Semester IV

Electrical Machines - II

1.1 Course Number: EE206
1.2 Contact Hours: 3-1-0 Credits: 11
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Class 10th level Mathematics, Science and FEEE
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma

2. **Objective:**

1. To know the operation and types of single-phase/three-phase induction motors and their applications.
2. To study the principle, construction and operation of synchronous generators and motors.
3. To impart knowledge on construction and operation of fractional horsepower Motors.

· **3**. **Course Content:**

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	Three Phase Induction Motor	Working principle: production of rotating magnetic field, Synchronous speed, rotor speed and slip. Constructional details of 3 phase induction motors: Squirrel cage induction motor and Slip ring induction motor. Rotor quantities: frequency, induced emf, power factor at starting and running condition. Characteristics of torque versus slip (speed), Torques: starting, full load and maximum with relations among them. Power flow diagram, Starters: need and types; stator resistance, auto transformer, star delta, rotor resistance and soft starters. Speed control methods: stator voltage, pole changing, rotor resistance and VVVF.	10
2	Single phase induction motors	Double field revolving theory, principle of making these motors self-start. Construction and working: Resistance start induction run, capacitor start induction run, capacitor start capacitor run, shaded pole, repulsion type, series motor, universal motor. Torque-speed characteristics for all of the above motors. Motor selection for different applications as per the load torque-speed requirements.	7

3	Three phase Alternators	Principle of working, moving and stationary armatures. Constructional details: parts and their functions, rotor constructions. Windings: Single and Double layer. E.M.F. equation of an Alternator with numerical by considering short pitch factor and distribution factor. Alternator loading: Factors affecting the terminal voltage of alternator; Armature resistance and leakage reactance drops. Voltage regulation: direct loading and synchronous impedance methods.	8
4	Synchronous motors	Principle of working /operation, significance of load angle. Torques: starting torque, running torque, pull in torque, pull out torque. Synchronous motor on load with constant excitation (numerical), effect of excitation at constant load (numerical). V-Curves and Inverted V-Curves. Hunting and Phase swinging. Methods of Starting of Synchronous Motor. Losses in synchronous motors and efficiency.	8
5	Fractional horse power (FHP) Motors	Construction and working: Synchronous Reluctance Motor, Switched Reluctance Motor, Permanent Magnet Synchronous Motors, AC servomotors. Torque speed characteristics of above motors. Applications of above motors	8
Total			**41**

4. Readings

4.1 Recommended Books:

References:

1. P.S. Bimbhra, Electric Machines, Khanna Book Publishing Co., New Delhi (ISBN: 978-93-86173- 294)
2. Mittle, V.N. and Mittle, Arvind., Basic Electrical Engineering, McGraw Hill Education New Delhi, ISBN :9780070593572
3. Kothari, D. P. and Nagrath, I. J., Electrical Machines, McGraw Hill Education. New Delhi, ISBN:9780070699670
4. Bhattacharya, S. K., Electrical Machines, McGraw Hill Education, New Delhi, ISBN:9789332902855
5. Theraja, B.L., Electrical Technology Vol-II (AC and DC machines), S.Chand and Co. Ltd., New Delhi, ISBN : 9788121924375
6. Sen, S. K., Special Purpose Electrical Machines, Khanna Publishers, New Delhi, ISBN: 9788174091529

7. Janardanan E. G, Special Electrical Machines, Prentice Hall India, New Delhi ISBN: 9788120348806

5. Outcome of the Course:

After the completion of this course the students will be able to

1. Operate and maintain three phase squirrel cage and slip ring induction motors.

2. Understand the operation of synchronous machine.

3. Inference the theory of single phase induction motor.

4. Select FHP motors used in different applications.

Microprocessor and Microcontroller

1.1 Course Number: EE207
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: Digital Electronics
1.5Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani, Dr. Santosh Kumar Verma.

