DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABUS

Under CBCS

(Applicable for Students admitted from Academic Year 2018-19)

M. Tech. Power System Engineering

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

SCHOOL OF ELECTRICAL SCIENCES
HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE
VISION AND MISSION

VISION

To make every man a success and no man a failure.

MISSION

To provide every individual with a conducive environment suitable to achieve his / her career goals, with a strong emphasis on personality development, and to offer the academically inclined the resources to gain quality education in all spheres of engineering, applied sciences and management, without compromising the quality and code of ethics to each student of the Institution.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
VISION AND MISSION

VISION

To educate the students in the recent developments of emerging fields in Electrical and Electronics Engineering, to encourage research activities, innovative techniques and to develop managerial abilities so as to make them excel globally

MISSION

➢ To enable the students to function as accomplished professionals in Electrical Engineering field with due emphasis on personality development and communication skills
➢ Students should develop the capacity to absorb new techniques and innovative ideas in modern technological environment.
M. Tech. Power System Engineering
PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The program is expected to enable the students to

PEO I  Design and develop innovative products and services in the field of power system and engineering
PEO II  keeps abreast with the latest technology and toolset.
PEO III Communicate effectively to propagate ideas and promote teamwork
PEO IV  Attain intellectual leadership skills to cater to the changing needs of power industry, academia, society and environment

PROGRAM OUTCOMES (ALIGNED WITH GRADUATE ATTRIBUTES) (PO)

At the end of this program, graduates will be able to

PO1:  An ability to apply knowledge of fundamentals of mathematics, science, and engineering.
PO2:  An ability to identify, formulate and solve Electrical and Electronics Engineering problems.
PO3:  An ability to understand and correctly interpret the impact of engineering solutions in a social/global context.
PO4:  An ability to use research approaches for problem analysis and design.
PO5:  An ability to skillfully use modern engineering tools and techniques necessary for engineering design, analysis and applications.
PO6:  Ability to apply contextual knowledge relevant to professional engineering practices.
PO7:  Understand the need for sustainable development and impact of professional engineering solutions in societal and environmental context.
PO8: Understanding of professional and ethical responsibility.

PO9: An ability to function and/or develop leadership in multi-disciplinary teams.

PO10: Ability to communicate effectively.

PO11: Ability to apply engineering and management principles to manage projects.

PO12: An ability to engage in life-long learning to follow developments in Electrical and Electronics Engineering.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: An ability to design and develop environmental friendly electrical Products

PSO2: To introduce application of electronics devices for conversion, control and automation

PSO3: Apply appropriate techniques and modern Engineering hardware and software tools in power systems to engage in life-long learning and to successfully adapt in multi-disciplinary environments.

PSO4: Understand the impact of Professional Engineering solutions in societal and environmental context, commit to professional ethics and communicate effectively.
## M.TECH – POWER SYSTEM ENGINEERING

### (65 CREDIT STRUCTURE)

#### SEMESTER - I

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## M.TECH –POWER SYSTEM ENGINEERING

### (65 CREDIT STRUCTURE)

### SEMESTER – III

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## List of Departmental Electives with Grouping - Semester Wise

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## List of Non Departmental Electives Offered by Electrical Department with Grouping - Semester Wise

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## Semester - I
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**LEARNING LEVEL**  
BTL-3

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<td>Getting idea about basic fundamentals of probability</td>
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<td>Getting idea about optimization techniques</td>
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<tr>
<td>3</td>
<td>Getting idea about differential calculus</td>
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**Prerequisites** : Nil

**MODULE 1 – ADVANCED MATRIX THEORY (9L)**
- Matrix norms
- Jordan canonical form
- Generalized eigenvectors
- Singular value decomposition
- Pseudo inverse
- Least square approximations
- QR algorithm

**MODULE 2 – NUMERICAL SOLUTION OF ALGEBRAIC EQUATIONS (9L)**
- Solutions of large systems of equations using Gauss Elimination method
- Principle behind sparsity and optimal ordering
- Relevance of the solution technique for engineering applications

**MODULE 3 – NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS (9L)**
- Single and multi-step methods
- Explicit and implicit methods
- Advantages of implicit methods
- Solution of differential algebraic methods encountered in power engineering

**MODULE 4 – LINEAR PROGRAMMING (9L)**
- Basic concepts
- Graphical and Simplex methods
- Transportation problem
- Assignment problem

**MODULE 5 – DYNAMIC PROGRAMMING (9L)**
- Elements of the dynamic programming model
- Optimality principle
- Examples of dynamic programming models and their solutions

**REFERENCE BOOKS**

### E BOOKS
1. https://nptel.ac.in/downloads/111105035/

### MOOC
1. https://nptel.ac.in/courses/111105035/
3. https://www.coursera.org/learn/seo-strategies

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<td>To explain the characteristics of loads, concepts of load forecasting and its types for power system planning.</td>
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<td>To comprehend the significance of reliability in power system, various methods and tools used for reliability analysis.</td>
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<td>3</td>
<td>To describe the concepts of reliability in generation and transmission system, and system interconnection.</td>
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<td>To discriminate the different modes of system failure and to explain various approaches to assess power system failure</td>
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<td>5</td>
<td>Loss of load in power system will be analysed</td>
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**Prerequisites:** Power system analysis, Power system transmission and distribution

### MODULE 1 – LOAD FORECASTING (9L)

### MODULE 2 – RELIABILITY ANALYSIS (9L)
**Suggested Reading:** Different semiconductor devices can be studied  
**Applications:** AC-DC Converter, DC-DC Converter, DC-AC Converter

### MODULE 3 – TRANSMISSION RELIABILITY (9L)
Transmission system reliability model analysis – average interruption rate - LOLP method - frequency and duration method  
**Suggested Reading:** Comparison of different converters  
**Applications:** Renewable Energy Conversion

### MODULE 4 – LOAD SYSTEM (9L)
Two plant single load system - two plant two load system - load forecasting uncertainly interconnections
benefits

Applications: Domestic and Commercial applications

MODULE 5 – SYSTEM MODES OF FAILURE (9L)
Introduction to system modes of failure – the loss of load approach – frequency & duration approach – spare value assessment – multiple bridge equivalents.

LAB / MINI PROJECT / FIELD WORK
Students should do the simulation of two plant two load system

TEXT BOOKS

REFERENCE BOOKS

MOOC
1. https://nptel.ac.in/courses/114106041/25
2. https://nptel.ac.in/courses/108105067/

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<td>To solve ac and dc load flow for single and three phase systems</td>
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<tr>
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<td>To analyse the faults in the power system networks</td>
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<td>4</td>
<td>To apply the concepts of optimization in power system.</td>
<td>1,2,3</td>
</tr>
<tr>
<td>5</td>
<td>To explain the concept of state estimation in power system and the role of statistics in state estimation.</td>
<td>1,2,3,5,12</td>
</tr>
</tbody>
</table>

Prerequisites: Power System analysis

MODULE 1 – NETWORK MODELLING (9L)
Network modeling – Single phase and three phase modelling of alternators, transformers and transmission lines, Conditioning of Y Matrix – Incidence matrix method, Method of successive elimination, Triangular factorization – Sparse matrix

MODULE 2 – LOAD FLOW ANALYSIS (9L)

MODULE 3 – FAULT ANALYSIS (9L)

MODULE 4 – SYSTEM OPTIMIZATION (9L)
System optimization - strategy for two generator systems – generalized strategies – effect of
transmission losses - Sensitivity of the objective function - Formulation of optimal power flow solution by Gradient method-Newton’s method.

