DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

Dr. Babasaheb Ambedkar Technological University (Established as a University of Technology in the State ofMaharashtra)
(Under Maharashtra Act No XXIX of 2014)
P.O. Lonere, Dist. Raigad, Pin 402 103, Maharashtra
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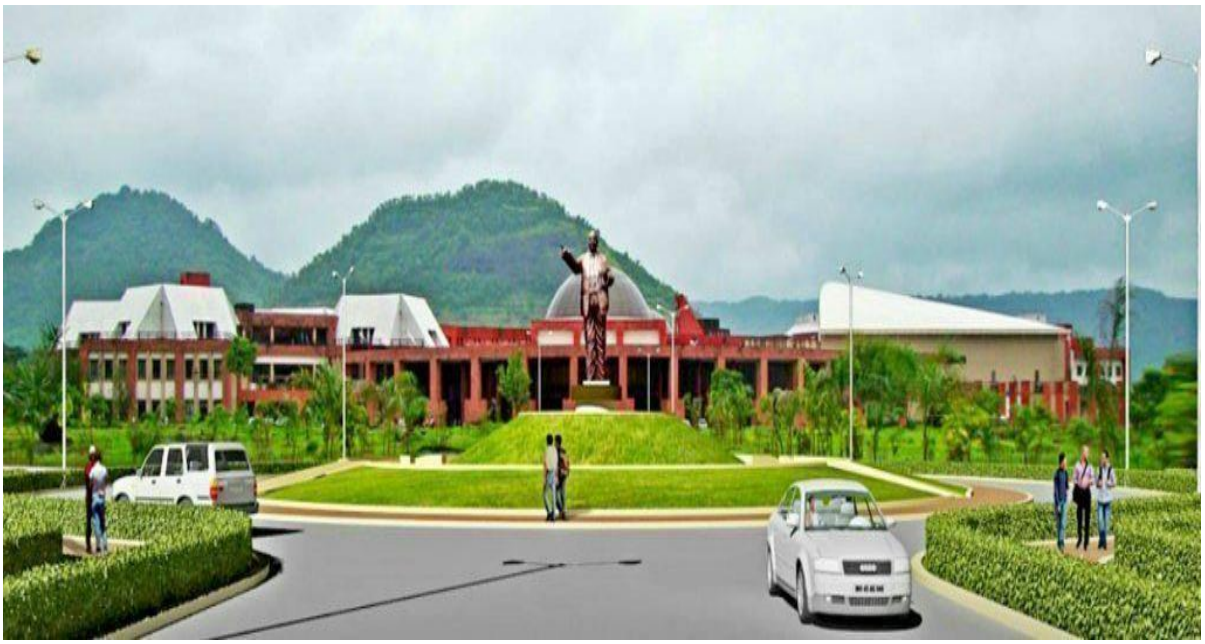
CURRICULUM

UNDER GRADUATE PROGRAMME

THIRD YEAR B. TECH.

ELECTRICAL AND INSTRUMENTATION ENGINEERING

With effect from the Academic Year 2022-2023



DR. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY, LONERE

B. Tech in Electrical & Instrumentation Engineering
Curriculum for Third Year

Semester V										
Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				Credit
			L	T	P	CA	MSE	ESE	Total	
PCC 1	BTEIC501	Electrical Machine	3	1	-	20	20	60	100	4
PCC 2	BTEIC502	Process Control	3	1	-	20	20	60	100	4
PCC 3	BTEIC503	Advanced Power Electronics and Devices	3	1	-	20	20	60	100	4
PEC 2	BTEIPE504	Group B	3	-	-	20	20	60	100	3
OEC 1	BTEIOE505	Group C	3	-	-	20	20	60	100	3
HSSMC	BTHM506	Soft Skills	-	-	-	-	-	-	-	Audit
LC	BTEIL507	Electrical Machine – I Lab	-	-	2	60	-	40	100	1
LC	BTEIL508	Process Control Lab	-	-	2	60	-	40	100	1
Project	BTEIM509	Mini Project I	-	-	4	60	-	40	100	2
Internship	BTEIP408	Internship – 2 Evaluation	-	-	-	-	-	50	50	1
		Total	**15**	**3**	**8**	**220**	**100**	**430**	**750**	**23**
Semester VI										
Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				Credit
			L	T	P	CA	MSE	ESE	Total	
PCC 1	BTEIC601	Power System Operation and Control	3	1	-	20	20	60	100	4
PCC 2	BTEIC602	Instrumentation System Design	3	1	-	20	20	60	100	4
PCC 3	BTEIC603	Switchgear and Protection	3	1	-	20	20	60	100	4
PEC 3	BTEIPE604	Group D	3	-	-	20	20	60	100	3
OEC 2	BTEIOE605	Group E	3	-	-	20	20	60	100	3
LC	BTEIL606	Instrumentation System Design Lab	-	-	2	60	-	40	100	1
LC	BTEIL607	Switchgear and Protection Lab	-	-	2	60	-	40	100	1
Project	BTEIM608	Mini Project II	-	-	4	60	-	40	100	2
Internship	BTEIP609	Field Training / Internship/Industrial Training (minimum of 4 weeks which can be completed partially in third semester and fourth semester or in at one time).	-	-	-	-	-	-	-	Credits To be evaluated in VII Sem.
		Total	**15**	**3**	**8**	**220**	**100**	**380**	**700**	**22**

BSC = Basic Science Course, ESC = Engineering Science Course, PCC = Professional Core Course
PEC = Professional Elective Course, OEC = Open Elective Course, LC = Laboratory Course
HSSMC = Humanities and Social Science including Management Courses

- **Important Note: Minimum Eight Experiment to perform based on the syllabus for the laboratory subject.**

Group B [Sem - V] (Professional Elective)

Sr. No.	Course Code	Course Title
01	BTEIPE504 A	Industrial Automation
02	BTEIPE504 B	Power System Transmission and Distribution
03	BTEIPE504 C	Control System Engineering

Group C [Sem - V] (Open Elective)

Sr. No.	Course Code	Course Title
01	BTEIOE505 A	Signals and System
02	BTEIOE505 B	Microprocessor and Microcontroller
03	BTEIOE505 C	Embedded System

Group D [Sem - VI] (Professional Elective)

Sr. No.	Course Code	Course Title
01	BTEIPE604 A	High Voltage Engineering
02	BTEIPE604 B	Instrumentation System Components
03	BTEIPE604 C	Smart Grid Technology

Group E [Sem - VI] (Open Elective)

Sr. No.	Course Code	Course Title
01	BTEIOE605 A	Power Plant Instrumentation
02	BTEIOE605 B	E-Waste Management
03	BTEIOE605 C	Sensor Technology

SEMESTER V

BTEIC501 ELECTRICAL MACHINES 4 Credits

Unit 1: Transformers **7 Hours**

Construction and working principal, emf equation and equivalent circuit, voltage regulation and efficiency, Determination of parameter from OC & SC tests, Back to Back test, parallel operation and load sharing. Auto Transformer: Principle of operation, Phasor diagram, Equivalent circuit. Three Phase Transformer: Construction of various types, operating characteristics of Star–Star, Star–Delta, Delta – star, Delta – Delta, Open – Delta and Zigzag connections, Vector Groups, Phase transformation, Three phase to Two phase, Three phase to Six phase, Three phase to Twelve phase transformation, Scott connection, parallel operation of Three phase transformer.

