COEP Technological University Pune
(A Unitary Public University of Govt. of Maharashtra)

NEP 2020 Compliant

Proposed Curriculum Structure

M. Tech.
Electrical – Power Electronics and Power Systems

(Effective from: A.Y. 2024-25)

PG Program in Power Electronics & Power Systems (PEPS)

PG Program in Power Electronics & Power System (PEPS) has following objectives:

The M. Tech. Power Electronics and Power Systems program has following Program Outcomes (POs).

PO1. To investigate complex power system scenarios, independently carry out research and development work to solve practical problems related to Power Systems optimally.

PO2. To write and present a substantial technical project report, journal papers in Power Systems and Power Electronics area.

PO3. To model, design and analyze the power systems and power electronics systems using modern simulation tools and advanced mathematics for operation, control and protection of power systems.

Program Specific Outcomes

PSO4: To apply advanced technology such as WAMs, Embedded systems and computing techniques to solve real time power systems problems.

PSO5: To design a component, system or process related to Power and Energy Systems (PES) for a defined objective, as well as to analyze and interpret the data.

PSO6: Select, Configure & use appropriate modern tool to solve and analyze electrical Power system

PG Program [M. Tech. Electrical – Power Electronics and Power Systems]
Proposed Curriculum Structure
w.e.f AY 2024-25

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	3	4.41%
PSBC	Program Specific Bridge Course	1	3	4.41%
PCC	Program Core Course	6	18	26.47%
PEC	Program Specific Elective Course	3	9	1h.24%
LC	Laboratory Course	3	6	8.82 %
VSEC	Vocational and Skill Enhancement Course	2	18	26.47 %
OE	Open Elective	1	3	4.41 %
SLC	Self-Learning Course	2	6	8.82 %
AEC	Ability Enhancement Course	1	1	1.47 %
MLC	Mandatory Learning Course	2	--	--
CCA	Co-curricular & Extracurricular Activities	1	1	1.47 %
	Total	**23**	**68**	**100%**

PG Program [M. Tech. Electrical – Power Electronics and Power Systems]
Proposed Curriculum Structure

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	S	
1.	PSMC	PSMC-01	Mathematical Modeling of Electric Machines	3	--	--	1	3
2.	PSBC	PSBC-01	Embedded Systems	3	--	--	1	3
h.	PEC-I	PEC-01	a. Wind and Solar Energy system b. Engineering Optimization c. EHVAC Transmission d. Fuzzy Logic and Neural Networks e. Any otter course offered by faculty and approved by School Council	3	--	--	1	3
4.	MLC	MLC-01	Research Methodology and Intellectual Property Rights	0	--	--	2	--
5.	MLC	MLC-02	Effective Technical Communication	0	--	--	1	--
6.	PCC	PCC-01	Advanced Control Theory	3	--	--	1	3
7.	PCC	PCC-02	Advanced Power Electronics	3	--	--	1	3
8.	PCC	PCC-03	Power System Analysis	3	--	--	1	3
9.	LC	LC-01	Simulation Laboratory	--	--	4	-	2
10.	LC	LC-02	Embedded Systems Laboratory	--	--	4	-	2
			Total Credits	**18**	**--**	**8**	**9**	**22**

•

PG Program [M. Tech. Electrical – Power Electronics and Power Systems]
Proposed Curriculum Structure

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme L	T	P	S	Credits
1	OE	OE-01	Engineering Optimization	3	0	0	1	3
2	PEC	PEC-02	a. Energy Storage Systems b. Power Quality Issues and Mitigation c. Smart Grid Technologies d. Electric Mobility e. Substation Design f. Any other course offered by faculty approved by School Council	3	--	--	1	3
3	PEC	PEC-03	a. Power System Transients b. Artificial Intelligence and Machine Learning c. Electrical Power Distribution Systems d. Restructured Power Systems e. Advanced Electric Drives f. Any other course offered by faculty approved by School Council				1	3
4.	PCC	PCC-04	Power Systems Dynamics and Stability	3	--	--	1	3
5.	PCC	PCC-05	HVDC and FACTS	3	--	--	1	3
6.	PCC	PCC-06	Digital Protection	3	--	--	1	3
7.	LC	LC-03	DSP Application Laboratory	--	--	4	-	2
8.	AEC	AEC-01	HIL Laboratory	--	--	2	-	1
9	CCA	CCA-01	Liberal Learning Course	1	--	--	1	1
			Total Credits	**19**	**--**	**6**	**7**	**22**

- Exit option to qualify for **PG Diploma in Power Electronics and Power Systems**:
- Eight weeks domain specific industrial internship in the month of June-July after successfully completing first year of the program.

PG Program [M. Tech. Electrical – Power Electronics and Power Systems]
Proposed Curriculum Structure

Semester-III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	S	
1.	VSEC	VSEC-01	Dissertation Phase–I	--	--	18	12	9
2.	SLC	SLC-01	MOOC 1	3	--	--	3	3
			Total Credits	**3**	**--**	**18**	**15**	**12**

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	S	
1.	VSEC	VSEC-02	Dissertation Phase–II	--	--	18	12	9
2.	SLC	SLC-02	MOOC 2	3	--	--	3	3
			Total Credits	**3**	**--**	**18**	**15**	**12**

MOOC Courses Identified

- Recent Advances In Transmission Insulators
- Applied Linear Algebra For Signal Processing, Data Analytics And Machine Learning
- Control And Tuning Methods In Switched Mode Power Converters, Prof. Santanu Kapat,
- Computer Aided Power System Analysis, Prof. Biswarup Das, IIT Roorkee
- Digital Image Processing
- high Power Multilevel Converters - Analysis, Design And Operational Issues, Prof. Anandarup Das
- VLSI Technology Prof. Nandita Dasgupta
- Usability Engineering, Prof. Debayan Dhar

Any other relevant course of 8/12 weeks offered by Swayam -NPTEL during the respective semester

SEMESTER-I

[PSMC-01] Mathematical Modeling of Electric Machines

Teaching Scheme:
Lectures: 3 Hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Analyze electromechanical devices and machines
2. Use reference frame theory to study and analyze the behavior of induction and synchronous machines
3. Calculate the machine inductances for use in machine analysis
4. Model the electrical machine from the terminal junction with transmission systems

Course Contents:

Principle of unified machine theory, generalized torque equation, performance evaluation of DC machine and speed control, three phase induction motor-transformation methods, stationary, rotor and synchronous frames and corresponding equivalent circuits, three phase synchronous motor: representation, Park transformation, drives, various control techniques, concept of space vector, field oriented control and direct torque control of IM, permanent magnet synchronous motors-machine model (d-q) and control methods, reluctance machines models.

