JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION	L	T	P	C
		3	0	0	3

Pre-requisite:

Basics of Electrical and Electronics Engineering.

Course Objectives:

- To understand and analyze the factors that effect the various measuring units.
- To choose the appropriate meters for measuring of voltage, current, power, power factor and energy qualities and understand the concept of standardization.
- Describe the operating principle of AC & DC bridges for measurement of resistance, inductance and capacitance.
- To understand the concept of the transducer and their effectiveness in converting from one form to the other form for the ease of calculating and measuring purposes.
- To understand the operating principles of basic building blocks of digital systems, record and display units.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the construction and working of various types of analog instruments.

CO2: Describe the construction and working of wattmeter and power factor meters

CO3: Know the construction and working various bridges for the measurement resistance inductance and capacitance

CO4: Know the operational concepts of various transducers

CO5: Know the construction and operation digital meters

UNIT - I

Analog Ammeter and Voltmeters

Classification – deflecting, control and damping torques – PMMC, moving iron type and electrostatic instruments – Construction – Torque equation – Range extension – Errors and compensations – advantages and disadvantages. Instrument transformers: Current Transformer and Potential Transformer – theory –Ratio and phase angle errors–Numerical Problems.

UNIT - II

Analog Wattmeters and Power Factor Meters

Electrodynamometer type wattmeter (LPF and UPF) – Power factor meters: Dynamometer and M.I type (Single phase and Three phase) – Construction – torque equation – advantages and disadvantages. Potentiometers: Principle and operation of D.C Crompton's potentiometer – Standardization –Applications –AC Potentiometer (Polar and coordinate types) –Standardization – Applications – Numerical Problems.

UNIT - III

Measurements of Electrical parameters

DC Bridges: Method of measuring low, medium and high resistance –Wheat stone's bridge for measuring medium resistance– Kelvin's double bridge for measuring low resistance – Loss of charge method for measurement of high resistance – Megger – measurement of earth resistance – Numerical Problems.

AC Bridges: Measurement of inductance and quality factor – Maxwell's bridge – Hay's bridge – Anderson's bridge. Measurement of capacitance and loss angle – Desauty's bridge – Schering Bridge – Wien's bridge –Numerical Problems.

UNIT - IV

Transducers

Definition – Classification – Resistive, Inductive and Capacitive Transducer – LVDT – Strain Gauge – Thermistors – Thermocouples – Piezo electric and Photo Diode Transducers – Hall effect sensors – Numerical Problems.

UNIT - V

Digital meters

Digital Voltmeters – Successive approximation DVM – Ramp type DVM and Integrating type DVM – Digital frequency meter – Digital multimeter – Digital tachometer – Digital Energy Meter – Q meter. CRO – measurement of phase difference and Frequency using lissajious patterns – Numerical Problems.

Text Books:

1. Electrical Measurements and measuring Instruments by E.W. Golding and F.C.Widdis - 5th Edition - Wheeler Publishing.
2. Modern Electronic Instrumentation and Measurement Techniques by A.D. Helfrick and W.D. Cooper - PHI - 5th Edition - 2002.

Reference Books:

1. Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co. Publications - 19th revised edition - 2011.
2. Electrical and Electronic Measurements and instrumentation by R.K.Rajput

- S.Chand - 3rd edition.
3. Electrical Measurements by Buckingham and Price - Prentice – Hall
4. Electrical Measurements by Forest K. Harris. John Wiley and Sons

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105153

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	MICROPROCESSORS AND MICROCONTROLLERS	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in digital electronics, fundamentals of computers.

Course objectives:

- To understand the organization and architecture of Microprocessor
- To understand addressing modes to access memory
- To understand 8051 micro controller architecture
- To understand the programming principles for 8086 and 8051
- To understand the interfacing of Microprocessor with I/O as well as other devices
- To understand how to develop cyber physical systems

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the concepts of the Microprocessor capability in general and explore the evaluation of microprocessors.

CO2: Analyse the instruction sets - addressing modes - minimum and maximum modes operations of 8086 Microprocessors

CO3: Analyse the Microcontroller and interfacing capability

CO4: Describe the architecture and interfacing of 8051 controller

CO5: Know the concepts of PIC micro controller and its programming.

UNIT - I

Introduction to Microprocessor Architecture

Introduction and evolution of Microprocessors – Architecture of 8086 – Memory Organization of 8086 – Register Organization of 8086– Introduction to 80286 - 80386 - 80486 and Pentium (brief description about architectural advancements only).

UNIT - II

Minimum and Maximum Mode Operations

Instruction sets of 8086 - Addressing modes – Assembler directives –Simple Programs- General bus operation of 8086 – Minimum and Maximum mode operations of 8086 – 8086 Control signal interfacing – Read and write cycle timing diagrams.

UNIT - III

Microprocessors I/O interfacing

8255 PPI– Architecture of 8255–Modes of operation– Interfacing I/O devices to 8086 using 8255–Interfacing A to D converters– Interfacing D to A converters– Stepper motor interfacing– Static memory interfacing with 8086 – Architecture and interfacing of DMA

controller (8257).

UNIT - IV

8051 Microcontroller

Overview of 8051 Microcontroller – Architecture– Memory Organization – Register set – Instruction set – Simple Programs - I/O ports and Interrupts – Timers and Counters – Serial Communication – Interfacing of peripherals.

UNIT - V

PIC Architecture

Block diagram of basic PIC 18 micro controller – registers I/O ports – Programming in C for PIC: Data types - I/O programming - logical operations - data conversion.

Text Books:

1. Ray and Burchandi - "Advanced Microprocessors and Interfacing"- Tata McGraw–Hill - 3rd edition - 2006.
2. Kenneth J Ayala - "The 8051 Microcontroller Architecture- Programming and Applications" - Thomson Publishers - 2nd Edition.
3. PIC Microcontroller and Embedded Systems using Assembly and C for PIC 18 - - Muhammad Ali Mazidi - RolindD.Mckinay - Danny causey -Pearson Publisher 21st Impression.

