4.2

# 4.2 Third Year B.Tech. Electrical Engineering
## Academic Scheme and Course Content
## Year: 2016-17

**Scheme for T.Y.B.Tech. In Electrical Engineering, (Semester - V)**
**Effective from the Academic Year 2016-2017.**

| Sr. No. | Subject | Code | Course Plan for Each Week (Hrs) | | | Credits | Evaluation (Marks) | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Laboratory | Tutorial | | Test 1 | Test 2 | End Semester | | End Semester Weightage (%) | In Semester Evaluation | |
| | | | | | | | | | Marks | Duration (Hrs) | | | |
| 1 | Electromagnetic Fields and Waves | BTE301 | 4 | -- | 2 | 5 | 20 | 20 | 100 | 3 | 60 | 25 | 125 |
| 2 | Control System I | BTE302 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 3 | Electrical Machine II | BTE303 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 4 | Power System Analysis | BTE304 | 4 | -- | 2 | 5 | 20 | 20 | 100 | 3 | 60 | 25 | 125 |
| 5 | Digital Signal Processing | BTE305 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 6 | Power Electronics | BTE306 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | --- | 100 |
| | **Laboratory Work** | | | | | | | | | | | | |
| 1 | Control System I | BTE351 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |
| 2 | Electrical Machine II | BTE352 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Digital Signal Processing | BTE353 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |
| 4 | Power Electronics | BTE354 | | 2 | -- | 1 | | | | | | 25# | 25# |
| | **Total** | | **22** | **8** | **4** | **29** | **120** | **120** | **600** | **--** | **--** | **150** | **750** |

1. Test 1, Test 2 and End semester weightage marks will be added and shown as the theory marks in the mark sheet.Duration of Test 1, Test 2 is of 1 hour.
2. For passing in theory subjects, Student must secure minimum 40% marks in each subject with all heads of passing taken together and minimum 40% marks in the end semester examination
3. Laboratory work is considered as separate head and student must secure 40 % of marks for passing.
4. # Distribution of marks for in semester evaluation will as under, Attendence - 30 %, practical Performed during semester and graded assignment submission/graded drawing sheet submission/ mini project/ graded assignment submission/graded sketchbook submission/graded drawing sheet submission – 40 %, MCQ/Quiz/Practical Examination/presentation and speeches – 30 %

**Scheme for T.Y.B.Tech. In Electrical Engineering, (Semester - VI)**
**Effective from the Academic Year 2016-2017.**

| Sr. No. | Subject | Code | Course Plan for Each Week (Hrs) | | | Credits | Evaluation (Marks) | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Lectures | Laboratory | Tutorial | | Test 1 | Test 2 | End Semester | | End Semester Weightage (%) | In Semester Evaluation | |
| | | | | | | | | | Marks | Duration (Hrs) | | | |
| 1 | Power System Operation and Control | BTE326 | 4 | -- | 2 | 5 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 2 | Control System II | BTE327 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 3 | Communication Engineering | BTE328 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | 25 | 125 |
| 4 | Switchgear and Protection | BTE329 | 4 | -- | -- | 4 | 20 | 20 | 100 | 3 | 60 | -- | 100 |
| 5 | Environmental Engineering and Management System | BTE330 | 2 | -- | 2 | 3 | 10 | 10 | 50 | 2 | 60 | 50 | 100 |
| 6 | Elective | | 4 | -- | 2 | 5 | 20 | 20 | 100 | 3 | 60 | --- | 100 |
| | **Laboratory Work** | | | | | | | | | | | | |
| 1 | Control System II | BTE376 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |
| 2 | Communication Engineering | BTE377 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Switchgear and Protection | BTE378 | -- | 2 | -- | 1 | -- | -- | -- | -- | -- | 25# | 25# |
| | **Total** | | **22** | **6** | **6** | **28** | **110** | **110** | **550** | **--** | **--** | **150** | **200** |

**Elective**

**1 Project Management (BTE331)**

**2 VLSI.: (BTE332)**

1. Test 1, Test 2 and End semester weightage marks will be added and shown as the theory marks in the mark sheet.Duration of Test 1, Test 2 is of 1 hour.
2. For passing in theory subjects, Student must secure minimum 40% marks in each subject with all heads of passing taken together and minimum 40% marks in the end semester examination
3. Laboratory work is considered as separate head and student must secure 40 % of marks for passing.
4. # Distribution of marks for in semester evaluation will as under, Attendence - 30 %, practical Performed during semester and graded assignment submission/graded drawing sheet submission/ mini project/ graded assignment submission/graded sketchbook submission/graded drawing sheet submission – 40 %, MCQ/Quiz/Practical Examination/presentation and speeches – 30 %

| **SEMESTER - V** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE : BTE 301** | **COURSE: Electromagnetic Fields and Waves** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | Credit | **05** | |

*60% Weight age for end semester

**Course Objectives:**

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on concepts of electrostatics, electric potential, energy density and its applications.
3. To impart knowledge on concepts of magneto statics, magnetic flux density, scalar and vector magnetic potential and its applications.
4. Explain time varying electric and magnetic fields and wave theory

**Course Outcomes:**

1. Ability to understand applies basic science, circuit theory, and electromagnetic theory to electrical engg. problems.
2. Able to demonstrate basics of machines and power system through field theory approach.
3. Use numerical techniques and computerized tools to investigate the performance of power system and machine component at different conditions through field theory.

**Course Contents**

| **Module** | **Details** | Hrs |
|---|---|---|
| **1.** | **Vector Basics:**<br>Introduction to Coordinate System: Rectangular, Cylindrical and Spherical Coordinate System, Differential length, area and volume. Introduction to line, Surface and Volume Integrals, Definition of Curl, Divergence and Gradient. | **04** |
| **2.** | **Static Electric Fields:**<br>Coulomb's Law in Vector Form, Definition of Electric Field Intensity, Principle of Super position, Electric Field due to discrete charges, Electricfield due to continuous charge distribution, Electric Field due to line charge, Electric Field on the axis of a uniformly charged circular disc, Electric Field due to an infinite uniformly charged sheet. Electric Scalar Potential, Relationship between potential and electric field, Potential due to infinite uniformly charged line Potential due to electrical dipole , Electric Flux Density, Gauss Law and Applications. | **10** |
| **3.** | **Static Magnetic Fields:**<br>BiotSavart Law in vector form, Magnetic Field intensity due to a finite and infinite wire carrying a current I, Magnetic field intensity on the axis of a circular and rectangular loop carrying a current I, Ampere's circuit allow and simple applications. Magnetic flux density, The Lorentz force equation for a moving charge and applications, Force on a wire carrying a current I placed in a magnetic field, Torque on a loop carrying a current I, | **08** |

| | | |
|---|---|---|
| | Magnetic moment, Magnetic Vector Potential. | |
| **4.** | **Electric and Magnetic Fields in Materials**:<br>Poisson's and Laplace's equation, Electric Polarization, Nature of dielectric materials, Definition of Capacitance, Capacitance of various geometries using Laplace's equation, Electrostatic energy and energy density, Boundary conditions for electric fields, Electric current, Current density, point form of ohm's law, continuity equation for current. Definition of Inductance, Inductance of loops and solenoids, Definition of mutual inductance, simple examples. Energy density in magnetic fields, Nature of magnetic materials, magnetization and permeability, magnetic boundary conditions. | **10** |
| **5.** | **Time varying Electric and Magnetic Fields:**<br>Faraday's law, Maxwell's Second Equation in integral form from Faraday's Law, Equation expressed in point form. Displacement Current, Ampere's circuit allow in integral form, Modified form of Ampere's circuit allow as Maxwell's first, equation in integral form, Equation expressed in point form. Maxwell's four equations in integral form and differential form. | **04** |
| **6.** | **Wave Theory and power flow :**<br>Derivation of Wave Equation, Uniform Plane Waves, Maxwell's equation in Phasor form, Wave equation in Phasor form, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, Plane waves in lossydielectrics, Propagation in good conductors. The importance of characteristics impedance and the propagation constant. The wave travel, the concept of phase velocity and group velocity in wave travel. The voltage standing wave ratio. Travelling wave in transmission lines.**Power Flow:** Poynting Vector and the flow of power, Power flow in a co-axial cable, Instantaneous average and complex Poynting vector. | **10** |
| **7.** | **Introduction to computational Electromagnetic :**<br>Introduction to finite difference method (FDM) and finite element method (FEM) method | **02** |

**Term work:**

Termworkconsists of minimum eight tutorials (at least one on each module) and two Computer programs.

