Proposed Semester-wise B. Tech Curriculum Structure for EE

*Minimum credits: 160
Maximum credits: 165

1. Students from 5th semester and onwards may opt for inter-departmental courses in conformity with the work force requirements in the industries within the credit range.
2. Students may also opt for Massive Open Online Courses (MOOCs) for 20% of the total credit range in conformity with the concept of digital education.
3. For Open Elective courses: Students may opt for any course offered by the University from the preferable subjects enlisted in Table A. and recommended by the department, as per AICTE guidelines.
4. Students will undergo a summer training of 6 weeks after 6th semester during summer vacation and submit the report and the certificate of completion in the department in the beginning of 7th semester.

Semester-I

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For Program Elective – 1

EE 317 Electrical Machine Design

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**For Program Elective – 4 and Program Elective – 5**

EE 413  Wind and Solar Energy Systems  
EE 414  Electrical and Hybrid Vehicles  
EE 415  Power System Protection  
EE 416  HVDC Transmission Systems  
EE 417  Power Quality and FACTS  
EE 418  Power System Dynamics and Control

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**For Program Elective – 6**

EE 419  Advanced Electric Drives
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<td>Strength of Materials</td>
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<tr>
<td>12</td>
<td>OEC</td>
<td>Fluid Machinery</td>
<td>3</td>
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<tr>
<td>13</td>
<td>OEC</td>
<td>Automobile Engineering</td>
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<tr>
<td>14</td>
<td>OEC</td>
<td>Electrical Materials</td>
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<td>15</td>
<td>OEC</td>
<td>Modern Manufacturing Processes</td>
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</tr>
<tr>
<td>16</td>
<td>OEC</td>
<td>Internet of Things</td>
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<tr>
<td>17</td>
<td>OEC</td>
<td>Big Data Analysis</td>
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### Structure of Undergraduate Engineering program:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Topic</th>
<th>Credits as given in AICTE guidelines</th>
<th>Credits after revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Humanities and Social Sciences including Management</td>
<td>12</td>
<td>Eng (3) + Eco (3) + Acc &amp; Fin (3) + Managelec (3) = 12</td>
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<tr>
<td>2.</td>
<td>Basic Sciences</td>
<td>5.5 (Chem) + 4 (Maths I) + 5.5 (Physics) + (4+4) (Maths II &amp; III) + 3 (Bio) = 26</td>
<td>4 (Chem) + 4 (Maths I) + 5 (Physics) + (4+3) (Maths II &amp; III) + 3 (Bio) = 23</td>
</tr>
<tr>
<td>3.</td>
<td>Engineering Sciences including workshop, drawing, basics of electrical/mechanical/computer etc.</td>
<td>Programming or intro computing (5) + Workshop (3) + graphics (3) + BEE(5) + EM (4) = 20</td>
<td>Programming or intro computing (5) + Workshop (2) + graphics (3) + BEE(4) + EM (4) = 18</td>
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<td>4.</td>
<td>Professional Core Subjects</td>
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<td>5.</td>
<td>Professional Subjects: Subjects relevant to chosen specialization/branch</td>
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<td>6.</td>
<td>Open Subjects: Electives from other technical and/or emerging subjects</td>
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<td>7.</td>
<td>Project work, seminar and internship in industry or elsewhere</td>
<td>3+8 = 11</td>
<td>6+10 = 16</td>
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<td>8.</td>
<td>[Environmental Sciences, Induction Program, Indian Constitution, Essence of Indian Traditional Knowledge]</td>
<td>Non-credit</td>
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<td><strong>Total</strong></td>
<td>158</td>
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</table>
### Syllabus of B. Tech Curriculum Structure for EE as per AICTE guidelines 2018

*(All L, T, P's are in terms of hours per week)*

#### Semester-I

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Type Code</th>
<th>Course Name</th>
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<td>13</td>
<td>1</td>
<td>4</td>
<td>18</td>
<td>22</td>
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</tbody>
</table>

**Course Outcomes:**

At the end of this course, students will demonstrate the ability

- To understand and analyse basic electric and magnetic circuits.
- To study the working principles of electrical machines and power converters.
- To introduce the components of low-voltage electrical installations.

#### UNIT 1: DC Circuits (8 hours)


#### UNIT 2: AC Circuits (8 hours)

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.

#### UNIT 3: Transformers (6 hours)

Magnetic materials and magnetic circuits, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

#### UNIT 4: Electrical Machines (8 hours)

UNIT 5: Introduction to Semiconductor Devices (6 hours)
Semiconductor materials, Concept of energy band diagram and doping, Diode, special diodes, clipping and clamping circuits, rectifier circuits using diode, principle and working of BJT, MOSFET, Basic digital electronics concept.

UNIT 6: Electrical Installations (6 hours)
Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

Suggested Text / Reference Books

Course Outcomes
To understand and analyze basic electric and magnetic circuits
To study the working principles of electrical machines and semiconductor devices.
To introduce the components of low voltage electrical installations.

| EE 104 | Basic Engineering Laboratory | 0 | 0 | 1 | 1 | 2 |

List of Laboratory Experiments/Demonstrations:


2. Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a storage oscilloscope).

3. Transformers: Observation of the no-load current waveform on an oscilloscope (nonsinusoidal wave-shape due to B-H curve nonlinearity should be shown along with a discussion about harmonics). Loading of a transformer: measurement of primary and secondary voltages and currents, and power.

4. Three-phase transformers: Star and Delta connections. Voltage and Current relationships (line-line voltage, phase-to-neutral voltage, line and phase currents).

Phase-shifts between the primary and secondary side. Cumulative three-phase power in balanced three-phase circuits.

5. Demonstration of cut-out sections of machines: dc machine (commutator-brush arrangement), induction machine (squirrel cage rotor), synchronous machine (field winging - slip ring arrangement) and single-phase induction machine.

6. Torque Speed Characteristic of separately excited dc motor.


8. Synchronous Machine operating as a generator: stand-alone operation with a load. Control of voltage through field excitation.

9. Demonstration of characteristic of different diode, Input output characteristic of BJT, MOSFET. Basic structure of clipping clamping circuit.

**Course Outcomes**

To familiarize with the basic electrical/electronic equipment/component and its working with its operation characteristic.
To develop an ability to identify, formulate and solve problems related to basic Electrical Engineering.
To develop an ability to design, perform, analyze and interpret experiment/experimental result on Network/Circuit Theory/Electrical Machines/BJT/MOSFET
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Type Code</th>
<th>Course Name</th>
<th>L</th>
<th>T</th>
<th>P</th>
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<td>Physics-II</td>
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<td>9.</td>
<td>MS 105</td>
<td>Mathematics-II</td>
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<td>CE 103</td>
<td>Engineering Graphics</td>
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<td>Computing Lab</td>
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<td>6</td>
<td><strong>20</strong></td>
<td><strong>26</strong></td>
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</tbody>
</table>
AIM
To learn about the basics of analysis and synthesis techniques used in electric circuits.