Reference Books:

1. Microprocessors and Interfacing - Douglas V Hall - Mc–Graw Hill - 2nd Edition.
2. R.S. Kaler - "A Text book of Microprocessors and Micro Controllers" - I.K. International Publishing House Pvt. Ltd.
3. Ajay V. Deshmukh - "Microcontrollers – Theory and Applications" - Tata McGraw–Hill Companies –2005.
4. Ajit Pal - "Microcontrollers – Principles and Applications" - PHI Learning Pvt Ltd - 2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/105/108105102
2. https://archive.nptel.ac.in/courses/108/103/108103157
3. https://nptel.ac.in/courses/106108100

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	POWER SYSTEM ANALYSIS	L	T	P	C
		3	0	0	3

Pre-requisite:
Concepts of electrical circuits and power systems-II

Course Objectives:

- To develop the impedance diagram (p.u) and formation of Y_{bus}
- To learn the different load flow methods.
- To learn the Z_{bus} building algorithm.
- To learn short circuit calculation for symmetrical faults
- To learn the effect of unsymmetrical faults and their effects.
- To learn the stability of power systems and method to improve stability.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Draw impedance diagram for a power system network and calculate per unit quantities.
CO2: Apply the load flow solution to a power system using different methods.
CO3: Form Z_{bus} for a power system networks and analyse the effect of symmetrical faults.
CO4: Find the sequence components for power system Components and analyse its effects of unsymmetrical faults.
CO5: Analyse the stability concepts of a power system.

UNIT - I

Circuit Topology

Graph theory definitions – Formation of element node incidence and bus incidence matrices – Primitive network representation – Formation of Y_{bus} matrix by singular transformation and direct inspection methods.

Per Unit Representation

Per Unit Quantities–Single line diagram – Impedance diagram of a power system – Numerical Problems.

UNIT - II

Power Flow Studies

Necessity of power flow studies – Derivation of static power flow equations – Power flow solution using Gauss-Seidel Method – Newton Raphson Method (Rectangular and polar coordinates form) – Decoupled and Fast Decoupled methods – Algorithmic approach – Numerical Problems on 3–bus system only.

UNIT - III

Z-Bus Algorithm

Formation of Z_{bus}**:** Algorithm for the Modification of Z_{bus} Matrix (without mutual impedance) – Numerical Problems.

Symmetrical Fault Analysis

Reactance's of Synchronous Machine – Three Phase Short Circuit Currents - Short circuit MVA calculations for Power Systems – Numerical Problems.

UNIT - IV

Symmetrical Components

Definition of symmetrical components – symmetrical components of unbalanced three phase systems – Power in symmetrical components – Sequence impedances and Sequence networks of Synchronous generator , Transformers and Transmission line-Numerical Problems.

Unsymmetrical Fault analysis

Various types of faults: LG– LL– LLG and LLL on unloaded alternator-Numerical problems.

UNIT - V

Power System Stability Analysis

Elementary concepts of Steady state – Dynamic and Transient Stabilities – Swing equation – Steady state stability – Equal area criterion of stability – Applications of Equal area criterion – Factors affecting transient stability – Methods to improve steady state and transient stability – Numerical problems.

Text Books:

1.Power System Analysis by Grainger and Stevenson - Tata McGraw Hill.2003
2. Modern Power system Analysis – by I.J.Nagrath & D .P.Kothari: Tata McGraw–Hill Publishing Company - 3rd edition - 2007.

Reference Books:

1. Power System Analysis – by A.R.Bergen - Prentice Hall - 2nd edition - 2009.
2. Power System Analysis by HadiSaadat – Tata McGraw–Hill 3rd edition - 2010.
3. Power System Analysis by B.R.Gupta - A H Wheeler Publishing Company Limited - 1998.
4. Power System Analysis and Design by J.Duncan Glover - M.S.Sarma - T.J.Overbye – Cengage Learning publications - 5th edition - 2011.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/117/105/117105140
2. https://archive.nptel.ac.in/courses/108/105/108105104

III Year II Semester	SWITCHGEAR AND PROTECTION	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Electrical Machines and Power Systems.

Course Objectives:

- To explain the working principles and applications of circuit breakers in power systems, including MCBs, oil, SF6, and vacuum breakers.
- To provide an understanding of electromagnetic protection mechanisms, particularly relays used in fault detection and system protection (overcurrent, under-voltage, directional, differential).
- To analyze protection techniques for generators and transformers, including fault protection schemes like percentage differential protection and Buchholz relays.
- To explore feeder and busbar protection methods using advanced relay systems such as distance and static relays.
- To study over-voltage protection systems including lightning arresters and neutral grounding methods to safeguard the power system.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand and describe the operation of circuit breakers, including their ratings, principles of arc interruption, and types.

CO2: Analyze relay-based protection systems, identifying and explaining their roles in overcurrent, undervoltage, and fault detection.

CO3: Design protection schemes for generators and transformers, addressing faults like restricted earth faults and inter-turn faults.

CO4: Implement feeder and busbar protection using advanced relays such as distance, impedance, and static relays.

CO5: Evaluate over-voltage protection strategies, including the use of lightning arresters, and understand various neutral grounding techniques.

UNIT – I

Circuit Breakers

Miniature Circuit Breaker(MCB)– Elementary principles of arc interruption– Restriking Voltage and Recovery voltages– Restriking phenomenon - RRRV– Average and Max. RRRV– Current chopping and Resistance switching– Concept of oil circuit breakers– Description and operation of Air Blast– Vacuum and SF_6 circuit breakers– Circuit Breaker ratings and specifications– Concept of Auto reclosing.

UNIT – II

Electromagnetic Protection

Relay connection – Balanced beam type attracted armature relay - induction disc and

induction cup relays–Torque equation - Relays classification–Instantaneous– DMT and IDMT types– Applications of relays: Over current and under voltage relays– Directional relays– Differential relays and percentage differential relays– Universal torque equation– Distance relays: Impedance– Reactance– Mho and offset mho relays– Characteristics of distance relays and comparison.