2. Objective:

i) Understand the architecture of 8085 and 8051.
ii) Impart the knowledge about the instruction set.
iii) Understand the basic idea about the data transfer schemes and its applications.
iv) Develop skill in simple program writing for 8085 & 8051 and applications.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	Introduction to microprocessor 8085	Introduction to Microprocessor, Basic Block diagram of Microcomputer system, Architecture of 8085, Pin Diagram of 8085, Interrupts.	8
2	Instructions and Programmingin 8085	The instruction set of 8085, Timing Diagram, Programming of 8085.	8
3	Peripheral Interface	Interfacing and I/O ports, PPI e.g. 8255 A, 8155 in detail, 8257 in detail, Serial I/O data communication.	8
4	Introduction 8051 microcontroller	Introduction to 8051 Micro-Controllers, Architecture; Memory Organization; Special Function register; Port Operation; Memory Interfacing, I/O Interfacing; Programming 8051 resources, interrupts;	8
5	Instruction set and programming 8051	Programmer's model of 8051; Operand types, Operand addressing; Data transfer instructions, Arithmetic instructions, Logic instructions, Control transfer instructions; Programming.	**7**
Total			**39**

4. Readings

1. Microprocessor Architecture, Programming and Applications with 8085 by RS Gaonkar
2. Microprocessor and Applications by B Ram
3. Comprehensive Study of Microprocessor by Naresh Grover
4. Introduction to Microprocessor by Adithya P Mathur, Tata McGraw Hill Publishers, New Delhi
5. Microprocessorsand Microcontrollers by Krishna Kant, PHI Learning Private Limited.
6. The 8051 Microcontroller and Embedded Systems, Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D.M C Kinlay, Pearson Education, Second Edition, 2008.

5. Outcome of the Course:

After the completion of this course the student will be able to:

1) Understand and demonstrate the basic architecture of 8085 and 8051.
2) Impart the knowledge about the instruction set.
3) Understand the basic idea about the data transfer schemes and its applications.
4) Develop skill in simple program writing for INTEL 8085 and INTEL 8051.

Linear Control System

1.1 Course Number: EE208
1.2 Contact Hours: 3-0-0 Credits:9
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: Mathematics-I & II and Transform Calculus
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma.

2. Objective:

i) To understand the operation of manual and automatic control systems.
ii) To analyse and understand the stability aspects of physical systems using transfer function model.
iii) To provide adequate knowledge to understand the time response specifications of second order systems and multiloop control systems.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Introduction**	Basic elements of the control system, open loop and closed-loop control systems, manually controlled closed loop systems, automatic controlled closed loop systems, control system examples from mechanical systems, electrical systems.	8
2	**Modelling of Linear Time Invariant (LTI) System**	First principal modelling: Mechanical, Electrical and Electromechanical systems.	8
3	**Control system representation**	Transfer function, block diagram, reduction of block diagram, Mason's formula signal flow graph.	8
4	**Time Response Analysis**	Standard test signals, time response of first and second-order system, time constant, time response of second other system, time response specifications, steady-state errors and error constants.	8
5	**Frequency Response Analysis and Stability**	Introduction, Frequency domain specifications, Bode plot diagrams-Determination of Phase margin and Gain margin, Stability analysis from Bode plots, Polar plots and Root Locus.	7
Total			**39**

4. Readings

4.1 Textbooks:

1. Control Systems by Nagrath and Gopal.
2. Control Systems by B.C. KUO.
3. Control Systems by Ogata.
4. Control Systems by RC Shukla.

4.2 References Books:

1. Chemical Process Control by Stephenapolis.

5. Outcome of the Course:

1) Illustrate different applications of manual and automatic control systems.
2) Develop the transfer function model of physical system and analyse their stability.
Analyse the time response of a second order system and multiloop control systems.

Electrical and Electronic Measurements

1.1 Course Number: EE209
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: NA
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma.

2. Objective:

i) To learn the basic principles of all measuring instruments.
ii) To understand the voltage, current, resistance power and energy measurement.
iii) To understand the operation of digital storage oscilloscope and digital meters.

