DIT UNIVERSITY
Dehradun

Detailed Course Structure & Syllabus
of
Ph.D. in Electrical Engineering

Approved by the Academic Council at its 17th Meeting held on 24.03.2021

Course Structure & Syllabus of Ph.D. EE
Applicable for Batch: 2021 Onwards

Course Category	Course Code	Course Title	L	T	P	Credit
DC	MB901	Research Methodology	4	0	0	4
-	CPE-RPE	Research Publication & Ethics	2	0	0	2
DE		Elective 1	4	0	0	4
DE		Elective 2	4	0	0	4
DE		Elective 3	4	0	0	4
DC	EE901	Seminar	0	0	2	1
		Total Credits				**19**

List of Elective

Note: Apart from above listed Elective courses, Research Scholar may choose any course across departments being offered at PG level, if it is required/suggested by the Research Committee.

Course Structure & Syllabus of Ph.D. EE
Applicable for Batch: 2021 Onwards

Subject Code	**MB901**	**Subject Title**	**Research Methodology**						
LTP	4 0 0	**Credit**	4	**Subject Category**	DC	**Year**	1st	**Semester**	I / II

UNIT – I
Fundamentals of Research: Defining research, Objectives of research, types, research process, deductive and inductive reasoning;
Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review,
Definition of variables: Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

UNIT – II
Research Design: Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

UNIT – III
Sampling, Sampling distribution, and Data Collection: Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors. Sources of Data-Primary Data, Secondary Data, Data Collection methods

UNIT – IV
Statistical Data Analysis: Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

UNIT – V
Research Report: Writing a research report**-** Developing an outline, Formats of Report writing, Key elements-Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Books Recommended:

1. Ganesan R, Research Methodology for Engineers , MJP Publishers, Chennai. 2011
2. C.R.Kothari, “Research Methodology”, 5th edition, New Age Publication,
3. Cooper, “Business Research Methods”, 9th edition, Tata McGraw hills publication
4. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
5. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
6. Bordens K.S. and Abbott, B.b.: Research Design and Methods, McGraw Hill, 2008.
7. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197-222; 391–403

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 Structure & Syllabus of Ph.D. EE
Applicable for Batch: 2021 Onwards

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, Vectorizing 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	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.

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
Characterisation 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, Non linear 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	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
Stand alone 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	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	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	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	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	EE648	Course Title	Special Electric Machines						
LTP	4 0 0	Credit	4	Subject Category	DE	Year	1	Semester	II

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	**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	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		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