REGULATIONS - 2015

DEPARTMENT OF
ELECTRICAL AND ELECTRONICS ENGINEERING

CURRICULUM AND SYLLABI OF
M.E. – HIGH VOLTAGE ENGINEERING
## SEMESTER – I

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>SFC 15HE11C</td>
<td>Higher Engineering Mathematics®</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>PCC 15HE12C</td>
<td>Field Computation and Modeling of Electromagnetic Devices</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>PCC 15HE13C</td>
<td>Elements of High Voltage Engineering</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>PCC 15HE14C</td>
<td>Dielectric Engineering</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>PCC 15HE15C</td>
<td>High Voltage Equipments</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>PEC</td>
<td>Elective-I</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### THEORY COURSES

### PRACTICAL COURSES

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>PCC 15HE16C</td>
<td>High Voltage Laboratory-I</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total 18 4 4 22**

## SEMESTER – II

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PCC 15HE21C</td>
<td>Electrical Power System Transients</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>PCC 15HE22C</td>
<td>High Voltage Protection and Switchgear</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>PCC 15HE23C</td>
<td>Design of Insulations for High Voltage Equipments</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>PCC 15HE24C</td>
<td>Extra High Voltage Power Transmission</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>PEC</td>
<td>Elective-II</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### THEORY COURSES

### PRACTICAL COURSES

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td>PCC 15HE25C</td>
<td>High Voltage Laboratory-II</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>PCC 15HE26C</td>
<td>Research Paper and Patent Review – Seminar</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total 15 4 8 21**
### SEMESTER – III

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern&lt;sup&gt;⊕&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>THEORY COURSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>PEC</td>
<td></td>
<td>Elective-III</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>PEC</td>
<td></td>
<td>Elective-IV</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>PEC</td>
<td></td>
<td>Elective-V</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>OEC</td>
<td></td>
<td>Elective-VI</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>PRACTICAL COURSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>PCC</td>
<td>15HE31C</td>
<td>Project Work Phase-I</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td>12</td>
<td>0</td>
<td>12</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

SFC - Special Foundation Course, PCC – Programme Core Course, PEC – Programme Elective Course, OEC – Open Elective Course

*Common to CS, HVE and C&I, @ Common to HVE and C&I, £ Common to C&N and HVE

### SEMESTER – IV

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern&lt;sup&gt;⊕&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>PRACTICAL COURSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>PCC</td>
<td>15HE41C</td>
<td>Project Work Phase-II</td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>TOTAL</strong></td>
<td>0</td>
<td>0</td>
<td>24</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
### PROGRAMME ELECTIVE COURSES

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PEC</td>
<td>15HE01E</td>
<td>Electromagnetic Interference and Electromagnetic Compatibility</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>2.</td>
<td>PEC</td>
<td>15HE02E</td>
<td>Pulse Power Engineering</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>3.</td>
<td>PEC</td>
<td>15HE03E</td>
<td>Advanced Electromagnetic Fields</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>4.</td>
<td>PEC</td>
<td>15HE04E</td>
<td>Pollution Performance of Power Apparatus and Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>5.</td>
<td>PEC</td>
<td>15HE05E</td>
<td>High Voltage Direct Current Transmission</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>6.</td>
<td>PEC</td>
<td>15HE06E</td>
<td>Collision Phenomenon</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>7.</td>
<td>PEC</td>
<td>15HE07E</td>
<td>Advanced Topics in High Voltage Engineering</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>8.</td>
<td>PEC</td>
<td>15HE08E</td>
<td>High Voltage Fields</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>9.</td>
<td>PEC</td>
<td>15HE09E</td>
<td>Flexible AC Transmission Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>10.</td>
<td>PEC</td>
<td>15HE10E</td>
<td>Power Quality</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>11.</td>
<td>PEC</td>
<td>15HE11E</td>
<td>Restructured Power Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>12.</td>
<td>PEC</td>
<td>15HE12E</td>
<td>Power System Planning and Reliability</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>13.</td>
<td>PEC</td>
<td>15HE13E</td>
<td>Power System Analysis</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>14.</td>
<td>PEC</td>
<td>15HE14E</td>
<td>Power System Operation and Control</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>15.</td>
<td>PEC</td>
<td>15HE15E</td>
<td>Reactive Power Compensation and Management</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>16.</td>
<td>PEC</td>
<td>15HE16E</td>
<td>Power Electronics for Renewable Energy Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>17.</td>
<td>PEC</td>
<td>15HE17E</td>
<td>Modern Rectifiers and resonant Converters</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>18.</td>
<td>PEC</td>
<td>15HE18E</td>
<td>Analysis of Power Converters</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>19.</td>
<td>PEC</td>
<td>15HE19E</td>
<td>Power Electronics in Power Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>20.</td>
<td>PEC</td>
<td>15HE20E</td>
<td>Control of Electric Drives</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>21.</td>
<td>PEC</td>
<td>15HE21E</td>
<td>Computer Aided Design of Power Electronics Circuits</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>22.</td>
<td>PEC</td>
<td>15HE22E</td>
<td>Advanced Electrical Drives</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>23.</td>
<td>PEC</td>
<td>15HE23E</td>
<td>Soft Computing Techniques®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>24.</td>
<td>PEC</td>
<td>15HE24E</td>
<td>Advanced Digital Signal Processing*</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>25.</td>
<td>PEC</td>
<td>15HE25E</td>
<td>Evolutionary Computing®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>26.</td>
<td>PEC</td>
<td>15HE26E</td>
<td>Advanced Digital System Design®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>27.</td>
<td>PEC</td>
<td>15HE27E</td>
<td>Design of Embedded Systems®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>28.</td>
<td>PEC</td>
<td>15HE28E</td>
<td>Applications of MEMS Technology</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>29.</td>
<td>PEC</td>
<td>15HE29E</td>
<td>Microcontroller and DSP based System Design</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>30.</td>
<td>PEC</td>
<td>15HE30E</td>
<td>Optimization Techniques</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>31.</td>
<td>PEC</td>
<td>15HE31E</td>
<td>Wind Energy Conversion Systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>32.</td>
<td>PEC</td>
<td>15HE32E</td>
<td>Energy management</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>33.</td>
<td>PEC</td>
<td>15HE33E</td>
<td>Fundamentals of Nano Technology</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>34.</td>
<td>PEC</td>
<td>15HE34E</td>
<td>System Theory®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
<tr>
<td>35.</td>
<td>PEC</td>
<td>15HE35E</td>
<td>PC based Instrumentation System Design®</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
</tr>
</tbody>
</table>

SFC - Special Foundation Course, PCC – Programme Core Course, PEC – Programme Elective Course, OEC – Open Elective Course

*Common to CS, HVE and C&I, @ Common to HVE and C&I, £ Common to C&N and HVE
<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>C</th>
<th>Question pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>36.</td>
<td>PEC 15HE36E</td>
<td>Analysis of Electrical Machines</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>37.</td>
<td>PEC 15HE37E</td>
<td>Special Electrical Machines</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>38.</td>
<td>PEC 15HE38E</td>
<td>Condition Monitoring of High Voltage Power Apparatus</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>39.</td>
<td>OEC</td>
<td>Courses offered by other PG programmes</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question pattern</th>
<th>1 mark</th>
<th>2 marks</th>
<th>4 marks</th>
<th>10 marks</th>
<th>12 marks</th>
<th>16 marks</th>
<th>20 marks</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 Qn Compulsory &amp; 4 Qns (either or type)</td>
<td>100</td>
</tr>
<tr>
<td>C</td>
<td>10</td>
<td>-</td>
<td>10 out of 12</td>
<td>1 Qn Compulsory &amp; 4 Qns (either or type)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>D</td>
<td>10</td>
<td>10</td>
<td>5 out of 6</td>
<td>1 Qn Compulsory &amp; 4 Qns (either or type)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100</td>
</tr>
<tr>
<td>E</td>
<td>-</td>
<td>10</td>
<td>5 out of 6</td>
<td>1 Qn Compulsory &amp; 4 Qns (either or type)</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>100</td>
</tr>
</tbody>
</table>
FORMAT FOR COURSE CODE

1 5  H  E  2 3  C

- Compulsory Course
- Course Sequence Number
- Semester Number
- Specialization Name
- Year of Regulation

1 5  H  E  0 1  E

- Elective Course
- Course Sequence Number
- Specialization Name
- Year of Regulation
15HE11C  HIGHER ENGINEERING MATHEMATICS  
(Common to HVE and C&I)  
L T P C  
3 2 0 4  

COURSE OUTCOMES  
Upon completion of this course, the students will be able to  
CO 1 : learn the concepts of matrix theory. (K1)  
CO 2 : understand simplex method, two phase method and graphical solution in linear programming. (K2)  
CO 3 : learn moment generating functions and one dimensional random variables. (K1)  
CO 4 : understand queueing models and computation methods in engineering. (K2)  

UNIT I  ADVANCED MATRIX THEORY  

UNIT II  LINEAR PROGRAMMING  

UNIT III  ONE DIMENSIONAL RANDOM VARIABLES  
Random variables - Probability function – moments – moment generating functions and their properties – Binomial, Poisson, Geometric, Uniform, Exponential, Gamma and Normal distributions.  