**Text books:**

1. W.Hayt, "Engineering electromagnetic", McGrawHill, 4th edition, 1987.
2. Edminister, "Schaum'sseries in electromagnetic", McGrawHillpublications, 3rd edition.
3. N.NarayanRao, "Elements ofelectromagnetic", PHI publication, 4th edition, 2001.
4. E.C.Jordan&K.G.Balmain,"Electro magneticWaves and Radiating Systems", Prentice
5. Hall of India 2nd edition 2003. (Unit IV, V). McGrawHil

**Reference books:**

1. Fenmann, "Lectures onphysics",Vol–2, Addition Wesley, 1965
2. S.seely, "Introduction to electromagnetic fields", McGrawHill, 1958.
3. David K. cheng, "Field and electromagnetic", Addison Wesley, 2nd edition, 1999.
4. Corson and lerrain, "Electromagnetic", CBS publications, 2nd edition, 1986.
5. Ramo,Whinnery and Van Duzer, "Fields andWavesin Communications Electronics",
1. JohnWiley&Sons (3rd edition 2003)
2. 6.M.N.O.Sadiku, "Elements of Engineering Electromagnetic", Oxford University Press, Third edition.
6. David K. Cherp, "FieldandWave Electromagnetics", Second Edition, Pearson Edition.

7. David J. Grithiths, "Introduction to Electrodynamics", III Edition, PHI.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T 1 | 1 , 2 |
| 2 | T 2 | 3, 4 |
| 3 | END SEMESTER | 1 to 7 |

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| **SEMESTER - V** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE: BTE 302** | **COURSE : Control System- I** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | Credit | **05** | |

*60% Weightage for end semester

**Course Objective:**
Student should learn to;

1. Understand and appreciate the philosophy of control system and difference between manual and automatic control system.Distinguish between open loop and closed loop control system.
2. Represent simple physical system into Linear Time Invariant (LTI) mathematical models for analysis in control system context and identify the various specification used in time domain analysis
3. Comment on the different stability criterion for LTI systems and analyse the system from root locus.
4. Understand the idea of compensator and specifically PID, Lead, Lag and Lag-Lead compensator using the Sketch the root locus.
5. Apply root locus technique to design the various compensators as per the system requirements.

**Course Outcomes:**
Student shall be able to;

1. Convincingly identify the difference between open loop, closed loop, automatic and manual control system.
2. Transform simple physical system into the LTI models and shall be able to quantify system performance in terms of time domain specifications.
3. Comment on the stability of the system given to them by applying various stability criterions.
4. Draw the root locus sketch of the given LTI system and analyse them for various specifications.
5. Explain the need of compensator and appreciate the use of compensator to improve the performance of the LTI system.
6. Design the various compensators for the LTI system as per the given required specifications through root locus sketch and test the designed compensators performance through simulations.

**Course Contents:**

| Module | Details | Hrs |
|---|---|---|
| | **Pre requisite:** Electrical Network. | |
| **1.** | **Concept of Open loop and Closed loop Systems:** Examples and applications of open and closed loop systems. Control system components, Examples | **03** |
| **2.** | **Mathematical Modelling:** Representation of physical system by differential equations. Transfer Function, Block diagram reduction technique, Signal flow graph method | **07** |
| **3.** | **Time response analysis:** Time response Analysis of first order and second order systems. Steady state error and error constants. Design specifications in time domain. | **06** |
| **4.** | **Stability of the System:** Absolute stability and relative stability, Routh Hurwitz's stability criterion. | **06** |
| **5.** | **Root Locus:** Definition, Properties, and Sketching Rules, stability analysis from root locus. Effect of addition of poles and zeros, Sensitivity and root locus | **08** |
| **6.** | **Compensator / Controller**: Elementary ideas of compensating network, PID, Lag, Lead and Lag, lead. | **08** |
| **7.** | **Design via root locus techniques**: Cascade compensation (P, PI, PD, PID, Lag, Lead) and Feedback compensation Design. | **10** |

**Term Work:**

Term work shall consist of minimum 8 Simulations / Practical /demonstrations based on topics such as-

1) Mathematical model of physical systems
2) Time response analysis
3) Stability analysis
4) Design of compensators

**Text Books:**

1. Norman Nise, "Control Systems Engineering",4th Edition 1995
2. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India Pvt.Ltd
3. I.G. Nagrath& M. Gopal, "Control Systems Engineering", Wiley Eastern Ltd 5thEdition, 2000.

**Reference Books:**

1. J.J. D'Azzo, C.H.Houpis and S.N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Marcel Dekker, 2003.
2. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3 |
| 2 | T2 | 4, 5 |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER-V** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE351** | **COURSE:Control System I Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02perbatch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objective:**

Student should learn to;

1. Understand and appreciate the philosophy of control system and difference between manual and automatic control system.Distinguish between open loop and closed loop control system.
2. Represent simple physical system into Linear Time Invariant (LTI) mathematical models for analysis in control system context and identify the various specification used in time domain analysis
3. Comment on the different stability criterion for LTI systems and analyse the system from root locus.
4. Understand the idea of compensator and specifically PID, Lead, Lag and Lag-Lead compensator using the Sketch the root locus.
5. Apply root locus technique to design the various compensators as per the system requirements.

**Course Outcomes:**

Student shall be able to;

1. Convincingly identify the difference between open loop, closed loop, automatic and manual control system.
2. Transform simple physical system into the LTI models and shall be able to quantify system performance in terms of time domain specifications.
3. Comment on the stability of the system given to them by applying various stability criterions.
4. Draw the root locus sketch of the given LTI system and analyse them for various specifications.
5. Explain the need of compensator and appreciate the use of compensator to improve the performance of the LTI system.
6. Design the various compensators for the LTI system as per the given required specifications through root locus sketch and test the designed compensators performance through simulations.

**List of Experiments:**

1. Simulate the various first order, second order and higher order open loop system and observe the performance of the systems.
2. Simulate the simple open loop and closed loop transfer functions and observe the effect of feedback on system performances and comment on the difference.
3. Simulate the typical second order system for various combinations of damping ratio and natural frequency of oscillations. Note down the various observations and verify them with hand calculations.
4. Simulate to plot the root locus of different transfer functions representing various systems and note down the observations from the root locus. Verify them by plotting them in time scale.
5. Design the PI, PD and PID controller for meeting the required specifications through Root Locus and verify them through time domain simulations.
6. Design the Lag, Lead and Lag-Lead compensator for meeting the required specifications through Root Locus and verify them through time domain simulations.
7. Observe through simulations effect of changing gains if PID controller and comment on the observations.

| **SEMESTER - V** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE : BTE 303** | **COURSE: Electrical Machines II** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | 02 | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | Credit | **05** | |

*60% Weightage for end semester

**Course Objectives:**

1. Discuss the principle and operation of generating machine both 1-phase and 3-phase
2. Demonstrate the behaviour of generating and motoring machine for different operating conditions.
3. To demonstrate the principle of fractional kilowatt machine
4. Discuss the special types of machines and applications (motors and generators)

**Course Outcomes**

1. Able to understand the fundamental concept of electrical machine in electrical power generation
2. Students will be able to analyseelectrical machine performance using trigonometry, complex algebra, and phasors to find correct solutions.
3. Students should be able to apply the knowledge of basic machines to understand the operation of special machines

**Course Contents**

| **Module** | **Details** | **Hrs** |
|---|---|---|
| **1.** | **Synchronous Machines**:<br>Construction, emf induced, winding factors, Armature reaction, Phasor diagrams of cylindrical pole synchronous generator at different power factor | **04** |
| **2.** | Methods of voltage regulation of alternator. | **08** |
| **3.** | (i) Principle of operation of Synchronous Motor, starting methods.<br>Power flow and maximum power of synchronous machines,<br>(ii) Excitation & power circles,V& O curves, power angle characteristics, synchronizing | **08** |

| | | |
|---|---|---|
| | power and torque, hunting, synchronous condenser | |
| **4.** | Operation on infinite bus for a change in excitation for motors and generators, Parallel operation of alternators,Load sharing | **06** |
| **5.** | **Salient pole machine**: Blondel's two reaction theory, Measurement of $X_d$&$X_q$, Power flow equation. | **06** |
| **6.** | **Fractional kW machines:** Construction, principle of operation. and applications of Single phase induction motor, capacitor start, capacitor run motor, Shaded pole motor. | **08** |
| **7.** | **Special purpose Machines:** Construction, principle of operation and applications of Stepper motor and their types, Permanent Magnet Synchronous Motor, Brushless DC motor. | **08** |

**Term-work:-**

Term work shall consist of minimum six practicals and one mini project/seminar
( in group of maximum 5 students).

