# COURSES AND EVALUATION SCHEME

**B.Tech. (Electrical Engineering)**

**BOS 2021-22**

# G.B.Pant Institute of Engineering and Technology,

**Pauri-Garhwal (Uttarakhand), PIN-246194**

**(November 2021)**

## COURSES AND EVALUATION SCHEME
## YEAR I, SEMESTER I
## (B.Tech. Electrical Engg.)
## (Effective from session: 2021-22)

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | Credit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | |
| | | | L | T | P | CT | TA | Total | | | |
| **THEORY** | | | | | | | | | | | |
| 1. | TCS 111 | Programming for problem solving | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2. | TME111 | Basic Mechanical Engineering | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 3. | TAH 111 | Engg. Chemistry | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4. | TAH 112 | Engg. Mathematics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5. | TAH 115 | Professional Communication | 2 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 2 |
| **PRACTICAL** | | | | | | | | | | | |
| 6. | PCS 111 | Programming for problem solving | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 7. | PME111 | Basic Mechanical Engineering Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 8. | PAH 111 | Engg. Chemistry Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 9 | PME112 | Workshop Practices | 1 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 3 |
| 10 | PAH 115 | Language Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 11 | GPP 111 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| **SEMESTER TOTAL** | | | **15** | **4** | **10** | **200** | **225** | **425** | **625** | **1050** | **21** |

**COURSES AND EVALUATION SCHEME**
**YEAR I, SEMESTER II**
**(B. Tech. Electrical Engineering)**
**(Effective from session: 2021-22)**

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **THEORY** | | | | | | | | | | | |
| 1. | TEC 121 | Basic Electronics Engineering | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2. | TEE 111/121 | Basic Electrical Engineering | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 3. | TCE 121 | Environmental Science | 2 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 2 |
| 4. | TAH 122 | Engg. Mathematics-II | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5. | TAH 124 | Engg. Physics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| **PRACTICAL** | | | | | | | | | | | |
| 1. | PEC 121 | Basic Electronics Engineering Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 2. | PEE 111/121 | Basic Electrical Engineering Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 3. | PCE 121 | Engg Graphics | 1 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 3 |
| 4. | PAH 124 | Engg. Physics Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 5. | GPP 121 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| **SEMESTER TOTAL** | | | **15** | **4** | **8** | **190** | **210** | **400** | **600** | **1000** | **20** |

**COURSES AND EVALUATION SCHEME**
**YEAR II, SEMESTER III**
**(B. Tech. Electrical Engineering)**
**(Effective from session: 2022-23)**

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 231 | Analog Electronics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2 | TEE 232 | Electrical Machine-I | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 4 |
| 3 | TEE 233 | Network Analysis and Synthesis | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4 | TEE 234 | Measurement and Instrumentation | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5 | TEE 235 | Electromagnetic Field Theory | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 6* | TAS 232 | Human Values | 2 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 0 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 231 | Analog Electronics Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 2 | PEE 232 | Electrical Machine-I Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 3 | PEE 233 | Network Analysis and Synthesis Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 4 | PEE 234 | Measurement and Instrumentation Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 3 | GPP 231 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| | | **Semester Total** | **17** | **5** | **8** | **240** | **210** | **450** | **700** | **1150** | **20** |

***Mandatory audit course for passing only (passing marks overall 40%).**

**COURSES AND EVALUATION SCHEME**
**YEAR II, SEMESTER IV**
**(B. Tech. Electrical Engineering)**
**(Effective from session: 2022-23)**

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 241 | Digital Electronics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2 | TEE 242 | Electrical Machine-II | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 4 |
| 3 | TEE 243 | Microprocessors and Microcontrollers | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4 | TEE 244 | Signals and Systems | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5 | TEE 245 | Power Generation and Economics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 6* | TAS 243 | Constitution of India | 2 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 0 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 241 | Digital Electronics Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 2 | PEE 242 | Electrical Machines-II Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 3 | PEE 243 | Microprocessors and Microcontrollers Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 4 | PEE 244 | Seminar | 0 | 0 | 2 | 30 | 20 | 50 | 0 | 50 | 1 |
| 5 | GPP 241 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| | | **Semester Total** | **17** | **5** | **8** | **255** | **220** | **475** | **675** | **1150** | **20** |

***Mandatory audit course for passing only (passing marks overall 40%).**

**COURSES AND EVALUATION SCHEME**
**YEAR III, SEMESTER V**
**(B. Tech. Electrical Engineering)**
**(Effective from session: 2023-24)**

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 351 | Power System Transmission and Distribution | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 4 |
| 2 | TEE 352 | Control System | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 3 | TEE 353 | Power Electronics | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4 | EEE 35X | Program Elective-I | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5 | TAS 351 | Principle of Management | 3 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 351 | Power System Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 2 | PEE 352 | Control System Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 3 | PEE 353 | Power Electronics Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 4 | PEE 354 | Industrial Internship Seminar- I | 0 | 0 | 2 | 30 | 20 | 50 | - | 50 | 1 |
| 4 | GPP 351 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| - | | **Semester Total** | **15** | **4** | **8** | **225** | **200** | **425** | **575** | **1000** | **20** |

**List of Program Elective – I**
EEE 351: Electric Machine Design
EEE 352: Electrical Energy Conservation and Auditing
EEE 353: High Voltage Engineering
EEE 354: Transducers & Signal conditioning

## COURSES AND EVALUATION SCHEME
## YEAR III, SEMESTER VI
## (B. Tech. Electrical Engineering)
## (Effective from session: 2023-24)

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 361 | Switchgear and Protection | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2 | TEE 362 | Power System Analysis | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 4 |
| 3 | TEE 363 | Electrical Drives | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4 | TEE 364 | Digital Signal Processing | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5 | EEE 364 | Program Elective-II | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 361 | Switchgear and protection lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 2 | PEE 362 | Electrical Drives Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 2 | PEE 363 | Electronics Design Lab | 0 | 0 | 2 | 15 | 10 | 25 | 25 | 50 | 1 |
| 3 | PEE 364 | Industrial Internship Seminar- II | 0 | 0 | 2 | 30 | 20 | 50 | - | 50 | 1 |
| 4 | GPP 361 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| | | **Semester Total** | **15** | **5** | **8** | **225** | **200** | **425** | **575** | **1000** | **20** |

**List of Program Elective – II**
**EEE 361:** Modern Control Systems
**EEE 362:** Project Management and Entrepreneurship
**EEE 363:** Fundamentals of Python
**EEE 364:** Robotics and Automation

## COURSES AND EVALUATION SCHEME

### YEAR IV, SEMESTER VII
### (B. Tech. Electrical Engineering)
### (Effective from session: 2024-25)

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 471 | Intelligent Systems | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2 | EEE 47X | Program Elective-IV | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 3 | EEE 47X | Program Elective-V | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 4 | TOE 05X | Open Elective-I | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 5* | TAH 471 | Engineering Economics | 2 | 0 | 0 | 30 | 20 | 50 | 100 | 150 | 0 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 471 | Project Stage-I | 0 | 0 | 8 | 50 | 50 | 100 | 150 | 250 | 5 |
| 2 | PEE-472 | Industrial Internship Seminar- III | 0 | 0 | 2 | 30 | 20 | 50 | - | 50 | 1 |
| 3 | PEE-473 | Advanced Simulation Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 3 | GPP 471 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| | | **Semester Total** | **14** | **4** | **12** | **240** | **235** | **475** | **675** | **1150** | **19** |

**List of Program Elective – IV**
**EEE 470:** Solar and Wind Energy Systems
**EEE 471:** Optimization Techniques
**EEE 472:** Power System Transient
**EEE 473:** Special Electrical Machines

**List of Program Elective – V**
**EEE 474:** HVDC Transmission Systems
**EEE 475:** Power Quality and FACTS
**EEE 476:** Power System Dynamics and Control
**EEE 477:** Biomedical Instrumentation

***Mandatory audit course for passing only (passing marks overall 40%).**

** List of Open Electives is given at end of scheme (for other branch students only).

## COURSES AND EVALUATION SCHEME

### YEAR IV, SEMESTER VIII
### (B. Tech. Electrical Engineering)
### (Effective from session: 2024-25)

| S. No. | COURSE CODE | SUBJECT | PERIODS | | | EVALUATION SCHEME | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | SESSIONAL EXAM | | | ESE | Subject Total | Credit |
| | | | L | T | P | CT | TA | Total | | | |
| **Theory Subject** | | | | | | | | | | | |
| 1 | TEE 481 | Process Control Instrumentation | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 2 | EEE 48X | Program Elective-VI | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| 3** | TOE 05X | Open Elective-II | 3 | 1 | 0 | 30 | 20 | 50 | 100 | 150 | 3 |
| **PRACTICALS** | | | | | | | | | | | |
| 1 | PEE 481 | Instrumentation Lab | 0 | 0 | 2 | 10 | 15 | 25 | 25 | 50 | 1 |
| 2 | PEE 482 | Project Stage-II | 0 | 0 | 16 | 100 | 100 | 200 | 250 | 450 | 10 |
| 2 | GPP 481 | General Proficiency | 0 | 0 | 0 | 0 | 50 | 50 | 0 | 50 | 0 |
| | | **Semester Total** | **9** | **3** | **18** | **200** | **225** | **425** | **575** | **1000** | **20** |

**List of Program Elective – VI**
**EEE 481:** Electric Hybrid Vehicles
**EEE 482:** Advanced Power Electronics
**EEE 483:** Reliability Analysis
**EEE 484:** Machine Modelling

** List of Open Electives is given at end of scheme (for other branch students only).

**List of Open Elective Subjects:**

| | | |
|---|---|---|
| 1. | TOE-050 | Electrical Machines |
| 2. | TOE-051 | Non-Conventional Energy System |
| 3. | TOE-052 | Digital Control System |
| 4. | TOE-053 | Power Station Practice |
| 5. | TOE-054 | Electrical Materials |
| 6. | TOE-055 | Soft computing techniques |
| 7. | TOE-056 | Bio Medical Signal Processing |
| 8. | TOE-057 | Electrical Instrumentation |
| 9. | TOE-058 | Instrumentation Process Control |
| 10. | TOE-058 | Electric Vehicle Components |

## TEE-111/121: BASIC ELECTRICAL ENGINEERING

**L T P**
**3 1 0**

**Module 1: DC Circuits (8 hours)**
Electrical circuit elements (R, L and C), voltage and current sources, Kirchhoff current and voltage laws, Nodal and Mesh Analysis, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems, Maximum Power Transfer Theorem,

**Module 2: AC Circuits (8 hours)**
Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor, power factor improvement. 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, Single and Three phase power measurement using Wattmeter.

**Module 3: Transformers (6 hours)**
Magnetic Circuits, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency, Auto-transformer

**Module 4: Electrical Machines (8 hours)**
Construction and working principle of DC machines, Types of DC machine, Generation of rotating magnetic fields, Three-phase and single-phase induction motor-Construction, Classification and Principle of Operation, Construction and working principle of synchronous generators.

**Module 5: Introduction to Power System & Electrical Installations (12 hours)**
Generalized layout of Power system, Standard transmission and Distribution Voltages, Concept of Grid. Introduction to 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.

**Text / References:**


1. D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
2. D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009.
3. L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press, 2011.
4. E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
5. V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989.


**Course Outcomes:**

At the end of this course, students will be able to:

1. Discuss the basic electric and magnetic circuits.
2. Explain the working principles of electrical machines and power systems
3. understand and apply the protection of power system
4. synthesize the electrical circuits
5. apply the various theorems

## PEE-111/PEE-121: BASIC ELECTRICAL LAB

**L T P**
**0 0 2**

**A minimum of 10 experiments from the following:**

1. Verification of KCL and KVL.
2. Verification of Thevenin's and Norton's Theorems.
3. Verification of Maximum power transfer and Superposition theorems.
4. Measurement of power in a three phase circuit by two wattmeter method.
5. Measurement of efficiency of a single phase transformer by load test.
6. Determination of parameters and losses in a single phase transformer by OC and SC test.
7. Load characteristics of DC generator.
8. Speed control of dc shunt motor.
9. Study of running and reversing of a three phase induction motor.
10. Calibration of a single phase energy meter.

****Additional or any other experiment may be added based on contents of syllabi.

## TEE-231: ANALOG ELECTRONICS

**L T P**
**3 1 0**

**MODULE 1**: BIPOLAR JUNCTION TRANSISTOR: Review of BJT biasing circuits, biasing stabilization techniques, thermal runaway, Ebers-Moll model, model and T-model, Early effect, analysis of low frequency BJT amplifiers. BJT AMPLIFIERS: Cascade amplifiers, coupling of amplifiers, RC coupled, direct coupled and transformer coupled amplifiers, differential amplifier, Darlington-amplifier, bootstrapping, tuned amplifiers.

**MODULE 2**: FEEDBACK AMPLIFIERS: Classification, feedback concept, transfer gain with feedback, General characteristics of negative feedback amplifiers, analysis of voltage-series, voltage-shunt, current-series and current-shunt feedback amplifiers, stability criterion.

**MODULE 3:** HIGH FREQUENCY AMPLIFIERS: Hybrid model, conductance and capacitance of hybrid model, high frequency analysis of CE amplifier, gain-bandwidth product, calculation of current gain at high frequencies, high frequency analysis of common-source, common-gate and common-drain FET amplifiers.

**MODULE 4**: OSCILLATORS: Classification, criterion for sinusoidal oscillations, Hartley, Colpitts, Clapp, RC phase-shift, Wien-bridge and crystal oscillators, astable, monostable and bistable multivibrators using transistors. Design Filter with Op-Amp.

**MODULE 5**: POWER AMPLIFIERS: Classification; class-A, class-B, class-AB and class C amplifiers, push-pull amplifier, complementary-symmetry amplifier, distortion in power amplifiers, thermal consideration and power dissipation in power amplifiers.

**BOOKS:**


1. Boylestad and Nashelsky, Electronic Devices and Circuit Theory, PHI, 2013.
2. Milman, Halkias & Jit, Electronic Devices and Circuits, TMH, 2007.
3. Deshpande, Electronic Devices and circuits, McGraw-Hill, 2007.
4. Kulshrestha, ‘Electronic Devices and Circuits’ PHI, 2007.
5. Sedra, Microelectronic Circuits, 5e (Intl. Version), Oxford, 2017.
6. Bell,Electronic Devices and Circuits, Oxford, 2009.


**COURSE OUTCOMES:**

1. Students will be able to design and analyse single and multistage amplifier circuits for small signal applications.
2. Students will be able to understand feedback concepts in amplifier and oscillator circuits.
3. Students will be able to understand the concepts used to design and analyse high frequency amplifier circuits.
4. Students will be able to design and analyse power amplifier circuits.
5. This course will enhance the capability of students for solving engineering problems related to electronics circuits.

## TEE-232: ELECTRICAL MACHINE-I

**L T P**
**3 1 0**

**Module 1: Electromagnetic force and torque: (10 Hours)**
Review of magnetic circuits - MMF, flux, reluctance, and inductance; 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.

**Module 2: 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.

**Module 3: 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

**Module 4: Single Phase Transformers (8 Hours)**
Principle, construction and operation of single-phase transformers, equivalent circuit, phasor diagram, voltage regulation, losses and efficiency Testing - open circuit and short circuit tests, polarity test, back-to-back test, separation of hysteresis and eddy current losses, Autotransformers - construction, principle, applications and comparison with two winding transformer,

**Module 5: Three Phase Transformers (8 Hours)**
Three-phase transformer - construction, types of connection and their comparative features, Parallel operation of single-phase and three-phase transformers, Magnetizing current, effect of nonlinear B-H curve of magnetic core material, harmonics in magnetization current, Phase conversion - Scott connection, three-phase to six-phase conversion, Tap-changing transformers - No- load and on-load tap-changing of transformers, Three-winding transformers. Cooling of transformers.

**Text / References**


1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", New York, McGraw Hill Education, 2013.
2. A. E. Clayton and N. N. Hancock, "Performance and design of DC machines", CBS Publishers, 2004.
3. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
4. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
5. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.


