



Department of Computer Science & Engineering

MATS University

Aarang, Raipur (C.G.)

Syllabus Scheme of B. Tech.

III Semester



| S. No. | Code | Subject | Periods per week | | | Scheme of marks | | Total Credit |
|--------|-------|--|------------------|----------|----------|-----------------|------------|--------------|
| | | | L | T | P | ESE | IM | |
| 1. | BT320 | Mathematics – III | 3 | 0 | - | 70 | 30 | 3 |
| 2. | BT321 | Problem Solving & Logic Building using C | 3 | 0 | - | 70 | 30 | 3 |
| 3. | BT322 | Digital Electronics & Logic Design | 4 | 0 | - | 70 | 30 | 4 |
| 4. | BT323 | Electronic Circuit & Network Theory | 4 | 0 | - | 70 | 30 | 4 |
| 5. | BT324 | Computer Organization & Design | 4 | 0 | - | 70 | 30 | 4 |
| 6. | BT325 | Data Communication | 4 | 0 | - | 70 | 30 | 4 |
| 7. | BT326 | Programming with C Lab | - | - | 2 | 30 | 20 | 1 |
| 8. | BT327 | Digital Electronic and Logic Design Laboratory | - | - | 2 | 30 | 20 | 1 |
| 9. | BT328 | Web Technology Lab(HTML / DHTML/CSS/XML) | - | - | 2 | 30 | 20 | 1 |
| 10. | BT329 | Electronic Circuit & Network Lab | - | - | 2 | 30 | 20 | 1 |
| | | Total | 22 | 0 | 8 | 540 | 260 | 26 |

L – Lecture, T – Tutorial, ESE – End Semester Examination,

P – Practical, IM – Internal Marks (Include Class Test & Teacher's Assessments)



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MATHEMATICS-III (BT320)



Course Objective:

1. To make the scholars perceive the series analysis could be a powerful methodology wherever the formulas square measure integrals and to possess information of increasing periodic functions that explore sort of applications of Fourier series.
2. To produce information of mathematician remodel of elementary functions together with its properties and applications to solve normal differential equations.
3. To produce a sound background of advanced analysis to perform an intensive investigation of major theorems of complex analysis and to use these ideas to a large vary of issues that features the analysis of each complex line integrals and real integrals.
4. To possess intensive information of PDE those arise in mathematical descriptions of things in engineering. To review a few amount which will take any of a given vary of values that will not be foreseen because it is however can be delineated in terms of their likelihood.

UNIT – I FOURIER SERIES

Periodic functions, Euler's formula, Dirichlet conditions, Change of interval, Even and Odd functions, Half range Fourier series, Parseval's identity, Practical harmonic analysis.

UNIT – II PARTIAL DIFFERENTIAL EQUATION

Formation, Solution of PDE by direct integration method, Linear PDE of first order, Homogeneous linear equations with constant coefficients, Non-homogeneous linear PDE, Solution of PDE by method of separation of variables.

UNIT – III COMPLEX VARIABLES

Limit and derivative, Analytic functions, Cauchy-Riemann equations, Harmonic functions, Flow problems, Complex integration, Cauchy's theorem, Cauchy integral formula, Taylor & Laurent series, Singularities, Residues, Cauchy's residue theorem, Evaluation of real definite integrals.

UNIT – IV NUMERICAL SOLUTION OF ORDINARY & PARTIAL DIFFERENTIAL EQUATIONS

Numerical solution of ODE's by Taylor's series method, Picard's method, Euler's method, Euler's modified method, Runge-Kutta methods, Predictor-corrector methods-Milne's method, Adams-Bashforth method.

Numerical solution of PDE's, Classifications of second order PDE, Elliptic equations, solution of Laplace equations, solution of Poisson's equation, Solution of elliptic equation by relaxation method, Parabolic equations, Solution of one dimensional and 2-D heat equations, Hyperbolic equation, Wave equations.

UNIT – V NUMERICAL SOLUTION OF ALGEBRAIC, TRANSCENDENTAL AND SIMULTANEOUS EQUATIONS DIFFERENTIAL

Numerical solution of algebraic and transcendental equations: Newton-Raphson method, Secant method, Birge-Vieta method, Bairstow method, Numerical solution of simultaneous linear equations: Direct methods-Gauss elimination, Gauss-Jordan & Crout's Triangularisation method. Iterative methods-Jacobi's, Gauss-Seidel & Successive over Relaxation method.