UNIT – III

Generator Protection

Protection of generators against stator faults– Rotor faults and abnormal conditions– restricted earth fault and inter turn fault protection– Numerical examples.

Transformer Protection

Percentage differential protection– Design of CT's ratio– Buchholz relay protection– Numerical examples.

UNIT – IV

Feeder and Bus bar Protection & Static Relays:

Over current Protection schemes – PSM - TMS – Numerical examples – Carrier current and three zone distance relay using impedance relays. Protection of bus bars by using Differential protection. Static relays: Introduction – Classification of Static Relays – Basic Components of Static Relays.

UNIT – V

Protection against over voltage and grounding

Generation of over voltages in power systems– Protection against lightning over voltages– Valve type and zinc oxide lighting arresters. Grounded and ungrounded neutral systems – Effects of ungrounded neutral on system performance – Methods of neutral grounding: Solid–resistance–Reactance–Arcing grounds and grounding Practices.

Text Books:

1. Power System Protection and Switchgear by Badri Ram and D.N Viswakarma - Tata McGraw Hill Publications - 2nd edition - 2011.
2. Power system protection- Static Relays with microprocessor applications by T.S.Madhava Rao - Tata McGraw Hill - 2nd edition.

Reference Books:

1. Fundamentals of Power System Protection by Paithankar and S.R.Bhide. - PHI - 2003.
2. Art & Science of Protective Relaying – by C R Mason - Wiley Eastern Ltd.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/107/108107167
2. https://archive.nptel.ac.in/courses/108/105/108105167

III Year II Semester	ADVANCED CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic concepts of Control Systems.

Course Objectives:

- To understand the concept of controllability, observability, and their tests for continuous-time systems, as well as the principle of duality in state-space analysis.
- To understand the state-space methods to assess controllability, observability, and design state feedback controllers via pole placement.
- To know the stability of nonlinear systems using phase-plane analysis, describing functions, and Lyapunov's stability theorems.
- To Learn optimal control strategies using the calculus of variations, including constrained minimization and the minimum principle.
- To learn Optimal control and state regulator problems.

Course Outcomes: At the end of the course, student will be able to

CO1: Explain controllability, observability, and the principle of duality in state-space systems.

CO2: Apply state-space methods to analyze controllability, observability, and design state feedback controllers.

CO3: Analyze the stability of nonlinear systems using phase-plane analysis and Lyapunov's stability theorems.

CO4: Examine the minimization of functional and control variable inequality constraints.

CO5: Formulate and solve the optimal regulator problems.

UNIT – I

Controllability - Observability and Design of Pole Placement

General concepts of controllability and observability -Tests for controllability and observability for continuous time systems - Principle of duality - Effect of state feedback on controllability and observability - Design of state feedback control through pole placement, full order and reduced order observers.

UNIT – II

Nonlinear Systems

Introduction to nonlinear systems - Types of nonlinearities. Introduction to phase plane analysis, construction of phase trajectories-Analytical and Isocline method, Describing function - Describing functions of on-off nonlinearity, on-off nonlinearity with hysteresis, and relay with dead zone.

UNIT – III

Stability analysis by Lyapunov Method

Stability in the sense of Lyapunov – Lyapunov's stability and Lyapunov's instability theorems – Direct method of Lyapunov for the linear and nonlinear continuous time autonomous systems.

UNIT – IV

Calculus of Variations

Minimization of functionals - functionals of single function – Constrained minimization – Minimum principle – Control variable inequality constraints – Control and state variable inequality constraints.

UNIT –V

Optimal Control

Necessary conditions for optimal control, Formulation of the optimal control problem, minimum time problem, minimum energy problem, minimum fuel problem, state regulator problem, output regulator problem.

Text Books:

1. Modern Control Engineering – by K. Ogata - Prentice Hall of India - 3rd edition - 1998.
2. Automatic Control Systems by B.C. Kuo - Prentice Hall Publication.

Reference Books:

1. Modern Control System Theory – by M. Gopal - New Age International Publishers - 2nd edition – 1996.
2. Optimal control theory: an Introduction by Donald E.Kirk by Dover publications.
3. Control Systems Engineering by I.J. Nagarath and M.Gopal - New Age International (P) Ltd.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/103/108103007
2. https://archive.nptel.ac.in/courses/108/107/108107115

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II semester	RENEWABLE AND DISTRIBUTED ENERGY TECHNOLOGIES	L	T	P	C
		3	0	0	3

Pre-requisite: Power system I

Course Objectives:

- To understand the basic concepts on wind energy systems.
- To understand the various relations between speed, power and energy in the wind systems.
- To analyze the solar energy systems, various components of solar thermal systems, applications in the relevant fields and design of PV systems.
- To design the Hydel system components and to get an idea on different other sources like tidal, geothermal and gas based units.
- To understand the concepts of hybrid renewable energy systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate basic concepts of renewable and distributed sources of wind energy.
CO2: Demonstrate the components of wind energy conversion systems.
CO3: Model PV systems and analyze MPPT Techniques.
CO4: Illustrate the concept of Energy Production from Hydro - Tidal and Geothermal.
CO5: Explain the aspects of hybrid renewable energy systems.

UNIT – I

Introduction and Wind energy systems

Brief idea on renewable and distributed sources - their usefulness and advantages. Wind Energy Systems: Estimates of wind energy potential-wind maps- Aerodynamic and mechanical aspects of wind machine design - Conversion to electrical energy - Aspects of location of wind farms.

UNIT – II

Wind power and energy

Wind speed and energy - Speed and power relations - Power extraction from wind - Tip speed ratio (TSR) - TSR characteristics- Functional structure of wind energy conversion systems - Pitch and speed control - Power vs speedcharacteristics - Fixed speed and variable speed wind turbine control - Power optimization - Electrical generators - Self-Excited and Doubly-Fed Induction Generators operation and control.

