DIT UNIVERSITY
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IMAGINE ASPIRE ACHIEVE

DETAILED COURSE STRUCTURE& SYLLABUS

OF

M.TECH. IN ELECTRICAL ENGINEERING
(POWER SYSTEM)
BATCH 2022–24

Approved by 19th Meeting of Academic Council-DIT University

COURSE STRUCTURE & SYLLABUS OF M. TECH (EE)-POWER SYSTEM APPLICABLE FOR BATCH 2022-24

COURSE STRUCTURE

Year 1 **Semester I**

Course Category	Course Code	Course Title	L	T	P	Credit
UC	MA601	Advanced Mathematics	4	0	0	4
DC	EE601	Advanced Control System	4	0	0	4
DC	EE602	Advanced Power Electronics	4	0	0	4
DE		Elective-I	4	0	0	4
		Total				**16**

Year 1 **Semester II**

Course Category	Course Code	Course Title	L	T	P	Credit
DC	EE604	Soft Computing	4	0	2	5
DC	EE605	Power System Operation and Control	4	0	0	4
DE		Elective-II	4	0	0	4
DE		Elective-III	4	0	0	4
		Total				**17**

Year 2 **Semester III**

Course Category	Course Code	Course Title	L	T	P	Credit
DE		Elective – IV	4	0	0	4
DE		Elective – V	4	0	0	4
DC	EE701	Seminar	0	0	2	1
DC	EE702	Dissertation-I	0	0	20	10
		Total				**19**

Year 2 **Semester IV**

Course Category	Course Code	Course Title	L	T	P	Credit
DC	EE703	Dissertation Phase-II	0	0	32	16
		Total				**16**

Elective Basket

Elective -I

S.N.	Course Code	Course Title
1	EE641	Advanced Electric Drives
2	EE643	Generalized Theory of Electrical Machines

Elective -II

S.N.	Course Code	Course Title
1	EE642	Energy Management & Audit
2	EE644	Optimization Techniques / Optimization from fundamentals* (MOOC:SWAYAM)(https://onlinecourses.nptel.ac.in/noc21_me10/preview)
3	EE645	Power Converters

Elective -III

S.N.	Course Code	Course Title
1	EE646	Power Electronics for Renewable Energy Systems
2	EE647	Renewable Energy Systems
3	EE648	Special Electric Machines

Elective -IV

S.N.	Course Code	Course Title
1	EE741	Advanced Electrical Machines
2	EE742	Computer Methods in Power System Analysis
3	EE743	Digital Signal Processing
4	EE744	Direct Energy Conversion
5	EE745	Distributed Power Generation System
6	EE746	FACTS Devices

Elective -V

S.N.	Course Code	Course Title
1	EE747	High Voltage Direct Current Transmission
2	EE748	High Voltage Generation & Measurement
3	EE749	Instrumentation in Power Electronics System
4	EE751	Measurement & Control
5	EE752	Power Quality
6	EE753	Switched Mode Power Supply

CREDIT SUMMARY

Year	Semester	Credit	Year Credit
First Year	I	16	33
	II	17	
Second Year	III	19	35
	IV	16	
Total			**68**

Course Code	EE601	Course Title	ADVANCED CONTROL SYSTEM						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1	Semester	I

Course Outcome

At the end of the course, the student will be able to

CO1 Understand the concepts modelling & analysis of a LTI system without and with disturbance.
CO2 Student will be able to represent any control system in state-space form.
CO3 Understand the concept of discrete time control system its representation and analysis.
CO4 Student will be able to design different controllers and compensations.
CO5 Student will understand nonlinear system, its representation and analysis methods.

Detailed Syllabus:

UNIT-I **(12 hrs)**

Review of Modeling and Analysis of LTI Systems:

Modelling of physical Systems. Design specifications and performance indices, Motion control systems, Transportation lags. Approximation of time-delay functions, Sensitivity of control systems to parameter variations. Effects of disturbance of signals. Disturbance rejection.

UNIT-II **(10 hrs)**

Analysis in State-Space:

A perspective on state-space design, State variables, State models for physical systems, SISO and MIMO systems, Solution of state equations. Transfer function, Eigenvalues and eigenvectors, Jacobian linearization technique, State transformations and diagonalisation, Transformation to phase-variable canonical form, Controllability and observability, Duality property, Stability.

UNIT-III **(10 hrs)**

Introduction to Discrete-Time Systems:

Basic elements of discrete-time control system, Z-transform and properties, Inverse Z-transform, Difference equation and its solution by Z-transform method, Z-transfer function, State diagram of digital systems, Time delay, Direct, cascade and parallel decomposition of Z-transfer functions.

UNIT-IV **(10 hrs)**

Feedback Control Design:

Continuous control design, Proportional, derivative and integral control action, PID controller tuning rules, Ziegler-Nichols method, two degree of freedom control systems, Compensator design using Bode diagram in frequency response approach, Lag, Lead, Lag-lead compensator, Control law design for full state feedback by pole placement, Full order observer system, Observer based state feedback, Separation principal.

UNIT-V **(10 hrs)**

Non Linear System:

Classification and types of non-linearity, Phenomena peculiar to non-linear systems, Methods of analysis, Linearization based on Taylor's series expansion, Jacobian Linearization, Phase trajectory and its construction, Phase-plane analysis of linear and non-linear systems, Existence of limit cycles, Describing function of typical non-linearities, Stability analysis by DF method, Introduction to DIDF, Popov's circle criterion, Stability analysis by Lyapunov's indirect and direct methods, Lyapunov's theorem.

TEXT BOOKS:

1. Ogata, K – Modern Control Engineering, PHI Learning
2. Kuo, B.C. – Automation Control Systems, Prentice Hall
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
4. Nagrath, J. J. Gopal, M – Control System Engineering, New Age Pub.

REFERENCES:

1. Schulz, D.G. and Melsa, L. – State Functions and Linear Control Systems, McGraw-Hill.
2. Stepheni, Shahian, Savant, Hostetler – Design of feedback control systems, Oxford University Press.
3. Vidyasagar- Nonlinear system analysis, Prentice-Hall.

COURSE STRUCTURE & SYLLABUS OF M. TECH (EE)-POWER SYSTEM APPLICABLE FOR BATCH 2022-24

Course Code	EE602	Course Title	ADVANCED POWER ELECTRONICS						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1	Semester	I

Course Outcomes: At the end of the course the student will be able to:
CO1 Select an appropriate power semiconductor device and design a power converter for the required application
CO2 Determine the power circuit configuration needed to fulfill the required power conversion with applicable constraints.
CO3 Design the control circuit and the power circuit for a given power converter
CO4 Determine the drive circuit requirements in terms of electrical isolation and the requirement of bipolar drive and ease of control.

UNIT-I Review of Power 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.

UNIT-II Switching Voltage Regulators:
Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations like 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, Cuck convert, design criteria for SMPS; Multi-output switch mode regulator.