UNIT IV  QUEUEING MODELS  

UNIT V  COMPUTATIONAL METHODS IN ENGINEERING  

REFERENCES  
15HE12C  FIELD COMPUTATION AND MODELING OF ELECTROMAGNETIC DEVICES

L T P C
3 2 0 4

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: recall the basic concepts in electric and magnetic fields. (K1)
CO 2: choose the new techniques to find the solutions of electro static boundary value problems. (K6)
CO 3: improve the new techniques to achieve the accurate results. (K6)
CO 4: determine and find the various parameters of field configurations. (K5)
CO 5: model the various electrical apparatus. (K3)

UNIT I INTRODUCTION

UNIT II SOLUTIONS OF FIELD EQUATIONS I
Limitations of the conventional design procedure need for the field analysis based design – Problem definition and solution by analytical methods - Direct integration method – Variable separable method – Method of images – Solution by numerical methods – Finite Difference Method.

UNIT III SOLUTIONS OF FIELD EQUATIONS II

UNIT IV FIELD COMPUTATION FOR BASIC CONFIGURATIONS
Computation of electric and magnetic field intensities – Capacitance and Inductance – Force, Torque, Energy for basic configurations.

UNIT V DESIGN APPLICATIONS
Insulators- Bushings – Cylindrical magnetic actuators – Transformers – Rotating machines.

L: 45 T: 30 TOTAL: 75 PERIODS

REFERENCES
5. User manuals of MAGNET, MAXWELL & ANSYS software.
COURSE OUTCOMES

Upon completion of this course, the students will be able to
CO 1: identify the various methods for generation of HVAC. (K3)
CO 2: appraise the various types for generation of HVDC. (K5)
CO 3: design the generator circuits for impulse voltage and current. (K6)
CO 4: identify the suitable measurement techniques of HVAC, HVDC and impulse voltages and currents. (K3)
CO 5: coordinate the various standards for testing of HV equipments. (S4)

UNIT I GENERATION OF HIGH AC VOLTAGES

UNIT II GENERATION OF HIGH DC VOLTAGES

UNIT III GENERATION OF IMPULSE VOLTAGES AND CURRENTS

UNIT IV MEASUREMENT OF HIGH VOLTAGES AND CURRENTS

UNIT V HIGH VOLTAGE TESTING METHODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, students will be able to
CO 1: summarize the general properties of dielectric materials (K2)
CO 2: select the different dielectric materials in electrical equipments applications (K5)
CO 3: dissect the different breakdown mechanism in gaseous dielectrics (K4)
CO 4: perceive the various breakdown mechanisms in solid dielectrics (K5)
CO 5: appraise the conduction and breakdown mechanism in liquid dielectrics (K5)

UNIT I  INTRODUCTION 9

UNIT II  DIELECTRIC MATERIALS 9
Classification based on insulating materials and application – Application of insulating materials in transformers, rotating machines, circuit breakers, cables, power capacitors and bushings.

UNIT III  BREAKDOWN IN GASES AND VACCUM 9

UNIT IV  BREAKDOWN IN SOLIDS 9
Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown – Chemical and electrochemical deterioration – Breakdown due to tracking and treeing – Partial discharges.

UNIT V  ELECTRICAL CONDUCTION AND BREAKDOWN IN LIQUIDS 9

L: 45 TOTAL: 45 PERIODS

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: inspect the behavior of HV Power Transformer (K4)
CO2: illustrate the basic concepts of different types of cables and protection devices (K2)
CO3: identify the appropriate bushing techniques for high voltage applications (K3)
CO4: outline the basic concepts of circuit breakers (K2)
CO5: appraise the theory of Gas Insulated Substation (K5)

UNIT I HIGH VOLTAGE POWER TRANSFORMER

UNIT II HIGH VOLTAGE CABLES AND HIGH PROTECTION DEVICES

UNIT III HIGH VOLTAGE BUSHINGS
Types – Non-condenser bushing – Condenser bushing – Bushing application for different equipments like Alternator, transformer, switchgear, wall bushing – Design of bushing and testing procedures.

UNIT IV HIGH VOLTAGE CIRCUIT BREAKERS
Arc interruption concept – Circuit making and breaking – Types – Airbreak, SF6 and vacuum circuit breakers.

UNIT V GAS INSULATED SUBSTATION (GIS)
Comparison of GIS and air insulated substations – Design and layout of GIS – Description of various components of GIS - Advantages of GIS. appraise

REFERENCES

COURSE OUTCOMES
Upon completion of this course, the students will be able to
- CO 1: tell the basic requirements and safety precautions (K1)
- CO 2: analyze the various (electrical, thermal, mechanical and chemical) properties of liquid dielectrics (K4)
- CO 3: perform the simulation of various impulse voltage generator circuits (S2)
- CO 4: practice simulation software for designing various HV equipments (A2)
- CO 5: design and analyze the different combinations of R, L and C of transient circuit (K6)

LIST OF EXPERIMENTS
1. Basics of Dielectrics Laboratory
2. Measurement of dielectric strength of liquid dielectric (Transformer Oil)
3. Measurement of Loss angle and resistivity of liquid dielectric (Transformer Oil)
4. Measurement of Flash point & Fire point of liquid dielectrics
5. Measurement of Viscosity of liquid dielectrics
6. Measurement of pH
7. Measurement of Conductivity of samples
8. Simulation of Lightning and Switching Impulse voltage generator
9. Simulation of RL, RC and RLC-DC transient circuit
10. FEM Simulation of different electrode configurations
11. FEM Simulation of single and composite dielectrics field distribution
12. FEM Simulations of Insulators

P: 60 TOTAL: 60 PERIODS
15HE21C ELECTRICAL POWER SYSTEM TRANSIENTS

L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: appraise the concept of travelling waves on transmission line (K5)
CO 2: evaluate the transient effects in power networks and components (K5)
CO 3: describe the mechanism of over voltages and its effects (A1)
CO 4: discuss the behavior of electrical equipments under transient conditions (A2)
CO 5: formulate the insulation coordination of different types of sub stations (A4)

UNIT I TRAVELLING WAVES ON TRANSMISSION LINE

UNIT II COMPUTATION OF POWER SYSTEM TRANSIENTS

UNIT III LIGHTNING, SWITCHING AND TEMPORARY OVERVOLTAGES

UNIT IV BEHAVIOUR OF WINDING UNDER TRANSIENT CONDITION

UNIT V INSULATION CO-ORDINATION
Principle of insulation coordination in Air Insulated Substation (AIS) and Gas Insulated Substation (GIS) – Insulation level – Statistical approach – Coordination between insulation and protection level – Overvoltage protective devices – Lightning arresters – Substation earthing.

L:45 TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: summarize the various levels of insulation in power apparatus (K2)
CO 2: describe the circuit interruption techniques (A1)
CO 3: analyze the problems associated with circuit interruption by a circuit breaker (K4)
CO 4: discuss different types of circuit breakers (A2)
CO 5: explain about the testing of circuit breakers (A3)

UNIT I             INTRODUCTION                    9
Insulation of switchgear – Coordination between inner and external insulation – Insulation clearances in air, oil, SF₆ and vacuum – Bushing insulation – Solid insulating materials – Dielectric strength consideration.

UNIT II            CIRCUIT INTERRUPTION              9

UNIT III           SHORT CIRCUIT CALCULATIONS AND RATING OF CIRCUIT BREAKERS 9

UNIT IV            TYPES OF CIRCUIT BREAKERS         9
Classification of circuit breakers – Design, construction and operating principles of bulk oil, minimum oil, air blast, SF₆ and vacuum circuit breakers – Comparison of different types of circuit breakers.

UNIT V             TESTING OF CIRCUIT BREAKERS         9
Type tests and routine tests – Short circuit testing – Synthetic testing of circuit breakers – Recent advancements in high voltage circuit breakers.

REFERENCES
15HE23C DESIGN OF INSULATIONS FOR HIGH VOLTAGE EQUIPMENTS L T P C 3 2 0 4

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: interpret the performance of insulating systems (K3)
CO 2: outline the basic concepts of insulating materials for high voltage application (K4)
CO 3: design the insulators, capacitors and bushings (K5)
CO 4: make use of the insulation schemes, design the power transformer (K5)
CO 5: evaluate the design parameters related to instrumental transformers (K5)

UNIT I INTRODUCTION 15
Basic arrangements of the insulation systems- Measures to avoid intensification of electric stress –
Rigid and leak proof connections to insulating parts – Measures for air sealing oil insulated devices
– temperature rise calculation of insulating systems - factors affecting the performance of
Dielectric materials - Electric field distribution-utilization factor.

