VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examination and Syllabus
B.E. ELECTRICAL AND ELECTRONICS ENGINEERING
VI SEMESER
(Effective from Academic year 2015-16)

BOARD OF STUDIES IN ELECTRICAL AND ELECTRONICS ENGINEERING
July 2017
### VI Semester

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Subject Code</th>
<th>Subject (Course)</th>
<th>Title</th>
<th>Teaching Department</th>
<th>Teaching Hours /Week</th>
<th>Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Theory</td>
<td>Practical/ Drawing</td>
<td>Duration in hours</td>
</tr>
<tr>
<td>1</td>
<td>15EE61</td>
<td>Core Subject</td>
<td>Control Systems</td>
<td>EEE 04</td>
<td>--</td>
<td>03 80 20 100</td>
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<tr>
<td>2</td>
<td>15EE62</td>
<td>Core Subject</td>
<td>Power System Analysis – I</td>
<td>EEE 04</td>
<td>--</td>
<td>03 80 20 100</td>
</tr>
<tr>
<td>3</td>
<td>15EE63</td>
<td>Core Subject</td>
<td>Digital Signal Processing</td>
<td>EEE 04</td>
<td>--</td>
<td>03 80 20 100</td>
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<tr>
<td>4</td>
<td>15EE64</td>
<td>Core Subject</td>
<td>Electrical Machine Design</td>
<td>EEE 04</td>
<td>--</td>
<td>03 80 20 100</td>
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<tr>
<td>5</td>
<td>15EE65X</td>
<td>Professional Elective</td>
<td>Professional Elective – II</td>
<td>EEE 03</td>
<td>--</td>
<td>03 80 20 100</td>
</tr>
<tr>
<td>6</td>
<td>15EE66Y</td>
<td>Open Elective</td>
<td>Open Elective - II</td>
<td>EEE 03</td>
<td>--</td>
<td>03 80 20 100</td>
</tr>
<tr>
<td>7</td>
<td>15EEL67</td>
<td>Laboratory</td>
<td>Control System Laboratory</td>
<td>EEE 01-Hour Instruction 02-Hour Practical</td>
<td>03 80 20</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>15EEL68</td>
<td>Laboratory</td>
<td>Digital Signal Processing Laboratory</td>
<td>EEE 01-Hour Instruction 02-Hour Practical</td>
<td>03 80 20</td>
<td>100</td>
</tr>
</tbody>
</table>

**TOTAL**

- **Theory:** 22 hours
- **Practical:** 06 hours
- **Total:** 28 hours
- **Total Marks:** 800
- **Credits:** 26

### Elective

**Courses under Code 15EE65X**

<table>
<thead>
<tr>
<th>Title</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Aided Electrical Drawing</td>
<td>15EE651</td>
</tr>
<tr>
<td>Advanced Power Electronics</td>
<td>15EE652</td>
</tr>
<tr>
<td>Energy Audit and Demand side Management</td>
<td>15EE653</td>
</tr>
<tr>
<td>Solar and Wind Energy</td>
<td>15EE654</td>
</tr>
</tbody>
</table>

**Courses under Code 15EE66Y**

<table>
<thead>
<tr>
<th>Title</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Neural Networks and Fuzzy logic</td>
<td>15EE661</td>
</tr>
<tr>
<td>Sensors and Transducers</td>
<td>15EE662</td>
</tr>
<tr>
<td>Batteries and Fuel Cells for Commercial, Military and Space Applications</td>
<td>15EE663</td>
</tr>
<tr>
<td>Industrial Servo Control Systems</td>
<td>15EE664</td>
</tr>
</tbody>
</table>

Students can select any one of the open electives offered by any Department (Please refer to consolidated list of VTU for open electives). Selection of an open elective is not allowed provided;

- The candidate has pre – requisite knowledge.
- The candidate has not studied during I and II year of the programme.
- The syllabus content of open elective is similar to that of Departmental core courses or professional electives.
- A similar course, under any category, is prescribed in the higher semesters.

Registration to electives shall be documented under the guidance of Programme Coordinator and Adviser.

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Electives relevant to chosen specialization/ branch.
3. **Open Elective:** Electives from other technical and/or emerging subject areas.
CATEGORIZATION FOR THE THINKING PROCESS

Bloom’s Taxonomy (Revised)

- **Creating**
  - Can the student create a new product or point of view?
  - assemble, construct, create, design, develop, formulate, write

- **Evaluating**
  - Can the student justify a stand or decision?
  - appraise, argue, defend, judge, select, support, value, evaluate

- **Analyzing**
  - Can the student distinguish between different parts?
  - appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test

- **Applying**
  - Can the student use information in a new way?
  - choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write

- **Understanding**
  - Can the student explain ideas or concepts?
  - classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase

- **Remembering**
  - Can the student recall or remember the information?
  - define, duplicate, list, memorize, recall, repeat, state
### Bloom’s Revised Taxonomy

*Levels, Level Definitions and attributes levels along with action verbs that can be used when developing learning outcomes.*