**MODULE 5 – STATE ESTIMATION (9L)**


**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**

1. https://easyengineering.net/power-systems-books/

**MOOC**

1. https://nptel.ac.in/courses/111107105/8

**COURSE TITLE** | **MODELLING AND ANALYSIS OF ELECTRICAL MACHINES** | **CREDITS** | 3  
---|---|---|---
**COURSE CODE** | EEB3703 | **COURSE CATEGORY** | **CIA** | **LEARNING LEVEL** | **BTL-4** | **PO** | 
**CIA** | 50% | **ESE** | 50% | 
**CO** | **COURSE OUTCOMES** | 
1. | To understand the principle of electromagnetic energy conversion. | 1,2,3 | 
2. | To understand the basic concepts of rotating machines and to derive the torque and voltage equation for DC motor. | 1,2,3 | 
3. | To represent the dynamic model of three phase induction motor in arbitrarily rotating reference frame. | 1,2,3 | 
4. | To analyze the dynamic performance of two phase asymmetrical induction machine and single phase induction machine. | 1,2,3,5 | 
5. | To analyze the dynamic performance of permanent magnet synchronous motor and switched reluctance motor. | 1,2,3,12 | 

**Prerequisites**: Electromagnetic field theory, Vector algebra and fundamentals of all electrical rotating machines

**MODULE 1-ELECTROMECHANICAL ENERGY CONVERSION (9L)**

Principles of Electromagnetic Energy Conversion, General expression of stored magnetic energy, co-energy and force/torque, example using single and doubly excited system.

**Suggested Reading**: Modelling and simulation for self-excited doubly salient retarder system using MATLAB.

**Applications**: Electrostatic actuators, dielectric actuators

**MODULE 2-BASIC PRINCIPLE OF DC MACHINES (9L)**

Basic Concepts of Rotating Machines-Calculation of air gap mmf and per phase machine inductance using physical machine data; Voltage and torque equation of dc machine.

**Suggested Reading**: Sensorless speed control of DC motor using MATLAB.
Applications: Space operated vehicles, electric aircraft.

### MODULE 3 - MODELING OF AC MACHINES (9L)

Three phase symmetrical induction machine and salient pole synchronous machines in phase variable form; Application of reference frame theory to three phase symmetrical induction and synchronous machines, dynamic direct and quadrature axis model in arbitrarily rotating reference frames.  
**Suggested Reading:** Steady-state modelling and analysis of synchronous motor using MATLAB.  
**Applications:** Phonograph turntables, Constant speed constant load drives.

### MODULE 4 - DYNAMIC ANALYSIS OF AC MACHINES (9L)

**Suggested Reading:** Field Oriented Control of Induction Motors using Symmetrical Optimum Method  
**Applications:** Hybrid electric vehicles, linear actuators.

### MODULE 5 - DYNAMIC ANALYSIS OF SPECIAL MACHINES (9L)

Special Machines - Permanent magnet synchronous machine: Surface permanent magnet (square and sinusoidal back emf type) and interior permanent magnet machines. Construction and operating principle, dynamic modeling and self-controlled operation; Analysis of Switch Reluctance Motors.  
**Suggested Reading:** Modelling and Simulation of Switched Reluctance Motor using MATLAB  
**Applications:** Hybrid electric vehicles, power generation from Ocean Waves by Engine for Producing Energy from Sea Waves (EPEW).

### LAB / MINI PROJECT/FIELD WORK

Vector Control of Permanent Magnet Synchronous Motor using MATLAB

### TEXT BOOKS


### REFERENCE BOOKS


### E BOOKS


### MOOC
1. https://nptel.ac.in/courses/108106023/

<table>
<thead>
<tr>
<th>COURSE TITLE</th>
<th>ELECTRICAL TRANSIENTS IN POWER SYSTEMS</th>
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<tr>
<td>CO</td>
<td>COURSE OUTCOMES</td>
<td>PO</td>
</tr>
<tr>
<td>1</td>
<td>To know about high voltage transient Behavior travelling on line</td>
<td>1,2,3</td>
</tr>
<tr>
<td>2</td>
<td>To get knowledge about voltage solutions under transient conditions using lattice diagram</td>
<td>1,2,3</td>
</tr>
<tr>
<td>3</td>
<td>To get knowledge about lightning and switching voltage travelling behavior using EMTP</td>
<td>1,2,3</td>
</tr>
<tr>
<td>4</td>
<td>To get knowledge about insulation coordination under transients</td>
<td>1,2,3,12</td>
</tr>
<tr>
<td>5</td>
<td>To get knowledge about high voltage Transient behavior travelling on line.</td>
<td>1,2,3,12</td>
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</table>

Prerequisites: Analog, digital and Power electronic circuits.

**MODULE 1 – TRAVELLING WAVES ON TRANSMISSION LINE (9L)**


**MODULE 2 – COMPUTATION OF POWER SYSTEM TRANSIENTS (9L)**


**MODULE 3 – LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES (9L)**

Lightning: Physical phenomena of lightning - Interaction between lightning and power system - Factors contributing to line design - Switching: Short line or kilometric fault - Energizing transients – closing and re-closing of lines - line dropping, load rejection - Ferro resonance-Double frequency transients, Voltage induced by fault - Very Fast Transient Overvoltage (VFTO)

**MODULE 4 – BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION (9L)**

Initial and Final voltage distribution - Winding oscillation - traveling wave solution - Behaviour of the transformer core under surge condition - Rotating machine - Surge in generator and motor

**MODULE 5 – INSULATION CO-ORDINATION (9L)**
Principle of insulation co-ordination in Air Insulated substation (AIS) and Gas Insulated Substation (GIS), insulation level, statistical approach, co-ordination between insulation and protection level - overvoltage protective devices – types of surge diverters-lightning arresters, substation earthing.

**TEXT BOOKS**

**REFERENCE BOOKS**

**E BOOKS**

**MOOC**
1. [https://nptel.ac.in/courses/108104051/9](https://nptel.ac.in/courses/108104051/9)
2. [https://nptel.ac.in/courses/108104051/10](https://nptel.ac.in/courses/108104051/10)

**COURSE TITLE**
RESEARCH METHODOLOGY & IPR

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**CIA**

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**LEARNING LEVEL**

**COURSE OUTCOMES**

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<tbody>
<tr>
<td>1.</td>
<td>Understand research problem formulation.</td>
</tr>
<tr>
<td>2.</td>
<td>Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.</td>
</tr>
<tr>
<td>3.</td>
<td>Understanding that when IPR would take such important place in growth of individuals &amp; nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general &amp; engineering in particular.</td>
</tr>
<tr>
<td>4.</td>
<td>Understand that IPR protection provides an incentive to inventors for further research work and investment in R &amp; D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.</td>
</tr>
<tr>
<td>5.</td>
<td>Analyze research related information and to follow research ethics</td>
</tr>
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</table>

**Prerequisites:** Nil

**MODULE 1 – RESEARCH PROBLEM FORMULATION**

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

**MODULE 2 – RESEARCH PROPOSAL AND ETHICS**

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical
writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

<table>
<thead>
<tr>
<th>MODULE 3 - DATA ANALYSIS AND INTERPRETATION (9L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification of Data, Methods of Data Collection, Sampling, Sampling techniques procedure and methods, Ethical considerations in research Data analysis, Statistical techniques and choosing an appropriate statistical technique, Hypothesis, Hypothesis testing, Data processing software (e.g. SPSS etc.), statistical inference, Interpretation of results.</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>MODULE 4 - NATURE OF INTELLECTUAL PROPERTY (9L)</th>
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<table>
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<tr>
<th>MODULE 5 –PATENT RIGHTS AND NEW DEVELOPMENTS IN IPR (9L)</th>
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<table>
<thead>
<tr>
<th>REFERENCE BOOKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science &amp; engineering students’,</td>
</tr>
<tr>
<td>2 Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”</td>
</tr>
<tr>
<td>10 C.R. Kothari, Gaurav Garg, Research Methodology Methods and Techniques, New Age International publishers, Third Edition</td>
</tr>
<tr>
<td>12 Business Research Methods – Donald Cooper &amp; Pamela Schindler, TMGH, 9th edition</td>
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</table>
### Course Title: Design and Simulation of Power System Simulation I Laboratory

