of Automation systems –Counters – Modes of operation- Frequency, Period, Time interval measurements, Prescaler, Heterodyne converter for frequency measurement, Single and Multi channel Data Acquisition systems.	9

2.	**INTERFACING AND DATA TRANSMISSION:** Data transmission systems – 8086 Microprocessor based system design – Peripheral Interfaces – Time Division Multiplexing (TDM) – Digital Modulation – Pulse Modulation – Pulse Code Format – Interface systems and standards – Communications	**9**
3	**INSTRUMENTATION BUS** Introduction, Modem standards, Basic requirements of Instrument Bus standards, Bus communication, interrupt and data handshaking, Interoperability, interchangeability for RS-232, USB, RS-422, RS-485.	**9**
4	**PARALLEL PORT BUSES** Field bus, Mod bus, GPIB, IEEE-488, VME, VXI, Network buses – Ethernet –	**9**
5	**CASE STUDIES** PC based DAS, Data loggers, PC based industrial process measurements like flow, temperature, pressure and level development system, CRT interface and controller with monochrome and colour video display	**9**
	TOTAL	**45**

Learning Outcomes:-

After learning the course the students should be able to

1. Use A/D and D/A convertors and Data Acquisition System 3. Carry out interfacing using USB ports and different networks medium 4. Carry out the industrial application
2. Understand the different communication protocols
3. Carry out interfacing using USB ports and different networks medium
4. Carry out the industrial application

Teaching & Learning Methodology:-

Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. A.J. Bouwens, “Digital Instrumentation” , TATA McGraw-Hill Edition, 1998.

2. H S Kalsi, “Electronic Instrumentation” Second Edition, Tata Mc GrawHill 2006.
3. Joseph J. Carr, “Elements of Electronic Instrumentation and Measurement” Third Edition, Pearson Education, 2003.
4. Buchanan, “Computer busses”, Arnold, London, 2000. 5. Jonathan W Valvano, “Embedded Microcomputer systems”, Asia Pvt. Ltd., Brooks/Cole, Thomson,
5. Jonathan W Valvano, “Embedded Microcomputer systems”, Asia Pvt. Ltd., Brooks/Cole, Thomson, 2001.
6. S. K. Singh, “Industrial Instrumentation and Control”, TATA McGraw-Hill. 2004
7. N. Mathivanan, “PC-Based Instrumentation”, PHI, 2009

E-Resources:

http://nptel.iitm.ac.in/coursecontents_elec.php

ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007

List of Experiments:

1. To study the A/D and D/A convertors and it’s characteristics
2. To study the Data Acquisition System
3. To study Interfacing of DC motor with microprocessor and microcontrollers
4. To study the modulation technique
5. Read the sensor data using RS-232, USB, RS-422, RS-485
6. To study the characteristics of Ethernet, Field bus and CAN bus
7. Case study of various industrial instrumentation applications

   a. Temperature measurement

   b. Flow measurement

   c. Speed measurement

Major Equipments: NA

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SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

ELECTRICAL DRIVES

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	2	7	7	30	20	70	30	150

Objectives: - The course on Electric Drives is designed to introduce the concept of control of electric drives for various types of mechanical loads. In this course, mainly the dc motor, induction motor and synchronous motor steady-state modeling and steady state torque and speed control of these motors are emphasized. The course exposes the applications of semiconductor controlled converters to control the DC and AC machines for better torque and speed response.

Prerequisites :- Fundamentals of electromagnetics; Basic knowledge of power electronics and electrical machines

Course outline:- Fundamental knowledge of power electronics converter control of AC and DC Motor.

Sr. No.	Course Contents	Number of Hours
1	**Fundamentals of Electrical Drives**	8

	Dynamics of electrical drives, components of load torque, classification of load torque, concept of multi-quadrant operation, steady-state stability criteria.	
2.	**DC Drives with phase controlled converters** 1-phase fully controlled converter fed separately excited DC motor, modes of operation, steady-state motor performance equations, mode identification, speed-torque characteristics, operation with controlled fly-wheeling; operation with 1-phase half controlled converter; 3-phase fully controlled converter fed separately excited motor; Pulse width modulated rectifiers, equal pulse-width modulation, sinusoidal pulse width modulation; current control; multi-quadrant operation of fullycontrolled converter fed DC motor; Dual converters based drives; Closed loop control of DC drives.	**6**
3	**DC drives with dc-dc converters** Principle of Motoring operation of separately excited and series motor with DC-DC converter, Steady-state analysis for time ratio control and current limit control; Regenerative braking; Dynamic and composite braking; multi-quadrant operation with dc-dc converters	**6**
4	**Fundamental of Induction Motor (IM) and its control Review of IM:** Steady-state analysis of an Induction motor; Starting and Braking methods; Speed control methods: variable terminal 5 8 voltage, variable frequency control, rotor resistance control, injection of voltage in the rotor circuit;	**8**
5	**Control of IM with solid state converters Control of IM using VSI :** Six step inverter, PWM inverter, braking and multi-quadrant control, VVVF control Control of IM using CSI :Three-phase CSI, Braking, PWM in a thyristor CS inverter, PWM with GTO based CSI, Variable frequency drives, Comparison of CSI and VSI based drives. Current controlled PWM inverters AC voltage controllers : AC voltage controller circuits, four quadrant control and closed-loop operation; fan/pump and crane/hoist drives; ac voltage controller starters Slip power controlled IM dirves: analysis of stator rotor resistance control, Static scherbius drive: power factor considerations, rating and applications, performance	**7**
6	**Synchronous motor drives** Wound field cylindrical rotor motor, equivalent circuits, operation with constant voltage and frequency response : motoring and regenerative braking operations, power factor control and V-curves, operation with	**7**