<table>
<thead>
<tr>
<th>Level</th>
<th>Level Definitions and attributes</th>
<th>Verbs (not comprehensive)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower order thinking skills (LOTS)</strong></td>
<td>Students exhibit memory/rote memorization of previously learnt materials by recognition, recalling facts, terms, basic concepts, and simple answers. Able to remember, but not necessarily fully understanding the material.</td>
<td>Copy, Choose, Define, Discover, Describe, Duplicate, Enumerate, Find, How, Identify, Label, List, Locate, Listen, Memorize, Match, Name, Omitt, Quote, Recall, Relate, Reproduce, Recognize, Select, Show, Spell, Tell, Tabulate, Who, When, Where etc.</td>
</tr>
<tr>
<td><strong>Remembering (Knowledge) (L_1 - \text{Rembr})</strong></td>
<td>Students demonstrate understanding of facts and ideas by interpreting, exemplifying, classifying, inferring, summarizing, comparing and explaining main ideas with own words.</td>
<td>Ask, Classify, Compare, Contrast, Demonstrate, Describe, Extend, Differentiate, Distinguish, Discuss, Express, Explain, Group, Illustrate, Infer, Interpret, Outline, Paraphrase, Rephrase, Relate, Show, Summarize, Select, Translate, Restate etc.</td>
</tr>
<tr>
<td><strong>Understanding (Comprehension) (L_2 - \text{Undrst})</strong></td>
<td>Students solve problems in new situations by applying acquired knowledge, facts, techniques and rules in a different way.</td>
<td>Calculate, Predict, Apply, Solve, Illustrate, Use, Demonstrate, Determine, Model, Build, Construct, Develop, Experiment With, Identify, Make Use Of, Organize, Plan, Select etc.</td>
</tr>
<tr>
<td><strong>Applying (Application) (L_3 - \text{Apply})</strong></td>
<td>Students are able to examine and break information into component parts by identifying motives, causes arrangement, logic and semantics. They can make inferences and find evidence to support generalization.</td>
<td>Analyse, Assume, Break Down, Classify, Categorize, Conclusion, Compare, Contrast, Diagram, Discover, Dissect, Distinguish, Divide, Examine, Function, Illustrate, Inference, Inspect, List, Motive, Outline, Relationships, Simplify, Survey, Take Part In, Test For etc.</td>
</tr>
<tr>
<td><strong>Analysing (Analysis) (L_4 - \text{Analy})</strong></td>
<td>Students are able to present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria. They can justify a decision or course of action.</td>
<td>Agree, Appraise, Assess, Award, Build, Create, Compose, Choose, Compare, Conclude, Criteria, Criticize, Design, Derive, Develop, Decide, Deduct, Determine, Disprove, Defend, Estimate, Formulate, Generate, Invent, Modify, Evaluate, Explain, Influence, Judge, Interpret, Justify, Mark, Measure, Perceive, Rate, Prioritize, Recommend, Rule On, Select, Support, Value etc.</td>
</tr>
<tr>
<td><strong>Evaluating (Evaluation) (L_5 - \text{Evlute})</strong></td>
<td>Students are able to compile, generate or view information, ideas or products together in a different way by combining elements in a new pattern or by proposing alternative solutions. Also, use information to form a unique product. This requires creativity and originality.</td>
<td>Assemble, Adapt, Anticipate, Build, Change, Choose, Combine, Collaborate, Collect, Create, Compile, Compose, Construct, Delete, Design, Develop, Discuss, Develop, Devise, Elaborate, Estimate, Formulate, Happen, Hypothesize, Imagine, Improve, Invent, Imagine, Intervene, Make Up, Maximize, Modify, Originate, Plan, Predict, Propose, Rearrange, Solve, Suppose, Substitute, Test etc.</td>
</tr>
<tr>
<td><strong>Creating (Synthesis) (L_6 - \text{Create})</strong></td>
<td>Students exhibit memory/rote memorization of previously learnt materials by recognition, recalling facts, terms, basic concepts, and simple answers. Able to remember, but not necessarily fully understanding the material.</td>
<td>Sick, leave etc.</td>
</tr>
</tbody>
</table>

**Graduate attributes:** Graduate attributes are the qualities, skills and understandings a university community agrees its students should develop during their time with the institution. These attributes include but go beyond the disciplinary expertise or technical knowledge that has traditionally formed the core of most university courses. They are qualities that also prepare graduates as agents of social good in an unknown future.

Bowden, Hart, King, Trigwell & Watts (2000)
## B.E. Electrical and Electronics Engineering (EE) 
### Choice Based Credit System (CBCS) 
### Semester - VI 

### CONTROL SYSTEMS (Core Subject) 

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>Exam Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>15EE61</td>
<td></td>
<td>03</td>
<td>80</td>
</tr>
</tbody>
</table>

### Credits - 04

### Course Objectives:
- To define a control system
- To explain the necessity of feedback and types of feedback control systems.
- To introduce the concept of transfer function and its application to the modeling of linear systems.
- To demonstrate mathematical modeling of control systems.
- To obtain transfer function of systems through block diagram manipulation and reduction
- To use Mason’s gain formula for finding transfer function of a system
- To discuss transient and steady state time response of a simple control system.
- To discuss the stability of linear time invariant systems and Routh-Hurwitz criterion
- To investigate the trajectories of the roots of the characteristic equation when a system parameter is varied.
- To conduct the control system analysis in the frequency domain.
- To analyze stability of a control system using Nyquist plot.
- To discuss stability analysis using Bode plots.
- To determine the controller or compensator configuration and parameter values relative to how it is connected to the controlled process given the design specifications.

### Module-1

**Introduction to Control Systems:** Introduction, classification of control systems.

**Mathematical Models of Physical Systems:** Modelling of mechanical system elements, electrical systems, Analogous systems, Transfer function, Single input single output systems, Procedure for deriving transfer functions, servomotors, synchros, gear trains.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying, L₄ – Analysing.</th>
</tr>
</thead>
</table>

### Module-2

**Block Diagram:** Block diagram of a closed loop system, procedure for drawing block diagram and block diagram reduction to find transfer function.

**Signal Flow Graphs:** Construction of signal flow graphs, basic properties of signal flow graph, signal flow graph algebra, construction of signal flow graph for control systems.

<table>
<thead>
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</thead>
</table>

### Module-3

**Time Domain Analysis:** Standard test signals, time response of first order systems, time response of second order systems, steady state errors and error constants, types of control systems.

**Routh Stability Criterion:** BIBO stability, Necessary conditions for stability, Routh stability criterion, difficulties in formulation of Routh table, application of Routh stability criterion to linear feedback systems, relative stability analysis.

|--------------------------------|---------------------------------------------------------------------|

### Module-4

**Root Locus Technique:** Introduction, root locus concepts, construction of root loci, rules for the construction of root locus.

**Frequency Response Analysis:** Co-relation between time and frequency response – 2nd order systems only.

**Bode Plots:** Basic factors $G(jω)/H(jω)$, General procedure for constructing bode plots, computation of gain margin and phase margin. Stability analysis with Bode plots.

<table>
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<tr>
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VI EEE (2015-16) - 5
### Nyquist plot

**Design of Control Systems:** Introduction, Design with the PD Controller, Design with the PI Controller, Design with the PID Controller, Design with Phase-Lead Controller, Design with Phase-Lag Controller.

### Revised Bloom’s Taxonomy Level
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Remembering</td>
</tr>
<tr>
<td>L2</td>
<td>Understanding</td>
</tr>
<tr>
<td>L3</td>
<td>Applying</td>
</tr>
<tr>
<td>L4</td>
<td>Analysing</td>
</tr>
</tbody>
</table>

### Course outcomes:
At the end of the course the student will be able to:
- Discuss the effects of feedback and types of feedback control systems.
- Evaluate the transfer function of a linear time invariant system.
- Evaluate the stability of linear time invariant systems.
- Apply block diagram manipulation and signal flow graph methods to obtain transfer function of systems.
- Demonstrate the knowledge of mathematical modeling of control systems and components.
- Determine transient and steady state time response of a simple control system.
- Investigate the performance of a given system in time and frequency domains.
- Discuss stability analysis using Root locus, Bode plots and Nyquist plots.
- Determine the controller or compensator configuration and parameter values relative to how it is connected to the controlled process given the design specifications.