References:

1. P. C. Krause, “Analysis of Electric Machinery”, McGraw Hill, New York, 1987.
2. Chee Mun Ong, “Dynamic simulation of Electrical Machinery using Matlab/Simulink” Prentice Hall PTR, 1997.
3. P. Vas, “Vector Control of A.C. Machines”, Clarendon Press, Oxford 1990.
4. J .M. D. Murphy and F.G. Turnbull, “Power Electronic Control of AC motors”, Pergamum Press, 1988.
5. W. Leonhard, “Control of Electrical Drives”, Springer Verlag, 1985.

[PSBC-01] Embedded Systems

Teaching Scheme:
Lectures: 3 Hrs/week
Self study: 1 Hr/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Deploy low end applications using low and high level languages on microcontroller platform.
2. Test and debug peripherals in embedded system.
3. Identify and design applications on embedded platform.
4. Implement and deploy applications using embedded platform.

Course contents:

Introduction to Embedded System and Embedded System Design Flow. Signal Conditioning & Various Signal Chain Elements, Critical Specifications, How to smartly choose elements from wide choice available in market. Use Case Analysis. Systems on Chip, Memory Subsystem , Bus Structure, Interfacing Protocol, Peripheral interfacing, Testing & Debugging, Power Management, Software for Embedded Systems, Design of Analog Signal Chain from Sensor to Processor with noise, power, signal bandwidth, Accuracy Considerations. Software Programming Optimization, Concurrent Programming. Real Time Scheduling, I/O Management, Embedded Operating Systems. RTOS, Developing Embedded Systems, Building Dependable Embedded Systems.

References:

1. Steve Heath, "Embedded Systems Design", Newnes (an imprint of Butterworth-Heinemann Ltd); 2nd edition (30 October 2002).
2. Wyne Woff "Principles of Embedded computing system design", Morgan Koffman publication 2000
3. Rajkamal, "Embedded Systems- Architecture, Programming and Design", 2007- TMH.
4. Qing Li, "Real Time Concepts for Embedded Systems", Elsevier, 2011.
5. Shibu K.V, "Introduction to Embedded Systems", Mc Graw Hill.

[PEC-1] Wind and Solar Energy Systems

Teaching Scheme:
Lectures:3 hrs/week
Self study: 1 hr/week

Examination Scheme:
T1, T2 – 20 marks each
End-Sem Exam - 60

Course Outcomes:

After successful completion of this course, students will be able to:

1. Understand the basics of wind energy, wind turbines, solar energy and grid integration
2. Explain and classify wind turbines, instruments for measuring solar radiation, solar collectors, solar cell and solar MPPT techniques
4. Analyze different types of wind generators, solar cell and solar collectors
5. Outline about integration of solar and wind energy systems

Course Contents:

Wind energy Basics History of wind power, Indian and Global statistics, Characteristics of Wind, principles and components of wind energy conversion system, classification of wind turbines, modern wind turbine technologies, different types of Induction generator, and their characteristics, power quality standards for wind turbines, technical regulations for interconnections of wind farm with power systems, isolated wind systems.
Solar Thermal Physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, instruments for measuring solar radiation. Classification of concentrating collectors, orientation and thermal analysis, advanced collectors.
Solar photovoltaic energy conversion, solar cell fundamentals, solar cell classification-Amorphous, mono-crystalline, polycrystalline, performance of solar cell, V-I characteristics of a PV panel, Maximum Power point Tracking (MPPT) algorithm
Integration of solar and wind Wind power integration into grid-power system stability, economics of grid network, codes and standards for grid integration, grid connected PV systems, control scheme used for single stage grid connected PV system, case study on hybrid system (PV-Wind)

References:

1. Thomas Ackermann, Editor, "Wind power in Power Systems", John Willy and sons ltd.2005.
2. Siegfried Heier, "Grid integration of wind energy conversion systems", John Willy and sons ltd., 2006.
3. K. Sukhatme and S.P. Sukhatme, "Solar Energy". Tata MacGraw Hill, Second Edition, 1996.

[PEC-01] Engineering Optimization

Teaching Scheme:
Lectures: 3 Hrs/week
Self Study: 1 hr/week

Examination Scheme:
T1, T2 – 20 marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Explain and use the basic theoretical principles of optimization and various optimization techniques.
2. Develop and select appropriate models corresponding to problem descriptions in engineering and solve them correctly.
3. Solve and analyze complex optimization problems in power system/control system/machine drive.
4. Develop and implement various optimization software tools to solve engineering problems.

Course Contents:

Introduction to optimization, Classical Optimization: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with inequality constraints. Linear Programming: Simplex Method, Duality, Transportation problems. Nonlinear Programming: One dimensional minimization methods, unconstrained and constrained optimization.

Dynamic Programming: Development of dynamic programming, Principle of optimality. Practical Aspects of Optimization: Reduced basic techniques, Sensitivity of optimum solution to problem parameters, evolutionary optimization techniques, applications of optimization techniques to power system/control systems/power electronics and machine drives.

References:

1. R. Fletcher, "Practical Optimization", Second edition, John Wiley and Sons, New York, 1987.
2. S. S. Rao, "Engineering Optimization-Theory and practice", fourth edition, Wiley Easter Publications, January 2009.
3. K. V. Mital and C. Mohan, "Optimization Methods in Operations Research and System Analysis", New age International Publishers, Third edition, 1996.
4. Bazaraa M. S., Sherali H.D. and Shetty C. "Nonlinear Programming Theory and Algorithms", John Wiley and Sons, New York 199h.

[PEC-01] EHV AC Transmission

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Appreciate the necessity, merits and demerits of EhVAC transmission and mechanical aspects
2. Evaluate the Inductance and capacitance of two conductor and multi conductor lines
3. Analyze the effect of corona, electrostatic field of EhVAC lines
4. Analyze the surface gradient on two conductor and bundle with more than h sub conductors
5. Select EHVAC transmission system components, protection and insulation level for overvoltages

Course Contents:

Introduction: Engineering aspect and growth of EHVAC Transmission line trends and preliminaries, power transferability, transient stability and surge impedance loading. Calculation of line and ground parameters: Resistance, power loss, temperature rise properties of bundled conductors, inductance and capacitance of EHV lines, positive, negative and zero sequence impedance and line parameters for modes of propagations. Voltage gradients of conductor: Charge potential relations for multi-conductor lines, surface voltage gradients on the conductor line, distribution of voltage gradients on sub conductors of bundle. Corona in EHV lines – Corona loss formulae- attenuation of travelling waves due to Corona – Audio noise due to Corona, its generation, characteristic and limits. Measurements of audio noise radio interference due to Corona – properties of radio noise – frequency spectrum of RI fields – Measurements of RI and RIV. Theory of the Travelling and standing waves, Lighting and lighting protection, Over voltage in EHV system covered By switching operations, Power frequency voltage control and over voltage, Insulation Coordination, Design of EHV - AC lines