**Course Outcome**

At the end of course, the students will be able to

1. Explain the importance of electromechanical energy conversion
2. Explain, analyse and apply the working principle of DC generator
3. Explain, analyse and apply the working principle of DC motor
4. Explain, analyse and apply the working principle transformer
5. Explain, analyse and apply the importance of three phase transformer

# TEE- 233: NETWORK ANALYSIS AND SYNTHESIS

**L T P**
**3 1 0**

**Module 1: Network Theorems and Graphs Theory (12 Hours)**
Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Analysis with dependent current and voltage sources, Reciprocity, Substitution and Millman's theorem, Concept of duality and dual networks.

**Graph Theory:** Graph of a Network, definitions, tree, co tree, link, basic loop and basic cut set, Incidence matrix, cut set matrix, Tie set matrix

**Module 2: Solution of First and Second order networks (8 Hours)**
Solution of first and second order differential equations for Series and parallel R- L, R-C, R-L-C circuits, resonance, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response.

**Module 3: Sinusoidal steady state analysis (8 Hours)**
Representation of sine function as rotating phasor, phasor diagrams, impedances and admittances, AC circuit analysis, effective or RMS values, form factor, peak factor, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

**Module 4: Two Port Network and Network Functions (6 Hours)**
Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

**Module 5: Network Synthesis (8 Hours)**
Positive real function, definition and properties; Properties of LC, RC and RL driving point functions, synthesis of LC, RC and RL driving point immittance functions using Foster and Cauer first and second forms.

**Text / References:**


1. M. E. Van Valkenburg, "Network Analysis", Prentice Hall, 2006.
2. D. Roy Choudhury, "Networks and Systems", New Age International Publications, 1998.
3. W. H. Hayt and J. E. Kemmerly, "Engineering Circuit Analysis", McGraw Hill Education, 2013.
4. C. K. Alexander and M. N. O. Sadiku, "Electric Circuits", McGraw Hill Education, 2004.
5. Behrouz Peikari, "Fundamentals of Network Analysis & synthesis", Jaico Publishing House, 2006.


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

1. Understand the various laws and theorems related to electric networks.
2. Able to calculate the DC transient.
3. Understand the Sinusoidal steady state analysis.
4. understanding the concept of two port networks
5. familiarisation with network synthesis

## TEE-234: MEASUREMENT & INSTRUMENTATION

**L T P**
**3 1 0**

**Module –1**

**Philosophy Of Measurement:** Methods of Measurement, Measurement System**,** Classification of instrument system, Characteristics of instruments & measurement system**,** Errors in measurement & its analysis, Standards

**Introduction of Transducer**: Definition, Transducers, Sensors and Actuators, transducer as a function of instrumentation system, Classification of transducers-active and passive, primary and secondary, Inverse Transducers, electrical transducers and their advantages.

**Analog Measurement of Electrical Quantities:** Electro-dynamic, Thermocouple, Electrostatic & Rectifier type Ammeters & Voltmeters, Electro-dynamic Wattmeter, Three Phase Wattmeter, Power in three phase system, errors & remedies in wattmeter and energy meter.

**Module –2**

**Instrument Transformers:** Theory, construction, characteristics and their application of current and potential transformers. Ratio and phase angle errors and their minimization, Introduction to measurement of speed, frequency and power factor.

**Module –3**

**Measurement of R,L,C Parameters:** Different methods of measuring low, medium and high resistances**,** measurement of inductance & capacitance with the help of Wheatstone, Kelvin, Maxwell, Hay's, Anderson, Owen, Heaviside, Campbell, Schering, Wien bridges; Bridge sensitivity; Wagner Earthing Device; Q Meter.

**Module –4**

**AC Potentiometer:** Polar type & Co-ordinate type AC potentiometers, application of AC Potentiometers in electrical measurement.

**Magnetic Measurement:** Ballistic Galvanometer, **f**lux meter**,** determination of hysteresis loop, measurement of iron losses**.**

**Module –5**

**Digital Measurement of Electrical Quantities:** Concept of digital measurement, block diagram, Study of digital voltmeter, frequency meter, Power Analyzer and Harmonics Analyzer; Electronic Multimeter.

**Cathode Ray Oscilloscope :** Basic CRO circuit (Block Diagram), Cathode ray tube (CRT) & its components, **a**pplication of CRO in measurement, Lissajous Pattern; Dual Trace & Dual Beam Oscilloscopes.

**Books:**

1. E. W. Golding & F.C. Widdis, "Electrical Measurement & Measuring Instrument", A.W. Wheeler& Co. Pvt. Ltd. India.
2. A. K. Sawhney, "Electrical & Electronic Measurement & Instrument", Dhanpat Rai & Sons, India.
3. Forest K. Harries, "Electrical Measurement", Willey Eastern Pvt. Ltd. India.
4. W. D. Cooper, "Electronic Instrument & Measurement Technique", Prentice Hall International.

**Course Outcomes**:

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

1. Describe the various Principle Of Measurements
2. Perform error calculation.
3. Apply the Instruments principles.
4. explain the concept of CRO
5. familiarisation with measuring and testing

# TEE-235: ELECTROMAGNETIC FIELD THEORY

**L T P**
**3 1 0**

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

**Module 2: Static Electric Field (6 Hours)**
Coulomb's law, Electric field intensity, Electrical field due to point charges. Line, Surface and Volume charge distributions. Gauss law and its applications. Absolute Electric potential, Potential difference, Calculation of potential differences for different configurations. Electric dipole, Electrostatic Energy and Energy density.

**Module 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.

**Module 4: Static Magnetic Fields (12 Hours)**
Biot-Savart Law, Ampere Law, Magnetic flux and magnetic flux density, Scalar and Vector Magnetic potentials. Steady magnetic fields produced by current carrying conductors.

Force on a moving charge, Force on a differential current element, Force between differential current elements, Nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Magnetic circuits, inductances and mutual inductances.

**Module 5: Maxwell's and Wave Equations (12 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.
**Electromagnetic Waves:** 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:**

1. M. N. O. Sadiku, "Elements of Electromagnetics", Oxford University Publication, 2014.
2. A. Pramanik, "Electromagnetism - Theory and applications", PHI Learning Pvt. Ltd, New Delhi, 2009.
3. A. Pramanik, "Electromagnetism-Problems with solution", Prentice Hall India, 2012.
4. G.W. Carter, "The electromagnetic field in its engineering aspects", Longmans, 1954.
5. W.J. Duffin, "Electricity and Magnetism", McGraw Hill Publication, 1980.
6. W.J. Duffin, "Advanced Electricity and Magnetism", McGraw Hill, 1968.
7. E.G. Cullwick, "The Fundamentals of Electromagnetism", Cambridge University Press, 1966.


**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
1. Understand the magnetic field
2. Understand the Electric field.
3. Understand the concepts of Maxwell equations.
4. Understand Poynting theorem for waves
5. Apply the field in real time

## PEE-231: ANALOG ELECTRONIC CIRCUITS LAB

**L T P**
**0 0 2**

1-To design and verify various biasing techniques for BJTs.

2. To determine voltage-gain output impedance and output power of a Darlington pair compound amplifier.

3. To determine "h" parameters of a PNP transistor in common emitter mode.

4. To determine the frequency response of an IFT amplifier.

5. To determine voltage-gain and plot the frequency response of a FET amplifier in common source mode.

6. To study the effect of negative feedback on voltage gain & bandwidth in a two-stage amplifier.

7. To determine frequency of a Hartley Oscillator circuit with change in the capacitor of the tank circuit.

8. To determine frequency and wave shape of a Colpitt's oscillator circuit.

9. To determine frequency and wave shape of a crystal oscillator circuit.

10. To determine frequency and wave shape of a phase shift oscillator circuit.

11. To determine voltage-gain and plot the frequency response of a single stage, two stage RC coupled and direct coupled amplifiers.

12. Design and implementation of nonlinear oscillator (Vander pol, doffing etc.)

****Additional or any other experiment may be added based on contents of syllabi.

## PEE 232 Electrical Machine-I Lab

**LT P**
**0 0 2**

1-Open Circuit & Load characteristics of DC shunt generator
2-Load characteristics of Cumulative & Differential compound generator
3-Determination of efficiency of DC series generator by Field test and load test
4-Pre-determination of efficiency on identical shunt machines by Hopkinson's test
5-Determination of performance of DC shunt motor with and without loading
6-Determination of efficiency of DC series motor by direct loading
7-Load characteristics of Cumulative and Differential compound motor
8-Perform speed control of DC shunt motor & find the losses by Retardation test
9-Determination of performance of single phase transformer with & without loading
10-Sumpner's test on single phase transformers
11-Scott connection of single phase transformers
12-Parallel operation of single phase transformers

**PEE-233: Network Analysis and Synthesis Lab**

**LT P**
**0 0 2**

1. Verification of principle of Maximum power transfer and superposition with dc and ac sources.
2. Verification of Thevenin and Norton theorems in ac circuits.
3. Verification of Tellegen's theorem for two networks.
4. Study the series resonance.
5. Study the parallel resonance.
6. Study the response in RLC series circuit with step voltage input for underdamped, critically damp and overdamped cases.
7. Study the transient response of RC circuit for step input.
8. Study the transient response of RL circuit for step input.
9. Determination of Z and Y parameters for a network
10. Determination of 'h' and ABCD parameters
11. Determination of driving point and transfer functions of a two port ladder network and verify with theoretical values.
12. Determination of image impedance and characteristic impedance of T and ∏ networks.
13. Verification of parameter properties in inter-connected two port networks: series, parallel and cascade also study loading effect in cascade.
14. Determination of frequency response of a Twin – T notch filter.
15. To determine attenuation characteristics of a low pass / high pass filters.
16. To plot magnitude & phase plot of a network function for step input.

****Additional or any other experiment may be added based on contents of syllabi.

**Books:**


1. Irvine, Calif, "PSPICE Manual" Microsim Corporation, 1992.
2. Paul W. Tuinenga, "SPICE: A guide to circuit Simulation and Analysis Using PSPICE", Prentice Hall, 1992.
3. M.H. Rashid, "SPICE for Circuits and Electronics Using PSPICE" Prentice Hall of India, 2000.

## PEE 234: MESAUREMENT & INSTRUMENTATION LAB

**L T P**
**0 0 2**

**Lectures/Demonstrations:**

1. Concepts relating to Measurements: True value, Accuracy, Precision, Resolution, Drift, Hysteresis, Dead-band, Sensitivity.
2. Errors in Measurements. Basic statistical analysis applied to measurements: Mean, Standard Deviation, Six-sigma estimation, $C_p$, $C_{pk}$.
3. Sensors and Transducers for physical parameters: temperature, pressure, torque, flow. Speed and Position Sensors.
4. Current and Voltage Measurements. Shunts, Potential Dividers. Instrument Transformers, Hall Sensors.
5. Measurements of R, L and C.
6. Digital Multi-meter, True RMS meters, Clamp-on meters, Meggers.
7. Digital Storage Oscilloscope.

**Experiments**

1. Measurement of a batch of resistors and estimating statistical parameters.
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.
4. Measurement of Low Resistance using Kelvin's double bridge.
5. Measurement of High resistance and Insulation resistance using Megger.
6. Usage of DSO for steady state periodic waveforms produced by a function generator. Selection of trigger source and trigger level, selection of time-scale and voltage scale. Bandwidth of measurement and sampling rate.
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.
9. Current Measurement using Shunt, CT, and Hall Sensor.

## TEE-241: DIGITAL ELECTRONICS

L T P
3 1 0

**Module 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 lCs, digital logic families, TTL, Schottky TTL and CMOS logic, interfacing CMOS and TTL, Tri-state logic.

**Module 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 adder, 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.

**Module 3: Sequential circuits and systems (7Hours)**
A 1-bit memory, the circuit properties of Bistable latch, the clocked SR flip flop, J- K-T and typesflipflops,applicationsofflipflops,shiftregisters,applicationsofshiftregisters,serialtoparallel converter, parallel to serial converter, ring counter, sequence generator, ripple(Asynchronous) counters, synchronous counters, counters design using flip flops, special counter IC's, asynchronous sequential counters, applications of counters.

**Module 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 lCs, 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/Dconverter,A/Dconverterusingvoltagetofrequencyandvoltagetotimeconversion,specificationsofA/Dconverters, example of A/D converter ICs.

**Module 5: Semiconductor memories and Programmable logic devices. (7Hours)**
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:**


1. R. P. Jain, "Modern Digital Electronics", McGraw Hill Education, 2009.
2. M. M. Mano, "Digital logic and Computer design", Pearson Education India, 2016.
3. A. Kumar, "Fundamentals of Digital Circuits", Prentice Hall India, 2016.


**Course Outcomes**:
At the end of this course, students will demonstrate the ability to
1. Understand the working of logic family and gate
2. Design the combinational circuit.
3. Design the sequential circuit.
4. Understand A/D and D/A converter
5. Understand the memories

# TEE-242: ELECTRICAL MACHINES-II

**L T P**
**3 1 0**

**Module 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

**Module 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.

**Module 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.

**Module 4: Single-phase induction motors (6 Hours)**
Constructional features, double revolving field theory, equivalent circuit, determination of parameters.. Split-phase starting methods: Capacitor start/run single phase induction motor and applications

**Module 5: Synchronous machines (10 Hours)**
Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

**Text/References:**


1. A. E. Fitzgerald and C. Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
2. M. G. Say, "Performance and design of AC machines", CBS Publishers, 2002.
3. P. S. Bimbhra, "Electrical Machinery", Khanna Publishers, 2011.
4. I. J. Nagrath and D. P. Kothari, "Electric Machines", McGraw Hill Education, 2010.
5. A. S. Langsdorf, "Alternating current machines", McGraw Hill Education, 1984.
6. P. C. Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons, 2007.


**Outcome**
At the end of course, the students will be able to
1. Understand and design the winding
2. Understand the concepts of rotating magnetic field
3. Understand and apply the working principle of induction machine
4. Understand and apply the working principle of single phase induction machine
5. Understand and apply the working principle of synchronous machi

# TEE243: MICROPROCESSORS AND MICROCONTROLLERS

**L T P**
**3 1 0**

**Module 1: Fundamentals of Microprocessors: (7 Hours)**
Fundamentals of Microprocessor Architecture.8-bitMicroprocessor and Microcontroller architecture, Comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers. Definition of embedded system and its characteristics, Role of microcontrollers in embedded Systems. Overview of the 8051 family.

**Module 2: The 8051 Architecture (8 Hours)**
Internal Block Diagram, CPU, ALU, address, data and control bus, working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, Memory Structures, Data and Program Memory, Timing diagrams and Execution Cycles.

**Module 3: Instruction Set and Programming (8 Hours)**
Instruction set, Instruction syntax, Data types, Addressing modes, Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction, 8051 Instruction timings. Assembly language programs, C language programs, Assemblers and compilers.

**Module 4: Memory and I/O Interfacing (6 Hours)**
Memory and I/O expansion, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, ADC, DAC, timers, counters, memory devices.

**Module 5: External Communication Interface and Applications (6 Hours)**
Synchronous and Asynchronous Communication. RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.
LED, LCD and keyboard interfacing. Stepper motor interfacing, DC Motor interfacing, sensor interfacing.

**Text / References:**

1. M .A.Mazidi, J. G. Mazidi and R. D. McKinlay, “The8051Microcontroller and Embedded Systems: Using Assembly and C”, Pearson Education, 2007.
2. K. J. Ayala, “8051 Microcontroller”, Delmar Cengage Learning,2004.
3. R. Kamal, “Embedded System”, McGraw Hill Education,2009.
4. R. S. Gaonkar, “Microprocessor Architecture: Programming and Applications with the 8085”, Penram International Publishing, 1996
5. D.A. Patterson and J.H. Hennessy, "Computer Organization and Design: The Hardware/Software interface”, Morgan Kaufman Publishers, 2013.
6. D. V. Hall, “Microprocessors & Interfacing”, McGraw Hill Higher Education, 1991.

**Course Outcomes:**

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

1. Explain working of 8-bit microprocessors/microcontrollers
2. Write assembly/C language programs for 8051 microcontroller
3. Design 8051 system with seven segment display and keyboard
4. Interface peripherals to 8051 like I/O, A/D, D/A, timer, sensor etc.
5. Draw a microcontroller-based communicating system.

# TEE-244: SIGNALS AND SYSTEMS

**L T P**
**3 1 0**

**Module 1: Introduction to Signals and Systems (8 hours)**
Signals and systems in everyday life, Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the Module impulse, the sinusoid, the complex exponential, some special time- limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.