<table>
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**CIA** 60% | **ESE** 40%

**Learning Level**: BTL-4

**Course Outcomes**

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<tbody>
<tr>
<td>1</td>
<td>Determine under-utilization of system resources</td>
<td>1,3,4,5</td>
</tr>
<tr>
<td>2</td>
<td>View &amp; analyze initial &amp; post-disturbance actions</td>
<td>1,3,4,5,12</td>
</tr>
<tr>
<td>3</td>
<td>Design more efficient &amp; reliable power systems</td>
<td>1,3,4,5,12</td>
</tr>
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</table>

**Prerequisites**: Basic Power System

**Practical**: 45

2. Power flow analysis by Fast decoupled method.
3. Unit commitment: Priority-list schemes and dynamic programming.
5. Analysis of switching surge: Energization of a long distributed-parameter line.
7. Co-ordination of over-current and distance relays for radial line protection.
8. Digital Over Current Relay Setting and Relay Coordination.
9. Reliability Assessment on Power system.

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### Semester II

**Course Title**: Flexible AC Transmission Systems

<table>
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**CIA** 50% | **ESE** 50%

**Learning Level**: BTL-5

**Course Outcomes**

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<tbody>
<tr>
<td>1</td>
<td>Identify the conditions in conventional power system where the installation of FACTS controllers or Devices becomes vital.</td>
<td>2,3,4,5,12</td>
</tr>
<tr>
<td>2</td>
<td>Analyze the performance of a conventional transmission system and apply the principles of reactive power compensation for improvement.</td>
<td>2,3,4,5,12</td>
</tr>
<tr>
<td>3</td>
<td>Illustrate the modes of operation of thyristor based and voltage source converter based FACTs controllers and explain the capabilities and modeling aspects.</td>
<td>2,3,4,5,12</td>
</tr>
<tr>
<td></td>
<td>Analyze different series, shunt or combined series-shunt FACTs controllers and compute the performance when installed in a given transmission system.</td>
<td>2,3,4,5,12</td>
</tr>
<tr>
<td>---</td>
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<tr>
<td>5</td>
<td>Analyze the different modes of operation of UPFC. Comparing the performance of UPFC with other FACTS controllers</td>
<td>2,3,4,5,12</td>
</tr>
</tbody>
</table>

**Prerequisites:** Power System Analysis, Power Conversion techniques or equivalent

**Module 1 - INTRODUCTION** (9L)

Fundamentals of ac power transmission - transmission problems and needs - emergence of FACTS - FACTS control considerations - FACTS controllers

**Suggested Reading:** EVHAC lines

**Applications:** Transmission Line

**Module 2 - STATIC VAR COMPENSATOR (SVC) (9L)**

Principles of shunt compensation – Variable Impedance type & switching converter type - Static Synchronous Compensator (STATCOM) configuration - characteristics and control

**Applications:** Improve the performance of transmission Line

**Module 3 - THYRISTOR CONTROLLED SERIES CAPACITOR (TCSC) AND APPLICATIONS (9L)**

Principles of static series compensation using GCSC, TCSC and TSSC – applications - Static Synchronous Series Compensator (SSSC)

**Suggested Reading:** Place of adding series compensators in transmission lines

**Applications:** Series compensators in transmission lines

**Module 4 - VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS (9L)**

Principles of operation - Steady state model and characteristics of a static voltage regulators and phase shifters - power circuit configurations

**Suggested Reading:** Need for VSC’s

**Applications:** Transmission Lines

**Module 5 - UNIFIED POWER FLOW CONTROLLER (9L)**

UPFC - Principles of operation and characteristics - independent active and reactive power flow control - comparison of UPFC with the controlled series compensators and phase shifters

**Suggested Reading:** UPFC control

**Applications:** Reactive and Real power compensation in Transmission Lines

**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**

**ELECTIVES**

<table>
<thead>
<tr>
<th>COURSE TITLE</th>
<th>LINEAR AND NON-LINEAR SYSTEMS THEORY</th>
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<tbody>
<tr>
<td>1</td>
<td>Understand and model physical systems using state vectors.</td>
</tr>
<tr>
<td>2</td>
<td>Analyze the stability of linear systems.</td>
</tr>
<tr>
<td>3</td>
<td>Design state feedback controllers and observers.</td>
</tr>
<tr>
<td>4</td>
<td>Understand and analyze non-linear systems using linear approximations.</td>
</tr>
<tr>
<td>5</td>
<td>Inspect the stability of non-linear systems by direct and indirect methods.</td>
</tr>
</tbody>
</table>

**Prerequisites**: Control System

**MODULE 1 - STATE SPACE REPRESENTATION**

Introduction to state space modeling, modeling of physical systems. Solution to vector differential equations and state transition matrix.

**Suggested Reading**: Modelling of different Electrical and Mechanical systems

**MODULE 2 - CONTROLLABILITY AND OBSERVABILITY**


**Suggested Reading**: Analysis of Multi input Multi output systems

**MODULE 3 - MODAL CONTROL**

State feedback controller design using pole placement. Observer design using Kalman filter algorithm. LQR and LQG controller design

**Suggested Reading**: Pole placement by feedback for multi input systems

**MODULE 4 - NONLINEAR SYSTEMS**

Introduction to nonlinear systems. Phase plane analysis of nonlinear system using linear approximation. Limit cycle and periodic solutions. Singular points (equilibrium points) and qualitative behavior near singular points.

**Suggested Reading**: Types of nonlinearity

**MODULE 5 - STABILITY**

Stability of nonlinear systems. Lyapunov direct and indirect methods. Input-to-state stability and relative stability

**Suggested Reading**: Aids to finding Lyapunov function for Nonlinear continuous time autonomous system

**TEXT BOOKS**

### Reference Books


### E Books

1. M. Gopal, "Modern Control System Theory", Halsted Press New York, NY, USA

### MOOC


<table>
<thead>
<tr>
<th>Course Title</th>
<th>Advanced Topics in Power Electronics</th>
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<table>
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<tr>
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<tbody>
<tr>
<td>Understand the principles of operation of advanced Silicon devices.</td>
<td>2,3,</td>
</tr>
<tr>
<td>Appraise various advanced converter topologies and the suitable control schemes.</td>
<td>2,3,</td>
</tr>
<tr>
<td>Recognize recent developments in design aspects of reactive elements such as the material, the structure etc and the effect on performance.</td>
<td>2,3,4</td>
</tr>
<tr>
<td>Understand nuances of advanced energy storage systems such as battery energy storage system (BESS), ultra-capacitors, etc and strategies for power management in such systems.</td>
<td>4,5,12</td>
</tr>
<tr>
<td>Distinguish between various possible solutions pertaining to thermal management and EMI/EMC problems and devise solutions for simple power electronic systems</td>
<td>3,4,5,12</td>
</tr>
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</table>

**Prerequisites:** Power Electronics.

### Module 1 – Power Semiconductor Devices (9L)

- Introduction to switches - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT & EST. SiC devices - diodes, thyristors, JFETs & IGBTs. Gallium nitrate devices - Diodes, MoSFETs

### Module 2 – Advanced Converter (9L)

- Advance converter topologies for PEE - Interleaved converters, Z-Source converters, Multi level converters (Cascaded H-Bridge, Diode clamped, NPC, Flying capacitor) Multi pulse PWM current
source converters, Advanced drive control schemes.