Unit 2: DC Machines **7 Hours**

Working principal of DC generator, Action of commutator, Construction, armature winding, Lap and Wave winding, EMF equation for a generator, concept of Armature reaction, DC Generator Types Methods of excitation, power flow and voltage regulation. DC motor: operation and Back emf, Speed torque characteristics of motors, Methods of speed control, Starters, Losses and Efficiency, Swinburne‘s test & Hopkinson‘s test.

Unit 3: Induction Motor **7 Hours**

Construction and Operation of induction motors, slip, rotor frequency, torque equation, power flow diagram, equivalent circuit and phasor diagram, speed – torque curve – effect of rotor resistance, deep bar and double cage rotors, performance calculation from circle diagram, Starters, methods of speed control, losses and efficiency.

Unit 4: Three phase Synchronous machines **7 Hours**

Construction, rotating-field type and rotating-armature type, salient-pole type and non-salient-pole type. Principle of operation, Emf equation and winding factors, rating of generator. Generator on no-load and on balanced load. Armature reaction and its effect under different load power factors. Voltage drop due to armature resistance, leakage flux and synchronous reactance. Per phase equivalent circuit and phasor diagram. Open circuit and short circuit test on

synchronous generator, determination of voltage regulation. Parallel operation Process of synchronizing alternator with infinite bus-bar by lamp methods and by use of synchro scope. Synchronizing torque, power and current.

Unit 5: Synchronous motor and Special Machines **10 Hours**

Synchronous Motor: Operating principle, starting methods, equivalent circuit, phasor diagram under various excitation, torque equation and mechanical power developed, V curve, synchronous condenser.

Special machines: Universal motor, single phase induction motor, stepper motor, servo motor, permanent magnet motors, switched reluctance motors; Selection of motor for specific application; Engineering aspects of electric machine performance and operation.

Text / Reference Books

1. Fitzgerald A E, C. Kingsley Jr. and S. D. Umars, Electrical Machinery, McGraw Hill, 1983.
2. J. Nagrath and D. P. Kothari, Electric Machines, Tata McGraw Hill, 1985.
3. Fitzgeraid A. E., Kingsley C. and Kusko A., –Electric Machinery‖, 6th Ed., McGraw-Hill International Book Company.
4. Kimbark E.W., –Power System Stability, Vol. III: Synchronous Machines‖, Wiley India.
5. P.S. Bimbhra, Electrical Machines, Khanna Publishers.
6. Dr. S.K. Sen, Electrical Machines, Khanna Publishers.

BTEIC502 PROCESS CONTROL 04 Credits

Unit 1: Fundamentals of Process Control **8 Hours**

Elements of process control loop, concept of process variables, set point, controlled variable, manipulated variables, Types of process (dead time, Single and multi-capacity, self and non-self-regulating, Interacting and non-interacting, linear and nonlinear process) Process gains, process reaction curves, process time constant and constant step analysis method for finding time constant, dead time. Dynamic element in control loops. Analysis of flow, pressure, level and temperature loops.

Unit 2: Control Actions **8 Hours**

Discontinuous: On / off, multiposition control, floating control.

Continuous: proportional, integral, derivative, proportional – integral, proportional – derivative, PID controller, anti-reset windup, bump-less transfer in PID controller. Selection and application of control action

Unit 3: Tuning of PID controller: **6 Hours**

Process reaction curve (open loop), Z-N method (close loop), set point tuning vs load disturbance tuning, Digital PID controllers: concept of velocity and position algorithm.

Unit 4: Multi loop and multi variable process control systems **8 Hours**

Feedback, feed forward control, cascade control, ratio control, auto selective control, split range control, Predictive control systems and Adaptive control system. (Interaction and de coupling, relative gain analysis, procedure to calculate relative gain and its applications)

Unit 5: Control valve **8 Hours**

Basics of control valve, definition, types, control valve coefficient, actuator and types, selection of control valve, leakage class, testing of control valve, Effects & remedies of cavitations & Flashing. Anti-cavitation trims, Pressure drop across the valve, valve noise, flow characteristics linear, equal percentage, quick opening.

Text/ References Books

1. Process Control Systems – F. G. Shinskey (TMH)
2. Process Control – B.G. Liptak (Chitlon)
3. Computer based Industrial Control – Krishna Kant (PHI)
4. Feedback Controller Tuning, Application and Design – F. G. Shinsky (TMH)
5. Instrumentation for Process Measurement and Control By : Nirman Anderson, (Chilton)
6. Tuning PID controller (ISA)
7. Chemical Process control – G. Stephanopoulos. (PHI)
8. Process Instrumentation and Control Hand book – Considine (MGH)
9. Process control instrumentation – C.D. Johnson (PHI)
10. Continuous Process Control (ISA)

11. Statistical Process Control (ISA)

BTEIC503 ADVANCED POWER ELECTRONICS AND DEVICE 4 Credits

Unit 1: Introduction **7 Hours**

Concept of Power Electronics, Different types of power electronics devices, converter systems, areas of application, recent developments. Device characteristics, protection and operation: Terminal characteristics of major power electronics devices (SCR, BJT, MOSFET, IGBT, GTO, TRIAC,), ratings, protection, heating, cooling and mounting, series and parallel operation, firing circuits, Snubber circuits.

Unit 2: Phase controlled rectifiers **7 Hours**

Analysis and design of diode rectifier circuits and controlled rectifier circuits (for R, RL, RLE load), Phase control, power factor, DC load voltage, Polyphase rectifiers, Current and voltage waveforms analysis, Applications for DC motor drives. Effect of source impedance on the performance of converters, dual converters.