UNIT II INSULATING MATERIALS IN HIGH VOLTAGE TECHNOLOGY 15
Requirements of insulating materials – Properties and testing of insulating materials – Natural
organic and inorganic materials – Synthetic organic insulating materials.

UNIT III DESIGN OF INSULATORS, BUSHINGS AND CAPACITORS 15
High Voltage capacitors - Basic configurations – Design of wound capacitors – Types of design,
Bushings and lead outs – basic configuration – calculations of capacitive grading – Types of
design.

UNIT IV DESIGN OF POWER TRANSFORMERS 15
Insulation schemes in transformer, design of transformer windings, surge phenomena in
Transformer windings-effect of series and shunt capacitance and stress control techniques.

UNIT V DESIGN OF INSTRUMENT TRANSFORMERS 15
Instrument transformer- inductive voltage transformers – circuitry – error calculation – design-
capacitive voltage transformers - circuitry – error calculation – design – current transformers -
circuitry – error calculation – design.

REFERENCES
1. Dieter Kind and Hermann Karner, “High Voltage insulation technology”, translated from
India Pvt. Ltd, 2005
Inc., 1996.
1987.
1979.
15HE24C EXTRA HIGH VOLTAGE POWER TRANSMISSION

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: explain the role of EHVAC Transmission and Mechanical considerations (A3)
CO 2: calculate the line parameters for multi-conductor lines (K4)
CO 3: estimate the voltage gradients of conductors (K6)
CO 4: discuss the concepts of corona and radio interference (A2)
CO 5: illustrate the effect of electrostatic field on humans and vehicles (K4)

UNIT I INTRODUCTION

UNIT II CALCULATION OF LINE PARAMETERS
Calculation of resistance, inductance and capacitance for multi-conductor lines – Calculation of sequence inductances and capacitances – Line parameters for different modes of propagation – Resistance and inductance of ground return.

UNIT III VOLTAGE GRADIENTS OF CONDUCTORS
Charge-potential relations for multi-conductor lines – Surface voltage gradient on conductors – gradient factors and their use – Distribution of voltage gradient on sub conductors of bundle – voltage gradients on conductors in the presence of ground wires on towers.

UNIT IV CORONA EFFECTS

UNIT V ELECTROSTATIC FIELD OF EHV LINES
Effect of EHV line on heavy vehicles – Calculation of electrostatic field of AC lines – Effect of high field on humans, animals, and plants – Electrostatic induction in un-energized circuit of a D/C line – Induced voltages in insulated ground wires.

L:45 T:30 TOTAL:75 PERIODS

REFERENCES
15HE25C               HIGH VOLTAGE LABORATORY – II                             L T P C
                                                                  0 0 4 2

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: evaluate the breakdown strength of solid dielectrics (K5)
CO 2: measure the generated AC, DC and Impulse voltage (K5)
CO 3: determine the AC and DC breakdown voltage of gaseous dielectric (K5)
CO 4: examine the partial discharge and THD behavior of dielectric materials (K4)
CO 5: perform the power frequency and impulse voltage test on insulators and cable (S2)

LIST OF EXPERIMENTS
1. Measurement of dielectric strength of solid dielectric (Rubber gloves)
2. Measurement of capacitance and tan delta using high voltage Schering Bridge
3. Generation and measurement of AC, DC and Impulse voltage
4. Breakdown measurement of gaseous dielectric under AC Voltage
5. Breakdown measurement of gaseous dielectric under DC Voltage
7. Measurement of total harmonics distortion (THD) using harmonic analyzer
8. Earth resistance measurement
9. Power frequency test on Insulators
10. Power frequency test on Cables
11. Lightning Impulse voltage test on 11kV Pin type insulator
12. Lightning Impulse voltage test on 11kV Disc type insulator

P: 60 TOTAL: 60 PERIODS
15HE26C  RESEARCH PAPER AND PATENT REVIEW – SEMINAR

L T P C
0 0 4 2

The student will make at least two technical presentations on recent research publication and patent related to their specialization. The presentations will be assessed by a committee constituted by the head of the department. The students also expected to submit a report at the end of the semester.

P: 60 TOTAL: 60 PERIODS
15HE01E ELECTROMAGNETIC INTERFERENCE AND ELECTROMAGNETIC COMPATIBILITY L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: describe the characteristics and design of electromagnetic compatibility (A1)
CO 2: discuss the methods of coupling and grounding (K6)
CO 3: summarize filtering, shielding and coating methods (K2)
CO 4: explain the digital logic noise and ground noise (A3)
CO 5: list the standard and laboratory techniques (K1)

UNIT I INTRODUCTION 9

UNIT II METHOD OF GROUNDING 9

UNIT III BALANCING, FILTERING AND SHIELDING 9

UNIT IV DIGITAL CIRCUIT NOISE AND LAYOUT 9

UNIT V ELECTROSTATIC DISCHARGE, STANDARDS AND LABORATORY TECHNIQUES 9

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1: identify the static and dynamic breakdown strength of dielectric materials. (K3)
CO2: estimate energy storage in Marx generators and pulse discharge capacitors. (K6)
CO3: distinguish the types and operation of various switches. (K4)
CO4: illustrate the pulse forming networks (K2)
CO5: appraise the pulse transmission and transformation theory. (K5)

UNIT I STATIC AND DYNAMIC BREAKDOWN STRENGTH OF DIELECTRIC MATERIALS

UNIT II ENERGY STORAGE

UNIT III SWITCHES

UNIT IV PULSE FORMING NETWORKS
Transmission lines – Terminations and junctions – Transmission lines with losses – The finite transmission line as a circuit element – Production of pulses with lossless transmission lines – RLC networks – Circuit simulation with LEITER.

UNIT V PULSE TRANSMISSION AND TRANSFORMATION

L: 45 TOTAL: 45 PERIODS

REFERENCES
15HE03E ADVANCED ELECTROMAGNETIC FIELDS L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the basic concepts in electrostatics. (K5)
CO 2: illustrate the concepts of electric fields and space charge free fields. (K2)
CO 3: distinguish the different techniques for analyzing the electric fields. (K4)
CO 4: analyze the electric fields with combination of different computation techniques. (K4)
CO 5: estimate the electric fields behavior in conductors and dielectrics. (K6)

UNIT I ELECTROSTATICS

UNIT II ELECTRIC FIELDS-1

UNIT III ELECTRIC FIELDS-2

UNIT IV ELECTRIC FIELDS-3
Analytical calculations of fields with space charges – Numerical computation of fields with space charges finite element technique – Finite element technique combined with the method of characteristics – Charge simulation technique combined with the method of residues – Electric stress control and optimization.

UNIT V CONDUCTORS & DIELECTRICS
Behavior of conductors in an electric field – Conductors and insulators – Electric field inside a dielectric material – Polarization – Dielectric – Conductor and dielectric – Dielectric boundary conditions – Energy stored and energy density in a static electric field – Current density – Conduction and convection current densities – Ohm’s law in point form – Equation of continuity.

L :45 TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to
CO 1: explain the Mechanism of pollution flashover, Analytical determination. (K5)
CO 2: perform the artificial pollution testing methods. (S2)
CO 3: discuss the pollution performance of insulators. (K6)
CO 4: illustrate the pollution performance of surge diverters. (K2)
CO 5: demonstrate the pollution performance of indoor equipments. (A3)

UNIT I INTRODUCTION
Fundamental process of pollution flashover – Development and effect of contamination layer – Creepage distance – Pollution conductivity – Mechanism of pollution flashover – Analytical determination of flashover voltage.

UNIT II POLLUTION TESTING

UNIT III POLLUTION PERFORMANCE OF INSULATORS
Ceramic and non-ceramic insulators – Design of shed profiles and their effect in insulators – Rib factor effect in AC and DC insulators – Various techniques to improve the performance of insulators – Modeling of insulators – Study of Flashover performance of various types of Insulators with non uniform pollution.

UNIT IV POLLUTION PERFORMANCE OF SURGE DIVERTERS
External insulation – Effect of pollution on the protective characteristics of gap and gapless arresters – Modeling of surge diverters under polluted conditions.

UNIT V POLLUTION PERFORMANCE OF INDOOR EQUIPMENT
Condensation and Contamination of indoor switch gear – Performance of organic insulator under polluted conditions – Accelerated testing techniques.

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: describe the DC power transmission technology (A1)
CO 2: analyze HVDC converters (K4)
CO 3: describe the various types, control and protection of MTDC systems (A1)
CO 4: analyze harmonics and filters (K4)
CO 5: discuss the simulation tools and modeling of HVDC system (K6)

UNIT I DC POWER TRANSMISSION TECHNOLOGY

Introduction – Comparison of AC and DC transmission – Application of DC transmission –
Description of DC transmission system – Planning for HVDC transmission – Modern trends in DC transmission – DC breakers – Cables – VSC based HVDC.