UNIT-III Inverters:
Classification; Review of line commutated inverters; Bridge inverters with 120°,180°, and 150° modes of operation; Harmonic reduction techniques; Sine-triangular PWM; Space Vector Pulse Width Modulation; Curren Source Inverters.

UNIT-IV 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); Cascade connected drive circuits; Thyristor drive circuits; Protection in driver circuits; Blanking circuits for bridge inverters.

UNIT-V Multi-Level Converters:
Bridge inverters, need for multi-level inverters, Concept of multi-level, Topologies for multi-level: Diode Clamped, flying capacitor and Cascaded multi-level configurations; Features and relative comparison of these configurations; Switching device currents; DC link capacitor voltage balancing, features of multi-level converters, Applications. 4 quadrant operation of dc-dc converters.

REFERENCE BOOKS:
1. Rashid, M. H., “Power Electronics Circuits, Devices, and Applications”, Prentice-Hall of India Pvt. Ltd., New
Delhi, 2nd edition, 1999.
2. Ned Mohan, Tore M. Undeland and William P. Robbins, “Power Electronics Converters, Applications, and
Design”, John Wiley & Sons, Inc., 2nd Edition, 1995.
3. B. K. Bose, “Modern Power Electronics and AC drives”, Pearson Education Asia, 2003.
4. Rashid, M. H., “Power Electronics Handbook”, Elsevier Academic Press, 2001.

Course Code	EE641	Course Title	ADVANCED ELECTRIC DRIVES						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	I

Course Objectives: To impart knowledge about fundamentals of Electric drives and control, operational strategies of dc and ac motor drives as per different quadrant operations and to discuss

Course Learning Outcome: On the completion of the course, the student will be able

- To acquire the knowledge of selection of drives as per practical operational industrial requirement.
- To apply their knowledge to prepare control schemes as per different types of motors used in industries.
- To estimate & solve harmonic and power factor related problems in controlling AC and DC drives.

Modeling - Dynamic modeling of induction machines – 3-phase to 2-phase transformation –power equivalence – generalized model in arbitrary reference frame – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – equations in flux linkages - dynamic d-q model of synchronous machines.

Vector Control - Vector controlled induction motor drive – Principle of vector or field oriented control – direct rotor flux oriented vector control – estimation of rotor flux and torque– implementation with current source and voltage source inverters - Stator flux oriented vector control - Indirect rotor flux oriented vector control scheme - implementation

Static Drives & Torque Control - Doubly-fed machine speed control by rotor rheostat – static kramer drive – phasor diagram, equivalent – speed control – power factor improvement – Static Scherbius drive – Modes of operation - Direct torque control of induction motor – principle – control strategy – space vector modulation – reduction of torque and flux ripple – comparison of DTC and FOC – simulation of DTC of induction motor using MATLAB/SIMULINK

Permanent Magnet Synchronous And Brushless Dc Motor Drives – types of permanent magnet synchronous machines – Vector control of PM synchronous machine – model of PMSM – Vector control – control strategies – constant torque-angle control, unity power factor control, constant mutual flux-linkages control, optimum torque per ampere control, flux weakening operation, direct flux weakening algorithm, speed-controlled PMSM drive – sensorless PMSM drive – PM brushless DC motor – modeling – drive scheme – Switched reluctance motor drives.

REFERENCE BOOKS

1. R Krishnan, Electric Motor Drives, PHI
2. D W Novotny and T A Lipo, Vector Control and Dynamics of AC Drives, Oxford University Press
3. B K Bose, Modern Power Electronics and AC Drives, PHI
4. Leonhard, Control of Electric Drives, Springer
5. Kazmierkowski, Krishnan, Blaabjerg, Control in Power Electronics-Selected Problems, Academic Press
6. John Chiasson, Modeling and High Performance Control of Electric Machines, Wiley- IEEE Press
7. I Boldea, S A Nasar, Electric Drives, CRC Press

Course Code	EE643	Course Title	GENERALIZED THEORY OF ELECTRICAL MACHINES						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	I

Course Outcomes (COs): After the successful completion of the course the students will be able to:

- To express the revolving field and reference frame theory
- To develop mathematical model of three-phase AC machines and parameters in different reference frame
- To simulate the transient performance of three-phase ac machines in different reference frames.
- To investigate the transient performance of different DC machines.

Introduction:

Unified approach to the analysis of electrical machine – basic two-pole machine – Kron's primitive machine – voltage, power and torque equation –linear transformation from 3-phase to 2-phase - transformation from rotating axes to stationary axes – power invariance – park's transformation for 3-phase synchronous and induction machines.

Induction Machines:

3-phase induction machine- generalized model – voltage equation – electric transients in induction machines – applications in speed control of induction machine – induction motor modeling in arbitrary reference frame and in field oriented frame

Polyphaser Synchronous Machines:

Generalized machine equations – steady state analysis of salient
pole and non-salient pole machines – phasor diagrams – power angle characteristics – reactive power – short circuit ratio – transient analysis – sudden 3-phase short circuit at generator terminals – reactance – time constants – transient power angle characteristics**.**

REFERENCE BOOKS

1. PS. Bhimbra, Generalized Theory of Electrical Machines, Khanna Publishers
2. Krauss, Wasyncsuk and Sudholf, Analysis of Electrical Machines and Drive Systems, John Wiley
3. A E Fitzgerald, Kingsley, Umans, Electric Machinery, McGraw Hill
4. Bimal K Bose, Modern Power Electronics & AC Drives, Pearson Education

Course Code	EE603	Course Title	ADVANCED INSTRUMENTATION						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1	Semester	II

Course Outcomes (COs): After the successful completion of the course the students will be able to:

CO1: Explain theoretical principles of, MASS and NMR spectroscopy.

CO2: Learn basic instrumentation of NMR and mass spectrometer.

CO3: Explain theoretical principles of x-rays, instrumentation and identification of organic compounds.

CO4: Learn basic principles and instrumentation of thermal analysis

CO5: Describe general principles and procedures involved in extraction techniques.

CO6: Learn basic instrumentation and applications of hyphenated techniques.

CO7: Explain general principles and instrumentation of radioimmune assay

CO8: Learn basic knowledge about the calibration of analytical instruments.

Generalized Measurement Systems:

System concept of measurement schemes, Generalized performance characteristics of measurement systems.

Error Analysis: types of errors, Methods of error analysis, uncertainty analysis, statistical analysis, and propagation of errors.

Sensors & Transducers:

Classification, selection of Transducer, transducer conditioning, transducer selection and specification, capacitive transducer, inductive transducer, resistive transducer, electromagnetic transducer, magnetostrictive transducer, photo sensors, hall effect sensors. Smart Sensors.

Data Acquisition:

Introduction to data acquisition, Sampling fundamentals, Input/output techniques and buses. ADC, DAC, Digital I/O, Data acquisition interface requirements. Signal conditioning, DAQ hardware configuration.

Radiation Detection:

Ionization Chamber, Geiger Muller Counter, Proportional Counter, scintillation Counters. Methods of data

Transmission:

General telemetry systems, DC & AC telemetry system, Modulation, Pulse telemetry systems, Digital telemetry.