Text Books:

1. Advanced Engineering Mathematics, Kreyszig Erwin; Wiley Eastern, New Delhi
2. Higher Engineering Mathematics, B. S. Grewal; Khanna Publishers, New Delhi.

Reference Books:

1. Advance Engineering Mathematics, R.K. Jain & S.R.K. Iyenger, Narosa Publication House.
2. Advanced Engineering Mathematics, E. Kreysig, John Wiley & Sons.
3. Applied Mathematics, P. N. Wartikar & J.N. Wartikar. Vol- II, Pune Vidyarthi Griha Prakashan, Pune.
4. Differential Equations, Sharma and Gupta; Krishna Prakashan Media (P) Ltd., Meerut.
5. Advance Engineering Mathematics, V. O'Neil, Thomson (Cengage) Learning.

Course Outcome:

After completion of this course the students are going to be able to

1. Apply series, transformation, and theory of advanced variable, partial differential equations and variant to technology issues and solve them. Hands on these Mathematical topics can build them equipped to organize for higher studies through competitive examinations.



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PROBLEM SOLVING AND LOGIC BUILDING USING C (BT321)



Course Objective:

1. To distinguish and recognize low-level and high-level programming languages
2. To know modular programming concepts
3. To know the use of rich set of data types in C suitable to exact programming problems.
4. Express the use of various operators
5. Express the use of the various control flow constructs.
6. To make use of arrays & pointers to proficiently to design C program to solve problems.
7. Express formation and use of own data types.

UNIT – I ELEMENTS OF C LANGUAGE

Origin of C, Features & Characteristic of C, C Compiler, Character Set, Keywords, Identifiers, Constants, Variables, Input/ Output Statements, Basic Data Types, Operators and Expressions, Tools for Problem Solving: Problem Analysis, Flowchart, Algorithm Development. Top-Down Program Design, Structured Design Approach, Basic structure of C programs, A simple C Program.

UNIT – II CONTROL FLOW CONSTRUCTION

Decision making and branching: Simple if statement, if else statement, Nesting of if-else statement, else - if Ladder, Switch statement, Operator, goto statement, Decision making and looping, While statement, Do-While statement, For statement, Jumps in loops, Break and Continue statement.

UNIT – III DEFINING AND MANIPULATING ARRAYS

One Dimensional Arrays: Declaration of Arrays, Initialization of Arrays, Reading and Writing of integer, Real and Character arrays, Sorting and Searching in Arrays, Multi Dimensional Arrays, Handling of Character Strings.

UNIT – IV USER DEFINED FUNCTIONS

Syntax of Function, Calling functions, Actual & Formal Arguments, Categories of Functions, Function prototype, Scope Rules: Local & Global variables, Recursion, Recursion vs. iteration, Passing Arguments: call by values & call by reference, Passing array to function.

Structures: Declaration and initialization of Structure, Array of structures, Array within structure, structure within structure, Structures and functions, Introduction to unions.

UNIT – V POINTER DATA TYPE AND ITS APPLICATION

Pointer Operator, Pointer Expression, Initialization of pointers, Pointer Arithmetic, Pointer and Function Arguments, Pointer to function, Pointer and Arrays, Pointers and String, Arrays of Pointers, Pointers to Pointers.

Files in C: Defining and Opening a file, Closing a file, Input/ Output operations on files, Error handling during I/O operations, Random access to files.

Text Books:

1. The C programming Language, Dennis M Ritchie and Kernighan, PHI.
2. Let us C, Yashwant Kanetkar, BPB Publication.
3. Programming in C, E. Balagurusamy, TMH.

Reference Books:

1. Programming in C, Byron Gottfrid, Schoum's series outline TMH.
2. Programming in C, Ghosh, PHI.
3. Computer Programming in C, V. Rajaraman, PHI.

Course Outcome:

After completion of the course study, students are going to be in a position to

1. Use and differentiate between basic ideas of element and software system.
2. Use information illustration for the elemental information varieties in C and perform conversions between binary-hexa-decimal date representations.
3. Read, perceive and trace the execution of programs written in C language.
4. Analyze issues and style algorithms in pseudo code.
5. Write down C program for a given algorithm by means of modular approach.