UNIT II ANALYSIS OF HVDC CONVERTERS AND HVDC SYSTEM CONTROL

Pulse number – Choice of converter configuration – Simplified analysis of Graetz circuit -
Converter bridge characteristics – Detailed analysis of converters - General principles of DC link control – Converter control – System control hierarchy - Firing angle control – Current and extinction angle control – Generation of harmonics and filtering.

UNIT III MULTITERMINAL DC SYSTEMS

Introduction – Potential applications of MTDC systems – Types of MTDC systems – Control and protection of MTDC systems – Study of MTDC systems.

UNIT IV POWER FLOW ANALYSIS IN AC/DC SYSTEMS

Per unit system for DC Quantities – Modeling of DC links – Solution of DC load flow – Solution of AC-DC power flow – Case studies.

UNIT V SIMULATION OF HVDC SYSTEMS


REFERENCES

15HE06E       COLLISION PHENOMENON      L T P C
                              3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
  CO 1: explain the concepts of collision phenomenon. (A3)
  CO 2: discuss the behavior of charged particles in gaseous medium under different electric
        fields conditions. (K6)
  CO 3: illustrate the concept of self sustaining discharge breakdown mechanisms. (K2)
  CO 4: summarize the concepts of partial discharge and breakdown mechanism under
        alternating fields. (K2)
  CO 5: explain the concepts of breakdown, glow and plasma. (K5)

UNIT I     INTRODUCTION  9
Ionization, Deionization and Electron Emission – Ionization and plasma conductivity – Production
of charged particles – Ionization by cosmic rays – Thermal ionization – The free path – Excited
states – Metastable states – Diffusion – Recombination – Negative ions – Photoelectric emission –
Thermionic emission – Field emission.

UNIT II   BEHAVIOUR OF CHARGED PARTICLES IN A GAS IN ELECTRIC
          FIELDS OF LOW E/p AND HIGH E/p     9
Definition and significance of mobility – Forces between ions and molecules – Diffusion under low
fields – Electron drift velocity – High E/p – Coefficient of ionization by electron collision –
Evaluation of $\alpha$ – Electron avalanche – Effect of the cathode – Ionization coefficient in alternating
fields.

UNIT III  SELF-SUSTAINING DISCHARGE BREAKDOWN MECHANISMS 9
Ionization by positive-ion collision – Cathode processes – Space-charge field of an avalanche –
Critical avalanche size – Townsend mechanism and its limitations – Streamer formation – The
transition between the breakdown mechanisms – The effect of electron attachment.

UNIT IV   PARTIAL BREAKDOWN AND BREAKDOWN UNDER ALTERNATING
          FIELDS  9
Electron current – Positive ion current – Total current – Characteristic time – Effect of space
charge – Anode coronas – Cathode coronas.

UNIT V    BREAKDOWN GLOW AND PLASMA 9
Breakdown: Mobility controlled breakdown – Microwave of diffusion controlled breakdown – Non-
uniform alternating field breakdown – Laser breakdown. Glow and Plasma: General description –
The cathode zone – Negative glow and Faraday dark space – Positive column – Anode region –
Other effects – Definition of plasma – Debye length – Scope of known plasmas – Plasma
oscillations – High-temperature plasmas – Plasma diagnostics.

REFERENCES
   Willey & Sons, 1971.
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: discuss the measurement and diagnostic technologies (K6)
CO 2: list the various application of high voltage engineering in industry. (K1)
CO 3: explain about the safety and electrostatic hazards, Lightning protection. (K5)
CO 4: analyze the electrical breakdown, pulse generators and treatment chamber design (K4)
CO 5: apply PEF technology in food preservation (K3)

UNIT I MEASUREMENT AND DIAGNOSTIC TECHNOLOGIES  9

UNIT II APPLICATION OF HIGH VOLTAGE ENGINEERING IN INDUSTRY  9

UNIT III SAFETY AND ELECTROSTATIC HAZARDS  9

UNIT IV PULSED ELECTRIC FIELDS  9

UNIT V APPLICATION OF PEF TECHNOLOGY IN FOOD PRESERVATION  9
Processing of juices, milk, egg, meat and fish products – Processing of water and waste – Industrial feasibility, cost and efficiency analysis.

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to:

- CO1: analyze the 2D and 3D dielectric systems using finite difference method (K4)
- CO2: apply charge simulation method to analyze single and multi dielectric media (K3)
- CO3: estimate the field parameters using finite element method (K6)
- CO4: formulate 2D and 3D dielectric systems using boundary element method (A4)
- CO5: list the analytical methods of electric field calculation (K1)

UNIT I  FINITE DIFFERENCE METHOD

FDM formulations for homogeneous medium in 3-D system with unequal nodal distances – FDM formulations for multi-dielectric media in 2-D system with unequal nodal distances – FDM formulations for multi-dielectric media in axi-symmetric system with equal nodal distances.

UNIT II  CHARGE SIMULATION METHOD


UNIT III  FINITE ELEMENT METHOD

Minimum field energy and basic potential equation at nodes for triangular elements considering homogeneous medium and also multi-dielectric media for two-dimensional and axi-symmetric field – Element interpolation – Simplex coordinates – Simplex-Cartesian relation – Interpolation on 1 Simplexes – Interpolation functions on n-Simplexes – Interpolation for curvilinear elements – Local coordinates – Integration by Gauss Quadrature Method – Hybrid method comprising CSM and FEM – Comparison between CSM and FEM.

UNIT IV  BOUNDARY ELEMENT METHOD

Basic formulations for 2-D and 3-D systems based on Green’s function kernel – Fundamental solution and weighting function for solution – Evaluation of integrals for constant and linear elements – Treatment of corners – Multi-boundary problems – Multi-dielectric system. Surface Charge Simulation Method – Basic formulations for 2-D and axi-symmetric systems considering ideal homogeneous medium – Straight-line and elliptic arc elements – Formulations for lossy dielectric including volume and surface resistivity.

UNIT V  ANALYTICAL METHODS OF ELECTRIC FIELD CALCULATION

Solution of field perturbations due to a long conducting/dielectric cylinder in uniform field – Solution of field perturbations due to a conducting/dielectric sphere in uniform field. Mechanical forces in HV systems: Mechanical pressure on electrode boundary – Mechanical pressure within an insulator – Film pressure on insulator boundary – Total pressure at the insulator – Insulator boundary.

REFERENCES


L: 45 TOTAL: 45 PERIODS
15HE09E FLEXIBLE AC TRANSMISSION SYSTEMS L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the fundamental idea about FACTS controllers. (K5)
CO 2: design of SVC voltage regulator using TCR-TSC logic. (K6)
CO 3: describe Transient stability model of TCSC. (A1)
CO 4: explain about basic principle of operation of STATCOM. (A3)
CO 5: explain controller interactions & its types. (K2)

UNIT I INTRODUCTION
Reactive power control in electrical power transmission lines – Uncompensated transmission line – series compensation – Basic concepts of Static Var Compensator (SVC) – Thyristor Controlled Series capacitor (TCSC) – Unified power flow controller (UPFC).

UNIT II STATIC VAR COMPENSATOR (SVC) AND APPLICATIONS

UNIT III THYRISTOR CONTROLLED SERIES CAPACITOR AND APPLICATIONS

UNIT IV VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS

UNIT V CO-ORDINATION OF FACTS CONTROLLERS
Controller interactions – SVC – SVC interaction – Coordination of multiple controllers using linear control techniques – Control coordination using genetic algorithms.

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: explain the production of voltages sags, over voltages and harmonics and methods of control. (K2)
CO 2: list the various methods of power quality monitoring (K1)
CO 3: discuss the various types of measurements and analysis methods. (K6)
CO 4: outline the concepts of Mitigation methods. (K2)
CO 5: Illustrate the overview of power quality improvement (K2)

UNIT I INTRODUCTION


UNIT II NON-LINEAR LOADS


UNIT III MEASUREMENT AND ANALYSIS METHODS


UNIT IV ANALYSIS AND CONVENTIONAL MITIGATION METHODS


UNIT V POWER QUALITY IMPROVEMENT


REFERENCES

15HE11E  RESTRUCTURED POWER SYSTEMS  L T P C
3  0 0  3

COURSE OUTCOMES
Upon completion of this course, the students will be able to

CO 1: list the operators involved in Restructured market and methods used for pricing and congestion process. (K1)
CO 2: explain the functions and operations of U.S. Re-structured markets. (K2)
CO 3: evaluate the structure and functions of OASIS and ATC calculation. (K5)
CO 4: discuss the importance, factors and derivative instruments of electric energy trading. (K6)
CO 5: identify the factors and challenges of electric price volatility and forecasting methods. (A1)

UNIT I  OVERVIEW OF KEY ISSUES IN ELECTRIC UTILITIES ESTRUCTURING  9

UNIT II  ELECTRIC UTILITY MARKETS IN THE UNITED STATES  9

UNIT III  OASIS: OPEN ACCESS SAME TIME INFORMATION SYSTEM  9

UNIT IV  ELECTRIC ENERGY TRADING  9

UNIT V  ELECTRICITY PRICING - VOLATILITY, RISK AND FORECASTING  9

L :45 TOTAL:45 PERIODS
REFERENCES

15HE12E             POWER SYSTEM PLANNING AND RELIABILITY                         L T P C
                                                                                       3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: outline the objectives and importance of load forecasting and the methods
involved in it. (K2)
CO 2: evaluate the LOLP and reliability of ISO. (K5)
CO 3: perform contingency analysis and load flow reliability analysis.(S2)
CO 4: explain the concept, procedure and problems faced in Expansion planning. (A3)
CO 5: develop the planning, protection and coordination of protective devices in
distribution systems. (K6)

UNIT I        LOAD FORECASTING
Objectives of forecasting – Load growth patterns and their importance in planning – Load
forecasting based on discounted multiple regression technique – Weather sensitive load
forecasting – Determination of annual forecasting – Use of AI in load forecasting.

