Department of Electrical and Electronics Engineering
BIRLA INSTITUTE OF TECHNOLOGY
(A Deemed University u/s 3 of UGC act, 1956)
Mesra: Ranchi – 835 215 (INDIA)
Phone: (EPBX) 0651- 2275444 / 2275896 / 2276002 / 2276006 Fax : 0651 – 2275401 Website : www.bitmesra.ac.in

Metric 1.2.1.1

Department/Section: EEE Department

Percentage of new courses introduced of the total number of courses across all Programmes offered during the last five years

| Sr. No. | Name of the new course introduced in the last 5 years | Program Name | Program code | Course code | Year of Introduction |
|---|---|---|---|---|---|
| 1. | Signal and Systems | B.Tech. | BT0107 | EE255 | 2018 |
| 2. | Professional Practice Law & Ethics | B.Tech. | BT0107 | EE403 | 2018 |
| 3. | Sensors and Transducers | B.Tech. | BT0107 | EE413 | 2018 |
| 4. | Bio-Instrumentation and Concepts | B.Tech. | BT0107 | EE415 | 2018 |
| 5. | Special Electric Machines | B.Tech. | BT0107 | EE419 | 2018 |
| 6. | Soft Computing Techniques | B.Tech. | BT0107 | EE427 | 2018 |
| 7. | Machine Learning | B.Tech. | BT0107 | EE447 | 2018 |
| 8. | Artificial Intelligence for Electrical Engineering | B.Tech. | BT0107 | EE449 | 2018 |
| 9. | Adaptive Control System Laboratory | M.Tech | MT0107 | EE504 | 2018 |
| 10. | System Identification and Adaptive Control | M.Tech | MT0107 | EE505 | 2018 |
| 11. | Robotics and Automation | M.Tech | MT0107 | EE513 | 2018 |
| 12. | Image Processing and Computer Vision | M.Tech | MT0107 | EE517 | 2018 |
| 13. | Modelling of Power Electronic Systems | M.Tech | MT0307 | EE525 | 2018 |
| 14. | Modern Power System Planning | M.Tech | MT0207 | EE533 | 2018 |
| 15. | HVDC and FACTS | M.Tech | MT0207 | EE535 | 2018 |
| 16. | Substation Design and Automation | M.Tech | MT0207 | EE537 | 2018 |
| 17. | Embedded Control of Switching Power Converter | M.Tech | MT0307 | EE561 | 2018 |
| 18. | Smart Grid Technology | M.Tech | MT0207 | EE567 | 2018 |
| 19. | Soft Computing Techniques in Electrical Engineering | M.Tech | MT0207 | EE571 | 2018 |
| 20. | Renewable Sources of Electrical Energy and Grid Integration | M.Tech | MT0207 | EE583 | 2018 |
| 21. | Hybrid Electric Vehicle | M.Tech | MT0307 | EE585 | 2018 |
| 22. | Electromechanical Energy Conversion | M.Tech | MT0307 | EE587 | 2018 |
| 23. | Power Semiconductor Devices | M.Tech | MT0307 | EE589 | 2018 |
| 24. | Process Measurement and Control | M.Tech | MT0107 | EE601 | 2018 |
| 25. | Power Converter Design Laboratory | M.Tech | MT0307 | EE604 | 2018 |
| 26. | Micro- grid Operation and Control | M.Tech | MT0207 | EE605 | 2018 |
| 27. | Smart Grid Laboratory | M.Tech | MT0207 | EE606 | 2018 |
| 28. | Physiological Control System | M.Tech | MT0107 | EE611 | 2018 |
| 29. | Power System Reliability Evaluation | M.Tech | MT0207 | EE631 | 2018 |
| 30. | Power Quality | M.Tech | MT0207 | EE633 | 2018 |
| 31. | Wide Area Monitoring System | M.Tech | MT0207 | EE635 | 2018 |
| 32. | Electrical Engineering Laboratory | B.Tech | BT0107 | EE102 | 2018 |

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| | | | | | |
|---|---|---|---|---|---|
| 33. | Advanced Digital Signal Processing | M.Tech | MT0207 | EE501 | 2018 |
| 34. | Advanced Digital Signal Processing Laboratory | M.Tech | MT0207 | EE502 | 2018 |
| 35. | Modern Control Theory | M.Tech | MT0107 | EE503 | 2018 |
| 36. | Advanced Power Electronics Laboratory | M.Tech | MT0307 | EE506 | 2018 |
| 37. | Advanced Power Electronics | M.Tech | MT0307 | EE507 | 2018 |
| 38. | Control and Power Electronics Laboratory | M.Tech | MT0207 | EE508 | 2018 |
| 39. | Advanced Power System Analysis | M.Tech | MT0207 | EE509 | 2018 |
| 40. | Optimization in Engineering design | M.Tech | MT0107 | EE511 | 2018 |
| 41. | Dynamic Behaviour of Electrical Machines | M.Tech | MT0307 | EE521 | 2018 |
| 42. | Intelligent motor controllers | M.Tech | MT0307 | EE523 | 2018 |
| 43. | EHV AC Power transmission | M.Tech | MT0207 | EE531 | 2018 |
| 44. | Optimal Control Theory | M.Tech | MT0107 | EE551 | 2018 |
| 45. | Control System Design Laboratory | M.Tech | MT0107 | EE552 | 2018 |
| 46. | Nonlinear Control System | M.Tech | MT0107 | EE553 | 2018 |
| 47. | Power Electronics and Drives Laboratory | M.Tech | MT0307 | EE554 | 2018 |
| 48. | Statistical Control Theory | M.Tech | MT0107 | EE555 | 2018 |
| 49. | Power Electronics Applications | M.Tech | MT0307 | EE557 | 2018 |
| 50. | Power Electronics Simulation Laboratory | M.Tech | MT0307 | EE558 | 2018 |
| 51. | Electric Drives | M.Tech | MT0307 | EE559 | 2018 |
| 52. | Electric drives Laboratory | M.Tech | MT0307 | EE560 | 2018 |
| 53. | Power System Simulation Laboratory | M.Tech | MT0207 | EE562 | 2018 |
| 54. | Advanced Power System Protection | M.Tech | MT0207 | EE563 | 2018 |
| 55. | Advanced Power System Laboratory | M.Tech | MT0207 | EE564 | 2018 |
| 56. | Power system operation and control | M.Tech | MT0207 | EE565 | 2018 |
| 57. | Embedded system and applications | M.Tech | MT0307 | EE573 | 2018 |
| 58. | Control of Electric Drives | M.Tech | MT0307 | EE577 | 2018 |
| 59. | Power System Deregulation | M.Tech | MT0207 | EE591 | 2018 |

09.01.2020

Prof and Head
EEE Department

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Date: 28/04/18

Based on the meeting of Board of Studies (BoS) conducted on 24/04/18 at 10.30 a.m. in ESR, the following Courses are being prepared for revision/ implementation after the consideration from reviews done by the subject experts:

| Sr. No. | Name of the new course introduced in the last 5 years | Program Name | Program code | Course code | Year of Introduction |
|---|---|---|---|---|---|
| 1. | Signal and Systems | B.Tech. | BT0107 | EE255 | 2018 |
| 2. | Professional Practice Law & Ethics | B.Tech. | BT0107 | EE403 | 2018 |
| 3. | Sensors and Transducers | B.Tech. | BT0107 | EE413 | 2018 |
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| 5. | Special Electric Machines | B.Tech. | BT0107 | EE419 | 2018 |
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| 22. | Electromechanical Energy Conversion | M.Tech | MT0307 | EE587 | 2018 |
| 23. | Power Semiconductor Devices | M.Tech | MT0307 | EE589 | 2018 |
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| 25. | Power Converter Design Laboratory | M.Tech | MT0307 | EE604 | 2018 |
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| Sr. No. | Name of the new course introduced in the last 5 years | Program Name | Program code | Course code | Year of Introduction |
|---|---|---|---|---|---|
| 32. | Electrical Engineering Laboratory | B.Tech | BT0107 | EE102 | 2018 |
| 33. | Advanced Digital Signal Processing | M.Tech | MT0207 | EE501 | 2018 |
| 34. | Advanced Digital Signal Processing Laboratory | M.Tech | MT0207 | EE502 | 2018 |
| 35. | Modern Control Theory | M.Tech | MT0107 | EE503 | 2018 |
| 36. | Advanced Power Electronics Laboratory | M.Tech | MT0307 | EE506 | 2018 |
| 37. | Advanced Power Electronics | M.Tech | MT0307 | EE507 | 2018 |
| 38. | Control and Power Electronics Laboratory | M.Tech | MT0207 | EE508 | 2018 |
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(Dr. P. R. Thakura)
Prof. and HOD
Chairman, BoS

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Date: 25/04/18

**Minutes of the Meeting**

A meeting of Board of Studies (BoS) of EEE Department was held on 25/04/18 at 10.00 a.m. in ESR to revise the course structure and implementation of CBCS from session 2018-2019 (MO/2018) of UG & PG Programme. Following members of the BoS attended the meeting:

| | | |
|---|---|---|
| 1. | Dr. P. R. Thakura, Prof. & Head (EEE) | Chairman (BoS) |
| 2. | Dr. T. Ghose, Professor, EEE, BIT Mesra | Member |
| 3. | Dr. D. K. Mohanta, Professor, EEE, BIT Mesra | Member |
| 4. | Dr. (Mrs.) Vijaya Laxmi, Professor, EEE, BIT Mesra | Member |
| 5. | Dr. (Mrs.) Sarbani Chakraborty, Professor, EEE, BIT Mesra | Member |
| 6. | Dr. (Mrs.) Debomita Ghosh, Assistant Professor, EEE, BIT Mesra | Member |
| 7. | Mr. Prem Prakash, Assistant Professor, EEE, BIT Mesra | Member |
| 8. | Dr. G. Sahoo, Professor, CSE, BIT Mesra | Member |
| 9. | Dr. Nirbhar Neogi, Executive Director (Retd), SAIL R&D, Ranchi | External Member |
| 10. | Mr. Deepak Kumar, AGM, MECON, Ranchi | External Member |
| 11. | Dr. Anup Kumar Panda, NIT, Rourkela | External Member |
| 12. | Dr. Amitava Chaterjee, Professor, Jadavpur University | External Member |
| 13. | Mr. Sujit Kumar, DGM, MECON, Ranchi | External Member |
| 14. | Mr. Amrendra Ranjan, Tata Steel, Jamshedpur | External Member |
| 15. | Mr. Shivam Priya, UG Student | Member |
| 16. | Mr. Rahul Raj, PG Student | Member |
| 17. | Mr. V. K. Karan, PhD Student | Member |

Following suggestions approved by the BoS:

1. CBCS implementation from session 2018-2019 (MO/2018).
2. Incorporation of MOOC course in course structure of UG and PG both.
3. Increase in the number of Program Electives for both UG and PG.
4. Provision of Minor and Major specialization in UG programme.
5. Mandatory Summer Internship for UG programme.
6. In VIII Semester student should devote only for Project/Internship.
7. Open Electives of total 12 credits for UG and 6 credits for PG.
8. For UG lab may be of 1(2 Hrs.) or 1.5 (3 Hrs.) credits and 2 credits for PG (4 Hrs.).
9. Classes should be of one Hour.
10. Total credits of 167 for UG must be there instead of 160 credits as decided earlier and 70 credits for PG.
11. Theory and laboratory courses in III Semester along with Thesis in PG programme.
12. To remove obsolete/duplicate topics from courses.

25.04.18

(P. R. Thakura)
Chairman (BoS)

25/4/18

A meeting of Board of study (BOS) was held on 25/4/18 at 10.00 am at ESR to discuss the implementation of CBCS.

The minutes of the meeting is attached

The following members attended the meeting.