**Module 2: Behaviour of continuous and discrete-time LTI systems (8 hours)**
Impulse response and step response, convolution, input-output behaviour with aperiodic convergent inputs, cascade interconnections. Characterization of causality and stability of LTI systems. System representation through differential equations and difference equations. State-space Representation of systems. State-Space Analysis, Multi-input, multi-output representation. State Transition Matrix and its Role. Periodic inputs to an LTI system, the notion of a frequency response and its relation to the impulse response.

**Module 3: Fourier Transform (8 hours)**
Fourier series representation of periodic signals, Waveform Symmetries, Calculation of Fourier Coefficients. 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).

**Module 4: Laplace and z- Transforms (8 hours)**
Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, solution to differential equations and system behavior. The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis.

**Module 5: Sampling and Reconstruction (6 hours)**
Representation of continuous time signal by its sample: The sampling theorem, impulse train sampling, sampling with zero-order hold, first-order hold. Reconstruction of signal from its sample using interpolator, Aliasing and its effects. Discrete time processing of continuous Time signals: Digital differentiator and half sample delay, Sampling of discreet time signals:

**Text/References:**


1. A. V. Oppenheim, A. S. Willsky and S. H. Nawab, "Signals and systems", Prentice Hall India, 1997.
2. J. G. Proakis and D. G. Manolakis, "Digital Signal Processing: Principles, Algorithms, and Applications", Pearson, 2006.
3. H. P. Hsu, "Signals and systems", Schaum's series, McGraw Hill Education, 2010.
4. S. Haykin and B. V. Veen, "Signals and Systems", John Wiley and Sons, 2007.
5. A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing", Prentice Hall, 2009.
6. M. J. Robert "Fundamentals of Signals and Systems", McGraw Hill Education, 2007.
7. B. P. Lathi, "Linear Systems and Signals", Oxford University Press, 2009.


**Course Outcomes:**

**At the end of this course, the student will be able to**

- Apply continuous time and discrete time systems
- explain different type of signal
- Perform analysis using Fourier transform.
- Perform analysis the Laplace and Z- transform.
- Sampling and reconstruction of signal.

# TEE-245: Power Generation and Economics

**L T P**
**3 1 0**

**Module-1**
**Economic aspects of generation**
Basic concept on generation, transmission and distribution, type of loads: industrial, commercial, and agricultural, Load curve, load duration curve, load factor, capacity factor, diversity factor. Base load station and peak load station, captive power plants, operating & spinning reserves. Load forecasting and its solving techniques, site selection of thermal, hydroelectric, nuclear, diesel and gas power plants.

**Module-2:**
**Tariffs and Power factor**
Electric utility services, general tariff forms and different types of tariffs, concept of power and energy in electrical system, maximum demand indicators and recorders. Evolution and definition of power factor (pf), concept of pf lagging & leading, zero pf lagging & leading, causes and effects of low power factor, necessity of power factor improvement and power factor improvement techniques.

**Module-3:**
**Power Plants and their coordinated operation**
Type of power plants and their operation: thermal, hydroelectric, nuclear with nuclear fuel processing and waste handling, diesel and gas. Field of application of power plants, advantages of coordinated operation of different types of power plants, hydro–thermal scheduling, short-term and long-term hydrothermal scheduling (without derivation), steam power plant coordination with run-off river, dam storage, pumped storage and gas turbine plants.

**Module-4:**
**Economic Operation of Power Plants**
Input-output characteristics of thermal and Hydro plants, system constraints, Optimal operation of thermal unit without and with transmission losses, penalty factor, incremental transmission loss, transmission loss formula (without derivation), hydrothermal scheduling long and short terms
**Power station auxiliaries**: Types of Turbines and their operation: Pelton, Francis, and Kaplan. Fuel feeding system both for coal and biomass fuel, boilers, governors, excitation system, auto voltage regulators (AVR), busbar arrangements, battery charger.

**Module-5:**
**Non-conventional energy sources (NCES) and Magneto-hydro-dynamic (MHD) generators**
Scenario of Renewable energy, Type of NCES and their operation: solar, wind, tidal, geo-thermal, Solar thermal collectors, Solar cell, module, panel and array and PV characteristics, Wind turbine aerodynamics, VAWT and HAWT, Betz limit, MHD generator, Open and closed cycle operation of MHD generators with advantages, problems, and future trends.

**Books:**

1. Gilbert M. Masters, 'Renewable and Efficient Electric Power Systems' John Wiley Publications
2. B. R. Gupta, 'Generation of electric energy' (Eurasia publishing house; Delhi).
3. M. V. Deshpande, 'Elements of power station design' (wheeler Publishing houses).
4. Soni, Gupta, Bhatnagar and Chakrabarti, A Textbook on 'Power System (A Course in Electrical Power)'.
5. B.H. Khan, 'Non-conventional energy resources', TMH Publication.


**Course Outcomes**:
At the end of this course, students will demonstrate the ability to
1. Analyze the concepts of conventional and non-conventional energy generation.
2. Understand the economic aspects of power system.
3. Know about the working and construction of different types of power plants.
4. Must be able to draw the layout of all types of generation power plants.
5. Able to synthesize the useful tariff for electricity utility.

## PEE-241: DIGITAL ELECTRONICS LAB

**L T P**
**0 0 2**

**1.** Bread-board implementation of various flip-flops.

**2.** Bread-board implementation of counters & shift registers.

**3.** Determination of Delay time and NAND, NOR, Ex-OR, AND & OR Gates.

**4.** Experiments with clocked Flip-Flop.

**5.** Design of Counters.

**6.** Implementation of Arithmetic algorithms.

**7.** Bread Board implementation of Adder/Subtractor (Half, Full)

**8.** Transfer characteristics of TTL inverters & TTL Schmitt Trigger inverter.

**9.** Transfer characteristics of CMOS inverters series and CD40 series and

**10.** Estimation of Gate delay of CD40 series CMOS inverter.

**11.** Monoshot multivibrators using 74121 and 74123.

**12.** Clock circuit realization using 555 and CMOS inverter and quartz crystal.

**13.** Demultiplexer / Decoder operation using IC-74138.

**14.** To verify experimentally output of A/D and D/A converters.

****Additional or any other experiment may be added based on contents of syllabi.

**PEE-242 Electrical Machines-II Lab**

**L T P**
**0 0 2**

1-Performance of 3ø squirrel cage induction motor with and without load
2-Predetermination of performance of 3ø squirrel cage induction motor using circle diagram
3- Performance of 3ø slip ring induction motor
4- Performance of 1ø induction motor with and without load
5- Determination of equivalent circuit parameters of single phase induction motor load test on 3ø alternator
7- Pre-determination of regulation of an alternator by EMF method
8 -Pre-determination of regulation of an alternator by MMF method
9- Pre-determination of regulation of an alternator by ZPF method
10- Synchronization of 3ø of alternator with infinite bus bars
11- V and inverted-V curves of 3ø synchronous motor
12 -Performance of synchronous motor
13- Slip test and regulation of 3ø alternator
14 -Separation of iron losses of 1ø transformer
15- Performance test on induction generator

## PEE-243: MICROPROCESSOR & MICROCONTROLLER LAB

**L T P**
**0 0 2**

**Programming based Experiments (8051 µC)**

1. Study microcontroller 8051 working with simulator EdSIM51.
2. Write Assembly Code to Divide an 8-bit number A by another 8-bit number B using 8051 microcontroller.
3. Write Assembly Code to Multiply A with B when address of operand A is given in R0 (address is 20H)
4. Write Assembly Code to find the sum of a series of ten 8-bit numbers.
5. Write Assembly Code to create a table of decimal number 20..

**Interfacing based Experiments (any five)**

1. Write Assembly Code to display "AMERICA" AT RAM 40H FROM PROG MEM 250H
2. Write Assembly Code to display "INDIA" AT RAM 40H FROM PROG MEM 250H
3. Write a program to scans the keypad (4 X 3 matrix)
4. Write a program to LED display "1", "2", "3", "4", in sequence program
5. Write a program to generate a ramp on the DAC
6. Write a program to get the value of x from P1 and send sqr(x) to p2, continuously.
7. Write a program to reads the analogue input voltage on the ADC and displays it on the scope via the DAC.
8. Stepper motor controller interfacing
9. DC Motor interfacing

## TEE-351: Power System Transmission and Distribution

**L T P**
**3 1 0**

**Module-1**

**Power System Components:** Single line Diagram of Power system, Per unit system, Brief description of power system elements: Synchronous machine, transformer, transmission line, bus bar, circuit breaker and isolator.

**Supply System:** Different kinds of supply system and their comparison, choice of transmission voltage.

**Transmission Lines:** Configurations, types of conductors, resistance of line, skin and proximity effect, Kelvin's law.

**Module-2**

**Over Head Transmission Lines:** Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit transmission lines, Representation and performance of short, medium and long transmission lines, Ferranti effect, Concept of loss-less transmission line, Surge impedance loading.

**Module-3**

**Corona and Interference:** Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona and interference. Electrostatic and electromagnetic interference with communication lines.

**Overhead line Insulators:** Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency.

**Module-4**

**Mechanical Design of transmission line:** Catenary curve, calculation of sag & tension, effects of wind and ice loading, sag template, vibration dampers.

**Insulated cables:** Type of cables and their construction, dielectric stress, grading of cables, insulation resistance, capacitance of single phase and three phase cables, dielectric loss, heating of cables.

**Module-5**

**Neutral grounding:** Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices.

**Distribution System:** Structure of a distribution system, Distribution feeder configurations and substation layouts, Radial and ring mains system

**Books**:


1. W. D. Stevenson, "Element of Power System Analysis", McGraw Hill.
2. I. J. Nagrath and D. P. Kothari, "Modern Power System", TMH Publication.
2. C. L. Wadhwa, "Electrical Power Systems" New age international Ltd. Third Edition.
3. Ashfaq Hussain, "'Power System", CBS Publishers and Distributors.
4. B. R. Gupta, "Power System Analysis and Design" Third Edition, S. Chand & Co.
5. M. V. Deshpande, "Electrical Power System Design" Tata McGraw Hill.


**Course Outcomes**:

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

1. Discuss and apply the concepts of power systems.
2. Analyze the various power system components.
3. Analyze the working and Draw the layout of transmission and distribution network.
4. Understand the working and construction of insulators and cables.
5. Describe corona and interference free transmission line.

## TEE-352: CONTROL SYSTEM

**L T P**
**3 1 0**

**Module 1: Introduction to control problem (5 hours)**
Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Feedback. Block diagram algebra.

**Module 2: Time Response Analysis (10 hours)**
Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

**Module 3: Frequency-response analysis (6 hours)**
Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.

**Module 4: Introduction to Controller Design (10 hours)**
Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Liapunov Stability for continuous system. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Analog and Digital implementation of controllers.

**Module 5: State variable Analysis (6 hours)**
Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

**Text/References:**


1. M. Gopal, “Control Systems: Principles and Design”, McGraw Hill Education, 1997.
2. B. C. Kuo, “Automatic Control System”, Prentice Hall, 1995.
3. K. Ogata, “Modern Control Engineering”, Prentice Hall, 1991.
4. I. J. Nagrath and M. Gopal, “Control Systems Engineering”, New Age International, 2009


**Course Outcomes**:

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

1. Understand the modeling of LTI system.
2. Analyze LTI system.
3. Analyze the stability criteria.
4. Discriminate time and frequency response.
5. Design feedback controller.

## TEE- 353: POWER ELECTRONICS

**L T P**
**3 1 0**

**Module 1: Power switching devices (8 Hours)**
Diode, Thyristor, MOSFET, IGBT: I-V Characteristics; Firing circuit for thyristor; Voltage and current commutation of a thyristor; drive circuits for MOSFET and IGBT.

**Module 2: Thyristor rectifiers (8 Hours)**
Single-phase half-wave and full-wave rectifiers, Single-phase full-bridge thyristor rectifier with R-load and highly inductive load; Three-phase full-bridge thyristor rectifier with R-load and highly inductive load; Input current wave shape and power factor.

**Module 3: DC-DC converters (8 Hours)**
Elementary chopper, concepts of duty ratio and average voltage, power, Buck converter, duty ratio control. Boost converter, relation between duty ratio and average output voltage. Buck-Boost Converter. Configurations of Cuk Converter, Sepic Converter, Zeta Converter.

**Module 4: Single-phase voltage source inverter (8 Hours)**
Single- phase voltage source inverter, switch states and instantaneous output voltage, square wave operation of the inverter, concept of average voltage over a switching cycle, Modulation techniques, bipolar sinusoidal modulation and unipolar sinusoidal modulation, Harmonics and THD.

**Module 5: Three-phase voltage source inverter (8 Hours)**
Three-phase voltage source inverter, 120-degree and 180-degree mode six-step inverters, average output voltages over a sub-cycle, sinusoidal modulation, harmonic analysis. Configurations of Multilevel Inverters and Current Source Inverters.

**Text/References:**


1. M. H. Rashid, "Power electronics: circuits, devices, and applications", Pearson Education India, 2009.
2. N. Mohan and T. M. Undeland, "Power Electronics: Converters, Applications and Design", John Wiley & Sons, 2007.
3. R. W. Erickson and D. Maksimovic, "Fundamentals of Power Electronics", Springer Science & Business Media, 2007.
4. L. Umanand, "Power Electronics: Essentials and Applications", Wiley India, 2009.


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

1. Discuss power level devices characteristics and driver circuits.
2. Select and employ controlled rectifier circuits for an application.
3. Analyse the operation of DC-DC Converters.
4. Explain the operation of single-phase voltage source inverters and their analysis.
5. Analyse a three-phase voltage source inverter performance.

# EEE 351: ELECTRICAL MACHINE DESIGN

**L T P**
**3 1 0**

**Module 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.

**Module 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.

**Module 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.

**Module 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.

**Module 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:**


1. A. K. Sawhney, "A Course in Electrical Machine Design", Dhanpat Rai and Sons, 1970.
2. M.G. Say, "Theory & Performance & Design of A.C. Machines", ELBS London.
3. S. K. Sen, "Principles of Electrical Machine Design with computer programmes", Oxford and IBH Publishing, 2006.
4. K. L. Narang, "A Text Book of Electrical Engineering Drawings", Satya Prakashan, 1969.
5. A. Shanmugasundaram, G. Gangadharan and R. Palani, "Electrical Machine Design Data Book", New Age International, 1979.
6. K. M. V. Murthy, "Computer Aided Design of Electrical Machines", B.S. Publications, 2008.
7. Electrical machines and equipment design exercise examples using Ansoft's Maxwell 2D machine design package.


**Course Outcomes:**
At the end of this course students will demonstrate the ability to
1. Gain the knowledge of design.
2. Understand the design of machines
3. Design the machines.
4. Explain the CAD.
5. Design the machine through CAD.

## EEE 352: ELECTRICAL ENERGY CONSERVATION AND AUDITING

**L T P**
**3 1 0**

**Module 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 strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

**Module 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, Modules and conversion.

**Module 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.

**Module 4: 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.

**Module 5: Energy Efficient Technologies in Electrical Systems (8Hours)**
Electrical system: Electricity billing, electrical load management. 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**

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. S. C. Tripathi, “Utilization of Electrical Energy and Conservation”, McGraw Hill, 1991.
4. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)


**Course Outcomes:**
At the end of this course students will demonstrate the ability to
1. Understand the importance of energy conservation
2. Understand the equipments involved in energy conservation
3. Explain the energy efficient devices.
4. Explain the importance of energy auditing
5. Understand the industrial importance of energy conservation and its auditing.

## EEE 353: HIGH VOLTAGE ENGINEERING

**L T P**
**3 1 0**

**Module 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

**Module 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.

**Module 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.

**Module 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.

**Module 5: Over-voltages and Testing (11 Hours)**
Charge formation in clouds, Stepped leader, Dart leader, Lightning Surges. Switching over-voltages, Protection against over-voltages, Surge diverters, Surge modifiers.