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DIGITAL ELECTRONICS AND LOGIC DESIGN (BT322)



Course Objective:

1. To learn various number systems, knowledge of these number systems is necessary in foundation computer science
1. Subjects.
2. To glance at brief idea about the diverse digital circuits which are used to develop the digital devices.
3. To know the concepts of Memories, Programmable Logic Devices & Digital Integrated Circuit.
4. To stimulate the students to develop their logic to design new digital circuits utilizable for hardware design.
5. To stimulate our students to use these digital circuits in integrated circuit design using VLSI.

UNIT – I INTRODUCTION

Characteristics of digital system, Types of Digital circuits, Number system: Direct conversion between bases Negative numbers & BCD and their arithmetic's, Boolean algebra, Minimization of Boolean Functions: K Map upto 6 variable and multiple output circuits Error Detecting & Correcting codes, Hamming & Cyclic codes.

UNIT – II COMBINATIONAL LOGIC CIRCUITS

Design Procedure, Adders, Subtractors & Code conversion, Multiplexers/ Demultiplexers, Encoder / Decoders, Decimal Adders & Amplitude Comparators, ROM as Decoder, PLA & PAL.

UNIT – III SEQUENTIAL LOGIC CIRCUITS

Flip –Flops and their conversions, Analysis and Synthesis of synchronous sequential circuit, Excitation table, State table & State diagram, Design of Synchronous Counters, Shift Registers and their Application.

UNIT – IV LOGIC FAMILIES

Diode, BJT & MOS as a switching element concept of transfer characteristics, Input characteristics and Output characteristics of logic gates, Fan-in, Fan-out, Noise margin, Circuit concept and comparison of various logic families: TTL, IIL, ECL, NMOS, CMOS Tri-state logic, Open collector output, Interfacing BTween logic families, Packing density, Power consumption & Gate delay.

UNIT – V MEMORIES

Sequential & Random Access, NMOS & CMOS Static and Dynamic Memory Elements, One and Multi Dimensional selection arrangement, Read only memories, Formation of Memory banks. Static and dynamic Hazard: Gate delay, Generation of spikes, Determination of Hazard in Combinational circuits, Fault detection methods: Fault Table & Path sensitizing methods.

Text Books:

1. Digital Design, M. Moris Mano, 2nd Edition, PHI.
2. Introduction to Digital Microelectronic Circuits, Gopalan, TMH

Reference Books:

1. Switching Circuit & Logic Design, Hill & Peterson, Wiley
2. Digital Circuit & Logic Design, Holsworth.

Course Outcome:

After finishing of this course, students will be capable to -

1. Acknowledge about the basics of digital circuit design.
2. To realize the operation of Latch circuits & Flip flops.
3. Take curiosity to designing & build up ICs in VLSI industries.
4. To become skilled at operation of different Semiconductor Memories.



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ELECTRONIC CIRCUITS & NETWORK THEORY (BT323)

Course Objective:

1. To realize Operating point calculations and working of BJTs at low and high frequencies.
2. To amend Frequency response of BJT
3. To become skilled to operate BJT, FET, Integrators, Clipper.
4. To be aware of the fundamental concepts and analysis of electric circuits.
5. To make the students to be trained on how to synthesize an electrical network from a given impedance / admittance function.

UNIT – I ANALOG CIRCUITS

Review of equivalent circuit for semi conductor devices (BJT, FET etc) classification of amplifiers , Voltage amplifier , Current amplifiers , Amplifier characteristics, BW, Gain , Input Impedance, Output Impedance, Distortion etc. Transistor Biasing and Stabilization, Bias compensation, Thermal Runaway.

UNIT – II SWITCHING

Switching Characteristics of BJT and FET, Linear and Non-linear wave shaping circuit, Bistable, Monostable and Astable multi-vibrators, RC integrators and Differentiators, Clipper and Clamper circuits.

UNIT – III AMPLIFIERS

Classification of Amplifiers, Operational Amplifiers (OP-AMP), Inverting & Non inverting mode comparators, Zero Crossing Detector, VF and FV converter, Rectifier circuit using op- amp, 555 Timer and it's application.

UNIT – IV NETWORK CIRCUITS

Circuit Elements, KVL, KCL, Elementary Graph Theory, Incidence Matrix, Cut-Set, Tie- Set, Network Theorems, Superposition, Thevenin's, Norton's, Reciprocity, Max. Power Transfer, Millman's, Tellegen's Theorem, and Magnetically Coupled Circuits.