References:

1. R.D. Begamudre , "EhV AC transmission Engineering." New Academic Science Ltd; 4 edition, 2011
2. S Rao, "EHV -AC & HVDC transmission system engineering", Khanna Publication,3rd edition

[PEC-01] Fuzzy Logic and Neural Networks

Teaching Scheme
Lectures: 3 Hrs/week

Examination Scheme
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

1. Apply the concept of fuzziness involved in various systems
2. Design fuzzy logic control for any application.
3. Form neural network of appropriate architecture suitable to any application

Course Contents:

Introduction to Fuzzy Logic, Fuzzy Set Theory, Fuzzy Arithmetic, Fuzzy Relations. Fuzzy Logic in Databases. Fuzzy Clusters., power system application, Medical Application, control system applications, Fuzzy Decision Trees, PCA
Introduction to Artificial Intelligence System, Fundamentals of Neural Networks, Learning rules and various activation functions. Neural Network Architecture: Single layer Feed-forward networks. Multilayer Feed-forward networks. Recurrent Networks. Architecture of Back-propagation(BP) Networks, Back-propagation Learning, Variation of Standard Back propagation algorithms. applications to power system and industrial problems

References:

1. Bishop, C. M. Neural Networks for Pattern Recognition. Oxford University Press. 1995.
2. Neural Networks,Fuzzy Logic and Genetic Algorithms, by S.Rajasekaran and G.A. Vijayalakshmi Pai.
3. Neuro-Fuzzy Systems, Chin Teng Lin, C. S. George Lee, PhI.
4. Build_Neural_Network_With_MS_Excel_sample by Joe choong.

[ML-01] Research Methodology and Intellectual Property Rights

Teaching Scheme :
Self Study: 2 hrs/week

Examination Scheme:
Continuous evaluation
Assignments/Presentation/Quiz/Test

Course Outcomes:

After successful completion of this course the students will be able to,

1. Demonstrate research problem formulation and approaches of investigation of solutions for research problems.
2. Learn ethical practices to be followed in research and apply research methodology in case studies and acquire skills required for presentation of research outcomes

3. Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
4. Summarize that it is an incentive for further research work and investment in R & D, leading to creation of new and better products and generation of economic and social benefits

Course Content:

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.

Effective literature studies approaches, analysis. Use Design of Experiments /Taguchi Method to plan a set of experiments or simulations or build prototype. Analyze your results and draw conclusions or Build Prototype, Test and Redesign.

Plagiarism, Research ethics, Effective technical writing, how to write report, Paper. Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.
Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights.
Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting,
Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies.
New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development, International Scenario: WIPO, TRIPs, Patenting under PCT

References:

1. Aswani Kumar Bansal, "Law of Trademarks in India"
2. B L Wadehra, "Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications".
3. G.V.G Krishnamurthy, " The Law of Trademarks, Copyright, Patents and Design".
4. Satyawrat Ponkse, "The Management of Intellectual Property".

5. S K Roy Chaudhary & H K Saharay, “The Law of Trademarks, Copyright, Patents”
6. T. Ramappa “Intellectual Property Rights under WTO”, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO : WIPO Guide To Using Patent Information
9. Halbert, “Resisting Intellectual Property” ,Taylor & Francis
10. Mayall, “Industrial Design”, Mc Graw Hill
11. Niebel , “Product Design”, Mc Graw Hill

[MLC-2] Effective Technical Communication

Teaching Scheme:	**Examination Scheme:**
Self-study: 1hr / week	Continuous evaluation Assignments/Presentation/Quiz/Test

Course Outcomes:

After successful completion of this course, students will be able to:

1. produce effective dialogue for business related situations.
2. use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively.
3. analyze critically different concepts / principles of communication skills.
4. demonstrate productive skills and have a knack for structured conversations.
5. appreciate, analyze, evaluate business reports and research papers.

Course Content:

Fundamentals of Communication: 7 Cs of communication, common errors in English, enriching vocabulary, styles, and registers

Aural-Oral Communication: The art of listening, stress and intonation, group discussion, oral presentation skills.

Reading and Writing: Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

References:

1. Raman Sharma, “Technical Communication”, Oxford University Press.
2. Raymond Murphy “Essential English Grammar” (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock “English Pronunciation in Use” Cambridge University Press.
4. Shirley Taylor, “Model Business Letters, Emails and Other Business Documents” (seventh edition), Prentise Hall
5. Thomas Huckin, Leslie Olsen “Technical writing and Professional Communications for Non-native speakers of English”, McGraw Hill.

[PCC-01] Advanced Control Systems

Teaching Scheme
Lectures: 3 hrs/week
Self study: 1hr/hrs

Examination Scheme:
T1, T2 – 20 marks each,
End-Sem Exam – 60

Course Outcomes:
After successful completion of this course, students will be able to:

1. Analyse linear control system using state space approach.
2. Design linear control system using state space to achieve desired system performance.
3. Determine optimal control signal to extremize the given performance criterion.
4. Identify and analyse the non- linear systems.
5. Obtain discrete representation of LTI systems.

Course Contents:

Linear System analysis in state space: State variable description, state space model, Eigen value and Eigen vector of a matrix, diagonalization, solution of state equation, Controllability, Observability and Stability, Luapunov stability analysis of SISO and MIMO linear systems. Minimal realizations and co-prime fractions.

Control Design: State feedback controller by pole placement and design of observer for linear systems.

Optimal Control: Formulation of optimal control problem, linear quadratic regulator (LQR)

Non-linear Systems: Introduction to nonlinear systems, phase plane and describing function methods for analysis of linear systems and linearization.

Digital Control System: Discrete time systems, discretization, sampling, aliasing, choice of sampling frequency, ZOH equivalent

References:

1. Chi-Tsong Chen, ”Linear System Theory and Design”, Oxford University Press.
2. John S. Bay, ”Linear System Theory”.
3. Thomas Kailath,” Linear System”, Prentice Hall, 1990
4. Gillette, ”Computer Oriented Operation Research”, Mc-Graw Hill Publications.
5. K. Hoffman and R. Kunze, ”Linear Algebra”, Prentice-Hall (India), 1986.
6. G.H. Golub and C.F. Van Loan, ”Matrix Computations”, North Oxford Academic, 1983.
7. H. K. Khalil, ”Nonlinear Systems”, Prentice Hall, 2001.
8. K. Ogata,”Discrete Time Control Systems”, Prentice hall, 1995.

