**ANNA UNIVERSITY, CHENNAI**

**AFFILIATED INSTITUTIONS**

**REGULATIONS 2025**

**B.E. ELECTRICAL AND ELECTRONICS ENGINEERING – (TRAINING INTEGRATED)**

**CHOICE BASED CREDIT SYSTEM**

**I TO IV SEMESTERS CURRICULUM AND SYLLABUS**

**Semester I**

| S. No. | Course Code | Course Title | Category | Periods per week | | | Total contact periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | MA25102 | Ordinary Differential Equations and Transform Techniques | T | 3 | 1 | 0 | 4 | 4 |
| 2. | TI25101 | Electrical Circuit Analysis | LIT | 3 | 0 | 2 | 5 | 4 |
| 3. | TI25102 | Electromagnetic Theory | T | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25103 | Digital Electronics | T | 3 | 0 | 0 | 3 | 3 |
| 5. | TI25104 | Analog Electronics | T | 3 | 0 | 0 | 3 | 3 |
| 6. | TI25105 | Training Integrated | L | 0 | 0 | 4 | 4 | 2 |
| 7. | TI25106 | Electronics Laboratory | L | 0 | 0 | 4 | 4 | 2 |
| **Total Credits** | | | | **15** | **1** | **10** | **26** | **21** |

**Semester II**

| S. No. | Course Code | Course Title | Cate Gory | Periods Per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | MA25201 | Statistics and Numerical Methods | T | 3 | 1 | 0 | 4 | 4 |
| 2. | TI25201 | Electrical Machines I | T | 3 | 0 | 0 | 3 | 3 |
| 3. | TI25202 | Problem Solving and Python Programming | T | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25203 | Problem Solving and Python Programming Laboratory | L | 0 | 0 | 4 | 4 | 2 |
| 5. | TI25204 | Electrical Machines Laboratory I | L | 0 | 0 | 4 | 4 | 2 |
| 6. | TI25205 | Training Integrated | L | 0 | 0 | 4 | 4 | 2 |
| **Total Credits** | | | | **9** | **1** | **12** | **22** | **16** |

## Semester III

| S. No. | Course Code | Course Title | Cate Gory | Periods Per Week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25301 | Electrical Machines II | T | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25302 | Transmission and Distribution | T | 3 | 0 | 0 | 3 | 3 |
| 3. | TI25303 | Microprocessor and Microcontroller | T | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25304 | Electrical Machines Laboratory II | L | 0 | 0 | 4 | 4 | 2 |
| 5. | TI25305 | Microprocessor and Microcontroller Laboratory | L | 0 | 0 | 4 | 4 | 2 |
| 6. | TI25306 | Training Integrated | L | 0 | 0 | 4 | 4 | 2 |
| **Total Credits** | | | | **9** | **0** | **12** | **21** | **15** |

## Semester IV

| S. No. | Course Code | Course Title | Cate gory | Periods Per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25401 | Measurements and Instrumentation | T | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25402 | Control Systems | T | 3 | 0 | 0 | 3 | 3 |
| 3. | | Professional Elective I | T | 3 | 0 | 0 | 3 | 3 |
| 4. | | Professional Elective II | T | 3 | 0 | 0 | 3 | 3 |
| 5. | TI25403 | Control and Instrumentation Laboratory | L | 0 | 0 | 4 | 4 | 2 |
| 6. | TI25404 | Training Integrated | L | 0 | 0 | 4 | 4 | 2 |
| **Total Credits** | | | | **12** | **0** | **8** | **20** | **16** |

**Professional Elective Courses**

| Power engineering | Converters and drives | Embedded systems | Electric vehicle technology | Advanced control | Diversified courses |
|---|---|---|---|---|---|
| Under Ground Cable Engineering | Special Electrical Machines | Embedded System Design | Electric Vehicle Architecture | Process Modeling and Simulation | Energy Storage Systems |
| Substation Engineering and Substation Automation | Analysis of Electrical Machines | Embedded C-Programming | Design of Motor and Power Converters for Electric Vehicles | Computer Control of Processes | Hybrid Energy Technology |
| HVDC and FACTS | Multilevel Power Converters | Embedded Processors | Electric Vehicle Design, Mechanics and Control | System Identification | Design and Modelling of Renewable Energy Systems |
| Energy Management and Auditing | Electrical Drives | Embedded Control for Electric Drives | Design of Electric Vehicle Charging System | Model Based Control | Grid integrating Techniques and Challenges |
| Power Quality | SMPS and UPS | Smart System Automation | Testing of Electric Vehicles | Non Linear Control | Sustainable and Environmental Friendly HV Insulation System |
| Smart Grids | Power Electronics for Renewable Energy Systems | Embedded System for Automotive Applications. | Grid Integration of Electric Vehicles | Optimal Control | Power System Transients |
| Restructured Power Market | Control of Power Electronics Circuits | VLSI Design | Intelligent control of Electric Vehicles. | Adaptive Control | PLC Programming |
| | - | MEMS and NEMS | - | Machine Monitoring System | Big Data Analytics |
| - | - | Digital Signal Processing System Design | - | - | - |

**Registration of Professional Elective Courses:**

Professional Elective Courses will be registered from Semester V onwards. These courses are listed in different groups that represent a particular area of specialisation / diversified group. Students are permitted to choose all the Professional Electives from a particular group or from different group. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, two courses are permitted from the same row, provided one course is enrolled in Semester V and another in semester VI.

Total number of professional elective courses per group may change in the each programme of study as 6 or 7 or 8. If there is shortage of courses in a group the same may be chosen from another group of the same programme.

## Professional Elective Courses

### Power Engineering

| S. No. | Course code | Course Title | Category | Periods Per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25001 | Under Ground Cable Engineering | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25002 | Substation Engineering and Automation | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | TI25003 | HVDC and FACTS | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25004 | Energy Management and Auditing | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | TI25005 | Power Quality | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | TI25006 | Smart Grid | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | TI25007 | Restructured Power Market | PEC | 3 | 0 | 0 | 3 | 3 |

### Converters and Drives

| S. No. | Course Code | Course title | Category | Periods Per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25008 | Special Electrical Machines | PEC | 2 | 0 | 2 | 3 | 3 |
| 2. | TI25009 | Analysis of Electrical Machines | PEC | 2 | 0 | 2 | 3 | 3 |
| 3. | TI250010 | Multilevel Power Converters | PEC | 2 | 0 | 2 | 3 | 3 |
| 4. | TI25011 | Electrical Drives | PEC | 2 | 0 | 2 | 3 | 3 |
| 5. | TI25012 | SMPS and UPS | PEC | 2 | 0 | 2 | 3 | 3 |
| 6. | TI25013 | Power Electronics for Renewable Energy Systems | PEC | 2 | 0 | 2 | 3 | 3 |
| 7. | TI25014 | Control of Power Electronics Circuits | PEC | 2 | 0 | 2 | 3 | 3 |

## Embedded Systems

| S. No. | Course code | Course Title | Cate Gory | Periods Per Week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25015 | Embedded System Design | PEC | 2 | 0 | 2 | 3 | 3 |
| 2. | TI25016 | Embedded C-programming | PEC | 2 | 0 | 2 | 3 | 3 |
| 3. | TI25017 | Embedded Processors | PEC | 2 | 0 | 2 | 3 | 3 |
| 4. | TI25018 | Embedded Control for Electric Drives | PEC | 2 | 0 | 2 | 3 | 3 |
| 5. | TI25019 | Smart System Automation | PEC | 2 | 0 | 2 | 3 | 3 |
| 6. | TI25020 | Embedded System for Automotive Applications | PEC | 2 | 0 | 2 | 3 | 3 |
| 7. | TI25021 | VLSI Design | PEC | 2 | 0 | 2 | 3 | 3 |
| 8. | TI25022 | MEMS and NEMS | PEC | 2 | 0 | 2 | 3 | 3 |
| 9. | TI25023 | Digital Signal Processing System Design | PEC | 2 | 0 | 2 | 3 | 3 |

## Electric Vehicle Technology

| S. No. | Course code | Course Title | Cate gory | Periods Per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25024 | Electric Vehicle Architecture | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25025 | Design of Motor and Power Converters for Electric Vehicles | PEC | 2 | 0 | 2 | 3 | 3 |
| 3. | TI25026 | Electric Vehicle Design, Mechanics and Control | PEC | 2 | 0 | 2 | 3 | 3 |
| 4. | TI25027 | Design of Electric Vehicle Charging System | PEC | 2 | 0 | 2 | 3 | 3 |
| 5. | TI25028 | Testing of Electric Vehicles | PEC | 2 | 0 | 2 | 3 | 3 |
| 6. | TI25029 | Grid Integration of Electric Vehicles | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | TI25030 | Intelligent Control of Electric Vehicles | PEC | 2 | 0 | 2 | 3 | 3 |

**Advanced Control**

| S. No. | Course code | Course title | Cate gory | Periods per week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25031 | Process Modeling and Simulation | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25032 | Computer Control of Processes | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | TI25033 | System Identification | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25034 | Model Based Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | TI25035 | Non Linear Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | TI25036 | Optimal Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | TI25037 | Adaptive Control | PEC | 3 | 0 | 0 | 3 | 3 |
| 8. | TI25038 | Machine Monitoring System | PEC | 3 | 0 | 0 | 3 | 3 |

**Diversified courses**

| S. No. | Course code | Course title | Cate Gory | Periods Per Week | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| 1. | TI25039 | Energy Storage Systems | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | TI25040 | Hybrid Energy Technology | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | TI25041 | Design and Modeling of Renewable Energy Systems | PEC | 3 | 0 | 0 | 3 | 3 |
| 4. | TI25042 | Grid integrating Techniques and Challenges | PEC | 2 | 0 | 2 | 3 | 3 |
| 5. | TI25043 | Sustainable and Environmental Friendly HV Insulation System | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | TI25044 | Power System Transients | PEC | 3 | 0 | 0 | 3 | 3 |
| 7. | TI25045 | PLC Programming | PEC | 3 | 0 | 0 | 3 | 3 |
| 8. | TI25046 | Big Data Analytics | PEC | 2 | 0 | 2 | 3 | 3 |

# Semester I

| MA25102 | Ordinary Differential Equations and Transform Techniques | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives**

To acquaint the students with Differential Equations which are significantly used in engineering problems and to understand the Laplace transforms techniques. Further, to develop the analytic solutions engineering by using Fourier series and various transforms.

**Ordinary Differential Equations**

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

**Activities**:

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER
3. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Laplace Transforms**

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem.

**Activities**:

1. Symbolic computation of Laplace transform
2. Plotting Laplace transforms
3. Application of Laplace transform in electrical engineering.
4. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Inverse Laplace Transforms**

Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

**Activities**:

1. Symbolic computation of Inverse Laplace transform
2. Plotting Inverse Laplace transforms
3. Application of inverse laplace transform in electrical engineering.
4. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Fourier Series**

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

**Activities**:
1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series
4. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Fourier transforms**

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

**Activities**:
1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms
3. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Z – Transform and Difference Equations**

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

**Activity:**
1. Symbolic computation of Z-Transforms
2. Quiz, assignment, visual demonstration, seminar, review of GATE questions.

**Course Outcomes**:

CO1: Explain the meaning of ordinary differential equations, Laplace transforms, fourier series and various transform techniques.

CO2: Examine ordinary differential equations, Laplace Transforms, Fourier Series, Fourier Transforms & Z – transform and the procedure to find solutions.

CO3: Explore the techniques for solving ordinary differential equations, Laplace Transforms, Fourier Series, Fourier Transforms & Z – transform and the procedure to find solutions

**Text books:**


1. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.


**References:**


1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., "Advanced Engineering Mathematics", Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.

3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

**CO – PO Mapping:**

| Course Outcomes | Programme outcomes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **P10** | **P11** | **P12** |
| CO1 : | 3 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 |
| CO2 : | 3 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 |
| CO3 : | 3 | 3 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 |

| TI25101 | Electric Circuit Analysis | L T P C<br>3 0 2 4 |
|---|---|---|

**Objectives:**

To study the concepts related with electrical circuits under steady state and transient conditions.

**introduction to DC circuits**

Types of sources, Independent and Dependent; Ohm's law, Kirchhoff's laws, Mesh, Node, super mesh and Super node analysis.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Introduction to AC Circuits**

AC Circuits: Basic definitions; phasors and complex representation; RMS, Average value, form factor, peak factor- AC signals; solution of RLC networks; power, energy relations and power factor calculations. Mesh and Nodal Analysis.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Network Reduction Techniques and Network Theorems**

Series parallel circuits; star and delta transformation; Superposition, Reciprocity, Compensation, Thevenin's, Norton's and Maximum Power Transfer Theorems; Analysis with dependent and independent sources-Application to DC and AC networks.

1. Network Theorems
    a. Application and experimental verification of network theorems (Thevenin's, Norton's,Superposition, Maximum Power Transfer and Reciprocity theorem).

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Solution Of First and Second Order Networks**

Solution of first and second order differential equations for Series and Parallel R-L, R-C, R-L-C circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response. Application of Laplace transforms and inverse Laplace transforms for electrical circuits.

a. Experimentation to compute time constant of series RL, RC circuits.
b. Experimental of frequency response of RLC circuits.
c. Experimental analysis of series RL, RC and RLC circuits.

**Activity**: Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Resonance and Two Port Networks**

Resonant circuits-series, parallel, series-parallel circuits-effect of variation of Q on

resonance. Relations between circuit parameters- Q, resonant frequency and bandwidth.

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks

1. Experimental determination of resonant frequency and bandwidth for Series and Parallel resonant circuits.
2. Real time determination of impedance, admittance, transmission and hybrid parameters for two port networks.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Three Phase Circuits**

Three phase balanced / unbalanced circuits, phase sequence – analysis of three phase 3-wire and 4-wire circuits with star and delta connected loads, balanced & un balanced loads – phasor diagram of voltages and currents – power and power factor measurements in three phase circuits.

- Experimental determination of power in a three phase balanced and unbalanced circuits.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Course Outcomes:**

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

**CO1** Explain the concepts of electrical circuits, fundamental laws magnetic coupling and theorems.

**CO2** Observe the natural response and the forced response to excitations of the first and second order networks.

**CO3** Apply the concepts of complex frequency and its use in relating the forced response and natural response.

**CO4** Explore the concepts of poly phase circuits.

**Text Books:**


1. M Nahvi I J A Edminster “Electric Circuits”; Schaum's outline series , Tata McGraw Hill, 4th Edition, 2009
2. Charles K. Alexander, Mathew N.O. Sadiku, “Fundamentals of Electric Circuits”, Fifth Edition,McGraw Hill, 2013.
3. David A Bell ,” Electric circuits “, Oxford University Press, 2011


**References:**


1. Mehdi Rahmani-Andebili, DC Electrical Circuit Analysis, Practice Problems, Methods, and Solution, Springer,2020.

2. Mehdi Rahmani-Andebili, Advanced Electrical Circuit Analysis, Practice Problems,Methods, and Solution, Springer,2020
3. William H. Hayt Jr, Jack E. Kemmerly and Steven M. Durbin, Engineering Circuit Analysis", Tata McGraw Hill publishers, New Delhi, 2013.
4. Sudhakar. A, Shyammohan. S.P Circuits and Networks-Analysis and Synthesis. TataMcGraw Hill publishers, 5th Edition, 2015.

| Course Outcomes | Programme Outcomes | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **P10** | **P11** | **PSO1** | **PSO2** | **PSO3** |
| CO 1 : | 3 | 3 | 2 | 3 | 2 | | | | | | 1 | 3 | 3 | 2 |
| CO 2 : | 3 | 3 | 2 | 3 | 2 | | | | | | 1 | 3 | 3 | 2 |
| CO 3 : | 3 | 3 | 2 | 3 | 2 | | | | | | 1 | 3 | 3 | 2 |
| CO 4 : | 3 | 3 | 2 | 3 | 2 | | | | | | 1 | 3 | 3 | 2 |

| TI25102 | Electromagnetic Theory | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

To study the concepts of electrical field, magnetic field and electro dynamic fields. Further, basics of electro magnetic waves are to be studied.

**Mathematical Preliminaries**

Vector calculus- Gradient, Divergence and Curl, theorems and applications,

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Electrostatics I**

Sources, effects and exposure limits of electromagnetic fields, Coordinate systems, Coulomb's Law – Electric field intensity – Electric Field due to discrete and continuous charges – Gauss's law and applications.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Electrostatics II**

Electric potential – Electric fields and equipotential plots, Uniform and Non-Uniform fields, Utilization factor – Electric field in free space, conductors, dielectric - Dielectric polarization – Dielectric strength , Electric fields in multiple dielectrics – Boundary conditions, capacitance, Energy density, Poisson's and Laplace's equations – solutions by Direct Integration method, Applications.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Magnetostatics**

Lorentz force, magnetic field intensity (H) — Biot– Savart's Law - Ampere's Circuit Law and practical applications— Magnetic flux density (B) – B in free space, conductor, magnetic materials — Magnetization, Magnetic field in multiple media — Boundary conditions, Scalar and vector potential, Poisson's Equation, Magnetic force, Torque, Inductance and mutual inductance, Energy density, Applications.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Electrodynamic Fields**

Magnetic Circuits - Faraday's law – Transformer and motional EMF – Displacement current - Maxwell's equations (differential and integral form) – Time varying potential – Relation between field theory and circuit theory, Applications.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Electromagnetic Waves**

Electromagnetic Wave Generation and Wave equations – Wave parameters; velocity, intrinsic impedance, propagation constant – Waves in free space, lossless and lossy dielectrics, conductors-skin depth, Poynting vector, Plane wave reflection and refraction – Standing Wave, Applications.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Course Outcomes:**

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

**CO1** Explore the fundamentals of electromagnetic theory

**CO2** Calculate various electrical and magnetic field parameters using the standard procedures.

**CO3** Analyse the various features of electro magnetic waves.

**CO4** Explain different methods of e.m.f. generation and analyze Maxwell's equations.

**CO5** Explain the concept of electromagnetic waves and characterizing parameters.

**Text Books:**


1. Mathew N. O. Sadiku, S.V.Kulkarni,'Principles of Electromagnetics', 6th Edition, Oxford University Press, 2015, Asian Edition.
2. Bhag Singh Guru and Hüseyin R. Hiziroglu "Electromagnetic field theory fundamentals",Cambridge University Press; Second Revised Edition, 2009.
3. Ashutosh Pramanik, 'Electromagnetism – Theory and Applications', PHI Learning Private Limited, New Delhi, Second Edition-2008.


**References:**


1. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Third Edition (Schaum's Outline Series), Tata McGraw Hill, 2010
2. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', Tata McGraw Hill, 8th Revised edition, 2012
3. Kraus and Fleisch, 'Electromagnetics with Applications', McGraw Hill International Editions,Fifth Edition, 2017.
4. Karl E Lonngren, Sava V. Savov, Randy J. Jost, 'Fundamentals of Electromagnetics with MATLAB", 2nd Edition, PHI Learning Pvt. Ltd., 2009.


| COs | POs | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PS O1 | PS O2 | PS O3 |
| CO1 | 3 | 3 | 1 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | - | 2 |
| CO2 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 2 | 1 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 1 | 2 |
| Avg | 3 | 3 | 1.4 | 2 | 3 | 2.4 | 1.6 | 1.2 | 3 | 2 | 2 | 2 | 1.5 | 2 |

| TI25103 | Digital Electronics | L T P C<br>3 0 0 3 |
|---|---|---|

**Course Objectives:**
To acquaint the students with the concepts of digital circuits and its applications.

**Number Systems and Boolean Algebra**

Number system, error detection, corrections & codes conversions, Boolean algebra: De-Morgan's theorem

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Combination Circuit Minimization**
Switching functions and minimization using K-maps and quine McCluskey method.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Design of Combinational Logic Circuits Using Gates and MSI Devices**

Design of adder, subtractor, comparators, code converters, encoders, decoders, multiplexers and demultiplexers, Realisation of Boolean Functions using MSI devices, memories and PLA.
**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Analysis and Design of Synchronous Sequential Circuits**

Flip flops-- SR, D, JK and T, shift registers, counters, state assignments analysis and design of synchronous sequential circuits, state diagram; state reduction.

**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Analysis and Design of Asynchronous Sequential Circuits**

Latches- SR -D, Asynchronous sequential logic circuits-Transition table, flow table – race conditions – circuits with latches, analysis of asynchronous sequential logic circuits – introduction to design –implication table.
**Activity**:
Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Logic Families and Arithmetic Circuits**

Logic families : RTL ad DTL circuits ,TTL ECL NMOS and CMOS :Design – Binary adder-4-bit adder IC, Adder/subtractor circuit using adder ICs, concept of carry look ahead, hardware multiplier circuit, Design with Multiplexers / Demultiplexers. Introduction to VHDL.
**Activity**:Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Course Outcomes:**

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

**CO1** Understand and examine the structure of various number systems and its application in digital design to solve real world problems.

**CO2** Analyze, design and implement combinational logic circuits.

**CO3** design and implementation of synchronous sequential logic circuits/ asynchronous logic circuits using Flip flops and gates/latches and gates.

**CO4** Design of arithmetic circuits.

**Text books:**


1. Morris Mano.M, 'Digital Logic and Computer Design', Prentice Hall of India, 3rd Edition, 2005.
2. Donald D. Givone, 'Digital Principles and Design', Tata McGraw Hill, 1st Edition, 2003
3. Thomas L Floyd, 'Digital fundamentals', Pearson Education Limited, 11th Edition, 2015


**References:**


1. Tocci R.J., Neal S. Widmer, 'Digital Systems: Principles and Applications', Pearson EducationAsia, 2014.
2. Donald P Leach, Albert Paul Malvino, Goutam Sha, 'Digital Principles and Applications', TataMcGraw Hill, 7th Edition, 2010


**Mapping COs and POs:**

| COs | POs | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **PO 6** | **PO 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PS O1** | **PS O2** | **PS O3** |
| **CO1** | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| **CO2** | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| **CO4** | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| **Avg** | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |

| TI25104 | Analog Electronics | L T P C<br>3 0 0 3 |
|---|---|---|

**Course Objectives:**

Main objective is to understand the principles of electronic devices, electronic circuits and its applications. Also students should understand the concepts of OPAMPs and their application.

**Electronic Devices and their Characteristics**

PN junction diodes – structure, operation and VI characteristics: drift and diffusion current, transient capacitance – BJT: structure, operation and characteristics; biasing; Introduction to JFET, MOSFET and UJT - Applications.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Amplifier Circuits**

BJT small signal model – Analysis of CE amplifier, Gain and Frequency response Differential Amplifier - Two-stage amplifier-Common mode and Differential mode analysis Current mirror circuits - Introduction to internal circuit of typical OPAMPs.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**OPAMP and Characteristics**

Ideal OPAMP characteristics, DC characteristics, AC characteristics, Voltage-series feedback: non-inverting amplifier and voltage -shunt feedback: inverting amplifier-Frequency response of OPAMP.

**Basic applications of OPAMP**

inverting, non- inverting and differential amplifier circuits, Adder-subtractor circuits Differentiation and integrator circuits.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Application Of OPAMPS**

Instrumentation amplifiers, First-order and Second order active filters, converters, Comparators and multi-vibrators, Waveform generators, Clippers and Clampers, Peak detector.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**OPAMPS in Signal Conversion**

V to I and I to V D/A converters (Weighted resistance type and R-2R ladder type), A/D converters (Flash type, Dual slope type, Successive Approximation types and Sigma-Delta type).

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Special ICS**

555 Timer circuit: Functional block diagram, characteristics & applications – Astable and monostable multivibrator -566 Voltage Controlled Oscillator circuits - PLL Phase Locked Loop applications - Function generator circuit – Linear Voltage regulators.

**Activity**:

Quiz, assignment, visual demonstration, seminar, review of GATE questions

**Course Outcomes:**

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

**CO1** Understand the structure and underlying semiconductor devices.
**CO2** Design circuits employing electronic devices.
**CO3** Evaluate the characteristics of OPAMP and its internal components.
**CO4** Analyze, design analog electronic circuits involving OP-AMP/555 timer PLL

**Text Books:**


1. David A bell, " Electronic circuits" , Oxford University Press, 2011
2. Ramakant A Gayakwad , " Opamps and Linear Integrated Circuits", IV edition, PearsonEducation/ PHI, 2009.
3. D. Roy Choudary, S.B. Jain, " Linear Integrated Circuits", Third edition, New Age publishers,2014.
4. Donald A Neamen, “Electronic Circuits”, McGraw Hill, edition,2007.


**References:**


1. Millman and Halkias, " Integrated Electronics", McGraw Hill Publications, 2010.
2. Muhammad H. Rashid, " Linear Integrated Circuits", Cengage Learning, 2014.


| COs | POs | | | | | | | | | | | PSOs | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PS O1 | PS O2 | PS O3 |
| CO1 | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| CO2 | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| CO3 | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| CO4 | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |
| Avg | 2 | 1 | 2 | 3 | 3 | 1 | - | - | 2 | - | - | 3 | - | 1 |

**TI25106** **Electronics Laboratory** LT P C

0 0 4 2

**Course Objectives:**

- To be familiar with the structure of basic electronic devices
- To be exposed to the operation and application of electronic devices and their circuits
- To analyze circuit characteristics with signal analysis using Op-amp Ics.
- To design and construct application circuits with Ics as Op-amp, 555, etc.
- To study internal functional blocks and the applications of special ICs like Timers, DAC/ADCs

**I Experiments On Basic Electronic Devices:**

1. Introduction to circuit simulation package by:

i) PN junction characteristics

ii) Transistor (CE conf) characteristics

iii) JFET characteristics.

2. Frequency response of transistor amplifier circuit.

3. Line and load regulation of Zener regulator 4. UJT – relaxation oscillator circuit 5. Wien bridge oscillator 6. Transistorized Differential amplifier

**II Experiments using Linear Integrated Circuits (ICs) :**

7. OPAMP based amplifier circuits :

i) Inverting amplifier.

ii) Non-inverting amplifier and voltage follower

iii) Differential amplifier and Instrumentation amplifier.