**MODULE 3 – REACTIVE ELEMENTS**

| Advances in reactive elements - Advanced magnetic material, technology and design (Powder ferrite, Amorphous, Planar designs) Advance capacitive designs (Multilayer chip capacitors, double layers for storage, Aluminum electrolytic) |

**MODULE 4 – STORAGE SYSTEMS**

| Advance storage systems - Developments in battery systems, Ultra capacitors, Fly wheel energy storage, Hybrid storage systems for EV/HEV, Power management in hybrid systems, Energy storage in renewable. |

**MODULE 5 – THERMAL ENGINEERING**

| Thermal engineering with EMI/EMC techniques - Advanced thermal solutions ( fan cooled, liquid cooled, heat pipes, hybrid techniques) EMC techniques ( Conducted, Radiated emissions & Susceptibility), System design for EMC. |

**TEXT BOOKS**

| 2 | R D MiddleBrook& Slobodan CUK, 'Advances in Switched Mode Power Conversion', Vol I, II, & III, Tesla Co(optimum power conversion) |

**REFERENCE BOOKS**

| 2 | BIN Wu, ' High Power Converters and AC Drives', IEEE press Wiley Interscience, a John wiley& sons Inc publication 2006 |

**E BOOKS**


**MOOC**

| 1 | https://www.coursera.org/learn/converter-circuits |
| 2 | https://nptel.ac.in/courses/nptel_download.php?subjectid=10810038 |

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<td><strong>PO</strong></td>
<td>2,3</td>
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<tr>
<td>1</td>
<td>Recognize various issues related to energy market, its growth and its structural implications in India.</td>
<td></td>
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</table>
2. Analyze the performance of different battery storage systems.  
3. Employ different thermoelectric measurement techniques appropriately.  
4. Interpret the applications of super capacitors for appropriate storage systems.  
5. Understand and differentiate different types of fuel cells.

**Prerequisites**: Fundamental Chemistry and Material Science.

<table>
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<tr>
<th>MODULE 1 – INTRODUCTION</th>
<th>(9L)</th>
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<tbody>
<tr>
<td>Prospect for both traditional and renewable energy sources - detailed analysis of Indian energy market and future need through 2020 - energy, economic growth and the environment, implications of the Kyoto Protocol, and structural change in the electricity supply industry</td>
<td></td>
</tr>
<tr>
<td><strong>Suggested Reading</strong>: Present and Future Energy Scenario in India</td>
<td></td>
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<table>
<thead>
<tr>
<th>MODULE 2 – STORAGE SYSTEMS</th>
<th>(9L)</th>
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</thead>
<tbody>
<tr>
<td>Batteries - performance, charging and discharging, storage density, energy density, and safety issues, classical batteries - Lead Acid, Nickel-Cadmium, Zinc Manganese dioxide, and modern batteries - Zinc-Air, Nickel Hydride, Lithium Battery.</td>
<td></td>
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<tr>
<td><strong>Suggested Reading</strong>: Storage Battery Maintenance and Principles</td>
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<table>
<thead>
<tr>
<th>MODULE 3 – THERMOELECTRIC</th>
<th>(9L)</th>
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<tbody>
<tr>
<td>Thermoelectric - electron conductor and phonon glass, classical thermoelectric materials (i) four-proberesistivity measurement, Seebeck coefficient measurement, and thermal conductivity measurement.</td>
<td></td>
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<tr>
<td><strong>Suggested Reading</strong>: Applications:</td>
<td></td>
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<table>
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<th>MODULE 4 – SUPER CAPACITORS</th>
<th>(9L)</th>
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</thead>
<tbody>
<tr>
<td>Super capacitors - types of electrodes and some electrolytes, Electrode materials - high surface area activated carbons, metal oxide, and conducting polymers, Electrolyte - aqueous or organic, disadvantages and advantages of super capacitors - compared to battery systems, applications - transport vehicles, private vehicles, and consumer electronics - energy density, power density, price, and market.</td>
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<tr>
<td><strong>Suggested Reading</strong>: Linden’s Handbook of Batteries, Fourth Edition by by: Thomas B. Reddy</td>
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<table>
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<tr>
<th>MODULE 5 – FUEL CELLS</th>
<th>(9L)</th>
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</thead>
<tbody>
<tr>
<td>Fuel cells - direct energy conversion - maximum intrinsic efficiency of an electrochemical converter, physical interpretation - carnot efficiency factor in electrochemical energy convertors, types of fuel cells -hydrogen oxygen cells, hydrogen air cell, alkaline fuel cell, and phosphoric fuel cell.</td>
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</tr>
<tr>
<td><strong>Suggested Reading</strong>: fuel cells and its application</td>
<td></td>
</tr>
</tbody>
</table>

**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**


**MOOC**

1. https://ocw.tudelft.nl/course-lectures/introduction-energy-storage/
COURSE TITLE | ELECTRIC AND HYBRID VEHICLES | CREDITS | 3
---|---|---|---
COURSE CODE | EEB3724 | COURSE CATEGORY | DE
CIA | L-T-P-S | 3- 0- 0- 1
LEARNING LEVEL | BTL- 4
50% | 50%

CO | COURSE OUTCOMES | PO
---|---|---
1 | Understand mathematical models, performance and characteristics of hybrid and electric vehicles. | 2,3,4
2 | Analyze the concepts, topologies and power flow control of electric traction systems. | 2,3,4
3 | Appraise the configuration and control of various hybrid electric motor drives | 2,3,4,5
4 | Plan and design appropriate vehicle management system. | 2,3,4,5,12

Prerequisites: power electronics

**MODULE 1 – INTRODUCTION HYBRID AND ELECTRIC VEHICLES** (9L)

History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Basics of vehicle performance, vehicle power source characterization, transmission characteristics, mathematical models to describe vehicle performance.

**Suggested Reading:** Future prospectus of hybrid and electric vehicles

**Applications:** Modern hybrid vehicles

**MODULE 2 – ELECTRIC TRACTION SYSTEMS** (9L)

Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. Basic concepts of electric traction, introduction to various electric drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

**Suggested Reading:** [https://link.springer.com/chapter/10.1007/978-3-642-30281-7_2](https://link.springer.com/chapter/10.1007/978-3-642-30281-7_2) (Railway traction system)

**MODULE 3 – HYBRID ELECTRIC MOTOR DRIVES** (9L)

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

**Suggested Reading:** Modern Electric Hybrid Electric & Fuel Cell Vehicles by MehrdadEhsani (http://ceb.ac.in/knowledge-center)

**MODULE 4 – ELECTRICAL MACHINES AND INTERNAL COMBUSTION ENGINE** (9L)

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.

**Suggested Reading:** Selection of ICE and Electrical machines

**MODULE 5 – VEHICLE MANAGEMENT SYSTEM** (9L)
Introduction to energy management strategies used in hybrid and electric vehicle, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy strategies.