### Graduate Attributes (As per NBA)
Engineering Knowledge, Problem analysis, Modern Tool Usage, Life-long Learning.

### Question paper pattern:
- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

### Textbook
<table>
<thead>
<tr>
<th>Module</th>
<th>Title</th>
<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
<th>Year</th>
</tr>
</thead>
</table>

### ReferenceBooks
<table>
<thead>
<tr>
<th>Module</th>
<th>Title</th>
<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
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</thead>
</table>
**B.E ELECTRICAL AND ELECTRONICS ENGINEERING (EEE) CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER - VI**

### POWER SYSTEM ANALYSIS – 1 (Core Subject)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>IA Marks</th>
<th>Exam Hours</th>
<th>Exam Marks</th>
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<tbody>
<tr>
<td>15EE62</td>
<td>20</td>
<td>03</td>
<td>80</td>
</tr>
</tbody>
</table>

**Number of Lecture Hours/Week**: 04  
**Total Number of Lecture Hours**: 50  
**Credits**: 04

**Course objectives:**
- To introduce the per unit system and explain its advantages and computation.
- To explain the concept of one line diagram and its implementation in problems.
- To explain the necessity and conduction of short circuit analysis.
- To explain analysis of three phase symmetrical faults on synchronous machine and simple power systems.
- To discuss selection of circuit breaker.
- To explain symmetrical components, their advantages and the calculation of symmetrical components of voltages and currents in un-balanced three phase circuits.
- To explain the concept of sequence impedance and its analysis in three phase unbalanced circuits.
- To explain the concept of sequence impedances and network systems of an unloaded synchronous generator, transformers and transmission lines.
- To explain the analysis of synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
- To discuss the dynamics of synchronous machine and derive the power angle equation for a synchronous machine.
- Discuss stability and types of stability for a power system and the equal area criterion for the evaluation of stability of a simple system.

### Module-1

**Teaching Hours**: 10


### Module-2

**Teaching Hours**: 10


### Module-3

**Teaching Hours**: 10


### Module-4

**Teaching Hours**: 10


| Revised Bloom’s Taxonomy Level | L4 – Remembering, L2 – Understanding, L3 – Applying, L4 – Analysing. |
### Module-5


<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying, L₄ – Analysing.</th>
</tr>
</thead>
</table>

### Course outcomes:
At the end of the course the student will be able to:

- Show understanding of per unit system, its advantages and computation.
- Show the concept of one line diagram and its implementation in problems.
- Perform short circuit analysis on a synchronous machine and simple power system to select a circuit breaker for the system.
- Evaluate symmetrical components of voltages and currents in un-balanced three phase circuits.
- Explain the concept of sequence impedance and sequence networks of power system components and power system.
- Analyze three phase synchronous machine and simple power systems for different unsymmetrical faults using symmetrical components.
- Discuss the dynamics of synchronous machine, stability and types of stability.
- Discuss equal area criterion for the evaluation of stability of a simple system under different fault conditions.

### Graduate Attributes (As per NBA)
Engineering Knowledge, Problem analysis, The Engineer and Society, Ethics

### Question paper pattern:
- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

### Textbook

1. Modern Power System  
   D. P. Kothari  
   McGraw Hill  

### Reference Books

1. Elements of Power System  
   William D. Stevenson Jr  
   McGraw Hill  
2. Power System Analysis and Design  
   J. Duncan Glover et al  
   Cengage  
3. Power System Analysis  
   Hadi Sadat  
   McGraw Hill  
   1st Edition, 2002
**Course objectives:**
- To define Discrete Fourier transform and its properties.
- To evaluate DFT of various signals using properties of DFT.
- To explain different linear filtering techniques.
- To explain the evaluation of DFT and inverse DFT using fast and efficient algorithms.
- To design infinite impulse response Butterworth digital filters using impulse invariant and bilinear transformation techniques.
- To design infinite impulse response Chebyshev digital filters using impulse invariant and bilinear transformation techniques.
- To discuss direct, cascade, parallel and ladder methods of realizing a digital IIR filter.
- To discuss window functions used for the design of FIR filters.
- To discuss windowing technique of designing FIR filter.
- To discuss direct, cascade and linear phase form of realizing a digital FIR filter.
- To design infinite impulse response Butterworth digital filters using impulse invariant and bilinear transformation techniques.
- To design infinite impulse response Chebyshev digital filters using impulse invariant and bilinear transformation techniques.
- To discuss impulse invariant transformation, bilinear transformation techniques and their properties.
- To discuss frequency sampling technique of designing FIR filter.
- To discuss direct, cascade and linear phase form of realizing a digital FIR filter.

**Module-1**

**Discrete Fourier Transforms:** Definitions, properties-linearity, shift, symmetry, Properties - circular convolution – periodic convolution, use of tabular arrays, circular arrays, Stockham's method, linear convolution – two finite duration sequence, one finite & one infinite duration, overlap add and save methods.

Revised Bloom's Taxonomy Level

**Module-2**

**Fast Fourier Transforms Algorithms:** Introduction, decimation in time algorithm, first decomposition, number of computations, continuation of decomposition, number of multiplications, computational efficiency, decimation in frequency algorithms, Inverse radix – 2 algorithms.

Revised Bloom's Taxonomy Level

**Module-3**

**Design of IIR Digital Filters:** Introduction, impulse invariant transformation, bilinear transformations, All pole analog filters - Butterworth & Chebyshev filters, design of digital Butterworth filter by impulse invariant transformation and bilinear transformation, Frequency transformations.

Revised Bloom's Taxonomy Level

**Module-4**

**Design of IIR Digital Filters (Continued):** Design of digital Chebyshev – type filter by impulse invariant transformation and bilinear transformation, Frequency transformations.

**Realization of IIR digital systems:** direct form, cascade form and parallel form, Ladder structures for equal degree polynomial.

Revised Bloom's Taxonomy Level
B.E ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)
CHOICE BASED CREDIT SYSTEM (CBCS)
SEMESTER -VI

15EE63 DIGITAL SIGNAL PROCESSING (Core Subject)

Module-5

| Realization of FIR systems: direct form, cascade form, linear phase form |
| Teaching Hours |
| 10 |

Revised Bloom’s Taxonomy Level
L₁ – Remembering, L₂ – Understanding, L₃ – Applying, L₄ – Analysing, L₅ – Evaluating

Course outcomes:
At the end of the course the student will be able to:

- Compute the DFT of various signals using its properties and linear filtering of two sequences.
- Apply fast and efficient algorithms for computing DFT and inverse DFT of a given sequence.
- Design infinite impulse response Chebyshev digital filters using impulse invariant or bilinear transformation technique.
- Realize a digital IIR filter by direct, cascade, parallel and ladder methods of realization.
- Discuss different window functions and frequency sampling method used for design of FIR filters.
- Design FIR filters by use of window function or by frequency sampling method.
- Realize a digital FIR filter by direct, cascade, and linear phase form.