OBJECTIVES AND OUTCOMES:
• To study about various network theorems and analysis methods.
• To apply network theorems for analysis of electrical circuits.
• To understand the concept of transient and steady state response of electrical circuits
• To analyse circuits in sinusoidal steady state (1 ph and 3 phase systems).
• To analyse two port network circuits and apply them for solving circuit problems

UNIT 1: Network Theorems (10 Hours):

UNIT 2: Analysis of 1st and 2nd order networks (8 hours):

UNIT 3: Sinusoidal Steady state response (8 hours):

UNIT 4: Laplace Transform and its application in Electrical Circuit Analysis (8 hours):


UNIT 5: Two port networks (6 hours):

Network Elements – Classification of Network – Network Configuration – Parameters and Transfer Function – Z, Y, hybrid, ABCD parameters – Condition for Reciprocity and Symmetry – Inter-relationships between Parameters of Two-Port Networks – Types of Interconnections: series, parallel and cascaded.

TEXT BOOKS:

REFERENCE BOOKS:

| EC 201 | Electronics devices | 3 | 0 | 0 | 3 | 3 |


Generation and recombination of carriers; Poisson and continuity equation P-N junction characteristics, I-V characteristics, and small signal switching models; Avalanche breakdown, Zener diode, Schottky diode.
Bipolar Junction Transistor, I-V characteristics, Ebers-Moll Model, MOS capacitor, C-V characteristics, MOSFET, I-V characteristics, and small signal models of MOS transistor, LED, photodiode and solar cell;

Integrated circuit fabrication process: oxidation, diffusion, ion implantation, photolithography, etching, chemical vapor deposition, sputtering, twin-tub CMOS process.

**Text/Reference Books:**


**Course Outcomes:**

At the end of this course students will demonstrate the ability to
1. Understand the principles of semiconductor Physics
2. Understand and utilize the mathematical models of semiconductor junctions and MOS transistors for circuits and systems

<table>
<thead>
<tr>
<th>EC 202</th>
<th>Electronic Devices Lab</th>
<th>0</th>
<th>0</th>
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</thead>
</table>

Experiments using bipolar junction transistor (BJT) and Field effect transistor: Single and Multistage amplifier’s frequency response, JFET’s characteristics, MOSFET’s characteristics, differential amplifier’s frequency response, simulation using SPICE.

<table>
<thead>
<tr>
<th>EE 214</th>
<th>Electrical Machines-I</th>
<th>3</th>
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<th>0</th>
<th>3</th>
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</table>

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the concepts of magnetic circuits. Understand the operation of dc machines.
- Analyse the differences in operation of different dc machine configurations. Analyse single phase and three phase transformers circuits.

**UNIT 1: Magnetic fields and magnetic circuits (6 Hours)**
Review of magnetic circuits - MMF, flux, reluctance, inductance; review of Ampere Law and Biot Savart Law; Visualization of magnetic fields produced by a bar magnet and a current carrying coil - through air and through a combination of iron and air; influence of highly permeable materials on the magnetic flux lines.

UNIT 2: Electromagnetic force and torque (9 Hours)
B-H curve of magnetic materials; flux-linkage vs current characteristic of magnetic circuits; linear and nonlinear magnetic circuits; energy stored in the magnetic circuit; force as a partial derivative of stored energy with respect to position of a moving element; torque as a partial derivative of stored energy with respect to angular position of a rotating element. Examples - galvanometer coil, relay contact, lifting magnet, rotating element with eccentricity or saliency

UNIT 3: DC machines (8 Hours)
Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

UNIT 4: DC machine - motoring and generation (7 Hours)
Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited, shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines

UNIT 5: Transformers (12 Hours)

Text / References:

<table>
<thead>
<tr>
<th>EE 215</th>
<th>Electrical Laboratory-I Machines</th>
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Hands-on experiments related to the course contents of EE 214.

<table>
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<th>EC 205</th>
<th>Signals and Systems</th>
<th>3</th>
<th>0</th>
<th>0</th>
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</thead>
</table>

Signals and systems as seen in everyday life, and in various branches of engineering and science.

Energy and power signals, continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity; additivity and homogeneity, shift-invariance, causality, stability, realizability.


Periodic and semi-periodic inputs to an LSI system, the notion of a frequency response and its relation to the impulse response, Fourier series representation, the Fourier Transform, convolution/multiplication and their effect in the frequency domain, magnitude and phase response, Fourier domain duality. The Discrete-Time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT). Parseval's Theorem. The idea of signal space and orthogonal bases,

The Laplace Transform, notion of eigen functions of LSI systems, a basis of eigen functions, region of convergence, poles and zeros of system, Laplace domain analysis, solution to differential equations and system behavior.

The z-Transform for discrete time signals and systems- eigen functions, region of convergence, z-domain analysis.

Text/Reference books:


Course outcomes:

At the end of this course students will demonstrate the ability to

1. Analyze different types of signals
2. Represent continuous and discrete systems in time and frequency domain using different transforms
3. Investigate whether the system is stable
4. Sampling and reconstruction of a signal

Semester-IV

<table>
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<tr>
<th>Sl. No.</th>
<th>Course Type Code</th>
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</table>
Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand working of logic families and logic gates.
- Design and implement Combinational and Sequential logic circuits.
- Understand the process of Analog to Digital conversion and Digital to Analog conversion.
- Be able to use PLDs to implement the given logical problem.

UNIT 1: Fundamentals of Digital Systems and logic families (7Hours)
Digital signals, digital circuits, AND, OR, NOT, NAND, NOR and Exclusive-OR operations, Boolean algebra, examples of IC gates, number systems—binary, signed binary, octal hexadecimal number, binary arithmetic, one’s and two’s complements arithmetic, codes, error detecting and correcting codes, characteristics of digital ICs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

UNIT 2: Combinational Digital Circuits (7Hours)
Standard representation for logic functions, K-map representation, simplification of logic functions using K-map, minimization of logical functions. Don’t care conditions, Multiplexer, De-Multiplexer/Decoders, Adders, Subtractors, BCD arithmetic, carry look ahead adder, serial ladder, ALU, elementary ALU design, popular MSI chips, digital comparator, parity checker/generator, code converters, priority encoders, decoders/drivers for display devices, Q-M method of function realization.

UNIT 3: Sequential circuits and systems (7Hours)
A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J-K-T flipflops, applications of flipflops, shift registers, applications of shift registers, parallel to serial converter, parallel to serial converter, ring counter, sequence generator, ripple (Asynchronous) counters, synchronous counters, counters design using flipflops, special counter IC’s, asynchronous sequential counters, applications of counters.

UNIT 4: A/D and D/A Converters (7Hours)
Digital to analog converters: weighted resistor/converter, R-2R Ladder D/A converter, specifications for D/A converters, examples of D/A converter IC’s, sample and hold circuit, analog to digital converters: quantization and encoding, parallel comparator A/D converter, successive approximation A/D converter, counting A/D.
converter, dual slope A/D converter, A/D converter using voltage to frequency and voltage to time conversion, specifications of A/D converters, example of A/D converter ICs

UNIT 5: Semiconductor memories and Programmable logic devices. (7 Hours) Memory organization and operation, expanding memory size, classification and characteristics of memories, sequential memory, read only memory (ROM), read and write memory (RAM), content addressable memory (CAM), charge de coupled device memory (CCD), commonly used memory chips, ROM as a PLD, Programmable logic array, Programmable array logic, complex Programmable logic devices (CPLDS), Field Programmable Gate Array (FPGA).