[PCC-02] Advanced Power Electronics

Teaching Scheme:
Lectures:3 hrs/week
Self study: 1 hr/week

Examination Scheme:
T1,T2 – 20 marks each
End-Sem Exam - 60

Course Outcomes:

After successful completion of this course, students will be able to:

1. Describe the characteristics of switching devices and use them in practical systems.
2. Model and evaluate the performance of different types of power converters.
3. Design, implement, and analyze the performance of power converter with controllers
4. Analyze the performance of power converters with protection circuit of devices and converter.

Course Contents:

Solid-State Devices: MOSFET, GTO, IGBT, GTO, SIT, SITH, MCT, their operating characteristics; Heat sink design. DC-DC Converters: Power factor improvement techniques, Switch mode power converter, Buck, boost, buck-boost, Cuk, Fly-back, Forward Converters, operation, modeling, and design of DC-DC converters, Different control strategies of DC-DC converters. Voltage mode and current mode control methods. Inverters: Review of three-phase voltage source inverters, voltage and frequency control; Harmonic reduction techniques, PWM inverters, Space Vector Modulation; Multi-level inverters, Current source inverter, commutation circuits, transient voltage suppressing techniques, operation and control, AC-AC Converters: Three-phase ac regulators, cyclo-converters; Matrix converters, output voltage control techniques, commutation methods.

References:

1. Mohan N., Undeland T.M. and Robbins W.P., "Power Electronics: Converter, Applications and Design", 3rd Ed. John Wiley and Sons, India.
2. Rashid M.H., "Power Electronics-Circuits, Devices and Applications", Pearson Education.
3. B.K. Bose, "Power Electronics and variable frequency Drives-Technology and Applications", IEEE Press, Standard Publisher Distributer.
4. Christophe P. Basso, "Switch mode Power Supplies-Spice Simulations and Practical Designs", Mc Graw Hill.
5. Erickson Robert W. Dragan Maksimović, "Fundamentals of Power Electronics", Springer publication.

[PCC-03] Power System Analysis

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Analyze power systems using basic concepts and principles.
2. Formulate and solve power flow problems, economic and environmental dispatch problems.
3. Evaluate the voltage stability and power system security of given power system
4. Solve a practical system both under steady state and fault conditions
5. Analyze power system stability problems

Course Contents:

Algorithms for formation of bus admittance and impedance matrices, power flow solutions: Gauss Seidal, Newton-Raphson, Fast decoupled load flow, optimal power flow, sparsity exploitation in power system studies, Z - matrix for short circuit studies, concept security state and security analysis, contingency studies, unit commitment, state estimation, Weighted least squares state estimation, optimal hydro-thermal scheduling, voltage stability: Definition and classification, mechanism of voltage collapse, analytical concept of voltage stability for a two bus system, Artificial Intelligence applications to power system analysis, renewable generation for power flow analysis.

References:

1. G. W. Stagg and A. h. El-Abiad, "Computer Methods in Power System Analysis", McGraw hill 1968.
2. G. L. Kusic, "Computer Aided Power Systems Analysis", Prentice hall, 1986.
3. I. J. Nagrath and D. P. Kothari, "Modern Power Systems Analysis", Tata McGraw hill, 1980.
4. A J. Wood and B. F. Wollenberg, "Power Generation, Operation and Control", John Wiley, 1984.

[LC-01] Simulation Laboratory

Teaching Scheme:
Lectures: 4 hrs/week

Examination Scheme:
Continuous Assessment- 50 Marks
Final Practical/Oral Exam – 50 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Model electrical power system under steady state and transient conditions.
2. Use MATLAB and ATP/PSCAD for power system studies.
3. Determine the reactive power requirement of lines and compute VAR compensation required from voltage profile along the line.
4. Compute the Y-bus matrix, perform load flow studies and interpret the results.
5. Use Maxwell software for analysis of electric machines.
6. Use PSIM, PSPICE for power electronic circuit simulation.
7. Use ETAP for power system analysis

Course Contents:

This lab will cover simulation experiments/assignments on the platform like MATLAB, ATP/EMTP, PSCAD, MAXWELL, LABVIEW, PSIM, PSPICE, DigSILENT, etc. The problems will be related to the core subjects and electives.

References: Manuals of respective software.

[LC-02] Embedded System Lab

Teaching Scheme:
Lab:4 hrs/week

Examination Scheme:
Continuous Evaluation: 50 Marks
End-Sem Exam –50 marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. Perceive what is microcontroller, microcomputer, embedded system.
2. Compile different components of microcontroller and their interactions.
3. Become familiar with programming environment used to develop embedded system.
4. Experiment with key concepts of embedded systems like I/O, timers, interrupts.
5. Learn debugging techniques for an embedded system.

Lab Contents:
Experiments based on above objectives such as PID control, LED interface, timers, counters, ADC, DAC, PWM and Design of energy meter etc.

References:

1. Steve Heath, "Embedded Systems Design", Publisher Butterworth-Heinemann.
2. Wyne Woff "Principles of Embedded computing system design", Morgan Koffman publication 2000
3. Rajkamal, "Embedded Systems- Architecture, Programming and Design", 2007- TMH.
4. Qing Li, "Real Time Concepts for Embedded Systems", Elsevier, 2011.
5. Shibu K.V, "Introduction to Embedded Systems", Mc Graw Hill.
6. Frank Vahid, Tony Givargis, "Embedded System Design", John Wiley.
7. Lyla "Embedded Systems", Pearson, 2013.

SEMESTER-II

[OE-01] Engineering Optimization (Interdisciplinary Open Course)

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/week	T1, T2 – 20 marks each
Self Study: 1 hr/week	End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Explain and use the basic theoretical principles of optimization and various optimization techniques.
2. Develop and select appropriate models corresponding to problem descriptions in engineering and solve them correctly.
3. Solve and analyze complex optimization problems in various engineering applications.
4. Implement various optimization software tools to solve engineering problems.

Course Contents:

Introduction to optimization, Classical Optimization: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with inequality constraints. Linear Programming: Simplex Method, Duality, Transportation problems. Nonlinear Programming: One dimensional minimization methods, unconstrained and constrained optimization.

Dynamic Programming: Development of dynamic programming, Principle of optimality. Practical Aspects of Optimization: Reduced basic techniques, Sensitivity of optimum solution to problem parameters, evolutionary optimization techniques, applications of optimization techniques to various engineering applications.

References:

1. R. Fletcher, "Practical Optimization", Second edition, John Wiley and Sons, New York, 1987.
2. S. S. Rao, "Engineering Optimization-Theory and practice", fourth edition, Wiley Easter Publications, January 2009.
3. K. V. Mital and C. Mohan, "Optimization Methods in Operations Research and System Analysis", New age International Publishers, Third edition, 1996.
4. Bazaraa M. S., Sherali H.D. and Shetty C. "Nonlinear Programming Theory and Algorithms", John Wiley and Sons, New York 199h.
5. Bertsekas D. P., "Constrained Optimization and Lagrange Multiplier Methods", Academic Press, New York, 1982.Durga Das Basu, "Introduction to the Constitution of India" Prentice Hall EEE, 19th/20th Edn., 2001. (Students Edn.)