Graduate Attributes (As per NBA)
Engineering Knowledge, Problem analysis, Design/ Development of Solutions, Modern Tool Usage, Ethics,

Question paper pattern:
- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook

<table>
<thead>
<tr>
<th>Textbook</th>
<th>Author</th>
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</thead>
</table>

Reference Books
### Course Objectives:
- To discuss design factors, limitations in design and modern trends in design and manufacturing of electrical machines.
- To discuss the properties of electrical, magnetic and insulating materials used in the design of electrical machines.
- To derive the output equation of DC machine, single phase, three phase transformers, induction motor and synchronous machines.
- To discuss the selection of specific loadings, for various machines.
- To discuss separation of main dimensions for different electrical machines.
- To discuss design of field windings for DC machines and synchronous machines.
- To evaluate the performance parameters of transformer, induction motor.
- To discuss design factors, limitations in design and modern trends in design and manufacturing of electrical machines.
- To explain design of rotor of squirrel cage rotor and slip ring rotor.
- To define short circuit ratio and discuss its effect on machine performance.

### Module-1

**Fundamental Aspects of Electrical Machine Design:** Design of Machines, Design Factors, Limitations in design, Modern Trends in design, Manufacturing Techniques.


**Revised Bloom’s Taxonomy Level**

### Module-2


**Revised Bloom’s Taxonomy Level**

### Module-3

**Design of Transformers:** Output Equations of Single Phase and Three Phase Transformers, Choice of Specific Loadings, Expression for Volts/Turn, Determination of Main Dimensions of the Core, Estimation of Number of Turns and Conductor Cross Sectional area of Primary and Secondary Windings, No Load Current. Expression for the Leakage Reactance of core type transformer with concentric coils, and calculation of Voltage Regulation. Design of Tank and Cooling (Round and Rectangular) Tubes.

**Revised Bloom’s Taxonomy Level**

### Module-4


**Revised Bloom’s Taxonomy Level**
### Module-5


| Revised Bloom’s Taxonomy Level | L3 – Applying, L4 – Analysing, L2 – Understanding, L4 – Analysing. | 10 |

**Course outcomes**: At the end of the course the student will be able to:
- Discuss design factors, limitations, modern trends in design, manufacturing of electrical machines and properties of materials used in the electrical machines.
- Derive the output equations of transformer, DC machines and AC machines.
- Discuss selection of specific loadings and magnetic circuits of different electrical machines.
- Design the field windings of DC machine and Synchronous machine.
- Design stator and rotor circuits of a DC and AC machines.
- Estimate the number of cooling tubes, no load current and leakage reactance of core type transformer.
- Discuss short circuit ratio and its effects on performance of synchronous machines.
- Design salient pole and non-salient pole alternators for given specifications.

**Graduate Attributes (As per NBA)**
Engineering Knowledge, Problem Analysis, Design/Development of Solutions, Ethics

**Question paper pattern**:
- The question paper will have ten full questions carrying equal marks. Each full question consisting of 16 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook**

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<tbody>
<tr>
<td>1</td>
<td>Performance and Design of Alternating Current Machines</td>
<td>M.G.Say</td>
<td>CBS Publisher</td>
<td>3rd Edition, 2002</td>
</tr>
<tr>
<td>Subject Code</td>
<td>IA Marks</td>
<td>Total Number of Lecture Hours</td>
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<td>------------------</td>
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<tr>
<td>15EE651</td>
<td>20</td>
<td>40</td>
<td>80</td>
<td>03</td>
</tr>
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</table>

**Course objectives:**
- To discuss the terminology of DC and AC armature windings.
- To discuss design and procedure to draw armature winding diagrams for DC and AC machines.
- To discuss the substation equipment, their location in a substation and development of a layout for substation.
- To discuss different sectional views of transformers, DC machine, its parts and alternator and its parts.
- To explain development of sectional views of Transformers, DC machine and alternators using the design data, sketches.

**Suitable CAD software can be used for drawings**

### PART - A

**Module-1**

**Winding Diagrams:**
- (a) Developed Winding Diagrams of D.C. Machines: Simplex, Double Layer Lap and Wave Windings.
- (b) Developed Winding Diagrams of A.C. Machines:
- (c) Integral and Fractional Slot Double Layer Three Phase Lap and Wave Windings.
- (d) Single Layer Windings – Un-Bifurcated 2 and 3 Tier Windings, Mush Windings, Bifurcated 3 Tier Windings.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
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</table>

08

**Module-2**

**Single Line Diagrams:** Single line diagrams of generating stations and substations covering incoming circuits, outgoing circuits, busbar arrangements (single, sectionalised single, main and transfer, double bus double breaker, sectionalised double bus, one and a half circuit breaker arrangement, ring main), power transformers, circuit breakers, isolators, earthing switches, instrument transformers, surge or lightning arresters, communication devices (power-line carrier) and line trap.

<table>
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<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
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</table>

08

### PART - B

**Module-3**

**Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**
- Transformers - sectional views of single and three phase core and shell type transformers.

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<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
</tr>
</thead>
</table>

08

**Module-4**

**Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**
- D.C. Machine - sectional views of yoke with poles, armature and commutator dealt separately.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
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</thead>
</table>

08

**Module-5**

**Electrical Machine Assembly Drawings Using Design Data, Sketches or Both:**
- Alternator – sectional views of stator and rotor dealt separately.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
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</table>

08
Course Outcomes: At the end of the course the student will be able to:
- Discuss the terminology and types of DC and AC armature windings.
- Develop armature winding diagram for DC and AC machines.
- Develop a layout for substation using the standard symbols for substation equipment.
- Draw sectional views of core and shell types transformers using the design data.
- Draw sectional views of assembled DC machine or its parts using the design data or the sketches.
- Draw sectional views of assembled alternator or its parts using the design data or the sketches.

Graduate Attributes (As per NBA)
Engineering Knowledge, Problem Analysis, Modern tool usage, Ethics.

Question paper pattern:
- The question paper will have two parts, PART – A and PART – B.
- Each part is for 40 marks.
- Part A is for Modules 1 and 2.
- Questions 1 and 2 of PART - A will be only on DC windings or only on AC windings. Students have to answer any one of them. The marks prescribed is 25.
- Question 3 of PART – A covering module 2 is compulsory. The marks prescribed is 15.
- Part B is for Modules 3, 4 and 5.
- Questions 4 and 5 will cover any two modules of modules 3, 4 and 5. Students have to answer any one of them. The marks prescribed is 40.