Unit 3: Choppers **7 Hours**

Principle of chopper operation, Control strategies, Types of chopper circuits and steady state analysis. Commutation in chopper circuits, buck, boost and buck-boost chopper, Discontinuous current analysis, Non-ideal effects and dynamic performance, Applications for DC motor drives. Resonant converters – zero-voltage and zero current switching, PWM control and operation.

Unit 4: Inverters **7 Hours**

Classification of inverters, Single-phase and three-phase Voltage source Inverters, Methods of controlling output voltage, frequency and phase, Reduction of harmonics in the inverter output voltage, Current source inverters and operations. Applications for AC motor drives, Pulse Width Modulation (PWM): Types of PWM, Microprocessor control, Harmonics and reactive power.

Unit 5: AC Voltage Controller **12 Hours**

Types of AC voltage controllers, Single phase voltage controllers, Sequence control of ac voltage controllers, 3-phase AC voltage controller operation Application of AC-AC Phase Control, Single-phase and polyphase control circuits, Applications for AC motor drives.

Cycloconverters: Principles of Cycloconverters operation, Methods of controlling output voltage and frequency in cases of: Single phase to single phase, three phases to single phase, three phases to three phase operation.

Applications: Power supply applications, few applications in residential and industrial systems, Electric utility.

Text/ Reference Books

1. Power Electronics, P. C. Sen (TMH)
2. Power Electronics, Dubey (TMH)
3. Thyristorised Power Controllers, Dubey *et. al.* (TMH)
4. Power Electronics, Rashid Mohammed (PHI)
5. Power Electronics & Drives, V. Subrahmanyam, New Age

BTEIPE504A INDUSTRIAL AUTOMATION 3 Credits

Unit 1: Introduction to Automation **7 Hours**

Evolution & Aims of Industrial Automation. Standard Hierarchical Automation Systems Levels, Functional Levels & Database Organization Features & requirements of manufacturing automation & process automation. Automation options - DCS, PLC, PC, Fieldbus & hybrid architectures. Comparison & selection from among these systems.

Unit 2: PLC Basics **7 Hours**

Introduction: Families, Processors, operation, Programming tools, memory structure, access & programming modes. IEC 61131 standards. Hardware: Physical components, racks, slot, Power, CPU, Discrete & Analog Input/output modules, RTUs & HMI panels Programming: Numbering systems, Ladder Logic Symbols, basic Instructions, Program Logic Development, testing & debugging. Simple problem solving.

Unit 3: Advanced Techniques **7 Hours**

Programming Language Standards IEC 61131-3: IL, ST, SFC, FBD, LL Programming: Multi Rung Ladders, Sequence, Logic, transfer of control timers & counters. Process Interfacing: Discrete Sensors & Actuators, Analog Sensors &Actuators, Linear & Rotary Encoders.

Unit 4: PLC in Manufacturing Automation **7 Hours**

Programming: Logic Development steps, Failsafe Programming, Emergency shutdown, Safety Interlocks Case Studies: AC & DC Motor Controls, Variable speed AC motor drives, conveyers, hoist, robots, CNCs.

Unit 5: PLC in Process Automation and SCADA **10 Hours**

Programming: Logic Development steps Control strategies: Auto/Manual, Open loop, Closed loop, On-Off. Case Studies: Temperature, Level, Pressure & flow control, Continuous & Batch processing.

Commissioning & Maintenance

Project: Planning, Installing & Verifying Project, Project & Program Documentation. PLC Fault Handling & Diagnostics, Redundant configurations, networking.

SCADA

SCADA based plant monitoring & control concepts. Functions of SCADA, PLC/SCADA Communication, Graphics & HMI, Animation, Database configuration, Real-Time & historical trends.

Text/ Reference Books

1. Distributed computer control for Industrial Automation, Popovic & Bhatkar
2. Programmable Logic Controllers, Webb & Reis, PHI
3. Programmable Logic Controllers, John & Fredric Hackworth, Pearson
4. Introduction to Programmable Logic Controllers, Gary Dunning, Thomson
5. SCADA: Supervisory Control and Data Acquisition By: Stuart Boyer ISA

BTEIPE504B POWER SYSTEM TRANSMISSION AND DISTRIBUTION 3 Credits

Unit 1: Transmission Systems **7 Hours**

Introduction to transmission system; Transmission voltages; classification of Transmission system, advantages of High voltage transmission; comparison of Overhead and underground supply system; Double circuit three phase lines; Comparison of conductor for various overhead systems; Economic choice of conductor size.

Unit 2: Distribution Systems **7 Hours**

General aspects: Kelvin's Law, Introduction to distribution system (DS); Classification of DS; Feeders, distributors, service mains of a typical DS; Classification of AC DS; Connection

schemes of DS; Methods of calculations of AC DS; Current loading and voltage drop diagram.

Unit 3: Line Constants **7 Hours**

Introduction to overhead line constants; Copper cross section, conductor materials, Resistance: Resistance of Overhead line, Calculations of resistance; Inductance: Inductance of solid cylindrical conductor, composite conductors, two conductor single phase line, three phase single circuit and double circuit lines with symmetrical and unsymmetrical spacing, transposed and untransposed line, Skin and proximity Effects; Capacitance: Concept, Potential difference between two points due to charge, Capacitance of two wire line, three phase symmetrical and unsymmetrical line, Charging current, Effect of earth on capacitance of transmission line.

Unit 4: Load Flow Studies **7 Hours**

Introduction, Bus classification, Static load flow equation for a low-bus system, Nodal admittance matrix, Load flow equations, characteristics of a load flow equation, generalization to n-bus system, Iterative methods, Gauss-Seidel and Newton-Raphson method of solution of load flow equations for 2 bus and 3 bus system.; Fast Decoupled method.

Unit 5: Symmetrical and Unsymmetrical Fault Analysis **7 Hours**

Symmetrical Fault Analysis

3-phase short-circuit analysis of unloaded alternator, sub-transient, transient and steady state current and impedances, D.C. Offset, and effect of the instant of short-circuit on the waveforms, estimation of fault current without pre-fault current for simple power systems, selection of circuit-breakers and current limiting reactors and their location in power system.

Unsymmetrical Fault Analysis

Symmetrical components, transformation matrices, sequence components, power in terms of symmetrical components, sequence impedances of transmission line and zero sequence networks of transformer, solution of unbalances by symmetrical components, L-L, L-G, and L-L-G fault analysis of unloaded alternator and simple power systems with and without fault impedance.

Text/ Reference Books

1. Electrical Power System, C. L. Wadhwa, Wiley Eastem
2. Electrical Power System, Ashfaq Hussain, CBS Publishers
3. Generation of Electrical Energy, B. R. Gupta, S. Chand.

