JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Course Structure and Syllabi for Pre Ph.D

ELECTRICAL ENGINEERING (2009-10)

PART - I

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	**Restructured Power System**	09PH02101
2	**Power System Dynamics and Stability**	09PH02102
3	**Modern Control Theory**	09PH02103
4	**Principles of Machine Modeling and Analysis**	09PH02104
5	**Renewable Energy Sources**	09PH02105

Part – II

Choose any **one** subject of the following

S.NO	PAPER	PAPER CODE
1	**FACTS Controllers and Their Applications**	09PH02201
2	**Reliability Analysis of Power Systems**	09PH02202
3	**Power Quality**	09PH02203
4	**Static and Digital Power System Protection**	09PH02204
5	**Modern Power Electronics**	09PH02205
6	**Power Electronic Control of DC Drives**	09PH02206
7	**Special Electrical Machines**	09PH02207
8	**Power Electronic Control of AC Drives**	09PH02208
9	**Digital Control Systems**	09PH02209
10	**Optimal Control**	09PH02210
11	**Nonlinear Control Theory**	09PH02211
12	**Adaptive and Learning Control**	09PH02212
13	**Reliability Optimization**	09PH02213
14	**Neural and Fuzzy Systems**	09PH02214
15	**Advanced Digital Signal Processing**	09PH02215

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02101) RESTRUCTURED POWER SYSTEM

UNIT I: Key Issues in Electric Utilities
Introduction – Restructuring models – Independent System Operator (ISO) – Power Exchange - Market operations – Market Power – Standard cost – Transmission Pricing – Congestion Pricing – Management of Inter zonal/Intra zonal Congestion.

UNIT II: Open Access Same-time Information System (OASIS)
Structure of OASIS - Posting of Information – Transfer capability on OASIS.

UNIT III: Available Transfer Capability (ATC)
Transfer Capability Issues – ATC – TTC – TRM – CBM Calculations – Calculation of ATC based on power flow.

UNIT IV: Electricity Pricing
Introduction – Electricity Price Volatility Electricity Price Indexes – Challenges to Electricity Pricing – Construction of Forward Price Curves – Short-time Price Forecasting.

UNIT V: Power System Operation in Competitive Environment
Introduction – Operational Planning Activities of ISO- The ISO in Pool Markets – The ISO in Bilateral Markets – Operational Planning Activities of a GENCO.

UNIT VI: Market Power
Introduction - Different types of market Power – Mitigation of Market Power - Examples.

UNIT VII: Transmission Congestion Management
Introduction - Transmission Cost Allocation Methods : Postage Stamp Rate Method - Contract Path Method - MW-Mile Method – Unused Transmission Capacity Method - MVA-Mile method – Comparison of cost allocation methods.

UNIT VIII: Ancillary Services Management
Introduction – Reactive Power as an Ancillary Service – a Review – Synchronous Generators as Ancillary Service Providers**.**

References:

1. **Operation of Restructured Power System**, Kankar Bhattacharya, Math H.J. Boller and Jaap E.Daalder Kulwer Academic Publishers, 2001.
2. **Restructured Electrical Power Systems**, Mohammad Shahidehpour and Muwaffaq alomoush, Marcel Dekker, Inc., 2001.
3. **Power System Restructuring and Deregulation**, Loi Lei Lai, John Wiley & Sons Ltd., England.

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Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02102) POWER SYSTEM DYNAMICS AND STABILITY

Unit I:

Introduction to the power system stability – Basic concepts and definitions – classification of stability – Synchronous Machine modeling – mathematical description of a synchronous machine – The dqo transformation – equivalent circuits for direct and quadrature axes – steady state analysis – electrical transient performance characteristics – equations of motion.

Unit II:

Power system loads – Basic load modeling concepts – modeling of Induction motors – Synchronous motor model – acquisition of load – model parameters.

Unit III:

Excitation systems – Requirements – elements – Types –Dynamic Performance measures – control and protective functions - Modeling of excitation systems.

Unit IV:

Small – Signal Stability – fundamental concepts of stability of dynamic systems – Eigen properties of the state matrix – small signal stability of a single machine infinite bus system – effects of excitation system – power system stabilizer – system state matrix with amortisseurs – small signal stability of multi machine systems – special techniques for analysis of very large systems – characteristics small signal stability problems.

Unit V:

Transient Stability – an elementary view of transient stability – numerical integration methods – simulation of power system dynamic response – analysis of unbalanced faults – performance of protective relaying – case study of transient stability a large system – direct method transient stability analysis.