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**


1. M. S. Naidu and V. Kamaraju, "High Voltage Engineering", McGraw Hill Education, 2013.
2. C. L. Wadhwa, "High Voltage Engineering", New Age International Publishers, 2007.
3. D. V. Razevig (Translated by Dr. M. P. Chourasia), "High Voltage Engineering Fundamentals", Khanna Publishers, 1993.
4. E. Kuffel, W. S. Zaengl and J. Kuffel, "High Voltage Engineering Fundamentals", Newnes Publication, 2000.
5. R. Arora and W. Mosch "High Voltage and Electrical Insulation Engineering", John Wiley & Sons, 2011.
6. Various IS standards for HV Laboratory Techniques and Testing


**Course Outcomes:**

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

1. Describe the breakdown phenomena in gases
2. Explain the breakdown phenomena in solids
3. Analyse the breakdown phenomena in liquids
4. Explain the various testing techniques
5. Explain the various measuring techniques

## EEE-354 Transducers & Signal Conditioning

**L T P**
**3 1 0**

**Module 1:** Introduction of Transducer: Definition, Transducers, Sensors and Actuators, transducer as a function of instrumentation system, Classification of transducers-active and passive, primary and secondary, Inverse Transducers, electrical transducers and their advantages, typical example of transducer element. Characteristics and selection of transducers:-Input characteristics-type of input and operating range, transfer characteristics-transfer function, Output characteristics-type of electrical output, output impedance and useful range, selection criteria of transducers, typical specification of a transducer system.

**Module 2:** Resistive, Inductive and Capacitive Transducers: Resistive Transducers- Linear and nonlinear potentiometers, materials used, advantages and disadvantages of resistive transducers; Strain gauge principle and types-bonded, unbounded, semiconductor strain gauge. Inductance Transducer- Introduction, principle of working, change of self-induction, change of mutual induction and production of eddy currents. LVDT-construction, principle, advantages, disadvantages and uses. Capacitive Transducer- Introduction, principle of working, change in area of plates, change in distance between two plates and variation of two plates. Nonlinearity in capacitive transducers and differential arrangements, frequency response, advantages, disadvantages and uses.

**Module 3:** Miscellaneous Transducers: Digital Transducer- Introduction, types of digital encoding transducers, classification of encoders-Tachometer, incremental and absolute. Piezoelectric transducer- Principle, operation, equivalent circuit, loading effect, frequency response and uses. Hall Effect Transducer- Construction, Principle and uses. Optoelectronic Transducer- Photovoltaic cell and its application, photoconductive cell and semiconducting photodiode.

**Module 4:** Signal Conditioning and Data Acquisition Systems: Types of signal conditioning- DC and AC, Analog and Digital data acquisition system, single and multi-channel data acquisition systems. Components of data acquisition systems use of data acquisition systems.

**Module 5:** Data Transmission & Telemetry, Display and Recorders: Introduction of telemetry, general telemetry system, Landline Telemetry-voltage telemetry system, current telemetry system, position telemetry system and feedback telemetry system; RF (Radio frequency) Telemetry System general modulation methods (AM, FM) comparison between AM & FM, Pulse modulation, Pulse amplitude modulation and pulse code modulation telemetry systems, Transmission channel and media-wire line and radio link. Analog displays & recorders, digital recorders, digital displays, digital printers, barcode.

### Reference Books


1. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons
2. B.C. Nakra & K. Chaudhary, "Instrumentation, measurement and analysis", Tata Mc Graw Hill 2nd Edition
3. Dally. "Instrumentation for Engineering Measurement", 2nd edition, Wiley India
4. D Patranabis, "Telemetry Principle", TMH Ed-1, 1999


### Course Outcomes:

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

1. Describe the basics of transducers
2. Describe the measuring of temperature
3. Describe the measuring the pressure
4. Analyze the measurement of liquid level
5. Describe the concepts of sensors

## PEE-351: POWER SYSTEM LAB

**LT P**
**0 0 2**

1. To determine fault current for L-G, L-L, L-L-G and L-L-L faults at the terminals of an alternator at very low excitation
2. To study Ferranti effect and voltage distribution in long transmission line using transmission line model.
3. Plotting the equipotential lines of single and multilayer cables.
4. To study the performance characteristics of a radial distribution system.
5. To study the performance characteristics of a ring main distribution system.
6. To study and obtain ABCD parameters, h and image parameter of transmission line.
7. To study and obtain the string efficiency of insulators with and without guard ring.
8. To determine direct axis reactance ($X_d$) and quadrature axis reactance ($X_q$) of a salient pole alternator.
9. To determine negative and zero sequence reactances of an alternator.
10. To determine sub transient direct axis reactance (xd) and sub transient quadrature axis reactance (xq) of an alternator.

**Simulation Based Experiments (using MATLAB or any other software)**

11. To determine transmission line parameters of short, medium and long transmission line.
12. To obtain steady state, transient and sub-transient short circuit currents in an alternator.

****Additional or any other experiment may be added based on contents of syllabi.

**Course Outcomes**:

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

1. Able to demonstrate practical implementation of theory of transmission line, insulator, synchronous generator and cables.
2. Able to develop algorithms and MATLAB code to design Y- Bus matrix, N-R load flow, and fault analysis using Z-Bus matrix.

## PEE-352: CONTROL LAB

**L T P**
**0 0 2**

1. To determine response of first order and second order systems for step input for various values of constant 'K' using linear simulator Module and compare theoretical and practical results.
2. To study P, PI and PID temperature controller for an oven and compare their performance.
3. To study and calibrate temperature using resistance temperature detector (RTD).
4. To design Lag, Lead and Lag-Lead compensators using Bode plot.
5. To study behavior of separately excited dc motor in open loop and closed loop conditions at various loads.

**Software based experiments** (Use MATLAB, LABVIEW software etc.)

6. To determine time domain response of a second order system for step input and obtain performance parameters.
7. To convert transfer function of a system into state space form and vice-versa.
8. To plot root locus diagram of an open loop transfer function and determine range of gain 'K' for stability.
9. To plot a Bode diagram of an open loop transfer function.
10. To draw a Nyquist plot of open loop transfer functions and examine the stability of the closed loop system.

**Books**:


1. K. Ogata, "Modern Control Engineering", Prentice Hall of India.
2. Norman S. Nise, "Control System Engineering", John Wiley & Sons.
3. M. Gopal, "Control Systems: Principles & Design", Tata McGraw Hill.


****Additional or any other experiment may be added based on contents of syllabi.

## PEE-353: POWER ELECTRONICS LAB

**L T P**
**0 0 2**

1. To obtain V-I characteristics of SCR and measure latching and holding currents.
2. To study UJT trigger circuit for half wave and full wave control.
3. To study single-phase half wave controlled rectified with (i) resistive load (ii) inductive load with and without freewheeling diode.
4. To study single phase fully controlled by using cosine control scheme.
5. To study three-phase fully and half controlled bridge rectifier with resistive and inductive loads.
6. To study triggering of (i) IGBT (ii) MOSFET (iii) power transistor.
7. To study operation of IGBT/MOSFET chopper circuit
8. To study MOSFET/IGBT based single-phase bridge inverter.

**Software based experiments (PSPICE/MATLAB)**

9. To simulate the SCR and GTO characteristics.
10. To simulate MOSFET/ IGBT based single-phase full bridge rectifier circuits.
11. To simulate three-phase fully controlled bridge rectifier and draw load voltage and load current waveform for inductive load.
12. To simulate a Buck Converter with DC motor load.
13. To simulate of Boost Converter.
14. To simulate a 1-phase VSI circuit with PWM control.

****Additional or any other experiment may be added based on contents of syllabi.

# TEE-361: Switchgear and Protection

**LT P**
**3 1 0**

**Module-1**

**Introduction to power system protection:** Philosophy of power system protection**,** Introduction to protective system and its elements, function of protective relaying, protective zones, primary and backup protection, desirable qualities of protective relaying, basic terminology.
Introduction to protective relaying: Reliability, dependability and security, Elements of protection system: Battery, DC supply and Circuit Breakers.

**Module-2**

**Relays:** Relay operating principles**,** Detection of faults**, Different types of relays:** Electromechanical-attraction and induction type relays, thermal relay, gas actuated relay, Solid State Relays.
**Relay Applications and characteristics:** Amplitude and phase comparators, over current relays, directional relays, distance relays, differential relays.
**Static relays, Numerical and microprocessor based relay:** Comparison with electromagnetic relays, classification and their description, over current relays, directional relays, distance relays, differential relays.

**Module-3**

**Protection of transmission line:**
Transients in lumped parameter & distributed parameter circuits-wave equations, Reflection & Refraction coefficients, Time graded protection, differential and distance protection of feeders, choice between impedance, reactance and MHO relays, Elementary idea about carrier current protection of lines, protection of bus, auto reclosing, pilot wire protection.

**Module-4**

**Circuit Braking:** Arc phenomenon, properties of arc, arc extinction theories, recovery voltage and restriking voltage, current chopping, resistance switching, capacitance current interruption, circuit breaker ratings.
**Circuit breakers:** Need of circuit breakers, types of circuit breakers, operating modes, principles of construction, details of Air Blast, Bulk Oil, Minimum Oil, $SF_6$, Vacuum Circuit Breakers, DC circuit breakers.
**Testing of circuit breakers:** Classification, testing station & equipments, testing procedure, direct and indirect testing.

**Module-5**

**Apparatus Protection:** Types of faults on alternator, stator and rotor protection, negative sequence protection, loss of excitation and overload protection. Types of fault on transformers, percentage differential protection, isolated neutral system, grounded neutral system and selection of neutral grounding.

**Books:**


1.H.H. Stanley and A.G. Phadke 'Power System Relaying', John Wiley & Sons Ltd. Third Edition
2. W. D. Stevenson, "Element of Power System Analysis", McGraw Hill, USA.
3. C. L. Wadhwa, "Electrical Power Systems" New age international Ltd. Third Edition.
4. M. V. Deshpandey, "Elements of Power System Design", Tata McGraw Hill, India.
5. Soni, Gupta &Bhatnagar, "A Course in Electrical Power", DhanpatRai& Sons, India.


**Course Outcomes**:

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

1. Describe basic protection schemes.
2. Analyze the different components of a protection system
3. Design the protection schemes for different power system components.
4. Analyze the working and construction of different kind of circuit breakers.
5. Apply the different protection schemes in different power system equipments.

# TEE-362: Power System Analysis

**L T P**
**3 1 0**

**Module-1**

**Representation of Power System Components**: Impedance and reactance diagram of power system, Circuit model of synchronous generators and motors, transformers, transmission line and Induction motor.

**Symmetrical fault analysis**: Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions.

**Module-2**

**Symmetrical components**: Symmetrical Components of unbalanced phasor, power in terms of symmetrical components, sequence impedances and sequence networks.

**Unsymmetrical faults**: Analysis of single line to ground fault, line-to-line fault and Double Line to ground fault on an unloaded generators and power system network with and without fault impedance. Formation of $Z_{bus}$ using singular transformation and algorithm.

**Module-3**

**Load Flow Analysis**: Introduction, bus classifications, nodal admittance matrix ($Y_{bus}$), development of load flow equations, load flow solution using Gauss-Siedel and Newton-Raphson method, approximation to N-R method, Decoupled load flow, Fast decoupled load flow method.

**Module-4**

**Power System Stability**: Stability and Stability limit, Steady state stability study, derivation of Swing equation, transient stability studies by equal area criterion and step-by-step method. Factors affecting steady state and transient stability and methods of improvement. FACT Devices

**Module-5**

**Load Frequency Control:** Concept of load frequency control, load frequency control of single area system: turbine speed governing system and modeling, block diagram representation of single area system, steady state analysis, dynamic response control area concept, P-I control, Load frequency control of two area system tie line power modeling, block diagram representation of two area system, static and dynamic response.

**Books:**


1. W. D. Stevenson, Jr., "Elements of Power System Analysis", McGraw Hill.
2. I. J. Nagrath and D. P. Kothari, "Modern Power System", TMH Publication.
3. C. L. Wadhwa, "Electrical Power System", New Age International.
4. T. K. Nagsarkar& M. S. Sukhija, "Power System Analysis", Oxford University Press, 2007.
5. Chakraborthy, Soni, Gupta &Bhatnagar, "Power System Engineering", DhanpatRai& Co.


**Course Outcomes**:

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

1. Able to draw reactance and impedance diagram of a power system.
2. Evaluate fault currents for different types of faults.
3. Develop the numerical methods and algorithms to analyze a power system in steady state.
4. Able to synthesize stability constraints in a synchronous grid.
5. Able to create a load frequency control system for controlling a power system.

## TEE 363: ELECTRICAL DRIVES

**L T P**
**3 1 0**

**Module 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.

**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.

**Module 2: 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.

**Module 3: 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.

**Module 4: 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.

**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.

**Module 5: 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 / References:**

1. G. K. Dubey, "Power Semiconductor Controlled Drives", Prentice Hall, 1989.
2. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", Prentice Hall, 2001.
3. G. K. Dubey, "Fundamentals of Electrical Drives", CRC Press, 2002.
4. W. Leonhard, "Control of Electric Drives", Springer Science & Business Media, 2001.

**Course Outcomes**:

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

1. Able to apply the concepts of power electronics to machines.
2. Describe the concepts of Chopper for DC motor Speed Control.
3. Develop the Novel Speed control of DC motor
4. Develop the Novel method of Speed control of DC motor
5. Develop the Novel method of Speed control of induction motor

# TEE 364: DIGITAL SIGNAL PROCESSING

**L T P**
**3 1 0**

**Module 1: Discrete-Time Signals and Systems (8 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, Introduction to Z transform.

**Module 2: Discrete Fourier Transform (10 hours)**
Frequency Domain Analysis, Discrete Fourier Transform (DFT), Properties of DFT, Convolution of signals, Fast Fourier Transform (FFT) Algorithms: DIT and DIF algorithms.

**Module 3: Implementation of Discrete Time System-Filters (8hours)**

Structure realization of discrete time FIR filters: Direct form, Cascade form structure, Linear phase and Lattice structure realization, Structure realization of discrete time IIR filters: Direct Form-I, II, Cascade form structure, Parallel form structure, Transposed direct form realization (Signal Flow Graph), Lattice and Lattice Ladder structure realization.

**Module 4: Design of Digital Flters (12 hours)**
Design of digital filters from analog filters, Design of analog low pass Butterworth and Chebyshev Filters, Frequency transformation in analog domain, Design of IIR filters using analog filters, Frequency transformation in Digital domain, Design of FIR filters: Design of FIR Differentiators Design of Linear phase FIR filters using (Fourier series Method, windows Methods, Frequency sampling Method).

**Module 5: Linear Prediction and Optimal Linear Filter (8 hours)**
Random signal, correlation function and power spectra, Innovations representation of stationary process, Forward and backward linear prediction, AR lattice and ARMA lattice ladder filters, Wiener filters for filtering and prediction.

**Text/Reference Books:**


1. S. K. Mitra, "Digital Signal Processing: A computer based approach", McGraw Hill, 2011.
2. A.V. Oppenheim and R. W. Schafer, "Discrete Time Signal Processing", Prentice Hall, 1989.
3. J. G. Proakis and D.G. Manolakis, "Digital Signal Processing: Principles, Algorithms And Applications", Prentice Hall, 1997.
4. L. R. Rabiner and B. Gold, "Theory and Application of Digital Signal Processing", Prentice Hall, 1992.
5. J. R. Johnson, "Introduction to Digital Signal Processing", Prentice Hall, 1992.
6. D. J. DeFatta, J. G. Lucas and W. S. Hodgkiss, "Digital Signal Processing", John Wiley & Sons, 1988.


**COURSE OUT COMES**
**The student will able to**

- Analyze the frequency domain analysis of signals.
- understand the DFT and FFT algorithms.
- realize the digital filters.
- design and simulate IIR and FIR digital filters.
- apply the algorithms for wide area of recent applications.