4. Electric Power, Soni, Gupta Bhatnagar, Dhanpat Rai & Sons
5. A Course in Power Systems, J. B. Gupta, S. K. Katia & Sons
6. Electric Energy System Theory- An Introduction, O. I. Elgerd, Tata Mc Graw Hill.

BTEIPE504C CONTROL SYSTEM ENGINEERING 3 Credits

Unit 1: Introduction **7 Hours**

Concept of open & closed loop control system, Transfer Function: Concept of system: physical system, Physical model, Linear and nonlinear systems, Time variant and invariant system. Equations of physical systems (Mass-Spring-Dashpot system, R-L-C series & parallel circuit) transfer function, Procedure of obtaining transfer function.

Unit 2: Block diagrams and Signal flow graphs **7 Hours**

Block diagram, Block Diagram reduction, and Numerical examples, Signal flow graph, Masons gain formula for deriving overall transfer function of systems, Feedback characteristics of control system Concept of negative and positive feedback, Sensitivity of the system to parameter variation, using negative and positive feedback.

Unit 3: Time domain analysis **7 Hours**

Typical test signals, Time domain specifications, Steady state response, Types of system, Steady state error constants and steady state error, Numerical examples, transient response, Numerical, Concept of stability, Determination of stability by Routh - Hurwitz criterion.

Unit 4: Frequency domain analysis **7 Hours**

Introduction to frequency response, Advantages of frequency domain analysis, Polar plots, Numerical, Bode plots, Principle of argument, Nyquist criterion, Relative stability from Nyquist criterion, Numerical. Definition of Root Locus, Construction of root locus, and Stability from root locus plots, Root counters, Effect of addition of poles & zeros on root locus plots.

Unit 5: PID controllers and State Variable Technique **10 Hours**

PID Controllers: Introduction to Proportional (P), Integral (I) & Derivative (D) controller, individual effect on overall system performance, P-PI & PID control and effect on overall system performance, Numerical examples.

State Variable Technique: Concept of state & state variable, State Variable Analysis: Different forms of state variable representations (Phase, physical & canonical form), Concept of diagonalization, Obtaining state equations from transfer function representation and vice versa, solution of state equations, State transition matrix (STM), Methods of finding STM, Power series method, Laplace transform method, Calay Hamilton method, Controllability & observability of linear system, Kalman's test.

Text/ Reference Books

1. Ogata K., _Modem control Engineering', Prentice Hall
2. Kuo B. C., _Automatic Control System' Prentice Hall
3. Nagarath I. J., Gopal M., _Control System Engineering' Willey Eastern.
4. Gopal . M. – Control System.(Prentice Hall Of India).

BTEIOE505A SIGNALS AND SYSTEM 3 Credits

Unit 1: Elements of signal space theory 7 Hours

Objective and overview, signal and system types and classifications, Different types of signals; Linearity, time invariance and causality; Impulse sequence, impulse functions and other singularity functions.

Unit 2: Classification of System 7 Hours

CT and DT system, basic properties of system – linear time invariant system and properties, LTI system: Causality, stability, step response, impulse response.

Unit 3: Convolution 7 Hours

Convolution sum, convolution integral and their evaluation; Time-domain representation and analysis of LTI systems based on convolution and differential equations. Convolution for CT & DT signals and systems; Necessity of representations of Signals & Systems in Time- and Transformed-domains

Unit 4: Transform domain considerations 7 Hours

Laplace transforms, inverse Laplace transforms and Z-transforms; Applications of transforms to discrete and continuous systems-analysis; Transfer function, block diagram representation,

Unit 5: Fourier Series and Fourier Transform **7 Hours**

Fourier Series and Fourier Transform, Sampling theorem, Discrete Fourier transform (DFT), estimating Fourier transform using DFT.

Analysis of discrete time signal: sampling of CT signals and aliasing, DTFT and properties.

Text /Reference Books

1. Gabel R.A. and Robert R.A, _Signals and Linear Systems‘, John Wiley and Sons, New York
2. Oppenheim, Wilsky and Nawab, _Signals and Systems‘, Prentice Hall, New Delhi
3. C.T.Chen, _Systems and Signal Analysis‘, Oxford University Press, New Delhi
4. Cooper G.R and McGillem C.D, _Probabilistic Methods of Signals and System Analysis‘, Oxford University Press, Cambridge
5. Ziemer R.E., Tranter W.H., and Fannin D.R., _Signals and Systems‘, Pearson Education Asia, Singapore.

BTEIOE505B MICROPROCESSOR AND MICROCONTROLLER **3 Credits**

Unit 1: Microprocessor architecture **7 Hours**

8085 architecture, functional block diagram, Arithmetic Logic Unit (ALU), Timing and control Unit, Registers, Data and Address bus, Interface unit, 8085 instructions, Instruction word size: one byte, two byte and three byte instructions, addressing modes of 8085, assembly language programming Timing and control signals, Fetch operations, Execution operations, Machine cycle and state, Instruction and data flow, System timing diagram– interrupts.

Unit 2: Memory interfacing **7 Hours**

Types of main memories, Compatibility between memory and system BUS, Address space, Partitioning of address space, Special chips for address decoding, ROM and RAM interfacing, i/o interfacing: memory map i/o, i/o map i/o scheme. Programmable peripheral interface.

Unit 3: Data transfer techniques and their implementation **7 Hours**

Programmed data transfer, DMA mode of transfer, I/O port, Device polling in interrupt driven mode of data transfer, DMA controller and data transfer in DMA mode, Serial mode of data transfer. Applications of microprocessors, interfacing of A/D converters, interfacing of D/A

converter, wave generator, multiplex seven segment LED display system, measurement of frequency, phase angle and power factor. Traffic light controller and stepper motor controller.

Unit 4: 8051 Microcontroller **7 Hours**

Intel 8051 architecture, memory organization, flags, stack, and special function registers, I/O, ports - connecting external memory, counters and timers, serial data I/O, Interrupts. Microcontroller instructions - addressing modes, moving data, logical operations, arithmetic operations, jump and call instructions – subroutines - Interrupts and returns.

Unit 5: Microcontroller programming **7 Hours**

Assembly Language Programming, timer and counter programming, connection to RS 232 and RS 485, Interrupt programming. Peripherals and interfacing - Serial and parallel I/O (8251 and 8255), Programmable DMA controller, Programmable interrupt controller, ADC/DAC interfacing

Text/ Reference Books

1. John P. Hayes, Digital Systems and Microprocessors, McGraw-Hill I.E.
2. R. S. Gaonker, Microprocessor Architecture, Programming and Applications Wiley Eastern.
3. D. V. Hall, Microprocessor and Interfacing: Programming and Hardware McGraw-Hill I.E
4. John P. Hayes, Digital Systems and Microprocessors, McGraw- Hill I. E.