REFERENCES:

1. D. Partanabis Instrumentation and control
2. D. Partanabis Sensors and transducers
3. E. O. Doeblin Measurement Systems
4. E. Frank Electrical Measurement Analysis
5. Foard &Hauge A.C. Bridge Methods
6. B.S.Sonde Transducer and Display Systems
7. W. D. Cooper Electrical Instrumentation & measurement Techniques

Course Code	EE604	Course Title	SOFT COMPUTING							
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1	Semester	II	

Course Outcomes (COs): After the successful completion of the course the students will be able to:

1. To understand the fundamental theory and concepts of neural networks, Identify different neural network architectures, algorithms, applications, and their limitations
2. Understand appropriate learning rules for each of the architectures and learn several neural network paradigms and its applications.
3. Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.
4. Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic.
5. Basic concept of Genetic algorithm.
6. Reveal different applications of Fuzzy models to solve engineering and other problems

Artificial Neural Networks-I

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron and convergence theorem, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network.

Artificial Neural Networks-Ii

Back propagation-RBF Algorithms-Hope field networks, Introduction to Kohanan's Self organization map, architecture and algorithms and recurrent network.

Fuzzy Logic Systems - Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate Reasoning, Fuzzification, Membership value assignment, inference and defuzzification. Fuzzy knowledge and rule bases. Self-organizing fuzzy logic control.

Genetic Algorithm - Basic concept of Genetic Algorithm Mutation, Reproduction and crossover and detail algorithmic steps. Engineering applications.

Applications Fuzzy Logic: Design of Fuzzy PI controller for speed control of DC motor using Matlab fuzzy-logic toolbox. Inverted pendulum Neuro controller, **GA** with examples

REFERENCES:

1. Neural Networks: A comprehensive Foundation – Simon Haykins, Pearson Edition, 2003.
2. Fuzzy logic with Fuzzy Applications – T.J.Ross – Mc Graw Hill Inc, 1997.
3. Genetic Algorithms- David E Goldberg.
4. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication.
5. Introduction to Artificial Neural Systems - Jacek M. Zuarda, Jaico Publishing House, 1997.

List of Experiments

1. Study and Analysis of Genetic Algorithm Life Cycle.
2. Apply Genetic Algorithm to optimize standard test functions of optimization. (Suggested link https://en.wikipedia.org/wiki/Test_functions_for_optimization, https://www.sfu.ca/~ssurjano/optimization.html)
3. Design a PID Controller for a DC motor using GA.
4. Write a program of Perceptron Training Algorithm.
5. Write a program to Implement Hebb's Rule.
6. Write a program to Implement of Delta Rule.
7. Write a program for Back Propagation Algorithm.
8. Design and test fuzzy inference systems in MATLAB.

Course Code	EE605	Course Title	Power System Operation and Control						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1	Semester	II

Course Outcomes (COs): After the successful completion of the course the students will be able to:

- To make students understand Economic operation of power system and importance of LFC control.
- To allow students discuss about thermal and hydro power plants operation in meeting the load demand optimally.
- To improve student's ability in solving problems (numerical problems at present)
- Ability to discuss single area load frequency control and two area load frequency control.
- Ability to model and design turbine and Automatic controller

Unit 1 Introduction: Structure of power system, power system control center, level decomposition in power system, power system security, various operational stages of power system, power system voltage stability, introduction to SCADA

Unit 2 Economic operation: Concept and problems of unit commitment, input output characteristics of thermal and hydroplants, system constraints, Optimal operation of thermal units without and with transmission losses, penalty factor, incremental transmission loss, transmission loss formula (without derivation), hydrothermal scheduling long and short terms, concept of optimal power flow

Unit 3 Load frequency control: Concept of load frequency control, load frequency control of signal area system: turbine speed governing system and modelling, block diagram representation of single area system, steady state analysis, dynamic response control area concept, P-I control, load frequency Control and economic dispatch control. Load frequency control of two area system tie line power modelling, block diagram representation of two area system,

Unit 4 Automatic voltage control: Schematic diagram and block diagram representation, Different type of excitation system & their controllers. Concept of voltage control, methods of voltage control, control by tap changing transformer. Shunt compensation, series compensation, phase angle compensation

Unit 5 Fact Devices: Concept and objectives of facts controllers, Introduction to different FACT controllers like TCR, FC-TCR, TSC, SVC, STATCOM, TSSC, TCSC, SSSC, TC-PAR, UPFC

TEXTBOOK(S)

1. D.P. Kothari & I.J. Nagrath, "Modern Power System Analysis" Tata Mc Graw Hill, 3rd edition.
2. P.S.R. Murty, "Operation and Control in Power Systems" B.S. publications

REFERENCE BOOKS

1. N.G. Hingorani & I. Gyugyi, "Understanding Facts "Concepts and Technology of Flexible AC Transmission Systems", IEEE Press Publications
2. A.J. Wood & B.F. Wollenburg, "Power Generation, Operation and Control ", John Wiley & Sons
3. O.J. Elgerd,"Electric Energy System Theory", Tata Mc Graw Hill.
4. P. Kundur, "Power System Stability and Control", Mc Graw Hill.
5. M.H. Rashid, "Power Electronics: Circuits, Devices and Applications "Prentice Hall of India", 3rd edition.

Course Code	EE642	Course Title	ENERGY MANAGEMENT & AUDIT						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

Energy Scenario:
Energy sources, security, conservation, strategy, Basics of Energy and its various forms, Regulatory mechanism in power system, Electricity safety rules and regulations.

Energy Management & Audit:
Energy costs, Bench marking, efficiency, audit instruments, Energy Action Planning: Role, motivation, training, information systems.

Energy Monitor of Electrical System:
Power supply, Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.

Energy Efficient Motors:
losses, efficiency, selection, energy efficient motors, Factors affecting motor performance, Rewinding and motor replacement issues. Energy saving opportunities with Pumps, cooling towers, fans and blower.

Lighting System:
Light source, Choice of lighting, Luminance requirements, and Energy conservation avenues.

Energy Efficient Technologies in Electrical Systems:
Maximum demand controllers, Automatic power factor controllers, Energy efficient motors, Soft starters with energy saver, Variable speed drives, Energy efficient transformers, Electronic ballast, Occupancy sensors, Energy efficient lighting controls.

REFERENCE BOOKS

1. Albert: Plant Engineers & Managers Guide to Energy Conservation
2. Wayhe C.Tuner : Energy Management Handbook
3. Anthony J. Pansini.: Engineering Economic Analysis Guide Boo
4. D. Paul-Mehta: Handbook of Energy Engineering.
5. Paul O’Callaghan: Energy Management.
6. Books of Energy Management & Auditors, Bureau of Energy Efficiency, (A Statutory body under Ministry of Power, Government of India), www.bee-india.nic.in9 volume I, II, III & I

Course Code	EE644	Course Title	OPTIMIZATION TECHNIQUES						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

Course Outcomes (COs): After the successful completion of the course the students will be able to:

1. Formulate optimization problems as mathematical programming problems.
2. Choose suitable technique to solve a particular type of optimization problem.
3. Apply classical optimization techniques to solve linear and nonlinear optimization problems.
4. Apply Evolutionary algorithms to find global optimum of linear and nonlinear optimization problems.
5. Apply various optimization techniques to solve the problems in the area of Electrical Engineering.