**EEE 361: Modern Control Systems**

**L T P**
**3 1 0**

**Module 1: State variable Analysis (8 hours)**
Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback.

**Module 2: Discrete System Analysis (10 hours)**
Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Difference Equations, Solution of Discrete time systems. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

**Module 3: Nonlinear Control System (8 hours)**
Linearization techniques of nonlinear Systems, Phase plane and describing function techniques, Liapunov's stability analysis, Popov's Stability criteria

**Module 4: Optimal Control System (10 hours)**
Formation of optimal control problems, calculus of variation, minimization of functions, constrained optimization, dynamic programming, performance index, optimality principles, Hamilton – Jacobian equation, linear quadratic problem, Ricatti II equation and its solution, solution of two point boundary value problem

**Module 5: Adaptive Control System (6 hours)**
Model reference adaptive control system, Controller structure, Self tuning regulators, Various adaptive control systems

**Text/References:**


5. M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
6. B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.
7. K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
8. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009


**The student will able to**

- understand the state variable technique
- understand the optimal control therory
- understand the importance of adaptive control technique .
- design the controllers.
- apply the controllers to the system .

## EEE 362: ENTREPRENEURSHIP & PROJECT MANAGEMENT

**L T P**
**3 1 0**

**MODULE- 1**

Entrepreneurship : need, scope, Entrepreneurial competencies & traits, Factors affecting entrepreneurial development, Entrepreneurial motivation (Mc Clellend's Achievement motivation theory), conceptual model of entrepreneurship, entrepreneur vs. intrapreneur; Classification of entrepreneurs; Entrepreneurial Development Programmes- their relevance and achievements, Role of government in organizing such programmes, Women Entrepreneurs : Present status in India ; steps being taken for their promotion.

**MODULE-2**

Small Business : Concept & Definition, Role of Small Business in modern Indian Economy, Small entrepreneur in International business; Steps for starting a small industry, registration as SSI, Role of SIDBI; advantages and problems of SSIs; Institutional Support mechanism in India; Incentives & Facilities, Govt. Policies for SSIs

**MODULE- 3**

Project: Definition, characteristics, types, steps in identification of projects, project life-cycle. Project management: meaning, scope & importance, role of project manager; Project appraisal: Preparation of a real time project feasibility report containing Technical appraisal,; Environmental appraisal, Market appraisal (including market survey for forecasting future demand and sales) and Managerial appraisal.

**MODULE -4**

Project Financing: project cost estimation & working capital requirements, sources of funds, capital budgeting, Risk & uncertainty in project evaluation, preparation of projected financial statements viz. Projected balance sheet, projected income statement, projected funds & cash flow statements, Preparation of detailed project report, Project finance.

**MODULE – 5**

Implementation of projects: Graphic Representation of Project Activities, Network Analysis, Management & control of projects, Project scheduling, MIS in project, problems of project implementation, project audit

**Text Books:**

1. Prasanna Chandra, Projects : Planning, Analysis, Selection, Implementation & Review, Tata McGraw Hill
2. P.Gopala Krishnan & V.E Rama Moorthy, Project Management, MacMillan India

**Course outcome:** After completing this course, students will be able to understand:

1. Entrepreneurship & Business strategies
2. Project planning and financing for it
3. Project implementation
4. Understand the market needs
5. Create the demand in market

## EEE-363: Fundamentals of Python

**L T P**
**3 1 0**

**Module-1 Introduction to Python-** Writing and Executing First Python Program Literal, Constants, Numbers, Strings, Variables, and Identifiers, Data Types, Input/output Operation, Comments, Reserved Words Indentation, Operators and Expressions, Arithmetic Operators, Comparison Operators, Shortcut Operators, Unary Operators, Bitwise Operators, Shift Operators, Logical Operators, Membership Operators, Identity Operators, Operators Precedence and Associativity, Expressions in Python, Operations on Strings, Concatenation, Multiplication (or String Repetition), Slice a String, Type Conversion. Decision Control Statements: if statement, if-else Statement, Nested if statements, if-elseif-else statement, Basic Loop Structures: while loop, for Loop, Nested Loops, the break Statement, the continue Statement, the pass Statement.

**Module-2 Building Blocks in Python - Functions**: Definition, Calling, Parameters, Variable Scope and Lifetime, Local and Global Variables, return statement, Required Arguments, Keyword Arguments, Default Arguments, Variable-length Arguments, Lambda Functions, Documentation Strings, Recursive Functions. Modules: Name of Module, Making your own Modules.

**Module-3 Python Strings**: Concatenating, Appending, and Multiplying Strings, String Formatting Operator, Built-in String Methods, Slice Operation, in and not in operators, Comparing Strings, Iterating String, The String Module. Regular Expressions: match (), search (), sub (), findall(), finditer(). File Handling: File Path, Types of Files, ASCII Text Files, Binary Files, Opening and Closing Files, Reading and Writing Files, Renaming and Deleting Files. Data Structures: Lists, Tuple, Sets, Dictionaries, List Vs Tuple Vs Dictionary Vs Set.

**Module-4 Classes and Objects**: Introduction, Classes and Objects, Defining Classes, Creating Objects, Data Abstraction and Hiding through Classes, Class Method and self-Argument, The __init__() Method, The __del__() Method ,Public and Private Data Members, Private Methods, Calling a Class Method from Another Class Method, Built-in Functions to Check, Get, Set, and Delete Class Attributes, Built-in Class Attributes .

**Module-5 Inheritance Introduction** : Inheriting Classes in Python, Polymorphism and Method Overriding, Types of Inheritance, Composition or Containership or Complex Objects, Abstract Classes and Interfaces, Metaclass; Error and Exception Handling: Introduction to Errors and Exceptions, Syntax Errors, Logic Error, Exceptions, Handling Exceptions, Multiple Except Blocks, Multiple Exceptions in a Single Block, Except Block Without Exception, The else Clause, Raising Exceptions, Instantiating Exceptions, Handling Exceptions in Invoked Functions, Built-in and User-defined Exceptions, The finally Block, Pre-defined Clean–up Action Re-raising Exception, Assertions in Python.

**Books:** 1-Learning Python,4$^{th}$ Edition by Mark Lutz.
2-Programming Python, 4$^{th}$ Edition by Mark Lutz.
3-Dive Python, Mike

**Course outcome:** After completing this course, students will be able to understand:

- understand the principle of python programming
- understand the python code
- create application using python programming .
- implementing data base using SQLite
- apply the python code in real time.

## EEE 364: Robotics and Automation

**L T P**
**3 1 0**

**Module I** (7 hrs)

Introduction to Robotics: Types and components of a robot, Classification of robots, closed-loop and open loop control systems. Kinematics systems; Basic definitions of Robotics, Descriptions: Positions, Orientations, Frames, Robot Anatomy – Links, Joints and Joint Notation scheme, Degrees of Freedom (DOF), mechanisms and manipulators, Required DOF in a Manipulator.

**Module II** (7 hrs)

Robot Kinematics and Dynamics: Kinematic Modeling: Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics, Dynamic Modeling: Equations of motion: Euler-Lagrange formulation

**Module III** (8 hrs)

Robotic sensor: Contact and Proximity, Position, Velocity, Force, Tactile, Force-Torque sensors. Actuators: Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators. Vision System: Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations, Vision applications in robotics.

**Module IV** (7 hrs)

Robotics control: Second order linear system, Feedback control laws: P, PD, PID, Non-linear trajectory tracking control, joint controller, Control Hardware and Interfacing with sensors, actuators, components, Robotic Programming (ROS and VAL II), Applications of Industrial robot (PUMA, KUKA, FANUC, MTAB).

**Module V** (6 hrs)

Artificial Intelligence in Robotics: Applications in unmanned systems, defence, medical, process industries, Motion planning – potential fields, projective path planning, Robotics and Automation for Industry 4.0.

**Text Books**


1. Ashitava Ghoshal, Robotics Fundamental Concepts & Analysis, Oxford University Press. (2006).
2. Mittal and Nagrath, Robotics and Control, Tata McGraw-Hill Publishing Company Ltd., New Delhi (2004)
3. Nikku, S.B., Introduction to Robotics, Prentice Hall of India Private Limited (2002).
4. Saha, S.K., “Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.


**Reference Books**


1. Richard D. Klafter, Thomas A Chmielewski and Michael Negin, Robotics Engineering: An integrated approach, Prentice Hall. (1998)
2. John Craig, Introduction to Robotics, mechanics and control, Pearson Education, New Delhi. (2005)
3. M.P. Groover, Mitchell Weiss, Roger N. Nagel & Nicholas Godfrey, Industrial Robotics. Tata McGraw Hill Education Pvt. Ltd. (2001)
4. Gonzalex, R. C. and Fu, K. S., Robotics Control Sensing, Vision and Intelligence, McGraw Hill (1985).
5. Koren,Y., Robotics for Engineers, McGraw Hill (2004).


**Course Outcomes:**

1. Perform kinematic and dynamic analyses.
2. Design control laws for a robot.
3. Integrate mechanical and electrical hardware for a real prototype of robotic device.
4. Select a robotic system for given application.
5. Apply knowledge for various applications.

## PEE-361: SWITCH GEAR AND PROTECTION LAB

**LT P**
**0 0 2**

1. To study the instantaneous over current relay determine the time-current characteristics.
2. To study the IDMT over current relay and determine the time-current characteristics.
3. To study the earth fault relay and determine the time-current characteristics.
4. To study the thermal relay and determine the time-current characteristics.
5. To study percentage differential relay and plot its operating characteristics.
6. To study Impedance, MHO and Reactance type distance relays.
7. To study over-voltage relay and determine the time-voltage characteristics.
8. To study under-voltage relay and determine the time-voltage characteristics.
9. Measurement of earth resistance using Megger.

**Simulation Based Experiments (using MATLAB or any other software)**

10. To obtain formation of Y-bus and perform load flow analysis using N-R method.
11. To perform symmetrical fault analysis in a power system using Z-Bus Matrix.
12. To perform unsymmetrical fault analysis in a power system Z-Bus Matrix.

****Additional or any other experiment may be added based on contents of syllabi.

**Course Outcomes**:

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

1. Able to analyze different protection schemes like over-current, over-voltage, distance etc.
2. Able to demonstrate practical implementation of theory of all protection strategies of power system.

## PEE-362: ELECTRIC DRIVES LAB

**LT P**
**0 0 2**

1. To study speed control of separately excited dc motor by varying armature voltage using single-phase fully controlled bridge converter.
2. To study speed control of separately excited dc motor by varying armature voltage using single phase half controlled bridge converter.
3. To study speed control of separately excited dc motor using single phase dual converter (Static Ward- Leonard Control).
4. To study speed control of separately excited dc motor using MOSFET/IGBT chopper.
5. To study closed loop control of separately excited dc motor.
6. To study speed control of single phase induction motor using single phase ac voltage controller.
7. To study speed control of three phase induction motor using three phase ac voltage controller
8. To study speed control of three phase induction motor using three phase current source inverter.
9. To study speed control of three phase induction motor using three phase voltage source inverter.
10. To study speed control of three phase induction motor using (a) constant/V/F control (b) Constant Voltage and frequency control.
11. To study speed control of three phase slip ring induction motor using Static Scherbius slip power recovery control scheme.
12. To study speed control of three phase slip ring induction motor using static rotor resistance control using rectifier and chopper.

****Additional or any other experiment may be added based on contents of syllabi.

## PEE 363 Electronics Design Lab

**LT P**
**0 0 2**

### A. Arduino microcontroller-based experiments

1. Turns ON an LED for one second, then off for one second, repeatedly.
2. Read an analog input on pin 0, converts it to voltage, and prints the result to the Serial Monitor.
3. Read repeatedly from an analog input, calculating a running average and printing it to the computer. Keeps ten readings in an array and continually averages them.
4. Study of if () statements. Read the state of a potentiometer (an analog input) and turns on an LED only if the potentiometer goes above a certain threshold level. Print the analog value regardless of the level.
5. Interfacing Gyroscope and Accelerometer [Inertial measurement unit (IMU) sensor- GY521]
6. Interfacing Temperature and Humidity sensor modules [DHT11]
7. Interfacing Force sensitive resistor (FSR) sensors
8. Interfacing Digital Servo Motor

### B. Simulation experiments [Proteus]

1. Design a simple Switch and LED circuit simulation in Proteus.
2. Design a ±5 V regulated power supply
3. Design a logic gates simulation circuit in Proteus.
4. Design the Op-amp based inverting amplifier with a gain 10 and test the result.
5. Design a simple Low pass and high pass filter in Proteus and test its frequency response.
6. See the response of experiments performed in section A on Proteus Software.

### C. Printed Circuit Board (PCB) design experiments

1. Design a PCB for ±5 V regulated power supply using EasyEDA/ Eagle/ Altium/ KiCAD / Multisim/ OrCAD software.
2. Design a PCB for Op-amp based inverting amplifier with a variable gain.
3. Design and create PCB Layout for Astable Multivibrator using LM555CN IC.
4. Design and implement a PCB for clipper circuits.
5. Design and implement a PCB for clamper circuits.
6. Design a $2^{nd}$ Order Active Low Pass Filter having cut-off frequency of 100Hz.
7. Design a $2^{nd}$ Order Active High Pass Filter having cut-off frequency of 15Hz.

## TEE-471: INTELLIGENT SYSTEMS

**L T P**
**3 1 0**

**Module-1: Neural Networks (Introduction & Architecture): (6 hours)**
Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory

**Module-2: Neural Networks (Contd.)(Back propagation networks): (8 hours)**
Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications.

**Module-3: Fuzzy Logic (Introduction): (6 hours)**
Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory versus probability theory, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

**Module-4: Fuzzy Logic (Contd.) (Fuzzy Membership, Rules): (10 hours)**
Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfication & Defuzzification, Fuzzy Controller and its application.

**Module-5: Genetic Algorithm: (10 hours)**
Introduction, mutation, population, crossover. Application of Genetic Algorithm,

**Books:**


1. Kumar Satish, "Neural Networks" Tata Mc Graw Hill
2. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India.
3. Simon Haykin, "Neural Networks" Prentice Hall of India
4. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.


**Course Outcomes:**
1. Understand the importance of neural network.
2. Understand the importance of fuzzy logic.
3. Understand the importance of Genetic algorithm
4. Apply the intelligent techniques.
5. Analyze the intelligent techniques.

## EEE 470: SOLAR AND WIND ENERGY SYSTEMS

**L T P**
**3 1 0**

**Module 1: The Solar Resource and Solar photovoltaic (11 Hours)**
Introduction, solar radiation spectra, solar geometry, Earth Sun angles, observer Sun angles, solar day length, Estimation of solar energy availability.
Technologies-Amorphous, monocrystalline, polycrystalline; V-I characteristics of a PV cell, PV module, array, Power Electronic Converters for Solar Systems, Maximum Power Point Tracking (MPPT) algorithms. Converter Control.

**Module 2: Solar thermal power generation: (3 Hours)**
Technologies, Parabolic trough, central receivers, parabolic dish, Fresnel, solar pond, elementary analysis.

**Module 3: Physics of Wind Power: (5 Hours)**
History of wind power, Indian and Global statistics, Wind physics, Betz limit, Tip speed ratio, yaw, stall and pitch control, Wind speed statistics-probability distributions, Wind speed and power-cumulative distribution functions.

**Module 4: 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.

**Module 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 behaviour during grid disturbances. Power quality issues. Power system interconnection experiences in the world. Hybrid and isolated operations of solar PV and wind systems.

**Text / References:**
1. T. Ackermann, “Wind Power in Power Systems”, John Wiley and Sons Ltd., 2005.
2. G. M. Masters, “Renewable and Efficient Electric Power Systems**”,** John Wiley and Sons, 2004.
3. S. P. Sukhatme, “Solar Energy: Principles of Thermal Collection and Storage”, McGraw Hill, 1984.
4. H. Siegfried and R. Waddington, “Grid integration of wind energy conversion systems” John Wiley and Sons Ltd., 2006.
5. G. N. Tiwari and M. K. Ghosal, “Renewable Energy Applications”, Narosa Publications, 2004.
6. J. A. Duffie and W. A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley & Sons, 1991.

**Course Outcomes:**
At the end of this course, students will demonstrate the ability to
1. Explain the energy scenario and the consequent growth of the power generation from renewable energy sources.
2. Explain the basic physics of wind and solar power generation.
3. Explain the power electronic interfaces for wind and solar generation.
4. Explain the issues related to the grid-integration of solar and wind energy systems.