**Suggested Reading:** Advanced Vehicle Management System

### LAB / MINI PROJECT/FIELD WORK

#### TEXT BOOKS


#### REFERENCE BOOKS


#### E BOOKS


   Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives

#### MOOC

1. [https://www.edx.org/course/electric-cars-introduction](https://www.edx.org/course/electric-cars-introduction)

2. [https://www.edx.org/course/hybrid-vehicles](https://www.edx.org/course/hybrid-vehicles)

### COURSE TITLE

**DISTRIBUTED GENERATION AND MICROGRIDS**

<table>
<thead>
<tr>
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### CREDITS

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#### COURSE OUTCOMES

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<tbody>
<tr>
<td>1</td>
<td>Understand the current scenario of Distributed Generation and the need to implement DG sources.</td>
<td>2,3,4</td>
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<tr>
<td>2</td>
<td>Investigate the different types of RES as DGs.</td>
<td>2,3,4</td>
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<tr>
<td>3</td>
<td>Appraise the grid integration, interfaces and technical impacts of DGs upon transmission and distribution systems.</td>
<td>2,3,4,5</td>
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<tr>
<td>4</td>
<td>Analyze the aspects of Power Quality and Reliability.</td>
<td>3,4,5,12</td>
</tr>
<tr>
<td>5</td>
<td>To understand comprehensively about different types of Storage systems.</td>
<td>3,4,5,12</td>
</tr>
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</table>

**Prerequisites:** The students are preferred to have a basic knowledge in Power System Analysis and Distribution Systems

### MODULE 1 – INTRODUCTION, PLACING AND SIZING THE DISTRIBUTED ENERGY RESOURCES (9L)

Need for Distributed generation, renewable sources in distributed generation, current scenario in Distributed Generation, Planning of DGs – Siting and sizing of DGs – optimal placement of DG sources in distribution systems.
**Suggested Reading:** Detailed study of Renewable Energy Sources
**Applications:** Siting and Sizing of DGs using ETAP

### MODULE 2 – RENEWABLE ENERGY SOURCES (9L)
- Wind Power-Photovoltaic and Thermo-solar power-Biomass Power, Fuel cells types, types of Tidal power generation schemes, mini and micro hydro power schemes.

**Suggested Reading:** Micro turbines for DG, bulb and tubular turbines-

### MODULE 3 – GRID INTEGRATION, INTERFACES AND IMPACTS OF DGs (9L)
- Grid integration of DGs – Different types of interfaces - Inverter based DGs - Aggregation of multiple DG units. – Transmission systems, Distribution systems, De-regulation – Impact of DGs upon protective relaying

**Suggested Reading:** Rotating machine based interfaces

### MODULE 4 – POWER QUALITY AND RELIABILITY IN DER (9L)
- Voltage control techniques, Reactive power control, Harmonics, Power quality issues.
- Reliability of DG based systems – Steady-state and Dynamic analysis.

**Suggested Reading:** Various aspects of Operations

### MODULE 5 – ENERGY STORAGE AND CONTROL TECHNIQUES (9L)

**Suggested Reading:** Various aspects such as Market Management Retailing, Trading and Ancillary Services

### LAB / MINI PROJECT / FIELD WORK
Simulation in ETAP/HOMER

### TEXT BOOKS
2. “Renewable energy power for a sustainable future” by Godfrey Boyle, 2004 Oxford University Press in association with the Open university.

### REFERENCE BOOKS
3. N. Jenkins, J.B. Ekanayake and G. Strbac, Distributed Generation, The Institution of Engineering and Technology, 2010
4. S. Chowdhury, S.P. Chowdhury and P. Crossley,’Microgrids and Active Distribution Networks’, The Institution of Engineering and Technology

### E BOOKS
1. N. Jenkins, J.B. Ekanayake and G. Strbac,Distributed Generation, The Institution of Engineering and Technology, 2010
2. S. Chowdhury, S.P. Chowdhury and P. Crossley,’Microgrids and Active Distribution Networks’, The Institution of Engineering and Technology

### MOOC
COURSE TITLE: ELECTRICAL SYSTEMS IN WIND ENERGY
CREDITS: 3

COURSE CODE: EEB3726
COURSE CATEGORY: PE

LEARNING LEVEL: BTL-4

CIA: 50%
ESE: 50%

COURSE OUTCOMES:

PO 1 Explain the operation of electrical generators used in wind energy systems 2,3,4,5,12

PO 2 Carry out the steady-state analysis of electrical systems 2,3,4,5,12

PO 3 Design and implement the suitable closed-loop controller for specific applications. 2,3,4,5,12

Prerequisites: Electrical machines and power electronics.

MODULE 1 – WIND ENERGY FUNDAMENTALS (9L)
Wind energy basics, wind speeds, wind characteristics and power production, betz coefficient, limits, Air foil terminology , blade element theory, blade design, number of blades,shapes,tipspeed, lift and drag ratio ,rotor dynamics, types of loads, balancing technique

MODULE 2 – GRID CONNECTED INDUCTION GENERATORS (9L)
Principle of operation – steady-state analysis-characteristics of GCIGs- operation of GCIGs with different power electronic configurations.

MODULE 3 – SELF EXCITED INDUCTION GENERATORS (9L)
Process of self-excitation – steady-state equivalent circuit of SEIG and its analysis - performance equations - widening the operating speed-range of SEIGs by changing the stator winding connection with suitable solid state switching schemes - power electronic controllers used in standalone systems.

MODULE 4 – DOUBLY FED INDUCTION GENERATOR (9L)
Different operating modes- steady-state equivalent circuit- performance analysis- DFIG for standalone applications- operation of DFIGs with different power electronic configurations for standalone and grid connected operation

MODULE 5 – PERMANENT MAGNET SYNCHRONOUS GENERATOR (9L)
Operation of PMSGs- steady-state analysis- performance characteristics- operation of PMSGs with different power electronic configurations for standalone and grid-connected operation.

LAB / MINI PROJECT/FIELD WORK
Modeling wind turbine Generators in MATLAB

TEXT BOOKS

REFERENCE BOOKS
1 Siegfried Heier, Rachel Waddington, ‘Grid Integration of Wind Energy Conversion Systems, 2nd
COURSE TITLE: SMART GRID TECHNOLOGIES & IOT

<table>
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CIA: 50%

ESE: 50%

LEARNING LEVEL: BTL-4

COURSE OUTCOMES

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<tr>
<td>2,3,4,5,12</td>
<td>Get acquainted with different smart devices and smart meters</td>
</tr>
<tr>
<td>2,3,4,5,12</td>
<td>Describe how modern power distribution system functions</td>
</tr>
<tr>
<td>2,3,4,5,12</td>
<td>Identify suitable communication networks for Smart Grid applications</td>
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</table>

Prerequisites: Fundamentals of Power Distribution System, Transmission and Distribution, Power system Operation and Control, Communication Networks

MODULE 1 – INTRODUCTION TO SMART GRID

Introduction - Evolution of Electric Grid, Smart Grid Concept - Definitions and Need for Smart Grid – Functions – Opportunities – Benefits and challenges, Difference between conventional & Smart Grid, Technology Drivers

MODULE 2 – ENERGY MANAGEMENT SYSTEM


MODULE 3 – DISTRIBUTION MANAGEMENT SYSTEM


MODULE 4 – SMART METERS

Introduction to Smart Meters – Advanced Metering infrastructure (AMI), AMI protocols – Standards and initiatives, Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

MODULE 5 – COMMUNICATION NETWORKS & IOT

Elements of communication and networking – architectures, standards, PLC, Zigbee, GSM, BPL, Local Area Network (LAN) - House Area Network (HAN) - Wide Area Network (WAN) - Broadband over Power line (BPL) - IP based Protocols - Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

LAB / MINI PROJECT/FIELD WORK
### TEXT BOOKS

### REFERENCE BOOKS

### E BOOKS
1. [Link](https://books.google.co.in/books?isbn=1119969093)
2. [Link](https://books.google.co.in/books?isbn=135123093X)

### MOOC
1. [Link](https://www.mooc-list.com/course/smart-grids-electricity-future-edx)
2. [Link](https://www.mooc-list.com/course/distributed-energy-smart-grid-resourcesfuture-edx)

### COURSE TITLE
**DIGITAL SIMULATION OF POWER ELECTRONIC SYSTEMS**

<table>
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<td>2,3,4,5,12</td>
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</table>

### COURSE OUTCOMES
1. To develop algorithm and software models for power electronics and drives applications
2. To analyze the transient and steady performance of the designed models.
3. To choose suitable devices or models for appropriate applications
4. To choose suitable devices or models based on the required applications
5. Will be able to model a control circuitary based on the electric machine in use.