UNIT – V MATHEMATICAL ANALYSIS OF NETWORK

Differential Equations, First order & Second order system, Time constant, Initial Conditions, Laplace Transform & its application in circuit analysis, Initial & Final value Theorem, Network Functions, and Two Port Network Parameters.

Text Books:

1. Integrated Electronics, Milliman & Halkias Mc-Grow Hill Publication
2. Network Analysis, Van Valkenburg PHI publication

Reference Books:

1. Micro-Electronics Circuit, Sedra Smieth Oxford University Press.
2. Electronic Devices and Circuits by Boylsted.
3. Network Analysis & Synthesis, S. P. Ghosh, A. K.Chakraborty, Tata McGraw Hill.

Course outcome:

1. Student is capable to understand BJT amplifier at Low and High frequencies.
2. Student gets familiarity of multistage amplifier and power amplifier.
3. The notion of feedback used in amplifier is understood.
4. Students are capable to apply laplace transform in analyzing the circuits.
5. To assess properties & apply network theorems on various networks.
6. To assess two-port parameters of a given network.



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COMPUTER ORGANIZATION & DESIGN (BT324)

Course Objective:

The overall objective with the course is to know basic operating principles of computer hardware units and provides knowledge and insights into the design of recent computers, above all the processor design together with parallel computational pipelines and memory hierarchies.

UNIT – I CENTRAL PROCESSOR ORGANIZATIONS

Basic building blocks, Bus organized computer memory, Address structure, Memory data register, Program Counter, Accumulator, Instruction register, Instruction field, Address field, Micro-operations, Register transfer languages, Instruction fetch, Decoding and Execution, Instruction formats and Addressing modes.

UNIT – II CONTROL UNIT ORGANIZATION

Instruction Sequencing, Instruction interpretation, Hardwired control & micro-programmed control organization, Control memory, Address sequencing micro-instruction formats, Micro-program sequencer, Micro-programming, Bit slicing in AHPL, Emulation.

UNIT – III ARITHMETIC PROCESSOR:

Arithmetic Processor Design, Addition and Subtraction Algorithm, Multiplication algorithm, Division algorithm, Processor configuration, Design of control unit and floating point arithmetic.

UNIT – IV INPUT-OUTPUT ORGANIZATION

Programmed I/O, I/O addressing, I/O instruction, Synchronization, I/O interfacing, Standard I/O interfaces interrupt mechanism, DMA, I/O processors and data communication.

UNIT – V MEMORY ORGANIZATION AND MULTIPROCESSING

Basic concepts and terminology, Memory hierarchy, Semiconductor memories (RAM, ROM), Virtual memory, Associative memory, Cache memory, Cache mapping techniques, Memory allocation and management policies, Structure of Multiprocessors, Parallel processing, Pipeline processing.

Text Books:

1. Computer Organization and architecture- William Stallings, Macmillan Publishing Company, Fourth Edition.
2. Computer Architecture – Morris Mano, PHI Publication.

Reference Books:

1. Computer Systems Organization & Architecture – John D Carpinelli, Addison-Wesley.
2. Computer Organization, John P.Hayes (McGraw Hill)

Course Outcome:

1. To be all set to describe the essential hardware parts of a computing system.
2. To be acquainted with the binary and hex number systems together with computer arithmetic.
3. To be acquainted with the functional units of the processor like the register file and arithmetic-logical unit.
4. Students will be accustomed to the fundamentals of systems topics: parallel, pipelined, superscalar, and RISC/CISC architectures.
5. To be acquainted with the representation of data, addressing modes, an instruction sets.



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DATA COMMUNICATION (BT325)

Course Objective:

1. Provide students with an improved foundation of knowledge in current and reflective practice necessary to hold up a career in indulging the different protocols, software, and network architectures.
2. Understanding theory of local area networks, their topologies, protocols and applications
3. Computer networking at sophisticated professional level.

UNIT – I INTRODUCTION

Data Communication: Concept, Components, Data representation, Data transmission, Types of Computer Network (LAN, MAN, WAN etc), Network topologies, Concept of layers in Network Models, Protocols, Interfaces & Services, ISO-OSI reference model, TCP/IP Protocol Suite.