8. Design of Adder-subtractor circuits.

9. Square wave oscillator/ tri-angular wave oscillator. 10. OPAMP based RC –phase shift oscillator

11. 555 – timer IC based astable multi-vibrator

12. OPAMP based precision rectifier circuit/ clipper circuits.

**Course Outcomes:**

**After completion the above subject, students will be able to understand**

CO1: Ability to understand the structure and underlying semiconductor physics concepts.
CO2: Ability to design circuits employing electronic devices.
CO3: Analyze, comprehend and design of analog electronic circuits involving OP-AMP
CO4: Analyze, comprehend and design of analog electronic circuits involving timer 555
CO5: Analyze, comprehend and design of analog electronic circuits involving ADC & DAC otherspecializes.

| | **PO 1** | **PO 2** | **PO 3** | **PO 4** | **PO 5** | **P0 6** | **P0 7** | **PO 8** | **PO 9** | **PO 10** | **PO 11** | **PS 01** | **PS 02** | **PS 03** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | 3 | | | | | | | 3 | 2 | | 1 |
| CO2 | | | 3 | 3 | | | | | | | 3 | 2 | | 1 |
| CO3 | | 3 | 2 | 3 | 3 | | | | | | 3 | 2 | | 1 |
| CO4 | | 3 | 3 | 3 | 3 | | | | | | 3 | 2 | | 1 |
| CO5 | | | | | | | | | | | | | | |
| Avg | | 3 | 2.7 | 3 | 3 | | | | | | 3 | 2 | | 1 |

# Semester II

**MA25201** **Statistics and Numerical Methods** L T P C
3 1 0 4

**Course Objectives:**

- To understand the basics of random variables with emphasis on the standard discrete and continuous distributions
- To acquaint the knowledge of testing of hypothesis for small and large samples which plays an important role in real life problems.
- To understand the concept of analysis of variance and use it to improve the design of experiments.
- To introduce the basic concepts of solving algebraic and transcendental equations.
- To introduce the numerical techniques of interpolation in various intervals and numerical techniques of differentiation and integration which plays an important role in engineering and technology disciplines.

**One– Dimensional Random Variables**

Discrete and continuous random variables – Moments – Binomial, Poisson, Uniform, Exponential and Normal distributions

**Testing of Hypothesis**

Sampling distributions -Tests for single mean and difference of means (Large and small samples) – Tests for single variance and equality of variances—Chi square test for goodness of fit— Independence of attributes.

**Design of Experiments**

One way and two way classifications – Completely randomized design— Randomized block design— Latin square design.

**Solution of Equations and Eigen Value Problems**

Solution of algebraic and transcendental equations - Fixed point iteration method – Newton Raphson method- Solution of linear system of equations - Gauss elimination method – Pivoting - Gauss Jordan method—Iterative methods of Gauss Jacobi and Gauss Seidel-Eigen values of a matrix by Power method and Jacobi's method for symmetric matrices.

**Interpolation, Numerical Differentiation and Numerical Integration**

Lagrange's and Newton's divided difference interpolations —Newton's forward and backward difference interpolation–Approximation of derivates using interpolation polynomials–Numerical single and double integrations using Trapezoidal and Simpson's 1/3 rules.

**Textbooks:**

1. Grewal,B.S.,and Grewal,J.S.,"Numerical Methods in Engineering and Science", Khanna Publishers, 10th Edition, New Delhi, 2015.
2. Johnson,R.A.,Miller,I and Freund J.,“Miller and Freund’s Probability and Statistics for Engineers", Pearson Education, Asia, 8th Edition, 2015.

**References:**


1. Burden, R.L and Faires, J.D, "Numerical Analysis”, 9th Edition, Cengage Learning, 2016.
2. Devore.J.L.,"Probability and Statistics for Engineering and the Sciences”, Cengage Learning, New Delhi, 8th Edition, 2014.
3. Gerald.C.F.and Wheatley.P.O."Applied Numerical Analysis” Pearson Education, Asia,New Delhi, 7th Edition, 2007.
4. Gupta S.C. and Kapoor V. K., “Fundamentals of Mathematical Statistics”, Sultan Chand & Sons, New Delhi, 12th Edition, 2020.
5. Spiegel. M.R., Schiller. J. and Srinivasan. R.A., "Schaum’s Outlines on Probability and Statistics ", Tata McGraw Hill Edition, 4th Edition, 2012.
6. Walpole. R.E., Myers. R.H., Myers. S.L. and Ye. K., “Probability and Statistics for Engineers and Scientists", 9th Edition, Pearson Education, Asia, 2010.


**TI25201** **Electrical Machines-I** L T P C

3 0 0 3

**Course Objectives:**

- To understand the concept of electromechanical energy conversion system.
- To identify the appropriate machine for a given application based on its characteristics.
- To identify the appropriate test to determine the performance parameters of a given machine.
- To familiarize with the procedure for parallel operation of generators and transformers.
- To deliberate the working of autotransformer and three phase transformers.

**Electromechanical Energy Conversion**

Fundamentals of Magnetic circuits- Statically and dynamically induced EMF - Principle of electromechanical energy conversion forces and torque in magnetic field systems- energy balance in magnetic circuits- magnetic force- co-energy in singly excited and multi excited magnetic field system mmf of distributed windings — Winding Inductances-, magnetic fields in rotating machines- magnetic saturation and leakage fluxes.

**DC Generators**

Constructional details: armature windings and its types, Types of DC Generators, Principle of operation, EMF equation, wave shape of induced emf, armature reaction, demagnetizing and cross magnetizing Ampere turns, compensating winding,

commutation, methods of improving commutation, interpoles, OCC and load characteristics of different types of DC Generators. Parallel operation of DC Generators, equalizing connections- applications

**DC Motors**

Principle of operation, significance of back emf, torque equation and power developed, speed control Types of starters, load characteristics, losses and efficiency , condition for maximum efficiency. Testing: Brake test, Swinburne's test, Hopkinson's test, Field test, Retardation test, Separation of core losses-applications

**Single Phase Transformer**

Construction and principle of operation, equivalent circuit, phasor diagrams, ~~testing -~~ polarity test, open circuit and short circuit tests, voltage regulation, losses and efficiency, all day efficiency, Sumpner's test~~,~~ separation of core losses, parallel operation of single-phase transformers, applications~~.~~

**Auto Transformer and Three Phase Transformer**

Construction and working of auto transformer, comparison with two winding transformers, Three Phase Transformer- Construction, types of connections and their significance, Vector group of transformers, Scott connection – applications .

**Textbooks**


1. I.J.Nagrath and D.P.Kothari, "Electric Machines",McGrawHill Education,5th Edition,2017.
2. P.S.Bimbhra, "Electric Machinery", Khanna Publishers, 2nd Edition,2021.
3. A.E.Fitzgerald and C.Kingsley,"Electric Machinery",NewYork, McGrawHill Education,6th Edition 2017.


**References**


1. A.E.Clayton and N.N.Hancock, "Performance and design of DC machines",CBS Publishers, 2018.
2. M. G.Say, "Performance and design of AC machines", CBS Publishers, First Edition 2008.

**TI25202** **Problem Solving and Python Programming** L T P C
3 0 0 3

**Course objectives:**

- To understand the basics of algorithmic problem solving.
- To learn to solve problems using Python conditionals and loops.
- To define Python functions and use function calls to solve problems.
- To use Python data structures-lists, tuples, dictionaries to represent complex data.
- To do input/output with files in Python.

**Computational Thinking and Problem Solving**

Fundamentals of Computing —Identification of Computational Problems-Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudocode, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a cardin a list of sorted cards, guess an integer number in a range, Towers of Hanoi.

**Datatypes, Expressions, Statements**

Python interpreter and interactive mode, debugging; values and types: int, float, boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

**Control flow, Functions, Strings**

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if- elif-else);Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.

**Lists, Tuples, Dictionaries**

Lists: list operations,list slices, list methods, list loop, mutability, aliasing,cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: simple sorting, histogram, Students marks statement, Retail bill preparation.

**Files, Modules, Packages**

Files and exceptions: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: word count, copy file, Voter’s age validation, Marks range validation (0-100).

**Textbooks:**


1. Allen B. Downey, “Think Python: How to Think like a Computer Scientist”, 2nd Edition, O’Reilly Publishers, 2016.
2. Karl Beecher, “Computational Thinking: A Beginner's Guide to Problem Solving and Programming”, 1st Edition, BCS Learning & Development Limited, 2017.


**REFERENCES:**


1. Paul Deitel and Harvey Deitel, “Python for Programmers”, Pearson Education, 1st Edition,2021.
2. G Venkatesh and Madhavan Mukund, “Computational Thinking: A Primer for Programmersand Data Scientists”, 1st Edition, Notion Press, 2021.
3. John V Guttag, "Introduction to Computation and Programming Using Python: WithApplications to Computational Modeling and Understanding Data”, Third Edition, MIT Press, 2021
4. Eric Matthes, “Python Crash Course, A Hands - on Project Based Introduction to Programming”, 2nd Edition, No Starch Press, 2019.
5. https://www.python.org/
6. MartinC.Brown,“Python:TheCompleteReference”,4thEdition,Mc-GrawHill,2018.


**TI25203 Problem Solving and Python Programming Laboratory** L T P C
0 0 4 2

**Course objectives:**

- To understand the problem solving approaches.
- To learn the basic programming constructs in Python.
- To practice various computing strategies for Python-based solutions to real world problems.
- To use Python data structures- lists, tuples, dictionaries.
- To do input/output with files in Python.

**Experiments:**

Note: The examples suggested in each experiment are only indicative. The lab instructor is expected to design other problems on similar lines. The Examination shall not be restricted to the sample experiments listed here.

1. Identification and solving of simple real life or scientific or technical problems, and developing flow charts for the same. (Electricity Billing, Retail shop billing, Sin series, weight of a motorbike, Weight of a steel bar, compute Electrical Current in Three Phase AC Circuit, etc.)
2. Python programming using simple statements and expressions (exchange the values of two variables, circulate the values of n variables, distance between two points).
3. Scientific problems using Conditionals and Iterative loops. (Number series, Number Patterns, pyramid pattern)

4. Implementing real-time/technical applications using Lists, Tuples. (Items present in a library/Components of a car/ Materials required for construction of a building –operations of list & tuples)
5. Implementing real-time/technical applications using Sets, Dictionaries. (Language, components of an automobile, Elements of a civil structure, etc.- operations of Sets & Dictionaries)
6. Implementing programs using Functions.(Factorial, largest number in a list,area of shape)
7. Implementing programs using Strings. (reverse, palindrome, character count, replacing characters)
8. Implementing programs using written modules and Python Standard Libraries (pandas, numpy. Matplotlib, scipy)
9. Implementing real-time/technical applications using File handling. (copyfrom one file to another, word count, longest word)
10. Implementingreal-time/technicalapplicationsusingExceptionhandling.(dividebyzeroerror, voter's age validity, student mark range validation)
11. Exploring Pygame tool.
12. Developing a game activity using Pygame like bouncing ball, car race etc.

**TI25204** **Electrical Machines Laboratory – I** L T P C
0 0 4 2

**Course Objectives:**

- To expose the students to determine the characteristics of DC machines and transformers by performing experiments on these machines.
- To provide hands on experience to evaluate the performance parameters of DC machines and transformer by conducting suitable tests.

**List Of Experiments:**

1. Open circuit and load characteristics of DC shunt generator-calculation of critical resistance and critical speed.
2. Load characteristics of DC compound generator with differential and cumulative connections.
3. Load test on DC shunt motor.
4. Load test on DC compound motor.
5. Load test on DC series motor.
6. Swinburne's test and speed control of DC shunt motor.
7. Hopkinson's test on DC motor–generator set.
8. Load test on single-phase transformer and three phase transformers.
9. Open circuit and short circuit tests on single phase transformer.
10. Sumpner's test on single phase transformers.
11. Separation of no-load losses in single phase transformer.
12. Study of starters and 3-phase transformers connections.

# Semester III

**TI25301** **Electrical Machines – II** L T P C
3 0 0 3

**Course objectives:**

- To impart knowledge on the following Topics
- Construction and performance of salient and non–salient type synchronous generators.
- Principle of operation and performance of synchronous motor.
- Construction, principle of operation and performance of induction machines.
- Starting and speed control of three-phase induction motors.
- Construction, principle of operation and performance of single phase induction motors and special machines.

**Synchronous Generator**

Constructional details – Types of rotors –winding factor- EMF equation – Armature reaction – Phasor diagrams of non-salient pole synchronous generator connected to infinite bus-Synchronizing, parallel operation —Synchronizing torque – effect of change of excitation and mechanical input-Voltage regulation–EMF,MMF and ZPF–steady state power-angle characteristics– Two reaction theory –slip test - - Capability Curves.

**Synchronous Motor**

Principle of operation – Torque equation – Operation on infinite bus bars - V and Inverted V curves – Power input and power developed equations – Starting methods – Current loci for constant power input, constant excitation and constant power Developed-Hunting – natural frequency of oscillations – damper windings-synchronous condenser.

**Three Phase Induction Motor**

Constructional details —Types of rotors —-Principle of operation —Slip – cogging and crawling- Equivalent circuit —Torque-Slip characteristics - Condition for maximum torque —Losses and efficiency—Load test-No load and blocked rotor tests-Circle diagram—Separation of losses——Induction generators – Synchronous induction motor.

**Starting and Speed Control of Three Phase Induction Motor**

Need for starting – Types of starters–DOL, Rotor resistance, Autotransformer and Star delta starters – Speed control – Voltage control, Frequency control and pole changing – Cascaded Connection-V/f control – Slip power recovery Scheme-Braking of three phase induction motor: Plugging, dynamic braking and regenerative braking.

**Single Phase Induction Motors**

Constructional details of single phase induction motor – Double field revolving theory and operation – Equivalent circuit—No load and blocked rotor test—Performance analysis—Starting methods of single-phase induction motors – Capacitor-start capacitor run Induction motor- Shaded pole induction motor.

**Textbooks:**


1. A.E.Fitzgerald, Charles Kingsley, Stephen. D.Umans,'Electric Machinery', McGraw Hill publishing Company Ltd, 6th Education 2017.
2. Stephen J.Chapman,'Electric Machinery Fundamentals'4th edition, McGrawHill Education Pvt. Ltd, 4th Edition 2017.
3. D.P.Kothari and I.J.Nagrath,'Electric Machines',McGrawHill Publishing Company Ltd, 5th Edition 2017
4. P.S. Bhimbhra,'Electrical Machinery',Khanna Publishers, edition 2,2021.


**References**


1. Vincent DelToro, 'Basic Electric Machines 'Pearson India Education,2016.
2. M.N. Bandyopadhyay, Electrical Machines Theory and Practice, PHI Learning PVT LTD., New Delhi, 2011.
3. B.R.Gupta,'Fundamental of Electric Machines'NewageInternational Publishers,3rd Edition, Reprint 2015.
4. Murugesh Kumar,'Electric Machines',Vikas Publishing HousePvt. Ltd, First edition2010.
5. Alexander S.Langsdorf, 'Theory of Alternating-Current Machinery',McGraw Hill Publications, 2001.


**TI25302 Transmission and Distribution** L T P C
3 0 0 3

**Course Objectives**

- To impart knowledge about the configuration of the electrical power systems.
- To study the line parameters and interference with neighboring circuits.
- To understand the mechanical design and performance analysis of transmission lines.
- To learn about different insulators and underground cables.
- To understand and analyze the distribution system.

**Transmission Line Parameters**

Structure of electric power system – Parameters of single and three phase transmission lines with single and double circuits -Resistance, inductance, and capacitance of solid, stranded, and bundled conductors - Typical configuration, conductor types - Symmetrical and unsymmetrical spacing and transposition –self and mutual GMD; skin and proximity effects - Effects of earth on the capacitance of the transmission line - interference with neighboring communication circuits.

**Modelling and Performance of Transmission Lines**

Performance of Transmission lines – short line, medium line and long line – equivalent circuits, phasor diagram, attenuation constant, phase constant, surge impedance – transmission efficiency and voltage regulation, real and reactive power flow in lines–Power Circle diagrams–Ferranti effect–Formation of Corona – Critical Voltages – Effect on line Performance.

**Sag Calculation and Line Supports**

Mechanical Design of Overhead Lines – Line Supports – Types of Towers – Tension and Sag Calculation for different weather conditions – Methods of Grounding – Insulators: Types – Voltage Distribution in Insulator String – Improvement of String Efficiency – Testing of Insulators.

**Underground Cables**

Underground Cables – Types of Cables – Construction of Single-core and 3-core Belted Cables – Insulation Resistance – Potential Gradient – Capacitance of Single-core and 3-core Belted Cables – Grading of Cables – Power Factor and Heating of Cables – DC Cables – Testing of HT cables

**Distribution Systems**

Distribution Systems – General Aspects – Kelvin's Law – AC and DC Distributions – Concentrated and Distributed Loading – Techniques of Voltage Control and Power Factor Improvement – Distribution Loss – Types of Substations.

**Textbooks:**


1. D.P.Kothari,I.J. Nagarath,'Power System Engineering', McGraw-Hill Publishing Company limited, New Delhi, Third Edition, 2019.
2. C.L.Wadhwa,'Electrical Power Systems',New Age International Ltd, seventh edition 2022.
3. S.N.Singh,'Electric Power Generation,Transmission and Distribution', Prentice Hall of India Pvt. Ltd, New Delhi, Second Edition, 2008.
1. Hadi Saadat, 'Power System Analysis', McGraw Hill Education Pvt. Ltd., New Delhi, 3rd Edition, 23rd reprint, 2015.
2. ArunIngole,"Power transmission and distribution "Pearson Education, first edition, 2018


**References:**


1. B.R.Gupta, 'Power System Analysis and Design'S. Chand,New Delhi, Sixth Edition, 2011.
2. Luces M.Fualkenberry, Walter Coffer, 'ElectricalPower Distribution and Transmission', Pearson Education, 2007.
3. J.BrianHardy and Colin R.Bayliss 'Transmission and Distribution in Electrical Engineering', Newnes; Fourth Edition, 2011.
4. G. Ramamurthy,"Handbook of Electrical power Distribution,"Universities Press, 2013.
5. V.K.Mehta,RohitMehta,'Principles of power system',S.Chand & Company Ltd, New Delhi, 2013
6. R.K.Rajput, 'A Text Book of Power System Engineering' 2nd edition, Laxmi Publications (P) Ltd, New Delhi, 2016.

**TI25303** **Microprocessor and Microcontroller** L T P C
3 0 0 3

**Course objectives:**

- To study the addressing modes & instruction set of 8085 & 8051
- To develop skills in simple program writing in assembly languages
- To introduce commonly used peripheral/interfacing ICs.
- To study and understand typical applications of micro-processors.
- To study and understand the typical applications of micro-controllers

**Introduction to 8085 Architecture**
Functional block diagram – Memory interfacing – I/O ports and data transfer concepts – Timing diagram – Interrupt structure.

**8085 Instruction Set and Programming**
Instruction format and addressing modes – Assembly language format – Data transfer, data manipulation and control instructions – Programming: Loop structure with counting and indexing – Look-up table – Subroutine instructions – Stack.

**Interfacing Basics and ICs**
Study of architecture and programming of ICs: Intel 8255 PPI – Intel 8259 PIC – Intel 8251 USART – Intel 8279 Keyboard display controller – Intel 8254 Timer/Counter – Interfacing with 8085 – A/D and D/A converter interfacing.

**8051 Microcontroller**
Functional block diagram – Instruction format and addressing modes – Interrupt structure – Timer – I/O ports – Serial communication – Simple programming – Keyboard and display interface – Temperature control system – Stepper motor control – Usage of IDE for assembly language programming.

**Risc Based Architecture**
PIC16 / PIC18 architecture – Memory organization – Addressing modes – Instruction set – Programming techniques – Timers – I/O ports – Interrupt programming.

**Textbooks:**

1. RameshS.Gaonkar, 'Microprocessor Architecture Programming and Application', Pen ram International (P)ltd., Mumbai, 6th Education, 2013.
2. Muhammad Ali Mazidi & Janice Gilli Mazidi, 'The 8051 Micro Controller and Embedded Systems', Pearson Education, Second Edition 2011.
3. Muhammad Ali Mazidi & Janice Gilli Mazidi, 'The PIC Micro Controller and Embedded Systems', 2010


**References:**

1. Douglas V. Hall, "Micro-processors & Interfacing", Tata McGrawHill 3rd Edition, 2017.
2. KrishnaKant, "Micro-processors & Micro-controllers", Prentice Hall of India, 2007.
3. MikePredko,"8051Micro-controllers",McGrawHill, 2009
4. KennethAyala,'The8051 Microcontroller',Thomson, 3rd Edition 2004.

**TI25304** **Electrical Machines Laboratory – II** L T P C
0 0 4 2

**Course Objectives:**

- To expose the students to the operation of synchronous machines and induction motors and give them experimental skill.

**List of Experiments**

1. Regulation of three-phase alternator by EMF and MMF methods.
2. Regulation of three-phase alternator by ZPF method.
3. Regulation of three-phase salient pole alternator by slip test.
4. V and inverted V curves of three-phase synchronous motor.
5. Load test on three-phase induction motor.
6. No-load and blocked rotor tests on three-phase induction motor (determination of equivalent circuit parameters).
7. Separation of no-load losses of three-phase induction motor.
8. Load test on single-phase induction motor.
9. No-load and blocked rotor test on single-phase induction motor.
10. Study of induction motor starters.

**TI25305** **Microprocessor and Microcontroller Laboratory** L T P C
0 0 4 2

**Course Objectives:**

- To perform simple arithmetic operations using assembly language programs and study the addressing modes and instruction set of 8085 and 8051.
- To develop skills in simple program writing in assembly language.
- To write an assembly language program to convert analog input to digital output and digital input to analog output.
- To perform interfacing experiments with µP 8085.
- To perform interfacing experiments with µC 8051.

**Programming Exercises / Experiments with µP8085:**

1. Simple arithmetic operations: Multi precision addition/subtraction/multiplication/ division.
2. Programming with control instructions: Increment/Decrement, Ascending/Descending order, Maximum / Minimum of numbers, Rotate instructions, Hex / ASCII / BCD code conversions.
3. Interface Experiments: A/D Interfacing. D/A Interfacing. Traffic light controller
4. Stepper motor controller interface.
5. Displaying a moving/rolling message in the student trainer kit’s output device.

**Programming exercises / Experiments With µC8051:**

6. Simple arithmetic operations with 8051:Multi precision addition/subtraction/ multiplication/ division.
7. Programming with control instructions: Increment/Decrement, Ascending/Descending. order, Maximum / Minimum of numbers, Rotate instructions, Hex / ASCII / BCD code conversions.
8. Interface Experiments: A/D Interfacing. D/A Interfacing. Traffic light controller
9. Stepper motor controller interface.
10. Displaying a moving/rolling message in the student trainer kit's output device.
11. Programming PIC architecture with software tools.

# Semester IV

| TI25401 | **Measurements and Instrumentation** | L T P C |
|---|---|---|
| | | 3 0 0 3 |

**Course Objectives**

- To educate the fundamental concepts and characteristics of measurement and errors
- To impart the knowledge on the functional aspects of measuring instruments
- To infer the importance of various bridge circuits used with measuring instruments.
- To educate the fundamental working of sensors and transducers and their applications
- To summarize the overall measurement and instrumentation with the knowledge on digital instrumentation principles.

**Concepts of Measurements**

Instruments: classification, applications – Elements of a generalized measurement system – Static and dynamic characteristics – Errors in measurement – Statistical evaluation of measurement data - Instrument standards.

**Measurement of Parameters in Electrical Systems**

Classification of instruments – Moving coil and moving iron meters – Induction type and dynamometer type wattmeters – Energy meter – Megger – Instrument transformers (CT & PT).

**AC/DC Bridges and Instrumentation Amplifiers**

Wheatstone bridge – Kelvin double bridge – Maxwell bridge – Hay bridge – Wien bridge – Schering bridge – Errors and compensation in A.C. bridges – Instrumentation amplifiers.

**Transducers for Measurement of Non-Electrical Parameters**

Classification of transducers – Measurement of pressure, temperature, displacement, flow and angular velocity – Digital transducers – Smart sensors.

**Digital Instrumentation**

A/D converters: types and characteristics – Sampling and errors – Measurement of voltage, current, frequency and phase – D/A converters: types and characteristics – DSO – Data loggers – Introduction to virtual instrumentation.

**Textbooks:**


1. A.K.Sawhney, Puneet Sawhney‘A Course in Electrical & Electronic Measurements & Instrumentation’, Dhanpat Rai and Co, New Delhi, Edition 2011.
2. H.S.Kalsi,‘Electronic Instrumentation’,Tata McGraw-Hill, New Delhi,2010


**References:**


1. M.M.S.Anand,‘Electronics Instruments and Instrumentation Technology’,Prentice Hall India, New Delhi, 2009
2. J.J. Carr, ‘Elements of Electronic Instrumentation and Measurement’, Pearson Education India, New Delhi, 2011

**TI25402** **Control Systems** L T P C
3 0 0 3

**Course Objectives:**

- To make the students to familiarize with various representations of systems.
- To make the students to analyze the stability of linear systems in the time domain and frequency domain.
- To make the students to analyze the stability of linear systems in the frequency domain.
- To make the students to design compensator based on the time and frequency domain specifications.
- To develop linear models: mainly state variable model and Transfer function model

**Modeling of Linear Time Invariant System (LTIV)**

Control system: Open loop and closed loop – Feedback control system characteristics – First principle modeling: Mechanical, Electrical and Electromechanical systems – Transfer function representations: Block diagram and Signal flow graph.

**Time Domain Analysis**

Standard test inputs – Time response – Time domain specifications – Stability analysis: Concept of stability – Routh Hurwitz stability criterion – Root locus: Construction and interpretation – Effect of adding poles and zeros.

**Frequency Domain Analysis**

Frequency domain specifications - Bode plot – Polar plot – Introduction to closed loop frequency response

**State Variable Analysis**

State variable formulation – state space model – State transition matrix - Free and forced responses for time invariant and time varying systems – Controllability – Observability.