1. HOD, EEE Dr P.R. Thakura 25.04.18
2. Prof. Amitava Chatterjee, Jadavpur Univ. 25/4/18
3. Dr. Anup Kr. Panda, NIT, Rourkela
4. Mr. Sujit Kumar, MECON Ranchi
5. Mr. Anurendra Ranjan, Tata Steel, Jamshedpur
6. Dr. Nirbhar Neogi
7. Prof T. Ghose
8. Prof. D. K. Mondal
9. Dr. VIJAYA LAXMI
10. Dr S. Chakraborty 25/4/18
11. Dr. D. Ghosh 25/4/18
12. Mr. P. Prakash 25.4.18
13. Dr. G. Sahoo, Dept of CSE 25/4/18
14. Mr. Shivam Priya, BE Student 25/4/18
15. Mr. Rahul Raj
16. Mr. V.K. Karan, Research Scholar 25/4/18
17. Mr Deepak Kumar, MECON, Ranchi 25/4/18

## Syllabus

## (CS 101) Programming for Problem Solving

**Module I** **[9L]**

**Introduction to Programming:**

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

**Problem Solving**: Steps to solve logical and numerical problems.

Representation of Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code

**Module II** **[9L]**

Arithmetic expressions and precedence, Conditional Branching and Loops, Writing and evaluation of conditionals, Iterations, Loops.

**Module III** **[9L]**

Array, Character array, strings. Case studies to discuss the various Problems related to Basic science (Matrix addition, Matrix-matrix multiplication, Roots of an equation etc.), Sorting, Searching.

**Module IV** **[9L]**

Functions (including using built in libraries), Parameter passing in functions, call by value, call by reference. Passing arrays to functions, Recursion (Finding Factorial, Fibonacci series, Ackerman function etc.).

**Module V** **[9L]**

Structures, Defining structures and Array of Structures

**Pointers:** Defining pointers, Use of Pointers in self-referential structures, File Handling

**Text Books:**


1. Jery R Hanly, Problem solving and Program design in C, 7th Edition, Pearson Education.
2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill.
3. ReemaThareja, Introduction to C Programming, 2nd Edition, Oxford University Press, 2015.
4. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice.
5. Byron Gottfried, Schaum's Outline of Programming with C, Tata McGraw-Hill.

**CS 102 Programming for Problem Solving Lab**

**Syllabus**

**Sample Program List**

**Module 1 & Module 2: Introduction and Control Flow**

1. Write an interactive program that will read in a +ve integer value and determine the following
   i) If the integer is a prime number
   ii) If the integer is a Fibonacci number
2. WAP in C to compute sinx = $x - x^3/3! + x^5/3! - x^7/7!$ ….. to five places of accuracy. Test the program for x = 1, x = 2, and x = 3. In each case display the number of terms used to obtain the final answer.
3. WAP to generate every 3rd integer beginning with I = 2 and continue for all integers that are less than 150. Calculate the sum of those integers that are evenly divisible by 5.
4. WAP to find whether a given year is a leap year or not. Modify it to generate a list of leap years between two year limits given by user.
5. WAP to display the following pattern :

```
                11
            11  10  11
        11  10  9   10  11
    11  10  9   8   9   10  11
```

6. Using Ternary / Conditional operator find the greatest among 3 numbers.

7. WAP to convert a decimal number into an equivalent number of the input base. Test your program for base 2, 8 & 16.
8. WAP to read a number n, and print it out digit-by-digit, as a series of words. For e.g. 123 would be printed as “one two three”.
9. WAP to check whether any input +ve integer is palindrome or not.
10. WAP to simulate a simple calculator (+ - / * %) that takes two operands and an operator as input and displays the result.
11. WAP to find the GCD of two input +ve integer numbers. Using this find GCD of 9 numbers.
12. WAP to swap the values of two variables without using a third variable.

**Module 3: Array**

13. Read a line of mixed text, and then write it out with all lower case and uppercase letters reversed, all digits replaced by 0s and all other characters

(non-letters and non- digits) replaced by '*'.

14. WAP to find the product of two matrices A and B. Display the source matrices and product matrix C in matrix format.
15. WAP to find whether a given matrix is a triangular matrix or not.
16. WAP to find the transpose of a matrix. Display the source and the transposed matrix in matrix format.
17. Implement Prob. No. – 14 to 16 using functions for reading, manipulating and displaying the corresponding matrices in matrix form.
18. WAP to sort a list of strings alphabetically using a 2-dim. Character array.
19. WAP to display the row sum and the column – sum of an input 2- dim. Matrix. Display the source matrix with row and column sum.

**Module 4: Functions, Pointer & String**

1. Write a recursive function to calculate S = 2 + 4 + 6 + 8 + …… +2N. Implement the function in a complete C program.
2. Write a function that accepts two arguments an array and its size n. It performs Bubble up sort on the array elements. Using indirection operator '*' implement this in a complete C program. Display the source and the sorted array.
3. Using pointer, write a function that receives a character string and a character as argument. Delete all occurrences of this character in the string. The function should return corrected string with no holes.
4. Write a function for reading character string using pointer. Calculate the length of the string (without using strlen ()). Finally print the string in reverse order, using pointer.
5. Implement prob. No. 14 using pointers representation of 2 – dim. array.
6. Implement prob. No. 15 using pointer representation of 2 dim. array.
7. Implement prob. No. 16 using pointer representation of 2 dim. array.
8. WAP to sort a list of strings into alphabetical order using array of pointers.

**Module 5: Structure and File**

20. Create records of 60 students, where each record has fields-name, roll, GPA and fees. Write a function update () to reduce the fees of those students who have obtained GPA greater than 8.5 by 25% of the original fees. Write a complete program to exercise this function in the main program and display all the records before and after updation.
21. Define a structure that describes a hotel. It should have members that include the name, address, grade, average room charge and number of rooms. Write a function to perform the following operations:
    a) To print out hotels of a given grade in order of charges.
    b) To print out hotels with room charges less than a given value.
22. WAP to concatenate the contents of two files into a third file.
23. WAP to copy the content of one file into another file. Names of both the files are to be input as command line arguments

## Syllabus
## IT 201 Basics of Intelligent Computing

**Module I** **[8 L]**

**AI Concepts**

Introduction to AI and Intelligent Agents, AI problems and Solution approaches, Problem solving using Search and Heuristics, AI Knowledge-base: creation, updation and reasoning, Broad category of branches in AI and intelligent Systems.

**Module II** **[9 L]**

**Introduction to Machine Learning**

Introduction, Supervised and Unsupervised leaning with examples, Loss Function, Gradient Descent, Regularization, Logistic Regression, K-Means, Introduction to Genetic Algorithm.

**Module III** **[7 L]**

**Introduction to Artificial Neural Networks:**

Introduction, Activation and Transfer Functions, Single Layer Perceptron, Multiple Layer Perceptron, Hebbian Learning, Delta Learning, Concept of Back Propagation.

**Module IV** **[8 L]**

**Introduction to IOT**

The IoT Paradigm, Concept of Things, IoT Hardwares, IoT Protocols, IoT Architecture, enabling technologies of IoT, IoT Designing and its levels.

**Module V** **[8 L]**

**Introduction to Cloud computing**

Brief overview, historical developments, computing platform and technologies, element of distributed computing, virtualization: characteristics of virtualized environment, virtualization and cloud computing, pros and cons of virtualization, virtualization technologies, cloud computing architecture: IAAS, PAAS, SAAS, types of cloud, cloud application.

**Text books:**


1. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
2. Raj Kumar Buyya, Christian Vecchiola & S. ThamaraiSelvi Mastering Cloud Computing, McGraw Hill Publication, New Delhi – 2013.
3. Roger S., Girolami M., "A First Course in Machine Learning", 2nd Edition, Chapman & Hill, CRC Press, 2017
4. Graupe D., "Principles of Aritificial Neural Networks", 2nd Edition, World Scientific, 2008


**Reference Books:**


1. Pethuru Raj and Anupama C. Raman,"The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press.
2. AmitKonar, Computational Intelligence: Principles, Techniques and Applications, Springer.

**SYLLABUS:**
**EC 203 Digital System Design**

**Module I**:
Basics of Digital Electronics: Number representation, Binary number system, Number base conversion, Octal, Hexadecimal and BCD codes, binary Arithmetic, Logic gates, Introduction to VHDL and Verilog, VHDL Models, Logic Families: TTL, ECL, and CMOS Logic Circuits, Logic levels, voltages and currents, fan-in, fan-out, speed, power dissipation. Comparison of logic families.

**Module 2**:
Simplification of Boolean functions: Boolean Algebra, Basic theorems and Properties, De Morgan's theorem, Canonical & Standard forms, Simplification of Boolean function using Karnaugh map, POS & SOP simplification, Prime implicant, NAND and NOR implementation.

**Module 3:**
Design of Combinational Circuits: Analysis and design procedure, Parity Generators and Checkers, Adders, Subtractors, Look ahead carry, Adder, 4-bit BCD adder/subtractor, Magnitude comparator, Decoders, Encoders, Multiplexers, De-multiplexers, Design of 1-bit ALU for basic logic and arithmetic operations.

**Module 4:**
Design of Sequential Circuits and Memories: Basic Latch, Flip-Flops (SR, D, JK, T and Master-Slave), Triggering of Flip Flops, Synchronous and asynchronous counters, Registers, Shift Registers, Memories and Programmable Logic design, Types of memories, Memory Expansion and its decoding, Programmable Logic Arrays (PLA), Programmable Array Logic (PAL)

**Module 5**:
Design of simple computing machines: SAP-I concepts with stress on timing diagrams, Microinstructions, Fetch and Execution cycle variable machine cycle, Hardware control Matrix, Macroinstructions, Microprogramming, Bus concepts, Multiplexed Minimum system. Pipelining concepts.

**Books recommended:**
**Textbooks:**

1. "Digital Design", Morris Mano and Michael D. Ciletti ,5th edition PHI
2. "Digital System Design using VHDL", Charles H Roth, Thomson Learning


**Reference books:**

Digital computer Electronics AP Malvino, 3rd Edition Mc Graw Hill

**SYLLABUS**
**EC 204 Digital System Design Lab**

**List of experiments:**

1. Design and implement a controlled CMOS Inverter.
2. To study and verify the truth table of NAND and EX-OR gate using IC 7400.
3. Design and implement SEVEN segment display unit.
4. Design and verify half adder and full Adder circuits using gates and IC 7483.
5. Design and implement a 3:8 Decoder.
6. Design and implement 8:3 priority encoder.
7. Design a 4-bit magnitude comparator using combinational circuits.
8. Design and implement 8:1 multiplexer and 1:4 demultiplexer.
9. Design ALU with functions of ADD, SUB, INVERT, OR, AND. XOR, INC, DEC and CMP.
10. Design and verify decade Counter.
11. Design a ROM (8X4) using decoder, gates and diodes.
12. Design of pre settable up/down counter.

**## Implement all the above experiments using VHDL platform and verify.**

**Books recommended:**

**Textbooks:**

1. "Digital Design", Morris Mano and Michael D. Ciletti ,5th edition PHI
2. "Digital System Design using VHDL", Charles H Roth, Thomson Learning

**Reference books:**

1. Digital computer Electronics AP Malvino, 3rd Edition Mc Graw Hill

## Syllabus
## MA 203 Numerical Methods

**Module I: Errors and Nonlinear Equations**

**Error Analysis:** Definition and sources of errors, propagation of errors, floating-point arithmetic **Solution of Nonlinear equations:** Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method and its variants, General Iterative method.

**[5L]**

**Module II: System of Linear Equations**

Gauss-Elimination, Gauss-Jordan, LU-Decomposition, Gauss-Jacobi and Gauss- Siedel methods to solve linear system of equations and Power method to find least and largest eigenvalues.

**[5L]**

**Module III: Interpolation**

Lagrange's interpolation, Newton's divided differences interpolation formulas, inverse interpolation, interpolating polynomial using finite differences.

**[5L]**

**Module IV: Differentiation and Integration**

Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's rule

**[5L]**

**Module V: Solution of Ordinary Differential Equations**

Euler's method, modified Euler's method, Runge - Kutta Methods of second and fourth order to solve initial value problems.

**[5L]**

**Text Books:**


1. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI.
3. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.