Text/References:


<table>
<thead>
<tr>
<th>EE 218</th>
<th>Digital ElectronicsLaboratory</th>
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Hands-on experiments related to the course contents of EE07.

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<th>EE 219</th>
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</table>

Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the concepts of rotating magnetic fields.
- Understand the operation of ac machines.
- Analyse performance characteristics of ac machines.

UNIT 1: Fundamentals of AC machine windings (8 Hours)

Physical arrangement of windings in stator and cylindrical rotor; slots for windings; single turn coil - active portion and overhang; full-pitch coils, concentrated winding, distributed winding, winding axis, 3D visualization of the above winding types, Air-gap MMF distribution with fixed current through winding - concentrated and distributed, sinusoidally distributed winding, winding distribution factor

UNIT 2: Pulsating and revolving magnetic fields (4 Hours)

Constant magnetic field, pulsating magnetic field - alternating current in windings with spatial displacement, Magnetic field produced by a single winding - fixed current and alternating current
Pulsating fields produced by spatially displaced windings, Windings spatially shifted by 90 degrees, Addition of pulsating magnetic fields, Three windings spatially shifted by 120 degrees (carrying three-phase balanced currents), revolving magnetic field.

UNIT 3: Induction Machines (12 Hours)

Construction, Types (squirrel cage and slip-ring), Torque Slip Characteristics, Starting and Maximum Torque, Equivalent circuit, phasor Diagram, Losses and Efficiency, Effect of parameter variation on torque speed characteristics (variation of rotor and stator resistances, stator voltage, frequency), Methods of starting, braking and speed control for induction motors, Generator operation, Self-excitation, Doubly-Fed Induction Machines.

UNIT 4: Single-phase induction motors (6 Hours)

Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications

UNIT 5: Synchronous machines (10 Hours)

Constructional features, cylindrical rotor synchronous machine - armature reaction, generated EMF, equivalent circuit and phasor diagram, synchronous impedance, open circuit characteristic, short circuit characteristics, Zero power factor characteristics; Potier Triangle; voltage regulation, Salient pole machine – two reaction theory, analysis of phasor diagram, Power flow equation, power angle characteristics, Parallel operation of alternators - synchronization and load division, Effect of change of excitation and mechanical input, Generator capability curve. Starting of synchronous motor, Damper winding, Operating characteristics of synchronous machines, Effect of variation of field excitation and load; Mechanical Power, V and Inverted V curves, Hunting.

Text/References:

Hands-on experiments related to the course contents of EE 219

| EC 211 | Microcontroller and Microprocessor | 3 | 0 | 0 | 3 | 3 |

Overview of microcomputer systems and their building blocks, memory interfacing, concepts of interrupts and Direct Memory Access, instruction sets of microprocessors (with examples of 8085 and 8086);

Interfacing with peripherals - timer, serial I/O, parallel I/O, A/D and D/A converters; Arithmetic Coprocessors; System level interfacing design;

Concepts of virtual memory, Cache memory, Advanced co-processor Architectures- 286, 486, Pentium; Microcontrollers: 8051 systems,

Introduction to RISC processors; ARM microcontrollers interface designs.

Text/Reference Books:


Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Do assembly language programming
2. Do interfacing design of peripherals like, I/O, A/D, D/A, timer etc.
3. Develop systems using different microcontrollers
4. Understand RSIC processors and design ARM microcontroller based systems

| EC 212 | Microcontroller Lab | 0 | 0 | 1 | 1 | 2 |

Assembly language programming for 8085/8086: interfacing of 8085/8086: memory interfacing. Design of I/O modules and interfacing of different peripherals, parallel interfacing using A/D and D/A converters; 8051 based control of stepper motor.

Programming in Ardino UNO, peak and arm processor
Course Outcomes:
At the end of the course, students will demonstrate the ability
- To understand the basic laws of electromagnetism.
- To obtain the electric and magnetic fields for simple configurations under static conditions.
- To analyse time varying electric and magnetic fields.
- To understand Maxwell’s equation in different forms and different media.
- To understand the propagation of EM waves.

This course shall have Lectures and Tutorials. Most of the students find difficult to visualize electric and magnetic fields. Instructors may demonstrate various simulation tools to visualize electric and magnetic fields in practical devices like transformers, transmission lines and machines.

UNIT 1: Review of Vector Calculus (6 hours)
Vector algebra - addition, subtraction, components of vectors, scalar and vector multipliers, triple products, three orthogonal coordinate systems (rectangular, cylindrical and spherical). Vector calculus - differentiation, partial differentiation, integration, vector operators del, gradient, divergence and curl; integral theorems of vectors. Conversion of a vector from one coordinate system to another.

UNIT 2: Static Electric Field (6 Hours)

UNIT 3: Conductors, Dielectrics and Capacitance (6 Hours)
Current and current density, Ohms Law in Point form, Continuity of current, Boundary conditions of perfect dielectric materials. Permittivity of dielectric materials, Capacitance, Capacitance of a two wire line, Poisson’s equation, Laplace’s equation, Solution of Laplace and Poisson’s equation, Application of Laplace’s and Poisson’s equations.

UNIT 4: Static Magnetic Fields (6 Hours)

UNIT 5: Magnetic Forces, Materials and Inductance (6 Hours)

UNIT 6: Time Varying Fields and Maxwell’s Equations (6 Hours)
Faraday’s law for Electromagnetic induction, Displacement current, Point form of Maxwell’s equation, Integral form of Maxwell’s equations, Motional Electromotive forces. Boundary Conditions.

UNIT 7: Electromagnetic Waves (6 Hours)
Derivation of Wave Equation, Uniform Plane Waves, Maxwell’s equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossy dielectrics, Propagation in good conductors, Skin effect. Poynting theorem.

Text / References:
<table>
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<tr>
<th>Sl. No.</th>
<th>Course Type Code</th>
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</table>

**For Program Elective – 1**
EE317 Electrical Machine Design

*For Open Elective – 2:* Any course offered by the University from the preferable subjects enlisted in Table A. and recommended by the department, as per AICTE guidelines.

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**EE 311 | Power Systems-I | 3 | 0 | 0 | 3 | 3**

**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
- Understand the concepts of power systems.
- Understand the various power system components.
- Evaluate fault currents for different types of faults.
- Understand the generation of over-voltages and insulation coordination.
- Understand basic protection schemes.
- Understand concepts of HVdc power transmission and renewable energy generation.

**UNIT 1: Basic Concepts (4 hours)**

**UNIT 2: Power System Components (15 hours)**
Overhead Transmission Lines and Cables: Electrical and Magnetic Fields around conductors, Corona. Parameters of lines and cables. Capacitance and Inductance calculations for simple


UNIT 3: Over-voltages and Insulation Requirements (4 hours)

UNIT 4: Fault Analysis and Protection Systems (10 hours)

UNIT 5: Introduction to DC Transmission & Renewable Energy Systems (9 hours)

Text/References:
Hands-on experiments related to the course contents of EE 311. Visits to power system installations (generation stations, EHV substations etc.) are suggested. Exposure to fault analysis and Electro-magnetic transient program (EMTP) and Numerical Relays are suggested.

| EE 313 | Control Systems | 3 | 0 | 0 | 3 | 3 |

**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
- Understand the modelling of linear-time-invariant systems using transfer function and state-space representations.
- Understand the concept of stability and its assessment for linear-time invariant systems.
- Design simple feedback controllers.