Introduction to Optimization:
Statement of an optimization problem, Classification of optimization problems, Optimization techniques, Engg. applications of optimization.

Classical Optimization Techniques: Single variable optimization, Multivariable optimization with no constraints, Multivariable optimization with equality constraints, Multivariable optimization with in equality constraints.

Linear Programming: Standard form of linear programming, Graphical solution, Simplex method, Two-phase simplex method, Computer implementation of the simplex method, Duality theory.

Transportation Problem: North-West Corner rule, least cost method, Vogel approximation method, testing for optimality.

Non-Linear Programming:
One–Dimensional Minimization Methods:
Unimodal function, Dichotomous search, Fibonacci search, Golden Section, Cubic interpolation method, Direct root, Newton Raphson Method Unconstrained Multivariable Optimization Techniques: Random search method, Steepest descent method, Conjugate gradient method, Variable metric method. Newton Raphson Method, Evolutionary search, Hooke-Jeeves Method, Simplex search Method

Constrained Optimization Techniques:
Interior Penalty function method, Exterior penalty function method, Method of Multipliers, KKT Conditions

Further Topics in Optimization:
Critical path method (CPM), Program evaluation and review technique (PERT). Multi objective Optimization Techniques, Weighting method, ε- constraint method. Simulated annealing method

REFERENCES:

1. Rao, S.S.,'Optimization: Theory and Application' Wiley Eastern Press, 2nd edition 1984.
2. Deb Kalyanmoy, Optimisation for Engineering Design-Algorithms and Examples., Prentice Hall India-1998
3. Taha, H.A., Operations Research -An Introduction, Prentice Hall of India,2003
4. Fox, R.L., 'Optimization methods for Engineering Design', Addition Wesley, 1971.
5. Ravindran A., Ragsdell K.M. and Reklaitis G.V., Engineering Optimization: Methods and applications, Wiley, 2008.
6. Godfrey C. Onwubolu, B. V. Babu, New optimization techniques in engineering, Springer, 2004.

Course Code		Course Title	OPTIMIZATION FROM FUNDAMENTALS (MOOC: SWAYAM)						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

This is an online course conducted on SWAYAM. The details are as follows
Conducted by: Prof. Ankur A. Kulkarni | IIT Bombay
Link: https://onlinecourses.nptel.ac.in/noc21_me10/preview
Duration: 12 Weeks
Start Date: Mid-January
End Date: First-Second Week of April
Exam Date: Last week of April
Credit: 3 (online)
Credit: 4 (EECE-DITU)

Note: The remaining one DITU credit will be adjusted by Seminar/Lab/Compressive viva-voice by the faculty member for the above course.

Course Details

Week 1: Introduction to optimization and overview of real analysis
Week 2: Optimization over open sets
Week 3: Optimization over surface
Week 4: Transformation of optimization problems and convex analysis
Week 5: Introduction to linear programming
Week 6: Linear programming and duality
Week 7: Linear programming and duality
Week 8: Nonlinear and convex optimization
Week 9: Nonlinear and convex optimization
Week 10: Algorithms
Week 11: Algorithms
Week 12: Dynamic optimization

REFERENCES:

1. Rao, S.S.,'Optimization: Theory and Application' Wiley Eastern Press, 2nd edition 1984.
2. Deb Kalyanmoy, Optimisation for Engineering Design-Algorithms and Examples., Prentice Hall India-1998
3. Taha, H.A., Operations Research -An Introduction,Prentice Hall of India,2003.
4. Fox, R.L., 'Optimization methods for Engineering Design', Addition Welsey, 1971.
5. Ravindran A., Ragsdell K.M. and Reklaitis G.V., Engineering Optimization: Methods and applications, Wiley, 2008
6. Godfrey C. Onwubolu, B. V. Babu, New optimization techniques in engineering, Springer, 2004

Course Code	EE645	Course Title	POWER CONVERTORS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

Course Outcomes (COs): After the successful completion of the course the students will be able to:

CO1: Competency in function of various power electronics devices

CO2: Skill of analyzing power electronic devices

CO3: Know-how of advance Power electronics converter

CO4: Fitness in mitigating converter harmonics

Analysis of Switched Circuits

Ideal models of power switches – analysis of the thyristor controlled half wave rectifier – R, L, RL, RC load circuits – load circuit with electromotive force – thyristor specifications – heat sink calculations – Surge currents – limitation on di/dt, dv/dt, classification and analysis of commutation.

Improved P.F. Converters

Fully controlled and half controlled converters, Controlled freewheeling, sequence control of converters, simultaneous control of converters, PWM converters, power factor improvement techniques

DC-DC Switch Mode Converters

DC-DC converter systems – control of DC-DC converters, Buck converters – Continuous and discontinuous modes – Boost converters – continuous and discontinuous modes – Buck boost converters – continuous and discontinuous and discontinuous modes. Cuck converters – continuous and discontinuous models – DC-DC converter comparison; ZVS and ZCS resonant converters.

Choppers

Classification of DC chopper circuits – analysis of type A chopper and type B chopper – voltage, current and load commutation of choppers – step up chopper – pulse width modulated AC choppers – Current topologies and Harmonic elimination methods.

Inverters

Characteristics – output voltage and waveform control – bridge inverters – single phase and three phase versions – multilevel inverters: diode clamped MLI, flying capacitor MLI, cascade MLI,

REFERENCE BOOKS

1. Ned Mohan, Undeland and Robbins, “Power Electronics: concepts, applications and design”, John Wiley and sons, Singapore, 2000.
2. Dubey G.K., Doralda S.R., Joshi A., and sinha R.M.K., “Thyristorised power controllers”, Wiley Eastern Limited, 1986.
3. Rashid M.H., “Power Electronics Circuits, Devices and Applicati ons”, PHI, (3/e), 2004.
4. Sen P.C., “Thyristor DC Drives”, John Wiley and sons. 1981.

Course Code	EE646	Course Title	POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

Course Outcomes (COs): After the successful completion of the course the students will be able to:

CO1: To provide knowledge about engineering aspects of electrical energy generation and utilization and impacts of renewable energy generation on environment.

CO2: To provide knowledge about electrical machines for renewable energy conversion

CO3: To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.

CO4: To provide knowledge about the stand alone and grid connected renewable energy systems.

CO5: To Provide knowledge about hybrid renewable energy systems.

CO6: To develop maximum power point tracking algorithms.

Introduction

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems.

Electrical Machines for Renewable Energy Conversion

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

Power Converters

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection of inverter, battery sizing, array sizing

Wind: three phase AC voltage controllers- AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters.