**Reference Books:**


1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, 1985.
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003.
3. R. W. Hamming: Numerical Methods for Scientists and Engineers, Second Edition, Dover

**Syllabus**
**MA204 Numerical Methods Lab**

**List of Assignments**

1. Find a simple root of $f(x) = 0$ using bisection method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
2. Find a simple root of $f(x) = 0$ using Regula-Falsi method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
3. Find a simple root of $f(x) = 0$ using Secant method. Read the end points of the interval in which the root lies, maximum number of iterations and error tolerance eps.
4. Find a simple root of $f(x) = 0$ using Newton Raphson method. Read any initial approximation, maximum number of iterations and error tolerance eps.
5. Solution of a system of linear equations using Gauss elimination method.
6. Matrix inversion and solution of a system of linear equations using Gauss-Jordan method.
7. Program to solve a system of linear equation using Jacobi iteration method.
8. Program to solve a system of linear equation using Gauss-Seidel method.
9. Program for Lagrange interpolation.
10. Program for Newton divided difference.
11. Program for Newton's forward and backward interpolation.
12. Program to evaluate the integral using Trapezoidal rule.
13. Program to evaluate the integral using Simpson's rule.
14. Program to solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using Euler method.
15. Program to solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using the classical Runge-Kutta fourth order.

**Text Books**


1. Jain M.K.: Numerical Methods for Scientific and Engineering Computation, New Age Publication.
2. Sastry S.S.: Introductory Methods of Numerical Analysis, PHI
3. Yashavant Kanetkar: Let Us C, BPB Publications

**Reference Books**

1. Chapra S.C. and Canale R.P.: Numerical Methods for Engineers, McGraw Hill
2. Hamming R.W.: Numerical Methods for Scientists and Engineers, Dover Publications
3. Herbert Schildt: C++: The Complete Reference, McGraw-Hill Education

## Syllabus

## IT 202 BASIC IT WORKSHOP

**Module I** **[1L]**

**Introduction to MATLAB and Basics Part I:**

Introduction, Advantage, Disadvantage of MATLAB, MATLAB Environment, Variables and Array, Built-in Functions of MATLAB, Subarrays, Multidimensional Arrays, Data Files.

**Module II** **[2L]**

**MATLAB Basic Part II:**

Scalar and Array Operations, Hierarchy of Operations, Introduction to Plotting, Polar Plots, Subplots, MATLAB profiler. String Functions, Complex Data, Three-Dimensional Plot

**Module III** **[2L]**

**MATLAB Advanced Features:**

Sparse Arrays, Cell Arrays,Structure Arrays, I/O Functions, Object Handles, Position and Units, Graphical User Interface: Dialog Boxes, Menus, Toolbars.

**Module IV** **[2L]**

**Introduction to Python Basics**

Basics, I Python, Data Types, Operators, Arrays, Plotting

**Module V** **[3L]**

**Python Programming Part 2:**

Functions and loops, object oriented programming, Numerical Formalism

**Text Books:**


1. MATLAB® Programming for Engineers:Stephen J. Chapman, Thomson Corporation, 4th Edition
2. Introduction to Python for Engineers and Scientists, Sandeep Nagar, Apress, 2018


**Reference Books**


Learn Python The Hard Way, Zed A. Shaw, Addison-Wesley, Third Edition

## Syllabus
## MT123 Business Communication

**Module I**

**Introduction to Business Communication:**Importance and Objectives of Business communication, Process of communication, Barriers to effective communication, Techniques of effective communication. Forms of communication (Written, Oral, audio-visualcommunication**).** **[8L]**

**Module II**

**Managing Business Communication:**Formal and Informal communication, Non- verbal communication (Body language, Gestures, Postures, Facial expressions). The cross cultural dimensions of business communication.Techniques to effective listening, methods and styles of reading.

**[8L]**

**Module III**

Other aspects of communication:
Vocabulary:Single word substitution, Idioms and phrases, Precis writing, Comprehension. Group Discussions, Extempore, Principles of effective speech and presentations, Role playing**.** **[8L]**

**Module IV:**

Introduction to managerial writing: Business letters: Inquiries, Circulars, Quotations, Orders, Acknowledgement, Claims & adjustments, Collection letters, Sales letters, Drafting of different resumes, Covering letters Applying for a job, Social correspondence, Invitation to speak.Official Correspondence: Memorandum, Notice, Agenda, Minutes, Circular letters.

**[8L]**

**Module V:**

**Report writing:**

Business reports, Types, Characteristics, Importance, Elements of structure, Process of writing, Order of writing, the final draft, check lists for reports. **[8L]**

**Text Books:**

T1. Communication Skills, Sanjay Kumar &PushpLata, Oxford University Press
T2. Business Correspondence and Report Writing,R.C.Sharma, Krishna Mohan.Mcgraw Hill T3. Communication for Business,Shirley Taylor, V.Chandra, Pearson
T4. Business Communication- HorySankar Mukherjee, Oxford University Press
T5. Basic Business Communication- .Lesikar I Flatley, McGraw Hill.
T6. Business Communication Today ,Bovee, Thill and Chaterjee, Pearson

**Syllabus**
**MT 204 Constitution of India**

**Module 1:**
Introduction to the Constitution of India, Salient Features of the Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

**Module 2:**
Union and State Executives: President and Prime Minister, Council of Ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha. Governor: Role and Position, Chief Ministers and Council of ministers.

**Module 3:**
The Indian Judicial System – The Supreme Court and The High Court's – composition, Jurisdiction and functions, The Role of the Judiciary.

**Module 4:**
Local Government- District's Administration: Role and Importance, The Panchayatas – Gram Sabha, Constitution and Composition of Panchayatas , Constitution and Composition of Municipalities

**Module 5:**
Miscellaneous- Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

**Suggested Readings**


1. The Constitution of India by "Ministry of Law India" Kindle Edition
2. Constitutional History of India by Prof.M.V.PYLEE-S.Chand Publishing
3. Indian Administration by Avasti and Avasti-Lakshmi Narain Agarwal Educational Publishers.2017 edition.
4. Introduction to the Constitution of India by D D Basu by Lexis Nexis : 20th edition.
5. Constitution of India V.N.Shukla's EBC Explorer Edition 13th ,201

## SYLLABUS

### EE 403 Professional Practice Law & Ethics

**Module I**

Basic definitions and nomenclature ; the effects of electric current passing through the human body; lightning hazards; protection of personnel: earthing and double insulation; protection of personnel: residual current detectors; effects of electric and magnetic fields and electromagnetic radiation; electrosurgical hazards; electrical fires and their investigation; electrical safety and the law including the Indian electricity safety act; electrical safety in hazardous atmospheres: area classification; electrical equipment in hazardous areas; safety issues with emerging energy sources; electrical safety in medical environment; risk assessment procedure.

**Module II**

The earth; TT grounding system; TN grounding system; Protective multiple earthing (TN-C-S grounding system); IT grounding system; Extra-low-voltage systems ; Earth electrodes, protective conductors, and equipotential bonding conductors ;

**Module III**

Safety against overvoltages; Safety against static electricity and residual voltages;Testing the electrical safety ; Applications of electrical safety in special locations and installations.

**Module IV**

Ethics of Profession: Engineering profession: Ethical issues in Engineering practice, Conflicts between business demands and professional ideals. Social and ethical responsibilities of Technologists. Codes of professional ethics. Whistle blowing and beyond, Case studies.

**Module V**

Profession and Human Values: Values Crisis in contemporary society Nature of values: Value Spectrum of a good life Psychological values: Integrated personality; mental health Societal values: The modern search for a good society, justice, democracy, secularism, rule of law, values in Indian Constitution. Aesthetic values: Perception and enjoyment of beauty, simplicity, clarity Moral and ethical values: Nature of moral judgements; canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility

**Text books:**

1. Massimo A.G. Mitolo, “Electrical Safety of Low-Voltage Systems”, McGraw Hill, 2009.
2. “Deborah Johnson, Ethical Issues in Engineering, Prentice Hall, Englewood Cliffs, New Jersey 1991.
3. A N Tripathi, Human values in the Engineering Profession, Monograph published by IIM, Calcutta

**SYLLABUS**
**EE 413 Sensors and Transducers**

**Module-I**
Introduction about sensors and transducers, Principles of operation and their classification, Characteristics of sensors. Conventional sensors Type: Based on Resistive principles- Potentiometer and Strain Gauge. Based on Inductive principles- Ferromagnetic Plunge type,LVDT, Inductance with a Short circuited sleeve. Transformer type, Electromagnetic Transducers. Based on capacitive principles- The parallel plate capacitive sensor, Variable Permittivity Capacitive Sensor, Stretched Diaphragm Variable Capacitive Transducer.
Electrostatic and Piezoelectric Transducers, Quartz Resonators and Ultrasonic Sensors.
Based on Magnetic principles: Magnetoresistive, Hall effect, Inductance and Eddy current sensors.Angular/Rotary movement Transducer, Electromagnetic Flowmeter, Pulse wire sensor and SQUID sensor.

**Module-II**
Thermal Sensors: Acoustic Temp Sensor, Nuclear Thermometer, Magnetic Thermometer, Resistance Change Type thermometric sensor, Thermo emf, Junction Semiconductor Types, Thermal Radiation, Quartz Crystal, NQR, Spectroscopic Noise Thermometry, Heat flux sensors. Radiation Sensors: Basic Characteristics, Photo-emissive Cell and Photomultiplier, Photoconductive Cell- Photovoltaic and Photojunction Cell, Position-Sensitive Cell, X-ray and Nuclear Radiation Sensors. Fibre Optic Sensors.

**Module-III**
Smart Sensors: Introduction, Primary Sensors Excitation, Amplification, Fitters, Converters, Compensation, Information Coding/Processing.

**Module-IV**
Digital Transducers: Digital Encoder, Shaft Encoder, Switches: Pressure, Level, Flow, Temperature, Proximity Switches, Limit Switches and its types, Isolators (or Barriers).

**Module-V**
Recent trends in sensor Technologies: Introduction, Film Sensors, Semiconductor IC Technology, Microelectromechanical System (MEMS), Nano Sensors, Application of Sensors: Automotive Sensors, Home Appliance Sensors, Aerospace Sensors,

**Text books:**


1. Sensors and Transducers, 2nd Edition by D. Patranabis


**Reference books:**


1. Electrical & Electronics Measurements and Instrumentation by A.K.Shawhney, DhanpatRai&Sons
2. Electronics instrumentation by H. S. Kalsi [TMH]

## SYLLABUS

## EE 415 Bio-Instrumentation and concepts

**Module-I**
Physiology of cardiac system, pulmonary system, urinary system, nervous system and muscles. Generation and propagation of action potentials in muscle, heart and nervous system. **(8)**

**Module-II**
Electrocardiograph; Electromyograph; Electroencephalograph; Phonocardiograph; Plathysmograph; Pulmonary function test devices; Non-Invasive and Invasive Blood Pressure measurement. **(8)**

**Module-III**
Pacemaker; Defibrillator; Anesthesia machine; Ventilator; Heart-Lung machine; Hemodialysis machine; Audiometry and Hearing aids; Nerve and Muscle stimulators; Therapeutic and Surgical diathermies. **(8)**

**Module-IV**
Generation of X-ray; X-ray imaging device; Catheterization system; Computer Assisted Tomography; Generations of Computer Assisted Tomography System. **(8)**

**Module-V**
Ultrasound and Doppler equipment; Magnetic Resonance Imaging device; Functional Imaging with Gamma camera; Single Photon Emission Tomography; Positron Emission Tomography. **(8)**

**Text Books:**


1. Textbook of Medical Physiology by A. C. Guyton, 8th edition, Prism Indian Publication, Bangalore, 1991.
2. Handbook for Biomedical instrumentation by R. S. Khandpur, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014.


**Reference Books:**


1. Medical instrumentation, Application &Design by J. G. Webstar, 4th edition, Wiley Student Edition, New Delhi, 2009.
2. Introduction to Biomedical Equipment Technology by J. J. Kar and J. M. Brown, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016.