[PEC-02] Energy Storage Systems

Teaching Scheme:	**Examination Scheme:**
Lectures:3 hrs/week	T1, T2 – 20 marks each
Self study:1 hr/week	End-Sem Exam - 60

Course Outcomes:

After successful completion of this course, students will be able to:

1. Understand the emerging needs of Electrical Energy Storage Systems.
2. Analyze the performance of various Electrical Energy Storage Systems.
3. Assess the markets for the Electrical Energy Storage Systems.
4. Design the battery management system.

Course Contents:

Energy storage systems overview, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles. Types of Electrical Energy Storage Systems, Classification, Thermal, Mechanical, Chemical, Electromagnetic, Electrochemical Energy Storage systems: (a)Batteries-Working principle of battery, primary and secondary (flow)

batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery. (b) Supercapacitors- Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, (c) Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems.
Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles., Standards and Safety involved.

References:

1. IEC White paper on Electrical Energy Systems: www.iec.ch/whitepaper/pdf/iecWP
2. Energy Storage Systems, Volume I and II, EOLSS, www.eolssunesco@gmail.com
3. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
4. Ralph Zito, Energy storage: A new approach, Wiley (2010)
5. A.G.Ter-Gazarian, Energy Storage for Power Systems, Institution of Engineering and Technology, 2011.

[PEC-02]Power Quality Issues and Mitigation

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Assess power quality of the power system
2. Suggest mitigating equipment for power quality issues
3. Identify different power quality improvement techniques.
4. Select and use power quality monitoring meters
5. Design harmonic filter

Course Contents:

Terms and definitions, voltage sags and interruptions: sources of sags and interruptions, end user issues, transient over voltages: sources of transient overvoltages, devices for overvoltage protection, load switching transient problems, harmonics: harmonic distortion, total harmonic distortion, triplen harmonics, effects of harmonic distortion, locating sources of harmonics, modelling harmonic sources, computer tools for harmonic analysis, long duration voltage variations: devices for voltage regulation, capacitors for voltage regulations, regulating utility voltages with dispersed sources, monitoring and measurement of power quality. Mitigation equipment, filter design.

References:

1. Roger Dugan, h. Wayne, "Electrical power systems quality". McGraw hill, 2002
2. Alexander Kusko and Marc T. Thompson, "Power quality in electrical systems".
3. Arindam Ghosh, Gerard Ledwich, "Power Quality Enhancement using Custom Power Devices".
4. Math h. J. Bolen, "Understanding Power Quality Problems", IEEE power series on Power Engineering.
5. Wakileh, George J.," Power system harmonics, Fundamentals, Analysis and Filter Design", Springer

[PEC-02] Smart Grid Technologies

Teaching Scheme:	**Examination Scheme:**
Lectures:3 hrs/week	T1, T2 – 20 marks each
Self study:1 hr/week	End-Sem Exam – 60

Course Outcomes:

After successful completion of this course, students will be able to:

1. Express the need and specify the components of smart grid ~~and smart communication~~.
2. Understand the various smart grid technologies.
3. Identify the need of micro grid, smart metering, smart storage
4. Understand the role of smart sensors, smart communication for development of Smart cities and Smart substation

Course Contents:

Introduction to smart grid, smart grid vision and road map in India, Concept of Resilient and self-Healing Grid, Present international developments, smart cities, RTU, IED, PMU, smart substations, feeder automation, PHEV, V2G, G2V, CAES, real time prizing, AMR, OMS, smart sensors, Home and building automation, GIS, Concept of microgrid, architecture, DC micro grid, issues, integration of renewable energy sources, cyber controlled smart grid, Power quality and EMC in micro grid, web based PQ monitoring, smart grid communication architecture, WAMS, HAN, NAN, WAN, Bluetooth, ZigBee, GPS, Wi-Fi Max based communication, wireless network, cloud computing, cyber security, BPL, IP based protocols.

References:

1. Ali Keyhani, Mohammad N. Marwali, Min Dai, "Integration of green and renewable energy in electric power systems, John Weily.
2. Clark W. Gellings, 'Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press.
3. Stuart Borlase, "Smart Grids-Infrastructures, Technology and Soluations", CRC Press, Taylor and Francis group.
4. Janaka Ekanayake, Kithsiri Liyanage, J. Wu and Akihiko Yokoyama, 'Smart Grid-Technology and Applications, John Wily.

[PEC-02]: Electric Mobility

Teaching Scheme:
Lectures:3 hrs/week
Self study:1 hr/week

Examination Scheme:
T1, T2 – 20 marks each
End-Sem Exam – 60 Marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. Demonstrate the concept of Electric Vehicles, Hybrid Electric Vehicles & Plug in Hybrid Electric Vehicles
2. Evaluate the power electronics & electric machine requirements of EVs & HEVs
3. Address design issues of EVs & HEVs
4. Model EVs & HEVs

Course Contents:

A brief history of EV & PHV, Basics of EV & HEV, Architectures of EV & HEV, HEV fundamentals. Introduction to PHEVs, PHEV architectures, Power management of PHEVs, Fuel economy of PHEVs, PHEV design & component sizing, Aerodynamic considerations, Consideration of rolling resistance, Transmission efficiency, Consideration of vehicle mass, Electric vehicle chassis & body design, General issues in design. Vehicle-to-grid technology, Battery chargers used in EVs & HEVs, Emerging power electronic devices for EV, challenges in design, Batteries, Ultracapacitors, Fuel Cells Battery management systems, Introduction to modelling, Fundamentals of vehicle system modeling, HEV modeling, Case studies - Rechargeable battery vehicles, Hybrid vehicles, Autonomous Vehicles, smart mobility issues and challenges.

References:

1. Chris Mi, M. AbulMasrur, David WenzhongGao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", 2011, Wiley publication.
2. Allen Fuhs, "Hybrid Vehicles and the future of personal transportation", 2009, CRC Press.
3. James Larminie, John Lowry, "Electric Vehicle Technology Explained", 2003, Wiley publication.