### Prerequisites:

#### MODULE 1 - ANALYSIS OF DC CIRCUITS(L9)

**Suggested Reading:** Resonance in power converters circuits - [Link](https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=6374374)

**Applications:** To find resonance and transients

#### MODULE 2 - SIMULATION OF SEMICONDUCTOR SWITCHES AND DC CIRCUITS(L9)

**Suggested Reading:** Operation of all the power switches

**Applications:** Renewable energy systems, Speed control of Drives

#### MODULE 3 - ELECTRICAL MACHINE MODELLING AND SIMULATION (L9)
State space modeling and simulation of linear systems. Introduction to electrical machine modeling: induction, DC, and synchronous machines, simulation of basic electric drives, stability aspects.

**Suggested Reading:** The calculation and design of Electrical Apparatus Applications: In designing electrical machines

### MODULE 4 - SIMULATION OF RECTIFIERS AND CHOPPERS (L9)

Simulation of single phase and three phase uncontrolled and controlled (SCR) rectifiers, converters with self-commutated devices- simulation of power factor correction schemes, Simulation of converter fed dc motor drives, Simulation of thyristor choppers with voltage, current and load commutation schemes, Simulation of chopper fed dc motor.

**Suggested Reading:** Calculation for passive components used for rectifiers and choppers

Applications: Power System and Power electronics for RES

### MODULE 5 - SIMULATION OF INVERTERS AND ELECTRIC DRIVES (L9)

Simulation of single and three phase inverters with thyristors and self-commutated devices, Space vector representation, pulse-width modulation methods for voltage control, waveform control. Simulation of inverter fed induction motor drives.

**Suggested Reading:** Multi level inverter

Applications: Renewable Energy Systems, Electric Drives

**LAB / MINI PROJECT/FIELD WORK**

Design of Wind energy conversion system/Standalone PV system / Speed control of electric drives

**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**


**MOOC**

1. [https://www.coursera.org/specializations/power-electronics](https://www.coursera.org/specializations/power-electronics)
2. [https://www.edx.org/course/subject/electronics](https://www.edx.org/course/subject/electronics)

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<tr>
<td></td>
<td><strong>To understand different types of power quality problems with their source of generation.</strong></td>
<td>2,3,4,5,12</td>
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<tr>
<td>2</td>
<td><strong>To learn and characterize various power quality problems</strong></td>
<td>2,3,4,5,12</td>
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<tr>
<td>3</td>
<td><strong>To identify different mitigation techniques</strong></td>
<td>2,3,4,5,12</td>
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<td>4</td>
<td><strong>To design active &amp; passive filters for harmonic elimination.</strong></td>
<td>2,3,4,5,12</td>
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<tr>
<td>5</td>
<td><strong>To understand power quality monitoring and classification techniques</strong></td>
<td>2,3,4,5,12</td>
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</table>

**Prerequisites:** Power Systems, Signals and Systems

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**MODULE 1 - INTRODUCTION TO POWER QUALITY (9L)**

Electric power quality phenomena - IEC and IEEE definitions - power quality disturbances - voltage fluctuations- transients- unbalance- waveform distortion- power frequency variations.

*Suggested Reading:* Computer Business Equipment Manufacturers Associations (CBEMA) Curve

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**MODULE 2 - VOLTAGE SAGS AND INTERRUPTIONS (9L)**


*Suggested Reading:* Voltage Sag Due to Induction Motor Starting

---

**MODULE 3 - TRANSIENTS**


*Suggested Reading:* Introduction to computer analysis tools for transients

*Applications:* Protection of Transformers and Cables

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**MODULE 4 - HARMONICS**


*Suggested Reading:* Modelling and analysis of power quality problems by mathematical simulation tools

*Applications:* Harmonic / Spectrum Analyzer

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**MODULE 5 - POWER QUALITY CONDITIONERS**


*Suggested Reading:* Modelling and analysis of unified power flow controller.

*Applications:* Expert Systems for Power Quality Monitoring

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**LAB / MINI PROJECT/FIELD WORK**

SVC based Reactive Power Optimization using MATLAB

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**TEXT BOOKS**

<table>
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<tr>
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<td>CO</td>
<td>COURSE OUTCOMES</td>
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<tr>
<td>1.</td>
<td>Able to understand fundamentals of various AI based techniques</td>
<td>2,3,4,5,12</td>
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<tr>
<td>2.</td>
<td>Able to analyse various AI techniques presented for electrical machines and drives</td>
<td>2,3,4,5,12</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Able to analyse various evolution techniques</td>
<td>3,4,5,12</td>
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</table>

Prerequisites : power electronics

**MODULE 1 – ARTIFICIAL INTELLIGENT BASED SYSTEMS** (9L)

Natural language system – perception system for vision speech and touch - expert or knowledge based system – knowledge acquisition – knowledge of representation – inference strategy – expert controller.

**Suggested Reading:** Artificial Intelligence basics

**MODULE 2 – ARTIFICIAL INTELLIGENCE** (9L)

Definition, problem solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, multivalue logic.

**Suggested Reading:** Paradigms of Artificial Intelligence Programming

---

REFERENCE BOOKS


E BOOKS

1. https://epdf.tips/power-quality.html

MOOC

1. https://nptel.ac.in/courses/108106025/
5. https://players.brightcove.net/5229431846001/default_default/index.html?videoId=5713251730001&iframe=true&autoplay=true
<table>
<thead>
<tr>
<th>Applications: Renewable Energy</th>
</tr>
</thead>
</table>

**MODULE 3 – FUZZY LOGIC (9L)**
Concepts, fuzzy relations, membership functions, matrix representation, de-fuzzification methods

**Suggested Reading:** fuzzy logic with engineering application

**Applications:** Renewable Energy

**MODULE 4 – ARTIFICIAL NEURAL NETWORK (9L)**
Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

**Applications:** Domestic and Commercial applications

**MODULE 5 – EVOLUTIONARY TECHNIQUES (9L)**
Introduction and concepts of genetic algorithms and evolutionary programming

**Hybrid Systems:** Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy systems.

**Suggested Reading:** Modern evolutionary techniques

**Applications:** Renewable Energy Conversion

**LAB / MINI PROJECT / FIELD WORK**
-  

**TEXT BOOKS**

**REFERENCE BOOKS**

**E BOOKS**

**MOOC**
1. https://nptel.ac.in/courses/106105077/
2. https://onlinecourses.nptel.ac.in/noc18_cs51/

<table>
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**LEARNING LEVEL**
- BTL-5

**CO**

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<tbody>
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</table>
2 Design and analyze stand-alone and grid connected PV system.  
3 Describe the dynamics of wind turbine and electrical generator  
4 Select and design suitable configuration of the wind energy conversion system based on application.  
5 Suggest, design and analyze hybrid energy systems.  

**Prerequisites**: Basic Electronics and Machines, Power Electronics

### MODULE 1 – SOLAR ENERGY (9L)
- Definition, Energy available from Sun, Solar radiation data, solar energy conversion into heat, Flat plate and Concentrating collectors, Principle of natural and forced convection. power generation.
- PV Systems - Design of PV systems-Standalone system with DC and AC loads with and without battery storage-Grid connected PV systems-Maximum Power Point Tracking

### MODULE 2 – WIND ENERGY (9L)
- Wind energy – energy in the wind – aerodynamics - rotor types – forces developed by blades - Aerodynamic models – braking systems – tower - control and monitoring system - design considerations power curve - power speed characteristics-choice of electrical generators

### MODULE 3 – WIND TURBINE GENERATOR SYSTEMS (9L)

### MODULE 4 – NATURE OF GEOTHERMAL RESOURCES (9L)
- Definition and classification of resources, Utilization for electricity generation and direct heating, Wellhead power generating units. Basic features: Atmospheric exhaust and condensing, Exhaust types of conventional steam turbines. Pyrolysis of Biomass to produce solid, liquid and gaseous fuels. Biomass gasification, Constructional details of gasifier, Usage of biogas for chullas, various types of chullas for rural energy needs.