**Syllabus**
**EE 427 Soft Computing Techniques**

**Module - I**

**Introduction:** Background, uncertainty and imprecision, statistics and random processes,uncertainty in Information. Fuzzy sets and membership, chance versus ambiguity, fuzzy control from an industrial perspective, Knowledge based systems for process control, knowledge-based controllers, knowledge representation in knowledge-based controllers.

**Module – II**

**Mathematics of Fuzzy Control and Membership Function:** Classical sets, Fuzzy sets, Properties of fuzzy sets, operationson fuzzy sets. Classical relations and fuzzy relations - cartesian product, crisp relation, Fuzzy relations, Tolerance and Equivalence Relations, Fuzzy tolerance and equivalence relations, operation on fuzzy relations, The extension principle.Features of membership functions, standard forms and boundaries,Fuzzification, Membership value assignment. Fuzzy-to-Crisp conversions: Lambda-cuts for fuzzy sets, Lambda-cuts for fuzzy relations. Defuzzification Methods

**Module - III**

**Introduction:** Structure and foundation of Single Neuron, Neural Net Architectures, NeuralLearning Application, Evaluation of Networks, Implementation. Supervised Learning - Single Layer Networks, Perceptions, Linear separability, Perception, Training algorithms, Guarantee of success, Modifications.

**Module –IV**

**Multilayer Networks** - Multilevel discrimination, preliminaries, backpropagation algorithm,setting the parameter values, Accelerating the learning process, Applications, RBF Network.

**Module - V**

**Unsupervised learnings** - Winner take all networks, learning vector quantizers, ART,Topologically organized networks.
Associative Models - Non-iterative procedures for Association, Hopfield networks,

**Text Books:**


1. Fuzzy logic with Engineering Applications - Timothy J. Ross, McGraw-Hill International Editions.
2. Fuzzy Sets and Fuzzy logic: Theory and Applications - George J. Klir and Bo. Yuan, Prentice- Hall of India Private Limited.
3. Neural Networks: A Comprehensive Foundation – SimanHaykin, IEEE, Press, MacMillan, N.Y. 1994.


**Reference Books:**


1. Elements of Artificial Neural Networks – KishanMehrotra, Chilakuri K. Mohan, Sanjay Ranka (Penram International Publishing (India).

## SYLLABUS
## EE 449 Artificial Intelligence for Electrical Engineering

**Module I**
**Introduction to Artificial Intelligence:**

Introduction, Definition of Artificial Intelligence, Importance of Soft Computing, Main Components of Soft Computing: Fuzzy Logic, Artificial Neural Networks, Introduction to Evolutionary Algorithms, Hybrid Intelligent Systems, Single and multi-objective optimization.

**Module II**
**Artificial Neural Network and Supervised Learning:**

Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Generalized Neuron Models, Factors Affecting the Performance of Artificial Neural Network Models, Application of GN Models to Electrical Machine Modeling, Electrical Load Forecasting Problem: Short Term Load Forecasting Using Generalized Neuron Model, Aircraft Landing Control System Using GN Model.

**Module III**
**Introduction to Fuzzy Set Theoretic Approach:**

Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Set, Operations on Fuzzy Sets, Fuzzy Intersection, Fuzzy Union, Fuzzy Complement, Fuzzy Concentration, Fuzzy Dilation, Fuzzy Intensification, α-Cuts, Characteristics of Fuzzy Sets, Demorgan's Law, Fuzzy Cartesian Product, Various Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation,Defuzzification Methods

**Module IV**
**Applications of Fuzzy Rule Based System:**

Introduction, System's Modeling and Simulation Using Fuzzy Logic Approach, Selection of Variables, their Normalization Range and the Number of Linguistic Values, Selection of Shape of Membership Functions for Each Linguistic Value, Selection of Fuzzy Union and intersection Operators, Selection of Defuzzification Method, Steady State D.C. Machine Model, Transient Model of D.C. Machine, Fuzzy Control System, Power System Stabilizer Using Fuzzy Logic.

**Module V**
**Genetic Algorithms:**

Introduction, Crossover, Mutation, Survival of Fittest,PopulationSize,Evaluation of Fitness Function, Applications of Artificial Neural Network,Genetic Algorithms and Fuzzy Systems for Power System Applications: voltage control, voltage stability, security assessment, feeder load balancing, AGC, Economic load dispatch, Unit commitment, Condition monitoring.

**Reference Books:**

1. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication.

2. Chaturvedi, Devendra K, Soft Computing Techniques and its Applications in Electrical Engineering, Hardcover ISBN:- 978-3-540-77480-8, Springer.

3. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication

4. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication

5.Kevin Warwick, Arthur Ekwue, Rag Aggarwal, Artificial intelligence techniques in power systems. IEE Power Engineering Series-22.

## SYLLABUS

## EE447 Machine Learning

**Module I**
**Introduction:**
Introduction to Machine Learning, The concept Learning task, General-to-specific ordering of hypotheses, Version spaces, Inductive bias, Over-fitting, Cross-Validation, Machine Learning Applications.

**Module II**
**Probabilistic Models:**
Maximum Likelihood Estimation, MAP, Bayes Classifiers, Minimum description length principle, Bayesian Networks, Inference in Bayesian Networks, Bayes Net Structure Learning.

**Module III**
**Supervised learning:**
Decision Tree Learning, Instance-Based Learning: k-Nearest neighbor algorithm, Support Vector Machines, Support vector machines for classification and regression, Kernel methods, Basic of Artificial Neural Networks, Linear threshold units, Perceptrons, Multilayer networks and back-propagation. Ensemble learning: Boosting, Bagging, Random Forest.

**Module IV**
**Unsupervised learning:**
K-means and Hierarchical Clustering, Fuzzy-C-means, Gaussian Mixture Models, EM algorithm, Hidden Markov Models.

**Module V**
**Computational Learning Theory:**
Probably Approximately Correct (PAC) learning, Sample complexity, Computational complexity of training, Vapnik-Chervonenkis (VC) dimension, Reinforcement Learning.

**Reference Books**

1. Tom Mitchell. Machine Learning. McGraw Hill, 1997.
2. Christopher M. Bishop. Pattern Recognition and Machine Learning. Springer 2006.
3. Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification. John Wiley & Sons, 2006.
4. E. Alpaydin, Introduction to Machine Learning, Prentice Hall of India, 2006.

**SYLLABUS**
**EE 419 Special Electric Machine**

**Module I**
**Permanent Magnet Brushless DC Motors:**
Fundamentals of permanent magnets types- principle of operation magnetic circuit analysis- emf and torque equations,

**Module II**
**Permanent Magnet Synchronous Motor:**
Principle of operation –EMF and Torque equations, Power controllers, Torque speed characteristics, Digital controllers, Constructional features, operating principle and characteristics of synchronous reluctance motor.

**Module III**
**Switched Reluctance Motors:**
Constructional features, Principle of operation, Torque prediction Characteristics, Power controllers, Control of SRM drive- Sensor less operation of SRM – Applications

**ModuleIV**
**Stepper Motors:**
Constructional features, Principle of operation, Linear and Nonlinear analysis, Characteristics – Drive circuits – Closed loop control –Applications, High-Speed Operation of Stepper-Motors: Pull-out torque/speed, characteristics of Hybrid stepper motors

**Module V**
**Other Special Machines:**
Principle of operation and characteristics of Hysteresis motor, Linear motor –Applications..

**Text Books (T):**

1. Fundamental of Electrical Drives: G K Dubey
2. Electric Motor Drives, modelling analysis and control: R Krishnan

**Reference Books (R):**

1. Modern Power Electronics & Drives: B K Bose

## SYLLABUS

## EE 535 HVDC and FACTS

### Module I

**Introduction to HVDC Transmission:** Comparison with EHV AC power transmission, HVDC system configuration and classification: Monopolar links, Bipolar links, Homopolar links, Back- to-back connection, Multi-terminal HVDC System, HVDC systems elements: Converter transformers, D.C. smoothing reactors, Thyristor valves, Earth electrodes & Earth return, etc. HVDC-AC interactions: SCR, Problems with low ESCR system, Solutions to problems associated with weak system. (8L)

### Module II

**Principles of AC/DC Conversion with Harmonic Analysis and Filtering**: Steady state characteristics of converters, Combined characteristics of rectifier and inverter, Converter connections, Reactive power requirements, Characteristic and non-characteristic harmonics, Harmful effects of harmonics, Harmonic filters and detuning, Cost considerations of filters.

(8L)

### Module III

Protection and System Control in HVDC:Response to D.C. and A.C. system faults, D.C. line fault, A.C. system fault, Converter fault, Protection issues in HVDC, D.C. Circuit Breakers, Basic mechanism of HVDC system control, Power reversal, Power control, Constant ignition angle, constant current, constant extinction angle control, High level controllers. Converter mal-operations - misfire, arc through, commutation failure, Frequency Control of A.C. system, Stabilisation & damping of A.C. networks.

(8L)

### Module IV

FACTS Concept: Fundamentals of A.C. power transmission, Introduction to FACTS: Need for FACTS in emerging power systems, Definitions, Types of FACTS, Co-ordination of FACTS with HVDC, Static VAr Compensator (SVC) – Functional description and structures, Control components and Models, Concepts of voltage control, Controls and Applications, MATLAB Implementation. (8L)

### Module V

Static Shunt and Series Compensation – Principles of shunt compensation: Variable Impedance type & switching converter type , Static synchronous compensator (STATCOM) configuration, Characteristics, Principles of static series compensation using GCSC, TCSC and TSSC – applications, Static Synchronous Series Compensator (SSSC). (8L)

**Text Books**

1. Padiyar, K.R., _HVDC transmission systems ‘, Wiley Eastern Ltd., 2010.

2. Kimbark, E.W., _Direct Current Transmission-vol.1‘, Wiley Inter science,New York, 1971.

3. Hingorani,L.Gyugyi, _Concepts and Technology of Flexible AC Transmission System‘, IEEE Press New York, 2000 ISBN –078033 4588.

4. Padiyar K.R., _FACTS controllers for Transmission and Distribution systems‘ New Age International Publishers, 1st Edition, 2007.

**Reference Books**

1. Song, Y.H. and Allan T. Johns, _Flexible AC Transmission Systems (FACTS)‘, Institution of Electrical Engineers Press, London, 1999.
2. Vijay K. Sood, _HVDC and FACTS Controllers‘, Kluwer Academic Publishers, New York, 2004.
3. Arrilaga, J., _High Voltage Direct Current Transmission‘, 2nd Edition, Institution of Engineering and Technology, London, 1998.
4. Enrique Acha, Claudio R.Fuerte-Esqivel, Hugo Ambriz-Perez, Cesar Angeles-Camacho FACTS –Modeling and simulation in Power Networks‘ John Wiley & Sons, 2002.
5. Mohan Mathur R. and Rajiv K.Varma , _Thyristor - based FACTS controllers for Electrical transmission systems‘, IEEE press, Wiley Inter science , 2002.
6. Kamakshaiah, S and Kamaraju, V, _HVDC Transmission‘, 1st Edition, Tata McGraw Hill Education (India), New Delhi 2011.

## EE 585 Hybrid Electric Vehicles

**Module I: Introduction**

Hybrid and Electric Vehicles (HEV): History Overview and Modern Applications, Ground vehicles with mechanical powertrain and reasons for HEV development, HEV configurations and ground vehicle applications, Advantages and challenges in HEV design

(8L)

**Module II: Power Flow and Power Management Strategies in HEV**

Mechanical power: generation, storage and transmission to the wheels, Vehicle motion and the dynamic equations for the vehicle., Vehicle power plant and transmission characteristics and vehicle performance including braking performance., Fuel economy characteristics of internal combustion engine, Basic architecture of hybrid drive train and analysis series drive train., Analysis of parallel, series parallel and complex drive trains and power flow in each case., Drive cycle implications and fuel efficiency estimations.