[PEC-02] Substation Design

Teaching Scheme	**Examination Scheme:**
Lectures: 3 hrs/week	T1 and T2: 20 Marks each
	End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Estimate cost, schedule preparation
2. Develop of single line diagram
3. Select substation equipment, cable, busbar sizing & auxiliary system design (ac & dc)
4. Design plan layout and sectional layout
5. Design earthing, lightning and illumination system

Course Contents:

Background, Need Determination, Budgeting, Financing, Traditional and innovative Substation Design, Site Selection and Acquisition, Design, Construction and Commissioning Process, Ambient conditions, Disconnect switches, Load Break switches, high speed grounding switches, power fuses, circuit switches, circuit breaker, Transmission substation, distribution substation, collector substation, switching substations, gas insulated substations, air insulated substations, bus configurations: single bus, double bus, double break, main and transfer bus, double bus, single breaker, ring bus, break-and-a-half, cable sizing, transformer sizing, CT-PT sizing, Comparison of configurations. Reasons for substation grounding system, accidental ground circuit, Design criteria-Actual Touch and step voltage, soil resistivity, grid resistance, grid current, use of the design equations, selection of conductors, grounding fence, other design considerations. Lightning stroke protection-lightning parameters, empirical design methods. Substation fire protection-Fire hazards, fire protection measures, fire protection selection criterion. components of substation automation system, automation applications, protocol fundamentals, supervisory control and data acquisition (SCADA) historical perspective, SCADA functional requirements, SCADA communication requirements, components of SCADA system, SCADA communication protocols, the structure of a SCADA communication protocol, security for substation communications, security methods, security assessment, substation illumination using dialux

References:

1 R. S. Dahiya, Vinay Attri,"Sub-Station Engineering Design & Computer Applications" S K Kataria and sons Publications, 1 st Edition, 2013
2. P. S. Satnam, P. V. Gupta, "Substation Design and Equipment" Dhanapat Rai Publications, 1 st Edition, 2013.
3.Turan Gonen, "Electric Power Distribution Engineering" CRC press, third edition, 2014.
4. John D. McDonald, Electrical Power Substation Engineering, CRC Press, 3rd Edition, 2017.

Web Resources:

1. https://www.transgrid.com.au/what-we-do/our-network/connections
2. https://new.abb.com/substations
3. https://ieeexplore.ieee.org/document/1780164. 4. 4.
4.https://www.sciencedirect.com/topics/engineering/substations

[PEC-03] Power System Transients

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 hrs/week	T1 and T2: 20 Marks each
	End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Understand the transient phenomena in power system.
2. Analyze transient phenomena and develop the strategies to mitigate associated problems.
3. Evaluate the transient process due to lightning
4. Use of different software tools to study the transient phenomenon

Course Contents:

Sources of electrical transients, basic concepts, definitions, causes, effects, basic mathematical concepts for transient analysis, representation of transient wave shap, modelling power apparatus for transient analysis, capacitor switching, reactor switching, magnetizing inrush and ferroresonance, transmission lines, the wave equation, and line terminations, travelling wave attenuation and distortion, transients due to faults, electromagnetic induction, magnetic flux, and currents, transient electromagnetic phenomena, lightning induced transients, computation of lightning events, lightning protection using shielding and surge arresters, transient voltages and grounding practices, numerical simulation of electrical transients, simulation tools, international standards.

References:

1. Pritindra Chaudhari, "Electromagnetic transients in Power System", PhI.
2. J.C. Das, "Transients in Electrical Systems", McGraw-hill, 2010.
h. A. Greenwood, "Electrical Transients in Power Systems", Wiley-Interscience, 1991.
4. L. van der Sluis, "Transients in Power Systems", Wiley, 2001.
5. J.A. Martinez-Velasco, "Power System Transients: Parameter Determination", CRC Press, 2009.
6. L.V. Bewley, "Traveling Waves on Transmission Systems".
7. h. W. Dommell, EMTP Theory Book.
8. Alternate Transients Program Rule Book.

[PEC-03] Artificial Intelligence and Machine Learning

Teaching Scheme:	**Examination Scheme:**
Lectures:3 hrs/week	T1, T2 – 20 marks each
Self study:1 hr/week	End-Sem Exam – 60

Course Outcomes:

After successful completion of this course, students will be able to:

1. Identify problems where artificial intelligence techniques are applicable.
2. Select appropriate technologies for a given problem and anticipate the design implication.
3. Understand the fundamental issues and challenges of machine learning algorithms.
4. Design and Apply the machine learning algorithms to real world problems.
5. Analyze the machine learning algorithms applied to real world problems.

Course Contents:

Introduction to Artificial Intelligence: Artificial Intelligence problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation. Searching- Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search).

Introduction to Machine Learning: Basic definitions, types of learning, designing a learning system, perspectives and issues, hypothesis space and inductive bias, evaluation, cross-validation. Linear regression, Decision trees, Splitting Criteria, Issues in decision tree learning, overfitting and evaluation, nearest neighbor methods. Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network. Dimensionality Reduction: Feature reduction, Principal Component Analysis, Fischer's Discriminant Analysis. Probability and Bayes learning, Naive Bayes Model, Logistic

Regression, Reinforcement learning. Support Vector Machine, Kernel function and Kernel SVM, Clustering: partitioning, k-means clustering, hierarchical clustering, and Case studies.

Reference Books:

1. S. Russel and P. Norvig, “Artificial Intelligence – A Modern Approach”, Fourth Edition, Pearson Education
2. David Poole, Alan Mackworth, Randy Goebel,” Computational Intelligence: a logical approach”, Oxford University Press.
3. Ethem Alpaydin, Introduction to Machine Learning, Second Edition, The MIT Press, 2010.
4. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.
5. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, 2009.
6. Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
7. https://archive.nptel.ac.in/courses/106/105/106105152/

[PEC-03] Electrical Power Distribution Systems

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 hrs/week	T1 and T2: 20 Marks each
	End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Calculate load necessary for planning of new distribution systems
2. Design primary and secondary distribution systems.

h. Analyze unbalanced distribution systems and explain impact of integration of DGs.

4. Address the protection and reliability issues in distribution systems.
5. Design active network management

Course Contents:

Overview of power distribution systems, objectives and goals, physical layout, standards and requirements, Distribution network planning, distribution transformers, grounding and protection, Medium and long term load forecasting, three phase network modelling, analysis of unbalance networks, Distribution load flow, Distribution state estimation, Distribution losses, Reliability considerations and bench marking, Distributed generation (DG), distribution planning in presence of DGs, grid integration of DG, protection issues with DG, Electric vehicles, impact on forecasts, planning for charging networks, Battery storage systems sizing and location, Design of active networks, economic considerations of power distribution, microgrid and hybrid systems

References:

1. W. h. Kersting, "Distribution Systems Modeling and Analysis", CRC Press, Fourth Edition, 2017
2. Turan Gönen, " Electric Power Distribution System Engineering" (Second Edition)
3. NPTEL course on 'Electrical Distribution Systems' by Prof. Kumbhar

[PEC-03] Restructured Power Systems

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Understand the need for restructuring of power system and identify various market models
2. Study various ancillary services and management
3. Analyze transmission open access pricing issues and congestion management
4. Investigate effects of FACTS devices and distributed generation on restructured power systems

Course Contents:

Overview of Indian Power System: past and present status, Centralized and De-centralized dispatch philosophies, Introduction to Ancillary Services: Types and Classification, Ancillary Service Management, Transmission Congestion Management, Transmission Pricing Methods, Loss Allocation Algorithms, Locational Marginal Price (LMP) calculation and properties, Financial Transmission Rights (FTR), Transmission Expansion Planning, Role of FACTS devices in competitive power market, Distributed Generation in Restructured market, Working of International Power Markets, Restructured issues in Indian Power Sector.