Analysis of Wind and PV Systems

Standalone operation of fixed and variable speed wind energy conversion systems and solar System-Grid Connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system.

Hybrid Renewable Energy Systems

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

REFERENCE BOOKS

1. Rashid. M. H “power electronics Hand book”, Academic press, 2001.
2. Rai. G.D, “Non-conventional energy sources”, Khanna publishes, 1993.
3. Rai. G.D,” Solar energy utilization”, Khanna publishes, 1993.
4. Gray, L. Johnson, “Wind energy system”, prentice hall linc, 1995.
5. Non-conventional Energy Sources B. H. Khan Tata McGraw-Hill Publishing Company, New Delhi.

Course Code	EE647	Course Title	RENEWABLE ENERGY SYSTEMS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

Energy Resources:
Renewable energy sources, Environment, Energy and Global Climate Change energy parameters, cogeneration, rational use of energy, energy efficiency and conservation, distributed energy systems and dispersed generation, atmospheric aspects of electric energy generation, Impact of renewable energy generation on environment, GHG emissions from various energy sources, Electromagnetic Radiation from Extra High Voltage Overhead lines

Solar Energy: Solar Radiation and its Measurement, Solar Thermal Energy Collectors, Solar Thermal Energy Conversion Systems, Solar Photovoltaic System.

Wind Energy: Wind turbines and rotors, Wind Energy Extraction, Wind Characteristics, Power Density Duration Curve, Design of Wind Turbine Rotor, Design of Regulating System for Rotor, Wind Power Generation Curve, Sub-systems of a Horizontal Axis Wind Turbine Generator, Modes of Wind Power Generation, Estimation of Wind Energy Potential, Selection of Optimum Wind Energy Generator (WEG), Grid Interfacing of a Wind Farm, Methods of Grid Connection, Grid System and Properties, Capacity of Wind Farms for Penetration into Grid, Control System for Wind Farms, Economics of Wind Farms

Geothermal Energy: Structure of the Earth's Interior, Plate Tectonic Theory, Geothermal Sites, Geothermal Field, Geothermal Gradients, Geothermal Resources, Geothermal Power Generation, Geothermal Electric Power Plant, Geothermal-Preheat Hybrid with Conventional Plant

Ocean Energy: Development of a Tidal Power Scheme, Grid Interfacing of Tidal Power, Wave Energy, Mathematical Analysis of Wave Energy, Empirical Formulae on Wave Energy, Wave Energy Conversion, Principle of Wave Energy plant, Wave Energy Conversion Machines

Fuel Cells: Principle of Operation of Fuel Cell, Fuel Processor, Fuel Cell Types, Energy Output of a Fuel Cell, Efficiency, and EMF of a Fuel Cell, Operating Characteristics of Fuel Cells, Thermal Efficiency of a Fuel Cell

Hydrogen Energy System: Hydrogen Production, Hydrogen Storage, Development of Hydrogen Cartridge, Gas Hydrate

Hybrid Energy Systems: Hybrid Systems AND ITS Types, Electric and Hybrid Electric Vehicles, Hydrogen-Powered-Electric Vehicles.

REFERENCES:

1. Kothari DP, Singal KC and Ranjan Rakesh, Renewable energy sources and emerging technologies, 2nd ed, Prentice Hall (India)
2. G.D. Rai, Non-Conventional Sources of Energy, Khanna Publishers.
3. Bansal N.K., M. Kleemann, M. Heliss, Renewable energy sources and conversion technology, TMH
4. Abbasi SA, Abbasi N, Renewable energy sources andtheir environmental impact, PHI, 2001
5. Mittal KM, Renewable energy Systems, Wheelar Publishing, New Delhi, 1997.

<table>
<tr><td>Course Code</td><td>EE648</td><td>Course Title</td><td colspan="7">SPECIAL ELECTRIC MACHINES</td></tr>
<tr><td>LTP</td><td>4 0 0</td><td>Credit</td><td>4</td><td>Subject Category</td><td>DE</td><td>Year</td><td>1</td><td>Semester</td><td>II</td></tr>
</table>

Stepper Motor:
Introduction, Types, Hybrid stepper motor- construction, principle of operation, two phases energized at a time, conditions for operation, different configurations, VR Stepper motor- single stack and multi stack, Drive systems and circuit for open loop and Closed loop control of stepping motor. Dynamic characteristics. Single phase stepper Motor, Expression of voltage, current and torque for stepper motor and criteria for synchronization.

Switched Reluctance Motor:
Constructional features, principle of operation, Design Aspects and profile of the SRM, Torque equation, Power converters and rotor sensing mechanism, expression of torque and torque-speed characteristics,

Permanent Magnet Materials:
Permanent magnet materials, properties, minor hysteresis loop and recoil line, equivalent circuit, stator frames with permanent magnets,

Brushless DC Motor:
Construction, operation, sensing and switching logic scheme, Drive and power circuit, Theoretical analysis and performance prediction, transient Analysis.

Linear Induction Motor:
Construction and principle of operation of Linear Induction Motor, Approximate calculation of the force on rotor.

Course Outcomes (Cos):
After the successful completion of the course the students will be able to:
1. Understand special motor like Stepper motor, Reluctance motor, and brushless DC motor.
2. Analyse the properties and use of permanent magnetic materials.
3. Understand the linear induction motor.

REFERENCE BOOKS
1. Vekatratnam, “Special Electrical Machines”, Universities Press
2. Fitzerald and Kingsley,” Electrical Machines” McGraw Hill. Miller. T. J. E., “Brushless Permanent Magnet and Reluctance Motor Drives”, Clarendon Press, Oxford, 1989.
3. Kenjo. T and Nagamori. S, “Permanent Magnet and Brushless DC Motors”, Clarendon Press, Oxford, 1989.
4. Kenjo. T, “Stepping Motors and their Microprocessor Control”, Clarendon Press, Oxford, 1989

Course Code	EE741	Course Title	ADVANCED ELECTRICAL MACHINES						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Generalized Rotating Electrical Machine Theory:
Introduction, magnetically coupled circuits, electromechanical energy conversion, machine windings and air-gap MMF-Winding inductances and voltage equations, Introduction, Equation of transformation, stationary circuit variables transformed to the arbitrary reference frame- commonly used reference frames- transformation between reference frames, transformation of a balanced set, balanced steady state phasor relationships, balanced steady state voltage equations, variables observed from several frames of reference.

Stepper Motors:
Construction of stepper motors and types of stepper motors Various modes of operation of Variable reluctance (VR) stepper motor, construction and working Multi stack VR stepper motor, Construction and working of Permanent Magnet (PM) stepper motor, Construction and working of Hybrid stepper motor, Torque-angle characteristics of the stepper motor.

Switched Reluctance Motor:
Construction, operating performance, Type of converter and speed control, applications.

Brushless DC Machines:
Construction and working principle, Equivalent magnetic circuit, Type of converter and speed control, Comparison between the axial and radial permanent magnet motors, applications.