**Design of Feedback Control System**

Design specifications – Lead, lag and lag-lead compensators using root locus and Bode plot techniques – PID controller – Design using reaction curve and Ziegler-Nichols technique.

**Textbooks:**


1. Benjamin C.Kuo, “Automatic Control Systems”, 7$^{th}$ edition PHI Learning Private Ltd, 2010.
2. Nagarath,I.J. and Gopal,M., “Control Systems Engineering”, New Age International Publishers 2010.


**References:**


**1.** Richard C. Dorf and Bishop, R.H., “Modern Control Systems”, Education Pearson,3 Impression 2009.
2. JohnJ.D.,Azzo Constantine, H.and Houpis Sttuart, NSheldon,“Linear Control System Analysis and Design with MATLAB”, CRC Taylor& Francis Reprint 2009.

3. Katsuhiko Ogata,“Modern Control Engineering”,PHI Learning Private Ltd, 5th Edition,2010
3. NPTEL Video Lecture Noteson “Control Engineering” byProf. S.D. Agashe,IIT Bombay. R.B. Northrop, ‘Introduction to Instrumentation and Measurements’, Taylor & Francis, NewDelhi, 3rd Edition 2014.
4. E.O.Doebelin and D.N.Manik, “Measurement Systems—Application and Design”,Tata McGraw-Hill,New Delhi,6thEdition2017.
5. R.K.Rajput,“Electrical and Electronics Measurements and Instrumentation”, Chand Pub ,2016

**TI25403 Control and Instrumentation Laboratory** L T P C
0 0 4 2

**Course Objectives:**

- To make the students familiarize with various representations of systems.
- To make the students analyze the stability of linear systems in the time domain and frequency domain.
- To make the students design compensator based on the time and frequency domain Specifications.
- To develop linear models mainly state variable model and transfer function model
- To make the students to design a complete closed loop control system for the physical systems.

**List of Experiments:**

1. Simulation study of block diagram reduction technique
2. Determination of time domain specifications
3. Study of first and second order electrical networks
4. Stability analysis of linear systems
5. Compensator design in frequency and time domains
6. Analysis of controllability and observability properties of a system
7. Static and Dynamic characteristics of Electrical and Non electrical sensors.
8.Signal conditioning circuits for Instrumentation – Design of Bridges, Filters, Instrumentation amplifier.
9.Design of A/D and D/A converters.
10. Calibration of analog and digital instruments.
11. PLC programming for Process Control Applications.
12. Development of GUI application for Process control.

## Professional Elective Courses

## POWER ENGINEERING

**TI25001 UNDERGROUND CABLE ENGINEERING** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To impart knowledge on the following topics:
- Understanding power cable characteristics and applications.
- Cable manufacturing processes.
- Installation of underground power cables.
- Fault location techniques in underground cable systems.
- Testing and maintenance of underground cable systems.
- Cable performance and field assessment of power cables.

**UNIT I – INTRODUCTION TO ELECTRICAL POWER CABLES** (7+2 Skill) 9

Development of underground cables – Electric lighting – Distribution of energy for lighting – Paper insulated cables – Underground residential distribution systems – Medium voltage cable development.

**UNIT II – CABLE ARCHITECTURE, DIELECTRIC THEORY AND CABLE CHARACTERISTICS** (7+2 Skill)9

Architecture of underground cabling system – Basic dielectric theory of cable – Conductors – Armour and protective finishes – Cable characteristics: Electrical – Fundamentals of electrical insulation materials – Electrical properties of cable insulating materials – Cable standards and quality assurance – Cable design parameters – Current carrying capacity – Short circuit ratings.

**UNIT III – SUPPLY DISTRIBUTION SYSTEMS AND CABLES** (7+2 Skill) 9

Supply distribution systems – Distribution cable types, design and applications – Paper insulated distribution cables – PVC insulated cables – Polymeric insulated distribution cables for 6–30 kV – Manufacture of distribution cables – Joints and terminations for distribution cables – Testing of distribution cables.

**UNIT IV – TRANSMISSION SYSTEMS AND CABLES** (7+2 Skill) 9

Basic cable types for AC transmission – Self contained fluid filled cables – Gas pressure cables – High pressure fluid filled pipe cables – Polymeric insulated cables for transmission voltages – Techniques for increasing current carrying capacity – Transmission cable accessories and jointing for pressure assisted and polymeric cables.

**UNIT V – CABLE INSTALLATION, TESTING, MAINTENANCE** (7+2 Skill) 9

Installation of transmission cables – Splicing, terminating and accessories – Sheath bonding and grounding – Testing of transmission cable systems – Underground system fault locating – Field assessment of power cable systems – Condition monitoring tests – Partial discharge measurements.

**TOTAL: 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (GROUP SEMINAR/ MINI PROJECT/ ASSIGNMENT/ CONTENT PREPARATION/ QUIZ/ SURPRISE TEST /SOLVING GATE QUESTIONS /ETC. 10**

- Demonstration of cable architecture using cable samples of all types.
- Understanding the cable manufacturing process through a factory visit.
- Familiarization with cable laying procedures through field visits.
- Familiarization with cable jointing and end termination techniques.
- Understanding and familiarization with cable fault locating techniques through a field visit to a local distribution company or an in-house laboratory.
- Understanding testing procedures and condition monitoring tests.

**TEXTBOOKS:**


**1.** WilliamThue,'Electrical Power Cable Engineering', CRC Press Taylor& Francis Group., 6000 Broken Sound Parkway NW, Suite 300Boca Raton, FL 33487-2742, 3rd Edition 2017.

2. G.F.Moore,'ElectricCablesHandbook'-Thirdedition,BlackwellScienceLtd, 9600 Garsington Road, Oxford OX4 2DQ, UK., January 2017.


**REFERENCES:**


1. Leonard L.Grigsby, 'Electrical Power Cable Engineering'-CRC Press, Marcel Dekker,3rd Edition 2012.
2. Christian Flytkjaer Jensen, Online Location of Faultson AC Cables in Underground Transmission Systems (Springer Theses), 2014, March.
3. https://kafactor.com/content/technical-resources/kerite-underground-cable-engineering- handbook.pdf
4. Handbook on Cable Fault Localization (April 2020) https://rdso.indianrailways.gov.in/works/uploads/File/Handbook%20on%20Cable%20Fault%2 0 Localization (2).pdf
5. K. H.Alietal.: Industry Practice Guide for Underground Cable Fault-Finding intheLVDN: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9807279, June 2022.
6. R. W. Deltenre, J. J. Schwarz, and H. J. Wagnon, ''Underground cable fault location: A handbooktoTD-153,''BDMCorp., Albuquerque, NM, USA, Final Rep. EPRI EL-363, 1977. [Online]. Available: https://www.osti.gov/servlets/purl/7233049,doi: 10.2172/7233049, January 1997.

**TI25002 SUBSTATION ENGINEERING AND AUTOMATION** L T P C
3 0 0 3

**COURSE OBJECTIVES:**

- To help engineering students gain a holistic understanding of the concepts behind substation engineering and design.
- The course aims to expose students to practical requirements, including an overview of civil and mechanical aspects.
- The course aims to enhance knowledge and provide practical guidelines for site selection, construction, protection, maintenance, and safety in substations.
- It also aims to provide knowledge about state-of-the-art technologies in substation automation systems.

**UNIT I – SUBSTATION DESIGN DEVELOPMENT** (7+2 Skill) 9

Substation introduction and classifications – Different bus bar switching schemes for substations – Standards and practices – Factors influencing substation design: Altitude, ambient temperature, earthquake and seismic zones, pollution and corrosion – Testing of electrical equipment – Concept and development of single line diagram – Requirement of substation calculations.

**UNIT II – SUBSTATION EQUIPMENT** (7+2 Skill) 9

Selection and sizing of main substation equipment: Transformer, isolator, circuit breaker, surge arrester, instrument transformers – Classification of equipment with practical overview and performance parameters – Classifications of MV switchgear and key design parameters – MV/LV switchgear construction and design of control scheme – Station auxiliary equipment: Diesel generator system – Basics of AC/DC auxiliary power system and sizing of auxiliary transformer – DC system components – Battery sizing and charger sizing – DG set classification and sizing – Introduction to gas insulated substation: Operating principle of GIS – Advantages over AIS – Construction of GIS.

**UNIT III – PROTECTION AND SUBSTATION AUTOMATION** (7+2 Skill) 9

Power system protection – Overcurrent and earth fault protection and coordination – Distribution feeder protection – Transformer unit and main protection – Familiarization of numerical relays – Distance and differential protection for transmission lines – Substation automation: Evolution of substation automation – Communication system fundamentals – Protocol fundamentals and choosing the right protocol – Substation integration and automation functional architecture – Substation signal list: DI, DO, AI, AO – Bay control unit (BCU) – Remote terminal unit (RTU).

**UNIT IV – SUBSTATION DESIGN AND LAYOUT ENGINEERING** (7+2 Skill) 9

Layout aspects of outdoor air insulated substation and GIS – Statutory clearances – Equipment layout engineering aspects for outdoor substations and GIS with related calculations and guidelines – Cable routing layout – Erection key diagram (EKD) – Switchyard earthing design as per IEEE 80 – Importance and types of earthing –

Earthing design – Types of earthing material – Direct stroke lightning protection for switchyard as per IS/IEC 62305 – LV cables: Power and control – MV cables – Methods for cable installation – Practical aspects of cable sizing – Cable accessories – Illumination system design.

**UNIT V – INTERFACE ENGINEERING** (7+2 Skill) 9

Civil and structural engineering – Familiarization of site development plan – Equipment support structures – Foundation for equipment – Familiarization of control building and substation building – Infrastructure development – Mechanical systems: Fire detection and alarm system – Fire suppression system for transformers – Heating, ventilation and air-conditioning (HVAC) for substation.

**TOTAL:45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (GROUP SEMINAR/ MINI PROJECT/ ASSIGNMENT/ CONTENT PREPARATION/ QUIZ/ SURPRISE TEST /SOLVING GATE QUESTIONS /ETC. 10**

1. Battery sizing for a substation with a load cycle based on IEEE 1115 (Ni-Cd) – a case study. OR
2. DG and auxiliary transformer sizing for a substation auxiliary power supply – a case study.
3. Overcurrent relay coordination in a substation – a case study.
4. Earth mat sizing calculation for an outdoor substation based on IEEE 80 – a case study. OR
5. Direct stroke lightning protection calculation for an outdoor switchyard based on IEC 62305 – a case study.

**REFERENCES:**


1. McDonaldJohnD,“ElectricPowerSubstationsEngineering”,CRCPress,3rdEdition,2012
2. PartapSinghSatnam,P.V.Gupta,“Sub-stationDesignandEquipment”,Dhanpat Rai Publications, 1st Edition, 2013
3. SunilS.Rao,“Switchgear Protection and Power Systems (Theory, Practice & Solved Problems)”,Khanna Publications, 14th Edition, 2019 .
4. Electricalsubstationandengineering&practicebyS.Rao,3rdEdition,KhannaPublishers 2015
6. Manualon Substation by Central Board of irrigation and Power(CBIP)Publication No 342., 2006.
7. SubstationautomationsystemDesignandimplementationbyEvelioPadillabyWiley Publications, 1st Edition, 2015 November.

**TI25003** **HVDC AND FACTS** **L T P C**

**3 0 0 3**

**COURSEOBJECTIVES:**

- The problems in AC transmission systems and DC transmission systems.
- The operation and control of SVC and TCSC.
- The concepts of IGBT-based FACTS controllers.
- The basic operation of line-commutated converter (LCC) based HVDC links.
- The features of voltage source converter (VSC) based HVDC links.

**UNIT I – INTRODUCTION** (7+2 Skill) 9

Reactive power control in electrical power transmission lines – Load and system compensation – Uncompensated transmission line – Shunt and series compensation – Need for HVDC transmission – Comparison between AC and DC transmission – Types of HVDC transmission systems.

**UNIT II – STATIC VAR COMPENSATOR (SVC) AND THYRISTOR CONTROLLED SERIES COMPENSATOR (TCSC)** (7+2 Skill) 9

V–I characteristics of FC+TSR and TSC+TSR – Voltage control by SVC – Advantages of slope in dynamic characteristics – Influence of SVC on system voltage – Design of SVC voltage regulator – Thyristor controlled series compensator (TCSC) – Concept and operation of TCSC – Different modes of operation – Applications.

**UNIT III – VOLTAGE SOURCE CONVERTER BASED FACTS CONTROLLERS** (7+2 Skill) 9

Static synchronous compensator (STATCOM) – Principle of operation – V–I characteristics – Applications: Steady state power transfer enhancement, enhancement of transient stability, prevention of voltage instability – Static synchronous series compensator (SSSC) – Operation and V–I characteristics – Enhancement of power transfer capability – Unified power flow controller (UPFC) – Operation principle – Applications.

**UNIT IV – LINE COMMUTATED HVDC TRANSMISSION** (7+2 Skill) 9

Operation of Graetz bridge – Effect of delay in firing angle – Effect of commutation overlap – Equivalent circuit – Basic concept of HVDC transmission – Model of operation and control of power flow – CC and CIA modes of operation.

**UNIT V – VSC BASED HVDC TRANSMISSION** (7+2 Skill) 9

Basic two level IGBT inverter operation – Four quadrant operation – Phase angle control – dq control – Control of power flow in VSC based HVDC transmission – Topologies of MTDC systems.

**TOTAL: 45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 10**

1. Simulation of FC + TSR connected to the IEEE 5-bus system.
2. Realization of reactive power support by SVC in open-loop and closed-loop control through simulation.
3. Regulation of line flows using TCSC and TSSC in closed-loop control through simulation.
4. Simulation of a two-terminal HVDC link with closed-loop control in CC and CIA modes.
5. Realization of four-quadrant operation of VSC in open-loop mode through simulation.

**TEXTBOOKS:**


1. R.Mohan Mathur, Rajiv K.Varma ,"Thyristor–Based Facts Controllers for Electrical Transmission Systems", IEEE press and JohnWiley &S ons,Inc,2002.
2. Narain G.Hingorani, "Understanding FACTS-Concepts and Technology of FlexibleAC Transmission Systems", Standard Publishers Distributors,Delhi-110006,2011.


**REFERENCES:**


1. K.R.Padiyar,"FACTS Controllers in Power Transmission and Distribution", New Age International (P) Limited, Publishers, New Delhi, 2008
2. A.T.John,"Flexible A.C.Transmission Systems", Institution of Electrical and Electronic Engineers(IEEE),1999.
3. V.K.Sood, HVDC and FACTS controllers–Applications of Static Converters in Power System, APRIL2004, Kluwer Academic Publishers,2004.


**TI25004 ENERGY MANAGEMENT AND AUDITING L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

- To study the concepts behind economic analysis and load management.
- To understand the basics of materials and energy balance.
- To analyze energy efficiency in thermal utilities.
- To understand the concepts of compressed air systems.
- To illustrate the concepts of lighting systems and cogeneration.

**UNIT I – GENERAL ASPECTS OF ENERGY MANAGEMENT AND ENERGY AUDIT** (7+2 Skill) 9

Commercial and non-commercial energy – Final energy consumption – Energy needs of growing economy – Energy pricing – Energy conservation and its importance – Restructuring of the energy supply sector – Energy Conservation Act 2001 and Energy Conservation (Amendment) Act 2010 and its features – Electricity tariff – Thermal basics – Need and types of energy audit – Energy management and audit approach – Understanding energy costs – Maximizing system efficiencies – Optimizing the input energy requirements – Energy audit instruments – Case study.

**UNIT II – MATERIAL AND ENERGY BALANCE** (7+2 Skill) 9

Methods for preparing process flow – Material and energy balance diagrams – Energy policy purpose – Location of energy management – Roles and responsibilities of energy manager – Employee training and planning – Financial management: Financial analysis techniques, simple payback period, return on investment, net present value, internal rate of return – Case study.

**UNIT III – ENERGY EFFICIENCY IN THERMAL UTILITIES** (7+2 Skill) 9

Introduction to fuels – Properties of fuel oil, coal and gas – Principles of combustion – Combustion of oil, coal and gas – Boilers: Types, combustion in boilers, performance evaluation, analysis of losses, energy conservation opportunities, FBC boilers – Steam system: Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings – Furnaces: Classification, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery – Refractory: Types, selection and application of refractories, heat loss – Cogeneration: Classification and saving potentials – Case study.

**UNIT IV – ENERGY EFFICIENCY IN COMPRESSED AIR SYSTEM** (7+2 Skill) 9

Compressed air system: Types of air compressors, efficient compressor operation, compressed air system components, leakage test, savings opportunities – Refrigeration system: Vapour compression refrigeration cycle, refrigerants, coefficient of performance, factors affecting refrigeration and air conditioning system, savings opportunities – Vapour absorption refrigeration system: Working principle, types and comparison with vapour compression system, saving potential – Cooling tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving – Diesel generating system: Factors affecting selection, energy performance assessment of diesel generator, energy conservation avenues – Case study.

**UNIT V – ENERGY EFFICIENCY IN ELECTRICAL UTILITIES** (7+2 Skill) 9

Electrical load management and maximum demand control – Power factor improvement and its benefit – Selection and location of capacitors – Performance assessment of power factor capacitors – Automatic power factor controllers – Transformer losses – Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors, soft starters with energy saver, variable speed drives – Fans and blowers: Types, efficient system operation, flow control strategies – Pumps and pumping system: Types, system operation, flow control methods – Lighting system: Light source, choice of lighting, luminance requirements, ballast, occupancy sensors, energy efficient lighting controls, energy conservation avenues – Case study.

**TOTAL:45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 10**

1. Study of energy conservation and energy audit.
2. Performance study of electric motors.
3. Analysis of fan characteristic curves at different operating points.
4. Case study of illumination systems.
5. Performance analysis of compressors.

**TEXTBOOKS:**

**1.** Mehmet Kanoglu,YunusA Cengel,"Energy Efficiency and Management for Engineers", McGraw-Hill Education, First Edition, 2020.

**REFERENCES:**

1. Moncef Krati, 'Energy Audit of Building Systems: An Engineering Approach', Third Edition, CRC Press, Dec.2020.
2. Sonal Desai,'Handbook of EnergyAudit',McGraw Hill Education (India)Private Limited, 2015.
3. MichaelP.Deru,JimKelsey,'ProceduresforCommercialBuildingEnergyAudits',American Society of Heating, Refrigerating and Air conditioning Engineers, 2011.
4. Thomas D.Eastop, 'Energy Efficiency: For Engineers and Technologists',Longman Scientific & Technical, 1990, 1st Edition.
5. 'Energy Managers and Energy Auditors Guidebook', Bureau of Energy Efficiency,2006.
6. LarryC. Witte,PhilipS.Schmidt, DavidR.Brown, 'Industrial Energy Management and Utilization', Springer Berlin Heidelberg, 1988.

List of Open Source Software/ Learning website:

1. http://lab.fs.uni-lj.si/kes/erasmus/Energy%20Management%20Handbook.pdf
2. https://www.sciencedirect.com/science/article/pii/S2212827114004491
3. https://mppolytechnic.ac.in/mp-staff/notes_upload_photo/CS595EnergyEfficiencyinElectricalUtilities-5391.pdf
4. http://knowledgeplatform.in/wp-content/uploads/2017/03/1.3-Energy-management-Audit.pdf

**TI25005** **POWER QUALITY** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn the basic definitions in power quality.
- To study power quality issues in single-phase and three-phase systems.
- To understand the principles of power system harmonics.
- To understand the use of DSTATCOM for harmonic mitigation.
- To learn the concepts related to series compensation.

**UNIT I – INTRODUCTION** (7+2 Skill) 9

Introduction – Characterization of electric power quality: Transients, short duration and long duration voltage variations, voltage imbalance, waveform distortion, voltage fluctuations, power frequency variation, power acceptability curves – Power quality problems: Poor load power factor, non-linear and unbalanced loads, DC offset in loads, notching in load voltage, disturbance in supply voltage – Power quality standards.

**UNIT II – ANALYSIS OF SINGLE PHASE AND THREE PHASE SYSTEM**
(7+2 Skill) 9

Single phase linear and non-linear loads – Single phase sinusoidal and non-sinusoidal source supplying linear and non-linear loads – Three phase balanced system – Three phase unbalanced system – Three phase unbalanced and distorted source supplying non-linear loads – Concept of power factor – Three phase three wire system – Three phase four wire system.

**UNIT III – MITIGATION OF POWER SYSTEM HARMONICS** (7+2 Skill) 9

Introduction – Principle of harmonic filters – Series tuned filters – Double band pass filters – Damped filters – Detuned filters – Active filters – Power converters – Harmonic filter design – Tuned filter – Second order damped filter – Impedance plots for filter banks – Impedance plots for a three branch 33 kV filter.

**UNIT IV – LOAD COMPENSATION USING DSTATCOM** (7+2 Skill) 9

Compensating single phase loads – Ideal three phase shunt compensator structure – Generating reference currents using instantaneous p–q theory – Instantaneous symmetrical components theory – Generating reference currents when the source is unbalanced – Realization and control of DSTATCOM – DSTATCOM in voltage control mode.

**UNIT V – SERIES COMPENSATION OF POWER DISTRIBUTION SYSTEM**
(7+2 Skill) 9

Rectifier supported DVR – DC capacitor supported DVR – DVR structure – Voltage restoration – Series active filter – Unified power quality conditioner.

**TOTAL:45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 10**

1. Harmonic analysis of single-phase power converters (semi-converters and full converters) with R and RL loads through simulation.

2. Harmonic analysis of three-phase power converters (semi-converters and full converters) with R and RL loads through simulation.
3. Harmonic analysis of single-phase inverters with R and RL loads through simulation.
4. Harmonic analysis of three-phase inverters with R and RL loads through simulation.
5. Mitigation of harmonics using tuned filters.

List of Open Source Software/Learning website:

1. http://nptel.iitm.ac.in/courses.php
2. https://old.amu.ac.in/emp/studym/2442.pdf
3. https://electricalacademia.com/electric-power
4. https://www.intechopen.com/books/6214
5. https://www.cde.com/resources/technical-papers/Mitigation-of-Harmonics.pdf
6. https://www.academia.edu/43237017/Use_Series_Compensation_in_Distribution_Networks_33_KV

**TEXTBOOKS:**


1. Arindam Ghosh and GeradLedwich“ Power Quality Enhancement Using Custom Power Devices”, Kluwer Academic Publishers, First Edition,2002
2. G.T.Heydt, “Electric Power Quality”, Starsina Circle Publications, Second Edition, 2011.
3. George J.Wakileh, “Power System Harmonics –Fundamentals, Analysis and Filter Design”, Springer – Verlag Berlin Heidelberg, New York, 2019.


**REFERENCES:**


1. R.C.Duggan“Electric Power Systems Quality”,Tata MCGrawHill Publishers, Third Edition, 2012.
2. Arrillga“PowerSystem Harmonics”,JohnWiely andS ons,2003 2nd Edition.
3. Derek A.Paice “Power Electronic Converter Harmonics” IEEE Press, 1995, Wiley – IEE Press 1999, 18th Edition.

**TI25006** **SMART GRID** **L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the evolution of smart and interconnected energy systems.
- To understand the various challenges and benefits of smart grids and the national and international initiatives undertaken.
- To understand the concepts related to transmission and distribution in smart grid technologies.
- To gain insight into various smart measurement technologies.
- To understand the various computing technologies for smart operation of the grid.

**UNIT I – INTRODUCTION** (7+2 Skill) 9

Evolution of energy systems – Concept, definitions and need – Difference between conventional and smart grid – Drivers, structures, functions, opportunities, challenges and benefits of smart grid – Basics of microgrid – National and international initiatives in smart grid.

**UNIT II – SMART METERING** (7+2 Skill) 9

Introduction to advanced metering infrastructure (AMI): Drivers and benefits – AMI protocols, standards and initiatives – AMI needs in the smart grid – Real time management and control – Phasor measurement unit (PMU).

**UNIT III – SMART GRID TECHNOLOGIES (TRANSMISSION)** (7+2 Skill) 9

Technology drivers – Smart energy resources – Smart substations – Substation automation – Feeder automation – Transmission systems: Energy management system (EMS), wide area monitoring, protection and control.

**UNIT IV – SMART GRID TECHNOLOGIES (DISTRIBUTION)** (7+2 Skill) 9

Distribution management system (DMS) – Volt/VAr control – Fault detection, isolation and service restoration – Outage management – High efficiency distribution transformers – Phase shifting transformers – Electric vehicles.

**UNIT V – HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS** (7+2 Skill) 9

Local area network (LAN) – House area network (HAN) – Wide area network (WAN) – Broadband over power line (BPL) – IP based protocols – Computing technologies for smart grid applications: Web services to cloud computing – Role of big data and IoT – Cyber security for smart grid.

**TOTAL:45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 10**

1. Assignment-Familiarization of National and International Initiatives in Smart Grid
2. Simulation of smart meter using (MATLAB/ETAP/SCILAB/LABVIEW/Proteus/Equivalent opensource software).
3. Visit to a substation for analysing the Automation Technologies like Monitoring, Protection and control.

4. Awareness about High-Efficiency Distribution Transformers, Phase Shifting Transformers in a substation.
5. Introduction to recent technologies in electric vehicles and understanding the operation of EV, HEVand PHEV.
6. Simulation of IoT based digital communication system for smart grid applications.

**TEXTBOOKS:**


1. Smart Grids Advanced Technologies and Solutions, Second Edition, Edited by Stuart Borlase,CRC, 2018.
2. Janaka Ekanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, John Wiley,2012
3. JamesMomoh,SmartGridFundamentalsofDesignandAnalysis,IEEEpress2012.