(8L)

**Module III: Hybrid Electric Vehicle**

Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains, Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Torque-Coupling Parallel Hybrid Electric Drive Trains, Speed-Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains.

(8L)

**Module IV: Electric Vehicles**

Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Tractive Effort in Normal Driving, Energy Consumption

(8L)

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**Module V: Design of Hybrid Electric Vehicles**

Design of Series Hybrid Electric Vehicle, Design of Parallel Hybrid Electric Vehicle, Design of Electric Vehicle, Impact on Environment

**Books recommended:**

**TEXT BOOK**

1. Modern Electric, Hybrid Electric and Fuel Cell Vehicles. Mehrdad Ehsani, CRC Press
2. Modern Electric Vehicle Technology, C.C. Chan and K.T. Chau, Oxford University Press

**REFERENCE BOOK**

1. R.Krishnan, ‘Electric motor drives’ , Prentice hall of India,2002
2. T.J.E. Miller, ‘Brushless magnet and Reluctance motor drives’.

**SYLLABUS**
**EE 255 Signal and System**

**MODULE I:**
Objective and overview, classifications and types of signal and system, Representation of common signals and their properties, system modeling. Analogous System: Introduction, D Alembert's Principle, Force – voltage and Force – Current analogies, Electrical analogue of mechanical, hydraulic and Thermal systems.

**MODULE II:**
Fourier Transform Method: Introduction, Fourier Transform pair, Laplace transform: Introduction, Laplace Transform pair, Laplace Transformation of common functions, Gate function, Step function and Impulse function, Laplace Theorems: shifting, initial value, final value and convolution theorems. Inverse Laplace Transform by partial fraction expansion and convolution integral method

**MODULE III:**
System Analysis: System Analysis by Laplace Transform Method, System response, Natural, forced, transient and steady state responses, Transfer function and characteristic equation, Superposition integral, Concept of poles and zeros, Nature of system response from poles and zeros.

**MODULE IV:**
Systems and Signal Analysis Frequency domain representation of finite energy signals and periodic signals - energy spectral density and power spectral density - convolution theorem - response of linear time invariant system.

**MODULE V:**
Frequency response Analog Signal Transmission: Amplitude modulation - spectrum - power relations - modulator and demodulator circuits, Frequency modulation - deviation - modulation index - spectrum of FM signal - relationship between phase modulation and FM - JFET reactance modulator

**Text books:**
1. K. Sam Shanmugam: Digital and Analog Communication Systems., John Wiley and Sons, 1985

**Reference books:**
1. Simon Haykin: .An Introduction to Analog and Digital Communication Systems., John Wile & Sons, 1989.
2. Lathi B.P: Modern Digital and Analog Communication Systems., 3rd Edition, Oxford University Press, 1998.
3. Analysis of Linear Systems – D.K.Cheng, Narosa Publishing House, Indian Student Edition

# SYLLABUS

## EE505 System Identification and Adaptive Control

**Module I**

**Introduction to System Identification:** Data based identification (System Response Methods, Frequency Response Methods, Correlation Methods.

(8L)

**Module II**

**Time Invariant Systems Identification:** Static Systems Identification, Dynamic Systems Identification.

**Module III**

(8L)

**Introduction to Adaptive Control**: Models for Dynamic Systems, Stability.

**Module IV**

(8L)

**On-line Parameter Estimation:** Fundamentals of random signals, Spectral estimation, Optimum (Wiener and Kalman) linear estimation, Extended Kalman filter, Particle filter, Parameter Identifiers and Adaptive Observers.

(8L)

**Module V**

**Model Reference Adaptive Control (MRAC):** Simple Direct MRAC Schemes, MRC for SISO Plants, Direct MRAC with Unnormalized Adaptive Laws, Direct MRAC with Normalized Adaptive Laws.

(8L)

**Books recommended:**

**Text Books:**


1. Systems Identification: An Introduction – Karel J. Keesman, Springer, 2011.
2. Robust Adaptive Control - Petros A. Ioannou and Jing Sun, 1996.
3. Optimization, Estimation and Control - A.E. Bryson & Y.C. Ho
4. Applied Optimal Estimation - A. Gelb, NIT Press, Cambridge
5. Optimal Estimation, Identification and Control - RCK Lee, NIT Press,Combridge, Massachusetts, 1964.
6. Stochastic Optimal Linear Estimation and Control - J.S. Meditch, McGraw Hill, N.Y., 1969.

## SYLLABUS
## EE513 Robotics and Automation

**Module I**

**Basic components of robotic systems,Robot classification, Robot specifications, Applications, Direct Kinematics:** Coordinate frames; Rotations; Homogeneous coordinates; D-H representation; The Arm Equation.

(8L)

**Module II**

**Inverse Kinematics**: Inverse kinematics problem, General properties of solutions, Tool configuration, Robotic work cell, Workspace analysis. Trajectory planning. Workspace envelope. Workspace fixtures. Pick and place operation. Continuous-path motion. Interpolated motion. Straight line motion.

(8L)

**Module III**

**Sensing and Control of Robot Manipulators**: Different sensors in robotics: Range; Proximity; Touch; Torque; Force and others. Computed torque control; Near Minimum time control; Variable structure control; Non-Linear decoupled feedback control; Resolved motion and Adaptive control.

(8L)

**Module IV**

**Robotic Vision**: Image acquisition and Geometry. Pre-processing; Segmentation and Description of 3-D structures; Recognition and Interpretation. .

(8L)

**Module V**

**Robot Arm Dynamics**: Lagrange-Euler formulation; Newton Euler formulation; Generalized D‟Alembert‟s equation.

**Robot Programming Languages, Robot Intelligence and Task Planning**: Characteristics of Robot level languages. Task level languages- with examples C, prolog. Assembly etc. Problem reduction; Use of predicate logic; Robot learning; Expert systems.

(8L)

**Books recommended:**

**Text Book**

**1.** Fundamental of Robotics: Analysis and Control- Robert J. Schilling. **[T1]**

**2.** Robotics: Control, Sensing,Vision and Intelligence- K.S. Fu, R.C. Gonzalez and Lee. **[T2]**

**Reference Book**

1. Robotics and Control – R. K. Mittal and I. J. Nagrath. (**R1**)

## SYLLABUS
## EE517 Image Processing and Computer Vision

**Module I**

**Digital Image Fundamentals:** Fundamental steps in Digital Image Processing, Components of an Image processing system, Digital Image Representation, Basic relationship between pixels, Color Modules, Image negatives, Histogram Equalization, Local Enhancement, Image Subtraction, Image Averaging, Smoothing Spatial Filters, Sharpening Spatial Filters.

(8L)

**Module II**

**Image Transform:**Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform, Smoothing Frequency Domain filters, Sharpening Frequency Domain filters, Homomorphic filtering, Convolution and Correlation Theorems, Wavelet Transforms, The Fast Wavelet Transforms.

(8L)

**Module III**

**Image Restoration, Segmentation and Compression:** Noise Models, Mean filters, Median Filter, Minimum Mean Square Error (Wiener) Filtering, Geometric Mean Filter, Adaptive filters, Periodic Noise Reduction by Frequency Domain filtering, Inverse Filtering, Detection of Discontinuities, Point Detection, Line detection, Edge Detection, Fundamentals of image compression, Redundancy, Image Compression Models, Error-free and Lossy Compression techniques.

(8L)

**Module IV**

**Computer vision Fundamentals:** Shape Representation, Description and Feature Extraction: Deformable curves and surfaces, Snakes and active contours, Level set representations, Linear Filters, Texture, Edge detection, Boundary Descriptors, Regional Descriptors.

(8L)

**Module V**

**Image Processing and Computer Vision Applications**: Denoising of Image as pre-processing, Object recognition, Motion estimation, Object Tracking, Vision based control, vision for human computer interaction.

(8L)

**Text Books:**


**1.** R.C.Gonzalez and Richard E Woods, Digital Image Processing, 2e, Pearson Education.

**2.** D. A. Forsyth, J. Ponce, Computer Vision: A Modern Approach, PHI Learning 2009


**Reference Book**:


1. B.Chanda and D. Dutta Majumdar, Digital Image Processing and Analysis, PHI.

**SYLLABUS**
**EE571 Soft Computing Techniques in Electrical Engineering**

**Module - 1**

**Introduction to Soft Computing:** Introduction, Definition of Soft Computing Techniques, Importance of Soft Computing, Main Components of Soft Computing: Fuzzy Logic, Artificial Neural Networks, Introduction to Evolutionary Algorithms, Hybrid Intelligent Systems, Single and multi-objective optimization.

**(8L)**

**Module –2**

**Artificial Neural Network and Applications:**Introduction, Artificial Neuron Structure, ANN Learning; Back-Propagation Learning, Properties of Neural Networks, Unsupervised learnings, Hopfield networks, Application of GN Models to Electrical Machine Modeling, Short Term Electrical Load Forecasting Using Generalized Neuron Model, Aircraft Landing Control System Using GN Model.

**(8L)**

**Module - 3**

**Introduction to Fuzzy Logic and Genetic Algorithm:** Introduction, Uncertainty and Information, Types of Uncertainty, Introduction of Fuzzy Logic, Fuzzy Set, Operations on Fuzzy Sets, Fuzzy Intersection, Fuzzy Union, Fuzzy Complement, Fuzzy Concentration, Fuzzy Dilation, Fuzzy Intensification, α-Cuts, Characteristics of Fuzzy Sets, Demorgan"s Law, Fuzzy Cartesian Product, Various Shapes of Fuzzy Membership Functions, Methods of Defining of Membership Functions, Fuzzy Relation, Defuzzification Methods.Introduction to Genetic Algorithm, Crossover, Mutation, Survival of Fittest, Population Size, Evaluation of Fitness Function.

**(8L)**

**Module-4**

**Applications of Fuzzy Rule Based System:**Introduction, System"s Modeling and Simulation Using Fuzzy Logic Approach, Selection of Variables, Normalization Range and Number of Linguistic Values, Selection of Shape of Membership Functions for Each Linguistic Value, Selection of Fuzzy Union and intersection Operators, Selection of Defuzzification Method, Steady State D.C. Machine Model, Transient Model of D.C. Machine, Fuzzy Control System, Power System Stabilizer Using Fuzzy Logic.

**(8L)**

**Module-5**

**Applications of Soft Computing Techniques to Electrical Engineering:** Applications of Artificial Neural Network, Genetic Algorithms, Fuzzy and Hybrid Systems for Power System Applications: voltage control, voltage stability, Economic load dispatch, Unit commitment, Condition monitoring. Applications of Soft Computing Techniques for Power Electronics and Control Applications.

**(8L)**

**Text Books:**

1. Neural Networks: A Comprehensive Foundation – SimanHaykin, IEEE, Press, MacMillan, N.Y. 1994.
2. S. Rajasekaran, G. A. Vijayalakshmi, Neural Networks, Fuzzy logic and Genetic algorithms, PHI publication.
3. Fuzzy logic with Engineering Applications - Timothy J. Ross, McGraw-Hill International Editions.
4. Fuzzy Sets and Fuzzy logic: Theory and Applications - George J. Klir and Bo. Yuan, Prentice-Hall of India Private Limited.

**Reference Books:**

1. Chaturvedi, Devendra K, Soft Computing Techniques and its Applications in Electrical Engineering, Hardcover ISBN:- 978-3-540-77480-8, Springer.
2. Kalyanmoy Deb, Optimization for Engineering Design, PHI publication
3. Kalyanmoy Deb, Multi-objective Optimization using Evolutionary Algorithms, Willey Publication
4. Kevin Warwick, Arthur Ekwue, Rag Aggarwal, Artificial intelligence techniques in power systems. IEE Power Engineering Series-22.

**SYLLABUS**
**EE589 POWER SEMICONDUCTOR DEVICES**

**Module I:**

**Introduction:** Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching – Power diodes – Types, forward and reverse characteristics, switching characteristics – rating.