BTEIOE505C EMBEDDED SYSTEM 3 Credits

Unit 1: Embedded System Architectures **7 Hours**

Introduction, Components of Embedded Systems ARM processor and SHARC processor - architectural design -memory organization -data operation-bus configurations. System on-chip, scalable bus architectures, Design example: Alarm clock, hybrid architectures.

Unit 2: Sensor and Actuator I/O **7 Hours**

ADC, DAC, timers, Servos, Relays, stepper motors, H-Bridge, CODECs, FPGA, ASIC,

diagnostic port.

Unit 3: Real time operating systems (RTOS) 7 Hours

Real time kernel, OS tasks, task states, task scheduling, interrupt processing, clocking communication and synchronization, control blocks, memory requirements and control, kernel services.

Unit 4: Embedded Networks 7 Hours

Distributed Embedded Architecture Hardware and Software Architectures, Networks for embedded systems– I2C, CAN Bus, Ethernet, Internet, Network-based design–Communication Analysis, system performance Analysis, Hardware platform design, Allocation and scheduling, Design Example: Elevator Controller.

Unit 5: System Design 7 Hours

Specification, Requirements and Architectural design of PBX systems, Set-top box, Ink-jet printer, Laser printer, Personal digital Assistants.

Embedded Hardware: memory map, i/o map, interrupt map, processor family, external peripherals, memory- RAM, ROM, types of RAM and ROM, memory Testing, CRC, Flash memory.

Text/ Reference Books

1. The 8051 Microcontroller and Embedded Systems: Using Assembly and C, –Mazidi‖.
2. Making Embedded Systems, Elecia White.
3. NPTEL courses

SEMESTER VI

BTEIC601 POWER SYSTEM OPERATION AND CONTROL 4 Credits

Unit 1: Fundamentals of Power System **7 Hours**

Concepts of real and reactive powers, complex power, per-unit representation of power system, Transmission capacity, load characteristics, real power balance and its effect on system frequency, load frequency mechanism, reactive power, balance and its effect, on-load tap changing transformer and regulating transformer, Power Circle diagram: Receiving and sending end power circle diagram, universal power circle diagram, application of power circle diagram.

Unit 2: Reactive Power Management **7 Hours**

Necessity of reactive power control, reactive power generation by a synchronous machine, effect of excitation, loading capability curve of a generator, compensation in power system (series and shunt compensation using capacitors and reactors), Problems with Series Compensation, synchronous condenser.

Unit 3: Load Frequency Control **7 Hours**

Introduction, Automatic voltage regulator, exciter modeling, generator modeling and static performances of AVR loop, automatic load frequency control of single area systems, speed governing system, static performance of speed governor, closing the ALFC loop, Concept of control area static response of primary ALFC loop, dynamic response of ALFC loop, ALFC for multi control area system, the two area system, modeling of the tie-line block diagram representation of two area system, static response of two area system, dynamic response of two area system, tie-line bias control of two area system, static response, steady state instabilities. load frequency problem-Megawatt frequency (or P-f) control channel, MVAR voltages (or Q-V) control channel-Dynamic interaction between P-f and Q-V loops. Mathematical model of speed-governing system-Turbine models.

Unit 4: Power System Stability **7 Hours**

The stability problem-Steady state stability, transient stability and Dynamic Stability-Swing equation. Equal area criterion of stability-Applications of Equal area criterion, Step by step solution of swing equation-Factors affecting transient stability, Methods to improve steady state

and Transient stability, Introduction to voltage stability.

Unit 5: Economic Operation of Power System **12 Hours**

Distribution of load between units within a plant, transmission loss as function of plant generation, calculation of loss-coefficient, distribution of loads between plants with special reference to steam and hydro plants, automatic load dispatching, Unit commitment, constraints on unit commitment – spinning reserve, thermal and hydro constraints, methods of unit commitment – priority list and dynamic programming.

Power Control and Reliability: Interchange of power between interconnected utilities, economy interchange evaluation, interchange evaluation with unit commitment, types of interchange, capacity and diversity interchange, energy banking, emergency power interchange, inadvertent power exchange. Definition of reliability of power system, Hierarchical levels for reliability study, Reliability evaluation of generation system, loss of load probability (LOLP), loss of load expectation (LOLE), Expected Energy Not Supplied (EENS), generation model, load model, risk model, composite system reliability evaluation.

Text/ Reference Books

1. W. D. Stevenson, Elements of Power system analysis, Mcgraw Hill, Digitized on Dec., 2007.
2. C.L.Wadhwa, Electrical Power Systems, 3rd Edn, New Age International Publishing Co., 2001.
3. A. Chakrabarti and S. Halder, Power System Analysis: Operation and Control, PHI, 2006.
4. I. J. Nagrath and D. P. Kothari, Modern Power System Analysis, TMH, 2003
5. T. K. Nagsarkar and M. S. Sukhija, Power System Analysis, Oxford University Press, 2007

BTEIC602 INSRUMENTATION SYSTEM DESIGN 4 Credits

Unit 1: Industrial Standards **7 Hours**

NEMA, DIN, BIS and ANSI standards with special reference to packaging, one-line diagram of hydraulic, pneumatic and electronic instrumentations system, Instruments symbols and signals.

Unit 2 Design Aspects **8 Hours**

Performance characteristics for flow, temperature, pressure and level transducer, smart transmitter with control capability, range, specification standards and recommended practice for instruments, simulated technical data for design of transducer. Interface primary element with end devices, engineering display. Transducer measurement and performance test (electrical, impedance, noise, resolution test and threshold test, environment and life test), measurement units current, voltage and frequency. Design of instrumentation amplifier, isolation amplifier, active filter, and Electronic circuit design guidelines

Unit 3: Distributed Control Systems components **7 Hours**

Concepts of hierarchical control. Workstation & Workstation Hosts: issues, Design concepts & classification. Operator Interface evolution & HMI design. Networks in process automation, Fault-tolerant programming & real-time operating systems.

Unit 4: Vendor Architectures & Applications **7 Hours**

Popular DCS Architectures & specifications for Honeywell‘s TDC 3000 & EPKS, Siemens S7400H, Rockwell ControlLogix, Emerson‘s DeltaV & Ovation, Yokogawa CENTUM CS3000 and ABB‘s system 800XA.Case studies of Industrial use oil & gas fields and biotechnology plants.

