Course Structure & Syllabus for
Pre Ph.D. (EE) Course Work
Session: 2017-18

Approved by the Academic Council at its 6th Meeting held on 13.05.2017
## Pre Ph.D (EE)

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
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### List of Elective

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>EE641</td>
<td>Advanced Electric Drives</td>
</tr>
<tr>
<td>EE743</td>
<td>Digital Signal Processing</td>
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<td>EE601</td>
<td>Advanced Control System</td>
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<tr>
<td>EE752</td>
<td>Power Quality</td>
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<tr>
<td>EE646</td>
<td>Power Electronics for Renewable Energy Systems</td>
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<td>EE642</td>
<td>Energy Management &amp; Audit</td>
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<td>EE745</td>
<td>Distributed Power Generation System</td>
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<td>EE749</td>
<td>Instrumentation in Power Electronics System</td>
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<td>EE746</td>
<td>FACTS Devices</td>
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<tr>
<td>EE648</td>
<td>Special Electric Machines</td>
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<tr>
<td>EE747</td>
<td>High Voltage Direct Current Transmission</td>
</tr>
<tr>
<td>EE753</td>
<td>Switched Mode Power Converter</td>
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**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.
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 – Copyright 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:**
Pre Ph.D (EE)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Title</th>
<th>Advanced Electric Drives</th>
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<tbody>
<tr>
<td>EE641</td>
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</table>

- **LTP**: 4 0 0
- **Credit**: 4
- **Subject Category**: DE
- **Year**: 1st
- **Semester**: I / II


**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
4. Leonhard, *Control of Electric Drives*, Springer

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<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Title</th>
<th>Digital Signal Processing</th>
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<tr>
<th>Subject Code</th>
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<th>Advanced Control System</th>
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**LTP** | 4 | 0 | 0 | **Credit** | 4 | **Subject Category** | DE | **Year** | 1st | **Semester** | I / II |

**REVIEW OF MODELING AND ANALYSIS OF LTI SYSTEMS:**

**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.

**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.

**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.

**NON LINEAR SYSTEM:**

**REFERENCE BOOKS:**
1. Ogata, K – Modern Control Engineering, PHI Learning
3. Roy Choudhury, D – Modern Control Engineering, Prentice Hall
7. Vidyasagar- Nonlinear system analysis, Prentice-Hall.
9. Gopal, M, Digital Control and State Variable Methods, TMH

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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.


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.


REFERENCE BOOKS
3. Power Quality - R.C. Duggan
5. Power electronic converter harmonics –Derek A. Paice
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

ENERGY MANAGEMENT & AUDIT: Energy costs, Benchmarking, 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.


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

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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:
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:
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.


REFERENCE BOOKS
Pre Ph.D (EE)

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<thead>
<tr>
<th>Subject Code</th>
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<th>Special Electric Machines</th>
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<tbody>
<tr>
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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.

REFERENCE BOOKS

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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


REFERENCE BOOKS

2. **DC-TO-DC Converters**: Buck converter, Boost Converter, Buck-Boost Converter, Forward Converter, Push-Pull Converter, Fly-back Converter, Half and full bridge Converter.


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

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

**REFERENCE BOOKS:**