(8L)

**Module II:**

**Current Controlled Devices:** BJT"s – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; – Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT &Thyristor- Basics of GTO, MCT, FCT, RCT

(8L)

**Module III:**

**Voltage Controlled Devices:** Power MOSFETs and IGBTs – Principle of voltage-controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs – and IGCT. New semiconductor materials for devices – Intelligent power modules- Integrated gate commutated thyristor (IGCT) – Comparison of all power devices.

(8L)

**Module IV:**

**Firing and Protection Circuits:** Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. – Over voltage, over current and gate protections; Design of snubbers.

(8L)

**Module V:**

**Thermal Protection:** Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device.

(8L)

**Books recommended:**

**Text Books:**


1. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993.
2. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.
3. M. D. Singh, K. B. Khanchandani, "Power Electronics", 2nd Edn., Tata McGraw-Hill, 2007.


**Reference Books:**


1. R. Krishnan, "Electric Motor Drives: Modeling, Analysis and Control", 1st Edn., Prentice Hall,2001.
2. B. K. Bose, "Modern Power Electronics & AC Drives" , 1st Edn., Prentice Hall, 2001
3. L. Umanand, "Power Electronics: Essentials & Applications", 1st Edn. Wiley India Private Limited, 2009.
4. Jeremy Rifkin, "Third Industrial Revolution: How Lateral Power Is Transforming Energy, the Economy, and the World", 1st Edn., St. Martin"s, Press, 2011.

## SYLLABUS

## EE561 Embedded Control of Switching Power Converters

**Module 1:**

**Introduction to power converters:**

Introduction to switching power converters and emerging applications, such as dynamic voltage scaling, power amplifier, energy harvesting, etc.

(2 L)

**Module 2:**

**Modelling and Control in PWM Switching Converters:**

Introduction to basic DC-DC converter topologies, such as buck converter, boost converter, buck/boost converters, etc., PWM control techniques such as voltage mode control (VMC), current mode control (CMC); CCM and DCM operating modes, Modelling of PWM DC-DC converters, State-space averaging technique, small-signal modelling, Control challenges, limitations of analog control techniques and need for digital control in DC-DC converters

(10 L)

**Module 3**:

**Digital Pulse Width Modulator (DPWM) Architecture and analysis:**

DPWM architectures in DC-DC converters: Counter-based DPWM, tapped-delay line based DPWM, hybrid DPWM, segmented DPWM, Frequency domain analysis of digitally controlled DC-DC converters, special emphasis on effects of finite sampling and quantization, such as limit cycle oscillations, Discrete-time modelling and analysis for existence of sub-harmonic oscillations in DPWM DC-DC converters

(10 L)

**Module 4:**

**Compensation Techniques in digitally controlled DC-DC converters**:

Discrete-time compensation techniques in digitally voltage mode control, current mode control, and state-feedback control; Deadbeat control; Critical bandwidth formulation, compensator design for non-minimum phase converters, Auto-tuning in digitally controlled DC-DC converters such as Ziegler-Nichols tuning, relay-based tuning etc.

(10 L)

**Module 5:**

**Non- linear control and embedded control implementation:**

Sliding mode control in DC- DC converters, Time optimal control and physical limits in DC-DC converters. Introduction to Verilog HDL, Signal conditioning circuits: Selection of ADCs and DACs,

(8L)

**Text Books (T):**


1. P.T. Krein, Elements of Power Electronics. New York: Oxford Univ. Press, 1998.
2. R.W.Erickson and D. Maksimovic, Fundamentals of Power Electronics, 2nd ed Dordrecht, The Netherlands: Kluwer, 2001.
3. S. Banerjee and G. C. Verghese, Eds., Nonlinear Phenomenon Power Electronics: Attractors, Bifurcations, Chaos, and Nonlinear Control,New York: IEEE Press, 2001.
4. F. Maloberti, “Data Converters”, Springer, 2007

5. Michael D. Ciletti, “Modeling, synthesis, and rapid prototyping with the Verilog HDL”, Prentice Hall, 1999.
6. V.Bobal, J.Bohm, and J.Fessl,“Digital Self-Tuning Controllers: Algorithms, Implementation and Applications”1 st Ed.,Springer,2005.
7. Francesco Vasca, Luigi Iannell i,Eds,“Dynamics and Control of Switched Electronic Systems:Advanced
8. Perspectives for Modeling, Simulation and Control of Power Converters”, Springer,1st Ed.,2012

**Reference Books (R):**

1. Fundamental of Electrical Drives: G K Dubey
2. Electric Motor Drives, modelling analysis and control: R Krishnan
3. Power Electronics: Circuits, Devices, and Applications:MH.Rashid

## SYLLABUS

## EE 525 Modelling of Power Electronic Systems

**Module I**

**Introduction to Modelling of Power electronics system:** Modelling and control introduction for power converters and systems, Introduction to power electronics systems, Review of power converters basics, Basics of converters dynamics, Fundamentals of modelling and control of power converters.

(8L)

**Module II:**

**Modelling and control oriented to converter-level design**: Averaged switch modelling of DC DC converters, Small Signal analysis of various switching modes, Simulation-oriented modeling, Control loop design, Digital control design, Bond graph for modeling of DC DC converter, Lagrange method for modeling of dc dc converter.

(8L)

**Module III:**

**Modern Rectifier:** Power and Harmonics in Non-sinusoidal Systems, Pulse-Width Modulated Rectifiers: Modeling, analysis, and control of low-harmonic rectifiers Boost, fly back, and other topologies for controlling the input current waveform of an ac-dc rectifier Average-current, peak-current-mode, critical conduction mode, and nonlinear carrier control techniques Determination of rms currents, and comparison of performances of popular topologies System considerations. Modeling losses. Simulation

(8L)

**Module IV:**

**Modelling and control of inverters:** Inverter concepts and inverter topologies Basic Output Voltage Control: Square wave operation, Fundamentals of PWM modulation, Advanced Modulation Techniques Modelling and control of Single-Phase Voltage Source Inverters. Three-phase inverter with d-q control for renewable energy applications.

(8L)

**Module V:**

**Real cases design**: Buck converter with voltage mode control loop, Boost converter with average current mode control loop, Adapter for battery charge in mobile phone applications, Multiphase converter for high performance

(8L)

**Books recommended:**

**Text Book**


1. Abraham I.Pressman . Switching Power Supply Design. Mc Graw Hill. 1997
2. M.H. Rashid,"Power Electronics: Circuits, Device and Applications",2nd Ed.n, PHI, New Jersey, 1993
3. Mohan, Underland, Robbins; Power Electronics Converters, Applications and Design, 3rd Edn., 2003, John Wiley & Sons Pte. Ltd.

4. M. D. Singh, K. B. Khanchandani, “Power Electronics”, 2nd Edn., Tata McGraw-Hill, 2007.

**Reference Book**

1. K. Billings. Switching power supply handbook. Mc Graw Hill . 2011.
2. Kislovski, R. Redl, N. O. Sokal. Dynamic Analysis of Switching-Mode DC/DC Converters. Van Nostrand Reinhold. 2013

## SYLLABUS

### EE583 Renewable Sources of Electrical Energy and Grid Integration

**Module I: Drivers of Renewable sources of electrical energy**

Decarburization, Energy security, Expanding energy access ,Present status of RE generation and future projections, Wind energy, Solar energy, RE grid integration challenges, Non- controllable variability, Partial unpredictability, Locational dependency

(4L)

**Module II: Basics of solar PV**

Solar PV systems: Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, I-V and P-V characteristics, Array design

(4L)

**Module III: Power converters and control for PV**

Characteristics and circuit models, Topologies, principles of operation. Maximum power tracking algorithms and Buck-Boost Converter, single- and three-phase inverters for PV , PLL technique for grid interfacing, Harmonic analysis, power quality and filter design, Current injection control at unity power factor, reactive power control and smart inverters, interconnection standards such as IEEE 1547 , Steady-state and dynamic models of PV systems and implementation in simulation tools

(15L)

**Module IV: Wind Energy: Power converters and control for wind generators**

Overview of wind turbine systems and configurations, Detailed analysis of doubly fed induction generator and PMSM based wind generators ,Dynamic modelling of wind generators, Field oriented control of rotor side and grid side power converters , Control methods for maximum power extraction, active and reactive power control

(12L)

**Module V: Basics of other renewable sources**

Biomass Energy System: Biomass – various resources, energy contents, technological advancements, Hydro energy: Feasibility of small, mini and micro hydel plants scheme, Tidal and wave energy, Fuel Cell, Energy storage: Battery – types, equivalent circuit, performance characteristics, battery design, charging and charge regulators. Battery management, Ultra Capacitors.

(5L)

**Text Books**:


1. Renewable energy technologies - R. Ramesh, Narosa Publication.
2. Energy Technology – S. Rao, Parulkar 3. Non-conventional Energy Systems – Mittal, Wheelers Publication.

**Reference Books:**


1. Wind and solar systems by Mukund Patel, CRC Press.
2. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.
3. Wind Energy Technology – Njenkins, John Wiley & Sons
4. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
5. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
6. Solar Energy – S. Bandopadhay, Universal Publishing.
7. Guide book for National Certification Examination for EM/EA – Book 1

## SYLLABUS

## EE567 Smart Grid Technology

**Module-1:** Introduction

Basics about Power Grid operation, Concept of Smart Grid, necessity for pushing smart grid concept, operation and control architecture, Basic components, IEEE Standards on Distribution sources integration, Synchrophasor, Cyber Security.

[8L]

**Module 2:** Smart Grid and Generation

Renewable energy generation, Solar, Wind, Hydroelectric, Biomass, fuel cell, challenges with RE generation, uncertainty and risk estimation, concept of Converter design for grid tied RE sources.

[8L]

**Module 3:** Smart Grid and transmission system

Introduction, Wide area monitoring system, Phasor measurement units (PMUs) smart meters, multi-agent system technology, phasor measurement techniques: introduction, phasor estimation of nominal frequency signals, phasor updation using non-recursive and recursive updates, phasor estimation at off- nominal frequency input, hierarchy of phasor measurement systems, communication options for PMUs, functional requirements of PMUs and phasor data concentrators (PDCs).

[8L]

**Module 4:** Smart Grid and Communication system

Introduction, communication requirement, list of the standards, architecture of the communication system, wired and wireless communication, security and safety.

[8L]

**Module 5:** Smart Grid and Demand Response: Introduction, demand response, Types of demand Response Programmes, Aggregator concept, Advanced metering infrastructure, Smart home and building automation standards. Basic concept of Big data analysis.

[8L]

**Text Books:**


1. 1.Smart Grid Standards : Specifications, Requirements, and Technologies by by Takuro Sato, Daniel M. Kammen, Bin Duan, Martin Macuha, Zhenyu Zhou, Jun Wu, Muhammad Tariq, and Solomon A. Asfaw publisher John Wiley & Sons, Incorporated
2. 2.A.G. Phadke, J.S. Thorp, "Synchronized Phasor Measurements and their Applications", Springer 2008


**Reference Books:**


1. James Momoh**, "**SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012
2. Janaka Ekanayake, Kithsiri Liyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins "Smart Grid Technology and Applications", Wiley, New- Delhi, August 2015

**SYLLABUS**
**EE533 Modern Power System Planning**

**Module I**

**Introduction:** Hierarchy of modern power system planning, Brief description about short term and long term planning.Load Forecasting: Classification and characteristics of loads, Forecasting methodology (extrapolation and correlation), Energy forecasting, Peak demand forecasting, Non-weather sensitive forecast (NWSF), Weather-sensitive forecast (WSF), Total forecast, Annual and monthly peak demand forecast.

(8L)

**Module II**

**Power System Probabilistic Production Simulation**: Fundamentals of production simulation, Cumulant method in probabilistic production simulation, Equivalent energy function method, Simulation of hydroelectric generating units and pump-storage units.

(8L)

**Module III**

**Maintenance Scheduling of Generating Units in a Power System**: Introduction, Levelized reserve method, Levelized risk method, Maintenance scheduling using soft computing techniques.