Condition Monitoring of Electrical Machines:
Concept of condition monitoring, benefit of condition monitoring, Fault detection & diagnosis techniques for Transformer and Induction motor, Recent trends in condition monitoring.

Double Fed Induction Machines:
Comparison of DFIG with synchronous generator, constant voltage & frequency generation, reactive power compensation, Application of DFIG in wind power.

Course Outcomes (COs):
After the successful completion of the course the students will be able to:

1. Understand the generalized theory of rotating electrical machines with different reference frames of analysis.
2. Understand special motor like Stepper motor, Reluctance motor, and brushless DC motor.
3. Understand the double-feed induction generator with application in wind power.

REFERENCE BOOKS:

1. Charles Kingsley, Jr., A.E. Fitzgerald, Stephen D. Umans, “Electrical Machinery”, Tata McGraw Hill,6th Edition, 2003.
2. R. Krishnan, “Electrical Motor & Drives: Modeling, Analysis and Control”, Prentice Hall of India, 2001.
3. Miller, T.J.E, “Brushless permanent magnet and reluctance motor drives”, Clarendon Press, Oxford, 1989.
4. PS Bimbhra, ‘Generalized Theory of Electrical Machines”, Khanna Publishers, New Delhi.
5. D. C. Hanselman, “Brushless Permanent-Magnet Motor Design”, Tata McGraw Hill

6. V. V. Athani,“Stepper Motors: Fundamentals, Applications and Design”, New Age International Pvt. Ltd, 2002.
7. A. E. Fitzerald, Charles Kingsley and Stephen D Umans,“Electrical Machinery”, TMH Publication, 2002.
8. P. Tavner and J. Penam, “Condition Monitoring of Electrical Machines”, John Wiley & Sons. 1987.
9. M.G.Say, “Alternating Current Machines”, ELBS publication.
10. Paul C.Krause, Oleg Wasynnczuk, and S.D.Sudhoff, “Analysis of electrical machinery and drive systems”, Second edition, Wileyinterscinece.
11. Bhadra, Kastha&Benerajee, “Wind Electrical Systems”, OXFORD Higher Education.

Course Code	EE742	Course Title	COMPUTER METHODS IN POWER SYSTEM ANALYSIS						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Network Modeling: -
Impedance and Admittance representation. Power flow analysis – Gauss Siedel method, Newton Raphson method – DLF and FDLF method, DC Load flow, sparsity oriented programming, Optimal Power Flow Analysis

Short Circuit Analysis: -
SCA of multi node system using bus impedance matrix, Z-bus building algorithm, asymmetrical fault analysis using Z-bus, development of voltage and current equations under asymmetrical fault using symmetrical components.

Load Forecasting Techniques: -
Methods of Load Forecasting

Contingency Analysis: -
Power systems State estimation and various techniques like LSET & WLSET, The line power flow state estimation.

Computer Control of Power System: -
Need of real time and computer control of power system, Operating states of power system, SCADA & Energy Management Centers, Smart Grid.

REFERENCE BOOKS:

1. Glonn N. Stagg and Aimed H. El-abiad, "Computer Method in Power System Analysis", McGraw Hill, International edition 1988.
2. George L. Kusic, "Computer Aided Power System Analysis", Prentice Hall, 1986.
3. J. Arrillage, C.P. Amold and S. J. Harker, "Computer Modeling of Electrical Power Systems", John Wiley and Sons 1983.
4. Jos Arrillaga and Bruce Smith, "AC-DC Power System Analysis", IEE London UK, 1998.
5. L.P. Singh, "Advanced Power System Analysis and Dynamics", New Age International Ltd, New Delhi, 1992.
6. Hadi Sadat, "Power System Analysis", Tata McGraw Hill, New Delhi, 1999.
7. Mariesa Crow, "Computational methods for Electrical Power Systems", CRC press.

Course Code	EE743	Course Title	DIGITAL SIGNAL PROCESSING						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

MATLAB for Signal Processing:
Introduction, What Is MATLAB? Testing and Looping, Functions and Variables, Plotting and Graphing, Loading and Saving Data, Multidimensional Arrays, Bitwise Operators, Vectorising Code, Using MATLAB for Processing Signals.

Sampled Signals and Digital Processing:
Processing Signals Using Computer Algorithms, Digital Representation of Numbers, Sampling, Quantization, Image Display, Aliasing, Reconstruction, Block Diagrams and Difference Equations Linearity, Superposition, and Time Invariance, Practical Issues and Computational Efficiency.

Random Signals:
Random and Deterministic Signals, Random Number Generation, Statistical Parameters, Probability Functions, Common Distributions, Continuous and Discrete Variables, Signal Characterization, Histogram Operators, Median Filters. REPRESENTING SIGNALS AND SYSTEMS: Discrete-Time Waveform Generation, the z Transform, Polynomial Approach, Poles, Zeros, and Stability, Transfer Functions and Frequency Response, Vector Interpretation of Frequency Response, Convolution.

Temporal and Spatial Signal Processing:
Correlation, Linear Prediction, Noise Estimation and Optimal Filtering, Tomography. FREQUENCY ANALYSIS OF SIGNALS: Fourier series, Phase-Shifted Waveforms, The Fourier Transform, Aliasing in Discrete-Time Sampling, Time-Frequency Distributions, Buffering and Windowing, FFT, DCT.

Discrete-Time Filters:
Filter Specification, Design and Implementation, Filter Responses, Non-recursive Filter Design, Ideal Reconstruction Filter, Filters with Linear Phase, Fast Algorithms for Filtering, Convolution and Correlation, Recursive filters.

REFERENCE BOOKS

1. John W.Leis: Digital Signal Processing Using MATLAB for Students and Researchers, John Wiley & Sons.
2. Proakis J G and D G Manolakis: Digital Signal Processing: Principles, Algorithms, and Applications, Englewood Cliffs, NJ: Prentice Hall.
3. Kumar B P: Digital Signal Processing Laboratory, Oxford: Taylor and Francis.
4. Hamming R W: Digital Filters, Englewood Cliffs, NJ: Prentice Hall.
5. Jain A K: Fundamentals of Digital Image Processing, Englewood Cliffs, NJ: Prentice Hall.

Course Code	EE744	Course Title	DIRECT ENERGY CONVERSION						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Unit I
Conventional Energy Sources-Global & National Energy Scenarios, Environmental Aspects and Global Warming,

Unit II
Classification of Renewable Energy Sources, Solar Technology and Applications, Photo Electrochemical Conversion of Solar Energy,

Unit III
Mini, Micro and Pico Hydro Plants, Ocean Wave, Tidal and Ocean Thermal Energy Conversion

Unit IV
Magneto Hydrodynamic Power Generation, Environmental Aspects and Efficiency enhancement, Liquid Metal MHD,

Unit V
Thermoelectric and Thermionic Converters.