**EEE 471: Optimization Techniques**

**L T P**
**3 1 0**

**Module 1: Introduction to Optimization (10 hours)**
Introduction to Optimization: Two Variable LP model, Graphical LP Solution, Selected LP Applications, Convex Set, LP Model in Equation Form, Transition from Graphical to Algebraic Solution, Simplex Method, Artificial Starting Solution, Special Cases in the Simplex Method, Big M method (Penalty method)

**Module 2: Solution of Dual Problem (6 hours)**
The Simplex Method, Generalized Simplex Tableau in Matrix Form, Additional simplex algorithms: Dual Simplex Method, Generalized Simplex Algorithm, Post Optimal Analysis

**Module 3: Application of Linear Programming (10 hours)**
Definition of Transportation Problem, The Transportation Algorithm: North West corner method, Row & Column minima method, lowest cost entry method, The Assignment Model, Goal Programming Formulation, Goal Programming Algorithms: The Weights Method and The Pre-emptive Method

**Module 4: Non-Linear Programming (6 hours)**
Unconstrained Problems, Convex and Concave Functions. Fibonacci Method and Golden Section Method, Gradient of a Function, Descent Methods: Steepest Descent Method and Conjugate Gradient Method, Karush-Kuhn-Tucker (KKT) Conditions, Quadratic Programming

**Module 5**: **Introduction of computation techniques (3 hours)**
Drawbacks of the Classical Techniques, Introduction to Non-traditional Optimization Techniques.

**Text/References:**


1. H.A.Taha, Operations Research: An Introduction, Pearson Education, 9th Ed., 2012.
2. Ronald L. Rardin, Optimization in Operations Research, Pearson Education, 2nd Indian Reprint, 2003.
3. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, T M H, 8th Ed, 2005.
4. Pant J.C., Introduction to Optimization: Operations Research, Jain Brothers, New Delhi, 5th Ed, 2000.
5. G.C. Onwubolu and B.V. Babu, New Optimization Techniques in Engineering, Springer, 1st Ed, 2004.


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

- To understand the meaning of optimization and How to develop linear programming (LP) models with its solutions.
- To understand the concept of duality and relate the dual solution to the primal solution.
- To understand multiples objectives optimization and how to solve multi objective optimization.
- How to solve nonlinear programming problem.

## EEE-472: POWER SYSTEM TRANSIENTS

**L T P**
**3 1 0**

**Module-1:**
**Simple Switching Transients:** Introduction, Circuit Closing Transient, Recovery Transient, Double Frequency Transients. Resistance and Load Switching. **Abnormal Switching Transients:** Normal and Abnormal Switching Transients, Current Suppression, Capacitance Switching, Re-striking Phenomena, Transformer Magnetizing Inrush Current, Ferro-resonance.

**Module-2:**
**Transients in 3-φ Circuits:** Introduction, Importance of Neutral Connection, 3-φ Reactor with Isolated Neutral, 3-φ Capacitance Switching, Symmetrical Component Method for Solving 3-φ Switching Transients, Y-Δ Transformer, Circuit Reduction. **Transients in DC Circuits:** Interruption of Direct Currents in Low Voltage Circuits, Transients Associated with HVDC Circuit Breakers.

**Module-3:**
**Travelling Waves and Other Transients on Transmission Lines:** Circuits with Distributed Constants, Wave Equation, Reflection and Refraction of Travelling Waves, Travelling Waves at Line Terminations, Lattice Diagram, Attenuation and Distortion of Travelling Waves, Multi-conductor Systems and Multi-velocity Waves. **Behaviour of Transformer Windings under Transient Conditions:** Initial Voltage Distribution, Winding Oscillations, Travelling Wave Solution, Voltage Surge through Transformer

**Module-4:**.
**Transients in the Integrated Power System:** Introduction, Short Line or Kilometric Fault, Line Dropping and Load Rejection, Voltage Transients on Closing and Reclosing Lines, Switching HVDC Lines, Switching Surges on an Integrated System.

**Module-5:**
**Protection of Systems and Equipment against Transient Over-voltages:** Protection of Transmission Lines against Lightning, Surge Suppressors and Lightning Arresters, Application of Surge Arresters, Surge Capacitors and Reactors, Surge Protection of Rotating Machines. Transient Voltages and Grounding Practices.

**Books:**
1. Joseph B. Aidala and Leon Katz, "Transients in Electric Circuits", Prentice Hall.
2. Allan Greenwood, "Power System Transients".

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

- Understand the importance of transient
- Understand the transients involved in different equipments
- Analyze the transient responses.
- Understand the protection against transient
- Design the protective arrangement.

## EEE 473: SPECIAL ELECTRICAL MACHINES

**L T P**
**3 1 0**

**MODULE-I**

**Poly-phase AC Machines:**

Construction and performance of double cage and deep bar three phase induction motors; E.M.F. injection in rotor circuit of slip ring induction motor, concept of constant torque and constant power controls, static slip power recovery control schemes (constant torque and constant power)

**MODULE-II**

**Single phase AC Motors:** Single phase synchronous motor- Hysteresis motor, reluctance motor, and shaded pole motors. Construction, principle of operation, characteristics of universal and repulsion motors.

**Two Phase AC Servomotors:**

Construction, torque-speed characteristics, performance and applications.

**MODULE-III**

**Stepper Motors:**

Principle of operation, variable reluctance, permanent magnet and hybrid stepper motors, characteristics, drive circuits and applications.

**Switched Reluctance Motors and Synchronous Reluctance Motors:**

Construction; principle of operation; torque production, modes of operation, drive circuits.

**MODULE-IV**

**Permanent Magnet Machines:**

Types of permanent magnets and their magnetization characteristics, demagnetizing effect, permanent magnet dc motors, sinusoidal PM ac motors, PMBLDC and PMSM and their important features and applications, PCB motors; introduction to permanent magnet generators.

**MODULE-V**

**Linear Induction Motors**: Construction, principle of operation, Linear force, and applications.

**Text Books:**

1. P.S. Bimbhra "Generalized Theory of Electrical Machines" Khanna Publishers.
2. P.C. Sen " Principles of Electrical Machines and Power Electronics" John Wiley & Sons, 2001
3. G.K.Dubey "Fundamentals of Electric Drives", Narosa Publishing House, 2001

**Reference Books:**

4. Cyril G. Veinott "Fractional and Sub-fractional horse power electric motors" McGraw Hill International, 1987.
5.M.G. Say, "Alternating current Machines" Pitman & Sons.

**Course Outcomes:**

1. Perform analysis for polyphase induction motor dynamics.
2. Analyze 1-phase motors.
3. Explain behavior of different stepper motors.
4. Select PM based motor for a given special application.
5. Apply principles of LIM.

## EEE 474: HVDC TRANSMISSION SYSTEMS

**L T P**
**3 1 0**

**Module 1: DC Transmission Technology (4 hours)**
Comparison of AC and dc Transmission (Economics, Technical Performance and Reliability). Application of DC Transmission. Types of HVdc Systems. Components of aHVdc system. Line Commutated Converter and Voltage Source Converter based systems.

**Module 2: Analysis of Line Commutated and Voltage Source Converters (10 hours)**
Line Commutated Converters (LCCs): Six pulse converter, Analysis neglecting commutation overlap, harmonics, Twelve Pulse Converters. Inverter Operation. Effect of Commutation Overlap. Expressions for average dc voltage, AC current and reactive power absorbed by the converters.

Effect of Commutation Failure, Misfire and Current Extinction in LCC links.

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.

**Module 3: Control of HVDC Converters: (10 hours)**
Principles of Link Control in a LCC HVDC system. Control Hierarchy, Firing Angle Controls – Phase-Locked Loop, Current and Extinction Angle Control, Starting and Stopping of a Link. Higher level Controllers Power control, Frequency Control, Stability Controllers. Reactive Power Control. Principles of Link Control in a VSC HVDC system: Power flow and dc Voltage Control. Reactive Power Control/AC voltage regulation.

**Module 3: Components of HVDC systems: (8 hours)**
Smoothing Reactors, Reactive Power Sources and Filters in LCC HVDC systems DC line: Corona Effects. Insulators, Transient Over-voltages. dc line faults in LCC systems. dc line faults in VSC systems. dc breakers. Monopolar Operation. Ground Electrodes.

**Module 4: Stability Enhancement using HVDC Control (4 hours)**
Basic Concepts: Power System Angular, Voltage and Frequency Stability. Power Modulation: basic principles – synchronous and asynchronous links. Voltage Stability Problem in AC/dc systems.

**Module 5: MTdc Links (4 hours)**
Multi-Terminal and Multi-Infeed Systems. Series and Parallel MTDC systems using LCCs. MTDC systems using VSCs. Modern Trends in HVDC Technology. Introduction to Modular Multi-level Converters.

**Text/References:**


1. K. R. Padiyar, "HVDC Power Transmission Systems", New Age International Publishers, 2011.
2. J. Arrillaga, "High Voltage Direct Current Transmission", Peter Peregrinus Ltd., 1983.
3. E. W. Kimbark, "Direct Current Transmission", Vol.1, Wiley-Interscience, 1971.
4.


**Course Outcomes:**
1. Undestand the advantage of DC transmission over AC transmission.
2. Understand the importance of line commutated converters
3. Understand the importance of voltage source converters
4. Undersatnd the control strategies in HVDC system
5. Explain the improvements in power system stability using HVDC.

## EEE 475: POWER QUALITY AND FACTS

**L T P**
**3 1 0**

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

Basics of AC Transmission. Analysis of uncompensated AC transmission lines. Passive Reactive Power Compensation. Shunt and series compensation at the mid-point of an AC line. Comparison of Series and Shunt Compensation.

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

Description and Characteristics of Thyristor-based FACTS devices: Static VAR Compensator (SVC), Thyristor Controlled Series Capacitor (TCSC), Thyristor Controlled Braking Resistor and Single Pole Single Throw (SPST) Switch. Configurations/Modes of Operation, Harmonics and control of SVC and TCSC. Fault Current Limiter.

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

Voltage Source Converters (VSC): Six Pulse VSC, Multi-pulse and Multi-level Converters, Pulse-Width Modulation for VSCs. Selective Harmonic Elimination, Sinusoidal PWM and Space Vector Modulation. STATCOM: Principle of Operation, Reactive Power Control: Type I and Type II controllers, Static Synchronous Series Compensator (SSSC) and Unified Power Flow Controller (UPFC): Principle of Operation and Control. Working principle of Interphase Power Flow Controller. Other Devices: GTO Controlled Series Compensator. Fault Current Limiter.

**Module 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 a STATCOM.

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

Power Quality problems in distribution systems: Transient and Steady state variations in voltage and frequency. Unbalance, Sags, Swells, Interruptions, Wave-form Distortions: harmonics, noise, notching, dc-offsets, fluctuations. Flicker and its measurement. Tolerance of Equipment: CBEMA curve.

**Module 6: DSTATCOM (8 hours)**

Reactive Power Compensation, Harmonics and Unbalance mitigation in Distribution Systems using DSTATCOM and Shunt Active Filters. Synchronous Reference Frame Extraction of Reference Currents. Current Control Techniques in for DSTATCOM.

**Module 7: Dynamic Voltage Restorer and Unified Power Quality Conditioner (6 hours)**

Voltage Sag/Swell mitigation: Dynamic Voltage Restorer – Working Principle and Control Strategies. Series Active Filtering. Unified Power Quality Conditioner (UPQC): Working Principle. Capabilities and Control Strategies.

**Text/References**


1. N. G. Hingorani and L. Gyugyi, “Understanding FACTS: Concepts and Technology of FACTS Systems”, Wiley-IEEE Press, 1999.
2. K. R. Padiyar, “FACTS Controllers in Power Transmission and Distribution”, New Age International (P) Ltd. 2007.
3. T. J. E. Miller, “Reactive Power Control in Electric Systems”, John Wiley and Sons, New York, 1983.
4. R. C. Dugan, “Electrical Power Systems Quality”, McGraw Hill Education, 2012.
5. G. T. Heydt, “Electric Power Quality”, Stars in a Circle Publications, 1991


**Course Outcomes:**

1. Understand the advantage and need of FACTS.
2. Understand the concepts of power quality
3. Understand the devices used for power quality
4. Develop the FACTS controller
5. Implement the FACTS controllers to transmission line

# EEE 476: POWER SYSTEM DYNAMICS AND CONTROL

**L T P**
**3 1 0**

**Module 1: Introduction to Power System Operations and Dynamics (8 hours)**
Introduction to power system stability. Power System Operations and Control. Stability problems in Power System. Impact on Power System Operations and control.

**Analysis of Linear Dynamical System and Numerical Methods**
Analysis of dynamical System, Concept of Equilibrium, Small and Large Disturbance Stability. Modal Analysis of Linear System. Analysis using Numerical Integration Techniques. Issues in Modeling: Slow and Fast Transients, Stiff System.

**Module 2: Modeling of Synchronous Machines and Associated Controllers (12 hours)**
Modeling of synchronous machine: Physical Characteristics. Rotor position dependent model. D-Q Transformation. Model with Standard Parameters. Steady State Analysis of Synchronous Machine. Short Circuit Transient Analysis of a Synchronous Machine. Synchronization of Synchronous Machine to an Infinite Bus. Modeling of Excitation and Prime Mover Systems. Physical Characteristics and Models. Excitation System Control. Automatic Voltage Regulator. Prime Mover Control Systems. Speed Governors.

**Module 3: Modeling of other Power System Components (10 hours)**
Modeling of Transmission Lines and Loads. Transmission Line Physical Characteristics. Transmission Line Modeling. Load Models - induction machine model. Frequency and Voltage Dependence of Loads. Other Subsystems – HVDC and FACTS controllers, Wind Energy Systems.

**Module 4: Stability Analysis (11 hours)**
Angular stability analysis in Single Machine Infinite Bus System. Angular Stability in multi-machine systems – Intra-plant, Local and Inter-area modes. Frequency Stability: Centre of Inertia Motion. Load Sharing: Governor droop. Single Machine Load Bus System: Voltage Stability. Introduction to Torsional Oscillations and the SSR phenomenon. Stability Analysis Tools: Transient Stability Programs, Small Signal Analysis Programs.

**Module 5: Enhancing System Stability (4 hours)**
Planning Measures. Stabilizing Controllers (Power System Stabilizers). Operational Measures-Preventive Control. Emergency Control.

**Text/Reference Books**


1. K.R. Padiyar, "Power System Dynamics, Stability and Control", B. S. Publications, 2002.
2. P. Kundur, "Power System Stability and Control", McGraw Hill, 1995.
3. P. Sauer and M. A. Pai, "Power System Dynamics and Stability", Prentice Hall, 1997.


**Course Outcomes:**
1. Understand the problem of stability.
2. Understand the dynamics of power system
3. Analyze the linear dynamic systems
4. Explain the stability
5. Model the power system components

## EEE 477: Biomedical Instrumentation

**LT P**
**3 1 0**

**Module -1:**
**Basic Physiological system of body:** Problem encountered in measuring leaving system, bioelectric potentials, biomaterial.
**Basic transducers principles:** Active and passive transducers, transducer for biomedical applications. Generation, propagation and distribution of bioelectric potential (ECG, EEG and EMG)

**Module -2:**
**Bio Potential Electrodes:** Basic type (micro skin surface and needle electrodes), Biochemical transducers (PH, blood gas and specific ion electrodes).
**Cardiovascular System & Measurement:** Heart and cardiovascular system and circulation block diagram, blood pressure and measurement, characteristics of blood flow and heart sounds.
**Electrocardiography** ECG lead configuration, ECG recording and their types.

**Module -3:**
**Nervous System:** The anatomy of nervous system, neuronal communication, EPSP, IPSP, Organization of brain, Measurement from the nervous system.
**Systematic skin and body temperature measurement:** Temperature measurement, Brief idea about ultrasonic measurements.

**Module -4:**
**Patient Care Monitoring:** Elements of intensive care, Organization of the hospital for patient-care monitoring, Pace makers-type, systems, mode and generators, Defibrillator-types, Biotelemetry and application of telemeter in patient care.

**Module -5:**
**Automation of Chemical Test:** Instrumentation for diagnostic X rays, Interfacing computer with medical instrumentation and other equipments, Bio medical computer applications. Shock hazards from electrical equipments, methods of accident prevention.