**REFERENCES:**


1. Ahmed F. Zobaa, Trevor J. Bihl, Big data analytics in future power systems, 1st Edition, CRC press 2018.
2. C. Gungor et al., "Smart Grid Technologies: Communication Technologies and Standards," in IEEE Transactions on Industrial Informatics, vol. 7, no. 4, pp. 529-539, Nov. 2011.doi: 10.1109/TII.2011.2166794.
3. X. Fang, S. Misra, G. Xue and D. Yang, "Smart Grid ––The New and Improved Power Grid: A Survey," in IEEE Communications Surveys & Tutorials, vol. 14, no. 4, pp. 944- 980, Fourth Quarter 2012. doi: 10.1109/SURV.2011.101911.00087.
4. StuartBorlase“SmartGrid:Infrastructure,TechnologyandSolutions”,CRCPress2012 .

**TI25007** **RESTRUCTURED POWER MARKET** **L T P C**

**3 0 0 3**

**COURSEOBJECTIVES:**

**Students will be able to:**

- Describe various types of deregulated markets in power systems.
- Describe the technical and non-technical issues in the deregulated power industry.
- Classify different market mechanisms and summarize the role of various entities in the market.
- Analyze energy and ancillary services management in the deregulated power industry.
- Understand the restructuring framework of the US and Indian power sectors.

**UNIT I – INTRODUCTION** (7+2 Skill) 9

Reasons for restructuring – Understanding the restructuring process – Objectives of deregulation of various power systems across the world – Consumer behavior – Supplier behavior – Market equilibrium – Short run and long run costs – Various costs of production – Philosophy of market models – Market models based on contractual arrangements – Market architecture.

**UNIT II – TRANSMISSION CONGESTION MANAGEMENT** (7+2 Skill) 9

Importance of congestion management in deregulated environment – Classification of congestion management methods – Calculation of available transfer capability (ATC) – Non market methods – Market based methods – Nodal pricing – Inter-zonal and intra-zonal congestion management – Price area congestion management – Capacity alleviation method.

**UNIT III – LOCATIONAL MARGINAL PRICES (LMP) AND FINANCIAL TRANSMISSION RIGHTS** (7+2 Skill) 9

Fundamentals of locational marginal pricing – Lossless DCOPF model for LMP calculation – Loss compensated DCOPF model for LMP calculation – ACOPF model for LMP calculation – Risk hedging functionality of financial transmission rights – FTR issuance process – Treatment of revenue shortfall – Secondary trading of FTRs – Flow gate rights – FTR and market power.

**UNIT IV – ANCILLARY SERVICE MANAGEMENT AND PRICING OF TRANSMISSION NETWORK** (7+2 Skill) 9

Types of ancillary services – Load generation balancing related services – Voltage control and reactive power support services – Black start capability service – Mandatory provision of ancillary services – Markets for ancillary services – Co-optimization of energy and reserve services – International comparison – Pricing of transmission network: Wheeling – Principles of transmission pricing – Transmission pricing methods – Marginal transmission pricing paradigm – Composite pricing paradigm – Loss allocation methods.

**UNIT V – MARKET EVOLUTION** (7+2 Skill) 9

US markets: PJM market – Nordic power market – Reforms in Indian power sector: Framework of Indian power sector – Reform initiatives – Availability based tariff (ABT) – Electricity Act 2003 – Open access issues – Power exchange.

**TOTAL:45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/MiniProject/Assignment/Content Preparation / Quiz/ Surprise Test / etc) 10**

1. Analysis of ATC calculations using any one of the relevant software tools.
2. DC OPF–based LMP calculations using any one of the relevant software tools.
3. AC OPF–based LMP calculations using any one of the relevant software tools.
4. Analysis of social welfare maximization with different objectives.
5. Analysis of ABT components.
6.

**TEXTBOOKS:**

1. Mohammad Shahidehpour,Muwaffaq Alomoush,"Restructured electrical power systems: operation, trading and volatility" Marcel Dekker Pub., 2001, 1st Edition.
2. Kankar Bhattacharya, MathH.J.Boolen,and Jaap E.Daadler,"Operation of restructured power systems", Kluwer Academic Pub.,2001, 1st Edition.
3.

**REFERENCES:**

1. Sally Hunt,"Making competition work in electricity", JohnWilley and SonsInc.2002.
2. StevenStoft, Power System Economics: Designing Markets for Electricity", Wiley-IEEEPress, 2002.
3. Allen.J.WoodandBruceF.Wollenberg,'PowerGeneration,OperationandControl' ,John Wiley & Sons, Inc., 2016, 3rd Edition.

**List of Open Source Software/ Learning website:**

1. S.A. Khaparde, A.R. Abhyankar, "Restructured Power Systems", NPTEL Course, https://nptel.ac.in/courses/108101005/.

## CONVERTERS AND DRIVES

**TI25008 SPECIAL ELECTRICAL MACHINES L T P C**

**2 0 2 3**

**COURSEOBJECTIVES:**

- To understand the working of special machines such as stepper motors, switched reluctance motors, BLDC motors, and PMSMs.
- To derive torque equations and study the characteristics of special machines.
- To design controllers for special machines.
- To study the working principle of synchronous reluctance motors.
- To simulate the closed-loop operation of BLDC motors.

**UNIT I – STEPPER MOTORS** 6

Constructional features – Principle of operation – Types – Torque predictions – Linear and non-linear analysis – Characteristics – Drive circuits – Closed loop control – Applications.

**UNIT II – SWITCHED RELUCTANCE MOTORS** 6

Constructional features – Principle of operation – Torque prediction – Characteristics – Power controllers – Control of SRM drive – Speed control – Current control – Design procedures – Sensorless operation of SRM – Current sensing – Rotor position measurement and estimation methods – Sensorless rotor position estimation – Inductance based estimation – Applications.

**UNIT III – PERMANENT MAGNET BRUSHLESS DC MOTORS** 6

Fundamentals of permanent magnets – Types – Principle of operation – Magnetic circuit analysis – EMF and torque equations – Characteristics – Controller design – Transfer function of machine, load and inverter – Current and speed controller.

**UNIT IV – PERMANENT MAGNET SYNCHRONOUS MOTORS** 6

Permanent magnet AC machines – Machine configurations – PMSM principle of operation – EMF and torque equations – Phasor diagram – Torque speed characteristics – Evaluation of control characteristics – Design of current and speed controllers – Constructional features, operating principle and characteristics of synchronous reluctance motor.

**UNIT V – STUDY OF OTHER SPECIAL ELECTRICAL MACHINES** 6

Principle of operation and characteristics of hysteresis motor – AC series motors – Linear motor – Applications.

**30 PERIODS**

**LAB COMPONENT: 30PERIODS**

Using electromagnetic software

1) Simulation of BLDC motor
2) Simulation of SR Mmotor
3) Simulation of steppe rmotor
4) Simulation of PMSM motor
5) Simulation of any other special machines

**TOTAL:30+30=60PERIODS**

**REFERENCES:**


1. JacekF.Gieras, Dr.Rong-JieWang, Professor MaartenJ.Kamper-Axial Flux Permanent Magnet Brushless Machines-Springer Netherlands 2008.
2. Bilgin, Berker Emadi, AliJiang, James Weisheng-Switched reluctance motor drives: fundamentals to applications-CRC 2019.
3. Ramu Krishnan-Permanent Magnet Synchronous and Brushless DC Motor Drives-CRCPress, Marcel Applications -CRC Press 2009

4..T.Kenjo,‘Stepping motors and their microprocessor controls’, Oxford University

press, NewDelhi, 2000 Dekker 2009
5.T.J.E.Miller, 'Brushless magnet and Reluctance motor drives', Clar end on press,London,1989
6..R.Krishnan- Switched Reluctance Motor Drives Modeling, Simulation, Analysis, Design, and Applications -CRC Press 2017.

**TI25009 ANALYSIS OF ELECTRICAL MACHINES LT P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To model & simulate all types of DC machines
- To develop reference frame equations for various elements like R,L and C
- To model an induction (three phase and 'n' phase) and synchronous machine
- To drive reference frame equations for induction and synchronous machine
- To study the need and working of multiphase induction and synchronous machine

**UNIT I – MODELING OF BRUSHED DC ELECTRIC MACHINERY** 6
Fundamentals of operation – Introduction – Governing equations and modeling of brushed DC motor: Shunt, series and compound – State model derivation – Construction of model of a DC machine using state equations: Shunt, series and compound.

**UNIT II – REFERENCE FRAME THEORY** 6
Historical background – Phase transformation and commutator transformation – Transformation of variables from stationary to arbitrary reference frame.

**UNIT III – INDUCTION MACHINES** 6
Three phase induction machine – Equivalent circuit – Free acceleration characteristics – Voltage and torque equations in machine variables and arbitrary reference frame variables – Simulation under no load and load conditions – Machine variable form – Arbitrary reference variable form.

**UNIT IV – SYNCHRONOUS MACHINES** 6
Three phase synchronous machine – Voltage and torque equations in machine variables and rotor reference frame variables (Park's equations).

**UNIT V – MULTIPHASE (MORE THAN THREE PHASE) MACHINES CONCEPTS**6
Preliminary remarks – Necessity of multiphase machines – Evolution of multiphase machines – Advantages of multiphase machines – Working principle – Multiphase induction machine – Multiphase synchronous machine – Modeling of n-phase machine – Applications of multiphase machines.

**30 PERIODS**

**REFERENCES:**

1. Stephen D.Umans,"Fitzgerald&Kingsley's Electric Machinery",Tata Mc Graw Hill,7th Edition, 2020.

2. BogdanM.Wilamowski,J. DavidIrwin, The Industrial Electronics Handbook, Second Edition, Power Electronics and Motor Drives, CRC Press, 2011, 1st Edition.
3. PaulC.Krause,OlegWasynczuk,Scott D.Sudhoff,S teven D.Pekarek, "Analysis of Electric Machinery and Drive Systems", 3rd Edition, Wiley-IEEE Press, 2013.
4. R. Krishnan, Electric Motor& Drives: Modeling, Analysis and Control, Pearson Education, 1st Imprint, 2015, 1st Edition.
5. R.Ramanujam, Modeling and Analysis of Electrical Machines, I.k. International Publishing House Pvt.Ltd,2018.
6. CheeMunOng, Dynamic Simulation of Electric Machinery using MATLAB, Prentice Hall,1997, 1st Edition.
7. Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK,Wiley,2021,1stEdition

**TI250010 MULTI LEVEL POWER CONVERTERS L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To learn multilevel topology (Symmetry & Asymmetry) with common DC bus link.
- To study the working of cascaded H Bridge, Diode Clamped and Flying Capacitor MLI.
- To study the working of MLI with reduced switch count.
- To simulate three level diode clamped MLI and three level flying capacitor based MLI with resistive and reactive load
- To simulate the MLI with reduced switch count.

**UNIT I – MULTILEVEL TOPOLOGIES** 6

Introduction – Generalized topology with a common DC bus – Converters derived from the generalized topology – Symmetric topology without a common DC link – Asymmetric topology.

**UNIT II – CASCADED H-BRIDGE MULTILEVEL INVERTERS** 6

Introduction – H-bridge inverter – Bipolar pulse width modulation – Unipolar pulse width modulation – Multilevel inverter topologies – CHB inverter with equal DC voltage – H-bridges with unequal DC voltages – PWM – Carrier based PWM schemes – Phase shifted multicarrier modulation – Level shifted multicarrier modulation – Comparison between phase and level shifted PWM schemes – Staircase modulation.

**UNIT III – DIODE CLAMPED MULTILEVEL CONVERTER** 6

Introduction – Converter structure and functional description – Modulation of multilevel converters – Voltage balance control – Effectiveness boundary of voltage balancing in DCMC converters – Performance results.

**UNIT IV – FLYING CAPACITOR MULTILEVEL CONVERTER** 6

Introduction – Flying capacitor topology – Modulation scheme for the FCMC – Dynamic voltage balance of FCMC.

**UNIT V – MULTILEVEL CONVERTER WITH REDUCED SWITCH COUNT** 6

Multilevel inverter with reduced switch count – Structures – Working principles – Pulse generation methods.

**30 PERIODS**

**LABCOMPONENT:30PERIODS**

1. Simulation of fixed PWM and sinusoidal PWM for an inverter.
2. Simulation of an H-bridge inverter with R load.
3. Simulation of a three-level diode-clamped MLI with R load.
4. Simulation of a three-level capacitor-clamped MLI with R load.
5. Simulation of MLI with a reduced switch configuration.

TOTAL: 30+30=60PERIODS

**TEXT BOOKS:**


1. RashidM.H,"PowerElectronicsCircuits,DevicesandApplications",PrenticeHallIndia, Third Edition, New Delhi, 2014 Pearson 4th edition.
2. SergioAlbertoGonzalez, Santiago Andres Verne, Maria Ines Valla,"Multilevel Converters forIndustrial Applications", CRC Press, 22-Jul-2013, 20171st Edition.
3. BinWu,MehdiNarimani,HighPowerConvertersandACdrivesbyIEEEpress2017,2ndEdition.


**REFERENCE BOOKS:**


1. ThomasA.Lipo,PulseWidth Modulation for Power Converters: Principles and Practice, D.Grahame Holmes, John Wiley & Sons, Oct-2003, 1st Edition.
2. FangLinLuo,HongYe,AdvancedDC/ACInverters:ApplicationsinRenewableEnergy, CRC Press, 22-Jan-2013, 2017, 1st Edition.
3. Hani Vahedi, Mohamed Trabelsi, Single-DC-Source Multilevel Inverters, Springer, 2019, 1stEdition.
4. ErsanKabalcı,Multilevel Inverters Introduction and Emergent Topologies, AcademicPress Inc,2021, 1st Edition.
5. Iftekhar Maswood, Dehghani Tafti,Advanced Multilevel Converters and Applications in GridIntegration, Wiley, 2018, 1st Edition.

**TI25011** **ELECTRICAL DRIVES** **L T P C**
**2 0 2 3**

**COURSEOBJECTIVES:**

At the end of the course, students should have the ability to:

Understand the steady-state operation and transient dynamics of motor–load systems.

•Study and analyze the operation of converter- and chopper-fed DC drives, both qualitatively and quantitatively.

Study and understand the operation and performance of AC induction motor drives.

Study and understand the operation and performance of AC synchronous motor drives.

Analyze and design current and speed controllers for closed-loop solid-state DC motor drives.

**UNIT I – DRIVE CHARACTERISTICS** 6

Electric drive – Equations governing motor load dynamics – Steady state stability – Multi quadrant dynamics: Acceleration, deceleration, starting and stopping – Typical load torque characteristics – Selection of motor.

**UNIT II – CONVERTER/CHOPPER FED DC MOTOR DRIVE** 6

Steady state analysis of single and three phase converter fed separately excited DC motor drive – Continuous and discontinuous conduction – Time ratio and current limit control – Four quadrant operation of converter and chopper fed drive.

**UNIT III – INDUCTION MOTOR DRIVES** 6

Stator voltage control – Energy efficient drive – V/f control – Constant air gap flux – Field weakening mode – Voltage source inverter and current source inverter fed drives – Closed loop control.

**UNIT IV – SYNCHRONOUS MOTOR DRIVES** 6

V/f control and self control of synchronous motor – Margin angle control and power factor control – Permanent magnet synchronous motor drive.

**UNIT V – DESIGN OF CONTROLLERS FOR DRIVES** 6

Transfer function for DC motor, load and converter – Closed loop control with current and speed feedback – Armature voltage control and field weakening mode – Design of controllers: Current controller and speed controller – Converter selection and characteristics.

**30 PERIODS**

**LAB COMPONENT: 30PERIODS**

1. Simulation of converter- and chopper-fed DC drives.
2. Simulation of closed-loop operation of stator voltage control of induction motor drives.
3. Simulation of closed-loop operation of V/f control of induction motor drives.
4. Simulation of synchronous motor drives.

**TOTAL: 30+30=60PERIODS**

**TEXTBOOKS:**


1. GopalK.Dubey,FundamentalsofElectricalDrives,NarosaPublishingHouse,2nd Edition January 2010.
2. BimalK.Bose.ModernPowerElectronicsandACDrives,PearsonEducation,2002 1st Edition.


**REFERENCES:**


1. S.K.Pillai,A First course on Electrical Drives,Wiley EasternLimited,3rd Edition2012.
2. MurphyJ.M.D and Turnbull, Thyrist or Control of AC Motor, Pergamon Press,Oxford1988,1st Edition.
3. GopalK.Dubey,PowersemiconductorcontrolledDrives,PrenticeHallInc.,NewJersey,1989, 1st Edition.
4. R.Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, Prentice hall of India,2001, 1st Edition.


| TI25012 | SMPS AND UPS | L T P C<br>2 0 2 3 |
|---|---|---|

**COURSEOBJECTIVES:**

- To learn the working of isolated and non-isolated DC–DC converters.
- To design isolated and non-isolated DC–DC converters.
- To derive the equations related to converter dynamics.
- To design and simulate P, PI, and PID controllers for buck, boost, and buck–boost converters.
- To identify and study different configurations of UPS systems.

**UNIT I ANALYSIS OF NON-ISOLATED DC–DC CONVERTERS 6**

Basic topologies: Buck, Boost, and Buck–Boost converters – Principles of operation – Continuous conduction mode – Concepts of volt–second balance and charge balance – Analysis and design based on steady-state relationships – Introduction to discontinuous conduction mode.

**UNIT II ANALYSIS OF ISOLATED DC–DC CONVERTERS 6**

Introduction – Classification – Forward, flyback, push–pull, half-bridge, and full-bridge topologies – Cuk converter as a cascade combination of boost followed by buck – Isolated version of the Cuk converter – Design of SMPS – Introduction to the design of magnetic components for SMPS using relevant software – Simulation of bidirectional DC–DC converters (both non-isolated and isolated), considering EV as an example application.

**UNIT III CONVERTER DYNAMICS 6**

AC equivalent circuit analysis – State-space averaging – Circuit averaging – Transfer function models for buck, boost, and buck–boost converters – Simulation of basic topologies using derived state-space models – Comparison with circuit model–based simulations already carried out.

**UNIT IV CONTROLLER DESIGN 6**

Review of P, PI, and PID control concepts – Gain margin and phase margin – Bode plot–based analysis – Design of controllers for buck, boost, and buck–boost converters.

**UNIT V POWER CONDITIONERS AND UPS 6**

Introduction – Power line disturbances – Power conditioners – UPS: Offline and online – Need for filters – Filters for PWM VSI – Front-end battery charger – Boost charger.

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Simulation of basic topologies.
2. Simulation of bidirectional DC–DC converters (both non-isolated and isolated), considering EVs as an example application.
3. Simulation of basic topologies using derived state-space models and comparison with circuit model–based simulations already carried out.
4. Simulation study of controller design for basic topologies.
5. Simulation of battery chargers for EV applications.

**TOTAL:30+30=60PERIODS**

**TEXTBOOKS:**


1. Robert W. Erickson & Dragon Maksimovic, ” Fundamentals of Power Electronics”, Third Edition, 2020
2. Ned Mohan,” Power Electronics: A First Course”, Johnwiley, 2013.
3. Marian K. Kazimierczuk and Agasthya Ayachit,”Laboratory Manual for Pulse-Width Modulated DC– DC Power Converters”, Wiley 2016.
4. Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002.
5. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition 2017.


**TI25013 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS L T P C**

**2 0 2 3**

**COURSE OBJECTIVES:**

- To learn the various types of renewable sources of energy.
- To understand the electrical machines to be used for wind energy conversion

systems.

- To learn the principles of power converters used in solar PV system.
- To study the principle of power converters used in Wind system.
- To simulate the AC-DC, AC-AC Converters, Matrix Converters and PWM inverters.

**UNIT I INTRODUCTION TO RENEWABLE ENERGY SYSTEMS 6**

Classification of energy sources – Importance of non-conventional energy sources – Advantages and disadvantages of conventional energy sources – Environmental aspects of energy – Impacts of renewable energy generation on the environment – Qualitative study of renewable energy resources: ocean energy, biomass energy, hydrogen energy – Solar photovoltaic (PV) systems – Fuel cells: operating principles and characteristics – Wind energy: nature of wind, types, control strategies, and operating areas.

**UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS) 6**

Construction, principle of operation, and analysis of squirrel cage induction generators (SCIG), doubly fed induction generators (DFIG), and permanent magnet synchronous generators (PMSG).

**UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS 6**

Power converters: Line-commutated converters (in inversion mode), boost and buck–boost converters – Selection of inverter – Battery sizing – Array sizing – Simulation of line-commutated converters and buck/boost converters.

Analysis of solar PV systems: Block diagram – Types of solar PV systems: stand-alone PV systems and grid-integrated solar PV systems – Grid connection issues.

**UNIT IV POWER CONVERTERS FOR WIND SYSTEMS 6**

Power converters: Three-phase AC voltage controllers – AC–DC–AC converters – Uncontrolled rectifiers – PWM inverters – Grid-interactive inverters – Matrix converters.

**UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 6**

Need for hybrid systems – Range and types of hybrid systems – Case studies of diesel–PV, wind–PV, micro-hydel–PV, and biomass–diesel systems – Maximum power point tracking (MPPT).

**30 PERIODS**

**LAB COMPONENT: 30PERIODS**

1. Simulation on modeling of Solar PV System-VI Characteristics
2. Simulation on Modelling of fuel cell-VI Characteristics
3. Simulation of self-excited Induction Generator.
4. Simulation of DFIG/PMSG based Wind turbine.
5. Simulation on Grid integration of RES.

**TOTAL:30+30=60PERIODS**

**REFERENCES:**


1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009, 7th impression.
2. Rashid .M. H "Power electronics Hand book", Academic press,2nd Edition, 2006 4th Edition, 2017
3. Rai. G.D, "Non-conventional energy sources", Khanna publishers, 6th Edition, 2017.
4. Rai. G.D," Solar energy utilization", Khanna publishers, 5th Edition, 2008.
5. Gray, L. Johnson, "Wind energy system", prentice hall of india, 2nd Edition, 2006.
6. H.Khan "Non-conventional Energy sources ",Tata McGraw-hill Publishing Company, New Delhi, 2017, 3rd Edition.


**TI25014 CONTROL OF POWER ELECTRONICS CIRCUITS L T P C**

**2 0 2 3**

**COURSE OBJECTIVES:**

- To learn the basics of control system simulation.
- To do symbolic calculation.
- To study the principles of sliding mode control and the way of apply smc for buck converter.
- To learn the concept of power factor correction.
- To design simulate smc for buck converter and power factor correction circuit with controller.

**UNIT I SIMULATION BASICS IN CONTROL SYSTEMS 6**

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model.

**UNIT II SYMBOLIC CALCULATIONS 6**

Symbolic Variables - Symbolic Vector Variables, Commands for Handling Polynomial Expressions - Extracting Parts of a Polynomial -. Factorization and Roots of Polynomials, Symbolic Matrix Algebra - Operations with Symbolic Matrices - Other Symbolic Matrix Operations.

**UNIT III SLIDING MODE CONTROL BASICS 6**

Introduction- Introduction to Sliding-Mode Control- Basics of Sliding-Mode Theory- Application of Sliding-Mode Control to DC-DC Converters—Principle-Sliding mode control of buck converter.

**UNIT IV POWER FACTOR CORRECTION CIRCUITS 6**

Introduction, Operating Principle of Single-Phase PFCs, Control of boost converter based PFCs, Designing the Inner Average-Current-Control Loop, Designing the Outer Voltage-Control Loop, Example of Single-Phase PFC Systems.

**UNIT V CONTROLLER DESIGN FOR PFC CIRCUITS 6**

Power factor correction circuit using other SMPS topologies: C'uk and SEPIC converter - PFC circuits employing bridgeless topologies.

**30 PERIODS**

**LAB COMPONENT:** **30 PERIODS**

1. Simulation exercises on zero, first and second order basic blocks.
2. Simulation exercises based on symbolic calculations.
3. Simulation of Sliding mode control based buck converter.
4. Simulation of Single-Phase PFC circuit employing boost converter.
5. Simulation of Single-Phase PFC circuit employing C'uk converters.

**TOTAL: 30+30 = 60 PERIODS**

**TEXT BOOKS:**


1. Feedback Control problems using MATLAB and the Control system tool box By Dean Frederick and Joe Chow, 2000, 1st Edition, Cengage Learning.
2. Ned Mohan,"Power Electronics: A First Course", Johnwiley, 2013, 1st Edition.
3. Marian K. Kazimierczuk and AgasthyaAyachit,"Laboratory Manual for Pulse-Width Modulated DC-DC Power Converters", Wiley 2016, 1st Edition.
4. Power Electronics handbook, Industrial Electronics series, S.K.Varenina, CRC press, 2002, 1st Edition.


**REFERENCES:**


**1.** Sliding mode control for Switching Power Converters:, Techniques and Implementation, Slew-Chong Tan, Yuk Ming Lai Chi-Kong Tse, 1st Edition, CRC Press.

**2.** Andre Kislovski, "Dynamic Analysis of Switching-Mode DC/DC Converters", Springer 1991.

**3.** MATLAB Symbolic Algebra and Calculus Tools, Lopez Cesar, Apress, 2014.


**TI25015 EMBEDDED SYSTEM DESIGN** **L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

• To introduce the building blocks of an embedded system and software tools.
• To emphasize the role of input/output interfacing with bus communication protocols.
• To illustrate interrupt service routines (ISR) and scheduling for multitasking processes.
• To explain the basics of real-time operating systems (RTOS).
• To analyze applications based on embedded design approaches.

**UNIT I INTRODUCTION TO EMBEDDED SYSTEMS** **6**

Introduction to Embedded Systems –Structural units in Embedded processor,

selection of processor & memory devices- DMA — Memory management methods- Timer and Counting devices, Real Time Clock, In-circuit emulator, Target Hardware Debugging.

**UNIT II EMBEDDED NETWORKING 6**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols RS232 standard – RS485 – CAN Bus- Serial Peripheral Interface (SPI) – Inter-Integrated Circuits ($I^2C$).

**UNIT III INTERRUPTS THE SERVICE MECHANISM AND DEVICE DRIVER 6**

Programmed-I/O busy-wait approach without interrupt service mechanism-ISR concept-interrupt sources – multiple interrupts – context and periods for context switching, interrupt latency and deadline – Introduction to Device Drivers.