**Text Books:**

1. Nagrath and Kothari, "Electrical Machines", TMH Publication, 4th edition, 2010.
2. Sen P. C., "Principles of Electric Machines & Power Electronics", 2nd edition, 2007.
3. Bimbhra P.S, "Electrical Machinery", Khanna Publisher, VII Edition.
4. Bimbhra P.S., "Generalized Theory of Electrical Machines", Khanna Publisher, 5th Edition.
5. Gross Charles A., "Electrical Machines", CRC Press, 2007.

**Reference Books:**

1. M. G. Say, "Performance and Design of AC Machines", CBS Publisher
2. Fitzgerald et. al, "Electrical Machinery", Mc Hill Publication, 6th edition
3. Theodore Wildi, "Electrical Machines, Drives, and Power System", Pearson Education, 6th edition, 2007

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3(i) |
| 2 | T2 | 3(ii), 4, 5 |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER-V** | **CLASS: S.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE352** | **COURSE: Electrical Machines–II Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02perbatch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objective:**

1. Discuss the principle and operation of generating machine both 1-phase and 3-phase
2. Demonstrate the behaviour of generating and motoring machine for different operating conditions.
3. To demonstrate the principle of fractional kilowatt machine
4. Discuss the special types of machines and applications (motors and generators)

**Course Outcomes**

1. Able to understand the fundamental concept of electrical machine in electrical power generation
2. Students will be able to analyse electrical machine performance using trigonometry, complex algebra, and phasors to find correct solutions.
3. Students should be able to apply the knowledge of basic machines to understand the operation of special machines

**List of Experiments:**

1. Voltage Regulation of synchronous generator by EMF/MMF method
2. Voltage Regulation of synchronous generator synchronous generator by ZPF
3. Voltage Regulation of synchronous generator synchronous generator ASA Method
4. Slip Test on salient pole synchronous generator
5. VF-curves of synchronous motor
6. Performance characteristics of single phase induction motor

| **SEMESTER - V** | **CLASS: T.Y. B. Tech. Electrical** | | |
|---|---|---|---|
| **CODE : BTE 304** | **COURSE: Power System Analysis** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Course Objectives:**

1. To represent an unbalanced three phase power system.
2. To study the behavior of the system under symmetrical and unsymmetrical fault condition.
3. To perform load flow studies in the system.
4. To establish the steady state and transient stability of the system.
5. To understand travelling wave phenomena.

**Course Outcomes**

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

1. compare the fault current for different types of the fault on the system.
2. formulate $Y_{bus}$ for a connected system and classify different types of buses and implement different methods of of performing load flow studies.
3. implement different methods classify and analyze system stability issues.
4. analyze behavior of the power system during high frequency transient.

**Course Contents**

| **Module** | **Details** | **Hrs** |
|---|---|---|
| | **Pre-requisite:** Graph Theory, Numerical Techniques, Per Unit system | |

| | | |
|---|---|---|
| **1.** | **Symmetrical Components:** Unbalanced system Analysis using symmetrical components, Power in terms of symmetrical components, Sequence circuits of transmission lines, transformer and Synchronous Machines, Phase shift in star delta transformer, Formation of Sequence Networks. | **6** |
| **2.** | **Symmetrical and Unsymmetrical Fault Analysis:**<br>(i)3 phase Short circuit of a synchronous machine: no load and loaded conditions, 3 phase fault on a transmission line, Short circuit MVA Capacity of a bus.<br>(ii) Fault analysis using symmetrical components, Single line to ground (SLG) fault, Line to line (LL) fault, Double line to ground (LLG) fault, Open conductor fault. | **12** |
| **3.** | **Admittance Model, Impedance Model and Network Calculation:**<br>Nodal admittance matrix, Network incidence matrix and $Y_{bus}$, Review of Gaussian Elimination, Triangular Factorization (LU Decomposition), Sparsity and Optimal ordering, Bus Admittance and Impedance Matrices, Calculation of $Z_{bus}$ from $Y_{bus}$ | **8** |
| **4.** | **Load Flow Studies:** Power Flow Problem, Gauss Seidel (GS) method, Newton Raphson (NR) method, Decoupled & Fast Decoupled method, Comparison of different load flow methods. | **8** |
| **5**. | **Power System Stability:** Classification of Stability, Dynamics of synchronous machine, Power angle equation , Node elimination technique, Stability study of simple systems, Steady state stability. | **05** |
| **6.** | **Transient stability:** Equal area criteria and its applications, Numerical Solution of Swing Equation. Factors affecting Transient Stability. | **05** |
| **7.** | **Travelling waves intransmission lines:**wave equation, reflection and refraction of waves, Bewely Lattice Diagram, typical casesof line terminations. | **04** |

**Term-work:-**

Term work shall consist of six tutorials covering the entire syllabus and minimum two computer programs or simulations.

Recommended Simulation software: MATLAB, ETAP, Virtual Lab.

For Virtual Lab access refer web link www.vlab.co.in

**TextBooks:**

1. Kothari D. P NagrathI. J., "Modern Power System Analysis", TMH Publications, 3rd Ed. 2008.
2. WadhawaC. L., "Electrical Power Systems", New Age International, 4thEdition, 2007.
3. Grainger J. J., Stevenson JrW. D., "Power System Analysis", McGRAW-HILLInternational
4. George Kausic., "Computer Aided Power System Analysis", Prentice Hall Pub.2008.

**ReferenceBooks:**

1. SaadatHadi, "Power System Analysis, "TMH Edition, 2003.
2. PrabhaKundur, "Power System Stability and Control'', TMH Publication, 2008
3. *www.cdeep.iitb.ac.in/nptel/Electrical Engineering/Power System Protection*

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2(i) |
| 2 | T2 | 2(ii), 3 |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER - V** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE: BTE 305** | **COURSE: Digital Signal Processing** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | 02 | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Rationale:**
Digital Signal Processing (DSP) techniques can be traced to the 17th century when finite difference methods, numerical integration methods, and numerical interpolation methods were developed to solve physical problems involving continuous variables and functions. There has been tremendous growth since then and today digital signal processing techniques are applied in almost every field, such as telecommunications, military, consumer electronics, instrumentation and control, image processing, speech processing, medicine, seismology, etc. The course intends to introduce basics of signals, systems, signal manipulations, and various transforms and their applications in Electrical Engineering.

**Prerequisite**:
1. Knowledge of basics of signals, systems, signal manipulations, systems representations, etc.
2. Introduction to concepts of convolution, stability, mapping from s-place to z-plane, various tools of analysis of systems such as z-transform, Fourier transform, etc.
3. Understanding of system representation in time domain and frequency domain, relation between difference equations, z-transform and Fourier transform.
4. Knowledge of basics of MATLAB.

**Course Objectives:**
In this course students are expected to:
1. Get familiarized with representation of real world signals in digital format and understand transform-domain (Fourier and z-transforms) representation of the signals;
2. Learn the relationship between transforms such as ZT, DTFT, DFT, and calculate those for various signals;
3. Learn designing and applications of different types of filters and their real-time implementation.
4. Understand simulation of various signal processing operations and systems using programming

languages such as MATLAB;

**Course Outcomes:**
After completion of this course students are expected to be able to:
1. Understand analysis of signals & systems in time domain and transform domain.
2. Learn basic signal processing operations such as DTFT, DFT, FFT, etc. required in various practical electrical, electronics systems such as speech processing, image processing etc.
3. Design various electrical filters suitable for each real world application.
4. Implement various signal processing systems in high level programming languages such as MATLAB.