### MODULE 5 – HYBRID ENERGY SYSTEMS (9L)
- wind-diesel system, wind - PV system ,micro hydro-PV system ,biomass - PV-diesel system, geothermal-tidal and OTEC systems

### LAB / MINI PROJECT/FIELD WORK
- Mini Project: Prototype modelling of Renewable power Generation

### TEXT BOOKS

### REFERENCE BOOKS
E BOOKS
1. https://books.google.co.in/books?isbn=0215521137
2. https://books.google.co.in/books?isbn=0128132175

MOOC
2. https://www.edx.org/course/solar-energy

COURSE TITLE: ENERGY AUDITING AND MANAGEMENT
COURSE CODE: EEB3732
CREDITS: 3
COURSE CATEGORY: DE
L-T-P-S: 3-0-0-1

CIA: 50%
ESE: 50%
LEARNING LEVEL: BTL-4

COURSE OUTCOMES

PO

1. Assess the energy management on various electrical equipment and metering 2,3,4,5,12
2. Adopt Conservation methods in various systems. 2,3,4,5,12
3. Learn various technically proven ways to conserve Energy and then prioritize them based on the cost benefit analysis 2,3,4,5,12
4. Illustrate the concept of lighting systems and cogeneration. 2,3,4,5,12
5. Apply Tools for energy audit and recommend measures for energy conservation 2,3,4,5,12

Prerequisites: Nil

MODULE 1: INTRODUCTION (9L)
Need for energy management - energy basics- designing and starting an energy management program – energy accounting-energy monitoring, targeting and reporting-energy audit process.

Suggested Reading: Study of energy audit report

MODULE 2: ENERGY COST AND LOAD MANAGEMENT (9L)
Important concepts in an economic analysis - Economic models-Time value of money- Utility rate structures- cost of electricity-Loss evaluation- Load management: Demand control techniques- Utility monitoring and control system-HVAC and energy management-Economic justification.

Suggested Reading: Analysis of different economic models

MODULE 3: ENERGY MANAGEMENT FOR MOTORS, SYSTEMS, AND ELECTRICAL EQUIPMENT (L9)
Energy efficient motors, factors affecting efficiency, loss distribution, constructional details, characteristics - variable speed, variable duty cycle systems, RMS hp- voltage variation-voltage unbalance- over motoring- motor energy audit. Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study. Reactive Power management-Capacitor
Sizing-Degree of Compensation-Capacitor losses-Location-Placement-Maintenance.

**Suggested Reading:** Savings calculation after implementing the above methods

---

**MODULE 4  METERING FOR ENERGY MANAGEMENT(9L)**

- Relationships between parameters-Units of measure-Typical cost factors- Utility meters - Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters – Metering location vs. requirements
  - **Suggested Reading:** Metering techniques and practical examples

---

**MODULE 5  LIGHTING SYSTEMS & COGENERATION(9L)**

- Concept of lighting systems - The task and the working space -Light sources - Ballasts –Luminaries - Lighting controls-Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques-Lighting and energy standards
  - Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.
  - **Suggested Reading:** Electrical Design of Buildings

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**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**


**MOOC**


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**COURSE TITLE**

**HIGH VOLTAGE DC TRANSMISSION**

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**COURSE OUTCOMES**

1. Appraise the need of HVDC technology for bulk power transmission and choose appropriate type of HVDC link and converter. 2,3,4,5,12
2. Analyze the operation of Graetz circuit as rectifier and inverter without and with 2,3,4,5,12
3. Evaluate the operation and efficacy of different controllers and analyze the different faults in HVDC systems.  
4. Discriminate and evaluate the issues related with harmonics, reactive power control and protection of HVDC system.  
5. Recognize and appraise the recent trends in HVDC transmission systems.

**Prerequisites:** Power Electronics

**MODULE 1 - INTRODUCTION**

Introduction to HVDC transmission, Comparison between HVAC and HVDC systems - economic, technical and reliability, limitations, Types of HVDC links - monopolar, bipolar and homopolar links, Components of HVDC transmission system.

**Applications:** HVDC transmission

**MODULE 2 - ANALYSIS OF HVDC CONVERTERS**

Analysis of HVDC Converters, Rectifier and Inverter operation of Graetz circuit without and with overlap. Output voltage waveforms and DC voltage in both rectifier and inverter operation, Equivalent circuit of HVDC link

**Suggested Reading:** Basic circuit operation of converter and inverter circuits

**MODULE 3 - HVDC SYSTEM CONTROL**

Basic means of HVDC system control, desired features, power reversal, Basic controllers - constant ignition angle, constant current and constant extinction/advance angle control, power control, high level controllers. Converter mal operations - misfire, arc through, commutation failure

**Suggested Reading:** Sources of converter mal operations,

**MODULE 4 - POWER FLOW ANALYSIS**

Harmonics in HVDC system - Characteristic and uncharacteristic harmonics - troubles due to harmonics –harmonic filters - active and passive filters - Reactive power control of converters, Protection issues in HVDC, over voltage and over current protection, voltage and current oscillations, DC reactor design, DC Circuit breakers

**Suggested Reading:** Need for reactive power control

**Applications:** place of highly inductive loads

**MODULE V - RECENT TRENDS IN HVDC TRANSMISSION**

Recent trends in HVDC transmission-CCC based HVDC system, VSC based HVDC system, Multiterminal HVDC systems and HVDC system applications in wind power generation, Interaction between AC and DC systems

**Applications:** In renewable energy systems

**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**
1. www.engineeringbookspdf.com - padiyar
2. https://books.google.co.in/books/about/HVDC_power

**MOOC**
1. https://nptel.ac.in-courses

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<td>To understand the concepts of power system automation.</td>
<td>2,3,4,5</td>
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<tr>
<td>2</td>
<td>To understand the components of SCADA systems.</td>
<td>2,3,4,5</td>
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<tr>
<td>3</td>
<td>To comprehend the RTU, IED and other components of automation systems</td>
<td>2,3,4,5</td>
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<tr>
<td>4</td>
<td>To understand the transfer of signals from the field to an operator control terminal.</td>
<td>2,3,4,5</td>
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<tr>
<td>5</td>
<td>To design an interoperable powered automation system.</td>
<td>2,3,4,5,12</td>
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**Prerequisites**: Basic Knowledge of Transmission & Distribution systems and Measuring Instruments

**MODULE 1 - INTRODUCTION TO SCADA** (9L)
Evolution of Automation systems, History of Power system Automation, Supervisory Control And Data Acquisition (SCADA) Systems, Components of SCADA systems, SCADA Applications, SCADA in power systems, SCADA basic functions, SCADA application functions in Generation, Transmission and Distribution.

**Suggested Reading**: SCADA based protection system

**Applications**: Comprehensive operational planning and control, Network security, Economic dispatch

**MODULE 2 - SCADA SYSTEM COMPONENTS (9L)**

**Suggested Reading**: Operation and control of interconnected power system

**MODULE 3 - FEATURES OF RTU** (9L)
Remote Terminal Unit (RTU), Evolution of RTUs, Components of RTU, Communication, Logic, Termination and Test/HMI Subsystems, Power supplies, Advanced RTU Functionalities.