**Books:**
1. Cromwell- Biomedical Instrumentation and Measurements- PHI
2. Webster, J.G. –Bio- Instrumentation, Wiley (2004)
3. Carr & Brown –Introduction to Biomedical Equipment Technology – Pearson

**Course Outcomes:**
1. Understand the transducer for biomedical.
2. Understand the temperature measuring instrument
3. Analyze the ECG, EMG.
4. Explain MMG
5. Diagonize the ECG,EMG

## TEE-481: Process Control Instrumentation

**L T P**
**3 1 0**

**Module 1: Introduction to Process Control: (8 Hours)**
**Control Systems:** Process-Control Principles, Servomechanisms, Discrete-State Control Systems; Process-Control Block Diagram: Identification of Elements, Block Diagram, Control System Evaluation: Stability, Steady-State Regulation, Transient Regulation, Evaluation Criteria, Analog and Digital Processing: Data Representation, ON/OFF Control, Analog Control, Digital Control, Programmable Logic Controllers. Modules, Standards, and Definitions: Modules, Analog Data Representation, Process-Control Drawings, Sensor Time Response: First-Order Response, Second-Order Response.

**Module 2: Sensors: (10 Hours)**
**Thermal Sensors:** Resistance-Temperature Detectors; Thermistors; Thermocouples; Other Thermal Sensors- Bimetal Strips, Gas Thermometers, Vapour-Pressure Thermometers, Liquid-Expansion Thermometers, Solid-State Temperature Sensors; Design Considerations.
**Mechanical Sensors:** Displacement, Location, or Position Sensors; Strain Sensors; Strain Sensors; Pressure Sensors; Flow Sensors.
**Optical Sensors:** Optical Sources; Photodetectors; Pyrometry; Applications.

**Module 3: Controller Principles (8 Hours)**
Process Characteristics: Process Equation, Process Load, Process Lag, Self-Regulation; Control System Parameters: Error, Variable Range, Control Parameter Range, Control Lag, Dead Time, Cycling, Controller Modes, Discontinuous Controller Modes: Two-Position Mode, Multi-position Mode, Floating-Control Mode; Continuous Controller Modes: Proportional Control Mode, Integral-Control Mode, Derivative-Control Mode; Composite Control Modes: Proportional-Integral Control (PI), Proportional-Derivative Control Mode (PD), Three-Mode Controller (PID),

**Module 4: Analog Controllers (6 Hours)**
**Electronic Controllers:** Error Detector; Single Mode: Two-Position, Proportional Mode, Integral Mode, Derivative Mode; Composite Controller Modes: Proportional-Integral, Proportional-Derivative, PID (Three-Mode).
**Pneumatic Controllers:** Mode Implementation- Proportional, Proportional-Integral, Proportional-Derivative, Three-Mode.
Design Considerations.

**Module 5 (8 Hours)**
**Computer-Based Control:**
Digital Applications: Alarms, Two-Position Control; Computer-Based Controller: Hardware Configurations, Software Requirements; Other Computer Applications: Data Logging, Supervisory Control, Control System Networks.
**Control-Loop Characteristics:**
Control System Configurations: Single Variable, Cascade Control; Multivariable Control Systems: Analog Control, Supervisory and Direct Digital Control; Control System Quality: Definition of Quality, Measure of Quality; Stability; Stability Criteria; Process Loop Tuning: Open-Loop Transient Response Method, Ziegler-Nichols Method, Frequency Response Methods.

**Text / References:**
1. Stephanopoulis, G, Chemical Process Control, Prentice Hall of India, New Delhi, 1990
2. Eckman D.P., Automatic Process Control, Wiley Eastern Ltd., New Delhi, 1993
3. Johnson C.D., Process Control Instrument Technology, Prentice Hall Inc. 1988
4. Process Control, Third Edition – Liptak B.G., Chilton Book Company, Pennsylvania, 1995

**Course Outcomes:**
1. Understand the electronic controllers
2. Understand process involved
3. Analyze the different process .
4. Explain the closed loop process control
5. Explain the controllers

## EEE-481: ELECTRIC AND HYBRID VECHICLES

**L T P**
**3 1 0**

**MODULE 1:** History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization Transmission characteristics, Mathematical models to describe vehicle performance.

**MODULE 2:** Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

**MODULE 3:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, Permanent Magnet Motor-drives, Switched Reluctance Motor drives. Special motors.

**MODULE 4:** Matching the electric machine and the internal combustion engine (ICE) Sizing the propulsion motor, sizing the power electronics, Battery types, Battery performance parameters. Selecting the energy storage technology, supporting subsystems.

**MODULE 5:** Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies.

**BOOKS:**


1. K. T. Chau, “Electric Vehicle Machines and Drives: Design, Analysis and Applications”, John Wiley & Sons, 2015.
2. CRC Press, “Hybrid & Electric Vehicles”, Taylor & Francis Group, 2018.
3. Wei Liu, “Introduction to Hybrid Vehicle System Modeling and Control”, Wiley India, 2015.


**COURSE OUTCOMES:**

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

1. Classify the electric hybrid vehicles (EHVs)
2. Demonstrate the knowledge about fundamental concepts, principles and performance parameters
3. Discuss the working of various motors for EHVs
4. Match the electric motor and the internal combustion engine.
5. Select energy storage technology and energy management strategy

# EEE-471: ADVANCED POWER ELECTRONICS

**L T P**
**3 1 0**

**Module-1:** Power Supplies: Desirable specification of power supply, drawback of linear power supply. Switch mode power supply (SMPS)-schematic diagram, fly back converters, forward converter, push pull converters, half bridge and full bridge converter; uninterruptible power supply (UPS)-configuration of line and online UPS, switch mode and resonant power supplies, air craft power supply.

**Module-2:** Industrial Applications: High frequency inverters for induction and dielectric heating, ac voltage controllers for resistance heating and illumination control, high frequency fluorescent lighting, electric welding control.

**Module-3:** Effect of Harmonics: Parallel and series resonance, Effect of harmonics on static power plant transmission lines, transformers, capacitor banks, rotating machines, harmonic interference with ripple control systems, power system protection, consumer equipments and communication systems, power measurement.

**Module-4:** Elimination/Suppression of Harmonics: High power factor converter, multi-pulse converters using transformer connections (Delta, polygon) Passive Filters: Types of passive filters, single tuned and high pass filters, filer design criteria, double tuned filters, damped filters and their design.

**Module-5:** Active Power filters: Compensation principle, classification of active filters by objective, systems configuration, power circuit and control strategy. Shunt Active Filter: Single phase active filter, principle of operation, expression for compensating current, concept of constant capacitor voltage control; Three phase active filter: Operation, analysis and modeling; Instantaneous reactive power theory. Other Techniques: Unified Power Quality Conditioner, voltage source and current configurations, principle of operation for sag, swell and flicker control.

**Books:**


1. Ned Mohan, T. M. Undeland and William P. Robins, "Power Electronics: Converters, Applications and Design", John Wiley & Sons.
2. M.H. Rashid, "Power Electronics: Circuits, Devices and Applications" Prentice Hall of India.
3. K.R. Padiyar, "HVDC Power Transmission: Technology and System Reactions" New Age International.
4. Roger C. Dugan, Mark F. Mc Granhgan, Surya Santoso, "Electrical Power System Quality" Mc Graw hill, 2nd Edition.
5. Arindam Ghosh and Gerard Ledwich, "Power Quality Enhancement using custom power devices ", Kulwer academic publishers.


**Course outcome:** After completing this course the student will be able to understand

1. Different types of power supplies and converters
2. Industrial applications
3. Harmonics and its control and Active and Passive filter
4. Industrial applications
5. Apply the electronics devices in real time

**EEE 483: Reliability Analysis**

**L T P**
**3 1 0**

**Module 1:** Basics of Probability theory & Distribution **(12 Hours)**
Basic probability theory – rules for combining probabilities of events – Bernoulli's trials – probabilities density and distribution functions – binomial distribution – expected value and standard deviation of binomial distribution
Analysis of Series, Parallel, Series-Parallel networks – complex networks – decomposition method.

**Module 2:** Reliability functions **(8 Hours)**
Reliability functions f(t), F(t), R(t), h(t) and their relationships – exponential distribution – Expected value and standard deviation of exponential distribution – Bath tub curve – reliability analysis of series, parallel networks using exponential distribution – reliability measures MTTF, MTTR, MTBF.

**Module 3:** Markov Modelling **(8 Hours)**
Markov chains – concept of stochastic transitional probability Matrix, Evaluation of limiting state
Probabilities – Markov processes one component repairable system – time dependent probability
evaluation using Laplace transform approach – evaluation of limiting state probabilities using STPM – two component repairable models

**Module 4:** Generation System Reliability Analysis **(6 Hours)**
Reliability model of a generation system– recursive relation for Module addition and removal – load modelling.
Merging of generation load model – evaluation of transition rates for merged state model – cumulative Probability, cumulative frequency of failure evaluation – LOLP, LOLE.

**Module 5:** Composite and Distribution Systems Reliability Analysis **(8 Hours)**
Decompositions method – Reliability Indices – Weather Effects on Transmission Lines. Distribution System and Reliability Analysis: Basic Concepts – Evaluation of Basic and performance reliability indices of radial networks.

**Text / References:**


1. Reliability Evaluation of Engg. System – R. Billinton, R.N.Allan, Plenum Press, New York, reprinted in India by B.S.Publications, 2007.


**Course outcome:** After completing this course the student will be able to understand

2. Understand the importance of reliability
3. Analyze the reliability concept
4. Predict the system behaviour
5. Explain the Markov reliability
6. Design the solution for a system

## EEE-454: MACHINE MODELING

**LT P**
**3 1 0**

**Module-1:**

**Transformations:** Electromechanical Energy-Conversion Principles, Kron's Primitive machine, General expression of voltage, force and torque, Basic modeling of electrical machines from coupled circuit point of view. Techniques of transformations, reference frames, operationalized equivalent circuit.

**Module-2:**

**Modeling of D. C. Machines:** Analysis of motoring and generating action under steady state, transient and dynamic simulation, Effect of load change under dynamic conditions for different excitations, reversal and braking.

**Module-3:**

**Modeling of Synchronous Machines:** dq transformation**,** Concepts of Time varying inductances steady state and dynamic equations, Phasor diagram of Synchronous Machines, Electromagnetic and reluctance torque, Synchronous Machines dynamics, Response under short circuit, sub transient and transient condition. Dynamic simulation of vector controlled synchronous machines.

**Module-4:**

**Modeling of Poly-phase Induction Machines:** Equations under stationary, rotating and synchronous reference frames**,** derivation of torque and power expression, Equivalent circuit, Concepts of Time varying inductances, Dynamic under load changes, run up time, Speed reversal and braking. Computer simulation for dynamic response.

**Module-5:**

Doubly fed induction motor: Principles, operation its control. Induction generator: principles and operations. Doubly fed induction generator: principles and operations.

**Books:**

1. A. E. Fitzgerald, Charles Kingsley, Jr. and Stephen D. Umans, "Electrical Machinery", McGraw-Hill .
2. P. S. Bimbhra, "Generalized Theory of Machines", Khanna Publications.
3. R. Krishnan "" Modeling, Analysis and Control of Electric Drives.

**Course outcome:** After completing this course the student will be able to understand

1. Describe the importance of modeling
2. Apply the Parks transformation
3. Analyze the importance of 2-axis to 3-axis conversion and vice versa
4. Explain the induction machine modeling
5. Explain the DC and synchronous machine modeling

## TOE 050: ELECTRICAL MACHINES

**L T P**
**3 1 0**

**Module-I**

**Principles of Electro-mechanical Energy Conversion:** Introduction, Flow of Energy in Electromechanical Devices, Energy in magnetic systems-Field energy & Co-energy, Singly-Excited Systems and Doubly-excited Systems-generalized expression of torque, reluctance and electromagnetic torques.

**Module-II**

**D. C. Machines:** Constructing feature and principal of operation of shunt, series and compound generators and motors including EMF equation and armature reaction. Performance characteristics of generators and motors, starting, speed control and braking of motors. Two quadrant and four quadrant operation of motors, choice of DC motors for different applications, losses and efficiency.

**Module-III**

**Transformers:** Construction, EMF equation, Principle of operation, phasor diagram on no-load, effect of load, equivalent circuit, voltage regulation, Losses and efficiency, Tests on transformers, Prediction of efficiency and regulation, Auto transformers, Instrument transformers, Three phase transformers.

**Module-IV**

**Induction Motors:** Rotating magnetic fields, Principle of operation, Equivalent circuit, Torque-slip characteristic, Starters for cage and wound rotor type induction motors, speed control and breaking, single phase induction motors and methods of starting.

**Module-V**

**Synchronous Machines:** Construction, EMF, Effect of pitch and distribution, Armature reaction and determination of regulation of synchronous generators, Principle of motor operation, Effect of excitation on line current (V-curves). Methods of synchronization, Typical applications of AC motors in industries.

**References:**


1. I. J. Nagrath & D.P.Kothari, " Electrical Machines", Tata McGraw Hill.
2. Bhimbra P. S., "Electrical Machinery" Khanna Publication
3. A. E. Fitzgerald, C. Kingsley Jr and Umans," Electric Machinery" 6th Edition McGraw Hill, International Student Edition.
4. Irving L. Kosow, "Electric Machine and Transformers", Prentice Hall of India.
5. M. G. Say, "The Performance and Design of AC machines", Pit man & Sons.
6. Bhag S. Guru and Huseyin R. Hizirogulu, "Electric Machinery and Transformers" Oxford University Press, 2001.
7. Ashfaq Hussain, "Electric Machines" Dhanpat Rai & Company


**Course Outcome**

At the end of course, the students will be able to

1. Explain the importance of electromechanical energy conversion
2. Explain, analyse and apply the working principle of DC machines
3. Explain, analyse and apply the working principle of transformer
4. Explain, analyse and apply the working principle of induction motor
5. Explain, analyse and apply the importance of three phase synchronous machine.

## TOE051: NON-CONVENTIONAL ENERGY SYSTEM

**L T P**
**3 1 0**

**Module-1**

Introduction: Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits.

Solar Cells: Theory of solar cells, Solar cell materials, solar cell array, solar cell power plant, limitations.

**Module-2**

Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focusing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations.

**Module-3**

Geothermal Energy: Resources of geothermal energy, thermodynamics of geo-thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations.

Magneto-hydrodynamics (MHD): Principle of working of MHD Power plant, performance and limitations.

Fuel Cells: Principle of working of various types of fuel cells and their working, performance and limitations.

**Module-4**

Thermo-electrical and thermionic Conversions: Principle of working, performance and limitations. Wind Energy: Wind power and its sources, site selection, criterion, momentum theory, classification of rotors, concentrations and augments, wind characteristics. performance and limitations of energy conversion systems.

**Module-5**

Bio-mass: Availability of bio-mass and its conversion theory.

Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations.

Wave and Tidal Wave: Principle of working, performance and limitations. Waste Recycling Plants.

**Text/References Books:**


1. Raja et al, "Introduction to Non-Conventional Energy Resources" Scitech Publications.
2. John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications, 2006.
3. M.V.R. Koteswara Rao, "Energy Resources: Conventional & Non-Conventional" BSP Publications,2006.
4. D.S. Chauhan,"Non-conventional Energy Resources" New Age International.
5. C.S. Solanki, "Renewal Energy Technologies: A Practical Guide for Beginners" PHI Learning.
6. 


**Course Outcomes:**

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

1. Explain the energy scenario and the consequent growth of the power generation from renewable energy sources.
2. Explain the basic physics of wind and solar power generation.
3. Explain the Geo-thermal energy.
4. Explain the issues related to the bio-mass, wave and tidal energy systems.

## TOE 052: DIGITAL CONTROL SYSTEM

**L T P**
**3 1 0**

**Module 1: Discrete Representation of Continuous Systems (6 hours)**
Basics of Digital Control Systems. Discrete representation of continuous systems. Sample and hold circuit. Mathematical Modelling of sample and hold circuit. Effects of Sampling and Quantization. Choice of sampling frequency. ZOH equivalent.

**Module 2: Discrete System Analysis and Stability of Discrete Time System (10 hours)**
Z-Transform and Inverse Z Transform for analyzing discrete time systems. Pulse Transfer function. Pulse transfer function of closed loop systems. Mapping from s-plane to z plane. Solution of Discrete time systems. Time response of discrete time system.
Stability analysis by Jury test. Stability analysis using bilinear transformation. Design of digital control system with dead beat response. Practical issues with dead beat response design.