Unit 5: State of the art in DCS **10 Hours**

Integration of DCS, PLC, HMI & SCADA systems. Integration with RTUs, Multiplexers, field buses & Data Highways. Hybrid systems with discrete & analog capability. Sequence of Event recorders & post-trip reviews. OPC software architecture.

Design of Electronic Controllers: Selection of sensor, signal conditioning. ON-OFF and

Integral, Derivative, Proportional controllers for flow, level, pressure & temperature systems.

Text/ Reference Books

1. Electronic Instruments And instrumentation Technology, by Anand M S, New Delhi.Prentice Hall Of India, 2004.
2. Process Control, by B.G.Liptak
3. Industrial Process Control by Jocob
4. Process Control for Industries by Andrew Williams.
5. Distributed computer control for Industrial Automation: Popovic & Bhatkar, Dekker.
6. Understanding Distributed processor systems for control - smuel Herb, ISA.
7. Process software and Digital Networks. Bela Liptak, CRC Press.

BTEIC603 SWITCHGEAR AND PROTECTION 4 Credits

Unit 1: Introduction to Switchgear and Protection 7 Hours

Introduction, Need for power system protection, effects of faults, Requirement of Relays, Relays Terminology, basic circuit, relay connection with trip circuit and circuit breaker, types of relay.

Unit 2: Protective Devices 7 Hours

Philosophy of protection, zones of protection, primary and backup protection, Methods of earthing and their effect on fault conditions. Different types of relays: attracted armature type, balanced beam type, induction type.

Unit 3: Static and Numerical Relays 7 Hours

Amplitude and phase comparator techniques, Differential relays, directional relay, impedance relay, admittance relay, MHO relay, description of numerical relays, relaying algorithms, use of numerical relays as fault locator and disturbance recorder.

Microprocessor Based Relays: Advantages, over current relays, directional relays, distance relays.

Unit 4: Circuit Breakers and Fuses **7 Hours**

Introduction, arcing in circuit breakers, arc interruption, re-striking and recovery voltage, current chopping, resistance switch, Air blast circuit breakers, minimum and bulk oil circuit breakers, SF6 and Vacuum Circuit breakers, circuit breakers rating, testing of CB, point on wave switching, Definitions of terms in fuses, HRC fuses. Introduction, fuse characteristics, types of fuses, application of HRC fuses. selection of circuit breakers, high voltage DC breakers, ratings of circuit breakers, testing of circuit breakers

Unit 5: Protection of Transmission Lines **12 Hours**

Over current protection, construction and operation of instantaneous over current relay. Directional Over current relay, distance protection, unit protection schemes, carrier aided distance protection, protection of feeders, protection of ring main and parallel feeders, protection of radial feeders by over current relays, distance relays and carrier current protection scheme. Protection of induction motor‘s against overload, short-circuits, thermal release, miniature circuit breaker

Protection of Alternators & Transformers: Differential protection of alternator, protection of stator against phases to ground fault, phase to phase faults, inter turn fault, protection against unbalanced loading, protection of rotor against ground fault, field failure, reverse power, back up protection, field suppression, protection of bus bars, frame leakage protection. Differential protection of transformer for different winding configurations, difficulties encountered in differential protection and their remedies. standards and specifications related to switch gear and protection

Text/References Books

1. ―Power system protection and switchgear‖, Ravindranath and Chander, TMH
2. ―Fundamentals of power system protection‖, Paithankar and Bhide, PHI
3. J. L. Blackburn and T. J. Domin, Protective Relaying: Principles & Applications, CRC Press, 2006.
4. ―Electrical power system‖, Wadhwa, New Age. 2. ―Power system protection‖, Badri Ram, TMH.

BTEIPE604A HIGH VOLTAGE ENGINEERING 3 Credits

Unit 1: Conduction and breakdown in gases **7 Credits**

Gases as insulation media, ionization processes, Townsend‘s current growth equation, current growth in presence of secondary processes, Townsend‘s criterion for breakdown in electronegative gases, time lags for breakdown, Streamers theory, Paschen‘s law, breakdown in non-uniform fields and corona discharge, corona under positive & negative polarities, glow & arc discharge, considerations in using gases for insulation purpose.

Unit 2: Conduction and breakdown in liquid and solid dielectrics **7 Credits**

Pure and commercial liquids, breakdown in pure and commercial liquids, theories of breakdown in liquids. Breakdown in solid dielectrics: Intrinsic, electromechanical & thermal breakdown, chemical, electrochemical deterioration, treeing, tracking, internal discharges, breakdown in composite insulation, properties of solid insulators & other materials used in practice. Insulating materials: In power transformers, rotating machines, circuit breakers, cables, power capacitors and other equipment.

Unit 3: Over voltage due to lightening phenomenon **7 Credits**

Propagation of lightning voltage & current waves on transmission lines, reflection & transmission of traveling wave at junction, system control of over voltage due to switching protection of transmission lines against over voltage. Insulation co-ordination, surge diverters, equipment insulation level & co-ordination of substations.

Unit 4: Generation of high voltages & currents **7 Credits**

Generation of a) high d. c voltage b) power frequency high alternating voltage c) high frequency a. c. d) impulse voltages Standard impulse waves shapes and it‘s equation, multistage impulse generator, matrix circuit, generation of switching surges, tripping & control of impulse generators, generation of impulse currents

Unit 5: Measurement of high voltages & currents **7 Credits**

Measurement of high d. c., power frequency a. c., high frequency a. c., & impulse current, measurement of resistivity, dielectric constant & loss factor, partial discharges measurement, radio interference measurement

I. E. C. & IS codes for high voltage tests on electrical appliances & power apparatus & electrical motors, non- destructive testing, testing of insulators, bushings, isolators, circuit breakers, cables,

transformers, surge diverter, layout of high voltage laboratories & test facilities.

Text/References Books

1. C.L. Wadhawa, ―High Voltage Engineering‖, Wiley Eastern Ltd, New Age Ltd, India, 1995.
2. M.S. Naidu, V. Kamaraju, ―High Voltage Engineering‖, Tata McGraw Hill Publishing India, 1999.
3. ―High Voltage: Engineering fundamentals‖, Kuffel E ., Butterworth-Heineman, 2000
4. Ravindra Arora& Wolfgang Mosch: High voltage Insulation Engineering, New Age International Publishers, 2011
5. J. Kuffel and W. S. Zaengl, High Voltage Engineering: Fundamentals, Newnes, 2000.
6. ―High Voltage Engineering‖, Dr.R.S.Jha, DhanpatRai& Sons.