UNIT II      GENERATION SYSTEM RELIABILITY ANALYSIS
Probabilistic generation and load models – Determination of LOLP and expected value of demand
not served – Determination of reliability of ISO and interconnected generation systems.

UNIT III      TRANSMISSION SYSTEM RELIABILITY ANALYSIS
Deterministic contingency analysis – Probabilistic load flow – Fuzzy load flow probabilistic
transmission system reliability analysis – Determination of reliability indices like LOLP and
expected value of demand not served.

UNIT IV       EXPANSION PLANNING
Basic concepts on expansion planning – Procedure followed for integrate transmission system
planning, current practice in India – Capacitor placer problem in transmission system and radial
distributions system.

UNIT V        DISTRIBUTION SYSTEM PLANNING OVERVIEW
Introduction – sub transmission lines and distribution substations – Design of primary and
secondary systems – Distribution system protection and coordination of protective devices.

L :45 TOTAL:45 PERIODS

REFERENCES
3. Proceeding of workshop on energy systems planning & manufacturing CI.
15HE13E  POWER SYSTEM ANALYSIS  

COURSE OUTCOMES
Upon completion of this course, the students will be able to

CO 1: perform the various solution techniques for large scale power systems. (S2)
CO 2: discuss the various load flow analysis techniques and assessment of ATC. (K6)
CO 3: illustrate the importance of optimal power flow and methods involved in calculating OPF. (K2)
CO 4: compute the fault analysis calculation using bus impedance matrix. (K5)
CO 5: analyze the numerical integration methods and factors influencing numerical and transient stability. (K4)

UNIT I  SOLUTION TECHNIQUE  
Sparse Matrix techniques for large scale power systems: Optimal ordering schemes for preserving sparsity – Flexible packed storage scheme for storing matrix as compact arrays – Factorization by Bifactorization and Gauss elimination methods – Repeat solution using Left and Right factors and L and U matrices.

UNIT II  POWER FLOW ANALYSIS  

UNIT III  OPTIMAL POWER FLOW  

UNIT IV  SHORT CIRCUIT ANALYSIS  
Fault calculations using sequence networks for different types of faults – Bus impedance matrix (ZBUS) construction using Building Algorithm for lines with mutual coupling – Simple numerical problems –Computer method for fault analysis using ZBUS and sequence components – Derivation of equations for bus voltages – Fault current and line currents – Both in sequence and phase domain using Thevenin’s equivalent and ZBUS matrix for different faults.

UNIT V  TRANSIENT STABILITY ANALYSIS  

L: 45  TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the basic concept of load prediction and various approaches. (K2)
CO 2: develop the various method to get the solution for constraints. (K6)
CO 3: formulate the generation scheduling and the economic dispatch. (K6)
CO 4: describe the various control strategies of power systems. (A1)
CO 5: Evaluate the state estimation using different algorithms. (K5)

UNIT I LOAD FORECASTING

UNIT II UNIT COMMITMENT

UNIT III GENERATION SCHEDULING

UNIT IV CONTROL OF POWER SYSTEMS
Review of AGC and reactive power control – System operating states by security control functions – Monitoring – Evaluation of system state by contingency analysis – Corrective controls (Preventive, emergency and restorative) – Energy control center – SCADA system – Functions – Monitoring – Data acquisition and controls – EMS system.

UNIT V STATE ESTIMATION

REFERENCES
15HE15E REACTIVE POWER COMPENSATION AND MANAGEMENT L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: discuss the basic concepts of load compensation. (K6)
CO 2: develop the reactive power compensation in transmission line and its characteristic. (K6)
CO 3: illustrate the basic concepts of power quality and its issues. (K2)
CO 4: summarize the concepts of load shaping and tariffs. (K2)
CO 5: explain the reactive power management and its consideration. (K5)

UNIT I LOAD COMPENSATION 9
Objectives and specifications – Reactive power characteristics – Inductive and capacitive approximate biasing – Load compensator as a voltage regulator – Phase balancing and power factor correction of unsymmetrical loads – Examples.

UNIT II REACTIVE POWER COMPENSATION IN TRANSMISSION SYSTEM 9

UNIT III REACTIVE POWER COORDINATION 9

UNIT IV DEMAND SIDE MANAGEMENT 9
Load patterns – Basic methods load shaping – Power tariffs – KVAR based tariffs – Penalties for voltage flickers and Harmonic voltage levels.

UNIT V REACTIVE POWER MANAGEMENT 9

L :45 TOTAL:45 PERIODS

REFERENCES
15HE16E    POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS      L T P C
                      3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
   CO 1: explain the importance of renewable energy and different renewable energy
       resources. (A3)
   CO 2: analyze of wind electrical generators. (K4)
   CO 3: design different power converters namely AC to DC, DC to DC and AC to AC
       converters for renewable energy systems. (S5)
   CO 4: analyze the grid integrated wind and PV systems. (K4)
   CO 5: develop maximum power point tracking algorithms. (K6)

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

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION
Review of reference theory fundamentals – Principle of operation and analysis: IG, PMSG, SCIG
and DFIG.

UNIT III POWER CONVERTERS
Solar: Block diagram of solar photo voltaic system – Principle of operation: line commutated
converters (inversion-mode) – Boost and buck-boost converters – Selection of inverter – Battery
sizing – Array sizing – Wind: Three phase AC voltage controllers: AC-DC-AC converters:
uncontrolled rectifiers – PWM Inverters – Grid Interactive Inverters – Matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS
Stand alone operation of fixed and variable speed wind energy conversion systems and solar
system – Grid connection Issues – Grid integrated PMSG and SCIG Based WECS Grid Integrated
solar system.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS
Need for Hybrid Systems – Range and type of Hybrid systems – Case studies of Wind – PV
Maximum Power Point Tracking (MPPT).

L:45, TOTAL: 45 PERIODS

REFERENCES
   New Delhi, 2006
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain about the causes for arising the harmonics and basic filter techniques. (K5)
CO 2: discuss about the pulse width modulated rectifier and its control techniques. (K6)
CO 3: analyze the performance of resonant converter of its various types. (K4)
CO 4: develop the state space model and dynamic analysis of switching converter. (K6)
CO 5: design the various control schemes for resonant converter. (S5)

UNIT I POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS
Average power – RMS value of waveform – Power factor – AC line current harmonic standards
IEC1000 – IEEE 519 – The Single phase full wave rectifier – Continuous Conduction Mode –
Discontinuous Conduction Mode – Behaviour – Minimizing THD – Three phase rectifiers –
Continuous Conduction Mode – Discontinuous Conduction Mode – Harmonic trap filters.

UNIT II PULSE WIDTH MODULATED RECTIFIERS
Properties of Ideal rectifiers – Realization of non ideal rectifier – Control of current waveform –
Average current control – Current programmed Control – Hysteresis control – Nonlinear carrier
control – Single phase converter system incorporating ideal rectifiers – Modeling losses and
efficiency in CCM high quality rectifiers-Boost rectifier Example – Expression for controller duty
cycle – Expression for DC load current – Solution for converter Efficiency.

UNIT III RESONANT CONVERTERS
Zero Voltage Switching – Classification of Quasi resonant switches – Zero Current Switching of
Quasi Resonant Buck converter – Zero Current Switching of Quasi Resonant Boost converter –
Zero Voltage Switching of Quasi Resonant Buck converter – Zero Voltage Switching of Quasi
Resonant Boost converter: Steady State analysis.

UNIT IV DYNAMIC ANALYSIS OF SWITCHING CONVERTERS
Review of linear system analysis – State Space Averaging – Basic State Space Average Model –
State Space Averaged model for an ideal Buck Converter – Ideal Boost Converter – Ideal Buck
Boost Converter – For an ideal Cuk Converter.

UNIT V CONTROL OF RESONANT CONVERTERS
Pulse Width Modulation – Voltage Mode PWM Scheme-Current Mode PWM Scheme – Design of
Controllers: PI Controller – Variable Structure Controller – Optimal Controller for the source current
shaping of PWM rectifiers.