**UNIT IV RTOS-BASED EMBEDDED SYSTEM DESIGN 6**

Introduction to basic concepts of RTOS- Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-preemptive scheduling, Task communication- shared memory, message passing- Interprocess Communication- Introduction to process synchronization using semaphores.

**UNIT V EMBEDDED SYSTEM APPLICATION DEVELOPMENT 6**

Embedded Product Development Life Cycle - Case Study: Precision Agriculture- Autonomous car.

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Laboratory exercise: Use any Embedded processor/IDE/open source platform to give hands-on training on basic concepts of embedded system design:
   a) Introduction to IDE and Programming Environment.
   b) Configure timer block for signal generation (with given frequency).
   c) Interrupts programming example using GPIO.
   d) $I^2C$ communication with peripherals
   e) Master-slave communication between processors using SPI.
   f) Networking of processor using Wi-Fi.
   g) Basic RTOS concept and programming

2. Assignment: Introduction to VxWorks, ЧC/OS-II, RT Linux
3. Embedded systems-based Mini project.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**

1. Rajkamal, 'Embedded system-Architecture, Programming, Design, McGraw-Hill Edu, 3rd edition 2017
2. Peckol, "Embedded system Design", John Wiley & Sons,2010.

**REFERENCES:**

1. Shibu. K.V, "Introduction to Embedded Systems", TataMcgraw Hill, 2nd edition 2017.
2. Lya B.Das," Embedded Systems" ,Pearson Education, 1st edition 2012.
3. Parag H.Dave,Himanshu B.Dave," Embedded Systems-Concepts ,Design and Programming, Pearson Education,2015, 1st edition.
4. Elicia White, "Making Embedded systems", O'Reilly Series ,SPD,2011, 1st edition.
5. Jonathan W. Valvano, 'Embedded Microcomputer Systems Real-time Interfacing', Cengage Learning , 3rd edition 2010.
6. Tammy Noergaard, "Embedded Systems Architecture", Newnes, 2nd edition, 2013.

**List of Open Source Software/ Learning websites:**

1. https://nptel.ac.in/courses/108102045
2. https://ece.uwaterloo.ca/~dwharder/icsrts/Lecture_materials/A_practical_introduction_to_real-time_systems_for_undergraduate_engineering.pdf
3. https://www.circuitbasics.com/basics-of-the-i2c-communication-protocol/
4. https://www.tutorialspoint.com/embedded_systems/es_interrupts.htm
5. https://www.theengineeringprojects.com/2016/11/examples-of-embedded-systems.html#:~:text=Embedded%20Product%3A%20Automatic%20Washing%20Machine,done%20by%20your%20machine%20itself.

| **TI25016** | **EMBEDDED C- PROGRAMMING** | **LT P C** |
|---|---|---|
| | | **2 0 2 3** |

**COURSE OBJECTIVES:**

- To expose the students to the fundamentals of embedded Programming
- To Introduce the GNU C Programming Tool Chain.
- To study the basic concepts of embedded C.
- To teach the basics of 8051 Programming
- To involve Discussions/ Practice/Exercise in revising & familiarizing the concepts acquired over the 5 Units of the subject for improved employability skills.

**UNIT I BASIC C PROGRAMMING 6**

Typical C Program Development Environment - Introduction to C Programming - Structured Program Development in C - Data Types and Operators - C Program Control - C Functions - Introduction to Arrays.

**UNIT II EMBEDDED C 6**

Adding Structure to 'C' Code: Object-oriented programming with C, Header files for Project and Port, Examples. Meeting Real-time constraints: Creating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts.

**UNIT III 8051 Programming in C 6**

Data types and time delay in 8051, I/O programming in 8051, Logic operations in 8051, Data conversion program in 8051 Accessing code ROM space in 8051, Data serialization using 8051

**UNIT IV 8051 SERIAL PORT AND INTERRUPT PROGRAMMING IN C 6**

Basics of serial communication, 8051 interface to RS232- serial port programming in 8051. 8051 interrupts and programming, Programming for timer configuration.

**UNIT V 8051 INTERFACING 6**

8051: ADC interfacing , DAC interfacing, Sensor interfacing, LCD interfacing, Stepper motor interfacing.

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Laboratory exercise: Use 8051 microcontroller/Embedded processor/IDE/open source platform to give hands-on training on Embedded C- programming.

   a. Introduction to IDE (like code blocks, vscode ,etc)and Programming Environment (like Keililu vision, Proteus)
   b. Configuring an I/O port using bitwise programming.
   c. Configuring timer for generating hardware delay.
   d. Flashing an LED using an interrupt
   e. Serial communication using UART port of 8051
   f. Interfacing an ADC with 8051
   g. Interfacing an analog sensor with 8051
   h. Interfacing 16x2 LCD with 8051
   i. configuring timer for generating PWM signal
   j. Interfacing a stepper motor with 8051

2. Assignment: Introduction to Arduino IDE, Raspberry Pi
3. Embedded C-Programming -based Mini project.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**


1. Paul Deitel and Harvey Deitel, "C How to Program", 9th Edition, Pearson Education Limited, 2022, 1st edition.
2. Michael J Pont, "Embedded C", Addison-Wesley, An imprint of Pearson Education, 2002.
3. William von Hagen, "The Definitive Guide to GCC", 2nd Edition, Apress Inc., 2006.

4. Gowrishankar S and Veena A, "Introduction to Python Programming", CRC Press, Taylor & Francis Group, 2019.

**REFERENCES:**

1. Noel Kalicharan, "Learn to Program with C", Apress Inc., 2015, 1st edition.
2. Steve Oualline, "Practical C programming", O'Reilly Media, 1997, 3rd edition.
3. Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, 'The 8051 Microcontroller and Embedded Systems' Prentice Hall, 2nd Edition 2007.
4. Myke Predko, "Programming and customizing the 8051 microcontrollers",McGraww Hill 2000, 1st edition.

List of Open Source Software/ Learning websites:

- https://www.hackerrank.com/
- https://www.cprogramming.com/
- https://www.allaboutcircuits.com/technical-articles/introduction-to-the-c-programming-language-for-embedded-applications/
- https://onlinecourses.nptel.ac.in/noc19_cs42/preview
- https://microcontrollerslab.com/8051-microcontroller-tutorials-c/
- https://www.circuitstoday.com/getting-started-with-keil-uvision

**TI25017 EMBEDDED PROCESSORS LT P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To introduce the architecture of the ARM processor.
- To train students in ARM programming.
- To discuss memory management, append location development with an ARM processor.
- To involve Discussions/ Practice/Exercise in revising & familiarizing the concepts
- To impart the knowledge on single board embedded processors.

**UNIT I ARM ARCHITECTURE 6**

Architecture – Memory Organization – addressing modes -Registers – Pipeline - Interrupts – Coprocessors – Interrupt Structure

**UNIT II ARM MICROCONTROLLER PROGRAMMING 6**

ARM general Instruction set – Thumb instruction set –Introduction to DSP on ARM-basic programming.

**UNIT III PERIPHERALS OF ARM 6**

ARM: I/O Memory – EEPROM – I/O Ports – SRAM –Timer –UART - Serial Communication with PC – ADC/DAC Interfacing-stepper motor interfacing

**UNIT IV ARM COMMUNICATION 6**

ARM With CAN, $I^2C$, and SPI protocols

**UNIT V INTRODUCTION TO SINGLE BOARD EMBEDDED PROCESSOR 6**

Raspberry Pi Architecture - Booting Up RPi- Operating System and Linux Commands -Working with RPi using Python and Sensing Data using Python-programming - GPIO and interfacing peripherals With Raspberry Pi

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise:
   a) Programming with IDE - ARM microcontroller
   b) Advanced Timer Features, PWM Generator.
   c) RTC interfacing with ARM using Serial communication programming, Stepper motor control.
   d) ARM-Based Wireless Environmental Parameter Monitoring System displayed through Mobile device.
2. Seminar:
   a) ARM and GSM/GPS interfacing
   b) Introduction to ARM Cortex Processor
3. Raspberry Pi based Mini project.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**


1. Steve Furber, 'ARM system on chip architecture',Addisonn Wesley,2nd Edition,2015.
2. Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield's ARM System Developer's Guide Designing and Optimizing System Software', Elsevier 2004, 1st Edition.


**REFERENCES:**


1. William Hohl, ' ARMAssebly Language' Fundamentals and Techniques, CRC Press, 2nd Edition 2014.
2. Rajkamal," Microcontrollers Architecture, Programming, Interfacing, & System Design,Pearson,2012, 2nd Edition.
3. ARM Architecture Reference Manual, LPC214x User Manual www.Nuvoton .com/websites on Advanced ARM Cortex Processors
4. ARM System Developer's Guide: Designing and Optimizing System Software 1st Edition (Designing and Optimizing System Software) Publisher: Morgan Kaufmann Publishers, 2011.


**List of Open Source Software/ Learning websites:**

1. https://nptel.ac.in/courses/117106111
2. https://onlinecourses.nptel.ac.in/noc20_cs15/preview
3. https://www.csie.ntu.edu.tw/~cyy/courses/assembly/12fall/lectures/handouts/lec08_ARMarch.pdf
4. https://maxembedded.com/2013/07/introduction-to-single-board-computing/
5. https://www.youtube.com/watch?v=J4fhE4Pp55E&list=PLGs0VKk2DiYypuwUUM2wxzcI9BJHK4Bfh

**TI25018 EMBEDDED CONTROL FOR ELECTRIC DRIVES L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To provide the control concept for electrical drives
- To emphasize the need of embedded systems for controlling the electrical drives
- To provide knowledge about various embedded system-based control strategies for electrical drives
- To Impart the knowledge of optimization and machine learning techniques used for electrical drives
- To familiarize the high-performance computing for electrical drives.

**UNIT I INTRODUCTION TO ELECTRIC DRIVES 6**

Electric drives and its classification-Four-quadrant drive-Solid State Controlled Drives-Machine learning and optimization techniques for electrical drives.

**UNIT II EMBEDDED SYSTEM FOR MOTOR CONTROL 6**

Embedded Processors choice for motor control- Sensors and interface modules for Electric drives- IoT for Electrical drives applications

**UNIT III INDUCTION MOTOR CONTROL 6**

Speed control methods-PWM techniques- VSI fed three-phase induction motor-Fuzzy logic Based speed control for three-phase induction motor- Embedded processor based three phase induction motor speed control.

**UNIT IV BLDC MOTOR CONTROL 6**

Overview of BLDC Motor -Speed control methods -PWM techniques- Embedded processor based BDLC motor speed control.

**UNIT V SRM MOTOR CONTROL 6**

Overview of SRM Motor -Speed control methods -PWM techniques- Embedded processor based SRM motor speed control.

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise: Use any System level simulator/MATLAB/open source platform to give hands-on training on simulation study on Electric drives and control.
    a. Simulation of four quadrant operation and speed control of DC motor
    b. Simulation of 3-phase inverter.
    c. Simulation of Speed control of Induction motor using any suitable software package.
    d. Simulation of Speed control of BLDC motor using any suitable software package.
    e. Simulation of Speed control of SRM using any suitable software package
2. Seminar: IoT-based Control and Monitoring for DC Motor/ any Electric drives.

3. Mini project.: Any Suitable Embedded processor-based speed control of Motors (DC/IM/BLDC/PMSM/SRM)

**TOTAL: 30+30 = 60 PERIODS**

**TEXT BOOKS:**


1. R.Krishnan, “Electric Motor Drives – Modeling, Analysis and Control”,Prentice-Hall of India Pvt. Ltd., New Delhi,2010, 1st Edition.
2. Steve Kilts, "Advanced FPGA Design: Architecture, Implementation, and Optimization" Willey, 2007, 1st Edition.


**REFERENCES:**


1. VedamSubramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw- Hill publishing company Ltd., New Delhi, 2002, 2nd Edition.
2. K. Venkataratnam ,Special Electrical Machines, Universities Press, 2014, 1st Edition.
3. Steve Furber, ‘ARM system on chip architecture’, Addision Wesley, 2nd Edition 2015.
4. Ron Sass and AnderewG.Schmidt, “ Embedded System design with platform FPGAs: Principles and Practices”, Elsevier, 2010, 1st Edition.
5. Tim Wescott , Applied Control Theory for Embedded Systems **,** Elsevier, 2006, 1st Edition.


**List of Open Source Software/ Learning website:**

1) https://archive.nptel.ac.in/courses/108/104/108104140/
2) https://www.embedded.com/mcus-or-dsps-which-is-in-motor-control/
3) https://www.e3s-conferences.org/articles/e3sconf/pdf/2019/13/e3sconf_SeFet2019_01004.pdf
4) https://www.electronics-tutorials.ws/blog/pulse-width-modulation.html
5) http://kaliasgoldmedal.yolasite.com/resources/SEM/SRM.pdf

**TI25019 SMART SYSTEM AUTOMATION LT P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To introduce the smart system technologies and its role in real time applications
- To teach the architecture and requirements of Home Automation.
- To provide an insight into smart appliances and energy management concepts.
- To familiarize the design and needs of smart wearable devices
- To teach the basics of robotics and its role for automation.

**UNIT I INTRODUCTION 6**

Overview of a smart system - Hardware and software selection - Smart sensors and Actuators – Communication protocols used for smart systems.

**UNIT II HOME AUTOMATION 6**

Home Automation – System Architecture - Essential Components- Design Considerations: Control Unit, Sensing Requirements, Communication, Data Security.

**UNIT III SMART APPLIANCES AND ENERGY MANAGEMENT 6**

Significance of smart appliances for energy management -Smart Meters: Significance, Architecture & Energy Measurement Technique – Security Considerations.

**UNIT IV SMART WEARABLE DEVICES 6**

Body Area Networks - Sensors– communication protocol for Wearable devices- Application of Smart Wearable in Healthcare & Activity Monitoring.

**UNIT V EMBEDDED SYSTEMS AND ROBOTICS 6**

Fundamental concepts in Robotics- Robots and Controllers components - Embedded processor based: pick and place robot- Mobile Robot Design- UAV.

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise: Use Arduino/ R pi/ any other Embedded processors to give hands on training to understand concepts related to smart automation.
   a) Hands on experiments based on Ubidots & Thing speak / Open-source Analytics Platform
   b) Design and implementation of a smart home system .
   c) Bluetooth Based Home Automation Project using Android Phone
   d) GSM Based Home Devices Control
   e) Pick and place robots using Arduino/ any suitable Embedded processor
2. Assignment: Revolution of Smart Automation system across the world and its current scope available in India
3. Mini project: Design of a Smart Automation system ( for any application of students choice)

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**


1. Grimm, Christoph, Neumann, Peter, Mahlknech and Stefan, Embedded Systems for Smart Appliances and Energy Management, Springer 2013, 1st Edition.
2. KazemSohraby, Daniel Minoli and TaiebZnati, Wireless Sensor Networks Technology, Protocols, and Applications, John Wiley & Sons, 2007, 1st Edition.
3. NilanjanDey, Amartya Mukherjee, Embedded Systems and Robotics with Open-Source Tools, CRC press, 2016, 1st Edition.


**REFERENCES:**


1. Thomas Bräunl, Embedded Robotics, Springer, 2003.
2. Raj Kamal, Embedded Systems - Architecture, Programming and Design, McGraw- Hill, 2008
3. Karim Yaghmour, Embedded Android, O'Reilly, 2013.
4. Steven Goodwin, Smart Home Automation with Linux and Raspberry Pi, Apress , 2013
5. C.K. Toh, AdHoc mobile wireless networks, Prentice Hall, Inc, 2002.

6. Anna Ha´c, Wireless Sensor Network Designs, John Wiley & Sons Ltd, 2003.
7. J. J. Craig, “Introduction to Robotics Mechanics and Control”, Pearson Education.
8. Y. Koren, “Robotics for Engineers”, McGraw-Hill.
9. Robert Faludi, Wireless Sensor Networks, O’Reilly, 2011.

**List of Open Source Software/ Learning website:**

1. https://microcontrollerslab.com/home-automation-projects-ideas/
2. https://www.learnrobotics.org/blog/simple-robot/
3. https://robolabor.ee/homelab/en/iot
4. https://electrovolt.ir/wp-content/uploads/2018/03/Exploring_Raspberry_Pi_Molloy_Derek_ElectroVolt.ir_.pdf
5. http://www.robot.bmstu.ru/files/books/(Ebook%20-%20English)%20Mcgraw-Hil,%20Pic%20Robotics%20--%20A%20Beginner'S%20Guide%20To%20Robotic.pdf

**TI25020 EMBEDDED SYSTEM FOR AUTOMOTIVE APPLICATIONS LT P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To expose the students to the fundamentals and building of Electronic Engine Control systems**.**
- To teach on sensor functional components for vehicles.
- To discuss on programmable controllers for vehicles management systems.
- To teach logics of automation & communication techniques for vehicle communication.
- To introduce the infotainment system development.

**UNIT I INTRODUCTION TO AUTOMOTIVE SYSTEMS 6**

Overview of Automotive systems, fuel economy, air-fuel ratio, emission limits and vehicle performance; Electronic control Unit– open-source ECU.

**UNIT II SENSORS AND ACTUATORS FOR AUTOMOTIVES 6**

Review of automotive sensors- sensors interface to the ECU, Smart sensor and actuators for automotive applications.

**UNIT III VEHICLE MANAGEMENT SYSTEMS 6**

Energy Management system -Adaptive cruise control - anti-locking braking system - Safety and Collision Avoidance.

**UNIT IV ONBOARD DIAGONSTICS AND COMMUNICATION 6**

OBD , Vehicle communication protocols- Bluetooth, CAN, LIN, FLEXRAY and MOST.

**UNIT V RECENT TRENDS 6**

Navigation- Autonomous car- Role of IoT in Automotive systems.

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise: Use MATLAB SIMULINK /equivalent simulation /open source tools
   a) Simulation study of automotive sensors and actuators components
   b) Adaptive cruise control, Anti-Lock Braking System
   c) CAN Connectivity in an Automotive Application using vehicle network toolbox
   d) Interfacing a sensor used in car with microcontroller.
   e) Establishing connection between Bluetooth module and microcontroller.
2. Assignment: AUTOSAR
3. Mini project : Battery Management system for EV batteries.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**


1. William B. Ribbens ,"Understanding Automotive Electronics", Elseiver,8th Edition, 2017.
2. Jurgen, R., Automotive Electronics Hand Book, McGraw Hill, 2nd Edition, 1999.
3. L.Vlacic,M.Parent,F.Harahima,"Intelligent Vehicle Technologies",SAE International, 2001, 1st Edition, 2017.


**REFERENCES:**


1. Ali Emedi, Mehrdedehsani, John M Miller , "Vehicular Electric power system-land, Sea, Air and Space Vehicles" Marcel Decker, 2004, 1st Edition.
2. Jack Erjavec,JeffArias,"Alternate Fuel Technology-Electric ,Hybrid& Fuel Cell Vehicles",Cengage ,2012, 2nd Edition.
3. Electronic Engine Control technology – Ronald K Jurgen Chilton's guide to Fuel Injection – Ford 2nd Edition, 2004.
4. Automotive Electricals / Electronics System and Components, Tom Denton, 5th Edition, 2017.
5. Uwe Kiencke, Lars Nielsen, "Automotive Control Systems: For Engine, Driveline, and Vehicle", Springer; 1st Edition, 2005.
6. Automotive Electricals Electronics System and Components, Robert Bosch Gmbh, 5th Edition, 2014.
7. Automotive Hand Book, Robert Bosch, Bently Publishers, 10th Edition, 2018.


**List of Open Source Software/ Learning website:**

1) https://www.autosar.org/fileadmin/ABOUT/AUTOSAR_EXP_Introduction.pdf
2) https://microcontrollerslab.com/can-communication-protocol/

3) https://ackodrive.com/car-guide/different-types-of-car-sensors/
4) https://www.tomtom.com/blog/automated-driving/what-is-adaptive-cruise-control/
5) https://prodigytechno.com/difference-between-lin-can-and-flexray-protocols/
6) https://www.synopsys.com/automotive/what-is-autonomous-car.html

**TI25021 VLSI DESIGN LT P C**
**2 0 2 3**

**COURSE OBJECTIVES**

- To explain the basic concepts of CMOS and
- To introduce the IC fabrication methods
- To introduce the Reconfigurable Processor technologies
- To introduce the basics of analog VLSI design and its importance.
- To learn about the programming of Programmable device using Hardware description Language.

**UNIT I CMOS BASICS 6**
MOSFET Scaling - CMOS logic design- Dynamic CMOS –Transmission Gates-BiCMOS

**UNIT II IC FABRICATION 6**
CMOS IC Fabrications: n well, p well, twin tub, SoI - Design Rules and Layout.

**UNIT III PROGRAMABLE LOGIC DEVICES 6**
PAL, PLA, CPLD architecture and application.

**UNIT IV RECONFIGURABLE PROCESSOR 6**
FPGA- Architecture, FPGA based application development- Introduction to FPAA.

**UNIT V HDL PROGRAMMING 6**
Verilog HDL- Overview - structural and behavioural modeling concepts-Design examples- Carry Look ahead adders, ALU, Shift Registers.

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise : Use any FPGA Board /IDE/open source package/ platform to give hands on training on CMOS design/ reconfigurable processor based applications.

a) CMOS logic circuit simulation using any open source software package
b) Experiments : structural and behavioural modeling based Verilog HDL programs
c) Experiment: Combinational and sequential Digital logic implementation with FPGA.
d) Implementation of carry look ahead adder with FPGA
e) Implementation of ALU with FPGA

2. Assignment : Low Power VLSI.
3. FPGA based Mini project .

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**

1. M.J.S Smith, “Application Specific integrated circuits”,Addition Wesley Longman Inc.1st Edition 2010.
2. Kamran Eshraghian,Douglas A.pucknell and Sholeh Eshraghian,”Essentials of VLSI circuits and system”, Prentice Hall India,2005, 1st Edition.

**REFERENCES:**


1. Donald G. Givone, “Digital principles and Design”, Tata McGraw Hill 2002, 1st Edition.
2. Charles H. Roth Jr., “Fundamentals of Logic design”, Thomson Learning, 7th Edition 2013.
3. Nurmi, Jari (Ed.) "Processor Design System-On-Chip Computing for ASICs and FPGAs"
   Springer, 2007, 1st Edition.
4. Joao Cardoso, Michael Hübner, "Reconfigurable Computing: From FPGAs to Hardware/Software Codesign" Springer, 2011, 1st Edition.
5. Pierre-Emmanuel Gaillardon, Reconfigurable Logic: Architecture, Tools, and Applications,
   1st Edition, CRC Press , 2018.


**List of Open Source Software/ Learning website:**

1) https://archive.nptel.ac.in/courses/108/107/108107129/
2) http://gn.dronacharya.info/ECEDept/Downloads/QuestionPapers/7th_Sem/VLSI-DESIGN/UNIT-1/Lecture-3.pdf
3) https://web.itu.edu.tr/~ateserd/vlsi2/2007/FPGAs&CPLD.pdf
4) https://kanchiuniv.ac.in/coursematerials/GSK_Notes_on_PLD_in_VLSI_design.pdf
5) https://www.xilinx.com/products/silicon-devices/resources/programming-an-fpga-an-introduction-to-how-it-works.html
6) https://www.allaboutcircuits.com/technical-articles/what-is-an-fpga-introduction-to-programmable-logic-fpga-vs-microcontroller/
7) https://www.tutorialspoint.com/vlsi_design/vlsi_design_vhdl_introduction.htm#:~:text=VHDL%20stands%20for%20very%20high,DoD)%20under%20the%20VHSIC%20program.

**TI25022 MEMS AND NEMS LT P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To introduce the diverse technological and functional approaches of MEMS/NEMS and applications.
- To understand the microstructures and fabrication methods.
- To provide an insight of micro and nano sensors, actuators.
- To emphasis the need for NEMS technology.
- To update the ongoing trends and real time applications of MEMS and NEMS technology.

**UNIT I INTRODUCTION TO MEMS and NEMS 6**

Overview of Micro electro mechanical systems and Nano Electro mechanical systems, devices and technologies, Laws of scaling- Materials for MEMS and NEMS - Applications of MEMS and NEMS.

**UNIT II MICRO-MACHINING AND MICROFABRICATION TECHNIQUES 6**

Photolithography- Micro manufacturing, Bulk micro machining, surface micro machining, LIGA.

**UNIT III MICRO SENSORS AND MICRO ACTUATORS 6**

Micromachining : Capactive Sensors- Piezoresistive Sensors- Piezoelectric actuators.

**UNIT IV NEMS TECHNOLOGY 6**

Atomic scale precision engineering- Nano Fabrication techniques – NEMS for sensors and actuators.

**UNIT V MEMS and NEMS APPLICATION 6**

Bio MEMS- Optical NEMS- Micro motors- Smart Sensors - Recent trends in MEMS and NEMS.

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory experiment: Simulation of MEMS sensors and actuators using Multi physics tool
   a) Simulation of a typical piezo resistive sensor
   b) Simulation of a typical Piezoelectric actuator
   c) Simulation study of a bio sensor
   d) Simulation study of a micro motor
2. Assignment: Role of MEMS AND NEMS devices for Industry Standard 5.0.
3. Mini project : Design and analysis of any MEMS/NEMS device using multi physics tool.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**


1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2011, 2nd Edition.
2. Tai-.Ran Hsu, “MEMS and Microsystems: design , manufacture, and Nanoscale”- 2nd Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2008.
3. Lyshevski, S.E. “ Nano- and Micro-Electromechanical Systems: Fundamentals of Nano-and Microengineering “ (2nd ed.). CRC Press,2005.
4. Julian W Gardner and Vijay K Varadan, “ Microsensors, MEMS and Smart Devices”, John Wiley and Sons Ltd, 2001, 1st Edition.


**REFERENCES:**


1. Marc F madou“ Fundamentals of micro fabrication” CRC Press 2002 2nd Edition Marc Madou.
2. M.H.Bao “Micromechanical transducers :Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 16 Oct 2000, 1st Edition.
3. Maluf, Nadim “An introduction to Micro Electro-mechanical Systems Engineering “AR Tech house, Boston, June 30 2004, 2nd Edition.
4. Mohamed Gad – el – Hak “MEMS Handbook” Edited CRC Press 2001, 1st Edition.