Reference Books

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Author</th>
<th>Publisher</th>
<th>Edition Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A course in Electrical Machine design</td>
<td>A.K.Sawhney</td>
<td>DhanpatRai</td>
<td>6th, 2013</td>
</tr>
</tbody>
</table>
### Course Objectives:
- To study switching mode regulators and Boost converters, Resonant Pulse Inverters and multilevel inverters
- To learn the techniques for design and analysis of dc –dc converters, Resonant Pulse Inverters and multilevel inverters
- To explain the operation and frequency characteristics of resonant inverters and the techniques for zero-voltage zero-current switching.
- To study the performance parameters of resonant inverters
- To explain the techniques for analyzing and design of resonant inverters
- To explain the operation and features of multilevel inverters, their advantages and disadvantages.
- To explain the control strategy to address capacitor voltage unbalancing.
- To discuss potential applications of multilevel inverters.
- To study the types and circuit topologies of power supplies and explain the operation and analysis of power supplies.
- To study the applications of power electronic devices.

### Module 1: DC–DC Converters
- **Teaching Hours:** 08

  **Revised Bloom’s Taxonomy Level:**
  - L1 – Remembering
  - L2 – Understanding
  - L4 – Analysing

### Module 2: Resonant Pulse Inverters
- **Teaching Hours:** 08

  **Revised Bloom’s Taxonomy Level:**
  - L1 – Remembering
  - L2 – Understanding
  - L4 – Analysing

### Module 3: Multilevel Inverters
- **Teaching Hours:** 08

  **Revised Bloom’s Taxonomy Level:**
  - L1 – Remembering
  - L2 – Understanding
  - L4 – Analysing

### Module 4: Power Supplies
- **Teaching Hours:** 08

  **Revised Bloom’s Taxonomy Level:**
  - L1 – Remembering
  - L2 – Understanding
  - L4 – Analysing
### Module-5

**Residential and Industrial Applications:** Introduction, Residential Applications, Industrial Applications.

**Electrical Utility Applications:** Introduction, High Voltage DC Transmission, Static VAR Compensators, Interconnection of Renewable Energy Sources and Energy Storage systems to the Utility Grid, Active Filters.

### Revised Bloom's Taxonomy Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Remembering</td>
</tr>
<tr>
<td>L2</td>
<td>Understanding</td>
</tr>
<tr>
<td>L4</td>
<td>Analysing</td>
</tr>
</tbody>
</table>

### Course outcomes:

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

- Explain the types of switching – mode regulators, Resonant Pulse Inverters and multilevel inverters
- To discuss the techniques for design and analysis of dc-dc converters, Resonant Pulse Inverters and multilevel inverters
- Evaluate the performance parameters of resonant inverters
- Explain the techniques for zero-voltage and zero-current switching of resonant pulse inverters
- Explain the control strategy to address capacitor voltage unbalancing in multilevel inverters.
- Discuss the types, topologies operation and analysis of power supplies.
- Discuss residential, Industrial and Electrical utility applications of power electronic devices.

### Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis Design/ Development of Solutions, Conduct investigations of complex problems, Ethics

### Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

### Textbook

<table>
<thead>
<tr>
<th>Module</th>
<th>Title</th>
<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
</tr>
</thead>
</table>

### Reference Books

<table>
<thead>
<tr>
<th>Module</th>
<th>Title</th>
<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
</tr>
</thead>
</table>
### Course objectives:
- To explain the importance of energy audit, its types and energy audit methodology.
- To explain the parameters required for energy audit and the working of the instruments used in the measurement of the parameters.
- To explain the energy audit of different systems and equipment and buildings.
- To explain electrical load management techniques, harmonics and their effects, electricity tariffs and power factor improvement.
- To explain the scope of demand side management, its concept and implementation issues and strategies.
- To discuss energy conservation.

<table>
<thead>
<tr>
<th>Module</th>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module-1</td>
<td>08</td>
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<tr>
<td>Revised Bloom’s Taxonomy Level</td>
<td>L1 - Remembering, L2 - Understanding, L3 - Applying, L4 - Analysing.</td>
</tr>
<tr>
<td>Module-2</td>
<td>08</td>
</tr>
<tr>
<td>Energy Audit of Boilers: Classification of Boilers, Parts of Boiler, Efficiency of a Boiler, Role of excess Air in Boiler Efficiency, Energy Saving Methods.</td>
<td></td>
</tr>
<tr>
<td>Revised Bloom’s Taxonomy Level</td>
<td>L1 - Remembering, L2 - Understanding, L3 - Applying, L4 - Analysing.</td>
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<tr>
<td>Module-3</td>
<td>08</td>
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<td>Revised Bloom’s Taxonomy Level</td>
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</tr>
<tr>
<td>Module-4</td>
<td>08</td>
</tr>
<tr>
<td>Energy Audit of Motors: Classification of Motors, Parameters related to Motors, Efficiency of a Motor, Energy Conservation in Motors, BEE Star Rating and Labelling.</td>
<td></td>
</tr>
<tr>
<td>Revised Bloom’s Taxonomy Level</td>
<td>L1 - Remembering, L2 - Understanding, L3 - Applying, L4 - Analysing.</td>
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</table>
### Course Information

**Module-5**

<table>
<thead>
<tr>
<th>Energy Audit Applied to Buildings:</th>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy – Saving Measures in New Buildings, Water Audit, Method of Audit, General Energy – Savings Tips Applicable to New as well as Existing Buildings.</td>
<td>08</td>
</tr>
</tbody>
</table>

**Demand side Management:** Scope of DSM, Evolution of DSM concept, DSM planning and Implementation, Load management as a DSM strategy, Applications of Load Control, End use energy conservation, Tariff options for DSM, customer acceptance, implementation issues, Implementation strategies, DSM and Environment.


### Course outcomes:

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

- Understand the need of energy audit and energy audit methodology.
- Explain audit parameters and working principles of measuring instruments used to measure the parameters.
- Conduct energy audit of boilers, furnaces, power plant, steam distribution system and compressed air systems.
- Conduct energy audit HVAC systems, motors, pumps, blowers and cooling towers.
- Explain load management techniques, effects of harmonics, electricity tariff, improvement of power factor and losses in transmission.
- Conduct energy audit of lighting systems and buildings.
- Show an understanding of demand side management and energy conservation.