References:

1. Lorrin Philipson, h. Lee Willis, "Understanding electric utilities and de-regulation", Marcel Dekker Pub.,1998.• Steven Stoft, "Power system economics: designing markets for electricity", John Wiley and Sons, 2002.
2. Kankar Bhattacharya, Jaap E. Daadler, Math H. J. Boolen, "Operation of restructured power systems", Kluwer Academic Pub., 2001.
3. Mohammad Shahidehpour, Muwaffaq Alomoush, "Restructured electrical power systems:operation, trading and volatility", Marcel Dekker.

[PEC-03]: Advanced Electric Drives

Teaching Scheme:	**Examination Scheme:**
Lectures:3 hrs/week	T1, T2 – 20 marks each
Self study:1 hr/week	End-Sem Exam – 60 Marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. Comprehend state of the art technology of dc and ac advanced drives.
2. Solve problems; analyze performance of dc and ac drives.
3. Select suitable drives according to the application.
4. Design the advanced drive and compare the performance with the existing one.

Course Contents:

Review of drive fundamentals, dynamics of electric drives, selection of motor power rating. Review of fundamentals of DC Drives and Induction motor drives. Converters topologies for low, medium and high power drives. Frequency controlled, vector controlled, and Direct torque controlled for induction motor drives. Sensor and Senseless control, Ripple minimization techniques for DTC. PMSM and BLDC drives, Synchronous Reluctance and Switched Reluctance motor drives. Stepper motor drives. Drives for the slip ring induction machine, DFIG and its four-quadrant control.

References:

1. R. Krishnan, 'Switched Reluctance Motor Drives – Modeling, Simulation, Analysis, Design and Application', CRC Press, New York, 2001.
2. T. Kenjo and S. Nagamori, 'Permanent Magnet and Brushless DC Motors', Clarendon Press, London, 1988.
3. M.H. Rashid "Power Electronics", 3rd Ed, PHI Pub. 2004.
4. G. K. Dubey , "Fundamentals of Electrical Drives", Narosa Publishing house.
5. B. K. Bose, "Modern Power Electronics and AC Drives", Pearson Education, Asia, 2003.

[PCC-04] Power Systems Dynamics and Stability

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Comprehend concepts in the dynamic phenomena and stability of power systems
2. Model power system components, such as synchronous machines, excitation systems and governors
3. Analyze dynamic and oscillatory behavior of power systems and to alleviate the same.
4. Interpret results of system stability studies.

Course Contents:

Basic concepts of dynamical systems and stability, modelling of power system components for stability studies: generators, transmission lines, excitation and prime mover controllers, analysis of single machine and multi-machine systems, small signal angle instability (low frequency oscillations): damping and synchronizing torque analysis, Eigen value analysis, mitigation using power system stabilizers, PSS design for multi-machine systems, small signal angle instability (sub-synchronous frequency oscillations): analysis and counter-measures, transient instability: analysis using digital simulation and energy function method, transient stability controllers.

References:

1. K. R. Padiyar, "Power System Dynamics, Stability and Control", Interline Publishers, Bangalore,1996.
2. P. Kundur, "Power System Stability and Control", McGraw hill Inc, New York, 1995.
3. P. Sauer and M. A. Pai, "Power System Dynamics and Stability", Prentice hall, 1997.
4. E.W. Kimbark, "Power systems Stability", Vol. I and III.

[PCC-05] HVDC and FACTS

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Identify the need for hVDC systems.

2. Identify converters for hVDC application
3. Appreciate the use of filters for hVDC systems
4. Explain the operation of various FACTS devices.
5. Model FACTS devices to improve steady and dynamic performance of power system.

Course Contents:

HVDC: Introduction, various possible HVDC configurations, components of HVDC system, operation of 6-pulse and 12-pulse converter, Effect of source inductance, Generation of harmonics, Design of AC filters and DC filters, hVDC light and hVDC PLUS Series and Parallel operation of converters, Introduction to distribution FACTs devices.
The concept of flexible AC transmission – reactive power control in electrical power transmission lines, uncompensated transmission line, Introduction to FACTS devices and its importance in transmission Network, Introduction to basic types of FACTS controllers, Shunt Compensation: Methods of Var generation: Thyristor controlled reactor (TCR), Thyristor switched capacitor (TSC), Fixed capacitor- Thyristor controlled reactor (FC-TCR), STATCOM; Series Compensation : 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: The Unified Power Flow Compensator (UPFC); circuit and steady-state characteristic; effect on transmission line compensation; Interline Power Flow Controller (IPFC); circuit and steady-state characteristic;

References:

1. K. R. Padiyar , " hVDC Power Transmission System", Wiley Eastern Limited, New Delhi , First Edition1990.
2. T.J.E. Miller , " Reactive Power Control in Electrical System", John Wiley and Sons, New York ,1982.
3. N.G.hingorani, "Understanding FACTS :Concepts and Technology of FACTS Systems", IEEE Press,2000.
4. K.R.Padiyar "FACTS Controllers in Power Transmission and Distribution", New Age International (P) Ltd. 2007.
5. J.Arrillaga, " high Voltage Direct Current Transmission", Peter Pregnnus, London 1983.

[PCC-06] Digital Protection

Teaching Scheme:	**Examination Scheme:**
Lectures: 3Hrs/week	T1 and T2: 20 Marks each
	End-Sem Exam: 60 Marks

Course Outcomes:

After successful completion of this course the students will be able to,

1. Select various components (like CT, CVT, and numerical relay) for protection purpose.
2. Apply least squares, DFT, FFT phasor estimation algorithms for numerical protection.
3. Design and simulate over current, distance and differential protection schemes for power systems.
4. Develop the advanced schemes for power system protection using new technologies such as synchronized measurements, PMUs, GPS, fiber optics.

Course Contents:

Review of principles of power system protection: over current, directional, differential and distance protection, travelling wave based protection, review of sequence networks and short circuit analysis, relay coordination: over current and distance relay coordination, Current transformer and potential transformer, standards, effect on relaying philosophy, introduction to computer aided relaying, motivation, basic hardware, , estimation of phasors and frequency, algorithms for transmission line protection, out-of-step relaying, introduction to adaptive relaying and wide area measurements(WAM), transformer, generator and bus bar protection

References:

1. Prof. S. A. Soman, "A Web Course on Digital protection of power system", IIT Bombay.
2. A. G. Phadke, J. S. Thorp, "Computer relaying for power systems", research studies press ltd.England, John Wiley and sons inc., New York.
3. Blackburn, "Protection of Power Systems".
4. Y. G. Paithankar, S. R. Bhide, "Fundamentals of power system protection", Prentice hall, India.