| Unit | Contents | Hrs. |
|---|---|---|
| **1** | Review of Discrete-time signals and systems<br>Review of time-domain analysis of discrete-time systems | 2<br>2 |
| **2** | **Frequency domain analysis of LTI Systems**<br>• Introduction<br>• Frequency domain representation of discrete-time signals and systems.<br>• Relation between difference equations, z-transform and Fourier transform.<br>• DTFT<br>• Frequency domain analysis of systems using analytical and graphical techniques.<br>• Plotting magnitude and phase response of discrete-time LTI systems.<br>• System classification such as LPF, HPF, BPF, BSF, etc based on pass-band characteristics.<br>• System classification such as Minimum phase, Maximum phase, mixed phase, linear phase based on phase response. | <br><br><br>1<br><br>1<br>2<br><br><br>1 |
| **3** | **Discrete Fourier Transform**<br>• Introduction<br>• Discrete Fourier series and its properties.<br>• Relation between z-transform, DTFT and DFT.<br>• DFT, IDFT definition and calculations of DFT and IDFT coefficients.<br>• Introduction to twiddle factor, zero padding.<br>• Properties of DFT<br>• Circulation convolution, comparison between linear and circulation convolution, circulation convolution using graphical and analytical method.<br>• Circulation convolution using DFT / IDFT<br>• Response of LTI system (linear convolution or linear filtering) using circulation convolution<br>• Response of LTI system (linear convolution or linear filtering) using DFT / IDFT | <br><br><br>1<br>1<br>1<br>2<br>2<br><br>1<br><br>1<br><br>1 |
| **4** | **Fast Fourier Transform Algorithms**<br>• Introduction<br>• Comparison of computation complexity of direct computation of DFT and FFT.<br>• Radix-2 Decimation in Time algorithm, 4-point and 8-point DFT<br>• Radix-2 Decimation in Frequency algorithm, 4-point and 8-point DFT<br>• IDFT using FFT algorithms. | <br><br>1<br>1<br>1<br>1 |

| | | |
|---|---|---|
| | • Circular convolution using FFT algorithms. | 1 |
| **5** | **Linear Phase FIR Systems**<br>• Introduction<br>• Condition for linear phase, need, advantages, properties.<br>• Systems having symmetric and antisymmetric impulse response.<br>• Frequency response of four types linear phase FIR systems having symmetric and antisymmetric impulse response with even and odd lengths.<br>• Location of zeros for linear phase FIR systems. | <br><br><br>1<br>2<br>1 |
| **6** | **FIR Filter Designing**<br>• Introduction: Linear Phase FIR Filters, Frequency response of different types of linear phase FIR Filters, Locations of definite zeros of different types of FIR Filters.<br>• Designing of FIR filters using windowing technique, Gibbs Phenomenon (Hamming, Hanning, Rectangular, Bartlett window functions)<br>• Designing of FIR filters using Kaiser Window Function<br>• Designing of FIR filters using frequency sampling technique, frequency sampling realization of FIR Filters,<br>• Half Band FIR Filers. | <br><br>2<br><br>3<br><br>3 |
| **7** | **IIR Filter Designing**<br>• Introduction<br>• Designing of analog IIR filters using Butterworth, Chebyshev and inverse Chebyshev approximation<br>• Analog to analog spectral transformations,<br>• Designing of IIR digital filters using impulse invariance method, stability properties, effects of aliasing. Designing IIR digital filters using step invariance method, ramp invariance method.<br>• Designing of IIR digital filters using bilinear transformation method, stability properties. Designing of IIR digital filters using matched z-transformation method, backward difference algorithm. | <br><br><br>1<br><br>1 |

**Books Recommended:**

1. Digital Signal Processing, Oppenheim &Scaffer, Prentice Hall of India, 2nd Ed.
2. Digital Signal Processing, Proakis, Manolakis, Tata McGraw Hill, 3rd Ed.
3. Digital Signal Processing, P. Ramesh Babu, Scietch Pub., 3rd Ed.
4. Digital Signal Processing, S. Salivahanan, et. al., Tata McGraw Hill, 2nd Ed.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3 |
| 2 | T2 | 4, 5 |
| 3 | END SEMESTER | 1 to 7 |

| | | | |
|---|---|---|---|
| **SEMESTER-V** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
| **CODE:BTE353** | **COURSE: Digital signal Processing Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02perbatch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objective**

In this course students are expected to:

1. Get familiarized with representation of real world signals in digital format and understand transform-domain (Fourier and z-transforms) representation of the signals;
2. Learn the relationship between transforms such as ZT, DTFT, DFT, and calculate those for various signals;
3. Learn designing and applications of different types of filters and their real-time implementation.
4. Understand simulation of various signal processing operations and systems using programming languages such as MATLAB;

**Course Outcomes**

After completion of this course students are expected to be able to:

1. Understand analysis of signals & systems in time domain and transform domain.
2. Learn basic signal processing operations such as DTFT, DFT, FFT, etc. required in various practical electrical, electronic systems such as speech processing, image processing etc.
3. Design various electrical filters suitable for each real world application.
4. Implement various signal processing systems in high level programming languages such as MATLAB.

**List of Experiments:**

Term work consists of any five programs/simulations of the following in MATLAB.

1. Plotting magnitude and phase response of system (DTFT).
2. Calculation of DFT.
3. Calculation of IDFT.
4. Linear convolution using DFT / IDFT method.
5. Circulation convolution.
6. Circular convolution using DFT / IDFT.
7. Linear convolution using Circular convolution.
8. Implementation of IIR analog LPF, HPF using Butterworth approximation.
9. Implementation of IIR analog LPF, HPF using Chebyshev approximation.
10. Implementation of IIR analog LPF, HPF using inverse Chebyshev approximation.
11. Implementation of FIR filters using any window function such as Rectangular, Bartlett, Blackman, Hamming, Hanning, etc.

| | | | |
|---|---|---|---|
| **SEMESTE - V** | **CLASS: T.Y.B.Tech. Electrical** | | |
| **CODE: BTE306** | **COURSE: Power Electronics** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Course Objectives:**

1. Revise diode rectifiers
2. Explain controlled converters
3. Analyze current and voltage inverters and demonstrate the operation and control of inverter circuits
4. Discuss DC to DC converters
5. Explain AC to AC converter circuit

**Course Outcomes**

By learning this course students can

1. Understand difference in power and linear electronics
2. Analyze controlled and uncontrolled rectifiers
3. Understand phase control concept
4. Apply power factor improvement knowledge in real system

5. Construct chopper circuit and inverter circuit

**Course Contents:**

| Module | Details | Hrs |
|---|---|---|
| **1.** | **Silicon Controlled Rectifiers:**<br>Principle of operation of SCR, Static & Dynamic characteristics, Gate characteristics, pulse firing | **03** |
| **2.** | **Other Switching Devices:**<br>Principle of operation, characteristics, rating and applications of Triac, MOSFET, IGBT and power diodes, GTO.Comparison of devices on the basis of turn on, turn off time. | **07** |
| **3.** | **Rectifiers:**<br>Introduction to Half wave uncontrolled and controlled rectifiers with differnt load<br>Full wave controlled rectifiers with different load (single phase and three phase)<br>Power factor improvements in rectifiers.<br>Effect of load and source inductances | **06** |
| **4.** | **AC Filters:**<br>AC filter for grid connected converter, AC inductor design and need of LCL filter, LCL filter design | **06** |
| **5.** | **Inverters:**<br>(i) Principle of operation, Performance parameters, Single phase bridge Inverters with R-L, R-L-E and pure L load. 3 phase bridge Inverters: 180 degree conduction mode.<br>(ii) Voltage control of single phase and three phase inverters using PWM techniques, Connection of three phase inverter to grid, concept of active and reactive power flow between inverter and grid<br>(iii) Current source inverters<br>(iv) Space vector modulation | **12** |
| **6.** | **Choppers:**<br>Switching mode regulators – Buck, Boost, Buck-Boost and Cukregulators,Bi-directional chopper | **08** |
| **7.** | **AC Voltage Controllers:**<br>Principle of Phase Control, Single Phase bidirectional control with R-L load, Three phase full wave controllers, AC voltage controllers with PWM control, Applications | **06** |

**Term Work:-**

Term Work shall consist of minimum eight practicals covering the entire syllabus and two computer programs orsimulations.

**Text Books:**

1. Muhammad H. Rashid, “Power Electronics, Circuits Devices and Applications”, Third Edition, Prentice-Hall of India, 2006
2. Ned Mohan et. al,“Power Electronics: Converters, Applications and Design”, 3rd Ed., John Wiley Pub.
3. Alok Jain, “Power Electronics & its Applications,” Penram International Publishing (India) Pvt. Ltd.