BOOKS:
1. Reddy Solar Power Generation Technology, New Concepts & Policy
2. T. Abbasi & S.A. Abbasi Renewable Energy Sources Their Impact On Global Warming
3. Rowe Thermoelectric and Its Energy Harvesting, 2 Volume Set
4. Research Papers and Internet Search

Course Code	EE745	Course Title	DISTRIBUTED POWER GENERATION SYSTEM						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Renewable Energy Power Systems:
Development of renewable energy systems-solar thermal, solar PV, wind, small hydropower, bio-fuel & bio-waste, gassifiers, tidal, geo-thermal, their merits & demerits, reliability, need of cogeneration.

Hybrid Co-Generation:
Solar PV, wind, SHP, DG and their combinations; PV, wind and hydro based stand-alone hybrid power systems, control of hybrid power systems with and without grid connection, system planning, operating features and performance, zero-energy buildings.
Wind and DG stand-alone hybrid power systems, control of hybrid power systems with and without grid connection.

Power Electronic Systems:
Grid interactive systems, grid tied systems, inverters, FACTS and application of its devices, smart homes, power management and smart grid, intelligent metering.

Energy Storage Systems:
Energy storage systems, different battery systems and battery charging, system planning, operating features and performance calculations, selected topics.

REFERENCES:

1. B.H. Khan Non-Conventional Energy Sources, TMH, New Delhi.
2. R. M. Mathur& R. K. Verma, Thyristor-based FACTS Controller for Electrical Transmission system, IEEE Press/ John Wiley & Sons, New York.
3. N.G. Hingorani & L. Gyugyi, Understanding FACTS, IEEE Press,New York.
4. L. Freris & D. Infield Renewable Energy in Power Systems, John Wiley & Sons, Singapore.
5. G. Boyle Renewable Energy Systems, Oxford University Press, New Delhi.
6. D.P. Kothari Renewable Energy Sources & Emerging Technologies, PHI Learning, New Delhi.
7. Bhadra, Kestha& Banerjee Wind Electrical Systems, Oxford University Press, New Delhi.
8. M.R. Patel Wind & Solar Power Systems, Taylor & Francis

Course Code	EE746	Course Title	FACTS Devices						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Course Outcomes (COs): After the successful completion of the course the students will be able to:

- Describe the concept of FACTS, Reactive power control and discuss the various types of compensation techniques, and classify the various types of FACTS devices.
- Illustrate the characteristics and applications of static VAR compensator, and apply modeling of SVC for stability studies.
- Describe the functional operation and applications of TCSC, and apply modeling of TCSC for power flow & stability studies.
- Describe the principle, operation of STATCOM & UPFC
- Classify & Discuss the various FACTS controller interactions

Facts and Preliminaries:
FACTS concept and general system considerations - power flow in AC system - definitions on FACTS - basic types of FACTS controllers. Converters for Static Compensation - Three phase converters and standard modulation strategies (Programmed Harmonic Elimination and SPWM) - GTO Inverters - Multi-Pulse Converters and Interface Magnetics - Transformer Connections for 12, 24 and 48 pulse operation - Multi-Level Inverters of Diode Clamped Type and Flying Capacitor Type and suitable modulation strategies (includes SVM) - Multi-level inverters of Cascade Type and their modulation - Current Control of Inverters.

Static Shunt and Series Compensators:
Static Shunt Compensators - SVC and STATCOM - operation and control of TSC, TCR, STATCOM - Compensator Control - Comparison between SVC and STATCOM - STATCOM for transient and dynamic stability enhancement. Static Series Compensation - GCSC, TSSC, TCSC and SSSC - operation and control – external system control for series compensators - SSR and its damping - static voltage and phase angle regulators - TCVR and TCPAR - operation and control

UPFC AND IPFC: The Unified Power Flow Controller - operation, comparison with other FACTS devices - control of P and Q - dynamic performance - Special Purpose FACTS Controllers - Interline Power Flow Controller - operation and control.

Power Quality and Introduction to Custom Power Devices:
Power Quality issues related to distribution systems – custom power devices – Distribution STATCOM – Dynamic Voltage restorer – Unified Power Quality Conditioner – Application of D-STATCOM, DVR and UPQC for improving power quality in distribution systems.

REFERENCE BOOKS

1. K. R. Padiyar, FACTS Controllers in Power Transmission and Distribution, New Age International
2. N.G. Hingorani & L. Gyugyi, Understanding FACTS: Concepts and Technology of Flexible AC Transmission Systems, IEEE Press
3. T.J.E Miller, Reactive Power Control in Electric Systems, John Wiley & Sons.
4. Ned Mohan et.al, Power Electronics, John Wiley and Sons.
5. Dr Ashok S & K S Suresh Kumar "FACTS Controllers and applications" course book for STTP, 2003.

Course Code	EE747	Course Title	HIGH VOLTAGE DIRECT CURRENT TRANSMISSION						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Course Outcomes (COs): After the successful completion of the course the students will be able to:

- Illustrate the advantages and disadvantages of AC transmission and DC transmission
- Analyze the operation, characteristics and performance parameters of HVDC converters
- Analyze the characteristics of converter and HVDC system controller
- Illustrate the reactive power and harmonic control techniques for HVDC system.
- Illustrate the operation of DC system model
- Analyze the power flow in AC/DC Systems

Introduction:
Introduction to AC and DC Transmission – application of DC Transmission – description of DC transmission – DC system components and their functions – modern trends in DC Transmission

Converter: Pulse Number – Converter configuration – analysis of Graetz circuit – converter bridge characteristics – characteristics of 12 Pulse converter

HVDC Controllers:
General principle of DC link control – converter control characteristics – system control hierarchy – firing angle control – current and extinction angle control – Dc link power control – high level controllers

Filters
Introduction to harmonics – generation of harmonics – design of AC filters – DC filters – carrier frequency and RI noise

Protection:
Basics of protection – DC reactors – voltage and current oscillations – circuit breakers – over voltage protection – switching surges – lightning surges – lightning arresters for DC systems

REFERENCE BOOKS

1. Kimbark, "Direct Current Transmission – Vol. I", John Wiley and Sons Inc., New York, 1971
2. Padiyar. K. R., "HVDC Power Transmission Systems", Wiley Eastern Limited, New Delhi, 2000.
3. Arrillaga. J, "High Voltage Direct Current Transmission", Peter Peregrines, London, 1983

Course Code	EE748	Course Title	High Voltage Generation & Measurement						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Generation of High Direct Voltages:
Simple rectifier circuits, cascaded circuits: Cockcroft-Walton circuit, Electrostatic generators.

Generation of High Alternating Voltages:
Testing transformers, cascaded transformers, resonant transformers.

Generation of Impulse Voltages and Currents:
Single stage and multistage impulse generator circuits, Tripping and control of impulse generators.

High Voltage Measurement Techniques:
Peak Voltage, Measurement by spark gaps; Chubb-Fortescue Method; potential dividers; impulse voltage and current measurements, Layout and clearances of High Voltage Lab.