**UNIT 1: Introduction to control problem (4 hours)**
Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems.

**UNIT 2: Time Response Analysis (10 hours)**


**UNIT 3: Frequency-response analysis (6 hours)**

**UNIT 4: Introduction to Controller Design (10 hours)**
Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems.
Root-loci method of feedback controller design.

**UNIT 5: State variable Analysis (6 hours)**

UNIT 6: Introduction to Optimal Control and Nonlinear Control (5 hours)

Text/References:

**EE 314** Control Systems Laboratory

Hands-on/Computer experiments related to the course contents of EE 313.

**EE 315** Power Electronics

Aim: The course discusses introductory topics in power electronics for the UG level students of electrical engineering

Course Outcomes:
At the end of this course students will demonstrate the ability to
- Understand the differences between signal level and power level devices.
- Analyse controlled rectifier circuits.
- Analyse the operation of DC-DC choppers.
- Analyse the operation of voltage source inverters.

UNIT I: Power Switching Devices: (8 Hours):
Power Diodes – General Purpose, Fast Recovery, Schottky Diode; BJT, MOSFET, SCR, IGBT and their V-I characteristics; SCR: Operating Principle, Gate Characteristics, Two-Transistor model, di/dt and dv/dt Protection, Firing circuits, series and parallel operation, rating, selection; Thyristor Triggering techniques; Thyristor Commutation techniques; Snubber circuits. Gate Drives for MOSFET and IGBT

UNIT II: Thyristor Rectifiers (8 hours):
1-ϕ and 3-ϕ semi, half-wave, dual and full-wave controlled rectifiers with R and RL loads; freewheeling diode; detailed derivation of rms, average value, harmonic factor, THD, crest factor; half wave and full wave controlled rectifiers; Input current wave shape and power factor; Effect of Source impedance.

UNIT III: DC-DC Converters (10 Hours):

Principle; Elementary step-up and step-down choppers; concept of duty ratio and average voltage classification; power circuits of buck, boost and buck-boost converters, analysis and waveforms at steady state; control of duty ratio and the output; CCM and DCM modes of operation.

UNIT IV: DC-AC Converters/Inverter (single phase) (10 Hours):

Power Circuits of single-phase voltage source inverter; Concepts of switched mode inverters; Square wave operation; PWM switching; Series and parallel inverters; Concept of average voltage over a switching cycle; modulation; modulation index; modulation techniques.

UNIT V: DC-AC Converters/Inverter (Three phase) (8 Hours):

3-ϕ half bridge and full bridge inverter with R and RL loads; 120° & 180° degree conduction; harmonics reduction; Three phase sinusoidal modulation; Current source inverter; Zero current switching (ZCS); Zero voltage Switching (ZVS); Introduction of resonant inverters.

TEXT BOOKS:


REFERENCES:


<table>
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<tr>
<th>EE 316</th>
<th>Power ElectronicsLaboratory</th>
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</table>

Hands-on experiments related to the course contents of EE 315
Course Outcomes:
At the end of this course, students will demonstrate the ability to
• Understand the construction and performance characteristics of electrical machines.
• Understand the various factors which influence the design: electrical, magnetic and thermal loading of electrical machines.
• Understand the principles of electrical machine design and carry out a basic design of an ac machine.
• Use software tools to do design calculations.

UNIT 1: Introduction
Major considerations in electrical machine design, electrical engineering materials, space factor, choice of specific electrical and magnetic loadings, thermal considerations, heat flow, temperature rise, rating of machines.

UNIT 2: Transformers
Sizing of a transformer, main dimensions, kVA output for single- and three-phase transformers, window space factor, overall dimensions, operating characteristics, regulation, no load current, temperature rise in transformers, design of cooling tank, methods for cooling of transformers.

UNIT 3: Induction Motors
Sizing of an induction motor, main dimensions, length of air gap, rules for selecting rotor slots of squirrel cage machines, design of rotor bars & slots, design of end rings, design of wound rotor, magnetic leakage calculations, leakage reactance of polyphase machines, magnetizing current, short circuit current, circle diagram, operating characteristics.

UNIT 4: Synchronous Machines
Sizing of a synchronous machine, main dimensions, design of salient pole machines, short circuit ratio, shape of pole face, armature design, armature parameters, estimation of air gap length, design of rotor, design of damper winding, determination of full load field mmf, design of field winding, design of turbo alternators, rotor design.

UNIT 5: Computer aided Design (CAD):
Limitations (assumptions) of traditional designs, need for CAD analysis, synthesis and hybrid methods, design optimization methods, variables, constraints and objective function, problem formulation. Introduction to FEM based machine design. Introduction to complex structures of modern machines-PMSMs, BLDCs, SRM and claw-pole machines.

Text / References:
7. Electrical machines and equipment design exercise examples using Ansoft’s Maxwell 2D machine design package
Semester-VI

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For Program Elective – 2 and Program Elective – 3

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<td>EE 324</td>
<td>Electrical Drives</td>
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<td>EE 325</td>
<td>High Voltage Engineering</td>
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<td>EE 326</td>
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<td>EE 332</td>
<td>Computational Electromagnetics</td>
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<td>EE 333</td>
<td>Control Systems Design</td>
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*For Open Elective – 3: Any course offered by the University from the preferable subjects enlisted in Table A. and recommended by the department, as per AICTE guidelines.

EE 318       | Power Systems – II | 3L:0T:0P | 3 credits

Course Outcomes:
At the end of this course, students will demonstrate the ability to
Use numerical methods to analyse a power system in steady state.
Understand stability constraints in a synchronous grid.
Understand methods to control the voltage, frequency and power flow.
Understand the monitoring and control of a power system.
Understand the basics of power system economics

UNIT 1: Power Flow Analysis (7 hours)

UNIT 2: Stability Constraints in synchronous grids (8 hours)

UNIT 3: Control of Frequency and Voltage (7 hours)

UNIT 4: Monitoring and Control (6 hours)

UNIT 5: Power System Economics and Management (7 hours)

Text/References:
EE 319  Power Systems-II Laboratory  (0:0:1 – 1 credit)
Hands-on and computational experiments related to the course contents of EE20. This should include programming of numerical methods for solution of the power flow problem and stability analysis. Visit to load dispatch centre is suggested.

EE320  Measurements and Instrumentation Laboratory  2L:0T:2P  4 credits

Lectures/Demonstrations:
3. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation, $C_p$, $C_{pk}$.
7. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
8. Digital Storage Oscilloscope.

Experiments

2. Measurement of L using a bridge technique as well as LCR meter.
3. Measurement of C using a bridge technique as well as LCR meter.
7. Download of one-cycle data of a periodic waveform from a DSO and use values to compute the RMS values using a C program.
8. Usage of DSO to capture transients like a step change in R-L-C circuit.
Course Outcomes:
At the end of the course, students will demonstrate the ability to
- Understand the practical issues related to practical implementation of applications using electronic circuits.
- Choose appropriate components, software and hardware platforms.
- Design a Printed Circuit Board, get it made and populate/solder it with components.
- Work as a team with other students to implement an application.