**Module 3: State Space Approach for discrete time systems (10 hours)**
State space models of discrete systems, State space analysis. Lyapunov Stability. Controllability, reach-ability, Reconstructibility and observability analysis. Effect of pole zero cancellation on the controllability & observability.

**Module 4: Design of Digital Control System(8 hours)**
Design of Discrete PID Controller, Design of discrete state feedback controller. Design of set point tracker. Design of Discrete Observer for LTI System. Design of Discrete compensator.

**Module 5: 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 :**


1. K. Ogata, "Digital Control Engineering", Prentice Hall, Englewood Cliffs, 1995.
2. M. Gopal, "Digital Control Engineering", Wiley Eastern, 1988.
3. G. F. Franklin, J. D. Powell and M. L. Workman, "Digital Control of Dynamic Systems", Addison-Wesley, 1998.
4. B.C. Kuo, "Digital Control System", Holt, Rinehart and Winston, 1980.


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

1. Obtain discrete representation of LTI systems.
2. Analyse stability of open loop and closed loop discrete-time systems.
3. Design and analyse digital controllers.
4. Design state feedback and output feedback controllers.

## TOE0 53: POWER STATION PRACTICE

**L T P**
**3 1 0**

**Module-1**
**Economic aspects of generation**
Basic concept on generation, transmission and distribution, type of loads: industrial, commercial, and agricultural, Load curve, load duration curve, load factor, capacity factor, diversity factor. Base load station and peak load station, captive power plants, operating & spinning reserves. Load forecasting and its solving techniques, site selection of thermal, hydroelectric, nuclear, diesel and gas power plants.

**Module-2:**
**Tariffs and Power factor**
Electric utility services, general tariff forms and different types of tariffs, concept of power and energy in electrical system, maximum demand indicators and recorders. Evolution and definition of power factor (pf), concept of pf lagging & leading, zero pf lagging & leading, causes and effects of low power factor, necessity of power factor improvement and power factor improvement techniques.

**Module-3:**
**Power Plants and their coordinated operation**
Type of power plants and their operation: thermal, hydroelectric, nuclear with nuclear fuel processing and waste handling, diesel and gas. Field of application of power plants, advantages of coordinated operation of different types of power plants, hydro–thermal scheduling, short-term and long-term hydrothermal scheduling (without derivation), steam power plant coordination with run-off river, dam storage, pumped storage and gas turbine plants.

**Module-4:**
**Non-conventional energy sources (NCES) and Magneto-hydro-dynamic (MHD) generators**
Type of NCES and their operation: solar, wind, tidal, geo-thermal, MHD generator. Open and closed cycle operation of MHD generators with advantages, problems, and future trends.

**Module-5:**
**Power station auxiliaries**
Types of Turbines and their operation: Pelton, Francis, and Kaplan. Fuel feeding system both for coal and biomass fuel, boilers, governors, excitation system, auto voltage regulators (AVR), busbar arrangements, battery charger.

**Books:**
1. B. R. Gupta, 'Generation of electric energy' (Eurasia publishing house; Delhi).
2. M. V. Deshpande, 'Elements of power station design' (wheeler Publishing houses).
3. Soni, Gupta, Bhatnagar and Chakraborti, A Textbook on 'Power System (A Course in Electrical Power)'.

**Course Outcomes**:
At the end of this course, students will demonstrate the ability to
1. Analyze the concepts of generation economics.
2. Discuss the tariffs in power system.
3. Know about the coordination of power plants.
4. Must be able to draw the layout of NCES and MHD power plants.
5. Describe the power station auxiliaries.

# TOE 054: ELECTRICAL MATERIAL

**L T P**
**3 1 0**

**MODULE – 1**
**Crystal Structure of Materials**
Bonds in solids, crystal structure, co-ordination number, atomic radius representation of plane distance b/w two planed packing factor, Miller Indices, Bragg's law and x-ray diffraction, structural Imperfections, crystal growth.

**MODULE – 2**
**Dielectric Materials**
Polarization and Dielectric constant, Dielectric constant of mono-atomic, Poly atomic gases and solids, frequency dependence of electronic and ionic polarizabilities, dipolar relaxation, dielectric loss, piezoelectricity, ferroelectric materials.

**MODULE – 3**
**Conductivity**
Electron theory of metals, factors affecting electrical resistance of materials, thermal conductivity of metals, heat developed in current carrying conductors, Half effect, Drift and Diffusion currents, continuity equation, thermoelectric effect.

**MODULE – 4**
**Conducting and Insulating Materials**
Properties and applications of electrical conducting and insulating materials, mechanical properties of metals, Properties of semi-conducting materials, Properties of insulating materials, Superconductivity and super conducting materials, optical properties of solids.

**MODULE – 5**
**Magnetic Material**
Origin of permanent magnetic dipoles in matters, Classification, Diamagnetism, Para-magnetism, Ferromagnetism, Anti-ferromagnetism and Ferri-magnetism, magnetostriction, Properties of magnetic materials, soft and hard magnetic materials, permanent magnetic materials.

**Books:**

1. A. J. Dekker, "Electrical Engineering Materials" Prentice Hall of India.
2. Solymar, "Electrical Properties of Materials" Oxford University Press.
3. Ian P. Hones," Material Science for Electrical and Electronic Engineering," Oxford University Press.


**Course Outcomes**:
At the end of this course, students will demonstrate the ability to
1. Analyze the concepts of Crystal Structure of Materials
2. Discuss and apply the dielectric materials.
3. Classify the conducting and insulating materials.
4. Select the magnetic materials for applications.
5. Use soft magnetic materials for machines.

## TEE-055: Soft computing Techniques

**L T P**
**3 1 0**

**Module-1: Neural Networks (Introduction & Architecture): (6 hours)**
Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Various learning techniques; perception and convergence rule, Auto-associative and hetro-associative memory

**Module-2: Neural Networks (Contd.)(Back propagation networks): (8 hours)**
Architecture: perceptron model, solution, single layer artificial neural network, multilayer perception model; back propagation learning methods, effect of learning rule co-efficient ;back propagation algorithm, factors affecting back propagation training, applications.

**Module-3: Fuzzy Logic (Introduction): (6 hours)**
Basic concepts of fuzzy logic, Fuzzy sets and Crisp sets, Fuzzy set theory versus probability theory, Fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and Crisp relations, Fuzzy to Crisp conversion.

**Module-4: Fuzzy Logic (Contd.) (Fuzzy Membership, Rules): (10 hours)**
Membership functions, interference in fuzzy logic, fuzzy if-then rules, Fuzzy implications and Fuzzy algorithms, Fuzzyfications & Defuzzifications, Fuzzy Controller.

**Module-5: Optimization Algorithms (10 hours)**
Genetic Algorithm and its application, Particle swarm optimization algorithm and its application

**Books:**

1. Kumar Satish, "Neural Networks" Tata Mc Graw Hill
2. S. Rajsekaran & G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications" Prentice Hall of India.
3. Simon Haykin, "Neural Networks" Prentice Hall of India
4. Timothy J. Ross, "Fuzzy Logic with Engineering Applications" Wiley India.


**Course Outcomes:**
1. Discuss the importance of neural network.
2. Analyse and apply neural network principles
3. Describe the importance of Fuzzy Logic
4. Analyse and apply neural Fuzzy principles.
5. Analyze the Genetic algorithm techniques

## TOE 056: BIO MEDICAL SIGNAL PROCESSING

**L T P**
**3 1 0**

**Module -1**
Introduction to Biomedical Instrumentation: Components of the man- instrument system, Specifications of medical instrumentation systems, Problem encountered in measuring living system, Basic transducers principles, Active and passive transducers, transducer for biomedical applications.

**Module -2**
Bioelectric Potentials: Introduction to bioelectric potentials, Generation, propagation and distribution of bioelectric potential (ECG, EEG and EMG), Bio-potential electrodes, Microelectrodes, skin surface electrodes and needle electrodes, Biochemical transducers (pH electrode, blood gas electrodes and specific ion electrodes).

**Module -3**
Electrocardiogram (ECG): Anatomy of heart, Block diagram of electrocardiograph, ECG amplifier, ECG lead configuration, ECG recording, Electroencephalogram (EEG): Anatomy of nervous system, Block diagram of Electrocardiograph, Electromyogram (EMG): Block diagram of EMG instrument, Electrodes for EMG.

**Module -4**
Blood pressure measurement, Blood flow measurement, Systematic skin and body temperature measurement, Elements of intensive care unit, Pacemakers, Defibrillators, Biotelemetry and application of telemeter in patient care.

**Module -5**
Imaging techniques: Production of x-rays, block diagram of x-ray machine, x-rays Imaging techniques - CAT scan. Ultrasound imaging system, Principle & image reconstruction techniques of NMR and MRI; Application of computer in medical instrumentation; Shock hazards from electrical equipment, methods of accident prevention.

**Books:**
1. Cromwell– Biomedical Instrumentation and Measurements- PHI
2. Webster, J.G. – Bio- Instrumentation, Wiley (2004)
3. Khandpur R. S – Handbook of Biomedical Instrumentation", Tata McGraw Hill.

**Course Outcomes:**
1. Explain the transducer for biomedical.
2. Explain the temperature measuring instrument
3. Analyze the ECG, EMG.
4. Explain MMG
5. Diagonize the ECG,EMG

## TOE 057: ELECTRICAL INSTRUMENTATION

**L T P**
**3 0 0**

**Module-1**

**Introduction:** Basics of transducer, sensor and actuator; Active and passive transducers; Primary and secondary transducers; Analog and digital transducers; inverse transducers; Static characteristics of transducer and transducer system; Dynamic characteristics of nth, 0th, first and second order transducers.

**Measurement of Displacement and Strain:** Resistive, inductive and capacitive transducers for displacement; Wire, metal film and semiconductor strain gauges, Wheatstone-bridge circuit with one, two and four active elements, temperature compensation.

**Module -2**

**Measurement of Force and Pressure:** Column, ring and cantilever-beam type load cells; Elastic elements for pressure sensing; Using displacement sensors and strain gauges with elastic elements.

**Measurement of Temperature:** Resistance temperature detector, NTC and PTC thermistors, Seebeck effect, thermocouple and thermopile.

**Measurement of Flow and Liquid Level**.

**Module -3**

**Measurement of Vibrations:** Importance of vibration measurement, frequency range of vibrations; Absolute displacement, velocity and acceleration pick-ups; Mass-spring-damper system as absolute acceleration to relative displacement converter; Strain gauge and piezoelectric type acceleration pickups.

**Measurement of Speed and Torque:** Electro-magnetic and photoelectric tachometers; **Torque:** shaft, strain-gauge, electromagnetic and radio type torque meters.

**Module -4**

**Telemetry:** Meaning and basic scheme of telemetry; DC voltage and current telemetry schemes; Radio telemetry; PWM and digital telemetry schemes.

**Data Acquisition System:** Analog data acquisition system, digital data acquisition system, Modern digital data acquisition system.

**Module -5**

**Display Device and Recorders:** Display devices, storage oscilloscope, spectrum analyzer, strip chart and x-y recorders, magnetic tape and digital tape recorders.

**Recent Developments:** Computer aided measurements, fiber optic transducers, micro sensors, smart sensors, and smart transmitters.

**Books:**

1. A. K. Sawhney, "Advanced Measurements & Instrumentation", Dhanpat Rai & Sons
2. B.C. Nakra & K. Chaudhary, "Instrumentation, measurement and analysis", Tata McGraw Hill 2nd Edition
4. Dally. "Instrumentation for Engineering Measurement" 2nd edition, Wiley India

**Course Outcomes**:

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

1. Describe the various Principle Of Measurements
2. Perform error calculation.
3. Apply the Instruments principles.
4. explain the concept of CRO
5. familiarisation with measuring and testing.

## TOE 058: INDUSTRIAL PROCESS CONTROL

**L T P**
**3 1 0**

**Module I: Transducer – I**
Definition, advantages of electrical transducers, classification, characteristics, factor affecting the choice of transducers, Potentiometers, Strain gauges, Resistance thermometer Thermisters, Thermocouples, LVDT, RVDT.

**Module II: Transducer – II**
Capacitive, Piezoelectric Hall effect and opto-electronic transducers. Measurement of motion, Force pressure, temperature, flow and liquid level.

**Module III: Telemetry**
General telemetry system, land line & radio frequency telemetering system, transmission channel and media, receiver & transmitter. Data Acquisition System:
Analog data acquisition system, modern digital data acquisition system, modern digital data acquisition system.

**Module IV: Display Devices and Recorders**
Display devices, storage oscilloscope, spectrum analyzer, strip chart & x-y recorders, magnetic tape & digital tape recorders.

Recent Developments
Computer aided measurements, fibro optic transducers, microprocessors, and smart sensors smart transmitters.

**Module V: Process Control**
Principal element of process control system, process characteristics, proportional (P), Integral (I), derivative (D), PI, PD & PID control modes. Electronic, Pneumatic & digital controllers.

**Text Book:**

1. A.K Sawhney," Advance measurement & instrumentation", Dhanpat Rai & Sons.
2. B.C Nakara & K Chaudhry, instrumentation, measurement & analysis", Tata Mc Graw Hill 2nd Edition.
3. Curtis Johns, "Process Control Instrumentation Technology", Prentice Hall.

**Reference book:**

1. E.O Decblin, "Measurement system-application & design", McGraw Hill.
2. W.D Cooper & A.P Beltried,"Electronics Instrumentation and Measurement Techniques" Prentice Hall International.
3. Rajendera Prasad, "Electronic Measurement & Instrumentation Khanna Publisher.

**Course Outcomes:**

1. Explain the electronic controllers
2. Discuss the process involved
3. Analyze the different process.
4. Explain the closed loop process control.
5. Explain the controllers

## TOE-059: ELECTRIC VECHICLE COMPONENTS

**L T P**
**3 1 0**

**MODULE 1:** History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance.

**MODULE 2:** Basic concept of hybrid traction, hybrid drive-train topologies, Fuel efficiency analysis, Battery types, Battery performance parameters

**MODULE 3:** Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives configuration and control of Permanent Magnet Motor-drive Configuration and control of Switch Reluctance, special motors.

**MODULE 4:** 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.

**MODULE 5:** Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies Comparison of different energy management strategies Implementation issues of energy strategies.

**BOOKS:**


1. K. T. Chau, "Electric Vehicle Machines and Drives: Design, Analysis and Applications", John Wiley & Sons, 2015.
2. CRC Press, "Hybrid & Electric Vehicles", Taylor & Francis Group, 2018.
3. Wei Liu, "Introduction to Hybrid Vehicle System Modeling and Control", Wiley India, 2015.


**COURSE OUTCOMES:**
At the end of course the students will be able to:

1. Classify the electric hybrid vehicles
2. Demonstrate the knowledge about fundamental concepts, principles and performance parameters
3. Discuss the working of various motors for EVs
4. Match the electric motor and the battery requirement.
5. Select energy storage technology and energy management strategy.

## PEE 481 Instrumentation Lab

**LT P**
**0 0 2**

**A. LabVIEW-based Simulation experiments**

1. Create a VI (Virtual Instrument) to perform the arithmetic operations like: addition, subtraction, multiplication, division, increment, decrement, etc.
2. Create a VI (Virtual Instrument) to perform the string operations like: lower to upper case, upper to lower case, string length, concatenate strings, string subset, replace substring, etc.
3. Create a VI for averaging the marks obtained by a student in four subjects and grading. Use Sub-VI and MATLAB script.
4. Create a VI for simulating sine wave. Add a particular noise to this signal. Finally study the use filter to remove this noise.
5. Create a VI for the amplitude & level measurement and spectrum measurement on a signal.

**B. Study of Biomedical Instruments and the measurement of physiological parameters**

1. Blood pressure measurements
2. Electrocardiography
3. Electromyography
4. Body temperature
5. Blood flow
6. Heart rate.

****Additional or any other experiment may be added based on contents of syllabi.

**Course Outcomes**:
At the end of this course, students will be able

1. To create virtual instruments.
2. To understand different physiological parameters and variables.
3. To understand the signal conditioning used to acquire biomedical signals.