[LC-03] DSP Application Laboratory

Teaching Scheme:	**Examination Scheme:**
Lab:2 hrs/week	Continuous Evaluation: 50 Marks
Lecture:1 hr/week	End-Sem Exam – 50 marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. Write low level device drivers/Chip Support Libraries for standard peripherals such as UART/PWM/Timers Create/debug and develop applications in C for embedded environment.
2. Develop an embedded controller for power electronics and drive applications.

Lab Contents:

Experiments on the DSP/Micro- controllers, Interfacing peripherals to DSP/micro-controller, Assembly language programming, Real-time voltage/ current, speed sensing signal and processing, PWM strategies realization through DSP and controlling power electronic converters and Drive Systems.

References:

1. TI User Manuals TMS320C2x, TMS 28335.
2. Website www.ti.com and www.DSPguide.com.
3. Marven, C., Ewers, G. A simple approach to DSP Texas Instr. 1993.
4. MSP 430 Technical Reference Manual.

[AEC-01] HIL Lab

Teaching Scheme:
Lab:2 hrs/week

Examination Scheme:
Continuous Evaluation: 50 Marks
End-Sem Exam – 50 marks

Course Outcomes:

After successful completion of this course, students will be able to:

1. Mathematically formalize requirements based on design objectives.
2. Trace the design project requirements through modeling and control design.
3. Perform, analysis and design in the discrete domain using ADC and DAC.
4. The students will gain knowledge and hands on experience with sensor and actuator calibration, signal amplification, sampling, DAC and ADC, uncertainties and noise, continuous and discrete filters, safety measures for HIL implementations.
5. Independently setup HIL experiments using SIMULINK and dSpace virtual HIL software packages.
6. Creates a virtual real-time environment which contains a model of control system, and an external physical system.

Lab Contents:

Three lab sessions to work with MATLAB/SIMULINK. Develop the model and controller, and validate and verify their SIMULINK files according to the predefined requirements.

The learning objectives of the first two lab sessions were— 1) Develop and debug the model/controller in MATLAB/SIMULINK, 2) Design MIL tests in order verify and validate the model/controller according to predefined requirements, 3) Generate and debug production code, and performing SIL tests, 4) get hands on experience of V&V tools in MATLAB/SIMULINK

Three labs on dSPACE software package and verifying/validating their developed code with VHIL. The learning objectives of these three lab sessions were — 1) Independently setting up VHIL, and recording data using data acquisition tools in dSPACE, 2) Learning to work with dSPACE software packages, 3) Designing and implementing DOE tests on the VHIL platform.

Two labs to perform HIL simulation using dSpace and implementation of controller on real time system like power converters, electric motors.

References:

1. Martin Schlager, "Hardware-in-the-Loop Simulation" 2014, VDM
2. Adit Joshi, "Automotive Applications of Hardware-in-the-Loop (HIL) Simulation" SAE International
3. Manuals of respective devices and software.

[CCA-01] Liberal Learning Course

Teaching Scheme:
Lectures: 1 hrs/week

Examination Scheme:
T1 and T2: 20 Marks each
End-Sem Exam: 60 Marks

Course Outcomes:
After successful completion of this course the students will be able to,

1. Survey new topics from various disciplines and Select various sources and avenues to harvest/gather information.
2. Explain qualitative attributes of a good learner.
3. Demonstrate quantitative measurements of learning approaches and learning styles.
4. Appreciate openness to diversity.

Course Contents:

Topic selected by the student from areas displayed by the institute. The sample list is below. Agriculture (Landscaping, Farming, etc.), Business (Management, Entrepreneurship, etc.), Defense (Study about functioning of Armed Forces), Education (Education system, Policies, Importance, etc.), FineArts (Painting, Sculpting, Sketching, etc.), Linguistics, Medicine and health (Diseases, Remedies, Nutrition, Dietetics, etc.), Performing Arts (Music, Dance, Instruments, Drama,etc.), Philosophy, Social Sciences (history, PoliticalSc., Archeology, Geography, Civics, Economics, etc.)

References:

1. Expert(s), Books, Texts, Newspaper, Magazines, Research Papers, Journal, Discussion with peers or faculty.

SEMESTER-III

[VSEC-01] Dissertation Phase I

Course Outcomes:

After successful completion of this course the students will be able to,

1. Identify key research and development topics in the field of chosen dissertation area (Power Systems, Power electronics, Electrical machines, Energy systems and any interdisciplinary area).
2. Identify, summarize and critically evaluate relevant literature and write a literature review on the relevant topic.
3. Manage time effectively whilst working on independent research and prepare action plan.
4. Show evidence of clarity of argument, understanding of the chosen topic area, and presentation of technical information.
5. Use and develop written and oral presentation skills.

Course Contents:

The M. Tech. project is aimed at training the students to analyze independently any problem in the field of Electrical Engineering or interdisciplinary. The project may be analytical, computational, experimental or a combination of three. The project report is expected to show clarity of thoughts and expression, critical appreciation of the existing literature and analytical, experimental, computational aptitude.
The student progress of the dissertation work will be evaluated in stage I by the departmental evaluation committee

References:

1. Various books, research papers, patents and IPRs on the topic selected for the dissertation.

SEM-IV

[VSEC-02] Dissertation Phase – II

Course Outcomes:

After successful completion of this course the students will be able to,

1. Manage time and other resources effectively whilst working on independent research.

2. Identify, analyses and interpret suitable data to enable the research question to be answered.
3. Model, Simulate/ develop innovative hardware/ develop new algorithms/ emulate/ HIL/ develop prototype for the selected topic.
4. Describe the process of carrying out independent research in written format and report your results and conclusions with reference to existing literature and Analyze and synthesize research findings.
5. Use and develop written and oral presentation skills and Prepare good technical project reports for publication in journals and conferences.
6. Take up challenging issues in industry and provide solutions.

Course Contents:

The M. Tech. project is aimed at training the students to analyze independently any problem in the field of Electrical Engineering or interdisciplinary. The project may be analytical, computational, experimental or a combination of three. The project report is expected to show clarity of thoughts and expression, critical appreciation of the existing literature and analytical, experimental, computational aptitude.
The student progress of the dissertation work will be evaluated in stage II by the departmental evaluation committee and final viva voce will be conducted by the external examiner.

References:

1. Various books, research papers, patents and IPRs on the topic selected for the dissertation.