UNIT – II DATA TRANSMISSION

Communication Modes: Simplex, Half duplex, Full duplex. Transmission modes: Serial transmission, Parallel transmission. Synchronization: Asynchronous transmission, Synchronous transmission. Transmission media: Guided media (Twisted pair cable, Coaxial cable, Fiber optic cable), Unguided Media (Radio waves, Microwaves, Infrared).

UNIT – III NETWORKS

Network connecting devices (Switch, Hub, Repeater, Bridge, Router, Gateway), Circuit Switched Networks, Datagram Networks, Virtual Circuit Networks, Telephone Network, Modems, Digital Subscriber Line, Cable TV Networks, Cable TV for Data Transfer.

UNIT – IV DATA LINK AND NETWORK LAYER

Error Detection and Error Correction: Flow Control, Error Control, Stop and Wait – Go back – N ARQ – Selective Repeat ARQ – Sliding Window – Piggybacking – Random Access – CSMA/CD, CDMA/CA. Logical addressing: IPv4, IPv6. Address mapping: ARP, RARP.

UNIT – V TRANSPORT LAYER AND APPLICATION LAYER

Process to Process Delivery, TCP, UDP, SCTP, Congestion Control, Quality of Service, DNS, TELNET, E-mail, FTP, WWW, HTTP.

Text Books:

1. Computer Networks, Second Ed., A.S. Tannenbaum, Prentice Hall India.
2. Data Communication, Computer Networks, Halsall, Pearson Education.

Reference Books:

1. Data Networks, D.Bertsekas and R. Gailagher, PHI Second Ed.
2. Internetworking with TCP/IP, Vol. 1, D.E. Corner, Prentice Hall India.
3. Computer Networking with IP, Stalling, Pearson Education

Course Objectives:

On completion of this unit the student should be capable to:

1. To classify and relate vital theorems and formulae for the information-theoretic basis of communication and the performance of TCP/IP network protocols
2. Depict the basis and organization of conceptually layered Network protocol model.



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PROGRAMMING WITH C LAB (BT326)

List of Programs:

- 1 Write a program to take the radius of a sphere as input and print the volume and surface and surface area of that sphere.
- 2 Write a program to take a 5-digit number as input and calculate the sum of its digits.
- 3 Write a program to take three sides of a triangle as input and verify whether the triangle is an isosceles, scalene or an equilateral triangle.
- 4 Write a program that will take 3 positive integers as input and verify whether or not they form a Pythagorean triplet or not.
- 5 Write a program to print all the Prime numbers between a given range.
- 6 Write a program to define a function that will take an integer as argument and return the sum of digits of that integer.
- 7 Write a program to define a macro that can calculate the greater of two of its arguments. Use this macro to calculate the greatest of 4 integers.
- 8 Write a program to define a recursive function that will print the reverse of its integer argument.
- 9 Write a program to print the sum of first N even numbers using recursive function.
- 10 Write a program to sort an array using Bubble sort technique.
- 11 Write a program that will take the elements of two integer arrays of 5 element each, and insert the common elements of both the array into a third array (Set intersection)
- 12 Write a program to take 5 names as input and print the longest name.
- 13 Write a program to define a structure Student that will contain the roll number, name and total marks of a student. The program will ask the user to input the details of 5 students and print the details of all the students whose total marks is greater than a given value.
- 14 Write a program to define a union Contact that will contain the members Mobile no and E-mail id. Now define a structure Employee that will contain name, roll number, mode of contact (mob/e-mail) and a variable of type Contact as members. The program will ask the user to give the details of two Employees including mode of contact and the contact num/ E-mail. Print the details of both the Employees.
- 15 Write a program that will ask the user to input a file name and copy the contents of that file into another file.
- 16 Write a program that will take any number of integers from the command line as argument and print the sum of all those integers.
- 17 Write a program to process sequential file for payroll data.
- 18 Write a program to process random file of library data.

List of Equipments/Machine Required:

PCs, C-Compiler

References:

1. Programming in ANSI C – E. Balaguruswamy Tata Mc-Graw Hill.
2. Let us C, Yashwant Kanetkar, BPB Publication
3. C: The Complete Reference, Herbert Schildt, McGraw Hill.