**Reference Book:**

1. Cyril W. Landers, "Power Electronics", McGraw Hill, 1993
2. M. D. Singh, K. B. Khanchandani, "Power Electronics"Tata McGraw Hill, 2003
3. P.C.Sen, "Power Electronics", Tata McGraw-Hill Education, 2001
   Related Websites
4. A.V.d. Bossche and V. C. Valchev, "Inductor and Transgormer for power electronice". Boca Raton : Taylor and Francis,2005
5. W.G. Hurley and W.H. Wolfle, "Transformer and Inductor for power Electronics : theory ,design and applications" , 1st edition.Somerset ,NJ, USA : John Wiley and sons 2013.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3 |
| 2 | T2 | 4, 5(i) |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER-V** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE354** | **COURSE: Power Electronics Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02 per batch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objective**

1. Revise diode rectifiers
2. Explain controlled converters
3. Analyze current and voltage inverters and demonstrate the operation and control of inverter circuits
4. Discuss DC to DC converters
5. AC to AC converter circuit
6.

**Course Outcomes**

By learning this course students can

1. Understand difference in power and linear electronics
2. Analyze controlled and uncontrolled rectifiers
3. Understand phase control concept
4. Apply power factor improvement knowledge in real system
5. Construct chopper circuit and inverter circuit

**List of Experiments:**

1) Half wave diode converter
2) Half wave S.C.R. converter
3) Single phase Full wave fully controlled S.C.R. converter with resistive load.
4) Single phase Full wave fully controlled S.C.R. converter with RL load.
5) 3 phase full wave fully controlled S.C.R. converter with resistive load
6) Separately excited DC motor speed control using Dual Converter
7) Single phase Inverter
8) 2 Matlab simulations of uncontrolled & controlled converters

# Third Year B.Tech.
# Electrical Engineering

## Academic Scheme and Syllabus
## Year: 2016-17

## SEM VI

| **SEMESTER - VI** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE : BTE326** | **COURSE: Power System Operation and Control** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Course Objectives:**

1. To review the effect of different equipment constraints on operation of power system.
2. Discuss the effect of change in load on the frequency and also to study the effect of change in frequency on the active power.
3. Study the effect of reactive power on the voltage.
4. Methods to control the reactive power and the active power of the system.

**Course Outcomes**

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

1. Describe the effects equality constraints and inequality constraints on the operation of the power system.
2. Discuss the methods of controlling frequency of the system.
3. List different methods of compensating a system to maintain voltage of the system andCompare different methods to control power flowing through the tie line.
4. Select the generators for optimal load scheduling.
5. Illustrate the deregulated structure of the power system.

**Course Contents:**

| **Module** | **Details** | **Hrs** |
|---|---|---|
| | **Pre-requisite:** Performance of lines, load flow, Stability of power system. | |
| **1.** | **Equipment and Stability Constraints in System Operation:** Generator constraints, generator capability curves, transmission line constraints,thermal and dielectric limitations of a transmission line, effect of loading on voltages, power transmission capability versus distance, stability problems in power systems, large disturbance angle stability, voltage instability. | 10 |

| | | |
|---|---|---|
| **2.** | **Voltage and Reactive Power Flow Control:**<br>Power flow through transmission line, circle diagram,<br>Production and absorption of reactive power, means of voltage control in power systems, generator excitation systems and reactive power characteristics of power system components | 08 |
| **3.** | Introduction to reactive power characteristics of special devices such as HVDC converters, static var compensators etc. | 06 |
| **4.** | **Power Flow Control:**<br>Series compensation of lines**,** thyristor controlled series compensator**,** phase shifting transformers, ac-dc-ac conversion,dc link vs TCSC controlled ac link. | 08 |
| **5.** | **Frequency Control in a Power System:**<br>(i) Relationship between generator rotor speeds and "system frequency" during transients,<br>(ii) Calculation of system frequency, frequency control, speed governor, automatic generation control (AGC). | 08 |
| **6.** | **Real Power Scheduling:**<br>Constraints on system operation, real power scheduling, merit order dispatch, economic dispatch, some issues in economic dispatch optimal power flow. | 06 |
| **7.** | **Structure of a Deregulated Industry:**<br>Power system structure, the reasons for restructuring, structure of a deregulated industry. Different entities in a deregulated industry, Indian scenario. | 02 |

**Term Work:-**

Term Work shall consist of minimum six tutorials covering the entire syllabus and two computer programs or simulations.

**Text Books:**

1. Kothari. D. P, Nagrath. I. J., "Modern Power System Analysis", TMH Publication, Third Edition, 2008.
2. www.cdeep.iitb.ac.in/nptel/Electrical Engineering/Power System Operation and Control
3. Chakrabarti .A, Halder. S, "Power System Analysis- Operation and Control", PHI, Second Edition 2008
4. PrabhaKundur,"Power System Stability and Control", TMH Publication, 2008.

**Reference Books:**

1. Hingorani N.G.., "Understanding of Facts", Wiley Publications, 2013.
2. Allen. J. Wood., Bruce. F. Wollenberg, "Power Generation operation and Control", Wiley India, 2nd Ed., 2007.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2(i) |
| 2 | T2 | 2(ii), 3, 4 |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER - VI** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE : BTE 327** | **COURSE: Control System- II** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Course Objectives:**

Student should learn to;

1. Sketch, understand and analyse Polar plot, Nyquist plot and Bode plot for LTI system.
2. Appreciate the stability concepts Gain margin and Phase Margin in analysing LTI system in frequency domain.
3. Distinguish between frequency domain and time domain specifications and learn to find relation among them.
4. Design the compensator like Leg, Lead and Lag-Lead to satisfy the given requirements through the Bode Plots.
5. Represent the simple system into state space model and define various forms of state model.
6. The meaning of State trajectory and relationship between state model and transfer function in case of a linear system.
7. The concept of Similarity transformation and its invariance properties.
8. Find the solution of state model and understand the concept of Eigen values, Eigen vectors, state transition matrix, Generalized Eigen Vector and Modal Matrix.
9. The technique to transfer any state model to canonical form using Modal Matrix.
10. The concept of Controllability and Observability and techniques to determine the for LTI model.
11. The methods for design of controller i.e. pole placement technique to meet the specific requirements as well as design the observer while appreciating the importance of observer.

**Course Outcomes:**

After completion of the course student will be able to;

1. Sketch the Polar plot, Nyquist plot and Bode of a given system and analyse them in frequency domain by finding frequency domain specifications and stability margins and find the compensator for a given specifications by designing them using Bode Plot as tool and verify the design through simulations.

2. Represent the simple physical system into state model and will be able to explain invariance of stability properties under similarity transformation.
3. Provide solution of given state space model through different methods and simulate the state trajectories in Matlab.
4. Transform simple linear state model into canonical i.e. diagonalized state model.
5. Find the controllability and observability of LTI state model.
6. Design the various controllers for the LTI state model as per the given required specifications through pole placement technique and verify the design through simulation in Matlab.
7. Design the Observer for the system whose state variable is not accessible and verify the design through simulations in Matlab.

**Course Contents:**

| Module | Details | Hrs |
|---|---|---|
| | **Pre-requisite** : Electrical Network, Control System- I | |
| 1 | **Frequency response Analysis:**Nyquist plot, Polar Plot and Bode plot. Frequency Domain Specifications. Principal of Argument, Nyquist Stability criterion for minimum phase system. Gain Margin and Phase Margin concept in Nyquist plot and bode plot. | 08 |
| 2 | Design specification in frequency domain and their co-relation with time domain Design via Frequency response techniques**:** Transient and steady state compensation by gain, lag, lead and lag-lead compensator through Bode Plot. | 12 |
| 3 | **State Variable Analysis:**Concept of state, state variables and state model. Concept of state space, state trajectory and Vector matrix representation of state model. Physical, phase and canonical state space representation. Transfer function from state model. | 04 |
| 4 | Similarity transformation. Invariance properties of Similarity transformation. Controllability canonical form, Observability Canonical form, Diagonal Canonical Form and Jordan Canonical Form. | 05 |
| 5 | Solution of state equation. State Transition Matrix (STM): Significance and Properties. Evaluation of STM. Characteristics equation, Eigen Values, Eigen Vectors, Generalized Eigen Vector and Modal Matrix. Diagonalization of a square Matrix. Stability in State Space. | 05 |
| 6 | Controllability and Observability concept. Gilbert and Kalman test for controllability and Observability. Invariant theorems on controllability and observability. | 02 |
| 7. | Controller Design (Pole Placement technique) in state space. Observer: Concept and requirement analysis. Observer Design. | 12 |