REFERENCES
1. Robert W. Erickson and Dragon Maksimovic, “Fundamentals of Power Electronics”,
3. Simon Ang and Alejandro Oliva, “Power Switching Converters”, Taylor & Francis Group,
   2010.
15HE18E ANALYSIS OF POWER CONVERTERS  

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the types and its principle operation of single phase AC-DC converter. (K5)
CO 2: discuss the various three phase AC-DC converter and its operation. (K6)
CO 3: illustrate about the types of DC-DC converter and fundamentals of Resonant converter (K2)
CO 4: distinguish the various inverter and its analysis with different loads. (K4)
CO 5: summarize the voltage controller, cyclo converter and matrix converter. (K2)

UNIT I  SINGLE PHASE AC-DC CONVERTERS  

UNIT II  THREE PHASE AC-DC CONVERTERS  

UNIT III  DC – DC CONVERTERS  

UNIT IV  DC – AC CONVERTERS  
Voltage source inverters – Principle of operation of half and full bridge inverters – 180 degree and 120 degree conduction mode inverters – Voltage control of three phase inverters using various PWM techniques – Harmonics and various harmonic elimination techniques – Analysis with RL, RLE loads – Multi level inverters.

UNIT V  AC – AC CONVERTERS  
Principle of operation of AC Voltage Controllers – Cyclo converters – Analysis with RL, RLE loads – Introduction to Matrix converters.

L:45 TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to
CO 1: outline the fundamental concept of power electronic devices. (K2)
CO 2: explain the single phase and three phase power converter and its operation. (A3)
CO 3: discuss the single phase and three phase inverter with its control strategies. (K6)
CO 4: illustrate the reactive power compensation and the FACTS devices. (K2)
CO 5: appraise the power quality and various power quality problems. (K5)

UNIT I  INTRODUCTION
Basic Concept of Power Electronics – Different types of Power Electronic Devices – Diodes, Transistors and SCR, MOSFET, IGBT and GTO's.

UNIT II  AC TO DC CONVERTERS

UNIT III  DC TO AC CONVERTERS
General Topology of single Phase and three phase voltage source and current source inverters – Need for feedback diodes in anti parallel with switches – Multi Quadrant Chopper viewed as a single phase inverter – Configuration of Single phase voltage source inverter: Half and Full bridge, Selection of Switching Frequency and Switching Device – Voltage Control and PWM strategies.

UNIT IV  STATIC REACTIVE POWER COMPENSATION

UNIT V  POWER QUALITY

REFERENCES
15HE20E CONTROL OF ELECTRIC DRIVES  L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the concept of converter fed DC drives. (K5)
CO 2: discuss the various modes of operation of chopper fed DC drives. (K6)
CO 3: analyze the various inverters fed DC drives and its sampling techniques. (K4)
CO 4: develop the mathematical model of the frequency controlled drive also to study the
steady state and dynamic behavior. (K6)
CO 5: perform the various measurement and control techniques. (S2)

UNIT I CONVERTER FED DC DRIVES
Microcontroller hardware circuit – Flow charts waveforms – Performance characteristics of dc
drives fed through single phase converters – 3-phase converters – Dual converters – 1-phase fully
controlled converter and 3-phase fully controlled converter fed dc drive.

UNIT II CHOPPER FED DC DRIVES
Microcontroller hardware circuits and waveforms of various modes of operation of chopper fed DC
drives.

UNIT III INVERTER FED INDUCTION MOTOR DRIVE
Microcomputer controlled VSI fed induction motor drive – Detailed power circuit – Generation of
firing pulses and firing circuit – Flow charts and waveforms for 1-phase, 3-phase Non-PWM and 3-
phase PWM VSI fed induction motor drives – Sampling techniques for PWM inverter.

UNIT IV MATHEMATICAL MODELING OF FREQUENCY CONTROLLED DRIVE
Development of mathematical model for various components of frequency controlled induction
drive – Mathematical model of the system for steady state and dynamic behavior – Study of
stability based on the dynamic model of the system.

UNIT V CLOSED LOOP CONTROL OF MICROCOMPUTER BASED DRIVES
Voltage, Current, Torque and Speed measurements using digital measurement techniques –
Types of controllers – Position and velocity measurement algorithm – Closed loop control of
microcomputer based drives.

L :45 TOTAL:45 PERIODS

REFERENCES
15HE21E COMPUTER AIDED DESIGN OF POWER ELECTRONICS CIRCUITS L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the student will be able to
CO 1: outline the fundamentals of simulation and analysis of basic power electronic devices. (K2)
CO 2: develop the advanced algorithms in computer simulation. (K6)
CO 3: model the power electronic devices in simulation. (K3)
CO 4: infer the various analysis in simulation circuits. (K2)
CO 5: summarize the various case studies about the simulation of different power electronic devices. (K2)

UNIT I INTRODUCTION 9

UNIT II ADVANCED TECHNIQUES IN SIMULATION 9
Analysis of power electronic systems in a sequential manner – Coupled and decoupled systems – Various algorithms for computing steady state solution in power electronic systems – Future trends in computer simulation.

UNIT III MODELING OF POWER ELECTRONIC DEVICES 9

UNIT IV SIMULATION OF CIRCUITS 9

UNIT V CASE STUDIES 9

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the student will be able to
CO 1: appraise about dc and ac electrical drives (K5)
CO 2: model the induction motor using reference frame theory
CO 3: outline the vector control techniques for ac drives (K2)
CO 4: explain about sensorless control techniques for electric drives (K5)
CO 5: list the various control techniques for special electrical machines. (K1)

UNIT I  INTRODUCTION  9
Review of dc drives and scalar control of AC drives – Disadvantages of scalar control of AC drives

UNIT II  REFERENCE FRAME THEORY & MODELING OF INDUCTION MOTOR  9
Space vector theory – Dynamic d-q modeling of induction machines – Stator, rotor and synchronously rotating reference, frame models, state space equations and dynamic simulation, – Space Phasor model – Control – Principle of the induction motor

UNIT III  VECTOR CONTROL  9

UNIT IV  SENSOR LESS CONTROL  9
Principles for speed sensor less control - Sensor less methods for scalar control – Sensorless methods for vector control – Introduction to observer based techniques.

UNIT V  SPECIAL MACHINES  9

L: 45 TOTAL: 45 PERIODS

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: outline the concepts of intelligent expert system (K2).
CO 2: explain the components of fuzzy logic system (K5).
CO 3: distinguish various structures of ANN (K4).
CO 4: describe the basic concepts of genetic algorithms (K6).
CO 5: apply ANN, FLC and GA to various electrical applications (K3).

UNIT I  INTRODUCTION

UNIT II  ARTIFICIAL NEURAL NETWORKS

UNIT III  FUZZY LOGIC SYSTEM
Introduction to crisp sets and fuzzy sets – Basic fuzzy set operation and approximate reasoning – Introduction to fuzzy logic modeling and control – Fuzzification, inferencing and defuzzification – Fuzzy knowledge and rule bases – Fuzzy modeling and control schemes for nonlinear systems – Self-organizing fuzzy logic control – Fuzzy logic control for nonlinear time – Delay system.

UNIT IV  GENETIC ALGORITHM
Basic concept of Genetic algorithm and detail algorithmic steps – Adjustment of free parameters – Solution of typical control problems using genetic algorithm – Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

UNIT V  APPLICATIONS

L: 45 TOTAL: 45 PERIODS

REFERENCES
15HE24E ADVANCED DIGITAL SIGNAL PROCESSING (Common to CS, HVE and C&I) L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of the course, the students will be able to
CO 1: Discuss the essentials for the postgraduate level research in the area of statistical signal processing. (K1-K2)
CO 2: Model random signals and determine its solution. (K1-K3)
CO 3: Estimate the coefficient for perfect reproduction filter for both the stationary and non-stationary signals. (K1- K3)
CO 4: Design FIR and IIR adaptive filters using adaptive algorithms. (K1- K4)
CO 5: Estimate the power spectrum for discrete random signals using classical and non-classical methods. (K1- K3)

UNIT I DISCRETE RANDOM SIGNAL PROCESSING 9

UNIT II SIGNAL MODELING 9
Least Squares method, Pade approximations, Prony’s method – Pole zero modeling, All pole modeling, Linear prediction, Forward and Backward prediction, Finite data records, stochastic models, Solution of Prony’s normal equations – Levinson Durbin recursion.

UNIT III WIENER FILTERING 9

UNIT IV ADAPTIVE FILTERS 9

UNIT V SPECTRAL ESTIMATION 9
Nonparametric methods - Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods - ARMA, AR and MA model based spectral estimation.