Basic concepts on measurements; Noise in electronic systems; Sensors and signal conditioning circuits; Introduction to electronic instrumentation and PC based data acquisition; Electronic system design, Analog system design, Interfacing of analog and digital systems, Embedded systems, Electronic system design employing microcontrollers, CPLDs, and FPGAs, PCB design and layout; System assembly considerations. Group projects involving electronic hardware (Analog, Digital, mixed signal) leading to implementation of an application.

Text/Reference Books

For Program Elective – 2 and Program Elective – 3

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<tr>
<th>EE 323</th>
<th>Line-Commutated and Active PWM Rectifiers</th>
<th>3L:0T:0P</th>
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Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Analyze controlled rectifier circuits.
- Understand the operation of line-commutated rectifiers – 6 pulse and multi-pulse configurations.
- Understand the operation of PWM rectifiers – operation in rectification and regeneration modes and lagging, leading and unity power factor mode.

UNIT 1: Diode rectifiers with passive filtering (6 Hours)
Half-wave diode rectifier with RL and RC loads; 1-phase full-wave diode rectifier with L, C and LC filter; 3-phase diode rectifier with L, C and LC filter; continuous and discontinuous conduction, input current waveshape, effect of source inductance; commutation overlap.

UNIT 2: Thyristor rectifiers with passive filtering (6 Hours)
Half-wave thyristor rectifier with RL and RC loads; 1-phase thyristor rectifier with L and LC filter; 3-phase thyristor rectifier with L and LC filter; continuous and discontinuous conduction, input current waveshape.

UNIT 3: Multi-Pulse converter (6 Lectures)
Review of transformer phase shifting, generation of 6-phase ac voltage from 3-phase ac, 6-pulse converter and 12-pulse converters with inductive loads, steady state analysis, commutation overlap, notches during commutation.

UNIT 4: Single-phase ac-dc single-switch boost converter (6 Hours)
Review of dc-dc boost converter, power circuit of single-switch ac-dc converter, steady state analysis, unity power factor operation, closed-loop control structure.

UNIT 5: Ac-dc bidirectional boost converter (6 Hours)
Review of 1-phase inverter and 3-phase inverter, power circuits of 1-phase and 3-phase ac-dc boost converter, steady state analysis, operation at leading, lagging and unity power factors. Rectification and regenerating modes. Phasor diagrams, closed-loop control structure.

UNIT 6: Isolated single-phase ac-dc flyback converter (10 Hours)
Dc-dc flyback converter, output voltage as a function of duty ratio and transformer turns ratio. Power circuit of ac-dc flyback converter, steady state analysis, unity power factor operation, closed loop control structure.

Text / References:

EE 324 Electrical Drives: 3 0 0 3 3

Aim: The course discusses introductory topics in electrical drives for the UG level students of electrical engineering

Objectives:
- To learn the characteristics of dc motor and induction motor drives
- To study about the speed control of DC motor and Induction motor drives.
- To study the various power electronic converters used in DC motor and Induction motor drives and their control techniques.

UNIT 1: DC motor Characteristics: (5 hours)
Review of emf and torque equations of DC machine, review of torque-speed characteristics of separately excited dc motor, change in torque-speed curve with armature voltage, example
load torque-speed characteristics, operating point, armature voltage control for varying motor speed, flux weakening for high speed operation.

**UNIT II: Chopper fed DC drive (5 hours)**

Review of dc chopper and duty ratio control, chopper fed dc motor for speed control, steady state operation of a chopper fed drive, armature current waveform and ripple, calculation of losses in dc motor and chopper, efficiency of dc drive, smooth starting.

**UNIT III: Multi-quadrant DC drive (6 hours)**

Review of motoring and generating modes operation of a separately excited dc machine, four quadrant operation of dc machine; single-quadrant, two-quadrant and four-quadrant choppers; steady-state operation of multi-quadrant chopper fed dc drive, regenerative braking.

**UNIT IV: Closed-loop control of DC Drive (6 hours)**

Control structure of DC drive, inner current loop and outer speed loop, dynamic model of dc motor – dynamic equations and transfer functions, modeling of chopper as gain with switching delay, plant transfer function, for controller design, current controller specification and design, speed controller specification and design.

**UNIT V: Induction motor characteristics (6 hours)**

Review of induction motor equivalent circuit and torque-speed characteristic, variation of torque-speed curve with (i) applied voltage, (ii) applied frequency and (iii) applied voltage and frequency, typical torque-speed curves of fan and pump loads, operating point, constant flux operation, flux weakening operation.

**UNIT VI: Scalar control or constant V/f control of induction motor (6 hours)**

Review of three-phase voltage source inverter, generation of three-phase PWM signals, sinusoidal modulation, space vector theory, conventional space vector modulation; constant V/f control of induction motor, steady-state performance analysis based on equivalent circuit, speed drop with loading, slip regulation.

**UNIT VII: Control of slip ring induction motor (6 hours)**

Impact of rotor resistance of the induction motor torque-speed curve, operation of slip-ring
induction motor with external rotor resistance, starting torque, power electronic based rotor side control of slip ring motor, slip power recovery.

TEXT BOOKS:


REFERENCES:


<table>
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<th>EE 325</th>
<th>High Voltage Engineering</th>
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Course outcomes:
At the end of the course, the student will demonstrate
- Understand the basic physics related to various breakdown processes in solid, liquid and gaseous insulating materials.
- Knowledge of generation and measurement of D. C., A.C., & Impulse voltages.
- Knowledge of tests on H. V. equipment and on insulating materials, as per the standards.
- Knowledge of how over-voltages arise in a power system, and protection against these over-voltages.

UNIT 1: Breakdown in Gases (8 Hours)
Ionization processes and de-ionization processes, Types of Discharge, Gases as insulating materials, Breakdown in Uniform gap, non-uniform gaps, Townsend’s theory, Streamer mechanism, Corona discharge

UNIT 2: Breakdown in liquid and solid Insulating materials (7 Hours)
Breakdown in pure and commercial liquids, Solid dielectrics and composite dielectrics, intrinsic breakdown, electromechanical breakdown and thermal breakdown, Partial discharge, applications of insulating materials.

UNIT 3: Generation of High Voltages (7 Hours)
Generation of high voltages, generation of high D. C. and A.C. voltages, generation of impulse voltages, generation of impulse currents, tripping and control of impulse generators.
UNIT 4: Measurements of High Voltages and Currents (7 Hours)
Peak voltage, impulse voltage and high direct current measurement method, cathode ray oscillographs for impulse voltage and current measurement, measurement of dielectric constant and loss factor, partial discharge measurements.

UNIT 5: Lightning and Switching Over-voltages (7 Hours)
Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diveters, Surge modifiers.

UNIT 6: High Voltage Testing of Electrical Apparatus and High Voltage Laboratories (7 Hours)
Various standards for HV Testing of electrical apparatus, IS, IEC standards, Testing of insulators and bushings, testing of isolators and circuit breakers, testing of cables, power transformers and some high voltage equipment, High voltage laboratory layout, indoor and outdoor laboratories, testing facility requirements, safety precautions in H. V. Labs.