**Term Work:**

Term work shall consist of minimum 8 Simulations / Practical's /demonstrations based on topics such as-

1. State variable representation of physical systems
2. Representation of physical systems using Z transforms
3. Frequency response analysis
4. Design of controllers

**Text Books:**

1. Norman Nise, "Control Systems Engineering", Wiley students Edition, 4th Edition, year
2. Jacqueline Wilkie, et al, "Control Engineering an Introductory course", Palgrave, 1st Edition, 2002
3. K.Ogata, "Modern Control Engineering", Prentice Hall, 4th Edition
4. I.G Nagrath and M.Gopal, "Control Systems Engineering ", Wiley Eastern Limited, 5th Edition,

**Reference Books:**

1. J.J D'Azzo et al "Linear Control System Analysis and Design with MATLAB", Marcel Dekker, 2003.
2. G.F Franklin, "Feedback Control of Dynamic Systems", Pearson higher Education, 2002.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3(i) |
| 2 | T2 | 3(ii), 4, 5(i) |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE376** | **COURSE: Control system II Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02 per batch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objectives:**

Student should learn to;

1. Sketch, understand and analyse Polar plot, Nyquist plot and Bode plot for LTI system.
2. Appreciate the stability concepts Gain margin and Phase Margin in analysing LTI system in frequency domain.
3. Distinguish between frequency domain and time domain specifications and learn to find relation among them.
4. Design the compensator like Leg, Lead and Lag-Lead to satisfy the given requirements through the Bode Plots.
5. Represent the simple system into state space model and define various forms of state model.
6. The meaning of State trajectory and relationship between state model and transfer function in case of a linear system.
7. The concept of Similarity transformation and its invariance properties.
8. Find the solution of state model and understand the concept of Eigen values, Eigen vectors, state transition matrix, Generalized Eigen Vector and Modal Matrix.
9. The technique to transfer any state model to canonical form using Modal Matrix.
10. The concept of Controllability and Observability and techniques to determine the for LTI model.
11. The methods for design of controller i.e. pole placement technique to meet the specific requirements as well as design the observer while appreciating the importance of observer.

**Course Outcomes:**

After completion of the course student will be able to;

1. Sketch the Polar plot, Nyquist plot and Bode of a given system and analyse them in frequency domain by finding frequency domain specifications and stability margins and

find the compensator for a given specifications by designing them using Bode Plot as tool and verify the design through simulations.

2. Represent the simple physical system into state model and will be able to explain invariance of stability properties under similarity transformation.
3. Provide solution of given state space model through different methods and simulate the state trajectories in Matlab.
4. Transform simple linear state model into canonical i.e. diagonalized state model.
5. Find the controllability and observability of LTI state model.
6. Design the various controllers for the LTI state model as per the given required specifications through pole placement technique and verify the design through simulation in Matlab.
7. Design the Observer for the system whose state variable is not accessible and verify the design through simulations in Matlab.

**List of Experiments:**

1. Simulate the various first order, second order and higher order open loop system for frequency domain and observe the performance of the systems in frequency domain context.
2. Simulate the typical second order system for various combinations of damping ratio and natural frequency of oscillations through frequency domain and observe frequency domain specifications. Note down the various observations and verify them with hand calculations.
3. Simulate to observe Polar plot, Bode plot and Nyquist plot for various transfer functions and note down the observations and verify them through calculations. Also note down Gain Margin and Phase Margin observations in Bode and Nyquist plot.
4. Design the Lag, Lead and Lag-Lead compensator for meeting the required specifications through Bode Plot and verify them through time domain simulations.
5. Simulate various orders linear state space model for solution of state equation for different nature of input. Observe and note the nature of state trajectory, write your comments and conclusion based on eigen values of the state model.
6. Choose various state models for understanding the concept of Controllability and Observability and note down your observations.
   Observe the nature of Eigen values and Eigen Vector of the system.
7. Design the controller using complete state feedback to meet the requires specifications and verify them using simulations.
8. Design the observer for estimating the full states of the system and simulate the same.
9. Design the controller using full state feedback from the observer and simulate the same.

| | | | |
|---|---|---|---|
| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
| **CODE:BTE328** | **COURSE:Communication Engineering** | | |
| Periodperweek (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | InSemester | 01 | 20*2 |
| | EndSemester* | 03 | 100 |
| | Tutorial | --- | ---- |
| | LaboratoryWork(Journal) | | |
| | TOTAL | | 100 |

*60%Weightageforendsemester

**CourseObjectives:**

1. Discuss concepts of analog and digital modulation /demodulation.
2. Explain the importance of information theory.
3. Demonstrate with case study error detection/ correction code.
4. Overview of computer networking.

**CourseOutcomes:**

1. Incorporate different communication technologies.
2. Understand network and transport layer system, network security applications.
3. Appreciate importance of wireless sensors and cryptography.

**Course Contents:**

| Module | Details | Hrs. |
|---|---|---|
| 1 | **Basics of communication –**<br>Introduction, Components of communication systems, Data representation, Bandwidth, Bit rate, Baud rate, Transmission of digital signals. | **02** |
| 2 | **Analog and Digital Communication**<br>Analog modulation – AM, FM, PM<br>Digital modulation – ASK, FSK, PSK, QAM, PCM, DM<br>Information theory – Information, Entropy, Rate of information, Channel capacity, Shannon theorem, Huffman coding<br>Channel Coding – Linear block code, Cyclic code, Convolution code. | **12** |

| | | |
|---|---|---|
| **3** | **Utilization of Media Bandwidth**<br>Guided and unguided media – Twisted pair cable, Coaxial cable, Fiber optic, Radio waves, Microwaves, Infrared waves, Light waves,<br>Multiplexing – FDM, TDM<br>Spreading – DSSS, FHSS,<br>Introduction to networking. | **06** |
| **4** | **Small Area Networks**<br>Concept of LAN communication,<br>Wired & wireless LAN technologies – Ethernet, Serial communication standard (RS485), IEEE 802.11 (Wi-Fi) standard,<br>Concept of PAN communication,<br>Wired & wireless PAN technologies – Serial communication standards (USB, RS232), ZigBee, Bluetooth, Infrared.<br>. | **07** |
| **5** | **Large Area Networks :**<br>Concept of MAN communication,<br>Wired & wireless MAN technologies – Telephone Networks, Dial-up, DSL, Cable TV, PLCC, IEEE 802.16 (Wi-MAX) standard,<br>Concept of WAN communication,<br>Wired & wireless WAN technologies – SONET/SDH, Cellular networks, Satellite networks. | **07** |
| **6** | Wireless sensor networks, Data dissemination, Data gathering, sensor management, localization, conventional encryption, cipher-block, location of encryption devices, key distribution, public key cryptography.<br>RSA algorithms, Diffie-Hellman algorithms, message authentication, secure hash<br>function, HMAC, digital signature, key management, Secret key cryptography, DES, IDEA, AES. .<br>Network security applications, Authentication applications, email security, PGP, SMIME IP Security, authentication on header, encapsulating security payload, combining security associations, key management, web security requirements, SSL, TSL, SET | **10** |
| **7** | **Applications**<br>Communication aspect of smart grid, Home Automation Networks (HANs), Automatic Metering Infrastructure (AMI), Line protection, Substation automation, Remote monitoring. | **04** |

**Books**

1. Behrouz A. Forouzan, “Data Communications and Networking”, 4th Edition, 2007, McGraw-Hill publication.
2. Simon Haykin, “Communication Systems”, 5th Edition, Wiley publication.
3. Theodore S. Rappaport, “Wireless Communications: Principles & Practice”, 2nd Edition, 2002, Prentice Hall
publication
4.Ramjee Prasad and Luis Munoz, WLAN's and WPAN's towards 4G wireless, Artech House 2003
5. William Stallings, Cryptography and Network Security, 3rd Edition Pearson Education

**6.** R. P. Singh, S. D. Sapre, "Communication Systems: Analog & Digital", 3rd EditionMcGraw-Hill publication.

| SR.NO. | EXAMINATION | MODUL |
|---|---|---|
| 1. | T1 | 1,2,3 |
| 2. | T2 | 3,4,5, |
| 3. | ENDSEMESTER | 1 to 7 |

| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE377** | **COURSE: Communication Engineering** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02perbatch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objective**

1 Introduction to Analog and Digital Modulation.
2 Introduction to source and channel coding.
3 Overview of computer networking

**Course Outcomes**

1 Understand different modulators/demodulators.
2 Understand source and channel coding, cryptography algorithms through simulations.
**3** Incorporate different communication technologies with mini project.