### Graduate Attributes (As per NBA)

- Engineering Knowledge
- Problem Analysis
- Conduct investigations of complex Problems
- Environment and sustainability
- Ethics
- Individual and Team work
- Communication

### Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

### Textbook

1. **Handbook on Energy Audit**  
   Sonal Desai  
   McGraw Hill  

2. **Generation of Electrical Energy**  
   B R Gupta  
   S. Chand  
### Course Objectives:

- To discuss the importance of energy in human life, relationship among economy and environment with energy use.
- To discuss the increasing role of renewable energy, energy management, energy audit, energy efficiency, energy intensity.
- To discuss energy consumption status in India, energy saving potential and energy conservation efforts in India.
- To explain the concept of energy storage and the principles of energy storage devices.
- To discuss the characteristics and distribution of solar radiation, measurement of components of solar radiation and analysis of collected solar radiation data.
- To explain availability of solar radiation at a location and the effect of tilting the surface of collector with respect to horizontal surface.
- To describe the process of harnessing solar energy in the form of heat and working of solar collectors.
- To discuss applications of solar energy including heating and cooling.
- To discuss the operation of solar cell and the environmental effects on electrical characteristics of solar cell.
- To discuss sizing and design of typical solar PV systems and their applications.
- To discuss basic Principles of Wind Energy Conversion and to compute the power available in the wind.
- To discuss forces on the Blades, Wind Energy Conversion, collection of Wind Data, energy estimation and site selection.
- To discuss classification of WECS Systems, its advantages and disadvantages of WECS, and Types of Wind Machines (Wind Energy Collectors).
- To evaluate the performance of Wind-machines, Generating Systems.
- To discuss energy storage, applications of Wind Energy and Environmental Aspects.

### Module-1


**Revised Bloom’s Taxonomy Level**


### Module-2


**Revised Bloom’s Taxonomy Level**

### Module-3


<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁ – Remembering, L₂ – Understanding, L₃ – Applying, L₄ – Analysing.</td>
<td>08</td>
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</tbody>
</table>

### Module-4


**Wind Energy Systems:** Environment and Economics Environmental benefits and problems of wind energy, Economics of wind energy, Factors influence the cost of energy generation, machine parameters, Life cycle cost analysis.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁ – Remembering, L₂ – Understanding, L₃ – Applying, L₄ – Analysing.</td>
<td>08</td>
</tr>
</tbody>
</table>

### Module-5

**Basic Components of a Wind Energy Conversion (WEC) System:** Classification of WEC systems, Advantages and Disadvantages of WECs, Types of Wind Machines (Wind Energy Collectors), Analysis of Aerodynamic Forces Acting on the Blade, Performance of Wind-machines, Generating Systems, Energy Storage, Applications of Wind Energy, Environmental Aspects.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>L₁ – Remembering, L₂ – Understanding, L₃ – Applying.</td>
<td>08</td>
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</tbody>
</table>

### Course Outcomes:

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

- Discuss the importance of energy in human life, relationship among economy and environment with energy use and the increasing role of renewable energy.
- Explain the concept of energy storage and the principles of energy storage devices.
- To discuss solar radiation on horizontal and tilted surface, its characteristics, measurement and analysis of radiation data.
- Describe the process of harnassing solar energy and its applications in heating and cooling.
- Discuss fabrication, operation of solar cell, electrical characteristics, sizing and design of solar PV systems and their applications.
- Explain basic Principles of Wind Energy Conversion, collection of wind data, energy estimation and site selection.
- Discuss the performance of Wind-machines, energy storage, applications of Wind Energy and environmental aspects.

### Graduate Attributes (As per NBA)


### Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.
|----------|-----------------------------------|------------|-------------|------------------|

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<td>IA Marks</td>
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<td>Exam Hours</td>
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<td>Total Number of Lecture Hours</td>
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<td>Exam Marks</td>
<td>80</td>
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</table>

**Credits - 03**

**Course objectives:**
- To expose the students to the concepts of feed forward neural networks.
- To provide adequate knowledge about feedback networks.
- To teach about the concept of fuzziness involved in various systems.
- To provide adequate knowledge about fuzzy set theory.

### Module-1

**Fundamentals of Neural Networks:** Basic concepts of Neural networks, Human Brain, Model of an Artificial Neuron, Neural network architectures, Characteristics of Neural Networks, Learning methods, Taxonomy of Neural Network Architectures, Early Neural Network Architectures.

**Backpropagation Networks:** Architecture of a Back propagation network, the Perceptron Model, The solution, Single layer Artificial Neural Network, Model for Multilayer Perceptron, Backpropagation Learning, Illustration, Applications.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying.</th>
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<tbody>
<tr>
<td>Teaching Hours</td>
<td>08</td>
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</table>

### Module-2

**Backpropagation Networks (continued):** Effect of Tuning Parameters of the Backpropagation Neural Network, Selection of Various Parameters in BPN, Variations of Standard Backpropagation Algorithm.

**Associative Memory:** Autocorrelators, Heterocorrelators: Kosko’s Discrete BAM, Wang et al.’s Multiple Training Encoding Strategy, Exponential BAM, Associative Memory for Real-coded Pattern Pairs, Applications, Recent Trends.

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<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
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<tbody>
<tr>
<td>Teaching Hours</td>
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</table>

### Module-3

**Adaptive Resonance Theory:** Introduction, ART 1, ART 2, Applications, Sensitivities of Ordering of Data.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying.</th>
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<tbody>
<tr>
<td>Teaching Hours</td>
<td>08</td>
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</table>

### Module-4

**Fuzzy Set Theory:** Fuzzy versus Crisp, Crisp sets, Fuzzy Sets, Crisp Relations, Fuzzy Relations.

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<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying.</th>
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<tbody>
<tr>
<td>Teaching Hours</td>
<td>08</td>
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</table>

### Module-5

**Fuzzy Logic And Inference:** Crisp Logic, Predicate Logic, Fuzzy Logic, Fuzzy Rule based System, Defuzzification Methods, Applications.

**Type – 2 Fuzzy Sets:** Representation of Type – 2 Fuzzy Sets, Operations on Type – 2 Fuzzy Sets, Interval Type – 2 Fuzzy Sets.

<table>
<thead>
<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding, L₃ – Applying.</th>
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</thead>
<tbody>
<tr>
<td>Teaching Hours</td>
<td>08</td>
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</tbody>
</table>
Course outcomes:
At the end of the course the student will be able to:
- Show an understanding of Organization of the Brain, Biological and Artificial Neuron Models
- Show an understanding of Backpropagation network architecture, Perceptron Model, Single layer Artificial Neural Network, Model for Multilayer Perceptron, Backpropagation Learning,
- Show an understanding of Backpropagation training and summary of Backpropagation Algorithm
- Show an understanding of Bidirectional Associative Memory (BAM) Architecture
- Show an understanding of adaptive resonance theory architecture and its applications
- Differentiate between crisp logic, predicate logic and fuzzy logic.
- Explain fuzzy rule based system
- Show an understanding of Defuzzification methods.