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DIGITAL ELECTRONICS AND LOGIC DESIGN LAB (BT327)

List of Experiments

1. Bread-board implementation of various flip-flops.
2. Bread-board implementation of counters & shift registers.
3. Determination of Delay time and NAND, NOR, Ex-OR, AND & OR Gates.
4. Transfer characteristics of TTL inverters & TTL Schmitt Trigger inverter.
5. Transfer characteristics of CMOS inverters series.
6. Monoshot multivibrators using 74121 and 74123.
7. Clock circuit realization using 555 and CMOS inverter and quartz crystal.
8. Adder/ subtractor operation using IC7483 4 bit/ 8 bit.
9. Demultiplexer / Decoder operation using IC-74138.
10. Modulo N counter using programmable counter 74190.

Equipments required

1. Logic gate trainer
2. Digital ICs Trainer
3. Various ICs 7400, 7402, 7404, 7408, 7432, 7486, 74138, 74151, 74155 etc.

References:

1. Digital Logic and Computer Design, M.M. Mano, PHI.
2. Digital Fundamentals, Floyd, UBS.



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WEB TECHNOLOGY LAB (HTML/DHTML) (BT328)

List of Programs:

1. Design a HTML page describing your profile in one paragraph. Design in such a way that it has a heading, a horizontal rule, three links and your photo also write three HTML documents for the links.
2. Design HTML page describing your academic career. The page will tell about the degrees, Institutions and your hobbies. Add some lists too.
3. Design HTML page demonstrating Concept Of Internal Hyper-link
4. Design HTML page which gives the list of grocery Items by using Ordered List , List consist of Roman no, A,B.... and so on.
5. Design HTML page which gives the list of grocery Items by using Unordered List bullets are of form disc, square and circle.
6. Design a HTML page for partitioning browser window in frames display the different pages in partitioned windows.
7. Design HTML page to partition window, Design in such a way that link clicked in on page can display the corresponding pages in other window.
8. Design a HTML page on your native place.
9. Design a HTML page on your friends. List your friends; each friends name is a link. Prepare separate HTML document on each friend and call them in appropriate link.
10. Design HTML page listing popular car companies. For each company prepare a sub list showing various brands of cars it offers.
11. Design a HTML page for reserving a room in a Hotel.
12. Design a HTML form to reserve a Railway ticket.
13. Design a HTML form to see the result for a candidate when the results are published on the web.
14. Design a HTML form to find the railway fare from one place to another.
15. Design a HTML form to find out the balance for a mobile phone customer as on today.

References:

1. HTML Complete Reference- Tata McGraw hill
2. HTML and XML: An Introduction NIIT, Prentice-Hall of India
3. Building Enhanced HTML Help with DHTML and CSS by Jeannine M.E.Klien. Pearson Education
4. HTML for the World Wide Web, Fifth Edition, with XHTML and CSS
5. Visual QuickStart Guide 5th Edition Elizabeth Castro, Pearson Education Sams Teach Yourself HTML & XHTML in 24 Hours 6th Edition Dick Oliver, Michael Morrison, Pearson Education.



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ELECTRONIC CIRCUITS & NETWORK LAB (BT329)

List of Experiments:

1. To draw the characteristics of a semiconductor diode and to find cut-in voltage, reverse resistance, static resistance and dynamic resistance.
2. To draw the characteristics of FET using BFW – 10
3. To draw the characteristics of CE configuration of a transistor amplifier.
4. To draw the characteristics of CB configuration of a transistor amplifier.
5. To draw the characteristics of CC configuration of a transistor amplifier.
6. To design a Zener regulator circuit and to find the regulation characteristics.
7. To draw the load line of a transistor amplifier under CE configuration.
8. To design and verify the self bias circuit operation.
9. To design and verify the voltage divider biasing circuit.
10. To verify the effect of emitter bypass capacitor.
11. To design a regulator circuit using Zener diode.
12. Verification of principle of superposition with dc and ac sources
13. Verification of Thevenin, Norton and Maximum power transfer theorems in ac circuits
14. Verification of Tellegen's theorem for two networks of the same topology
15. Determination of transient response of current in RL and RC circuits with step voltage input
16. Determination of image impedance and characteristic impedance of T and Π networks, using O.C. and S.C. tests

List of Equipments/Machine Required:

Circuit components, Breadboard, Hook-up wire, Power supply, CRO, Function generator

Reference:

1. Laboratory Manual for Electronic Devices and Circuits, 4th Ed., David A. BELL, PHI