**List of Open Source Software/ Learning website:**

1. https://www.academia.edu/Lectures_on_MEMS_and_MICROSYSTEMS_DESIGN_AND_MANUFACTURE
2. https://nptel.ac.in/courses
3. https://www.iitk.ac.in/me/mems-fabrication
4. http://mems.iiti.ac.in/
5. https://onlinecourses.nptel.ac.in/noc22_ee36/preview

**TI25023 DIGITAL SIGNAL PROCESSING SYSTEM DESIGN L T P C**
**2 0 2 3**

**COURSE OBJECTIVES**:

- To introduce the concept of analyzing discrete time signals & systems in the time and frequency domain through mathematical representation.
- To study the various time to frequency domain transformation techniques.
- To Understand the computation algorithmic steps for Fourier Transform.
- To study about filters and their design for digital implementation.
- To introduce the programmable digital signal processor & its application.

**UNIT I INTRODUCTION 6**

Classification of systems: Continuous, discrete, linear, causal, stable, dynamic, recursive, time variance; classification of signals: continuous and discrete, energy and power; mathematical representation of signals; spectral density; sampling techniques, quantization, quantization error, Nyquist rate, aliasing effect. Digital signal representation.

**UNIT II DISCRETE TIME SYSTEM ANALYSIS 6**

Z-transform and its properties, inverse z-transforms; difference equation – Solution by z-transform, application to discrete systems - Stability analysis, frequency response – Convolution – Introduction to Fourier Transform– Discrete time Fourier transform.

**UNIT III DISCRETE FOURIER TRANSFORM & COMPUTATION 6**

DFT properties, magnitude and phase representation - Computation of DFT using FFT algorithm – DIT & DIF - FFT using radix 2 – Butterfly structure.

**UNIT IV DESIGN OF DIGITAL FILTERS 6**

FIR & IIR filter realization – Parallel & cascade forms. FIR design: Windowing Techniques – Need and choice of windows – Linear phase characteristics. IIR design: Analog filter design - Butterworth and Chebyshev approximations; digital design using impulse invariant and bilinear transformation - Warping, prewarping - Frequency transformation.

**UNIT V DIGITAL SIGNAL PROCESSORS 6**

Introduction – Architecture of one DSP processor for motor control – Features – Addressing Formats– Functional modes - Introduction to Commercial Processors

**30 PERIODS**

**LAB COMPONENTS: 30 PERIODS**

1. Laboratory exercise : Use any DSP processor/MATLAB/open source platform to give hands on training on basic concepts of Digital Signal Processing
   a) To determine impulse and step response of two vectors
   b) To perform convolution between two vectors .
   c) To compute DFT and IDFT of a given sequence.
   d) To perform linear convolution of two sequence using DFT
   e) Design and Implementation of FIR Filter
   f) Design and Implementation of IIR Filter
   g) To determine z-transform from the given transfer function and its ROC
2. Assignment : Implementation of FIR/IIR filter with FPGA.
3. DSP processors based Mini project.

**TOTAL: 30+30 = 60 PERIODS**

**TEXTBOOKS:**

1. J.G. Proakis and D.G. Manolakis, 'Digital Signal Processing Principles, Algorithms and Applications', Pearson Education, New Delhi, 4th Edition 2007.
2. Robert J.Schilling & Sandra L.Harris ,' Introduction to Digital Signal Processing using MATLAB', Cengage Learning, 2nd Edition 2013.

**REFERENCES:**

1. Emmanuel C Ifeachor and Barrie W Jervis ,"Digital Signal Processing – A Practical approach" Pearson Education, Second edition, 2002.

2. Alan V. Oppenheim, Ronald W. Schafer and John R. Buck, 'Discrete – Time Signal Processing', Pearson Education, New Delhi, 2nd Edition 2012.
3. SenM.kuo, Woonseng…s.gan, "Digital Signal Processors, Architecture, Implementations & Applications, Pearson, 1st Edition 2004.
4. S.K. Mitra, 'Digital Signal Processing – A Computer Based Approach', Tata McGraw Hill, New Delhi, 4th Edition 2013.
5. B. Venkataramani, M. Bhaskar, 'Digital Signal Processors, Architecture, Programming and Applications', Tata McGraw Hill, New Delhi, 2003, 1st Edition.

**List of Open Source Software/ Learning website:**

1. https://nptel.ac.in/courses/117102060
2. https://www.tutorialspoint.com/digital_signal_processing/index.htm
3. https://www.elprocus.com/digital-signal-processor/
4. https://www.sciencedirect.com/topics/computer-science/digital-signal-processing-algorithm#:~:text=Digital%20signal%20processing%20algorithms%20are,known%20as%20operations%20or%20ops.
5. https://www.electronicshub.org/introduction-to-fpga/

**TI25024 ELECTRIC VEHICLE ARCHITECTURE L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To learn the structure of Electric Vehicle, Hybrid Electric Vehicle
- To study about the EV conversion components
- To know about the details and specifications for Electric Vehicles
- To understand the concepts of Plug-in Hybrid Electric Vehicle
- To model and si mulate all types of DC motors

**UNIT I VEHICLE ARCHITECTURE and SIZING (7+2Skill) 9**

Electric Vehicle History, and Evolution of Electric Vehicles. Series, Parallel and Series parallel Architecture,MicroandMildarchitectures.MountainBike-Motorcycle-ElectricCarsandHeavyDuty EVs. -Details and Specifications.

**UNIT II VEHICLEMECHANICS (7+2Skill) 9**

Vehicle mechanics- Roadway fundamentals, Laws of motion, Vehicle Kinetics, Dynamics of vehicle motion, propulsion power, velocity and acceleration, Tire – Road mechanics, Propulsion System Design.

**UNIT III POWER COMPONENTS AND BRAKES (7+2Skill)9**

Power train Component sizing- Gears, Clutches, Differential, Transmission and Vehicle Brakes. EV power train sizing, HEV Powertrain sizing, Example.

**UNIT IV HYBRID VEHICLE CONTROL STRATEGY (7+2Skill)9**

Vehiclesupervisorycontroll,Modeselectionstrategy,ModalControlstrategies.

**UNIT V PLUG-IN HYBRID ELECTRIC VEHICLE (7+2Skill)9**

Introduction-History-Comparisonwithelectricalandhybridelectricalvehicle-Constructionandworking of PHEV-Block diagramand components-Charging mechanisms-Advantages of PHEVs.

**TOTAL:45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/ Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc) Basics of MATLAB simulation 10**

1. Variables and Expressions Formats, Vectors and Matrices,
2. Arrays, Vectors,
3. Matrices, Built-in functions, Trigonometric functions,
4. Data types and Plotting.
5. Simulation of drive cycles.

**REFERENCES:**


1. Mehrdad Ehsani, YiminGao, Sebastian E. Gay, Ali Emadi, 'Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design', CRC Press, 2004.
2. Build Your Own Electric Vehicle,Seth Leitman , Bob Brant, McGraw Hill, Third Edition 2013.
3. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press, First edition 2017.
4. The Electric Vehicle Conversion Handbook: How to Convert Cars, Trucks, Motorcycles, and Bicycles -- Includes EV Components, Kits, and Project Vehicles Mark Warner, HP Books, 2011.
5. Heavy-duty Electric Vehicles from Concept to Reality, Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi, Elsevier Science, 2021
6. Electric Vehicles Modern Technologies and Trends, Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen Springer, 2020
7. Hybrid Electric Vehicles: A Review of Existing Configurations and Thermodynamic Cycles, Rogelio León , Christian Montaleza , José Luis Maldonado , Marcos Tostado-Véliz and Francisco Jurado, Thermo, **2021**, 1, 134–150. https://doi.org/10.3390/thermo1020010.


**TI25025 DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES**

**L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To review the drive cycles and requirements of EVs

- To know the working of motors used in Electric Vehicle
- To analyze and model the buck/boost converter operation and to design the same
- To learn the simulation basics of control systems
- To derive transfer functions for DC-DC converters

**UNIT I ELECTRIC VEHICLE DYNAMICS 6**

Standard drive cycles-Dynamics of Electric Vehicles-Tractive force-Maximum speed, torque, power, energy requirements of EVs.

**UNIT II MOTORS FOR ELECTRIC VEHICLES 6**

Introduction – Speed And Torque control of above and below rated speed-Speed control of EV in the constant power region of electric motors. DC Motors, Induction Motor, Permanent Magnet Synchronous Motors (PMSM), Brushless DC Motors, Switched Reluctance Motors (SRMs). Synchronous Reluctance Machines-Choice of electric machines for EVs.

**UNIT III BASICS OF SIMULATION IN CONTROL SYSTEMS 6**

Transfer Function-How to build transfer function, identify Poles, zeros, draw time response plots, bode plot (Bode Plots for Multiplication Factors, Constant, Single and Double Integration Functions, Single and Double Differentiation Functions, Single Pole and Single Zero Functions, RHP Pole and RHP Zero Functions), state space modelling-transfer function from state space Model.

**UNIT IV MODELING OF DC-DC CONVERTERS 6**

Overview of PWM Converter Modelling -Power Stage Modelling - PWM Block Modelling - Voltage Feedback Circuit and Small-Signal Model of PWM Converter - Averaging Power Stage Dynamics - Average Models for buck/boost Converter - Small-Signal Model of Converter Power Stage - Frequency Response of Converter

**UNIT V POWER STAGE TRANSFER FUNCTIONS OF DC – DC CONVERTERS 6**

Power Stage Transfer Functions of buck-boost Converter in CCM Operation, Input-to-Output Transfer Function, Duty Ratio-to-Output Transfer Function, Load Current-to-Output Transfer Function.

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Simple simulation exercises of basic control systems
2. Bode plots and calculation of Gain margin and Phase margin for power stage transfer function via simulation.
3. Design of buck converter
4. Design of boost converter
5. Simulation of buck, boost and buck boost converter-open loop (With power circuit and Transfer function).

**TOTAL: 30+30 = 60 PERIODS**

**REFERENCES:**

1. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, First Edition 2017.
2. Fundamentals of Power Electronics with MATLAB, Randall Shaffer, 2nd Edition, 2013, Lakshmi publications
3. Feedback Control problems using MATLAB and the Control system tool box, Dean Frederick and Joe Cho, 2000, 1st Edition, Cengage learning.
4. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005,1st Edition.
5. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley,2021, 1st Edition.
6. Emerging Power Converters for Renewable Energy and Electric Vehicles Modeling, Design, and Control, Md. Rabiul Islam,Md. Rakibuzzaman Shah, Mohd. Hasan Ali, CRC Press,2021, 1st Edition.
7. Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Second Edition" CRC Press, Taylor & Francis Group, Third Edition 2021.

**TI25026 ELECTRIC VEHICLE DESIGN, MECHANICS AND CONTROL L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To learn the basics of EV and vehicle mechanics
- To know the EV architecture
- To study the energy storage system concepts
- To derive model for batteries and to know the different types of batteries and its charging methods
- To learn the control preliminaries for DC-DC converters.

**UNIT I INTERNAL COMBUSTION ENGINES 6**

IC Engines, BMEP and BSFC, Vehicle Fuel Economy, Emission Control Systems, Treatment of Diesel Exhaust Emissions.

**UNIT II ELECTRIC VEHICLES AND VEHICLE MECHANICS 6**

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings- Comparisons of EV with internal combustion Engine vehicles- Fundamentals of vehicle mechanics.

**UNIT III BATTERY MODELING, TYPES AND CHARGING 6**

Batteries in Electric and Hybrid Vehicles - Battery Basics -Battery Parameters. Types- Lead Acid Battery - Nickel-Cadmium Battery - Nickel-Metal-Hydride (NiMH) Battery - Li-Ion Battery - Li-Polymer Battery, Zinc-Air Battery, Sodium-Sulphur Battery, Sodium-Metal-Chloride, Research and Development for Advanced Batteries. Battery Modelling, Electric Circuit Models. Battery Pack Management, Battery Charging.

**UNIT IV CONTROL PRELIMINARIES 6**

Control Design Preliminaries - Introduction - Transfer Functions – Bode plot analysis for First order and second order systems - Stability - Transient Performance- Power transfer function for boost converter - Gain margin and Phase margin study-open loop mode.

**UNIT V CONTROL OF AC MACHINES 6**

Introduction- Reference frame theory, basics-modeling of induction and synchronous machine in various frames-Vector control- Direct torque control.

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Develop a model that could estimate Soc and SoH of Li-Ion Battery.
2. Modelling and thermal analysis of Li-Ion Battery.
3. Simulation of boost converter and calculating gain and phase margin from the transfer function.
4. Simulation of vector control of induction motor

**TOTAL: 30+30 = 60 PERIODS**

**REFERENCES:**


1. Electric and Hybrid Vehicles, Design Fundamentals, Third Edition, Iqbal Husain, CRC Press, 2021.
2. Power Electronic Converters,: Dynamics and Control in Conventional and Renewable Energy Applications, Teuvo Suntio, Tuomas Messo, Joonas Puukko, 1st Edition, Wiley - VCH.
3. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2003, 1st Edition.
4. C.C. Chan and K.T. Chau, 'Modern Electric Vehicle Technology', OXFORD University Press, 2001, 1st Edition.
5. Wie Liu, “Hybrid Electric Vehicle System Modeling and Control”, Second Edition, John Wiley & Sons, 2017, 2nd Edition.
6. Dynamic Simulation of Electric Machinery using MATLAB, Chee Mun Ong, Prentice Hall,1997, 1st Edition.
7. Electrical Machine Fundamentals with Numerical Simulation using MATLAB/ SIMULINK, Atif Iqbal, Shaikh Moinoddin, Bhimireddy Prathap Reddy, Wiley, 2021, 1st Edition.


**TI25027 DESIGN OF ELECTRIC VEHICLE CHARGING SYSTEM L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To know the charging station and standards
- To learn the concepts of power converters in charging

- To find the charging scheme in renewable based EV charging
- To demonstrate the wireless power transfer technique
- To design & simulate power factor correction circuits

**UNIT I CHARGING STATIONS AND STANDARDS 6**

Introduction-Charging technologies- Conductive charging, EV charging infrastructure, International standards and regulations - Inductive charging, need for inductive charging of EV, Modes and operating principle, Static and dynamic charging, Bidirectional power flow, International standards and regulations

**UNIT II POWER ELECTRONICS FOR EV CHARGING 6**

Layouts of EV Battery Charging Systems-AC charging-DC charging systems- Power Electronic Converters for EV Battery Charging- AC–DC converter with boost PFC circuit, with bridge and without bridge circuit - Bidirectional DC–DC Converters- Non-isolated DC–DC bidirectional converter topologies- Half-bridge bidirectional converter.

**UNIT III EV CHARGING USING RENEWABLE AND STORAGE SYSTEMS 6**

Introduction- - EV charger topologies , EV charging/discharging strategies - Integration of EV charging-home solar PV system , Operation modes of EVC-HSP system , Control strategy of EVC-HSP system - fast-charging infrastructure with solar PV and energy storage.

**UNIT IV WIRELESS POWER TRANSFER 6**

Introduction - Inductive, Magnetic Resonance, Capacitive types. Wireless Chargers for Electric Vehicles - Types of Electric Vehicles - Battery Technology in EVs - Charging Modes in EVs - Benefits of WPT. - WPT Operation Modes - Standards for EV Wireless Chargers, SAE J2954, IEC 61980. ISO 19363

**UNIT V POWER FACTOR CORRECTION IN CHARGING SYSTEM 6**

Need for power factor correction- Boost Converter for Power Factor Correction, Sizing the Boost Inductor, Average Currents in the Rectifier and calculation of power losses-

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Simulation and analysis for bi-directional charging V2G and G2V.
2. Design and demonstrate solar PV based EV charging station.
3. Simulate and infer wireless power charging station for EV charging.
4. Simulation of boost converter based power factor correction.

**TOTAL: 30+30 = 60 PERIODS**

**REFERENCES:**


1. Mobile Electric Vehicles Online Charging and Discharging, Miao Wang Ran Zhang Xuemin (Sherman) Shen, Springer 2016, 1st Edition.
2. Alicia Triviño-Cabrera, José M. González-González, José A. Aguado, Wireless Power Transferor Electric Vehicles: Foundations and Design Approach, Springer Publisher 1st Edition. 2020.

3. Nil Patel, Akash Kumar Bhoi, Sanjeevikumar Padmanaban, Jens Bo Holm-Nielsen, Electric Vehicles Modern Technologies and Trends. Springer Publisher 1st Edition, 2021.
4. Cable Based and Wireless Charging Systems for Electric Vehicles, Technology and control, management and grid integration, Rajiv Singh, Sanjeevikumar Padmanaban, Sanjeet Dwivedi, Marta Molinas and Frede Blaabjerg, IET 2021, 1st Edition.
5. Electric and Hybrid Electric Vehicles, James D Halderman, Pearson, 2022, 1st Edition.
6. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005.

**TI25028 TESTING OF ELECTRIC VEHICLES L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To know various standardization procedures
- To learn the testing procedures for EV & HEV components
- To know the functional safety and EMC
- To realize the effect of EMC in EVs
- To study the effect of EMI in motor drives and in DC-DC converter system

**UNIT EV STANDARDIZATION 6**

Introduction - Current status of standardization of electric vehicles, electric Vehicles and Standardization - Standardization Bodies Active in the Field – Standardization activities in countries like Japan. The International Electro Technical Commission - Standardization of Vehicle Components.

**UNIT II TESTING OF ELECTRIC MOTORS AND CONTROLLERS FOR ELECTRIC AND HYBRID ELECTRIC VEHICLES 6**

Test Procedure Using M-G Set, electric motor, controller, application of Test Procedure, Analysis of Test Items for the Type Test - Motor Test and Controller Test (Controller Only). - Test Procedure Using Eddy Current Type Engine Dynamometer, Test Strategy, Test Procedure, Discussion on Test Procedure. Test Procedure Using AC Dynamometer.

**UNIT III FUNDAMENTALS OF FUNCTIONAL SAFETY AND EMC 6**

Functional safety life cycle - Fault tree analysis - Hazard and risk assessment – software development - Process models - Development assessments - Configuration management - Reliability - Reliability block diagrams and redundancy - Functional safety and EMC - Functional safety and quality - Standards - Functional safety of autonomous vehicles.

**UNIT IV EMC IN ELECTRIC VEHICLES 6**

Introduction - EMC Problems of EVs, EMC Problems of Motor Drive, EMC Problems of DC-DC Converter System, EMC Problems of Wireless Charging System, EMC Problem of Vehicle Controller, EMC Problems of Battery Management System, Vehicle EMC Requirements-

**UNIT V EMI IN MOTOR DRIVE AND DC-DC CONVERTER SYSTEM 6**

Overview -EMI Mechanism of Motor Drive System, Conducted Emission Test of Motor Drive System, IGBT EMI Source, EMI Coupling Path, EMI Modelling of Motor Drive System. EMI in DC-DC Converter, EMI Source, The Conducted Emission High-Frequency, Equivalent Circuit of DC-DC Converter System, EMI Coupling Path

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Design and simulate motor controller for hybrid electric vehicle applications
2. Simulation of EMC analysis for Wireless power transfer EV charging.
3. Design and simulation of EMI filter

**TOTAL: 30+30 = 60 PERIODS**

**REFERENCES:**


1. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi, Taylor & Francis, 2005, 1st Edition.
2. Electromagnetic Compatibility of Electric Vehicle, Li Zhai, Springer 2021, 1st Edition.
3. EMC and Functional Safety of Automotive Electronics, Kai Borgeest, IET 2018, 1st Edition.
4. EMI/EMC Computational Modeling Handbook, Druce Archam beault, colin branch, Omar M.Ramachi ,Springer 2012, 2nd Edition.
5. Automotive EMC, Mark Steffika, Springer 2013, 1st Edition.
6. Electric Vehicle Systems Architecture and Standardization Needs, Reports of the PPP European Green Vehicles Initiative, Beate Müller, Gereon Meyer, Springer 2015, 1st Edition.

**TI25029 GRID INTEGRATION OF ELECTRIC VEHICLES L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To know the basic details of V2G
- To study the benefits & challenges of V2G
- To learn EV & V2G on the smart grids renewable energy systems
- To know the grid integration

**UNIT I DEFINITION, And STATUS Of V2G (7+2 Skill) 9**

Defining Vehicle to Grid (V2G) - History and Development of V2G. Incorporating V2G to the EV, Auditing and Metering, V2G in Practice , V2G - Power Markets and Applications . Electricity Markets and V2G Suitability , Long-Term Storage, Renewable Energy, and Other Grid Applications , Beyond the Grid: Other Concepts Related to V2G.

**UNIT II BENEFITS AND CHALLENGES OF V2G (7+2 Skill) 9**

Benefits of V2G, Technical Benefits: Storage Superiority and Grid Efficiency, Economic Benefits: EV Owners and Societal Savings, Environment and Health Benefits: Sustainability in Electricity and Transport, Other Benefits.

**UNIT III CHALLENGES TO V2G (7+2 Skill) 9**

**Technical Challenges-**Battery Degradation, Charger Efficiency, Aggregation and Communication, V2G in a Digital Society. **The Economic and Business Challenges to V2G** - Evaluating V2G Costs and Revenues , EV Costs and Benefits , Adding V2G Costs and Benefits , Additional V2G Costs , The Evolving Nature of V2G Costs and Benefits. **Regulatory and Political Challenges to V2G** , V2G and Regulatory Frameworks , Market Design Challenges. Other V2G Regulatory and Legal Challenges.

**UNIT IV IMPACT OF EV AND V2G ON THE SMART GRID AND RENEWABLE ENERGY SYSTEMS (7+2 Skill) 9**

Introduction - Types of Electric Vehicles - Motor Vehicle Ownership and EV Migration - Impact of Estimated EVs on Electrical Network - Impact on Drivers and the Smart Grid - Standardization and Plug-and-Play - IEC 61850 Communication Standard and IEC 61850-7-420 Extension.

**UNIT V GRID INTEGRATION AND MANAGEMENT OF EV (7+2 Skill) 9**

Introduction - Machine to Machine (M2M) in distributed energy management systems - M2M communication for EVs - M2M communication architecture (3GPP) - Electric vehicle data logging - Scalability of electric vehicles -M2M communication with scheduling.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / etc)**
**10**

1. Simulation of connecting three phase inverter to the grid.
2. Simulate and analyse the power quality issues of V2G systems
3. Design and simulate battery management system for smart grid with distributed generation.

**REFERENCES:**


1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press 2017, 1st Edition.
2. Plug In Electric Vehicles in Smart Grids, Charging Strategies, Sumedha Rajakaruna , Farhad Shahnia and Arindam Ghosh,Springer,2015, 1st Edition.
3. ICT for Electric Vehicle Integration with the Smart Grid, Nand Kishor [1;] Jesus Fraile-Ardanuy, IET 2020, 1st Edition.
4. Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid, Junwei Lu and Jahangir Hossain, IET 2015, 1st Edition.
5. Lance Noel · Gerardo Zarazua de Rubens Johannes Kester · Benjamin K. Sovacool, Vehicle-to-Grid A Sociotechnical Transition Beyond Electric Mobility, 2019, 1st Edition.


**TI25030 INTELLIGENT CONTROL OF ELECTRIC VEHICLES L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To design and drive the mathematical model of a BLDC motor and its characteristics
- To learn the different control schemes for BLDC motor
- To study the basics of fuzzy logic
- To study the FPGA & VHDL basics
- To implement fuzzy logic control of BLDC motor in real time

**UNIT I MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR 6**

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristics Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

**UNIT II SPEED CONTROL FOR ELECTRIC DRIVES 6**

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor-.

**UNIT III FUZZY LOGIC 6**

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy

measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems, overview of fuzzy expert system-fuzzy decision making..

**UNIT IV FPGA AND VHDL BASICS 6**

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors-Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection.

**UNIT V REAL TIME IMPLEMENTATION 6**

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA**.** .

**30 PERIODS**

**LAB COMPONENT: 30 PERIODS**

1. Design and simulate speed controller for induction motors in EV for both dynamic and steady state performance
2. Simulate a fuzzy logic controller based energy storage system for EV.
3. Fuzzy logic control of BLDC motor using FPGA in real time

**TOTAL: 30+30 = 60 PERIODS**

**REFERENCES:**


1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, Wiley 1st Edition 2018.
2. VHDL Primer, A (3rd Edition), Jayaram Bhasker, Prentice Hall, 1st Edition 2015.
3. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Third Edition” CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4. Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition.
5. M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley 2017, 2nd Edition
7. Electric and Plug-in Hybrid Vehicle Networks Optimization and Control, Emanuele Crisostomi • Robert Shorten, Sonja Stüdli • Fabian Wirth, CRC Press, 1st Edition. 2018.

## ADVANCED CONTROL

**TI25031 PROCESS MODELING AND SIMULATION L T P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To understand the important of mathematical models for Industrial processes
- To acquaint students with different forms of mathematical models.
- To develop and simulate mathematical models for different Industrial processes.
- To apply Mathematical tools while developing mathematical models.
- To analyze the graphical response of developed mathematical models.

**UNIT I GENERAL PRINCIPLES OF MODELLING (7+2 SKILL) 9**

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs Nonlinear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODEBVP

**UNIT II MODELLING OF DISTRIBUTED PROCESSES (7+2 SKILL) 9**

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate basedApproaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

**UNIT III INTRODUCTION TO PROCESS MODELLING (7+2 SKILL) 9**

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedomin a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selectionalgorithm, Information flow through subsystems, Structural effects of design variable selection, PersistentRecycle.

**UNIT IV MODELLING OF INDUSTRIAL PROCESSES ( 7+2 SKILL) 9**

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE)
systems, -steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers,strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical softwarelibraries

**UNIT V SIMULATION OF MATHEMATICAL MODELLING (7+2 SKILL)9**

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation softwares and their applications, Review of solution techniques and available numerical software libraries.- Case Studies.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)**
**10**

1. Developing steady state /Dynamic mathematical model of different unit processes (ODE or PDE)

2. Simulation of steady state/ dynamic models using appropriate software
3. Open loop study based on the developed mathematical model.
4. Development and simulation of unsteady state models for simple processes.