Graduate Attributes (As per NBA)
Engineering Knowledge

Question paper pattern:
- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook

Reference Books
4. Introduction to Neural Networks using MATLAB 6.0 S.N.Sivanandam, S. Sumathi, S.N. Deepa Tata McGrow Hills Education India 2005
## Course objectives:
- To discuss need of transducers, their classification, advantages and disadvantages.
- To discuss working of different types of transducers and sensors.
- To discuss recent trends in sensor technology and their selection.
- To discuss basics of signal conditioning and signal conditioning equipment.
- To discuss configuration of Data Acquisition System and data conversion.
- To discuss the basics of Data transmission and telemetry.
- To explain measurement of various non-electrical quantities.

### Module-1

<table>
<thead>
<tr>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensors and Transducers:</strong> Introduction, Classification of Transducers, Advantages and Disadvantages of Electrical Transducers, Transducers Actuating Mechanisms, Resistance Transducers, Variable Inductance Transducers, Capacitive Transducers, Piezoelectric Transducers, Hall Effect Transducers, Thermoelectric Transducers, Photoelectric Transducers.</td>
</tr>
<tr>
<td><strong>Revised Bloom’s Taxonomy Level</strong></td>
</tr>
</tbody>
</table>

### Module-2

<table>
<thead>
<tr>
<th>Teaching Hours</th>
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<tbody>
<tr>
<td><strong>Revised Bloom’s Taxonomy Level</strong></td>
</tr>
</tbody>
</table>

### Module-3

<table>
<thead>
<tr>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Signal Condition:</strong> Introduction, Functions of Signal Conditioning Equipment, Amplification, Types of Amplifiers, Mechanical Amplifiers Fluid Amplifiers, Optical Amplifiers, Electrical and electronic Amplifiers.</td>
</tr>
<tr>
<td><strong>Data Acquisition Systems and Conversion:</strong> Introduction, Objectives and Configuration of Data Acquisition System, Data Acquisition Systems, Data Conversion.</td>
</tr>
<tr>
<td><strong>Revised Bloom’s Taxonomy Level</strong></td>
</tr>
</tbody>
</table>

### Module-4

<table>
<thead>
<tr>
<th>Teaching Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Transmission and Telemetry:</strong> Data/Signal Transmission, Telemetry.</td>
</tr>
<tr>
<td><strong>Measurement of Non – Electrical Quantities:</strong> Pressure Measurement</td>
</tr>
<tr>
<td><strong>Revised Bloom’s Taxonomy Level</strong></td>
</tr>
</tbody>
</table>

### Module-5

<table>
<thead>
<tr>
<th>Teaching Hours</th>
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</thead>
<tbody>
<tr>
<td><strong>Revised Bloom’s Taxonomy Level</strong></td>
</tr>
</tbody>
</table>
Course outcomes:
At the end of the course the student will be able to:
- Discuss need of transducers, their classification, advantages and disadvantages.
- Show an understanding of working of various transducers and sensors.
- Discuss recent trends in sensor technology and their selection.
- Discuss basics of signal conditioning and signal conditioning equipment.
- Discuss configuration of Data Acquisition System and data conversion.
- Show knowledge of data transmission and telemetry.
- Explain measurement of non-electrical quantities - temperature, flow, speed, force, torque, power and viscosity.

Graduate Attributes (As per NBA)
Engineering Knowledge

Question paper pattern:
- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbook

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
<th>Year</th>
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Reference Books

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<th></th>
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<th>Author</th>
<th>Publisher</th>
<th>Edition</th>
<th>Year</th>
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<tbody>
<tr>
<td>2</td>
<td>A Course in Electrical and Electronic Measurements and Instrumentation</td>
<td>A. K. Sawhney</td>
<td>DhanpatRai</td>
<td>2015</td>
<td></td>
</tr>
</tbody>
</table>
Course objectives:
- To discuss the current status of various rechargeable batteries and fuel cells for various applications.
- To discuss the performance capabilities and limitations of batteries and fuel cells.
- To discuss the performance requirements for next-generation high-power rechargeable lithium-based batteries and sealed nickel-cadmium and lead-acid batteries.
- To discuss fuel cells that are best suited for applications where electrical power requirements vary between several kilowatts (kW) to a few megawatts (MW).
- To describe the high-power batteries currently used by EVs and HEVs and various next-generation rechargeable batteries best suited for all-electric cars, EVs, and HEVs.
- To discuss low-power battery configurations that are best suited for compact commercial, industrial, and medical applications.
- To identify the design aspects and performance characteristics of micro- and nano-batteries best suited for detection, sensing, and monitoring devices.

Module 1


Module 2


Module 3


Module 4

## Module-4
**Batteries for Electric and Hybrid Vehicles (continued):** Developed Earlier by Various Companies and Their Performance Specifications, Development History of the Latest Electric and Hybrid Electric Vehicle Types and Their Performance Capabilities and Limitations, Performance Requirements of Various Rechargeable Batteries, Materials for Rechargeable Batteries, Critical Role of Rare Earth Materials in the Development of EVs and HEVs.

### Revised Bloom’s Taxonomy Level
| L₁ – Remembering, L₂ – Understanding. |

## Module-5
**Low-Power Rechargeable Batteries for Commercial, Space, and Medical Applications:** Introduction, Low-Power Battery Configurations, Characteristics, Batteries for Miniaturized Electronic System Applications, for Embedded-System Applications, Batteries for Medical Applications, Selection Criteria for Primary and Secondary (Rechargeable) Batteries for Specific Applications.

### Revised Bloom’s Taxonomy Level
| L₁ – Remembering, L₂ – Understanding. |

### Course outcomes:
At the end of the course the student will be able to:
- Discuss the current status, the performance capabilities and limitations of rechargeable batteries and fuel cells for various applications.
- To discuss the performance requirements for next-generation high-power rechargeable lithium-based batteries and sealed nickel-cadmium and lead-acid batteries.
- Discuss fuel cells that are best suited for applications where electrical power requirements vary between several kilowatts (KW) to a few megawatts (MW).
- Describe the high-power batteries currently used by EVs and HEVs and various next-generation rechargeable batteries best suited for all-electric cars, EVs, and HEVs.
- Discuss low-power battery configurations that are best suited for compact commercial, industrial, and medical applications.
- Explain the design aspects and performance characteristics of micro- and nano-batteries best suited for detection, sensing, and monitoring devices.