**Suggested Reading**: Microcontroller based RTU for distribution automation system

**Applications**: RTU for Distribution Automation and Substation Monitoring applications

**MODULE 4 - COMMUNICATION SYSTEM STANDARDS FOR SCADA** (9L)
Intelligent Electronic Devices (IEDs), Evolution of IEDs, IED functional block diagram, The hardware and software architecture of IED, IED Communication subsystem, IED advanced functionalities, Typical IEDs, Data Concentrators and Merging Units, SCADA Communication Systems.
### MODULE 5 - FEATURES OF HMI (9L)
Master Station, Master station software and hardware configurations, Server systems in the master station, Small, medium and large master station configurations, Global Positioning Systems, Master station performance, Human Machine Interface (HMI), HMI components, Software functionalities, Situational awareness, Case studies in SCADA.

**Suggested Reading:** SCADA Simulation of a distributed generation system

**Applications:** Utility applications

### LAB / MINI PROJECT / FIELD WORK
Introduction to electrical Supervisory Control & Data Acquisition (eSCADA) using ETAP

### TEXT BOOKS

### REFERENCE BOOKS

### E BOOKS
1. https://epdf.tips/queue/electric-power-distribution-automation-protection-and-controla630f51c023e86aff603a2bad92c5f6e35450.html

### MOOC
1. https://nptel.ac.in/courses/108106022/11

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### COURSE TITLE
**PHOTOVOLTAIC AND FUEL CELL SYSTEMS**

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**COURSE CATEGORY:** OE

**Prerequisites:** Nil

**MODULE 1 - SOLAR PV SYSTEMS** *(L12)*

Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Supporting structures, mounting and installation, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule,
Monitoring, Data Management, Performance Analysis and Financial Analysis

**MODULE 2 - SOLAR PV POWER PLANTS**  (L12)

Array design, inverter types and characteristics, Power conditioning system: working algorithms, performance analysis; design of standalone, hybrid and grid interactive plants, commissioning of solar PV plant

**MODULE 3 - FUEL CELLS**  (L12)

Thermodynamics of fuel cells; free energy change and cell potentials; effects of temperature and pressure on cell potential; energy conversion efficiency; factors affecting conversion efficiency; polarization losses; important types of fuel cells (hydrogen-oxygen, organic compounds-oxygen, carbon or carbon monoxide-air, nitrogen compounds-air); electrode types; electrolytes for fuel cells; applications.

**TEXT BOOKS**

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<tr>
<th>No.</th>
<th>Title</th>
<th>Author(s)</th>
<th>Publisher/Year</th>
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<tr>
<td>4</td>
<td>Non-Conventional Energy Resources</td>
<td>N.K. Bansal</td>
<td>Vikas Publishing House Pvt Ltd, New Delhi , 2014</td>
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**REFERENCE BOOKS**

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<td>Photovoltaic Systems Engineering</td>
<td>Roger A. Messenger, Amir Abtahi</td>
<td>CRC Press, 2017</td>
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**E BOOKS**

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<td>Understand and analyse the operation and control of wind energy converter</td>
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**Prerequisites:** Nil

**MODULE 1 - WIND ENERGY**

Basics: Status, Advantages and disadvantages of wind energy systems, Advantages and disadvantages, Types of wind energy converters, Local Effects on wind, site selection: roughness length, wind shear, Wind Speed Variability, Obstacles to wind flow.


**MODULE 2 - COMPONENTS, OPERATION AND CONTROL OF A WIND ENERGY CONVERTER**

Components of a wind energy converter: Rotor Blades, Gearboxes, Synchronous or Asynchronous Generators, Towers, Miscellaneous components, Turbine Selection.

Operation and Control of Wind Energy Converters: grid requirements, Issue of Noise and Its Control, Power Curve and Capacity Factor, Pitch control, Stall Control, Yaw Control.

**MODULE 3 - HYDRO POWER**


Working principles: Locating a Hydropower Plant, Basics of Fluid Mechanics for hydro power, Single and multiple reservoir system, cascaded power plants.

Important Parts of Hydropower Station: Turbine, Electric Generator, Transformer and Power House, Structural parts: Dam and Spillway, Surge Chambers, Stilling Basins, Penstock and Spiral Casing, Tailrace, Pressure Pipes, Caverns, auxiliary parts.


**TEXT BOOKS**


**REFERENCE BOOKS**


**E BOOKS**

1. https://nptel.ac.in/courses/108105058/24
2. https://nptel.ac.in/courses/108108078/6

**MOOC**

## COURSE TITLE
**BIOMASS ENERGY SYSTEMS**

## CREDITS
3

## COURSE CODE
EEB3743

## COURSE CATEGORY
OE

## PREREQUISITES
Nil

## MODULE 1 - BIOMASS RESOURCE
**(L12)**

Characteristics of Biomass fuel, technologies for using biomass, comparison of direct combustion with other technologies

## MODULE 2 - BIOMASS GASIFIERS AND INDUSTRIAL USE OF BIOMASS
**(L12)**

Biomass Gasifiers: Basics of Gasification and types of Gasifiers, Thermodynamic Analysis Biogas Technology, Sizing/Selection and design of Gasifiers,

Industrial use of biomass: Industrial Boilers, biomass as fuel, co-firing and co-generation,

Economic analysis, Testing and Performance Evaluation of Gasifiers, Use of biomass for liquid fuel, Biomass policy

## MODULE 3 - BIOGAS
**(L12)**

Types of biogas plants, design and performance analysis, application of biomass

## TEXT BOOKS

## REFERENCE BOOKS
3. Energy Technology and Directions for the Future, John R. Fanchi, Elsevier Science February 2004

## E BOOKS
1. [https://nptel.ac.in/courses/108108078/7](https://nptel.ac.in/courses/108108078/7)
2. [https://nptel.ac.in/downloads/108108078/](https://nptel.ac.in/downloads/108108078/)

## MOOC
1. [https://www.edx.org/course/sustainable-energy-design-a-renewable-future](https://www.edx.org/course/sustainable-energy-design-a-renewable-future)
### POWER SYSTEM SIMULATION LABORATORY II

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#### COURSE OUTCOMES

**PO MAPPING**

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#### Prerequisites:
- Basic Power Electronics

#### Practical

1. Small-signal stability analysis of single machine-infinite bus system using classical machine model
2. Small-signal stability analysis of multi-machine configuration with classical machine model
3. Co-ordination of over-current and distance relays for radial line protection
4. Induction motor starting analysis
5. Load flow analysis of two-bus system with STATCOM
6. Transient analysis of two-bus system with STATCOM
7. Available Transfer Capability calculation using an existing load flow program
8. Computation of harmonic indices generated by a rectifier feeding a R-L load.

### SEMINAR

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#### COURSE OUTCOMES

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<td>2</td>
<td>Able to propose a project and defend its advantages.</td>
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<td>3</td>
<td>Able to implement a real time system as proposed.</td>
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#### Prerequisites:
- Basic Electrical and Electronics Engineering subjects.

#### Seminar

Seminar should be taken on state of the art topic of student’s own choice based on relevant specialization approved by an Department incharge. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide.
and head of the department/institute.

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**COURSE OUTOMES**

**PO**

1. Able to develop simple electrical and electronic models based on the knowledge gained. 1,3,4,5,12
2. Able to propose a project and defend its advantages. 1,3,4,5,12
3. Able to implement a real time system as proposed. 1,3,4,5,12

**Prerequisites:** Basic Electrical and Electronics Engineering subjects.

**MINI PROJECT**

To carry out a mini project and simple prototype in the area of interest based on the knowledge gained in Electrical and Electronics Engineering from undergraduate and first semester.

The students will carry out a project in one of the following Electrical and Electronics Engineering areas but with substantial multidisciplinary components:

- Power Electronics, Control system
- Transmission and Distribution, Power system
- Electrical Machines, Solid State Drives etc...

Every individual student will be assigned a faculty to guide them. There will be three major reviews which will be carried out as listed below.

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**End Semester Exam**