UNIT – III

Solar PV Systems

Present and new technological developments in photovoltaic - estimation of solar irradiance - components of solar energy systems - solarthermal system-applications- Modelling of PV cell - current-voltage and power-voltage characteristics - Effects of temperature and irradiance - Solar array simulator - Sun tracking - Peak power operations - PV system - MPPT techniques: Perturb and observe method, hill climbing and incremental conductance methods-Effects of partial shading on the characteristic curves and associated MPPT techniques - Solar park design outline-Solar Pond-Types of PV systems.

UNIT – IV

Small Hydro and other sources

Hydel:Small-Mini-Medium -Plant layouts Water power estimates -use of hydrographs -hydraulic turbine - characteristics and part load performance - design of wheels - draft tubes and penstocks.

Other sources**:** Tidal - geothermal - gas-based generations.

UNIT – V

Hybrid Renewable systems

Requirements of hybrid/combined use of different renewable and distributed sources -Need of energy storage- Control of frequency and voltage of distributed generation in Stand-alone and Grid-connected mode - use of energy storage and power electronics interfaces for the connection to grid and loads - Design and optimization of size of renewable sources andtheir storages.

Text Books :

1. Math J. Bollen - Fainan Hassan ‘Integration of Distributed Generation in the Power System’ - IEEE Press - 2011.
2. G.D.Rai ‘Non-Conventional Energy Sources’ KHANNA PUBLISHERS.

Reference Books

1. Studies’ Craig Anderson and Rudolf I. Howard ‘Wind and Hydropower Integration: Concepts - Considerations and Case - Nova Publisher - 2012.
2. Amanda E. Niemi and Cory M. Fincher ‘Hydropower from Small and Low-Head Hydro Technologies’ - Nova Publisher - 2011.
3. D. YogiGoswami - Frank Kreith and Jan F. Kreider ‘Principles of Solar Engineering’ - Taylor & Francis 2000.
4. Math J. Bollen - Fainan Hassan ‘Integration of Distributed Generation in the Power System’ - IEEE Press - 2011.
5. S. Heier and R. Waddington ‘Grid Integration of Wind Energy Conversion Systems’ – Wiley - 2006.

6. Loi Lei Lai and Tze Fun Chan 'Distributed Generation: Induction and Permanent Magnet Generators' - Wiley-IEEE Press - 2007.
7. G.N. Tiwari 'Solar Energy Technology' - Nova Science Publishers - 2005.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103206
2. https://archive.nptel.ac.in/courses/103/107/103107157

III Year II Semester	ELECTRIC DRIVES	L	T	P	C
		3	0	0	3

Pre-requisite: Electrical Circuit Analysis, Power electronics, Electrical Machines and Control Systems.

Course Objectives:

- To learn the fundamentals of electric drive and different electric braking methods.
- To analyze the operation of three phase converter controlled dc motors and four quadrant operation of dc motors using dual converters.
- To discuss the DC-DC converter control of dc motors.
- To understand the concept of speed control of induction motor by using AC voltage controllers, voltage source inverters and slip power recovery scheme.
- To learn the speed control mechanism of synchronous motors.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Explain the fundamentals of electric drive and different electric braking methods.

CO2: Analyze the operation of three-phase converter fed dc motors and four quadrant operations of dc motors using dual converters.

CO3: Describe the DC-DC converter fed control of dc motors in various quadrants of operation

CO4: Know the concept of speed control of induction motor by using AC voltage controllers and voltage source inverters and differentiate the stator side control and rotor side control

CO5: Learn the concepts of speed control of synchronous motor with different methods.

UNIT - I

Fundamentals of Electric Drives

Electric drive and its components– Fundamental torque equation – Load torque components – Nature and classification of load torques – Steady state stability – Load equalization– Four quadrant operation of drive (hoist control) – Braking methods**:** Dynamic Braking, Plugging and Regenerative Braking –Numerical problems.

UNIT - II

Converter Fed DC Motor Drives

3-phase half and fully-controlled converter fed separately and self-excited DC

motor drive – Output voltage and current waveforms – Speed-torque characteristics and expressions – 3-phase Dual converter fed DC motor drives – Numerical problems.

UNIT - III

DC–DC Converter Fed DC Motor Drives

Single quadrant, two quadrant and four quadrant DC-DC converter fed separately excited and self-excited DC motors – Continuous Current Mode of operation - Output voltage and current waveforms – Speed-torque characteristics and expressions – Closed loop operation (qualitative treatment only) – Numerical problems.

UNIT - IV

Control of 3-phase Induction motor Drives

Stator voltage control using 3-phase AC voltage regulators – Waveforms –Speed torque characteristics– Variable Voltage Variable Frequency control of induction motor by PWM voltage source inverter – Closed loop V/f control of induction motor drives (qualitative treatment only). Static rotor resistance control – Slip power recovery schemes – Static Scherbius drive – Static Kramer drive – Performance and speed torque characteristics– Numerical problems.

UNIT - V

Control of Synchronous Motor Drives

Separate control of synchronous motor – self-control of synchronous motor employing load commutated thyristor inverter - closed loop control of synchronous motor drive (qualitative treatment only)– PMSM: Basic operation and advantages – Numerical problems.

Text Books:

1. Fundamentals of Electric Drives – G K Dubey - Narosa Publications - 2nd edition – 2002.
2. Power Semiconductor Drives - S.B.Dewan - G.R.Slemon - A.Straughen - Wiley India - 1984.

Reference Books:

1. Electric Motors and Drives Fundamentals - Types and Apllications - by Austin Hughes and Bill Drury - Newnes.4th edition - 2013.
2. Thyristor Control of Electric drives – Vedam Subramanyam Tata McGraw Hill Publications - 1987.
3. Power Electronic Circuits - Devices and applications by M.H.Rashid - PHI - 3rd edition - 2009.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104140
2. https://nptel.ac.in/courses/108104011

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	DIGITAL SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

Pre-requisite:

Laplace Transforms, Z- Transforms, Fourier series and transforms.