3. Course Content:

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	**Measurement of voltage, current and resistance**	Types of instruments – Construction, working and derivation of torque equation of moving coil, moving iron, dynamometer type and induction type (shaded pole construction) instruments - Extension of instrument ranges –shunt and multiplier (calculation and requirements, Simple Problems)- Tong Tester -current transformer and potential transformer (No derivations, working principle only). Measurement of resistance –ohm meter (series and shunt type), Megger and Earth tester. Multimeter.	8
2	**Measurement of power and energy**	Types of wattmeter: Construction and operation of dynamometer type wattmeter - LPF wattmeter – 3 phase two element wattmeter. Construction and working of induction type single phase energy meter – friction compensation -creep and prevention – Errors and adjustments in energy meters- 3 phase energy meter (connection circuit only) – RSS meter Calibration of Energy meter - Introduction to Multi-function Energy meter Applications - Measurement of power and energy using CT and PT (Circuit only) Power factor meter - Single phase and three phase (dynamometer type) – construction and working.	8
3	**Electronic voltmeter**	Advantages over conventional multimeter for volt measurement with respect to input impendence and sensitivity. Principles of voltage, current and resistance measurement (block diagram only) Specifications of electronics voltmeter. Types of AC milli voltmeters and their block diagram description. Typical specification and their significance.	7

4	**Cathode Ray Oscilloscope**	Block diagram description of a basic CRO and triggered sweep oscilloscope, front panel controls specifications of CRO and their explanation. Measurement of current, voltage, frequency, time period and phase using CRO.CRO probes, special features of dual beam, dual trace, delay sweep. Digital storage oscilloscope: block diagram and working.	7
5	**Signal Generators and Analysis Instruments**	Explanation of block diagram specifications of low frequency and RF generators, Pulse generator, function generator. Distortion factor meter; wave analyzer and spectrum analyser.	7
Total			**37**

4. Readings

4.1 Textbooks

1. Electronics Measurement and Instrumentation by AK Sawhney, Dhanpat Rai & Sons, Delhi
2. Electronics Instrumentation by JB Gupta, Satya Prakashan, New Delhi

4.2 Reference Books:

1. Electronics Instrumentation by Cooper, Prentice Hall of India

5. Outcome of the Course:

1) Use different types of measuring instruments for measuring voltage, current, power and energy.
2) Measure the voltage, current and resistance through multimeter and electronic voltmeter.
3) Explain the principle of operation of DSO and digital meters.

Transmission And Distribution of Electrical Power

1.1 Course Number: EE210
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Class 10th level Mathematics & Science
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma

2. **Objective:**

1. To learn the basic structure and concepts of power systems.
2. To know the basic concepts of various electric power generating plants.
3. To study and analyze the performance of different types of transmission lines
4. To impart knowledge on various components of transmission and distribution line.

3. **Course Content:**

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	Introduction to Power Generation and Power plants	Conventional methods of power generations – schematic arrangement and choice of site for Hydel, thermal, nuclear power plants - Advantages and disadvantages - comparison of these power plants. Principle and types of co-generation - Schematic arrangement of diesel and gas power plants - Advantages and Disadvantages. Renewable Energy sources - Basic principle of Solar, Wind, Geothermal, Ocean, Biomass and Tidal Energy sources.	7
2	Basics of Transmission and Distribution	Single line diagrams with components of the electric supply transmission and distribution systems. Classification of transmission lines: Primary and secondary transmission; standard voltage level used in India. Classification of transmission lines: based on type of voltage, voltage level, length and others Characteristics of high voltage for power transmission.	8
3	Transmission Line Parameters and Performance	Line Parameters: Concepts of R, L and C of line parameters and types of lines. Performance of short line: Efficiency, regulation and its derivation, effect of power factor, vector diagram for different power factor. Performance of medium line: representation,	7