**TEXT BOOKS:**

1. Denn M. M.,"Process Modeling", Longman, 1986, 1st Edition.
2. Aris R.,"Mathematical Modeling,A Chemical Engineering Perspective (Process System Engineering)", Academic Press, 1999, Volume 1.

**REFERENCES:**

1 .Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, McGraw Hill, 2nd Edition, 1990.
2. D. F. Rudd and C. C. Watson, “ Strategy of Process Engineering”, Wiley international, 1st Edition, 1968.
3. M.M. Denn, “Process Modelling”, Wiley, New York, 1st Edition, 1986.
4. A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI,1st Edition, 2011.
5. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, , 1st Edition, 1975.
6. HussainAsghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, , 1st Edition, 1986.

**List of Open Source Software/ Learning website:**

https://archive.nptel.ac.in/courses/103/107/103107096/
https://nptel.ac.in/courses/103101111
https://nptel.ac.in/courses/111107105
https://www.academia.edu/37228967/Process_Modeling_Simulation_and_Control_for_Chemical_Engineers

**TI25032 OMPUTER CONTROL OF PROCESSES L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

- To represent the linear time invariant System in discrete State Space form
- To analyze the controllability, observability and stability of a Discrete time System.
- To estimate model parameters from input/output measurements
- To Design Digital Controllers
- To Design Multi-loop and Multivariable Controllers for multivariable system

**UNIT I DISCRETE STATE-VARIABLE TECHNIQUE (7+2 SKILL)9**

State equation of discrete data system with sample and hold – State transition equation – Methods of computing the state transition matrix – Decomposition of discrete data transfer functions – State diagrams of discrete data systems – System with zero-order hold – Controllability and observability of linear time invariant discrete data system–Stability tests of discrete-data system.

**UNIT II SYSTEM IDENTIFICATION (7+2 SKILL)9**

Identification of Non-Parametric Input-Output Models: -Transient analysis–Frequency analysis– Correlation analysis– Spectral analysis – Identification of Parametric Input-Output Models: - Least Squares Method – Recursive Least Square Method.

**UNIT III DIGITAL CONTROLLER DESIGN (7+2 SKILL) 9**

Review of z-transform – Modified of z-transform – Pulse transfer function – Digital PID controller – Dead-beat controller and Dahlin's controller – Kalman's algorithm, Pole Placement Controller

**UNIT IV MULTI-LOOP REGULATORY CONTROL (7+2 SKILL) 9**

Multi-loop Control - Introduction – Process Interaction – Pairing of Inputs and Outputs -The Relative Gain Array (RGA) – Properties and Application of RGA - Multi-loop PID Controller – Biggest Log Modulus Tuning Method – De-coupler.

**UNIT V MULTIVARIABLE REGULATORY CONTROL (7+2 SKILL) 9**

Introduction to Multivariable control –Multivariable PID Controller – Multivariable Dynamic Matrix Controller – Case Studies: - Distillation Column, CSTR and Four-tank system.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/ Assignment/ Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)**
**10**

1. Calculate the RGA to determine the recommended pairing between controlled and manipulated variables for any system.
2. Seminar on LS, RLS methods.
3. Design of DMC for distillation Column, CSTR and Four-tank systemin MATLAB.
4. Design a Multi-loop & Multivariable controller for MIMO system.
5. Design a model for any industrial process using parametric & non-parametric system.

**TEXT BOOKS:**


1. Stephanopoulos, G., "Chemical Process Control -An Introduction to Theory and Practice", Prentice Hall of India, 1st Edition, 2015.
2. Sigurd Skogestad, Ian Postlethwaite, "Multivariable Feedback Control: Analysis and Design", John Wiley and Sons, 2005, 2nd Edition.


**REFERENCE**


1. Thomas E. Marlin, Process Control – Designing Processes and Control systems for Dynamic Performance, Mc-Graw-Hill,2000, 2nd Edition.

2. Gopal, M., “Digital Control and State Variable Methods”, Tata Mc Graw Hill, 4th Edition, 2017.
3. P. Albertos and A. Sala, “Multivariable Control Systems An Engineering Approach”, Springer Verlag, 1st Edition, 2004
4. Bequette, B.W., “Process Control Modeling, Design and Simulation”, Prentice Hall of India, 1st Edition, 2003.
5. Dale E. Seborg, Duncan A. Mellichamp, Thomas F. Edgar, “Process Dynamics and Control”, Wiley John and Sons, 4th Edition, 2016.

**List of Open Source Software/ Learning website:**

https://nptel.ac.in/courses/103104050
https://www.mathworks.com/matlabcentral/mlc-downloads/downloads/submissions/10816/versions/1/previews/Mimotools/rga.m/index.html
https://in.mathworks.com/help/ident/
https://ctms.engin.umich.edu/CTMS/index.php?example=Introduction&section=ControlDigital

**TI25033 SYSTEM IDENTIFICATION L TP C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To elaborate the concept of estimating the state variables of a system using state estimation algorithms.
- To elaborate the concept of estimating the parameters of the Input-output models using parameter estimation algorithms.
- To make the student understand the various closed loop system identification techniques.
- To make the student understand the various closed loop system identification techniques.
- To provide the background on the practical aspects of conducting experiments for real time system identification.

**UNIT I NON PARAMETRIC METHODS (7+2 SKILL) 9**

Nonparametric methods: Transient analysis - frequency analysis - Correlation analysis - Spectral analysis.

**UNIT II PARAMETRIC METHODS (7+2 SKILL) 9**

Parametric model structures: ARX, ARMAX, OE, BJ models - The Least square estimate - Best linear unbiased estimation under linear constraints - Updating the Parameter estimates for linear regression models - Prediction error methods: Description of Prediction error methods - Optimal Prediction – Relationships between prediction error methods and other identification methods - theoretical analysis. Instrumental variable methods: Description of Instrumental variable methods - Theoretical analysis - covariance matrix of IV estimates - Comparison of optimal IV and prediction error methods.

**UNIT III RECURSIVE IDENTIFICATION METHODS (7+2 SKILL) 9**

The recursive least squares method - Recursive Instrumental variable method-the recursive prediction error method-model validation and model structure determination. Identification of systems operating in closed loop: Identifiability considerations - Direct identification - Indirect identification - Joint input – Output identification.

**UNIT IV CLOSED- LOOP IDENTIFICATION (7+2 SKILL) 9**

Identification of systems operating in closed loop: direct identification and indirect identification – Subspace Identification methods: classical and innovation forms – Relay feedback identification of stable processes.

**UNIT V NONLINEAR SYSTEM IDENTIFICATION (7+2 SKILL) 9**

Modeling of nonlinear systems using ANN- NARX & NARMAX - Training Feed-forward and Recurrent Neural Networks – TSK model – Adaptive Neuro-Fuzzy Inference System (ANFIS) - Introduction to Support Vector Regression.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)**

**10**

1. Familiarization of various system identification methods in MATLAB.
2. Seminar on ANFIS
3. Exploration of other advanced system identification methods.

**TEXT BOOKS:**


1. Lennart Ljung, “System Identification: Theory for the user”, 2nd Edition, Prentice Hall, 1999.
2. Dan Simon, “Optimal State Estimation Kalman, H-infinity and Non-linear Approaches”, John Wiley and Sons, 2006,
3. Tangirala, A.K., “Principles of System Identification: Theory and Practice”, CRC Press, 2014, 1st Edition.


**REFERENCE**


1. Cortes, C., and Vapnik, V., “Support-Vector Networks, Machine Learning”, 1995, 1st Edition.
2. Miller, W.T., Sutton, R.S., and Webrose, P.J., “Neural Networks for Control”, MIT Press, 1996, 1st Edition.
3. Van der Heijden, F., Duin, R.P.W., De Ridder, D., and Tax, D.M.J., “Classification, Parameter Estimation and State Estimation”, An Engineering Approach Using MATLAB, John Wiley & Sons Ltd., 2017, 2nd Edition.
4. Karel J. Keesman, “System Identification an Introduction”, Springer, 2011, 1st Edition.
5. Tao Liu and Furong Gao, “Industrial Process Identification and control design, Step-test and relay-experiment-based methods”, Springer- Verlag London Ltd., 2012, 1st Edition.


**List of Open Source Software/ Learning website:**

https://in.mathworks.com/help/ident/
https://nptel.ac.in/courses/103106149
https://in.mathworks.com/help/curvefit/nonparametric-fitting.html

**TI25034 MODEL BASED CONTROL L T P C**

**3 0 0 3**

**COURSEOBJECTIVES:**

- To introduce the Knowledge about Multivariable and Multiloop systems.
- To understand the Model predictive control schemes and its elements.
- Get exposed to state space MPC along with case studies.
- To acquire knowledge on various constrained MPC.
- To make the student understand the principles of STR, MRAC and Gain scheduling.
- To make the student design simple adaptive controllers for linear systems

**UNIT I INTRODUCTION TO MIMO CONTROL (7+2SKILL) 9**

Introduction to MIMO Systems – Multivariable control-Multiloop Control-Multivariable IMC-IMCPID- Case studies

**UNIT II MODEL PREDICTIVE CONTROL SCHEMES (7+2SKILL)9**

Introduction to Model Predictive Control - Model Predictive Control Elements - Generalized Predictive Control Scheme — Multivariable Generalized Predictive Control Scheme — Multiple Model based Model Predictive Control Scheme Case Studies

**UNIT III STATE SPACE BASED MODEL PREDICTIVE CONTROL SCHEME**

**(7+2SKILL) 9**

State Space Model Based Predictive Control Scheme - Review of Kalman Update based filters – State Observer Based Model Predictive Control Schemes–Case Studies

**UNIT IV CONSTRAINED MODEL PREDICTIVE CONTROL SCHEME**

**(7+2SKILL)9**

Constraints Handling: Amplitude Constraints and Rate Constraints–Constraints and Optimization –Constrained Model Predictive Control Scheme–Case Studies.

**UNIT V ADAPTIVECONTROLSCHEME (7+2SKILL)9**

Introduction to Adaptive Control-Gain Scheduling-Self tuning regulators–MARS-Adaptive Model Predictive Control Scheme –Case Studie

**TOTAL:45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content 10 Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)**

1. Explore various MIMO controllers presently used in industries.
2. Develop MPC, Adaptive and MIMO controllers for industrial processes.
3. Implement the controllers for MIMO systems.
4. Usingsoftwaretoolsforpracticalexposurestothecontrollersusedinindustriesby undergoing training.
5. Realization of various optimization techniques for economical operation of process.

**TEXTBOOKS:**


1. Coleman Brosilow, Babu Joseph,“Techniques of Model-Based Control”, Prentice Hall PTR Pub 2002, 1st Edition.
2. E.F.Camacho,C.Bordons,“Model Predictive Control”,Springer Verlag London Limited 2007, 2nd Edition.
3. K.J.Astromand B.J.Witten mark, “Adaptive Control”, Second Edition, Pearson Education Inc., second Edition 2013.


**REFERENCES:**


1. Paul Serban Agachi, Zoltan K. Nagy, Mircea Vasile Cristea, and Arpad Imre-Lucaci Model Based Control Case Studies in Process Engineering, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim 2007.1st Edition.
2. Ridong Zhang, Anke Xue Furong Gao,“Model Predictive Control Approaches Based on the Extended State Space Model and Extended Non-minimal State Space Model”,Springer Nature Singapore Pte Ltd. 2019, 1st Edition.
3. J.A. ROSSITER “Model-Based Predictive Control A Practical Approach ”Taylor& Francis e- Library, 2005, 1st edition.


**List of Open Source Software/ Learning website:**

1 https://nptel.ac.in/courses/103103037
2 https://nptel.ac.in/courses/108103007
3 https://onlinecourses.nptel.ac.in/noc21_ge01/preview
4 https://nptel.ac.in/courses/127106225

**TI25035 NONLINEAR CONTROL L T P C**
**3 0 0 3**

**COURSEOBJECTIVES:**

To provide knowledge on design in state variable form

- To provide knowledge in phase plane analysis.
- To give basic knowledge in describing function analysis.
- To study the design of optimal controller.
- To study the design of optimal estimator including Kalman Filter

**UNIT I STATEVARIABLEDESIGN (7+2SKILL) 9**

Introduction to state Model- effect of state Feedback-Necessary and Sufficient Condition for Arbitrary Pole-placement- pole placement Design- design of state Observers- separation principle- servo design: -State Feedback with integral control

**UNITII PHASEPLANE ANALYSIS (7+2SKILL) 9**

Features of linear and non-linear systems -Common physical non-linearities– Methods of linearization Concept of phase portraits –Singular points–Limit cycles–Construction of phase portraits–Phase plane analysis of linear and non-

linear systems–Isocline method.

**UNITIII DESCRIBING FUNCTION ANALYSIS (7+2SKILL) 9**

Basic concepts, derivation of describing functions for common on -linearities– Describing function analysis of non-linear systems–limit cycles–Stability of oscillations.

**UNITIV OPTIMALCONTROL (7+2SKILL) 9**

Introduction-Time varying optimal control–LQR steady state optimal control– Solution of Ricatti's equation–Application examples.

**UNITV OPTIMALESTIMATION (7+2SKILL) 9**

Optimal estimation – Kalman Bucy Filter – Solution by duality principle-Discrete systems- Kalman Filter-Application examples.

**TOTAL:45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar /Mini Project/Assignment/ Content Preparation /Quiz /Surprise Test/Solving GATE questions/ etc) 10**

1. Design of linear quadratic regulator (LQR)control system for any application of your own
2. Familiarization of Kalman filter in MATLAB
3. Seminar on pole placement design

**TEXTBOOKS:**


1. G.J.Thaler, "Automatic Control Systems ", Jaico Publishing House 1993.
2. M.Gopal, Modern Control System Theory, NewAge International Publishers,2002,2nd Edition.
3. K. P. Mohandas, "Modern Control Engineering", Sanguine Technical Publishers, 2006, 1st Edition.


**REFERENCES:**


1. Ashish Tewari, 'Modern Control Design with Matlab and Simulink', John Wiley, New Delhi, 2002, 1st Edition.
2. K.Ogata,'ModernControlEngineering',5thEdition,PHI,NewDelhi,2009.
3. T.GladandL.Ljung,,"ControlTheory–MultivariableandNon-LinearMethods",Taylor & Francis, 2002, 1st Edition.
4. D.S.Naidu, "Optimal Control Systems "First Indian Reprint, CRC Press, 2009,1st Edition.
5. William S Levine, "Control System Fundamentals," The Control Handbook, CRC Press, Tayler and Francies Group, 2011, 2nd Edition.


**List of Open Source Software/ Learning website:**

https://in.mathworks.com/discovery/kalman-filter.html

https://in.mathworks.com/help/control/getstart/design-an-lqr-servo-controller-insimulink.html

https://onlinecourses.nptel.ac.in/noc22_ee24/preview

http://www.nitttrc.edu.in/nptel/courses/video/101108047/lec22.pdf

**TI25036 OPTIMALCONTROL L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

- To provide an exposure to different type of optimal control problems such as time-optimal, fuel optimal, energy optimal control problems.
- To impart knowledge and skills needed to design Linear Quadratic Regulator for Time- invariant and Time-varying Linear system (Continuous time and Discrete-time systems).
- To introduce concepts needed to design optimal controller using Dynamic Programming Approach and H-J-B equation.
- To provide an exposure to various types of fault tolerant control schemes such as Passive and active approaches.
- To introduce concepts needed to design optimal controller in the presence of state constraints and time optimal controller.

**UNIT I CALCULUS OF VARIATIONS AND OPTIMAL CONTROL (7+2SKILL) 9**

Introduction–Performance Index – Constraints –Formal statement of optimal control system– Calculus of variations – Function, Functional, Increment, Differential and variation and optimum of function and functional–The basic variation problem Extrema of functionsand functional with conditions–variational approach to optimal control system.

**UNITII LINEAR QUADRATIC OPTIMAL CONTROL SYSTEM (7+2SKILL) 9**

Problem formulation – Finite time Linear Quadratic regulator – Infinite time LQR system: Time Varying case- Time-invariant case – Stability issues of Time-invariant regulator – Linear Quadratic Tracking system: Fine time case and Infinite time case

**UNITIII DISCRETE TIME OPTIMAL CONTROL SYSTEMS (7+2SKILL)9**

Variational calculus for Discrete time systems — Discrete time optimal control systems:- Fixed final state and open-loop optimal control and Free-final state and open-loop optimal control - Discrete time linear state regulator system —Steady state regulator system

**UNITIV PONTRYAGIN MINIMUM PRINCIPLE (7+2SKILL)9**

Pontryagin Minimum Principle – Dynamic Programming:- Principle of optimality, optimal control using Dynamic Programming – Optimal Control of Continuous time and Discrete-time systems–Hamilton-Jacobi-Bellman Equation–LQ R system using H-J-B equation

**UNITV CONSTRAINED OPTIMAL CONTROL SYSTEMS (7+2SKILL)9**

Time optimal control systems – Fuel Optimal Control Systems- Energy Optimal Control Systems – Optimal Control Systems with State Constraints

**TOTAL: 45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar / Mini Project/ Assignment/ Content Preparation/ Quiz/ Surprise Test /Solving GATE questions/ etc)**

1. Interactive MATLAB based project learning in an optimal control system.
2. Familiarize your self with optimal control software tool boxes.
3. Arrange a group brain storming process to generate new ideas and possible solutions to an optimal control problem in any field.
4. Analyse the difference between optimal control systems with other types of control system.

**TEXTBOOKS:**

1. Donald E. Kirk, Optimal Control Theory–An Introduction, DoverPublications, Inc.Mineola, NewYork,2012,10th Edition.

**REFERENCEBOOKS**

1. D.Subbaram Naidu, Optimal Control Systems, CRC Press, NewYork,2003,1st Edition.
2. Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control, 3rd Edition, Wiley Publication, 2012, 3rd Edition.
3. Yan Wang, Cheng-LinLiu, Zhi-ChengJi, Quantitative Analysis and Optimal Control of Energy Efficiency in Discrete Manufacturing System, Springer, 2020, 1st Edition.

**List of Open-Source Software/Learning website:**

1 https://in.mathworks.com/discovery/optimal-control.html#lqrlqg
2 https://www.codeproject.com/Articles/863257/Simple-Software-for-Optimal-Control
3 https://joss.theoj.org/papers/10.21105/joss.02809
4 https://www.ieee-ras.org/model-based-optimization-for-robotics/resources/optimization-tools
5 https://www.vlab.co.in/
6 https://ocw.mit.edu/courses/16-323-principles-of-optimal-control-spring-2008/

| TI25037 | ADAPTIVE CONTROL | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

- To impart knowledge on how to recursively estimate the parameters of discrete input – output models using recursive parameter estimation methods
- To make the student understand the principles of STR, MRAC and Gain scheduling.
- To make the student design simple adaptive controllers for linear systems using STR, MRAC and Gain scheduling

**UNIT I INTRODUCTION (7+2 SKILL)9**

Introduction - Adaptive Schemes - The adaptive Control Problem – Applications- Parameter estimation:-LS, RLS: and ERLS

**UNIT II GAIN SCHEDULING (7+2 SKILL) 9**

Introduction- The principle - Design of gain scheduling controllers- Nonlinear transformations - application of gain scheduling - Auto-tuning techniques: Methods based on Relay feedback.

**UNIT III DETERMINISTIC SELF-TUNING REGULATORS (7+2 SKILL) 9**

Introduction- Pole Placement design - Indirect Self-tuning regulators - direct self-tuning regulators – Disturbances with known characteristics

**UNIT IV STOCHASTIC AND PREDICTIVE SELF-TUNING REGULATORS (7+2 SKILL) 9**

Introduction – Design of minimum variance controller - Design of moving average controller - stochastic self-tuning regulators

**UNIT V MODEL – REFERENCE ADAPTIVE SYSTEM (7+2 SKILL) 9**

Introduction- MIT rule – Determination of adaptation gain - Lyapunov theory – Design of MRAS using Lyapunov theory – Relations between MRAS and STR.

**TOTAL:45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc)**

**10**

1 Learn any one relevant software tool (MATLAB/ SCILAB/ LABVIEW/ Equivalent open source software)
2 Design of gain scheduling adaptive control using any one software tool
3 Analysis/Problem Solving - Ability to identify and define problems and solutions
4 Design and verification of MRAC by simulation.

**TEXT BOOKS:**

1. K.J. Astrom and B. J. Wittenmark, “Adaptive Control”, Second Edition, Pearson Education Inc., second Edition 2013.

**REFERENCE BOOKS**

1. T. Soderstorm and Petre Stoica, “System Identification”, Prentice Hall International(UK) Ltd., 1989, 1st Edition.
2. Lennart Ljung, “System Identification: Theory for the User”, Second Edition, Prentice Hall, 1999.

**List of Open Source Software/ Learning website:**

https://archive.nptel.ac.in/courses/108/102/108102113/
https://in.mathworks.com/help/slcontrol/adaptive-control-design.html
https://in.mathworks.com/videos/nonlinear-model-based-adaptive-robust-controller-in-an-oil-and-gas-wireline-operation-1637577967956.html
https://www.dynalog-us.com/adaptive-robot-control.htm
https://www.vlab.co.in/

**TI25038 MACHINE MONITORING SYSTEM L T P C**

**3 0 0 3**

**COURSEOBJECTIVES:**

- To make the students familiarize with the concept of condition-based maintenance for effective utilization of machines.
- To Impart the knowledge of artificial intelligence for machinery fault diagnosis.
- To give basic knowledge on vibration monitoring.
- To study the machinery vibrations using signal processing techniques.
- To provide knowledge on FMECA.

**UNIT I INTRODUCTION TO MACHINE CONDITION MONITORING**

**(7+2SKILL) 9**

Machinery condition monitoring – Present status-Fault prognosis- Future needs.

**UNIT II MACHINERY MAINTENANCE (7+2SKILL)9**

Maintenance strategies —Reactive, Preventive, and Predictive —Benefits of planned maintenance–Bath tub curve–Failure Modes Effects and Criticality Analysis (FMECA).

**UNITIII INTRODUCTION TO MACHINERY VIBRATION AND MONITORING**

**(7+2SKILL) 9**

Characteristics of Vibration systems—Mode shapes & operational deflection shapes—Experimental modal analysis–Principles of vibration monitoring–Machinery faults diagnosed by vibration analysis.

**UNITIV SIGNAL PROCESSING IN MACHINERY MONITORING (7+2SKILL) 9**

FFT analysis–Time domain analysis–Time-frequency analysis–Signal filtering–Cepstrum analysis–Health condition of compressor & engine.

**UNITV MACHINE LEARNING FOR CONDITION MONITORING (7+2SKILL) 9**

Machine Learning: Feature extraction and feature selection methods – Feature reduction– Classification techniques – Case studies of condition monitoring in Nuclear plant components, Distillation column.

**TOTAL:45 PERIODS**

**SKILLDEVELOPMENTACTIVITIES (Group Seminar/ Mini Project/Assignment/ Content Preparation/Quiz/Surprise Test/Solving GATE questions/etc) 10**

1. Survey of critical machinery that requires monitoring system.
2. Exposure to practical machinery vibration & monitoring system presently in use.
3. Carryout FMECA using software.
4. Analyze the health condition of any machinery.

**TEXT BOOKS:**

1. Cornelius Scheffer and Paresh Girdhar, “Practical Machinery Vibration Analysis and Predictive Maintenance”, Elsevier, 2004, 1st Edition.
2. R. Mohanty, “Machinery Condition Monitoring: Principles and Practices” , CRC Press, Taylor & Francis, 1st Edition, 2017.

**REFERENCES:**


1. Stephen Marsland, Machine Learning: An Algorithmic Perspective, 2nd Edition, 2014, CRC, Press.
2. Collacot, “Mechanical Fault Diagnosis and Condition Monitoring”, Chapman- Hall, 1st Edition, 2011.
3. Davies, “Handbook of Condition Monitoring – Techniques and Methodology”, Springer, 1st Edition, 2011.
4. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, Elsevier, 3rd Edition 2011.
5. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, John Wiley & Sons, 2nd Edition, 2017.


**List of Open Source Software/ Learning website:**

**1** https://onlinecourses.nptel.ac.in/noc22_cs29/preview

**2** https://www.udemy.com/topic/maintenance-management/

**3** https://www.vi-institute.org/analyst-categories/

**4** https://in.mathworks.com/help/predmaint/ug/condition-monitoring-and-prognostics-using-vibration-signals.html

## DIVERSIFIEDCOURSES

**TI25039 ENERGY STORAGE SYSTEMS** **L T P C**
**3 0 0 3**

**COURSEOBJECTIVES:**

Students will be able to:

- understand the various types of energy storage Technologies.
- Analyze thermal storage system.
- Analyze different battery storage technologies
- Analyze the thermodynamics of Fuel Cell
- Study the various applications of energy storage systems.

**UNITI INTRODUCTION (7+2SKILL) 9**

Necessity of energy storage —types of energy storage —comparison of energy storage technologies–Applications.

**UNIT II THERMAL STORAGE SYSTEM (7+2SKILL) 9**

Thermal storage—Types—Modeling of thermal storage units—Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units-Modelling using porous medium approach, Use of TRNSYS.

**UNIT III ELECTRICAL ENERGY STORAGE (7+2SKILL) 9**

Fundamental concept of batteries – measuring of battery performance, charging and discharging, power density, energy density, and safety issues. Types of batteries —Lead Acid, Nickel — Cadmium, Zinc Manganese dioxide, Li-ion batteries - Mathematical Modelling for Lead Acid Batteries —Flow Batteries.

**UNITIV FUELCELL (7+2SKILL) 9**

FuelCell–History of Fuel cell, Principles of Electrochemical storage–Types–Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantages and disadvantages.