Course Objectives:

- To explore the basic concepts of digital signal processing.
- To connect the time domain signal to frequency domain signals using Fourier transform.
- To understand the basic structures of IRR systems.
- To understand and design FIR Digital filters.
- To explore the concepts of multiple sampling rates for DSP.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know the concepts of Digital signal processing - frequency domain representation &z- transform.

CO2: Compute discrete Fourier transform and fast Fourier transforms for different sequences.

CO3: Design IIR filters through analog filter approximation and basic structure of IIR filters.

CO4: Design FIR filters with window techniques and basic structure of FIR filters.

CO5: Learn the concepts of Multirate Signal Processing.

UNIT - I

Introduction to Digital Signal Processing

Discrete time signals & sequences - Classification of Discrete time systems - stability of LTI systems - Invertability - Response of LTI systems to arbitrary inputs. Solution of Linear constant coefficient difference equations. Frequency domain representation of discrete time signals and systems. Review of Z-transforms - solution of difference equations using Z-transforms - System function.

UNIT - II

Discrete Fourier Transforms and FFT Algorithms

Discrete Fourier Series representation of periodic sequences -Properties of Discrete Fourier Series - Discrete Fourier transforms: Properties of DFT - linear filtering methods based on DFT - Fast Fourier transforms (FFT) - Radix-2 decimation in time and decimation in frequency FFT Algorithms - Inverse FFT.

UNIT - III

Design and Realizations of IIR Digital Filters

Analog filter approximations – Butterworth and Chebyshev filters - Design of IIR Digital filters from analog filters withexamples. Analog and Digital frequency transformations.
Basic structures of IIR systems – Direct-Form Structures - Transposed Structures - Cascade-Form Structures - Parallel-Form Structures Lattice and Lattice-Ladder Structures.

UNIT - IV

Design and Realizations of FIR Digital Filters

Characteristics of FIR Filters with Linear Phase - Frequency Response of Linear Phase FIR Filters - Design of FIR Digital Filters using Window Techniques and Frequency Sampling technique - Comparison of IIR & FIR filters.
Basic structures of FIR systems – Direct-Form Structure - Cascade-Form Structures Linear Phase Realizations - Lattice structures.

UNIT - V

Multirate Digital Signal Processing

Decimation –Interpolation-Sampling Rate Conversion by a Rational Factor–Implementation of sampling rate converters–Applications of Multirate Signal Processing-Digital Filter Banks.

Text Books:

1. Digital Signal Processing – Principles Algorithms and Applications: John G. Proakis - Dimitris G.Manolakis - 4th Edition - Pearson Education / PHI - 2007.
2. Discrete Time Signal Processing – A.V.Oppenheim and R.W. Schaffer - PHI.
3. Digital Signal Processing: A Computer based approach. Sanjit K Mitra - 4th Edition - TMH - 2014.

Reference Books:

1. Digital Signal Processing: Andreas Antoniou - TATA McGraw Hill - 2006.
2. Digital Signal Processing: MH Hayes - Schaum's Outlines - TATA Mc-Graw Hill - 2007.
3. DSP Primer - C. Britton Rorabaugh - Tata McGraw Hill - 2005.
4. Fundamentals of Digital Signal Processing using Matlab – Robert J. Schilling - Sandra L.Harris - Thomson - 2007.
5. Digital Signal Processing – Alan V. Oppenheim - Ronald W. Schafer - PHI Ed. - 2006.
6. Digital Signal Processing – K Raja Rajeswari - 1st edition - I.K. International Publishing - House - 2014.

Online Learning Resources:

1. https://nptel.ac.in/courses/117102060
2. https://archive.nptel.ac.in/courses/108/101/108101174

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	HIGH VOLTAGE ENGINEERING	L	T	P	C
		3	0	0	3

Pre-requisite:
Material Science, Electromagnetic Fields and Basics of Transient Circuits.

Course Objectives:

- To understand HV breakdown phenomena in gases.
- To understand the breakdown phenomenon of liquids and solid dielectrics.
- To acquaint with the generating principle of operation and design of HVDC, AC voltages.
- To understand the generating principles of Impulse voltages & currents.
- To understand various techniques for AC, DC and Impulse measurements of high voltages and currents.

Course Outcomes:
After the completion of the course the student should be able to:

CO 1: Recognise the dielectric properties of gaseous materials used in HV equipment.
CO 2: Differentiate the break down phenomenon in liquid and solid dielectric materials.
CO 3: Acquaint with the techniques of generation of high AC and DC voltages
CO 4: Acquaint with the techniques of generation of high Impulse voltages and currents.
CO 5: Getting the knowledge of measurement of high AC - DC - Impulse voltages and currents.

UNIT - I
Break down phenomenon in Gaseous and Vacuum:
Insulating Materials: Types, properties and its applications. Gases as insulating media – Collision process – Ionization process – Townsend's criteria of breakdown in gases and its limitations – Streamers Theory of break down – time lag – Paschen's law- Paschen's curve, Penning Effect.
Breakdown mechanisms in Vacuum.

UNIT - II
Break down phenomenon in Liquids:
Liquid as Insulator – Pure and commercial liquids – Breakdown in pure and commercial liquids- Mechanisms.
Break down phenomenon in Solids:

Intrinsic breakdown – Electromechanical breakdown – Thermal breakdown – Breakdown of composite solid dielectrics.

UNIT - III

Generation of High DC voltages:

Voltage Doubler Circuit - Voltage Multiplier Circuit – Vande- Graaff Generator.

Generation of High AC voltages:

Cascaded Transformers – Resonant Transformers –Tesla Coil.

UNIT - IV

Generation of Impulse voltages:

Specifications of impulse wave – Analysis of RLC circuits - Marx Circuit.

Generation of Impulse currents:

Definitions – Circuits for producing Impulse current waves – Wave shape control - Tripping and control of impulse generators.