(8L)

**Module IV**

**Generation Expansion Planning:** Fundamental economic analysis, Generation planning optimized according to generating unit categories (WASP), Generation planning optimized according to power plants (JASP), Network Planning: Introduction, Heuristic methods of network planning, Network planning by mathematical optimization, Fast static security contingency analysis, Probabilistic load flow calculation.

(8L)

**Module V**

**Planning of Smart Grid:**Introduction, optimal placement of PMUs, planning of microgrid, planning of distributed generation

(8L)

**Books Recommended:**


1. Modern Power System Planning, X, Wang and J.R. McDonald, McGraw-Hill Book Company.
2. Power System Planning, R.L. Sullivan, McGraw-Hill International Book Company

## SYLLABUS
## EE537 Substation Design and Automation

### Module I

**Introduction to Sub-Station Design:** Principle of Sub-station design, Types of Sub- station, Bus bar systems and layout, Selection of Sub-station site, Benefits of Substation Automation system, Substation Automation with IEC 61850 Standard.

(8L)

### Module II

**Sub-Station Design Development:** Design of Sub-station grounding system, Design of Bus bars, Insulators, Sub-station equipment, Insulation Coordination and surge Arresters, Power Cables, Auxiliary supplies and battery systems.

(8L)

### Module III

**Automation and Protection in Sub-station:** Protection schemes, Electromagnetic pulse (EMP) protection in sub-station, Control and automation in Sub-station, Power line carrier Communication and Tele-control of Sub-stations.

(8L)

### Module IV

**Earthing Design and Calculation of Sub-station:** Factors influencing the choice of earthed and unearthed systems, system earthing & equipment earthing connections to earth, selection of an earthing conductor and connection of an electrode, voltage gradient around earth electrodes, connections to earth electrodes — earthing and protective Conductors, Earthing Arrangement for Protective Purposes, Earthing Arrangement for Functional Purposes, Equipotential Bonding Conductors, Typical Schematic of Earthing And Protective Conductors, Earthing In Power Stations and Substations, Earthing Associated with Overhead Power Lines, Calculation of Earth Fault Currents, Measurement of Earth Resistivity, Measurement of Earth Electrode Resistance, Measurement of Earth Loop Impedance.

(8L)

### Module V

**SF6 Gas Insulated Sub-station:** SF6 Gas Insulated Sub-station (GIS) and Gas insulated cables, Reactive power management, Testing and maintenance of Sub-station equipment.

(8L)

### Text Books:


1. Substation Structure Design Guide by Leon Kempner Jr., American Society of Civil Engineers, Technology & Engineering.
2. Electric Power Substations Engineering by John D. McDonald, CRC Press.


### Reference Books:


1. Electrical Transmission and Substation Structures by Marlon W. Vogt, American Society of Civil Engineers, Technology & Engineering.

## SYLLABUS
## EE587 Electromechanical Energy Conversion

### Module I

**Basic Concepts of Electromechanical Energy Conversion:** Electromagnetic induction, Classification and description of electrical machines, Rotor, Stator and field excitation. Generator and motor action, EMF and torque equations, Classification and description of electrical machines, Leakage flux, Losses and efficiency, Rating, Electrical and mechanical degrees.

(8L)

### Module II

**Transformers:** Construction, Principle of operation, Ideal and physical transformer, emf equation, transformation ratio, Phasor diagram. Equivalent circuit, Losses and efficiency, Autotransformer, 3-phase transformer, Three-phase transformer connections.

(8L)

### Module III

**Introduction to D.C. Machines:** Principle of operation, Armature winding- Lap and wave, Simplex and duplex, Method of excitation, emf and torque equations, commutation.

**DC Generators:** Magnetization characteristics, Critical resistance and critical speed, Process of building up of voltage.

**D.C. Motors:** Basic equation for voltage, Power, Torque and speed, Operating characteristics- Torque-current, and Speed-current and Torque-speed characteristics. Starters, Speed control methods.

(8L)

### Module IV

**Synchronous Machines:** Principle of operation, Excitation system, Effect of winding factor on EMF, Circuit model, Phasor diagram, O.C. and S.C. tests, Short-circuit ratio, Determination of voltage regulation by synchronous impedance, MMF and zero power factor methods. Two reaction theory, Power-angle characteristic of synchronous generators, synchronizing power and torque, Synchronizing methods.

(8L)

### Module V

**3-phase Induction Motor:** Principle of operation, Slip and rotor frequency, Comparison with transformer, Equivalent circuit model, Torque and power output, Losses and efficiency, Torque-slip characteristics, Effect of rotor resistance, starting torque and maximum torque, Starting and speed control methods.

**1-phase Induction Motor:** Introduction, Double revolving field theory, Equivalent circuit model Capacitor Motor, Torque-speed characteristic.

(8L)

## Text Book


1. I.J. Nagrath, D.P. Kothari, Electric Machines, 4th Edition, TMH, New Delhi, 2014.
2. P.S. Bimbhra, Electrical Machines, Khanna Publishers, New Delhi, 7th Edition 2014.


## Reference Books:


1. A.E. Fitzgerald, Charles Kinsley, Stephen D. Umansd; Electric Machinery, McGraw Hill Education (India) Pvt. Ltd, Noida, Indian 6th Edition 2003.
2. E.H. Langsdorf; Theory of Alternating Current Machinery, McGraw-Hill, New York 1955.
3. M.G. Say, –Alternating Current Machines‖, Pitman Publishing Ltd. 1976.

# LIST OF EXPERIMENTS
## EE504 Adaptive Control System Lab

1. To study and implementation of ON-OFF temperature controller.

2. To obtain the step response of first and second order RLC series circuit and determine the value of R and L for a given value of C through time response specification.
3. To obtain Bode plot of the given circuit through experimentation and in term determine the transfer function through by calculations and simulate the same system in Matlab.
4. To obtain the Nyquist plot of the given transfer function and determine the gain margin, phase margin, gain crossover frequency, phase crossover frequency. Comment on the stability.
5. To obtain the characteristics of synchros.

6. To obtain the characteristics of Linear Variable Differential Transformer (LVDT).

7. Study the effect of addition of poles and zeros and correlate the time and frequency domain behavior using MATLAB sisotool for a given system.
8. To study the characteristics of different sensors and transducers.

9. To design a PID controller for a DC motor using Z-N method and verify it in MATLAB.

10. Pole placement design of Inverted pendulum

11. PLC / PID controller based Pressure control using Process trainer kit

12. Study the operation of Twin rotor MIMO system

13. Study the operation of Magnetic Levitation system

**Books recommended:**

**Text Books:**

1.M. Gopal, "Control Systems Principles & Design", 2nd Edition, TMH. (T2)
2.K. Ogata, "Discrete Time Control Systems", 2nd Edition, Pearson Education. (T4)

**Reference Books:**

1.Norman Nise, "Control System Engineering", 4th Edition. (R1)
2.M. Gopal, "Digital Control & State Variable Method", TMH. (R2)
3. B. C. Kuo, "Digital Control System", 2nd Edition, Oxford. (R3)

## EE601 Process Measurement and Control

**Module-I:**
The general control system, transfer functions, process characteristics.
Concept of feedback and feed forward control system, process measurements- temperature, pressure, flow, level, physical properties - density, viscosity, pH, power, rotational speed.

**Module-II:**
Final control element, control valves and their characteristics, the controller, proportional integral, proportional integral derivatives controller, pneumatic and hydraulic controller. Servomotor technology in control.

**Module-III:**
Control system dynamics: transfer function of first order, second order systems. Response of control loop components to forcing functions. Transfer function of feedback control system. Tests for unstable system.
**Module-IV:**

Advanced control systems: multivariable control problem, ratio control, cascade control, computed variable control, feed forward control, override control, adaptive control.

**Module-V:**
Application of computer control, on line computer control, servomotor technology in control, brief idea about application of dynamic matrix control, predictive control, Fuzzy logic control.

**Books Recommended:**

1. "Process Control", F. G. Shinskey, McGraw Hill Book Company.
2. "Process, Modeling, Simulation and Control for Chemical Engineers", W. L. Luyben, McGraw Hill.
3. D.R. Coughanour, 'Process Systems analysis and Control', McGraw-Hill, 2nd Edition, 1991.
4. Coughanouer and Koppel, Process System analysis and Control

## EE611 Physiological Control Systems

**Module-1:**
Introduction: Systems Analysis, Physiological Control Systems Analysis, Differences between Engineering and Physiological Control Systems, Mathematical Modeling: Generalized System Properties, Models with Combinations of System Elements, Linear Models of Physiological Systems, Distributed-Parameter versus Lumped Parameter Models, Linear Systems and the Superposition Principle,

**Module-2:**
Static Analysis of Physiological Systems: Open-Loop versus Closed-Loop Systems, Determination of the Steady-State Operating Point, closed and open loop Regulation of Cardiac Output, Regulation of Glucose, Chemical Regulation of Ventilation, The Gas Exchanger, The Respiratory Controller, Closed-Loop Analysis: Lungs and Controller Combined.

**Module-3:** Time-Domain Analysis of Linear Control Systems: Linearized Respiratory Mechanics: Open Loop versus Closed-Loop, Open-Loop and Closed-Loop Transient Responses: First and second-Order Model, Impulse Response, Step Response, Open-Loop versus Closed-Loop Transient Responses, Reduction of the Effects of External Disturbances, Reduction of the Effects of Parameter Variations, Integral Control, Derivative Feedback, Transient Response Analysis, Frequency Response of a Model of Circulatory ontrol, requency Response of the Model, Frequency Response of Glucose-Insulin Regulation.

**Module-4:** Stability Analysis: Model of Cheyne-Stokes BreathinCO2 Exchange in the Lungs Transport Delays Contents Controller Responses Loop Transfer Functions

**Module-5:** Nonlinear Analysis of Physiological Control Systems Nonlinear versus Linear Closed-Loop Systems Phase-Plane Analysis Local Stability: Singular Points Method of Isoclines Nonlinear Oscillators Limit Cycles The van der Pol Oscillator Modeling Cardiac Dysrhythmias The Describing Function Method Methodology Application: Periodic Breathing with Apnea Models of Neuronal Dynamics Hodgkin-Huxley Mode The Bonhoeffer-van der Pol Model.

**Reference books:**

1. Physiological Control Systems by M. C. K. Khoo, PHI, 2001

**EE 605 Micro Grid Operation and Control**

**Module 1:**
Distributed generation and Microgrid concept: Introduction, Active distribution network, concept of microgrid , typical micro grid configuration, distributed renewable energy technologies, non-renewable distributed generation technologies, interconnection of micro grids, technical and economical advantages of micro grid, challenges and disadvantages of micro grid development, management and operational issues of a micro grid, dynamic interactions of microgrid with main grid. [8L]

**Module 2:**
Distributed energy resources: Introduction, Combined heat and power (CHP) systems, Micro-CHP systems, Wind energy conversion systems (WECS), Wind turbine operating systems, Solar photovoltaic (PV) systems, Types of PV cell, Small-scale hydroelectric power generation, Other renewable energy sources, Storage devices

[8L]

**Module-3:**
Control of single converter in grid connected mode, Master and slave control of microgrids, Primary droop control, Secondary voltage and frequency control in microgrids, Centralized and decentralized Energy Management System (EMS) in microgrids, Bidding Strategy in Microgrid market operation

[8L]

**Module-4:**
Advanced metering system, Demand response, Types of Demand Response Programmes, Real-time control effect in microgrid EMS, Voltage and frequency restoration, communication protocols

[8L]

**Module-5:**
Protection, power quality and reliability issues for microgrids: Islanding, different islanding scenarios, major protection issues of stand-alone microgrid, microgrid distribution system protection, Protection of micro-sources, neutral grounding requirements, impact of DG integration on power quality and reliability, power quality disturbances, power quality sensitive customers, power quality improvement technologies

[8L]

**Text books:**

1. S. Chowdhury, S.P. Chowdhury and P. Crossley, “Microgrids and Active Distribution Networks”, The Institution of Engineering and Technology, 2009.