### Graduate Attributes (As per NBA)
**Engineering Knowledge**

### Question paper pattern:
- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

### Textbook

### Reference Books
### Course Objectives:

- To explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- To discuss system analogs and vectors, with a review of differential equations.
- To discuss the concept of transfer functions for the representation of differential equations.
- To discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- To represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.
- To determine the frequency response techniques for proper servo compensation.
- To explain performance indices and performance criteria for servo systems.
- To discuss the mechanical considerations of servo systems.

### Module 1


**Module 2**

**Machine Servo Drives:** Types of Drives, Feed Drive Performance.

**Troubleshooting Techniques:** Techniques by Drive, Problems: Their Causes and Cures.

**Machine Feed Drives:** Advances in Technology, Parameters for making Application Choices.


**Module 3**

**Generalized Control Theory:** Servo Block Diagrams, Frequency-Response Characteristics and Construction of Approximate (Bode) Frequency Charts, Nichols Charts, Servo Analysis Techniques, Servo Compensation.

**Indexes of Performance:** Definition of Indexes of Performance for Servo Drives, Indexes of Performance for Electric and Hydraulic Drives.

**Module 4**

**Performance Criteria:** Percent Regulation, Servo System Responses.

**Servo Plant Compensation Techniques:** Dead-Zone Nonlinearity, Change-in-Gain Nonlinearity, Structural Resonances, Frequency Selective Feedback, Feedforward Control.

**Machine Considerations:** Machine feed drive Considerations, Ball Screw Mechanical Resonances and Reflected Inertias for Machine Drives.
### Module-5

<table>
<thead>
<tr>
<th>Machine Considerations: Drive Stiffness, Drive Resolution, Drive Acceleration, Drive Speed Considerations, Drive Ratio Considerations, Drive Thrust/Torque And Friction Considerations, Drive Duty Cycles</th>
<th>Teaching Hours</th>
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<tbody>
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<tr>
<th>Revised Bloom’s Taxonomy Level</th>
<th>L₁ – Remembering, L₂ – Understanding</th>
</tr>
</thead>
</table>

### Course outcomes:

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

- Explain the evolution and classification of servos, with descriptions of servo drive actuators, amplifiers, feedback transducers, performance, and troubleshooting techniques.
- Discuss system analogs and vectors, with a review of differential equations.
- Discuss the concept of transfer functions for the representation of differential equations.
- Discuss mathematical equations for electric servo motors, both DC and brushless DC servo motors.
- Represent servo drive components by their transfer function, to combine the servo drive building blocks into system block diagrams.
- Determine the frequency response techniques for proper servo compensation.
- Explain perform indices and performance criteria for servo systems.
- Discuss the mechanical considerations of servo systems.

### Graduate Attributes (As per NBA)

Engineering Knowledge

### Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 16 marks.
- There will be 2 full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

### Text Book


### Reference Books

Course objectives:

- To determine the time and frequency domain responses of a given second order system using software package or discrete components.
- To design and analyze Lead, Lag and Lag – Lead compensators for given specifications.
- To draw the performance characteristics of ac and dc servomotors and synchro-transmitter receiver pair.
- To simulate the DC position and feedback control system to study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
- To write a script file to plot root locus, Bode plot, Nyquist plots to study the stability of the system using a software package.

Experiments

1. Experiment to draw the speed torque characteristics of (i) AC servo motor (ii) DC servo motor
2. Experiment to draw synchro pair characteristics
3. Experiment to determine frequency response of a second order system
4. (a) To design a passive RC lead compensating network for the given specifications, viz, the maximum phase lead and the frequency at which it occurs and to obtain the frequency response.
   (b) To determine experimentally the transfer function of the lead compensating network.
5. (a) To design a passive RC lag compensating network for the given specifications, viz, the maximum phase lag and the frequency at which it occurs and to obtain the frequency response.
   (b) To determine experimentally the transfer function of the lag compensating network.
6. Experiment to draw the frequency response characteristics of the lag – lead compensator network and determination of its transfer function.
   Experiments 7 to 11 must be done using MATLAB/SCILAB only.
7. (a) To simulate a typical second order system and determine step response and evaluate time response specifications.
   (b) To evaluate the effect of additional poles and zeros on time response of second order system.
   (c) To evaluate the effect of pole location on stability.
   (d) To evaluate the effect of loop gain of a negative feedback system on stability.
8. To simulate a second order system and study the effect of (a) P, (b) PI, (c) PD and (d) PID controller on the step response.
9. (a) To simulate a D.C. Position control system and obtain its step response.
   (b) To verify the effect of input waveform, loop gain and system type on steady state errors.
   (c) To perform trade-off study for lead compensator.
   (d) To design PI controller and study its effect on steady state error.
10. (a) To examine the relationship between open-loop frequency response and stability, open-loop frequency and closed loop transient response.
    (b) To study the effect of open loop gain on transient response of closed loop system using root locus.
11. (a) To study the effect of open loop poles and zeros on root locus contour.
    (b) To estimate the effect of open loop gain on the transient response of closed loop system using root locus.
    (c) Comparative study of Bode, Nyquist and root locus with respect to stability.

### Course outcomes:
At the end of the course the student will be able to:

- Use software package or discrete components in assessing the time and frequency domain responses of a given second order system.
- Design and analyze Lead, Lag and Lag – Lead compensators for given specifications.
- Determine the performance characteristics of ac and dc servomotors and synchro-transmitter receiver pair used in control systems.
- Simulate the DC position and feedback control systems to study the effect of P, PI, PD and PID controller and Lead compensator on the step response of the system.
- Write a script files to plot root locus, Bode plot, Nyquist plots to study the stability of the system using a software package.
- Work with a small team to carryout experiments and prepare reports that present lab work.

### Graduate Attributes (As per NBA)
Engineering Knowledge, Problem Analysis, Individual and Team work, Modern tool usage, Communication.

### Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.
Course objectives:

- To explain the use of MATLAB software in evaluating the DFT and IDFT of given sequence.
- To verify the convolution property of the DFT.
- To design and implementation of IIR and FIR filters for given frequency specifications.
- To realize IIR and FIR filters.
- To help the students in developing software skills.

Course outcomes:

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

- Give physical interpretation of sampling theorem in time and frequency domains.
- Evaluate the impulse response of a system.
- Perform convolution of given sequences to evaluate the response of a system.
- Compute DFT and IDFT of a given sequence using the basic definition and/or fast methods.
- Provide a solution for a given difference equation.
- Design and implement IIR and FIR filters.
- Conduct experiments using software and prepare reports that present lab work.

Graduate Attributes (As per NBA)

Engineering Knowledge, Problem Analysis, Individual and Team work, Communication.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.