BTEIPE604B INSTRUMENTATION SYSTEM COMPONENT 3 Credits

Unit 1: Industrial Control Devices **7 Hours**

Switches: construction, symbolic representation, working, application of Toggle switch, Slide switch, DIP switch, Rotary switch, Thumbwheel switch, Selector switch, Push button, Drum switch, Limit switch, Temperature switch, Pressure switch, Level switch, Flow switch, Relays, Contactors.

Unit 2: Sequencing & Interlocking for Motors **7 Hours**

Standard symbols used for Electrical Wiring Diagram, Electrical Wiring Diagram in relation to motors, Concept of sequencing & Interlocking, Starting, Stopping, Emergency shutdown, (Direct on line, star delta), Protection of motors: Short circuit protection, Over load Protection, Low/Under, Voltage Protection, Phase reversal Protection, Over temperature Protection, Braking, Starting with variable speeds, Motor Control Center: Concept and wiring diagrams

Unit 3: Introduction to Pneumatic, Hydraulic & Electrical systems **7 Hours**

Introduction to Pneumatic, Hydraulic & Electrical systems & their Comparison, Pneumatic Power Supply and its components, Pneumatic relay (Bleed & Non bleed, Reverse & direct),

Single acting & Double acting cylinder, Special cylinders: Cushion, Double rod, Tandem, Multiple position, Rotary, Filter Regulator Lubricator (FRL), Pneumatic valves (direction controlled valves, flow control etc)

Unit 4: Hydraulics **7 Hours**

Hydraulic supply, Hydraulic pumps, Actuator (cylinder & motor), Hydraulic valves, Hydraulic Circuits, Standard Symbols for developing hydraulic circuits, Different Hydraulic Circuits: Meter in, Meter out, Reciprocating, speed control, Sequencing of cylinders, Direction control etc

Unit 5: Auxiliary components **7 Hours**

Construction, working & applications of: Synchro, Feeders, Dampers, Alarm annunciator, High/low selectors, Flow totalizer, Computing relays, Seals, Snubber. Circuit Breaker: Need of Circuit Breaker, Operating Principle, and Types. Fuses: Desirable characteristics, Materials according to rating, Terminology (Fusing Current, Current rating of fuse element, fusing factor) & Types of fuses.

Fluidic Control Devices: Characteristics, Principle of Operation, Bistable & Proportional Amplifier & applications Safety in Instrumentation & Control Systems: Hazardous Area & Material classification as per NEC Standards, Explosion Proof Housing, Encapsulation, Sealing, & Immersion, Purging systems.

Intrinsic Safety: -Definition, Designing for intrinsic Safety, Isolation or Encapsulation (Series & Shunt Protective elements, & Zener barrier)

Text/ Reference Books

1. Industrial Electronics, Petruzella, McGraw-Hill
2. Pneumatic Instrumentation, Majumdhar, TMH
3. Industrial Hydraulics, Pipenger
4. Process Control, Instrument Engineering Hand book, B.G. Liptak, Butterworth-Heinemann Ltd
5. Pneumatics, Festo Didactic
6. Hydraulics, Festo Didactic
7. Process control and Instrument technology, C.D.Johnson, TMH.

BTEIPE604C SMART GRID TECHNOLOGY 3 Credits

Unit 1: Introduction to Smart Grid **10 Hours**

Introduction, working definitions of Smart Grid, Need of Smart Grid, Present development & International policies in Smart Grid. Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS), Plug in Hybrid Electric Vehicles (PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation Smart Substations, Substation Automation, Feeder Automation. Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU). Associated Concepts –Smart Grid Functions-Traditional Power Grid and Smart Grid –New Technologies for Smart Grid – Advantages –Indian Smart Grid –Key Challenges for Smart Grid. Application and standards, Impacts of Smart Grid on reliability, Impacts of Smart Grid on air pollutant emissions reduction.

Unit 2: Smart Grid Architecture **7 Hours**

Components and Architecture of Smart Grid Design –Review of the proposed architectures for Smart Grid. The fundamental components of Smart Grid designs –Transmission Automation –Distribution Automation –Renewable Integration

Unit 3: Tools and Techniques for Smart Grid **7 Hours**

Computational Techniques –Static and Dynamic Optimization Techniques –Computational Intelligence Techniques –Evolutionary Algorithms –Artificial Intelligence techniques

Unit 4: Distribution Generation Technologies **7 Hours**

Introduction to Renewable Energy Technologies –Micro grids –Storage Technologies –Electric Vehicles and plug –in hybrids –Environmental impact and Climate Change –Economic Issues

Communication Technologies and Smart Grid: Introduction to Communication Technology –

Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Synchro Phasor Measurement Units (PMUs) –Wide Area Measurement Systems (WAMS). Two-way Digital Communications Paradigm, Network Architectures, IP- based Systems Power Line Communications.

Unit 5: Control of Smart Power Grid System **7 Hours**

Load Frequency Control (LFC) in Micro Grid System –Voltage Control in Micro Grid System – Reactive Power Control in Smart Grid. Case Studies and Test beds for the Smart Grids.

Security and Privacy: Cyber Security Challenges in Smart Grid, Load Altering Attacks, False Data Injection Attacks, Defense Mechanisms, Privacy Challenges

Text/References Books

1. James Momoh, ―Smart Grid Fundamentals of Design and Analysis,‖ Wiley, 2012
2. Keyhani, ―Smart Power Grid Renewable Energy Systems,‖ Wiley 2011
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, ‒Smart Grid: Technology and Applications‖, Wiley 2012
4. Jean Claude Sabonnadière, Nouredine Hadjsaïd, ‒Smart Grids‖, Wiley ISTE 2012

BTEIOE605A POWER PLANT ENGINEERING 3 Credits

Unit 1: Power generation from conventional sources **7 Hours**

Thermal, hydro, nuclear and gas power plants - their functions and control; types of prime movers, generators and excitation systems; Economic considerations in power systems. Alternate sources of power generation - solar, wind, geo-thermal, ocean-thermal, tidal, wave and MHD.

Unit 2: Hydro-electric power plants **7 Hours**

Selection of site, elements of power plant, classification, water turbines, governor action, hydro-electric generator, plant layout, pumped storage plants.

Thermal steam power plants: Selection of site, elements and operational circuits of the power plant, turbo-alternators, plant layout, steam turbines, controls and auxiliaries.