UNIT - V

Measurement of High DC & AC Voltages:

Resistance potential divider - Generating Voltmeter - Capacitor Voltage Transformer (CVT) - Electrostatic Voltmeters – Sphere Gaps.

Measurement of Impulse Voltages & Currents:

Potential dividers with CRO - Hall Generator - Rogowski Coils.

Text Books:

1. High Voltage Engineering: Fundamentals by E.Kuffel - W.S.Zaengl - J.Kuffel by Elsevier - 2nd Edition.
2. High Voltage Engineering by M.S.Naidu and V. Kamaraju – TMH Publications - 3rd Edition.

Reference Books:

1. High Voltage Engineering and Technology by Ryan - IET Publishers - 2nd edition.
2. High Voltage Engineering by C.L.Wadhwa - New Age Internationals (P) Limited – 1997.
3. High Voltage Insulation Engineering by RavindraArora - Wolfgang Mosch - New Age International (P) Limited - 1995.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/108/104/108104048
2. https://bharatsrajpurohit.weebly.com/high-voltage-engineering-course.html

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	FUNDAMENTALS OF ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

Pre-requisite:

Basic knowledge in Physics, Chemistry and Basics of Electrical and Electronics.

Course Objectives:

- To familiarize the students with the need and advantages of electric and hybrid electric vehicles.
- To understand various power converters used in electric vehicles.
- To be familiar all the different types of motors suitable for electric vehicles.
- To know various architecture of hybrid electric vehicles.
- To have knowledge on latest developments in batteries and other storage systems.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Illustrate the use and advantages of different types of electric vehicles.
CO2: Use suitable power converters for EV application.
CO3: Select suitable electric motor for EV power train.
CO4: Design HEV configuration for a specific application.
CO5: Analyse various storage systems and battery management system for EVs.

UNIT – I

Introduction

Fundamentals of vehicles – Vehicle model – Calculation road load and tractive force –Components of conventional vehicles – Drawbacks of conventional vehicles – Need for electric vehicles– Advantages and applications of Electric Vehicles – History of Electric Vehicles – EV Market in India and outside India – Types of Electric Vehicles.

UNIT – II

Components of Electric Vehicles

Main components of Electric Vehicles – Electric Traction MotorandController – Power Converters – Rectifiers used in EVs – Bidirectional DC–DC Converters – Voltage Source Inverters – PWM inverters used in EVs.

UNIT – III

Motors for Electric Vehicles

Characteristics of traction drive – requirements of electric machines for EVs – Comparison of Different motors for Electric and Hybrid Vehicles – Induction Motors – Synchronous Motors – Permanent Magnetic Synchronous Motors – Brushless DC Motors – Switched Reluctance Motors (Construction details and working only).

UNIT – IV

Hybrid Electric Vehicles

Evolution of Hybrid Electric Vehicles – Advantages and Applications of Hybrid Electric Vehicles – Architecture of HEVs – Series and Parallel HEVs – Complex HEVs – Range extended HEVs – Examples – Merits and Demerits.

UNIT – V

Energy Sources for Electric Vehicles

Batteries– Types of Batteries – Lithium-ion – Nickel-metal hydride – Lead-acid – Comparison of Batteries – Battery Charging – Fast Charging –Battery Management System – Ultra capacitors – Flywheels – Compressed air energy storage (CAES)– Fuel Cell – it's working.

Text Books

1. Iqbal Hussein - Electric and Hybrid Vehicles: Design Fundamentals - CRC Press - 2021.
2. Tom Denton, Hayley Pells - Electric and hybrid vehicles, Third Edition, 2024

Reference Books:

1. Kumar - L. Ashok - and S. Albert Alexander. Power Converters for Electric Vehicles. CRC Press - 2020.
2. Chau - Kwok Tong. Electric vehicle machines and drives: design - analysis and application. John Wiley & Sons - 2015.
3. Berg - Helena. Batteries for electric vehicles: materials and electrochemistry. Cambridge university press - 2015.

Online Learning Resources:

1. MOOC at https://www.edx.org/learn/electric-cars
2. https://archive.nptel.ac.in/courses/108/106/108106170

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	ELECTRICAL WIRING ESTIMATION AND COSTING	L	T	P	C
		3	0	0	3

Pre-requisite:

Electrical Circuits, Basics of Power Systems and Electrical Machines.

Course Objectives:

- Introduce the electrical symbols and simple electrical circuits
- Able to learn the design of electrical installations.
- Able to learn the design of electrical installation for different types of buildings and small industries.
- Learn the basic components of electrical substations.
- Familiarize with the motor control circuits

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Demonstrate the various electrical apparatus and their interconnections.
CO2: Examine various components of electrical installations.
CO3: Estimate the cost for installation of wiring for different types of building and small industries.
CO4: Illustrate the components of electrical substations.
CO5: Design suitable control circuit for starting of three phase induction motor and synchronous motor.

UNIT - I

Electrical Symbols and Simple Electrical Circuits

Identification of electrical symbols - Electrical wiring Diagrams - Methods of representation of wiring diagrams - introduction to simple light and fan circuits - system of connection of appliances and accessories.

UNIT - II

Design Considerations of Electrical Installations

Electric supply system - Three-phase four wire distribution system - protection of electric installation against overload - short circuit and earth fault - earthing - neutral and earth wire - types of loads - systems of wiring - permissible of voltage drops and sizes of wires - estimating and costing of electrical installations.

UNIT - III

Electrical Installation for Different Types of Buildings and Small Industries

Electrical installations for electrical buildings - estimating and costing of material - simple examples on electrical installation for residential buildings - electrical installations for commercial buildings - electrical installation for small industries-case study.

UNIT - IV

Substations

Introduction - types of substations - outdoor substations-pole mounted type - indoor substations-floor mounted type - simple examples on quantity estimation-case study.