**Reference books:**

1. Bansal, Ramesh, “Handbook of Distributed Generation: Electric Power Technologies, Economics and Environmental Impacts”, Springer, ISBN 978-3-319-51342-3

**SYLLABUS**
**EE 606 Smart Grid Laboratory**
**LIST OF EXPERIMENTS**

1. I-V and P-V curve for a given SPV system.
2. Simulation of MPPT algorithm using Perturb & Observe method.
3. Experiment on Boost converter for MPPT implementation for SPV system.
4. Bidirectional power flow between wind energy connected system and grid.
5. Wind and battery-based grid connected system and DC bus utilization.
6. Study and analyze generation control of RESs in isolated mode.
7. Study and analyze generation control of RESs in grid connected mode.
8. Risk assessment of generation from RESs in microgrid bidding operation.
9. Design and analysis of Demand Response program.
10. Analyzing the voltage and current in two bus system using Phasor Measurement Unit
11. To simulate PMU model by using MATLAB and to analyse the voltage and current signal for two bus system.
12. Design and analysis of Electric vehicle-grid application.
13. Modelling of Hybrid Electric vehicle batteries.
14. IOT based renewable energy management system.

**Books recommended:**


1. Takuro Sato, Daniel M. Kammen, , Bin Duan, , Martin Macuha, , Zhenyu Zhou, , Jun Wu, , Muhammad Tariq, , and Solomon A. Asfaw, "Smart Grid Standards : Specifications, Requirements, and Technologies" **PUBLISHER** John Wiley & Sons, Incorporated.
2. A.G. Phadke J.S. Thorp, "Synchronized Phasor Measurements and their Applications", springer 2008.
3. James Momoh**, "**SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012.
4. Janaka Ekanayake, KithsiriLiyanage, JianzhongWu, Akihiko Yokoyama, Nick Jenkins "Smart Grid Technology and Applications", Wiley, New- Delhi, August 2015.

5. Wind and solar systems by Mukund Patel, CRC Press.
6. Solar Photovoltaics for terrestrials, Tapan Bhattacharya.
7. Wind Energy Technology – Njenkins, John Wiley & Sons
8. Solar & Wind energy Technologies – McNeils, Frenkel, Desai, Wiley Eastern.
9. Solar Energy – S.P. Sukhatme, Tata McGraw Hill.
10. Solar Energy – S. Bandopadhay, Universal Publishing. 7. Guide book for National Certification Examination for EM/EA – Book 1

## Syllabus

## EE 631 Power System Reliability Evaluation

**Module 1:**

Reliability Principles : Failure Rate Model , Concept of Reliability of Population, Mean Time to Failures, Reliability of Series, Parallel and Complex Systems, Standby System Modeling, Concepts of Availability and Dependability, Reliability Measurement, General reliability function, Exponential distribution.

**Module 2:**

Power System Reliability in Perspective: Introduction, Need for Power system Reliability Evaluation, Definition of Power System Reliability, Functional Zones, Hierarchical Levels, Adequacy Analysis at different Hierarchical Levels, Typical reliability criteria, Reliability worth, Markov processes, System reliability using network and state space method.

**Module 3:**

Generating System Reliability Evaluation : Static Generating Capacity Reliability Evaluation: Introduction, Capacity outage probability tables, Loss of load probability (LOLP) method, Loss of energy probability (LOLE) method, Frequency and duration approach. Spinning Generating Capacity Reliability Evaluation: Introduction, Spinning capacity evaluation, Derated capacity levels.

[8L]

**Module 4:**

Transmission System Reliability Evaluation: Average interruption rate method, the frequency and duration approach, Stormy and normal weather effects, The Markov processes approach, System studies. Direct Current Transmission System Reliability Evaluation: System models of failure, Loss of load approach, Frequency and duration approach, Spare -valve assessment, multiple bridge equivalents. [8L]

**Module 5:**

Composite System Reliability Evaluation Considering Interconnection: Service quality criterion, Conditional probability approach, Two-plant single load and two load systems. The probability array for two interconnected systems, Loss of load approach, Interconnection benefits.

[8L]

**Text Books:**

1. Power System Reliability Evaluations - R. Billinton, Gordon and Breach Science Publishers, New York.
2. Reliability Modeling in Electric Power Systems, J. Endrenyi, John Wiley & Sons, New York.

**Reference Books:**

1. Practical Reliability Engineering, Patrick D.T. O'Connor, John Wiley & Sons, (Asia) Pte Ltd., Singapore.
2. Reliability of Engineering Systems - Principles and Analysis, I. Ryabinin, MIR Publishers, Moscow.

## EE 633 Power Quality

**Module-I**

Introduction–Overview of Power Quality–Concern about the Power Quality–General Classes of Power Quality Problems – Transients – Long-Duration Voltage Variations – Short-Duration Voltage Variation – Voltage Unbalance – Waveform Distortion – Voltage fluctuation – Power Frequency Variation – Power Quality Terms – Voltage Sags and Interruptions – Sources of Sags and Interruptions – Nonlinear loads. [8L]

**Module-II**

Transient Over Voltages – Source of Transient Over Voltages – Principles of Over Voltage Protection – Devices for Over Voltage Protection – Utility Capacitor Switching Transients – Utility Lightning Protection – Load Switching Transient Problems – Computer Tools for Transient Analysis. [8L]

**Module-III**

Harmonic Distortion and Solutions – Voltage vs. Current Distortion – Harmonic vs. Transients – Power System Quantities under Nonsinusoidal Conditions – Harmonic Indices – Sources of harmonics – Locating Sources of Harmonics – System Response Characteristics – Effects of Harmonic Distortion – Interharmonics– Harmonic Solutions Harmonic Distortion Evaluation – Devices for Controlling Harmonic Distortion – Harmonic Filter Design – Standards on Harmonics. [8L]

**Module-IV**

Long Duration Voltage Variations – Principles of Regulating the Voltage – Device for Voltage Regulation – Utility Voltage Regulator Application – Capacitor for Voltage Regulation – End-user Capacitor Application – Regulating Utility Voltage with Distributed Resources – Flicker. [8L]

**Module-V**

Distributed Generation and Power Quality – Resurgence of Distributed Generation – DG Technologies – Interface to the Utility System – Power Quality Issues – Operating Conflicts – DG on Low Voltage Distribution Networks – Interconnection standards – Wiring and Grounding – Typical Wiring and Grounding Problems – Solution to Wiring and Grounding Problems [8L]

**Text Books:**


1. Electrical Power Systems Quality, Dugan R C, McGranaghan M F, Santoso S, and Beaty H W, Second Edition, McGraw-Hill, 2002.
2. Power Quality Primer, Kennedy B W, First Edition, McGraw-Hill, 2000.


**References:**


1. Understanding Power Quality Problems: Voltage Sags and Interruptions, Bollen M H J,First Edition, IEEE Press; 2000.
2. Power System Harmonics, Arrillaga J and Watson N R, Second Editon, John Wiley & Sons, 2003.
3. Electric Power Quality control Techniques, W. E. Kazibwe and M. H. Sendaula, Van Nostrad Reinhold, New York.
4. Power Qualityc.shankaran, CRC Press, 2001.
5. Harmonics and Power Systems – Franciso C.DE LA Rosa-CRC Press (Taylor & Francis)
6. Power Quality in Power Systems And Electrical Machines-Ewald F. fuchs, Mohammad A.S. Masoum-Elsevier.

## EE 635 Wide Area Monitoring System

**MODULE 1:**

**Introduction to Computer Relaying**: Evolution of power system relaying from electromagnetic to static to computer relaying; Relay operating principles for computer relaying; Expected benefits of computer relaying, Computer relay architecture. Protection of Transmission Line using Computer Relaying Three zone protection of transmission line, algorithms for impedance calculations- Mann-Morrison algorithm - Three sample technique - Two sample technique - First and second derivative algorithms - Numerical integration methods. Protection of power system equipment using Frequency domain techniques Problems associated with differential protection of transformer and bus-bar, magnetic inrush current, LSQ algorithm, Fourier analysis of transformer protection

**MODULE 2:**

**Introduction:** Synchrophasor technology, advantages of synchrophasors over supervisory control and data acquisition (SCADA) system, challenges with synchrophasor measurement, world wide deployment of wide area measurement system (WAMS), application of synchrophasor data.

**MODULE 3:**

**Phasor measurement units (PMUs) for wide area grid observability:** Introduction, optimal placement of phasor measurement units (PMUs), need for optimal PMU placement for synchrophasors, algorithm for optimal PMU placement, observability index, optimal redundancy criterion.

**MODULE 4:**

**WAMS based power network protection:** WAMS architecture and communication, improved network protection during stressed conditions, online identification of protection element failure, adaptive protection.

**MODULE 5:**

**Wide area security assessment:** Introduction, state estimation, wide area severity index, data mining model, reliability evaluation and enhancement, situational awareness.

**Text books:**


1. A.G. Phadke, J.S. Thorp, 'Computer Relaying for Power Systems', John Wiley and Sons Ltd., Research Studies Press Limited, 2nd Edition, 2009.
2. A.G. Phadke, J.S. Thorp, 'Synchronized Phasor Measurements and Their Applications', Springer Publications, 2008
3. James Momoh**, "**SMART GRID: Fundamentals of Design and Analysis", IEEE (Power engineering series) – Wiley- Blackwell, April 2012.
4. D.K. Mohanta and J.B. Reddy (editors), "Synchronized phasor measurement for smart grid", Institution of Engineering and Technology 2017.

## SYLLABUS

## EE 604 Power Converter Design Laboratory

## LIST OF EXPERIMENTS

1. Name: Mathematical modelling of a Boost Converter and controller design.

**Aim:** (a) To develop state space model in DCM and CCM

(b) Obtain controller gains for obtaining particular time domain specifications.

2. Name: Simulate the closed loop control of Boost Converter with computed controller gains.

**Aim:** (a) Simulate developed State Space model to find step response

(b) Obtain frequency domain response using MATLAB

3. Name: Develop the firing circuit and power circuit of Boost Converter

**Aim:** (a) Design optically isolated firing circuit for Boost converter on a varo-board.

(b) Design power circuit on a varo-board using Power MOSFET

4. Name: Conduct experiment on hardware model of Boost converter to obtain efficiency vs duty cycle curve.

**Aim:** (a) Determine boost factor vs duty cycle curve

(b) Observe dynamic parameters in time domain and compare it with simulated result.

5. Name: Mathematical computation for filter design of a 3 Phase voltage source inverter.

**Aim:** (a) Obtain Fourier transform of Line voltage and phase voltage waveform.

(b) Compute the value of inductor and capacitor for filter design.

6. Name: Simulate 3 Phase VSI with filter and obtain filter response in terms of improvement in THD

**Aim:** (a) Simulate 3 Phase VSI without and with filter and obtain THD in each case.

(b) Implement Selected harmonics elimination based PWM technique in MATLAB environment.

7. Name: Design firing circuit of 3 phase VSI.

**Aim:** (a) Develop hardware model of firing circuit for 3 Phase VSI

(b) Interface Microcontroller and Gate terminal of Switches with correct biasing.

8. Name: Design Power Circuit of a 3 phase VSI

**Aim:** (a) Develop three phase VSI hardware on varo-board

(b) Design hardware of filter circuit

9. Name: Perform experiment on 3 phase VSI.

**Aim:** (a) Obtain MI vs RMS line voltage

(b) Obtain THD vs Carrier Frequency curve

10. Name: Simulate and obtain response of a CUK regulator.

**Aim:** (a) develop output voltage and output current expression.

(b) Verify Input and Output voltage and current waveform using MATLAB based Simulink.

**Text Books:**

1. P.S. Bimbra, Generalised Theory of Electric Machines, Khanna Publications, 7th Edition, Delhi, 2010
2. M.H. Rashid, Power Electronics, PHI,

**Reference Books:**

3. B K Bose: Modern Power Electronics and A C Drives, PHI , Delhi
4. G K Dubey, Fundamental of Electric Drives, 2nd Edition, PHI, Delhi.
5. C.M. Ong, Dynamic Simulation of Electric Machinery, PH, NJ.