**List of Experiments:**

Part A: Study of analog and digital modulator/demodulators.

1. Amplitude modulation
2. Frequency Modulation
3. Amplitude shift keying
4. Frequency shift keying
5. Phase shift keying
6. Pulse code modulation

7. Delta modulation

Part B: Simulations

1. Huffman coding
2. Channel coding (Linear block code)
3. Channel coding (Cyclic code)
4. Cryptography algorithm.

Part C: Mini project.

| **SEMESTER- VI** | **CLASS: T.Y.B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE: BTE329** | **COURSE: Switchgear and Protection** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | 02 | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | Total | --- | 125 |
| | **Credit** | **05** | |

* 60% Weightage for end semester

**Course Objectives:**

1. Discuss the art and science of power system protection.
2. Demonstrate the relaying practices.
3. Introduce the fundamentals of overvoltage protection and protection scheme for transmission lines , transformer, generator and motor
4. Discuss the principle and operation of HV and LV circuit breakers.

**Course outcomes**

**At the completion of this course, students will be able to**

1. Appreciate knowledge in instrument transformers
2. Evaluate performance of unit protection and system protection with hands on practice
3. Demonstrate &design the relevant protection scheme for the elements of a power system.
4. Appreciate field of switchgear and Exposure to the modern protection practices

**Course Contents:**

| **Module** | **Contents** | **Hrs** |
|---|---|---|
| | **Pre-requisite :**Fault Analysis | |
| **1.** | **Fundamentals of Protection:** Basic objective of system protection, Typical relay and relaying system, basic construction of electromagnetic, static and digital relays, Introduction to Numerical relay, Protective zones, Primary and backup protection, Desirable qualities. | **10** |

| | | |
|---|---|---|
| | Relay Input Sources: Equivalent circuit and classification of CTs, CT saturation and DC offset current, Equivalent circuit of voltage transformer (VT), CCVT and its classification. | |
| **2.** | **Neutral Grounding:**<br>Transient over voltages in ungrounded systems, Methods of neutral grounding | **03** |
| **3.** | **Principle and characteristics of:**<br>Over current Relays - Time setting, plug setting, Different characteristics like IDMT, very Inverse etc., Directional Relay, Distance Relay- Reactance, Impedance, MHO relay, Differential Relay. | **06** |
| **4.** | **Power Apparatus Protection:**<br>Protection of Transmission lines & feeders- over current protection and relay co-ordination, Distance relay application, Power swings and distance relaying, Pilot protection.<br>Protection of Transformer-The problems and hazard in transformer, Differential relay for 3 phase transformer winding protection, Magnetizing inrush, Restricted Earth fault protection, Buchholz relay.<br>Protection of Generator-The problems and hazard in generator, Differential protection for stator faults, Protection against loss of prime mover and loss of excitation, field suppression, out of step protection.<br>Motor Protection- The problems and hazards in Induction motor, Protection against single phasing, Thermal over load and short circuit protection using Type 2 co-ordination, Under voltage protection, Synchronous motor protection.<br>Bus Protection- Different bus arrangements with breakers, Ring bus arrangement, One and a half breaker arrangement and High impedance bus differential relay. | **18** |
| **5.** | **Principles of Circuit Braking:**<br>Initiation of arc, arc extinction, D.C and A.C. circuit breaking, arc voltage and current waveforms in an A.C. circuit., Definition of transient recovery voltage, rate of rise of TRV, expression for TRV for different values of arc resistance, current chopping, capacitance switching, Theories of arc extinction, arc control devices, Ratings and specifications of circuit breakers, making and breaking capacity. | **04** |
| **6.** | **Different types of LV and HV Switchgear:**<br>Air Circuit Breaker (ACB): construction and working, Miniature Circuit Breakers (MCB) and Moulded Case Circuit Breakers (MCCB)**,** Earth leakage circuit breaker, Power contactors, HRC Fuse, Principle of arc quenching in- Air Blast Circuit Breaker (ABCB), Bulk Oil Circuit Breaker (BOCB), Minimum Oil Circuit Breaker (MOCB), Vacuum Circuit Breaker, SF6 Circuit Breaker. | **04** |
| **7.** | **Protection against over voltage surges:**<br>Lightening phenomenon, over voltages due to lightning, different types of lighting arresters, Insulation Co-ordination between different devices, BIL. | **03** |

**Term Work:**
Term work shall consist of minimum eight practicals/ Simulations/ demonstrations/ computer Programs based on above syllabus.

**Text Books:**

1. Badri Ram and Vishwakarma D.N., "Power System Protection and Switchgear", TMH Publication, 1st Ed. 1994.
2. Ravindranath and Chander, "Switchgear and Protection", Wiley Eastern Ltd. 1st Ed. 1977.
3. Rao Sunil S., "Switchgear and Protection", Khanna Publication, 4th Ed., 1997.
4. Paithankar Y.G., "Transmission Network Protection", Marcel Dekker, Inc., 1998.
5. *www.cdeep.iitb.ac.in/nptel/Electrical Engineering/Power System Protection.*

**Reference Books:**

1. Lewis Blackburn, "Protective relaying: Principles and Applications", Marcel Dekker, Inc., 1987.
2. Phadke A.G. and Thorp J.S, "Computer Relaying for Power Systems", John Wiley & sons, 1st Ed. 1990.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1 , 2, 3 |
| 2 | T2 | 4 |
| 3 | End Semester | 1 to 7 |

| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
|---|---|---|---|
| **CODE:BTE378** | **COURSE: Switchgear and protection Lab** | | |
| Period per week (each of 60 minutes) | Lecture | - | |
| | Laboratory | 02 per batch | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | - | 25 |
| | End Semester* | - | - |
| | Practical | 02 | - |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 25 |

Distribution of marks for in semester evaluation will as under, Attendence - 20 %, practical Performed during semester and graded assignment submission/ – 40 %, /Practical Examination/mini project – 40 %

**Course Objectives:**

1. Discuss the art and science of power system protection.
2. Demonstrate the relaying practices.
3. Introduce the fundamentals of overvoltage protection. and protection scheme for transmission lines , transformer, generator and motor
4. Discuss the principle and operation of HV and LV circuit breakers.

**Course outcomes**

**At the completion of this course, students will be able to**

1. Appreciate knowledge in instrument transformers
2. Evaluate performance of unit protection and system protection with hands on practice
3. Demonstrate &design the relevant protection scheme for the elements of a power system.
4. Appreciate field of switchgear and Exposure to the modern protection practices

**List of Experiments:**

1. IDMT characteristic of non-directional over voltage relay.
2. Study of Miniature Circuit Breaker HRC fuse, MCCB: components identification and Applications
3. Study of Power Contactor

4. Air Circuit Breaker: components identification and Applications.
5. Simulation of 2O/C+ 1E/F protection scheme.
6. Numerical Relay: Study and Application
7. Generator protection
8. Differential protection using static relay
9. Microprocessor based distance protection

| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE: BTE330** | **COURSE: Environmental Engineering and Management System** | | |
| Period per week (each of 60 minutes) | Lecture | 02 | |
| | Laboratory | --- | |
| | Tutorial | 02 | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 03 min. | 10*2 |
| | End Semester* | 02 | 50 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 50 |
| | TOTAL | --- | 100 |

* 60% Weightage for end semester

**Course Objective and Outcome:**

The objective of thiscourse is to sensitize the student to the ever increasing problems and challenges in preserving the environment from further degradation. It also attempts in inculcating habits among the younger generation that can help to reduce the negative effects of development on the environment.