	current source; Wound field salient pole motor; operation with variable voltage source and constant frequency; Starting and braking when fed from constant freq source; brushless excitation of wound field machines; Permanent magnet motor operating from a fixed frequency source; Operation with non-sinusoidal supplies.	
	TOTAL	**42**

Learning Outcomes:- After learning the course the students should be able to

1. Ability to analyze the steady state models of DC and AC motors
2. Ability to evaluate the different speed control methods on different performance parameters
3. Ability to describe and operate the DC and AC machines in different quadrants as per load requirements
4. Ability to determine the components of electrical drive for the required applications
5. Ability to select and design the power electronics converter based control logic for speed control of DC and AC motors

Teaching & Learning Methodology:-

Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. G.K. Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall, New Jersey, 1989.
2. G.K. Dubey, 'Fundamentals of Electrical Drives', Narosa Publications, New Delhi, 1994.
3. B.K. Bose, “Modern Power Electronics and AC Drives”, Pearson Education, New Delhi, 2003.
4. Muhammad H. Rashid , “Power Electronics - Circuits, Devices and Applications”, Prentice Hall of India Ltd., New Delhi, 3rd ed., 2003.
5. P.C. Sen, “Thyristor DC Drives”, John Wiley and Sons Ltd., New York, April 1981.

6. R. Krishnan, “Electical Motor Drives – Modeling, Analysis and Control”, PHI Pvt. Ltd., New Delhi, 2003.

7. W Leohnard, “Control of Electric Drives”, Springer, 2001.

8. J.M.D. Murphy and F.G. Turnbull, “Power Electronic Control of AC motors”, Pergamon Press, 1989.

9. M.D. Singh, K.B. Khanchandani, “Power Electronics”, Tata McGraw-Hill, 2nd ed., 2006.

10. S. Dewan, B. Slemon, A. Straughen, “Power Semiconductor drives”, John Wiley and Sons, NewYork 1984.

11. V. Subramanyam, “Electric Drives – Concepts and applications”, Tata McGraw Hill Publishing Co., Ltd., New Delhi 2003.

E-Resources:

http://nptel.ac.in/courses/Webcourse-contents/IIT-Delhi/Industrial%20Drives/index.htm
http://nptel.ac.in/courses/108108077/

List of Experiments:

1. To study the various electrical drive system and identify its components operating on dc and ac supply
2. To develop simulation model and analyze constant speed-variable torque dc drive system using conventional resistive control mechanism.
3. To develop simulation model and analyze constant speed-variable torque dc drive system using fully controlled converter in open loop mode.
4. To develop simulation model and analyze constant speed variable torque dc drive system using fully controlled converter in close loop mode.
5. To develop mathematical model for dc shunt and dc series motor in MATLAB using i. Power System Blockset ii. Mathematical toolbox
6. To design constant speed dc motor drive using chopper.
7. Study and identify various modes of operation in motoring/generating for dc shunt motor.
8. To study and simulate equal and sinusoidal PWM techniques for dc drives.
9. To develop mathematical model for 3-phase induction motor and to obtain various characteristics for i. Variable stator voltage ii. Variable stator/rotor

resistance iii. Variable frequency iv. Constant V/f

10. To study the performance of a three phase induction motor fed from an inverter controlled in 120° and 180° conduction mode.

11. To study the performance and speed control of 3 phase slip ring Induction motor employing static rotor resistance controller.

12. To study the behavior of PWM inverter fed three phase induction motor (IM).

13. To study the controlled speed change/reversal of an induction motor using power converter.

14. To study performance of current controlled PWM inverters for ac drive applications.

Major Equipments:

Power Electronic Converters, Oscilloscopes (preferably DSO), Current Probe, Circuit Simulation Tools like MATLAB, PSIM or open source software to simulate power electronic converter circuits, and other basic equipment like meters, loads, motors etc.

SWARNIM STARTUP & INNOVATION UNIVERSITY

SCHOOL OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

ADVANCED POWER SYSTEM PROTECTION AND SWITCHGEAR

SUBJECT CODE: _____

M.E. SEMESTER:-1

Teaching & Evaluation Scheme:-

Teaching Scheme				Credits	Evaluation Scheme				
					Internal		External		Total
Th	Tu	P	Total		Th	Pr	Th	Pr	
3	2	2	7	7	30	20	70	30	150

Objectives: - The protection of power system is very important for its reliability and stability point of view. It is very important to cut / remove unhealthy part of the system during fault / or abnormal condition without affecting normal functions in remaining part of the system. A fast detection and speedy removal of fault is very important for system stability but at the same unwanted tripping may create unwanted problems and disturbance in system. A new algorithm and advance technology for protection of system is incorporated in the syllabus.