UNIT - V

Motor control circuits

Introduction to AC motors - starting of three phase squirrel cage induction motors - starting of wound rotor motors - starting of synchronous motors - contractor control circuit components - basic control circuits - motor protection – Schematic and wiring diagrams for motor control circuits.

Text Books:

1. Electrical Design and Estimation Costing - K. B. Raina and S.K.Bhattacharya – New Age International Publishers - 2007.

References Books:

1. Electrical wiring estimating and costing – S.L.Uppal and G.C.Garg – Khanna publishers - 6th edition - 1987.
2. A course in electrical installation estimating and costing – J.B.Gupta – Kataria SK & Sons - 2013.

Online Learning Resources:

1. https://onlinecourses.swayam2.ac.in/nou25_ec07/preview

III Year II Semester	ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LAB	L	T	P	C
		0	0	3	1.5

Course Objectives:

- To understand students how different types of meters work and their construction.
- To make the students understand how to measure resistance, inductance and capacitance by AC & DC bridges.
- To understand the testing of CT and PT.
- To Understand and the characteristics of Thermo couples, LVDT, Capacitive transducer, piezoelectric transducer and measurement of strain and choke coil parameters.
- To study the procedure for standardization and calibration of various methods.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Know about the phantom loading and calibration process.
CO2: Measure the electrical parameters voltage - current - power- energy and electrical characteristics of resistance - inductance and capacitance.
CO3: Gain the skill knowledge of various brides and their applications.
CO4: Learn the usage of CT's - PT's for measurement purpose.
CO5: Know the characteristics of transducers and measure the strains - frequency and phase difference.

Any 10 of the following experiments are to be conducted

1. Calibration of dynamometer wattmeter using phantom loading
2. Measurement of resistance using Kelvin's double Bridge and Determination of its tolerance.
3. Measurement of Capacitance using Schering Bridge.
4. Measurement of Inductance using Anderson Bridge.
5. Calibration of LPF Wattmeter by direct loading.
6. Measurement of 3 phase reactive power using single wattmeter method for a balanced load.
7. Testing of C.T. using mutual inductor – Measurement of % ratio error and phase angle of given C.T. by Null deflection method.
8. P.T. testing by comparison – V.G as Null detector – Measurement of % ratio error and phase angle of the given P.T.
9. Determination of the characteristics of a Thermocouple.
10. Determination of the characteristics of a LVDT.
11. Determination of the characteristics for a capacitive transducer.
12. Measurement of strain for a bridge strain gauge.
13. Measurement of Choke coil parameters and single-phase power using three

voltmeter and three ammeter methods.

14. Calibration of single-phase Induction Type Energy Meter.
15. Calibration of DC ammeter and voltmeter using Crompton DC Potentiometer.
16. AC Potentiometer: Polar Form / Cartesian Form - Calibration of AC voltmeter - Parameters of choke.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	MICROPROCESSORS AND MICROCONTROLLERS LAB	L	T	P	C
		0	0	3	1.5

Pre-requisite:
Concepts of Microprocessors and Microcontrollers

Course Objectives:

- To study programming based on 8086 microprocessor and 8051 microcontroller.
- To study 8086 microprocessor based ALP using arithmetic, logical and shift operations.
- To study to interface 8086 with I/O and other devices.
- To study parallel and serial communication using 8051& PIC 18 micro controllers.

Course Outcomes:
After the completion of the course the student should be able to:

CO1: Write assembly language program using 8086 microprocessor based on arithmetic - logical number systems and shift operations.
CO2: Write assembly language programs for numeric operations and array handling problems.
CO3: Write a assembly program on string operations.
CO4: Interface 8086 with I/O and other devices.
CO5: Do parallel and serial communication using 8051 & PIC 18 micro controllers.
CO6: Program microprocessors and microcontrollers for real world applications.

List of experiments
Any 10 of the following experiments are to be conducted:

8086 Microprocessor Programs

1. Arithmetic operations – Two 16-bit numbers and multibyte numbers :addition - subtraction - multiplication and division – Signed and unsigned arithmetic operations - ASCII – Arithmetic operations.
2. Logic operations – Shift and rotate – Converting packed BCD to unpacked BCD - BCD to ASCII conversion – BCD numbers addition.
3. Arrange the given array in ascending and descending order
4. Determine the factorial of a given number
5. By using string operation and Instruction prefix**:** Move block - Reverse string Sorting - Inserting - Deleting - Length of the string - String comparison.
6. Find the first and n^{th} number of 'n' natural numbers of a Fibonacci series.
7. Find the number and sum of even and odd numbers of a given array
8. Find the sum of 'n' natural numbers and squares of 'n' natural numbers
9. Arithmetic operations on 8051

10. Conversion of decimal number to hexa equivalent and hexa equivalent to decimal number
11. Find the Sum of elements in an array and also identify the largest & smallest number of a given array using 8051

Programs on Interfacing

12. Interfacing 8255–PPI with 8086.
13. Stepper motor control using 8253/8255.
14. Reading and Writing on a parallel port using 8051
15. Timer in different modes using 8051
16. Serial communication implementation using 8051
17. Understanding three memory areas of 00 – FF Using 8051 external interrupts.
18. Traffic Light Controller using 8051.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year II Semester	IOT APPLICATIONS OF ELECTRICAL ENGINEERING LAB	L	T	P	C
		0	1	2	2

Pre-requisite: Concepts of Computer Organization, Computer Networks.

Course Objectives:

- To understand the working of Arduino.
- To learn the programming of Raspberry PI.
- To know various sensors with Arduino/Raspberry Pi.
- To interface various displays with Arduino/Raspberry Pi.
- To connect with various wireless communication devices

Course Outcomes:

At the end of the course - students will be able to:
CO1:Operate the Arduino Integrated Development Environment with embedded c.
CO2: Program the embedded Python in Raspberry Pi OS.
CO3: Interface various sensors with Arduino/Raspberry Pi in the IoT environment.
CO4:Connect different displays with Arduino/Raspberry Pi
C05:Interconnect with wireless communication technologies.