REFERENCES:

1. E. Kuffel, W.S. Zaengl, and J. Kuffel, High Voltage Engineering Fundamentals, Elsevier India Pvt. Ltd, 2005
2. M.S. Naidu and V. Kamaraju, High Voltage Engineering, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Craggs & Meek High Voltage Laboratory Technique, Butterworths, London,
4. IEEE Transactions on Dielectrics and Insulation

Course Code	**EE749**	**Course Title**	**INSTRUMENTATION IN POWER ELECTRONICS SYSTEM**						
LTP	**4 0 0**	**Credit**	**4**	**Subject Category**	**DE**	**Year**	**1**	**Semester**	**III**

Transducer Instrumentation:
Primary sensors, voltage and current generating analogue Transducers, variable parameter analogue Transducers, Frequency generating and Digital Transducers, transducer selection factors.

Telemetry System:
Introduction to Information Transmission. Basic ideas. Transducer and Sensors: Definitions, classification of errors.

Devices for Instrumentation
Amplifiers, Multiplexes, Timers, Sample and Hold, Isolators, Signal Converters, ADC & DAC, Instrumentation & Signal Processing, drive related signals and their instrumentation and conditioning.

Data Acquisition System
basic structure, data acquisition of drive related variables.

REFERENCE BOOKS:

1. Cooper Helfrick, “Electrical Instrumentation and Measuring Techniques”, Prentice Hall India, 1986
2. D. C. Nakra and K. K. Chowdhry, “Instrumentation, Measurement, and Analysis”, Tata McGraw Hill Publishing Co., 1984

Course Code	EE751	Course Title	MEASUREMENT & CONTROL						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Measurement:
Transducers, different types of Transducers, Transducers Characteristics, Selection of an Instrumentation
Transducers. Digital Transducers, Measurement using laser, Measurement using ultrasonic waves, Measurement using radiation technique, Measurement using vacuum technique, Microprocessor based Instrumentation system.

Control:
Transfer function, transfer function for Mechanical System Control System Components, Signal flow Graph with Problems, Transient response of feedback control systems, Transient response of second order system, Steady State response and steady state Error, Problems, Stability: Routh criterion, Polar plots and bode plots, Niquist criterion,

Controllers:
Hydraulic and Pnematic Controllers.

REFERENCES:

1. D. Patranabis Principle of Industrial Instrumentation, (TMH)
2. B.C. Kuo Automatic Control System
3. M.Sayer& A. Mansingh Measurement, Instrumentation and Experiment Design in Physic and Engineering, (PHI)

Course Code	EE752	Course Title	POWER QUALITY						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Course Outcomes (COs): After the successful completion of the course the students will be able to:

- Implement compensating techniques for a given power quality problem
- Suggest protection techniques under different fault conditions
- Develop control techniques for compensating devices

Introduction

Characterization of Electric Power Quality: Transients, short duration and long duration voltage variations, Voltage imbalance, waveform distortion, Voltage fluctuations, Power frequency variation, Power acceptability curves – power quality problems: poor load power factor, Nonlinear and unbalanced loads, DC offset in loads, Notching in load voltage, Disturbance in supply voltage – Power quality standards.

Non-Linear Loads

Single phase static and rotating AC/DC converters, three phase static AC/DC converters, Battery chargers, Arc furnaces, Fluorescent lighting, pulse modulated devices, Adjustable speed drives.

Measurement and Analysis Methods

Voltage, Current, Power and Energy measurements, power factor measurements and definitions, event recorders, Measurement Error – Analysis: Analysis in the periodic steady state, Time domain methods, Frequency domain methods: Laplace's, Fourier and Hartley transform – The Walsh Transform – Wavelet Transform.

Analysis and Conventional Mitigation Methods

Analysis of power outages, Analysis of unbalance: Symmetrical components of phasor quantities, Instantaneous symmetrical components, Instantaneous real and reactive powers, Analysis of distortion: On–line extraction of fundamental sequence components from measured samples – Harmonic indices – Analysis of voltage sag: Detorit Edison sag score, Voltage sag energy, Voltage Sag Lost Energy Index (VSLEI)- Analysis of voltage flicker, Reduced duration and customer impact of outages, Classical load balancing problem: Open loop balancing, Closed loop balancing, current balancing, Harmonic reduction, Voltage sag reduction.

Power Quality Improvement

Utility-Customer interface –Harmonic filters: passive, Active and hybrid filters – Custom power devices: Network reconfiguring Devices, Load compensation using DSTATCOM, Voltage regulation using DSTATCOM, protecting sensitive loads using DVR, UPQC – control strategies: P-Q theory, Synchronous detection method – Custom power park – Status of application of custom power devices.

Reference Books

1. Arindam Ghosh "Power Quality Enhancement Using Custom Power Devices", Kluwer Academic Publishers, 2002
2. G.T.Heydt, "Electric Power Quality", Stars in a Circle Publications, 1994(2nd edition)
3. Power Quality - R.C. Duggan
4. Power system harmonics –A.J. Arrillga
5. Power electronic converter harmonics –Derek A. Paice

Course Code	EE753	Course Title	SWITCHED MODE POWER CONVERTER						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	III

Reactive Elements in Power Electronic Systems:
Design of inductor, Design of transformer, Capacitors for power electronic applications.

Dc-To-Dc Converters:
Buck converter, Boost Converter, Buck-Boost Converter, Forward Converter, Push-Pull Converter, Fly-back Converter, Half and full bridge Converter.

Closed Loop Control of Power Converters:
Design of compensators, closed loop performance functions, Effect of Input Filter on the Converter Performance, Design Criteria for Selection of Input Filter. Unity p.f. rectifiers.

Classification of Resonant Converters:
Basic resonant circuit concepts, Load resonant converters, Resonant Switch Converters, Zero Voltage Switching.

Design of Feedback Compensators:
Unity power factor rectifiers, Resistor emulation principle and applications to rectifiers.

REFERENCE BOOKS:

1. Switched Mode Power Conversion, Course Notes, CCE, IISc, 2004.
2. Issa Batarseh, “Power Electronic circuits”, John Wiley, 2004.

Course Code	EE701	Course Title	SEMINAR						
LTP	0 0 4	Credit	2	Subject Category	DC	Year	1	Semester	III

Objective:
To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self-esteem and courage that are essential for an engineer.

Individual students are required to choose a topic of their interest from power electronics and drives related topics preferably from outside the M. Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in power electronics) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Course Code	EE702	Course Title	DISSERTATION-I						
LTP	0 0 24	Credit	12	Subject Category	DC	Year	1	Semester	III

Course Code	EE703	Course Title	DISSERTATION-II						
LTP	0 0 32	Credit	16	Subject Category	DC	Year	1	Semester	IV

Objective:
To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in power electronics/drives related topics. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee will consist of at least three faculty members of which internal guide and another expert in the specified area of
the project shall be two essential members.

The student is required to undertake the master research project phase 1 during the third semester and the same is continued in the 4thsemester (Phase 2). Phase 1 consist of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.