**Course Contents:**

| **Module** | **Details** | **Hrs.** |
|---|---|---|
| **1.** | Introduction to Environmental Engineering | 02 |
| **2.** | Introduction to ISO 14001:2004(E) - Environmental management systems, Requirements with guidance for use. | 04 |
| **3.** | National Legislation (A): Constitutional provisions for safeguardingthe environment, The Environmental (Protection) Act, The Air (Prevention and Control of Pollution) Act, | 04 |
| **4.** | National Legislation (B): The Water (Prevention and Control of Pollution) Act,The Wildlife (Protection) Act, Forest Act, Biodiversity Act,Air Act 1981, EPA 1986 | 03 |
| **5.** | Int. Conventions and Treaties Ramsar Convention, CITES, Conventionon Biodiversity, Convention to Combat Desertification, Conventionon Climate Change | 03 |

| | | |
|---|---|---|
| **6.** | National rating system – GRIHA (Green Rating For Integrated Habitat Assessment): An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment. | 04 |
| **7.** | Case studies of GRIHA registered/rated buildings. Site selection and site planning, Building operation and Maintenance, Innovation points. | 04 |

**Term Work:** Lab Work shall consist of minimum two projects.

**RecommendedBooks:**

1. GRIHA Manual Volume 1 - Ministry of New and Renewable Energy, Government of India, New Delhi.
2. ISO 14001:2004(E) - Environmental management systems Requirements with guidance for use.
3. JagdishKrishnawamy, RJRanjitDaniels,"EnvironmentalStudies",Wiley India Private Ltd. New Delhi.
4. An InditaBasak, Environmental Studies, Pearson.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1, 2 |
| 2 | T 2 | 3,4 |
| 3 | END SEMESTER | 1 to 7 |

| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. Electrical** | | |
|---|---|---|---|
| **CODE: BTE331** | **COURSE: Project Management** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | 02 per batch | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Practical | --- | --- |
| | Laboratory Work (Journal) | --- | 25 |
| | TOTAL | --- | 125 |

* 60% Weightage for end semester

**Course Objectives:**

1. Discuss project management and its organization.
2. Demonstrate the techniques of project identification, formulation and appraisal.
3. Evaluate the project planning and scheduling techniques via CPM, PERT, GNATT charts.
4. Overview of contract law, contract and payment. Analyze the finance sources, n/w analysis, methods of cost estimation and control.
5. Demonstratethe concepts of material management and purchase management and introduction to project risk management and crisis management.

**Course Outcomes:**

1. Understand and able to apply the project identification and formulation techniques for creating and designing different types of projects.
2. Learn to write/draft the proper scope of a given project as per the given constraints of time, money, material and aim/products/services.
3. Able to appraise, estimate, recourse schedule, management of material, management of Risk and crisis of projects.
4. Apply the techniques of Quality control and Quality improvement for getting the accurate Products/services.
5. Demonstrate an understanding of professional and ethical responsibilities.

**Course Contents:**

| **Module** | **Details** | **Hrs.** |
|---|---|---|

| | | |
|---|---|---|
| **1.** | Project management and its organization, nature & purpose of PM, concept of project. | 06 |
| **2.** | Project identification, formula, analysis, risk, planning, project design and n/w analysis, Project, report, appraisal, project organization, establishing a project organization | 06 |
| **3.** | Account and finance, financing the project, cost estimation, cost control, controlling cash and credit. | 06 |
| **4.** | Planning and scheduling, planning with charts, critical path methods, resource scheduling. | 10 |
| **5.** | Contract administration, contract law, and contract and payment structure. | 10 |
| **6.** | Managing project material, material planning and control, project purchasing, inspection and expectations | 05 |
| **7.** | Project risk management, project quantity management. Software – Primavera. | 05 |

**Term Work:** Term work should consist of at least 8 tutorials properly recorded.

**Text Books:**

1. Handbook of Project Management, Dennis Lock 2nd Edition JPH.
2. Project Management, Vasant Desai, HPH.

**References:**

1. Projects, Planning, Analysis, Financing, Implementation and Review, Prasanna Chandra, 5th Edition Tata McGraw Hill
2. A Guide to the Project Management body of knowledge (PMBOK guide), Project Management Institute Newtown square, Pennsylvania, USA.

| Sr. No. | Examination | Module |
|---|---|---|
| 1 | T1 | 1, 2 |
| 2 | T 2 | 3,4 |
| 3 | END SEMESTER | 1 to 7 |

| | | | |
|---|---|---|---|
| **SEMESTER-VI** | **CLASS: T.Y. B.Tech. (Electrical)** | | |
| **CODE: BTE332** | **COURSE: VLSI** | | |
| Period per week (each of 60 minutes) | Lecture | 04 | |
| | Laboratory | --- | |
| | Tutorial | --- | |
| Scheme of Evaluation | | Hours | Marks |
| | In Semester | 01 | 20*2 |
| | End Semester* | 03 | 100 |
| | Tutorial | --- | ---- |
| | Laboratory Work(Journal) | | |
| | TOTAL | | 100 |

*60%Weightageforendsemester

**Course Objectives:**

1. To introduce the fundamental principles of VLSI circuit design and layout techniques.
2. To highlight the circuit design issues in the context of VLSI technology.
3. To examine the basic building blocks of large-scale digital integrated circuits.

**Course Outcomes:**

After successfully completing the course students will be able to

1. Demonstrate a clear understanding of choice of technology and technology scaling.
2. Design MOS based circuits and draw layout.
3. Realize logic circuits with different design styles.
4. Demonstrate a clear understanding of system level design issues such as protection, timing and power dissipation.

**Course Contents:**

| Module | Details | Hrs. |
|---|---|---|
| **1** | **Technology Trend:**<br>**Technology Comparison:** Comparison of BJT, NMOS and CMOS technology.<br>**MOSFET Scaling:** Types of scaling, Level 1 and Level 2 MOSFET Models, MOSFET capacitances. | **06** |

| | | |
|---|---|---|
| **2** | **MOSFET Inverters**<br>**Circuit Analysis:** Static and dynamic analysis (Noise, propagation delay and power dissipation) of resistive load and CMOS inverter, comparison of all types of MOS inverters, design of CMOS inverters, CMOS Latch-up<br>**Logic Circuit Design:** Analysis and design of 2-I/P NAND and NOR using equivalent CMOS inverter. | **10** |
| **3** | **MOS Circuit Design Styles**<br>**Design Styles:** Static CMOS, pass transistor logic, transmission gate, Pseudo NMOS.<br>**Circuit Realization:** SR Latch, JK FF, D FF, 1 Bit Shift Register, MUX, decoder using above design styles. | **08** |
| **4** | **Semiconductor Memories**<br>**SRAM:** ROM Array, SRAM (operation, design strategy, leakage currents, read/write circuits), DRAM (Operation 3T, 1T, operation modes, leakage currents, refresh operation, Input-Output circuits), Flash (mechanism, NOR flash, NAND flash) | **07** |
| **5** | **Data Path Design**<br>**Adder:** Bit adder circuits, ripple carry adder, CLA adder<br>**Multipliers and shifter:** Partial-product generation, partial-product accumulation, final addition, barrel shifter | **08** |
| **6** | **VLSI Clocking**<br>**Clocking:** CMOS clocking styles, Clock generation, stabilization and distribution.<br>**Low Power CMOS Circuits:** Various components of power dissipation in CMOS, Limits on low power design, low power design through voltage scaling. | **05** |
| **7** | **System Design**<br>**IO pads and Power Distribution:** ESD protection, input circuits, output circuits, simultaneous switching noise, power distribution scheme<br>**Interconnect:** Interconnect delay model, interconnect scaling and crosstalk | **05** |

**Tutorial:**
At least 10 experiments based on the entire syllabus of Subject should be set to have well predefined inference and conclusion. Computation/simulation based experiments are encouraged. The experiments should be students centric and attempt should be made to make experiments more meaningful, interesting and innovative. **Oral** exam will be based on the entire syllabus.

**Text books**

1. Sung-Mo Kang and Yusuf Leblebici, "*CMOS Digital Integrated Circuits Analysis and Design*", Tata McGraw Hill, 3rd Edition.
2. Neil H. E. Weste, David Harris and Ayan Banerjee, "*CMOS VLSI Design: A Circuits and Systems Perspective*", Pearson Education, 3rd Edition.

**References:**

1. Jan M. Rabaey, AnanthaChandrakasan and BorivojeNikolic, "*Digital Integrated Circuits: A Design Perspective*", Pearson Education, 2nd Edition.
2. Etienne Sicard and Sonia DelmasBendhia, "*Basics of CMOS Cell Design*", Tata McGraw Hill, First Edition.
3. Debaprasad Das, "*VLSI Design*", Oxford, 1st Edition.
4. Kaushik Roy and Sharat C. Prasad, "*Low-Power CMOS VLSI Circuit Design*", Wiley, Student Edition.

| SR.NO. | EXAMINATION | MODUL |
|---|---|---|
| 1. | T1 | 1,2,3 |
| 2. | T2 | 4,5,6 |
| 3. | ENDSEMESTER | 1TO7 |