REFERENCES
15HE25E EVOLUTIONARY COMPUTING (Common to HVE and C&N)  L T P C  3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
  CO 1: explain the basic concepts of evolutionary computation. (K2)
  CO 2: classify the various representations, selection and search operations (K2)
  CO 3: discuss the basics of fitness evaluation and constraint handling mechanism. (K2)
  CO 4: outline the concepts of hybrid systems. (K2)
  CO 5: interpret the effect of parameter setting and applications. (K3)

UNIT I INTRODUCTION TO EVOLUTIONARY COMPUTATION

UNIT II REPRESENTATION, SELECTION AND SEARCH OPERATORS

UNIT III FITNESS EVALUATION AND CONSTRAINT HANDLING

UNIT IV HYBRID SYSTEM
Self-adaptation – Meta evolutionary approaches – Neural – Evolutionary systems – New areas for evolutionary computation research in evolutionary systems – Fuzzy-Evolutionary Systems – Combination with Other Optimization Methods – Combination with local search – Combination with dynamic programming – Simulated annealing and tabu search – Comparison with existing optimization.

UNIT V PARAMETER SETTING AND APPLICATIONS

L:45 TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: design a small digital system to the specified functionality. (K3)
CO 2: apply modern tools in combinational and sequential circuit design with VHDL. (K3)
CO 3: explain new generation programmable logic devices. (K2)
CO 4: apply testability algorithms in the design of digital circuits. (K3)

UNIT I  SEQUENTIAL CIRCUIT DESIGN  9

UNIT II   ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN  9

UNIT III   FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS  9

UNIT IV   SYSTEM DESIGN USING VHDL  9

UNIT V   NEW GENERATION PROGRAMMABLE LOGIC DEVICES  9

L: 45 TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES
15HE27E DESIGN OF EMBEDDED SYSTEMS (Common to C&I and HVE)  L  T  P  C  3  0  0  3

COURSE OUTCOMES
Upon completion of the course, the students will be able to
- CO 1: explain the basic concepts and building blocks of embedded system. (K2)
- CO 2: infer the fundamentals of Embedded processor Modeling. (K2)
- CO 3: illustrate bus communication in processors and I/O interfacing. (K2)
- CO 4: summarize processor scheduling algorithms and to explain the basics of RTOS. (K2)
- CO 5: distinguish the different phases & modeling of embedded system with its applications on various fields. (K3)

UNIT I  INTRODUCTION TO EMBEDDED SYSTEMS
Introduction to Embedded Systems - The build process for embedded systems - Structural units in Embedded processor-Selection of processor & memory devices- DMA –Memory management methods - Timer and Counting devices, Watchdog Timer, Real Time Clock-Software Development tools-IDE, assembler, compiler, linker, simulator, debugger-In circuit emulator, Target Hardware Debugging, Boundary Scan.

UNIT II  HARDWARE SOFTWARE PARTITIONING

UNIT III  EMBEDDED NETWORKING AND INTERRUPTS SERVICE MECHANISM

UNIT IV  RTOS BASED EMBEDDED SYSTEM DESIGN
Introduction to basic concepts of RTOS-Need, Task, process & threads, interrupt routines in RTOS-Multiprocessing and Multitasking- Preemptive and non-preemptive scheduling-Task Communication - Shared memory - Message passing – Inter process Communication- Synchronization between processes-Semaphores-Mailbox-Pipes-Priority inversion-Priority inheritance-Comparison of Real time Operating systems: VxWorks, µC/OS-II, RT Linux.

UNIT V  EMBEDDED SYSTEM APPLICATION DEVELOPMENT WITH PROCESSOR
Objective, Need, different Phases & Modelling of the EDLC-Choice of Target Architectures for Embedded Application Development for Control Dominated-Data Dominated Systems-Case studies on Digital Camera, Adaptive Cruise control in a Car, Mobile Phone software for key inputs.

L : 45 TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, students will be able to
- CO 1: explain the basic of fabrication processes and electro mechanical concepts. (K2)
- CO 2: illustrate electrostatic sensors, actuators and its applications. (K2)
- CO 3: outline the concepts of thermal sensing and actuation techniques. (K2)
- CO 4: discuss the concepts of piezoelectric sensing and actuation techniques. (K6)
- CO 5: Summarize the various case studies in MEMS technology. (K2)

UNIT I MICRO-FABRICATION, MATERIALS AND ELECTRO-MECHANICAL CONCEPTS

UNIT II ELECTROSTATIC SENSORS AND ACTUATION
Principle – Material – Design and fabrication of parallel plate capacitors as electrostatic sensors and actuators – Applications

UNIT III THERMAL SENSING AND ACTUATION

UNIT IV PIEZOELECTRIC SENSING AND ACTUATION
Piezoelectric effect – Cantilever piezoelectric actuator model – Properties of piezoelectric materials – Applications.

UNIT V CASE STUDIES
Piezoresistive sensors – Magnetic actuation – Micro fluidics applications – Medical applications – Optical MEMS.

REFERENCES
15HE29E MICROCONTROLLER AND DSP BASED SYSTEM DESIGN L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the architecture, addressing modes and programming techniques of PIC 16C7X microcontroller. (A3)
CO 2: discuss the various peripherals of 16C7X microcontroller. (K6)
CO 3: illustrate the architecture, addressing modes and programming techniques of motor control signal processors. (K2)
CO 4: list the various peripherals of motor control signal processors. (K1)
CO 5: outline the applications of 16C7X microcontroller and motor control signal processors. (K2)

UNIT I PIC 16C7X MICROCONTROLLER 9
Architecture memory organization – Addressing modes – Instruction set – Programming techniques – Simple programs.

UNIT II PERIPHERALS OF PIC 16C7X 9
Timers – Interrupts – I/O ports – I2C bus for peripheral chip access – A/D converter – UART.

UNIT III MOTOR CONTROL SIGNAL PROCESSORS 9

UNIT IV PERIPHERALS OF SIGNAL PROCESSORS 9

UNIT V APPLICATIONS OF PIC AND SIGNAL PROCESSORS 9
Voltage regulation of DC-DC converters – Stepper motor and DC motor control – Clarke’s and parks transformation – Space vector PWM – Control of Induction Motors and PMSM.

L:45 TOTAL:45 PERIODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, students will be able to
- CO 1: outline the basic concepts of optimization problems (K2)
- CO 2: perform optimization using linear and non linear programming. (S2)
- CO 3: make use of integer, stochastic and geometric programming for optimization problems (K4)
- CO 4: summarize various direct search techniques in optimization techniques (K2)

UNIT I    INTRODUCTION
Engineering Applications of optimization – statement of an optimization problem – Classification of optimization problems.

UNIT II   LINEAR AND NON LINEAR PROGRAMMING

UNIT III  INTEGER, STOCHASTIC AND GEOMETRIC PROGRAMMING

UNIT IV   DIRECT SEARCH TECHNIQUES - I

UNIT V    DIRECT SEARCH TECHNIQUES - II

REFERENCES
15HE31E WIND ENERGY CONVERSION SYSTEMS L T P C 
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain about the fundamentals of wind energy conversion systems. (K5)
CO 2: illustrate the wind turbine concept with its design considerations. (K2)
CO 3: develop the model of fixed speed system for WECS. (K6)
CO 4: discuss about the variable speed system and the various generator used in WECS. (K6)
CO 5: analyze the Grid connected WECS and its controller. (K4)

UNIT I INTRODUCTION

UNIT II WIND TURBINES

UNIT III FIXED SPEED SYSTEMS

UNIT IV VARIABLE SPEED SYSTEMS
Need of variable speed systems – Power-wind speed characteristics – Variable speed constant frequency systems synchronous generator – DFIG – PMSG – Variable speed generators modeling – Variable speed variable frequency schemes

UNIT V GRID CONNECTED SYSTEMS
Stand alone and Grid Connected WECS system – Grid connection Issues – Machine side & Grid side controllers – WECS in various countries.

L: 45 TOTAL: 45 PERIODS

REFERENCES
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: analyze the energy economics with energy auditing (K4)
CO 2: estimate the electrical energy calculation. (K6)
CO 3: discuss about the energy conservation methods. (K6)
CO 4: select the proper electrical utilities. (A3)
CO 5: describe the concepts of energy management (A1)

UNIT I INTRODUCTION


UNIT II ECONOMIC ASPECTS OF ENERGY AUDIT

Cost evaluation by ROI – IRR Cost evaluation by payback terms – Organization for energy management – Conservation measures and diagnostic review.

UNIT III ENERGY AUDIT & CASE STUDIES


UNIT IV THE ELECTRIC UTILITY IN INDUSTRY


UNIT V MODERN ENERGY EFFICIENT TECHNOLOGIES


L:45 TOTAL: 45 PERIODS

REFERENCES

8. www.energymanagertraining.com,
9. www.bee-india.gov.in
COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO 1: explain crystal lattice structures. (K5)
CO 2: memorize the heterostructures and quantum structures.(S1)
CO 3: discuss the fabrication of nano structures. (K6)
CO 4: describe the characterization techniques.(A1)
CO 5: apply the nano technology in science and engineering. (K3)

UNIT I  CRYSTALLINE PROPERTIES OF SOLID  9
Crystal lattice and seven crystal systems – Unit cell concept – Weigner-Seitz cell – Bravais lattices – Space and point groups – Miller indices – Reciprocal lattice – Brillouin zone.