Prerequisites:- Fundamentals of Power System; Basics of Generation, Transmission and Distribution Systems, Operation of various equipments used in Power System

Course outline:- Fundamental knowledge of power system protection and switchgear.

Sr. No.	Course Contents	Number of Hours
1	**Introduction to Digital Relays** Comparison of digital relays with previous generation relays, Basic	8

	Components of Digital Relays with block diagram, Signal Conditioning Subsystems, Surge Protection Circuits, Anti aliasing filter, Conversion Subsystem, The Sampling Theorem, Sample and Hold Circuit, Concept of analog to digital and digital to analog conversion, Idea of sliding window concept, introduction to intelligent electronic device (IED), Different relay algorithms such as algorithms for pure sinusoidal relaying signal, algorithm based on solution of system differential equations, Fourier analysis based half cycle and full cycle algorithm. Apparatus Protection.	
2.	**Coordination of Inverse Definite Minimum Time (IDMT)/Directional Over Current (DOC) Relays in an Interconnected Power System Network** Protection of an interconnected system, Link net structure, Flowchart of Primary/Backup relay pairs, Flowchart of Time Multiplier Setting. Examples based on existing power system network	**6**
3	**Wide Area Protection and Measurement** Definition of wide-area protection, Architectures of wide-area protection, concept of synchronized sampling, wide area phasor measurement technology, concept of Adaptive relaying, advantageous of adaptive relaying and its application	**6**
4	**Auto-reclosing and Synchronizing** Introduction, history of auto-reclosing, advantageous of auto-reclosing, classification of auto-reclosing, auto-reclosing based on number of phases, auto-reclosing based on number of attempts, auto-reclosing based on speed, Sequence of events in single-shot auto-reclosing scheme, factors to be considered during reclosing such as choice of zone in case of distance	**8**
5	**System Response during Severe Upsets** Introduction, Nature of system response to severe upsets such as system response to Islanding conditions, Under generated islands, Over generated islands, Reactive Power Balance, Power Plant Auxiliaries, Power System Restoration, Load Shedding, Factors to be considered for load shedding scheme such as maximum anticipated overload, number of load shedding steps, size of load shed at each step, frequency setting, time delay, rate of frequency decline, frequency relays, Issues with islanding and methods of islanding	**7**
6	**Protection of Series Compensated Transmission Line**	**7**

	Introduction, The Degree of compensation, basic components of series compensated transmission lines, Voltage Profile of Series Compensated Line, Faults with Unbypassed Series Capacitors, Protection problems such as Voltage Inversion, Current Inversion, Overreaching/Underreaching of distance element	
	TOTAL	**42**

Learning Outcomes:- After learning the course the students should be able to

1 Analyze the tripping characteristics of various relays and its applications. Design inductors and transformers for power electronic converters.

2. To operate various static relays, set their parameters and also to confirm its operations

3. To operate various Numeric relays, set their parameters and also to confirm its operations.

Teaching & Learning Methodology:-

Chalk and Talk method mostly preferable and Power point presentation is also preferable for some needful topics.

Books Recommended:

1. Bhavesh Bhalja, R. P. Maheshwari and N. G. Chothani, "Protection and Switchgear," Oxford University Press, New Delhi, India, 2011.

2. P. M. Anderson, Power System Protection, IEEE Press, New York, 1999.

3. A. T. Johns and S. K. Salman, "Digital Protection for Power Systems," Peter Peregrinus Ltd, UK, 1995.

4. S. H. Horowitz and A. G. Phadke, "Power System Relaying," John Wiley & Sons, New York, 1996.

5. W. A. Almore, "Protective Relaying Theory and Applications," Marcel Dekker Inc; New York, 1994.

6. J. L. Blackburn, "Applied Protective Relaying," Westinghouse Electric Corporation, New York, 1982.

7. Van C. Warrington A. R. "Protective Relays: Their Theory and Practice,", Vol 1, Chapman & Hall Ltd, London, 1962.

8. A. G. Phadke and J. S. Thorp, “Computer Relaying for Power Systems,” Research study press Ltd, John Wiley & Sons, Taunton, UK, 1988

E-Resources:

http://nptel.iitm.ac.in/coursecontents_elec.php

ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007

List of Experiments:

1. Study of digital relays with detailed description of each component of the schematic diagram of digital relay.
2. Setting up IDMT relays for a radial feeder
3. Setting up IDMT/DOC relays for a power system using link net structure
4. Study of auto-reclosing with related details
5. Study of system response during severe upset and power system restoration
6. Study of load shedding schemes with all related details
7. Study of protection of transmission line which is compensated by fixed series capacitors
8. Simulation of fixed series capacitor compensated transmission line for fault at various location to explain the phenomena of current inversion and voltage inversion

Major Equipments: NA