		nominal 'T', nominal 'π' and end condenser methods. Skin effect and proximity effect.	
4	A.C Distribution System	AC distribution: Components classification, requirements of an ideal distribution system, primary and secondary distribution system. Feeder and distributor, factors to be considered in design of feeder and distributor. Types of different distribution schemes: radial, ring, and grid, layout, advantages, disadvantages and applications. Voltage drop, sending end and receiving end voltage. Distribution Sub-Station: Classification, site selection, advantages, disadvantages and applications.	8
5	Components of Transmission and Distribution Line	Overhead Conductors: Properties of material, types of conductor with trade names, significance of sag. Line supports: Requirements, types of line structures and their specifications, methods of erection. Line Insulators: Properties of insulating material, selection of material, types of insulators and their applications, causes of insulator failure, derivation of equation of string efficiency for string of three suspension insulator, methods of improving string efficiency. Underground Cables: Requirements, classification, construction, comparison with overhead lines, cable laying and cable jointing.	8
Total			**38**

4. Readings

4.1 Recommended Books:

References:

1. G.C. Garg, Utilization of Electric Power & Electric Traction, Khanna Book Publishing Co., New Delhi (ISBN: 978-93-86173-355)
2. Mehta, V.K., Principles of Power System, S. Chand and Co. New Delhi, ISBN: 9788121924962
3. Soni;Gupta; Bhatnagar, A Course in Electrical Power, Dhanpat Rai and Sons New Delhi, ISBN: 9788177000207
4. Gupta,J.B., A Course in Power Systems, S.K. Kataria and sons, New Delhi, ISBN: 9788188458523
5. Theraja, B.L.; Theraja, A.K., A Textbook of Electrical Technology Vol. III, S.Chand and Co. New Delhi, ISBN : 9788121924900
6. Uppal,S.L., A Course in Electrical Power, S.K.Khanna Publisher New Delhi, ISBN : 9788174092380

7. Sivanagaraju S.; Satyanarayana S., Electrical Power Transmission and Distribution, Pearson Education, New Delhi, , ISBN:9788131707913
8. Ned Mohan, Electrical Power System: A First Course, Wiley India Pvt. Ltd. New Delhi, ISBN:9788126541959
9. Gupta, B.R., Power System Analysis and Design, S. Chand and Co. New Delhi, ISBN: 9788121922388
10. Kamraju, V., Electrical Power Distribution System, Tata McGraw-Hill, New Delhi, ISBN:9780070151413

5. Outcome of the Course:

After the completion of this course the students will be able to:

1. Understand the working of different electric power generating plants.
2. Explain the basic concepts and structure of power systems.
3. Classify and analyze the performance of transmission lines.
4. Understand the various components of transmission and distribution line.

Switchgear and Protection

1.1 Course Number: EE211
1.2 Contact Hours: 3-0-0 Credits: 9
1.3 Semester-offered: 2nd Year –Even
1.4 Prerequisite: Class 10th level Mathematics & Science
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma

2. **Objective:**

1. To study the principles of operation of electromagnetic and static relays.
2. To learn the description and operation of different types of circuit breakers
3. To know the construction and operation of alternator, motor, transformer, and bus-bar protection.

3. **Course Content:**

Unit-wise distribution of content and number of lectures

Unit	Topics	Sub-Topic	Lectures
1	Basics of Protection	Necessity, functions of protective system. Normal and abnormal conditions. Types of faults and their causes. Protection zones and backup protection, Short circuit fault calculations in lines fed by generators through transformers. Need of current limiting reactors and their arrangements.	7
2	Circuit Interruption Devices	Isolators- Vertical break, Horizontal break and Pantograph type. HRC fuses – Construction, working, characteristics and applications. Arc formation process, methods of arc extinction (High resistance and Low resistance), Arc voltage, Recovery voltage, Re-striking voltage, RRRV. HT circuit breakers (Sulphur-hexa Fluoride (SF6), Vacuum circuit breaker) - Working, construction, specifications and applications. L.T. circuit breaker (Air circuit breakers (ACB), Miniature circuit breakers (MCB), Moulded case circuit breakers (MCCB) and Earth leakage circuit breaker (ELCB)) - Working and applications. Selection of LT and HT circuit breakers (ratings), Selection of MCCB for motors. Gas insulated switchgear	8