UNIT II  SEMICONDUCTOR HETEROSTRUCTURES AND LOW DIMENSIONAL QUANTUM STRUCTURES  9

UNIT III  FABRICATION OF NANO STRUCTURES  9
Basic compound semiconductors – Bulk single crystal growth techniques – Epitaxial growth techniques – Physical vapour deposition and sputtering – Thermodynamics and kinetics of growths – Nano scale growth modes.

UNIT IV  CHARACTERIZATION TECHNIQUES (Qualitative Treatment only)  9

UNIT V  APPLICATIONS OF NANO TECHNOLOGY  9
Future of semiconductor device and research – Necessity of innovative technology and prospect for future – Applications in food, energy, transportation, communication, entertainment, health and medicine.

L: 45 TOTAL: 45 PERIODS

REFERENCES

15HE34E SYSTEM THEORY (Common to C&I and HVE) L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: explain the state space models for a linear system. (K2)
CO 2: analyse the state space model with respect to observability and stabilizability. (K4)
CO 3: apply state variable feedback to place system poles. (K3)
CO 4: discuss state variable observers and controllers. (K2)
CO 5: apply lyapunou stability methods to solve linear problems. (K3)

UNIT I MODERN CONTROL THEORY
Limitations of conventional control theory - Concepts of State, State variables and State model – State model for linear time invariant systems: State space representation using physical-Phase and canonical variables.

UNIT II SYSTEM RESPONSE
Transfer function from state model - Transfer matrix - Decomposition of transfer functions Direct, Cascade and Parallel decomposition techniques - Solution of state equation - State transition matrix computation.

UNIT III SYSTEM MODELS
Characteristic equation - Eigen values and Eigen vectors - Invariance of Eigen values - Diagonalization - Jordan Canonical form - Concepts of Controllability and Observability - Kalman's and Gilbert's tests - Controllable and Observable phase variable forms - Effect of pole-zero cancellation on Controllability and Observability.

UNIT IV MODEL CONTROL

UNIT V LIAPUNOV STABILITY

L: 45 TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES
15HE35E PC BASED INSTRUMENTATION SYSTEM DESIGN
(Common to C&I and HVE) L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: describe the main functional units in a PC and the software used. (K2)
CO 2: explain the architecture of PC expansion bus and USB. (K2)
CO 3: differentiate PC expansion bus and USB. (K2)
CO 4: select a Virtual Instrument for a particular application. (K3)
CO 5: describe the functional units of a system for an application. (K2)

UNIT I PC AND ITS PROGRAMMING 9
Microcomputer systems - Data representation - Bus expansion - Microprocessor operation - Data transfer and control - Parallel versus serial I/O. PC memory - Memory operation - Memory organization - Data integrity - Memory terminology - Memory size - Memory speed - CMOS memory - BIOS ROM - PC memory allocation - BIOS data area - Disk drives. Choice of language - Software development - Control structures - Loops - Error checking and input validation - Event-driven programs - Testing.

UNIT II PC EXPANSION BUS SYSTEMS 9

UNIT III THE UNIVERSAL SERIAL BUS 9

UNIT IV VIRTUAL INSTRUMENTS 9
Selecting a virtual instrument - Instrument types - Instrument connection options - Digital storage oscilloscopes - Sampling rate and bandwidth - Resolution and accuracy - Low-cost DSO - High-speed DSO - High-resolution DSO - Choosing a computer-based DSO - Basic operation of a DSO - Waveform display - Parameter measurement - Spectrum analysis - Sound card oscilloscopes - Windows Oscilloscope - Software Oscilloscope - Waveform display - Parameter measurement - Spectrum analysis

UNIT V APPLICATIONS 9
Expansion cards - Approaches - PC instruments - Industrial PC systems - Backplane bus-based systems - Networked/distributed PC systems - Specifying hardware and software - Hardware design - Software design. Applications - Monitoring oscillator stability - Testing crystal filters - A speech enunciator - Strain measurement and display - Backup battery load test - Load sequencer - Environmental monitoring - Icing flow tunnel.

L: 45 TOTAL: 45 PERIODS

TEXT BOOK

REFERENCES
3. MAPLE V programming guide.
4. MATLAB/SIMULINK user manual.
5. MATHCAD/VIS SIM user manual.
6. LABVIEW simulation user manual.
15HE36E ANALYSIS OF ELECTRICAL MACHINES

COURSE OUTCOMES
Upon completion of this course, the students will be able to

CO 1: describe the concepts of electromechanical energy conversion (A1)
CO 2: discuss the fundamentals of reference frame and its transformation (K6)
CO 3: evaluate the steady state and dynamic characteristic of DC machines (K5)
CO 4: analyze the steady state and dynamic characteristic of Induction Machines using
reference frame variables (K4)
CO 5: recognize the steady state analysis, dynamic characteristic with computer simulation
(A4)

UNIT I PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION
General expression of stored magnetic energy – Coenergy and force/torque – Single and doubly
excited system – Calculation of air gap mmf and per phase machine inductance using physical
machine data.

UNIT II REFERENCE FRAME THEORY
Static and rotating reference frames – transformation of variables – Reference frames –
Transformation between reference frames – Transformation of a balanced set – Balanced steady
state phasor and voltage equations – Variables observed from several frames of reference.

UNIT III DC MACHINES
Voltage and torque equations – Dynamic characteristics of permanent magnet and shunt DC
motors – State equations – Solution of dynamic characteristic by Laplace transformation.

UNIT IV INDUCTION MACHINES
Voltage and torque equations – Transformation for rotor circuits – Voltage and torque equations in
reference frame variables – Analysis of steady state operation – Free acceleration characteristics
– Dynamic performance for load and torque variations – Dynamic performance for three phase
fault – Computer simulation in arbitrary reference frame.

UNIT V SYNCHRONOUS MACHINES
Voltage and Torque Equation – Voltage Equation in arbitrary reference frame and rotor reference
frame – Park equations - Rotor angle and angle between rotor – Steady state analysis – Dynamic
performances for torque variations – Dynamic performance for three phase fault – Transient
stability limit – Critical clearing time – Computer simulation.

L: 45 TOTAL: 45 PERIODS

REFERENCES
2002.
COURSE OUTCOMES
Upon completion of this course, students will be able to

CO 1: explain the construction, operation and the drive systems for stepper motor. (K2)
CO 2: analyze the construction, operation and controller for Switched Reluctance Motor. (K4)
CO 3: illustrate the constructional based types, operation and characteristics of Synchronous reluctance motor. (K2)
CO 4: develop the knowledge in construction, principle of operation, control techniques & its characteristics of PMSM. (K6)
CO 5: appraise the construction, principle of operation and control of Permanent Magnet BLDC motor. (K5)

UNIT I STEPPING MOTOR
Constructional features – Principle of operation – Modes of excitation – Torque production in variable reluctance stepping motor – Dynamic characteristics – Drive systems and circuit for open loop control – Closed loop control of stepping motor.

UNIT II SWITCHED RELUCTANCE MOTORS

UNIT III SYNCHRONOUS RELUCTANCE MOTORS

UNIT IV PERMANENT MAGNET SYNCHRONOUS MOTORS

UNIT V PERMANENT MAGNET BRUSHLESS DC MOTORS
Commutation in DC motors – Difference between mechanical and electronic commutators – Hall sensors, Optical sensors – Multiphase Brushless motor – Square wave permanent magnet brushless motor drives –Torque and emf equation –Torque speed characteristics – Controllers – Microprocessors based controller

L: 45 TOTAL: 45 PERIODS

REFERENCES
15HE38E  CONDITION MONITORING OF HIGH VOLTAGE POWER APPARATUS

COURSE OUTCOMES
Upon completion of this course, the students will be able to

CO 1: explain the general concept of condition monitoring of high voltage power apparatus. (K5)
CO 2: illustrate the condition monitoring in power transformer. (K2)
CO 3: perform the power generation condition monitoring. (S2)
CO 4: distinguish the idea of various diagnostic techniques and condition monitoring. (K4)
CO 5: outline the insulation materials in application area and various testing techniques. (K2)

UNIT I  INTRODUCTION 9
General concept of condition monitoring – General issues of condition monitoring – Main Components in a condition monitoring system – Condition monitoring techniques.

UNIT II  POWER TRANSFORMER CONDITION MONITORING 9

UNIT III  POWER GENERATION CONDITION MONITORING 9

UNIT IV  DIAGNOSTICS AND CONDITION MONITORING 9

UNIT V  INSULATION MATERIALS AND SYSTEMS 9
Outdoor insulation: Materials, ageing, diagnostic, polymeric materials, semi-conducting, Ceramic glazes – AC and impulse voltage flashover studies on a string of insulators – RIV and Corona Studies on insulator strings – High voltage testing – Dry, wet and pollution testing.

L: 45 TOTAL: 45 PERIODS

REFERENCES