**UNITV ALTERNATE ENERGY STORAGE TECHNOLOGIES (7+2SKILL) 9**

Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage–Applications, Pumped Hydro Storage–Applications.

**TOTAL:45PERIODS**

**SKILLDEVELOPMENTACTIVITIES (Group Seminar/ Mini Project/Assignment /Content Preparation / Quiz/ Surprise Test / etc) 10**

1. Model, simulate and analyze the performance characteristics of thermal storage systems
2. Develop a model for latent heat storage in phase changing materials.
3. Model, simulate and analyze the performance characteristics of Lead Acid Batteries
4. Model, simulate and analyze the performance characteristics of Fuel Cell
5. techno-economic analysis of different types of storage systems

**TEXTBOOKS:**


1. Ibrahim Dincer and Mark A. Rosen, 'Thermal Energy Storage Systems and Applications', John Wiley & Sons, 3rd Edition, 2021.
2. Ru-shi Liu, Lei Zhang and Xueliang sun, 'Electrochemical technologies for energy storage and conversion', Wiley publications, 2nd Volume set, 2012.
3. James Larminie and Andrew Dicks, 'Fuel cell systems Explained', Wiley publications,3rd Edition, 2018.


4. **REFERENCES:**


1. Lunardini.V.J, 'Heat Transfer in Cold Climates', John Wiley and Sons 1981, 1stEdition.
2. Schmidt.F.W. and Willmott.A.J., 'Thermal Energy Storage and Regeneration', Hemisphere Publishing Corporation, 1981, 1st Edition.


**List of open Source Software/ Learning website:**

1. Prof. Subhasish Basu Majumder, "Electrochemical Energy Storage", NPTEL Course, https://nptel.ac.in/courses/113105102.
2. Prof. PK Das, "Energy conservation and waste heat recovery", NPTEL Course,

https://nptel.ac.in/courses/112105221.

**TI25040 HYBRID ENERGY TECHNOLOGY LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To provide knowledge about different types of hybrid energy systems.
- To analyze the various electrical Generators used for the Wind Energy Conversion Systems.
- To design the power converters used in SPV Systems.
- To analyze the various power converters used in hybrid energy systems and to understand the importance of stand-alone and grid-connected operation in Hybrid renewable energy systems.
- To analyze the performance of the various hybrid energy systems

**UNIT I INTRODUCTION TO HYBRID ENERGY SYSTEMS (7+2Skill)9**

Hybrid Energy Systems –Need for Hybrid Energy Systems –Solar-Wind-Fuel Cell-Diesel, Wind- Biomass-Diesel, Micro-Hydel-PV, Ocean and geyser energy - Classification of Hybrid Energy systems – Importance of Hybrid Energy systems– Advantages and Disadvantages-Environmental aspects of renewable energy - Impacts of renewable energy generation on the environment -Present Indian and international energy scenario of conventional and Resources – Ocean energy, Hydel Energy-Wind Energy, Biomass energy, Hydrogen energy - Solar Photovoltaic (PV) and Fuel cells: Operating principles and characteristics.

**UNIT II ELECTRICAL MACHINES FOR WIND ENERGY CONVERSION SYSTEMS (WECS) (7+2Skill)9**

Review of reference theory fundamentals –Construction, Principle of operation and analysis: Squirrel Cage Induction Generator (SCIG), Doubly Fed Induction Generator (DFIG) - Permanent Magnet Synchronous Generator (PMSG).

**UNIT III POWER CONVERTERS AND ANALYSIS OF SOLAR PV SYSTEMS (7+2 Skill) 9**

Power Converters for SPV Systems **-**Line commutated converters (inversion-mode)- Boost and buck- boost converters- selection of inverter, battery sizing, array sizing - Analysis of SPV Systems - Block diagram of the solar PV systems - Types of Solar PV systems: Stand-alone PV systems.

**UNIT IV ANALYSIS OF POWER CONVERTERS FOR HYBRID ENERGY SYSTEMS (7+2Skill) 9**

Introduction to Power Converters – Stand-alone Converters -AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters - Bi-Directional Converters - Grid-Interactive Inverters - Matrixconverter– Merits and Limitations.

**UNIT V CASE STUDIES FOR HYBRID RENEWABLE ENERGY SYSTEMS (7+2Skill)9**

Hybrid Systems- Range and type of Hybrid systems–Performance Analysis– cost Analysis-Case studies of Diesel-PV, -PV-Fuel-cell, Micro-hydel-PV, Biomass-Diesel-Fuel-cell systems.

**TOTAL:45PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/ Mini Project /Assignment/ Content Preparation /Quiz/ Surprise Test/ Solving GATE questions/ etc) 10**

1. Simulation of Wind energy conversion system
2. Simulation of power converters
3. Simulations of AC-DC-AC converters, PWM inverters and Matrix Converters with Resistive and dynamic loads

**TEXT BOOKS**:


**1.** Bahman Zohuri, “Hybrid Energy Systems”, Springer, First Edition, 2018.

**2.** S.M. Muyeen, “Wind Energy Conversion Systems”, Springer First Edition, 2012

**3.** Md. Rabiul Islam, Md. Rakibuzzaman Shah, Mohd Hasan Ali, "Emerging Power Converters for Renewable Energy and Electric Vehicles", CRC Press, First Edison, 2021


**REFERENCES:**


1. Ernst Joshua, Wind Energy Technology, PHI, India, 2018, 3rd Edition.
2. S.N.Bhadra, D. Kastha, & S. Banerjee “Wind Electrical Systems”, Oxford University Press, 7th Impression, 2005.
3. Rashid.M. H “Power electronics Hand book”, Academic press,4th Edition, 2018.
4. Rai. G.D, “Non-conventional energy sources”, Khanna publishers, 6th Edition, 2017.
5. Rai. G.D, “Solar energy utilization”, Khanna publishers, 3rd Edition, 1987.
6. Gray, L. Johnson, “Wind energy system”, Prentice Hall of India, 2nd Edition, 2006.
7. B.H.Khan "Non-conventional Energy sources", Tata McGraw hill Publishing Company, New Delhi, 2017, 3rd Edition.


**List of Open Source Software/ Learning website:**

1. https://www.sciencedirect.com/topics/engineering/hybrid-energy-system
2. https://www.sciencedirect.com/topics/engineering/wind-energy-conversion-system
3. https://www.academia.edu/35619294/Modeling_and_Performance_Analysis_of_Solar_PV_S
4. System_and_DC_DC_Converters
5. https://www.mdpi.com/journal/energies/special_issues/Power_Converter_Electric_Machines
6. _Renewable_Energy_Systems_Transportation
7. https://www.intechopen.com/chapters/64317

**TI25041 DESIGN AND MODELLING OF RENEWABLE ENERGY SYSTEMS**

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

**COURSE OBJECTIVES:**

- To review the renewable energy systems and technology
- To learn the Single phase grid-connected photovoltaic systems and three phase photovoltaic systems
- To illustrate the small wind energy systems
- To simulate the Doubly-fed induction generator based WECS

**UNIT I RENEWABLE ENERGY SYSTEMS: TECHNOLOGY OVERVIEW AND PERSPECTIVES (7+2 Skill) 9**

Introduction-State of the Art- Examples of Recent Research and Development Challenges and Future Trends

**UNITII SINGLE-PHASE GRID-CONNECTED PHOTOVOLTAIC SYSTEMS (7+2 Skill) 9**

Introduction- Demands for Grid-Connected PV Systems-Power Converter Technology for Single-Phase PV Systems, Transformer less AC-Module Inverters (Module-Integrated PV Converters, Transformer less Single-Stage String Inverters, DC-Module Converters in Transformer less Double-Stage PV Systems

**UNIT III THREE-PHASE PHOTOVOLTAIC SYSTEMS: STRUCTURES, TOPOLOGIES (7+2 Skill) 9**

Introduction-PV Inverter Structures, Three-Phase PV Inverter Topologies- -Control Building Blocks for PV Inverters, Modulation Strategies for Three-Phase PV Inverters, Implementation of the Modulation Strategies., Grid Synchronization, Implementation of the PLLs for Grid Synchronization, Current Control, Implementation of the Current Controllers, Maximum Power Point Tracking.

**UNIT IV SMALL WIND ENERGY SYSTEMS (7+2 Skill) 9**

Introduction-Generator Selection for Small-Scale Wind Energy Systems- Turbine Selection for Wind Energy- Self-Excited Induction Generators for Small Wind Energy Applications- Permanent Magnet Synchronous Generators for Small Wind Power Applications- Grid-Tied Small Wind Turbine Systems-Magnus Turbine–Based Wind Energy System

**UNIT V DOUBLY-FED INDUCTION GENERATOR-BASED WECS (7+2 Skill) 9**

Introduction – modelling of induction machine in machine variable form and arbitrary reference frame, modelling of Doubly-fed Induction Generator.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE**

**questions/ etc) 10**

1. Simulation of inverter for PV systems
2. Simulation of WECS with DFIG

**List of Open Source Software/ Learning website:**

1. https://www.mdpi.com/journal/applsci/topical_collections/Susta_Energy
2. https://www.mathworks.com/help/sps/ug/single-phase-grid-connected-in-pv-system.html
3. https://www.sciencedirect.com/topics/engineering/three-phase-inverter
4. academia.edu/32704493/Wind_Power_Lecture_Notes
5. https://www.syscop.de/files/2018ss/WES/handouts/script.pdf
6. https://www.sciencedirect.com/topics/engineering/wound-rotor-induction-generator

**TEXT BOOKS:**

1. Ahmad Azar, Nashwa Kamal, "Design, Analysis and Applications of Renewable Energy Systems", Academic Press, First Edition, 2021
2. Ahmad Azar, Nashwa Kamal, "Renewable Energy Systems", Academic Press, First Edition, 2021
3. Nabil Derbel, Quanmin ZhuModeling, "Identification and Control Methods in Renewable Energy Systems" , Springer, First Edition, 2019

**REFERENCES:**

1. Power Conversion and Control of Wind Energy Systems, Bin Wu, 2011, Wiley-IEEE, 1st Edition.
2. Wind Electrical Systems, S.N. Bhadra, 2005, Oxford, 7th Impression.
3. Wind Power Integration - Connection and System Operational Aspects, Brendan Fox, 2014, IET, 2nd Edition.
4. Renewable Energy Devices and Systems with Simulations in MATLAB and ANSYS, Frede Blaabjerg, Dan M. Ionel, CRC press, 2017, 1st Edition.

**TI25042 GRID INTEGRATING TECHNIQUES AND CHALLENGES L T P C**

**2 0 2 3**

**COURSE OBJECTIVES:**

- To study about the present power Scenario
- To model a micro grid system
- To model power converter for grid interconnection
- To integrate wind energy conversion system with grid
- To simulate power converters like three phase inverters and DC-DC converters

**UNIT I PRESENT POWER SCENARIO IN INDIA 6**

Introduction - Thermal Power Plant , Components of Thermal Power Plant , Major Thermal Power Plants in India- Gas-Based Power Generation - Nuclear Power Plants -Hydropower Generation - Pumped Storage Plants - Solar Power - Wind Energy – Power plants India

**UNIT II POWER GRIDS 6**

Introduction -Electric Power ,Background , The Construction of a Power Grid System , Basic Concepts of Power Grids -Load Models - Transformers in Electric Power Grids - Modelling a Microgrid System

**UNIT III MODELING OF CONVERTERS IN POWER GRID DISTRIBUTED GENERATION SYSTEMS 6**

Introduction - Single-Phase DC/AC Inverters with Two Switches, Three-Phase DC/AC Inverters, Pulse Width Modulation Methods, The Triangular, The Identity Method, Analysis of DC/AC Three-Phase Inverters. Micro grid of Renewable Energy Systems- DC/DC Converters in Green Energy -Pulse Width Modulation -Sizing of an Inverter for Microgrid Operation, Sizing of a Rectifier for Microgrid Operation, The Sizing of DC/DC Converters for Micro grid

**UNIT IV WIND ENERGY SYSTEM GRID INTEGRATION 6**

Introduction- Significance of Electrical Power Quality in Wind Power System- Integration Issues in Grid-Connected Wind Energy- Effect of Power Quality Issues, Importance of Custom Power Devices- Power Quality Point of View.

**UNIT V GRID INTER CONNECTION 6**

Grid Code requirements-Grid integration of WECS-Grid Integration of PV systems

**30 PERIODS**

**LAB COMPONENT 30 PERIODS**

1. Develop a model for the control of DC micro grid for non linear loads
2. Simulation study of three phase inverters with fixed and sine PWM techniques, Simulation and Design of buck/boost converters.
3. Simulate a Grid Connected Wind Energy System with STATCOM and investigate the improvement in power quality.

**TOTAL: 30+30 = 60 PERIODS**

**TEXT BOOKS:**


1. Brian D’Andrade “The Power Grid”, Academic Press, 1st Edition, 2017.
2. Yang Han, "Modeling and Control of Power Electronic Converters for Microgrid Applications", Springer, 1st Edition 2022.
3. Siegfried Heier, "Grid Integration of Wind Energy: Onshore and Offshore Conversion Systems", John Wiley & Sons, Ltd, 2014, 3rd Edition.


**REFERENCES:**

1. Integration of Renewable Energy Sources with Smart Grid, M. Kathiresh, A. Mahaboob Subahani, and G.R. Kanaga chidambaresan, Scrivener & Wiley, 2021, 1st Edition.
2. Control and Operation of Grid-Connected Wind Energy Systems, Ali M. Eltamaly, Almoataz Y. Abdelaziz, Ahmed G. Abo-Khalil, Springer 2021, 1st Edition.
3. Design of smart power grid renewable energy systems, Third Edition, Ali Keyhani, Wiley 2019.
4. Power Electronic Converters, Teuvo Suntio, Tuomas Messo, Joonas Puukko, Wiley 2017, 1st Edition.
5. Fundamentals of Power Electronics with MATLAB, Randall Shaffer, Laxmi publications, 2013, 2nd Edition.
6. Power Conversion and Control of Wind Energy Systems, Bin Wu, 2011, Wiley-IEEE, 1st Edition.
7. Wind Power Integration - Connection and System Operational Aspects, Brendan Fox, 2014, IET, 2nd Edition.
8. Renewable Energy Devices and Systems with Simulations in MATLAB and ANSYS, Frede Blaabjerg, Dan M. Ionel, CRC press, 2017, 1st Edition.

**List of Open Source Software/ Learning website:**

1. https://www.academia.edu/14628492/Current_Power_Scenario_In_India
2. https://energyeducation.ca/encyclopedia/Electrical_grid
3. https://www.academia.edu/32120081/Power_Converters_Modeling_in_Matlab_Simulink_for_Micr
4. ogrid_Simulations_Power_Converters_Modeling_in_Matlab_Simulink_for_Microgrid_Simulations
5. https://dnv.com/services/wind-farm-control-and-grid-integration
6. https://www.wind-energy-the-facts.org/images/chapter2.pdf

## TI25043 SUSTAINABLE AND ENVIRONMENTAL FRIENDLY HV INSULATION SYSTEM

**LT P C**
**3 0 0 3**

**COURSE OBJECTIVES:**

- To Know about the products related with sustainable applicaton.
- To learn about Green Gaseous, liquid solid insulators.
- To understand the standards for green insulation systems.

### UNIT I SUSTAINABLE AND ENVIRONMENTAL ENERGY AND PRODUCTS 9

Carbon print, global warming potential, environment requirement for any product and system.

**UNIT II ALTERNATE GREEN GASEOUS INSULATORS 9**

SF6 gas and its hazardous environmental effects, alternate gases, gaseous mixtures and other sources and it's properties.

**UNIT III ALTERNATE GREEN LIQUID INSULATORS 9**

hazardous effects of existing liquid dielectric materials (such as organic oil), alternate sources of environmental friendly liquid such as ester oil, vegetable oils dielectric and it's properties.

**UNIT IV ALTERNATE GREEN SOLID INSULATORS 9**

hazardous effects of existing solid dielectric materials, alternate sources of environmental friendly solid dielectric and its properties.

**UNIT V EVOLVING STANDARDS FOR GREEN INSULATION SYSTEMS 9**

Requirements, evolving standards of management, testing, usage and disposal of alternate insulation systems, Major applications and standards

**TOTAL : 45 PERIODS**

**REFERENCES:**


1. https://www.iso.org/standard/79064.html
2. https://www.ictfootprint.eu/en/iec-tr-627252013-factsheet
3. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1275,25
4. https://www.iec.ch/ords/f?p=103:41:628762356646470::::FSP_ORG_ID,FSP_LANG_ID:3237, 25
5. https://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID,FSP_LANG_ID:1299,25
6. https://www.iec.ch/sdgs/sdg13
7. http://highperformanceinsulation.eu/wp- content/uploads/ 2016/08/ sustainability_a_guide.pdf


**TI25044 POWER SYSTEM TRANSIENTS LT P C**
**3 0 0 3**

**OBJECTIVES:**

- To study the generation of switching transients and their control using circuit – theoretical concept.
- To study the mechanism of lighting strokes and the production of lighting surges.
- To study the propagation, reflection and refraction of travelling waves.

- To study the impact of voltage transients caused by faults, circuit breaker action, load rejection on integrated power system.

**UNIT I INTRODUCTION AND SURVEY (7+2 Skill) 9**

Sources of different types of transients - RL circuit transient with sine wave excitation - double frequency transients - basic transforms of the RLC circuit transients - study of transients in system planning - Importance of grounding.

**UNIT II SWITCHING TRANSIENTS (7+2 Skill) 9**

Basic concept of switching transients - resistance switching and equivalent circuit for interrupting the resistor current - load switching and equivalent circuit - waveforms for transient voltage across the load and the switch - normal and abnormal switching transients. Current suppression - current chopping - effective equivalent circuit - capacitance switching with a restrike, with multiple restrikes - ferro resonance.

**UNIT III LIGHTNING TRANSIENTS (7+2 Skill) 9**

Theories of cloud formation - mechanism of lightning discharges and characteristics of lightning strokes – model for lightning stroke - factors contributing to good line design - protection using ground wires - tower footing resistance - Interaction between lightning and power system.

**UNIT IV TRAVELING WAVES ON TRANSMISSION LINE COMPUTATION OF TRANSIENTS (7+2 Skill) 9**

Computation of transients - transient response of systems with series and shunt lumped parameters and distributed lines. Traveling wave concept - step response - Bewely's lattice diagram - standing waves and natural frequencies - reflection and refraction of travelling waves. Computation of overvoltages using EMTP.

**UNIT V TRANSIENTS IN INTEGRATED POWER SYSTEM 9**

The short line and kilometric fault - distribution of voltages in a power system - Line dropping and load rejection - voltage transients on closing and reclosing lines - overvoltage induced by faults -switching surges on integrated system Qualitative application of EMTP for transient computation.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/ContentPreparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 8**

1. Simulation of circuit transients
2. Computation of over voltages for switching surges
3. Computation of over voltages for lightning surges
4. Computation of transients

**TEXT BOOKS:**

1. Allan Greenwood, 'Electrical Transients in Power Systems', Wiley Inter Science, New York, 2nd Edition, 1991.

2. Pritindra Chowdhari, “Electromagnetic transients in Power System”, John Wiley and Sons Inc., Second Edition, 2009.
3. C.S. Indulkar, D.P.Kothari, K. Ramalingam, ‘Power System Transients – A statistical approach’,
PHI Learning Private Limited, Second Edition, 2010.

**REFERENCES:**

1. M.S.Naidu and V.Kamaraju, ‘High Voltage Engineering’, Tata McGraw Hill, Fifth Edition, 2013.
2. R.D. Begamudre, ‘Extra High Voltage AC Transmission Engineering’, Wiley Eastern Limited, 1986.
3. Y.Hase, Handbook of Power System Engineering,” Wiley India, 2012.
4. J.L.Kirtley, “Electric Power Principles, Sources, Conversion, Distribution and use,” Wiley, 2012.

**TI25045 PLC PROGRAMMING L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

To know about the basics of PLC and Automation
To understand the importance of Automation
To explore various types and manufactures of PLCs.
To introduce types of programming languages of PLC and some exercise few programs.

**UNIT I INTRODUCTION (7+2 SKILL) 9**

Programmable Logic Controller (PLC)- Block diagram of PLC- Programming languages of PLC- Basic instruction sets- Design of alarm and interlocks- Networking of PLC- Overview of safety of PLC with case studies- Process Safety Automation: Levels of process safety through use of PLCs- IEC 61131-3 Standard - Application of international standards in process safety control.

**UNIT II IEC 61131-3 (7+2 SKILL) 9**

Rails- Rungs- Relay Logic- Latch switch- Timers- Counters- Boolean logics- Math Instructions- Data manipulation Instructions- Requirement of communication networks for PLC, PLC to PC Communication to computer- FBD equivalent to LL- FBD Programming- IL- SFC-ST.

**UNIT III SCADA (7+2 SKILL) 9**

Elements of SCADA system- History of SCADA, Remote Terminal Unit- Discrete control- Analog control, Master Terminal Unit- Operator interface.

**UNIT IV HART and Field Bus (7+2 SKILL) 9**

Introduction- Evolution of signal standards- HART communication protocol- communication modes- HART networks- HART commands- HART and OSI model- Field bus- Architecture- Basic requirements of field Busstandard- Field bus Topology- Interoperability- Interchangeability.

**UNIT V PLC PROGRAMMING (7+2 SKILL)9**

Exercise in Programming Languages from IEC 61131-3: Traffic Light Control- Two way- Four way – Water Level Control- Automatic Material Sorting System- Automatic Bottle Filling System, Code Converters- DC motor Control- Alarm Circuit.

**TOTAL : 45 PERIODS**

**SKILL DEVELOPMENT ACTIVITIES (Group Seminar/Mini Project/Assignment/Content Preparation / Quiz/ Surprise Test / Solving GATE questions/ etc) 10**

1. Taking Local area to implement simple closed loop system for any system using PLC.
2. Making a complete automated control loop with Supervisory and HMI system.
3. Implementing an Alarm based control scheme and run in a simulated environment.
4. Designing an entire PLC logic for filling and draining water tank automatically.

**TEXT BOOKS:**


1. Frank D. Petruzella, “Programmable Logic Controllers”, 5th Edition, McGraw-Hill, New York, 2019.
2. Stuart Boyer A, “SCADA: Supervisory control and data Acquisition”, Fourth Edition, ISA- The Instrumentation, Systems, and Automation Society,2010


**REFERENCES**


1. Bolton. W, “Programmble Logic Controllers”, Elsevier Newnes, 6th Edition 2015.


**List of Open-Source Software/ Learning website:**

1. https://nptel.ac.in/courses/108105062
2. https://nptel.ac.in/courses/108105088
3. http://www.nitttrc.edu.in/nptel/courses/video/105105201/lec56.pdf
4. https://nptel.ac.in/courses/108106022
5. https://new.siemens.com/global/en/products/automation/systems/industrial/plc/logo/logo-software.html
6. https://componentsearchengine.com/library/proteus?gclid=CjwKCAjw_ISWBhBkEiwAdqxb9okU2ZZHcQoa9fSRK2Uq41Rq0GZxdGUP6_6GlBv77p4JqGt_iDAljhoCksEQAvD_BwE

**TI25046 BIG DATA ANALYTICS L T P C**
**2 0 2 3**

**COURSE OBJECTIVES:**

- To understand big data.
- To learn and use NoSQL big data management.
- To learn mapreduce analytics using Hadoop and related tools.
- To work with map reduce applications
- To understand the usage of Hadoop related tools for Big Data Analytics

**UNIT I UNDERSTANDING BIG DATA 5**

Introduction to big data – convergence of key trends – unstructured data – industry examples of big data – web analytics – big data applications– big data technologies – introduction to Hadoop – open source technologies – cloud and big data – mobile business intelligence – Crowd sourcing analytics – inter and trans firewall analytics.

**UNIT II NOSQL DATA MANAGEMENT 7**

Introduction to NoSQL – aggregate data models – key-value and document data models – relationships – graph databases – schemaless databases – materialized views – distribution models – master-slave replication – consistency - Cassandra – Cassandra data model – Cassandra examples – Cassandra clients

**UNIT III MAP REDUCE APPLICATIONS 6**

MapReduce workflows – unit tests with MRUnit – test data and local tests – anatomy of MapReduce job run – classic Map-reduce – YARN – failures in classic Map-reduce and YARN – job scheduling – shuffle and sort – task execution – MapReduce types – input formats – output formats.

**UNIT IV BASICS OF HADOOP 6**

Data format – analyzing data with Hadoop – scaling out – Hadoop streaming – Hadoop pipes – design of Hadoop distributed file system (HDFS) – HDFS concepts – Java interface – data flow – Hadoop I/O – data integrity – compression – serialization – Avro – file-based data structures - Cassandra – Hadoop integration.

**UNIT V HADOOP RELATED TOOLS 6**

Hbase – data model and implementations – Hbase clients – Hbase examples – praxis. Pig – Grunt – pig data model – Pig Latin – developing and testing Pig Latin scripts. Hive – data types and file formats – HiveQL data definition – HiveQL data manipulation – HiveQL queries.

**TOTAL:30 PERIODS**

**LIST OF EXPERIMENTS:** **30 PERIODS**

1. Downloading and installing Hadoop; Understanding different Hadoop modes. Startup scripts, Configuration files.
2. Hadoop Implementation of file management tasks, such as Adding files and directories, retrieving files and Deleting files
3. Implement of Matrix Multiplication with Hadoop Map Reduce
4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm.
5. Installation of Hive along with practice examples.
7. Installation of HBase, Installing thrift along with Practice examples
8. Practice importing and exporting data from various databases.

**Software Requirements:**

**Cassandra, Hadoop, Java, Pig, Hive and HBase.**

**TOTAL:60 PERIODS**

**TEXTBOOKS:**


1. Michael Minelli, Michelle Chambers, and AmbigaDhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
2. Eric Sammer, "Hadoop Operations", O'Reilley, 2012.
3. Sadalage, Pramod J. “NoSQL distilled”, 2013


**REFERENCES:**


1. E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
2. Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
3. Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
4. Alan Gates, "Programming Pig", O'Reilley, 2011.