Topics to be covered in Tutorials

Module–1: Programming Arduino: (3 hrs)

Arduino - Classification of Arduino Boards - Pin diagrams – Arduino Integrated Development Environment (IDE) – Programming Arduino.

Module–2: Sensors: (5 hrs)

Working of temperature sensor, proximity sensor, IR sensor, Light sensor, ultrasonic sensor, PIR Sensor, Colour sensor, Soil Sensor, Heart Beat Sensor, Fire Alarms etc. Actuators: Stepper Motor, Servo Motor and their integration with Arduino/Raspberry Pi.

Module–3: Raspberry Pi: (2 hrs)

Introduction, Classification of Rasperberry Pi Series - Pin diagrams – Programming Rasperberry Pi.

Module–4: Display: (2 hrs)

Working of LEDs, LED, OLED display, LCDs, Seven Segment Display, Touch Screen etc. Analog Input and Digital Output Converter etc. and their integration with Arduino/Raspberry Pi.

Module–5: Wireless Communication Devices: (4 hrs)

Working of Bluetooth, Wi-Fi, Radio Frequency Identification (RFID), GPRS/GSM Technology, ZigBee, etc and their integration with Arduino/Raspberry Pi. Features of Alexa.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

List of experiments

Any 10 of the following experiments are to be conducted:

1. Familiarization with Arduino/Raspberry Pi and perform necessary software installation.
2. Interfacing of LED/Buzzer with Arduino/Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 seconds.
3. Interfacing of Push button/Digital sensor (IR/LDR) with Arduino/Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection.
4. Interfacing of temperature sensor with Arduino/Raspberry Pi and write a program to print temperature and humidity readings.
5. Interfacing of Organic Light Emitting Diode (OLED) with Arduino/Raspberry Pi
6. Interfacing of Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth.
7. Interfacing of Bluetooth with Arduino/Raspberry Pi and write a program to turn LED ON/OFF when '1'/'0' is received from smartphone using Bluetooth.
8. Write a program on Arduino/Raspberry Pi to upload and retrieve temperature and humidity data to thingspeak cloud.
9. Interfacing of 7 Segment Display with Arduino/Raspberry Pi
10. Interfacing of Joystick with Arduino/Raspberry Pi
11. Interfacing of Analog Input & Digital Output with Arduino/Raspberry Pi
12. Night Light Controlled & Monitoring System
13. Interfacing of Fire Alarm Using Arduino/Raspberry Pi
14. IR Remote Control for Home Appliances
15. A Heart Rate Monitoring System
16. Alexa based Home Automation System

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
(Established by Govt. of A.P., ACT No.30 of 2008)
KAKINADA – 533 003 (A.P) INDIA
R23 IIIrd Year ELECTRICAL AND ELECTRONICS ENGINEERING

III Year – II SEMESTER	AUDIT COURSE RESEARCH METHODOLOGY	L	T	P	C
		2	0	0	-

Minor Engineering Courses offered by EEE Department for Other Branches (Except EEE Branch)

		L	T	P	C
I	CONCEPTS OF CONTROL SYSTEMS	3	0	0	3

Pre-requisite:

Basic Engineering Mathematics

Course Objectives:

- To learn the mathematical modeling of physical systems and to use block diagram algebra and signal flow graph to determine overall transfer function
- To analyze the time response of first and second order systems and improvement of performance using PI, PD, PID controllers.
- To investigate the stability of closed loop systems using Routh's stability criterion and root locus method.
- To learn Frequency Response approaches for the analysis of LTI systems using Bode plots, polar plots and Nyquist stability criterion.
- To learn state space approach for analysis of LTI systems and understand the concepts of controllability and observability.

Course Outcomes:

After the completion of the course the student should be able to:

CO1: Derive the transfer function of physical systems and determination of overall transfer function using block diagram algebra and signal flow graphs.

CO2: Determine time response specifications of second order systems and to determine error constants.

CO3: Analyze absolute and relative stability of LTI systems using Routh's stability criterion and the root locus method.

CO4: Analyze the stability of LTI systems using frequency response methods.

CO5: Represent physical systems as state models and determine the response. Understanding the concepts of controllability and observability.

UNIT – I

Mathematical Modelling of Control Systems

Classification of control systems - open loop and closed loop control systems and their differences - transfer function of linear system - differential equations of electrical networks - translational and rotational mechanical systems – block diagram algebra – Feedback characteristics.

UNIT-II

Time Response Analysis

Standard test signals – time response of first and second order systems – time domain specifications - steady state errors and error constants – P, PI , PD &PID Controllers.

UNIT–III

Stability and Root Locus Technique

The concept of stability – Routh-Hurwitz Criteria – limitations of Routh-Hurwitz criterion-Root locus concept – construction of root loci (simple problems).

UNIT–IV

Frequency Response Analysis

Introduction to frequency domain specifications – Bode diagrams – Transfer function from the Bode diagram – phase margin and gain margin.

UNIT–V

State Space Analysis of Linear Time Invariant (LTI) Systems

Concepts of state - state variables and state model - state space representation of transfer function - State Transition Matrix and it's properties.

Text Books:

1. Modern Control Engineering by Kotsuhiko Ogata - Prentice Hall of India.
2. Automatic control systems by Benjamin C.Kuo - Prentice Hall of India - 2nd Edition.

Reference Books:

1. Control Systems principles and design by M.Gopal - Tata Mc Graw Hill education Pvt Ltd. - 4th Edition.
2. Control Systems by Manik Dhanesh N - Cengage publications.
3. Control Systems Engineering by I.J.Nagarath and M.Gopal - Newage International Publications - 5th Edition.
4. Control Systems Engineering by S.Palani - Tata Mc Graw Hill Publications.

Online Learning Resources:

1. https://archive.nptel.ac.in/courses/107/106/107106081
2. https://archive.nptel.ac.in/courses/108/106/108106098
3. https://nptelvideos.com/video.php?id=1423&c=14