3	Protective Relays	Fundamental quality requirements: Selectivity, Speed, Sensitivity, Reliability, Simplicity, Economy. Basic relay terminology- Protective relay, Relay time, Pick up, Reset current, current setting, Plug setting multiplier, Time setting multiplier. Protective relays: Classification, principle of working, construction and operation of – Electromagnetic (Attracted armature type, Solenoid type, Watt-hour meter type) relay, Thermal relay. Block diagram and working of Static relay. Overcurrent relay-Time current characteristics.	7
4	Protection of Alternator and Transformer	Alternator Protection: Faults, Differential protection Over current, earth fault, overheating and field failure, protection. Reverse power protection. Transformer Protection: Faults, Differential, over current, earth fault, over heating protection, Limitations of differential protection. Buchholz relay: Construction, operation, merits and demerits.	8
5	Protection of Motors, Bus-bar and Transmission Line Motor	Faults. Short circuit protection, Overload protection, Single phase preventer. Bus bar and Transmission line Faults on Bus bar and Transmission Lines. Bus bar protection: Differential and Fault bus protection. Transmission line: Over current, Distance and Pilot wire protection.	8
Total			**38**

4. Readings

4.1 Recommended Books:

References:

1. Mehta V. K ;Rohit Mehta, Principles of Power System, S .Chand and Co., New Delhi., ISBN: 978-81-2192-496-2.
1. Rao.Sunil S., Switchgear and Protection, Khanna Publishers, New Delhi, ISBN: 978-81-7409-232-3.
2. Singh, R. P., Switchgear and Power System Protection, PHI Learning, New Delhi, ISBN: 978-81-203-3660-5.
3. Gupta. J. B.. Switchgear and Protection, S. K. Kataria and Sons, New Delhi, ISBN: 978-93-5014-372-8.
4. Veerapan, N.,Krishnamurty, S. R., Switchgear and Protection, S .Chand and Co., New Delhi. ISBN: 978-81-2193-212-7.
5. Ram, Badri; Vishwakarma D. N., Power System Protection and Switchgear, McGraw-Hill, New Delhi. ISBN : 978-07-107774-X

5. Outcome of the Course:

After the completion of this course the students will be able to:

1. Understand the operation of Electromagnetic and Static relays
2. Analyze the principles of fuses and circuit breaker
3. Analyze the alternator, motor, transformer, and bus-bar protection

Electrical Machines-II Laboratory

1.1 Course Number: EE206L
1.2 Contact Hours: 0-0-2 Credits:2
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: NA
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani& Dr. Santosh Kumar Verma.

1. Conduct load test on three phase induction motor and plot
   a. Load Vs Efficiency
   b. Load Vs P.f.
   c. Torque Vs Slip characteristic curves.
2. Draw the equivalent circuit of a 3 phase Induction motor by conducting No load and Blocked rotor test.
3. Conduct load test on a single phase induction motor and plot
   a. Load Vs efficiency
   b. Load Vs Power factor
   c. Torque Vs Slip characteristic curves.
4. Predetermination of regulation of alternator by synchronous impedance method.
5. Synchronising of two alternators by lamp & synchroscope method.
6. Determination of 'V' Curve and inverted 'V' curves of a three phase synchronous motor.
7. Control the speed and reverse the direction of stepper motor
8. Control the speed and reverse the direction of the AC servo motor

Recommended Books:

1. P.S. Bimbhra, Electric Machines, Khanna Book Publishing Co., New Delhi (ISBN: 978-93-86173- 294)

2. Mittle, V.N. and Mittle, Arvind., Basic Electrical Engineering, McGraw Hill Education

New Delhi, ISBN :9780070593572

3. Kothari, D. P. and Nagrath, I. J., Electrical Machines, McGraw Hill Education. New Delhi, ISBN:9780070699670

4. Bhattacharya, S. K., Electrical Machines, McGraw Hill Education, New Delhi, ISBN:9789332902855

5. Theraja, B.L., Electrical Technology Vol-II (AC and DC machines), S.Chand and Co. Ltd., New Delhi, ISBN : 9788121924375

6. Sen, S. K., Special Purpose Electrical Machines, Khanna Publishers, New Delhi, ISBN: 9788174091529

7. Janardanan E. G, Special Electrical Machines, Prentice Hall India, New Delhi ISBN: 9788120348806

Microprocessors and Microcontroller Laboratory

1.1 Course Number: EE207L
1.2 Contact Hours: 0-0-2 Credits: 2
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: Digital Electronics
1.5Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani, &Dr. Santosh Kumar Verma.

1. Study of 8085 Microprocessor kit.
2. Write a program using 8085 and verify for: a. Addition of two 8-bit numbers. b. Addition of two 8-bit numbers (with carry)
3. Write a program using 8085 and verify for: a. 8-bit subtraction (display borrow) b. 16-bit subtraction (display borrow).
4. Write a program using 8085 for multiplication of two 8- bit numbers by repeated addition method.
5. Check for minimum number of additions and test for typical data and write a program using 8085 for multiplication of two 8- bit numbers by bit rotation method and verify.
6. Write a program using 8085 for division of two 8- bit numbers by repeated subtraction method and test for typical data.
7. Write a program using 8085 for dividing two 8- bit numbers by bit rotation method and test for typical data.
8.Write a program to interface a two-digit number using seven-segment LEDs. Use 8085 microprocessor and 8255 PPI.
9. Write a program to control the operation of stepper motor using 8085 microprocessor and 8255 PPI.
10. Write a program for traffic light controller using 8085 microprocessor and 8255 PPI.
11. Write a program to perform 8-bit addition and subtraction using 8051 microcontroller.
12. write a program to generate delay using serial port and on-chip timer / counter.

Recommended Books:

1. Microprocessor Architecture, Programming and Applications with 8085 by RS Gaonkar
2. Microprocessor and Applications by B Ram
3. Comprehensive Study of Microprocessor by Naresh Grover
4. Introduction to Microprocessor by Adithya P Mathur, Tata McGraw Hill Publishers, New Delhi
5. Microprocessor by SK Goel.
6. 8051 by Mcakenzie, Prentice Hall of India, New Delhi.

Electrical and Electronic Measurements Laboratory

1.1 Course Number: EE209L
1.2 Contact Hours: 0-0-2 Credits:2
1.3 Semester-offered: 2nd Year –Even
1.4 Pre-requisite: NA
1.5 Syllabus Committee Members: Dr. Chinmayee Hazarika, Dr. M. Chakkarapani & Dr. Santosh Kumar Verma.

1. Measurement of DC/AC current and voltage by Ammeter.
2. To measure power, power factor in a single-phase circuit, using wattmeter and power factor meter and to verify results with calculations.
3. Use two watt-meters for measuring active power of three-phase balanced load.
4. Testing of Energy meters (Single phase type).
5. To measure Energy at different Loads using Single Phase Digital Energy meter
6. Measurement of high current using current transformer
7. Measurement of high voltage using potential transformer
8. Study the working of (i) C.R.O. (ii) Digital Storage C.R.O. & (ii) C.R.O. Probes
9. Use CRO for the Measurement of supply frequency in single-phase circuit
10. Study the working and applications of Function Generator

Recommended books:

1. Electronics Measurement and Instrumentation by AK Sawhney, DhanpatRai& Sons, Delhi
2. Electronics Instrumentation by Cooper, Prentice Hall of India
3. Electronics Test and Instrumentation by Rajiv Sapra, Ishan Publications, Ambala
4. Electronics Instrumentation by JB Gupta, Satya Prakashan, New Delhi