Unit 3: Nuclear power plants **7 Hours**

Selection of site, nuclear reaction – fission process and chain reaction, constituents of power plant and layout, nuclear reactor – working, classification, control, shielding and waste disposal.

Unit 4: Renewable power plants **7 Hours**

Solar power generation, Photo-voltaic and solar thermal generation, solar concentrators, Wind power generation, types of wind mills, wind generators, tidal, biomass, geothermal and magneto-hydro dynamic power generation, micro-hydel power plants, fuel cells and diesel and gas power plants

Unit 5: Combined operation of power plants **7 Hours**

Plant selection, choice of size and number of generator units, interconnected systems, real and reactive power exchange among interconnected systems. Major electrical equipment in power plants, DC systems in power plants, station control - switch yard and control room. Economic considerations – types of costs, tariff and consumers.

Text/References Books

1. Wadhwa, C.L., _Generation Distribution and Utilisation of Electrical Energy', New Age International Publishers, 3rd Edition, 2010.
2. J.B.Gupta, _A Course in Power Systems‘, S.K.Kataria and Sons, Reprint 2010-2011.
3. M. M. El-Wakil, Power Plant Technology, Mcgraw Hill, Digitized on Dec 2000
4. B. G. A. Skrotzki & W. A. Vopat, Power Station Engineering & Economy, McGraw Hill, Digitized on Dec 2007.
5. Chakrabarti A., Soni M.L., Gupta P.V., and Bhatnagar U.S., 'A Text Book on Power Systems Engg', Dhanpat Rai and Sons, New Delhi, 2nd Revised Edition, 2010.

BTEIOE605B E-WASTE MANAGEMENT 3 Credits

Unit 1: Sources of E-Waste **7 Hours**

Sources, Composition and characteristic of hazardous waste, Hazardous Waste (Management and Handling) Rules, 1989 and amendments, Federal Hazardous Waste Regulations under RCRA, Superfund, CERCLA and SARA. Toxicology, public health impact, Protocols, issues and challenges in transportation of hazardous waste.

Unit 2: E-waste **7 Hours**

Introduction, toxicity due to hazardous substances in e-waste and their impacts, domestic e-waste disposal, e-waste management, technologies for recovery of resource from electronic waste,

Unit 3: Guidelines for E-waste Management **7 Hours**

Guidelines for environmentally sound management of e-waste, occupational and environmental health perspectives of recycling e-waste in India.

Unit 4: Electrical and Electronic Equipment Waste **7 Hours**

Hazardous substances waste Electrical and Electronic Equipment, characteristics of pollutants, batteries, electrical and electronic components, plastic and flame retardants, circuit boards, pollutants in waste electrical and electronic equipment.

Unit 5: E-Waste Recycling **7 Hours**

Technologies for recovery of resources from electronic waste, resource recovery potential of e-waste, steps in recycling and recovery of materials-mechanical processing, technologies for recovery of materials.

Text/References Books

1. New Delhi. Johri R., ―E-waste: implications, regulations, and management in India and current global best practices‖, TERI Press, New Delhi.
2. E-Waste Managing the Digital Dump Yard, Edited by Vishakha Munshi, ICFAI University Press
3. Techobanoglous G., Theisen H., Viquel S.A., ―Integrated Solid Waste Management: Engineering, Principles and Management issues‖, Tata McGraw Hill Publishing Company Ltd.

BTEIOE605C SENSOR TECHNOLOGY 3 Credits

Unit 1: Measurement and Characteristics **7 Hours**

Elements of a Measurement System; Classification of Instruments; Static Performance Parameters; Loading and Impedance Matching; Errors and Uncertainties in Measurement; Process and Standards of Calibration; Dynamic Characteristics Transfer Function Representation

of a Measurement System, Impulse and Step Responses of First and Second Order Systems, Frequency Response of First and Second Order Systems.

Unit 2: Mechanical Transducers **7 Hours**

Temperature- Bimetallic Element and Fluid Expansion type Thermometers; Pressure- Manometers and Bourdon Gauges; Force- Balances, Helical Spiral Springs, Load Cells and Elastic Force Devices; Torque- Torsion Bars and Flat Spiral Springs; Liquid Level- Float Systems and Level to Pressure Converters; Flow- Pitot Static Tubes and Turbine type Flow Meters. Hot Wire Anemometer. Proximity Sensors- Reed Sensors, Inductive proximity sensor, Capacitive proximity sensor, Optical sensor with through beam, Ultrasonic sensors.

Unit 3: Electrical Transducers **7 Hours**

Resistance Thermometers; Interfacing Resistive Transducers to Electronic Circuits; Thermistors- Measurement of Temperature and Thermal Conductivity, Temperature Control; Resistance Strain Gauges- Gauge Factor, Bonded and Unbonded Strain Gauges; Self Generating and Non-Self Generating Inductive Transducers; Linear Variable Differential Transformers; Capacitive Transducers – Potentiometric Transducers; Thermoelectric Transducers and Sources of Errors in Thermocouples; Piezoelectric Transducers

Unit 4: Basic Signal Conditioning Elements **7 Hours**

Amplifiers- Non-Electrical and Electrical types; Op Amps Inverting, Non-Inverting, Summing, Differential, and Charge Amplifiers; Differentiating and Integrating Elements; Filters; Data Transmission Elements- Electrical, Pneumatic, Position and Radio Frequency Transmission types; Compensation Elements for First and Second Order Systems – Basic Indicating, Recording, and Display Elements

Unit 5: Feedback in Instruments **7 Hours**

Principles of Feedback and Advantages & Disadvantages of Feedback; Digital Voltmeters-Ramp and Dual Slope types; Servo type Potentiometric and Magnetic Tape Recorders; Digital Recorders of Memory type; Data Displays-Analog and Digital types.

Text/References Books

1. Electronic Measurements and Instrumentation, K. Lal Kishore, Pearson Education Publications
2. Electronic Instrumentation, H. S. Kalsi-TMH Publications
3. Albert D Helfrick and William D Cooper; Modern Electronic Instrumentation and Measurement Techniques; 2004, PHI
4. B. C Nakra, and Chaudhry; Instrumentation, Measurement and Analysis; 2004, Tata McGrawHill.
5. DVS Murthy; Transducers and Instrumentation; 2003, PHI.
6. CS Rangan, GR Sarma, and VSV Mani; Instrumentation Devices and Systems; Tata McGraw-Hill
7. Doeblin and Ernest; Measurement Systems Application and Design; 2004, Tata McGraw-Hill.
8. Tilak Thakur ― Mechatronics ‖ Oxford University Press 2016.