Text/Reference Books
6. Various IS standards for HV Laboratory Techniques and Testing

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<th>EE 326</th>
<th>Electrical Energy Conservation and Auditing</th>
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Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the current energy scenario and importance of energy conservation.
- Understand the concepts of energy management.
- Understand the methods of improving energy efficiency in different electrical systems.
- Understand the concepts of different energy efficient devices.

UNIT 1: Energy Scenario (6 Hours)
Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy

UNIT 2: Basics of Energy and its various forms (7 Hours)
Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT 3: Energy Management & Audit (6 Hours)
Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

UNIT 4: Energy Efficiency in Electrical Systems (7 Hours)

UNIT 5: Energy Efficiency in Industrial Systems (8 Hours)
Compressed Air System: Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, leakage test, factors affecting the performance and savings opportunities in HVAC, Fans and blowers: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

UNIT 6: Energy Efficient Technologies in Electrical Systems (8 Hours)
Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

Text/Reference Books
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
Course Outcomes:

At the end of this course, students will demonstrate the ability to

Understand the electrical wiring systems for residential, commercial and industrial consumers, representing the systems with standard symbols and drawings, SLD.

Understand various components of industrial electrical systems.

Analyze and select the proper size of various electrical system components.

UNIT 1: Electrical System Components (8 Hours)

LT system wiring components, selection of cables, wires, switches, distribution box, metering system, Tariff structure, protection components- Fuse, MCB, MCCB, ELCB, inverse current characteristics, symbols, single line diagram (SLD) of a wiring system, Contactor, Isolator, Relays, MPCB, Electric shock and Electrical safety practices

UNIT 2: Residential and Commercial Electrical Systems (8 Hours)

Types of residential and commercial wiring systems, general rules and guidelines for installation, load calculation and sizing of wire, rating of main switch, distribution board and protection devices, earthing system calculations, requirements of commercial installation, deciding lighting scheme and number of lamps, earthing of commercial installation, selection and sizing of components.

UNIT 3: Illumination Systems (6 Hours)

Understanding various terms regarding light, lumen, intensity, candle power, lamp efficiency, specific consumption, glare, space to height ratio, waste light factor, depreciation factor, various illumination schemes, Incandescent lamps and modern luminaries like CFL, LED and their operation, energy saving in illumination systems, design of a lighting scheme for a residential and commercial premises, flood lighting.

UNIT 4: Industrial Electrical Systems I (8 Hours)

HT connection, industrial substation, Transformer selection, Industrial loads, motors, starting of motors, SLD, Cable and Switchgear selection, Lightning Protection, Earthing design, Power factor correction – kVAR calculations, type of compensation, Introduction to PCC, MCC panels. Specifications of LT Breakers, MCB and other LT panel components.

UNIT 5: Industrial Electrical Systems II (6 Hours)

DG Systems, UPS System, Electrical Systems for the elevators, Battery banks, Sizing the DG, UPS and Battery Banks, Selection of UPS and Battery Banks.

UNIT 6: Industrial Electrical System Automation (6 Hours)

Study of basic PLC, Role of in automation, advantages of process automation, PLC based control system design, Panel Metering and Introduction to SCADA system for distribution automation.
Text/Reference Books
4. Web site for IS Standards.

<table>
<thead>
<tr>
<th>EE 328</th>
<th>Digital Control Systems</th>
<th>3L:0T:0P</th>
<th>3 credits</th>
</tr>
</thead>
</table>

Course Outcomes:

At the end of this course, students will demonstrate the ability to
Obtain discrete representation of LTI systems.
   Analyse stability of open loop and closed loop discrete-time systems.
   Design and analyse digital controllers.
Design state feedback and output feedback controllers.

UNIT 1: Discrete Representation of Continuous Systems (6 hours)

UNIT 2: Discrete System Analysis (6 hours)

UNIT 3: Stability of Discrete Time System (4 hours)

UNIT 4: State Space Approach for discrete time systems (10 hours)

UNIT 5: Design of Digital Control System(8 hours)

UNIT 6: Discrete output feedback control (8 hours)
Design of discrete output feedback control. Fast output sampling (FOS) and periodic output feedback controller design for discrete time systems.
Text Books:


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<tr>
<td>EE 329</td>
<td>Digital Signal Processing</td>
<td>3L:0T:0P</td>
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**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
- Represent signals mathematically in continuous and discrete-time, and in the frequency domain.
- Analyse discrete-time systems using z-transform.
- Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.
- Design digital filters for various applications.
- Apply digital signal processing for the analysis of real-life signals.

**UNIT 1: Discrete-time signals and systems (6 hours)**
Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.

**UNIT 2: Z-transform (6 hours)**
z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.

**UNIT 2: Discrete Fourier Transform (10 hours)**

**UNIT 3: Design of Digital filters (12 hours)**

**UNIT 4: Applications of Digital Signal Processing (6 hours)**

Text/Reference Books:

| EE 330 | Computer Architecture | 3L:0T:0P | 3 credits |

Course Outcomes:
At the end of this course, students will demonstrate the ability to
Understand the concepts of microprocessors, their principles and practices.
Write efficient programs in assembly language of the 8086 family of microprocessors.
Organize a modern computer system and be able to relate it to real examples.
Develop the programs in assembly language for 80286, 80386 and MIPS processors in real and protected modes.
Implement embedded applications using ATOM processor.

UNIT 1: Introduction to computer organization (6 hours)
Architecture and function of general computer system, CISC Vs RISC, Data types, Integer Arithmetic - Multiplication, Division, Fixed and Floating point representation and arithmetic, Control unit operation, Hardware implementation of CPU with Micro instruction, microprogramming, System buses, Multi-bus organization.

UNIT 2: Memory organization (6 hours)
System memory, Cache memory - types and organization, Virtual memory and its implementation, Memory management unit, Magnetic Hard disks, Optical Disks.

UNIT 3: Input – output Organization (8 hours)

UNIT 4: 16 and 32 microprocessors (8 hours)
80x86 Architecture, IA – 32 and IA – 64, Programming model, Concurrent operation of EU and BIU, Real mode addressing, Segmentation, Addressing modes of 80x86, Instruction set of 80x86, I/O addressing in 80x86
UNIT 5: Pipelining(8 hours)
Introduction to pipelining, Instruction level pipelining (ILP), compiler techniques for ILP, Data hazards, Dynamic scheduling, Dependability, Branch cost, Branch Prediction, Influence on instruction set.

UNIT 6: Different Architectures (8 hours)
VLIW Architecture, DSP Architecture, SoC architecture, MIPS Processor and programming

Text/Reference Books

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Analyse transmission lines and estimate voltage and current at any point on transmission line for different load conditions.
- Provide solution to real life plane wave problems for various boundary conditions.
- Analyse the field equations for the wave propagation in special cases such as lossy and low loss dielectric media.
- Visualize TE and TM mode patterns of field distributions in a rectangular wave-guide.
- Understand and analyse radiation by antennas.

UNIT 1: Transmission Lines (6 hours)
Introduction, Concept of distributed elements, Equations of voltage and current, Standing waves and impedance transformation, Lossless and low-loss transmission lines, Power transfer on a transmission line, Analysis of transmission line in terms of admittances, Transmission line calculations with the help of Smith chart, Applications of transmission line, Impedance matching using transmission lines.

UNIT 2: Maxwell’s Equations (6 hours)
Basic quantities of Electromagnetics, Basic laws of Electromagnetics: Gauss’s law, Ampere’s Circuital law, Faraday’s law of Electromagnetic induction. Maxwell’s equations, Surface charge and surface current, Boundary conditions at media interface.

UNIT 3: Uniform Plane Wave (7 hours)
Homogeneous unbound medium, Wave equation for time harmonic fields, Solution of the wave equation, Uniform plane wave, Wave polarization, Wave propagation in conducting medium, Phase velocity of a wave, Power flow and Poynting vector.

UNIT 4: Plane Waves at Media Interface (7 hours)
Plane wave in arbitrary direction, Plane wave at dielectric interface, Reflection and refraction of waves at dielectric interface, Total internal reflection, Wave polarization at media interface, Brewster angle, Fields and power flow at media interface, Lossy media interface, Reflection from conducting boundary.

UNIT 5: Waveguides (7 hours)
Parallel plane waveguide: Transverse Electric (TE) mode, transverse Magnetic (TM) mode, Cut-off frequency, Phase velocity and dispersion. Transverse Electromagnetic (TEM) mode, Analysis of waveguide-general approach, Rectangular waveguides.

UNIT 6: Antennas (7 hours)
Radiation parameters of antenna, Potential functions, Solution for potential functions, Radiations from Hertz dipole, Near field, Far field, Total power radiated by a dipole, Radiation resistance and radiation pattern of Hertz dipole, Hertz dipole in receiving mode.

Text/Reference Books

| EE 332 | Computational Electromagnetics | 3L:0T:0P | 3 credits |

Course Outcomes:

At the end of this course, students will demonstrate the ability to
Understand the basic concepts of electromagnetics.
Understand computational techniques for computing fields. Apply the techniques to simple real-life problems.

UNIT 1: Introduction (6 hours)
Conventional design methodology, Computer aided design aspects – Advantages. Review of basic fundamentals of Electrostatics and Electromagnetics. Development of Helmholtz equation, energy transformer vectors- Poynting and Slepian, magnetic Diffusion-transients and time-harmonic.

UNIT 2: Analytical Methods (6 hours)
Analytical methods of solving field equations, method of separation of variables, Roth’s method, integral methods- Green’s function, method of images.

UNIT 3: Finite Difference Method (FDM) (7 hours)


UNIT 4: Finite Element Method (FEM) (7 hours)

Overview of FEM, Variational and Galerkin Methods, shape functions, lower and higher order elements, vector elements, 2D and 3D finite elements, efficient finite element computations.

UNIT 5: Special Topics(7 hours)

{Background of experimental methods-electrolytic tank, R-C network solution, Field plotting (graphical method)}, hybrid methods, coupled circuit - field computations, electromagnetic - thermal and electromagnetic - structural coupled computations, solution of equations, method of moments, Poisson’s fields.

UNIT 6: Applications (7 hours)

Low frequency electrical devices, static / time-harmonic / transient problems in transformers, rotating machines, actuators. CAD packages.

Text/Reference Books


<table>
<thead>
<tr>
<th>EE333</th>
<th>Control Systems Design</th>
<th>3L:0T:1P</th>
<th>4 credits</th>
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</thead>
</table>

Course Outcomes: At the end of this course, students will demonstrate the ability to

- Understand various design specifications.
- Design controllers to satisfy the desired design specifications using simple controller structures (P, PI, PID, compensators).
- Design controllers using the state-space approach.

UNIT 1: Design Specifications (6 hours)

Introduction to design problem and philosophy. Introduction to time domain and frequency domain design specification and its physical relevance. Effect of gain on transient and steady state response. Effect of addition of pole on system performance. Effect of addition of zero on system response.
UNIT 2: Design of Classical Control System in the time domain (8 hours)

UNIT 3: Design of Classical Control System in frequency domain (8 hours)
Compensator design in frequency domain to improve steady state and transient response. Feedback and Feed forward compensator design using bode diagram.

UNIT 4: Design of PID controllers (6 hours)
Design of P, PI, PD and PID controllers in time domain and frequency domain for first, second and third order systems. Control loop with auxiliary feedback – Feed forward control.

UNIT 5: Control System Design in state space (8 hours)

UNIT 6: Nonlinearities and its effect on system performance (3 hours)

Text and Reference Books:

Control Systems Design Laboratory
Hands on experiments as per the contents of EE 333

<table>
<thead>
<tr>
<th>EE 322</th>
<th>Summer Industry Internship</th>
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</table>

Minimum of six weeks in an Industry in the area of Electrical Engineering. The summer internship should give exposure to the practical aspects of the discipline. In addition, the student may also work on a specified task or project which may be assigned to him/her. The outcome of the internship should be presented in the form of a report.
**Semester-VII**

<table>
<thead>
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**For Program Elective – 4 and Program Elective – 5**

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<td>EE 413</td>
<td>Wind and Solar Energy Systems</td>
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<td>EE 414</td>
<td>Electrical and Hybrid Vehicles</td>
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<td>EE 415</td>
<td>Power System Protection</td>
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<td>EE 416</td>
<td>HVDC Transmission Systems</td>
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<td>EE 417</td>
<td>Power Quality and FACTS</td>
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<tr>
<td>EE 418</td>
<td>Power System Dynamics and Control</td>
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</tbody>
</table>

*For Open Elective – 4 and Open Elective – 5:* Any course offered by the University from the preferable subjects enlisted in Table A. and recommended by the department, as per AICTE guidelines.

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to
- Understand the energy scenario and the consequent growth of the power generation from renewable energy sources.
- Understand the basic physics of wind and solar power generation.
- Understand the power electronic interfaces for wind and solar generation.
- Understand the issues related to the grid-integration of solar and wind energy systems.

**UNIT 1: Physics of Wind Power: (5 Hours)**

History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

**UNIT 2: Wind generator topologies: (12 Hours)**

Review of modern wind turbine technologies, Fixed and Variable speed wind turbines, Induction Generators, Doubly-Fed Induction Generators and their characteristics, Permanent-
Magnet Synchronous Generators, Power electronics converters. Generator-Converter configurations, Converter Control.

**UNIT 3: The Solar Resource: (3 Hours)**
Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.

**UNIT 4: Solar photovoltaic: (8 Hours)**

**UNIT 5: Network Integration Issues: (8 Hours)**
Overview of grid code technical requirements. Fault ride-through for wind farms - real and reactive power regulation, voltage and frequency operating limits, solar PV and wind farm behavior during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

**UNIT 6: Solar thermal power generation: (3 Hours)**
Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis

**Text / References:**

| EE 414 | Electrical and Hybrid Vehicles | 3L:0T:0P | 3 credits |

**Course Outcomes:**

At the end of this course, students will demonstrate the ability to

- Understand the models to describe hybrid vehicles and their performance.
- Understand the different possible ways of energy storage.
- Understand the different strategies related to energy storage systems.

**UNIT 1: Introduction (10 hours)**

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

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

UNIT 3: Electric Trains (10 hours)

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

UNIT 4: Energy Storage (10 hours)

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems

UNIT 5: Energy Management Strategies (9 hours)


Text / References:

<table>
<thead>
<tr>
<th>EE 415</th>
<th>Power System Protection</th>
<th>3L:0T:0P</th>
<th>3 credits</th>
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</table>

Course Outcomes: At the end of this course, students will demonstrate the ability to

Understand the different components of a protection system.
Evaluate fault current due to different types of fault in a network.
Understand the protection schemes for different power system components.
Understand the basic principles of digital protection.
Understand system protection schemes, and the use of wide-area measurements.
UNIT 1: Introduction and Components of a Protection System (4 hours)
Principles of Power System Protection, Relays, Instrument transformers, Circuit Breakers

UNIT 2: Faults and Over-Current Protection (8 hours)
Review of Fault Analysis, Sequence Networks. Introduction to Overcurrent Protection and overcurrent relay co-ordination.

UNIT 3: Equipment Protection Schemes (8 hours)
Directional, Distance, Differential protection. Transformer and Generator protection. Bus bar Protection, Bus Bar arrangement schemes.

UNIT 4: Digital Protection (8 hours)
Computer-aided protection, Fourier analysis and estimation of Phasors from DFT. Sampling, aliasing issues.

UNIT 5: Modeling and Simulation of Protection Schemes (8 hours)

UNIT 6: System Protection (4 hours)

Text/References

<table>
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<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tr>
<td>EE 416</td>
<td>HVdc Transmission Systems</td>
<td>3 credits</td>
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</table>

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the advantages of dc transmission over ac transmission.
- Understand the operation of Line Commutated Converters and Voltage Source Converters.
- Understand the control strategies used in HVdc transmission system.
Understand the improvement of power system stability using an HVdc system.

UNIT 1: dc Transmission Technology (4 hours)

UNIT 2: Analysis of Line Commutated and Voltage Source Converters (10 hours)

Voltage Source Converters (VSCs): Two and Three-level VSCs. PWM schemes: Selective Harmonic Elimination, Sinusoidal Pulse Width Modulation. Analysis of a six pulse converter. Equations in the rotating frame. Real and Reactive power control using a VSC.

UNIT 3: Control of HVdc Converters: (10 hours)

UNIT 3: Components of HVdc systems: (8 hours)

UNIT 4: Stability Enhancement using HVdc Control (4 hours)

UNIT 5: MTdc Links (4 hours)

Text/References:
Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the characteristics of ac transmission and the effect of shunt and series reactive compensation.
- Understand the working principles of FACTS devices and their operating characteristics.
- Understand the basic concepts of power quality.
- Understand the working principles of devices to improve power quality.

UNIT 1: Transmission Lines and Series/Shunt Reactive Power Compensation (4 hours)

UNIT 2: Thyristor-based Flexible AC Transmission Controllers (FACTS) (6 hours)

UNIT 3: Voltage Source Converter based (FACTS) controllers (8 hours)

UNIT 4: Application of FACTS (4 hours)
Application of FACTS devices for power-flow control and stability improvement. Simulation example of power swing damping in a single-machine infinite bus system using a TCSC. Simulation example of voltage regulation of transmission mid-point voltage using aSTATCOM.

UNIT 5: Power Quality Problems in Distribution Systems (4 hours)

UNIT 6: DSTATCOM (8 hours)

UNIT 6: Dynamic Voltage Restorer and Unified Power Quality Conditioner (6 hours)

Text/References

| EE 418 | Power System Dynamics and Control | 3L:0T:0P | 3 credits |

Course Outcomes:
At the end of this course, students will demonstrate the ability to
- Understand the problem of power system stability and its impact on the system.
- Analyse linear dynamical systems and use of numerical integration methods.
- Model different power system components for the study of stability.
- Understand the methods to improve stability.

UNIT 1: Introduction to Power System Operations (3 hours)

UNIT 2: Analysis of Linear Dynamical System and Numerical Methods (5 hours)

UNIT 3: Modeling of Synchronous Machines and Associated Controllers (12 hours)

UNIT 4: Modeling of other Power System Components (10 hours)

UNIT 5 : Stability Analysis (11 hours)

UNIT 6 : Enhancing System Stability (4 hours)

Text/Reference Books


| EE 412 | Project Work –I | 0L:1T:5P | 6 credits |

The object of Project Work I is to enable the student to take up investigative study in the broad field of Electronics & Communication Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work.

The assignment to normally include:
1. Survey and study of published literature on the assigned topic;
2. Working out a preliminary Approach to the Problem relating to the assigned topic;
3. Conducting preliminary Analysis/Modelling/Simulation/Experiment/Design/Feasibility;
4. Preparing a Written Report on the Study conducted for presentation to the Department;
5. Final Seminar, as oral Presentation before a departmental committee.
## Semester-VIII

<table>
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<tr>
<th>Sl. No.</th>
<th>Course Type Code</th>
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### For Program Elective – 6

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<tr>
<td>EE 419</td>
<td>Advanced Electric Drives</td>
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*For Open Elective – 5 and Open Elective – 6: Any course offered by the University from the preferable subjects enlisted in Table A. and recommended by the department, as per AICTE guidelines.

### EE 419 Advanced Electric Drives

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### Course Outcomes:

At the end of this course, students will demonstrate the ability to

- Understand the operation of power electronic converters and their control strategies.
- Understand the vector control strategies for ac motor drives
- Understand the implementation of the control strategies using digital signal processors.

### UNIT 1: Power Converters for AC drives (10 hours)

PWM control of inverter, selected harmonic elimination, space vector modulation, current control of VSI, three level inverter, Different topologies, SVM for 3 level inverter, Diode rectifier with boost chopper, PWM converter as line side rectifier, current fed inverters with self-commutated devices. Control of CSI, H bridge as a 4-Q drive.

### UNIT 2: Induction motor drives (10 hours)

Different transformations and reference frame theory, modeling of induction machines, voltage fed inverter control-v/f control, vector control, direct torque and flux control(DTC).
UNIT 3: Synchronous motor drives (6 hours)

Modeling of synchronous machines, open loop v/f control, vector control, direct torque control, CSI fed synchronous motor drives.

UNIT 4: Permanent magnet motor drives (6 hours)

Introduction to various PM motors, BLDC and PMSM drive configuration, comparison, block diagrams, Speed and torque control in BLDC and PMSM.

UNIT 5: Switched reluctance motor drives (6 hours)

Evolution of switched reluctance motors, various topologies for SRM drives, comparison, Closed loop speed and torque control of SRM.

UNIT 6: DSP based motion control (6 hours)

Use of DSPs in motion control, various DSPs available, realization of some basic blocks in DSP for implementation of DSP based motion control.

Text / References:


| EE 420 | Project Work II & Dissertation | 0L:0T:10P | 10 credits |

The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under EC P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide
a good training for the student(s) in R&D work and technical leadership. The assignment to
normally include:
1. In depth study of the topic assigned in the light of the Report prepared under EEP1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment as
   needed;
5. Final development of product/process, testing, results, conclusions and future
directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar Presentation before a Departmental Committee