Unit VI:

Voltage stability – Basic concepts related to voltage stability – voltage collapse – voltage stability analysis – prevention of voltage collapse.

Unit VII:

Sub synchronous oscillations – turbine generator torsional characteristics – torsional interaction with power system controls – sub synchronous resonance – Impact of network switching disturbances – torsional interaction between closely coupled units – Hydro generator torsional characteristics.

Unit VIII:

Methods of improving stability – transient stability enhancement – small signal stability enhancement.

References:

1. **“Power System Stability and Control” by** P.Kundur Mc Graw-Hill Inc.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02103) MODERN CONTROL THEORY

UNIT I: Mathematical Preliminaries – Fields, Vectors and Vector Spaces – Linear combinations and Bases – Linear transformations and Matrices – Scalar Product and Norms – Eigen values, Eigen Vectors and a Canonical form representation of Linear operators – The concept of state – State equations for Dynamic systems – Time invariance and Linearity – Nonuniqueness of state model – State diagrams for Continuous time state models.

UNIT II: State Variable Analysis – Linear continuous time model for physical systems – Existence and Uniqueness of solutions to Continuous time state equations – Solutions – Linear time invariant Continuous – Time state equations – State transition matrix and it's properties.

UNIT III: Controllability and Observability – General concept of Controllability – General concept of Observability – Controllability tests for Continuous time invariant systems – Observability tests for Continuous – Time invariant systems – Controllability and Observability of state model in Jordan canonical form – Controllability and Observability Canonical forms of State model.

UNIT IV: State feedback Controllers and Observers – State Feedback Controller design through Pole assignment – State Observers: Full order and Reduced order.

UNIT V: Non Linear Systems- I – Introduction – Non Linear systems – Types of Non linearities – Saturation – Dead zone – Backlash – Jump Phenomenon etc; - Singular points – Introduction to Linearization of non linear systems , Properties of non linear systems – Describing function – Describing function analysis of non linear systems – Stability analysis of non linear systems through describing functions.

UNIT VI: Non Linear Systems – II – Introduction to Phase plane analysis – Method of Isoclines for constructing Trajectories, Singular points, Phase plane analysis of non linear control systems.

UNIT VII: Stability Analysis – Stability in the sense of Lyapunov, Lyapunov's stability theorems – Stability analysis of the linear continuous time invariant systems by Lyapunov second method – Generation of Lyapunov functions – Variable gradient method – Krasooviski's method.

UNIT VIII: Model decomposition and decoupling by state feedback – Disturbance rejection. Sensitivity and Complementary sensitivity functions.

References:

1. **Modern Control System Theory** by M. Gopal – New Age International -1984.
2. **Modern Control Engineering** by Ogata. K – Prentice Hall – 1997.
   Optimal Control by Kirk

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02104) PRINCIPLES OF MACHINE MODELING AND ANALYSIS

Unit I: Basic Principles for Machine Analysis
Magnetically coupled circuits, Machine windings and air-gap MMF, winding inductances and voltage equations.

Unit-II: Modeling and Analysis of DC Machines: Separately excited dc generators, Separately excited dc motors, inter connection of machines, transfer functions of dc machines, dc series motor, dc shunt machines, dc compound machines, linearization techniques for small perturbations, cross field machines, transfer functions of cross field machines, Electric braking of dc motors.

Unit-III: Reference Frame Theory: Introduction to transformations, equations of transformations, change of variables, transformation to an arbitrary reference frame, commonly used reference frames, transformation between reference frames, Steady-state phasor relationships and voltage equations.

Unit IV: Modeling of Three Phase Induction Machines: Voltage and torque equations in machine variables, Voltage and torque equations in arbitrary reference frame, Steady-state analysis and its operation.

Unit-V: Dynamic analysis of three-phase Induction Machine:
Free acceleration characteristics viewed from various reference frames, dynamic performance during sudden changes in load torque, dynamic performance during a three-phase fault at the machine terminals.

Unit VI: Modeling of Synchronous Machine: Voltage and torque equations in machine variables, Voltage equations in arbitrary and rotor reference frame, torque equations in in substitute variable, Steady-state analysis and its operation.

Unit VII: Dynamic Analysis of Synchronous Machine: Dynamic performance of synchronous machine, three-phase fault, comparison of actual and approximate transient torque characteristics, Equal area criteria.

Unit VIII: Modeling of Brushless DC Motor: Voltage and torque equations in machine variables, Voltage and torque equations in rotor reference frame variables, Analysis of steady state operation, dynamic performance.

References:

1. **Analysis of Electric Machinery And Drive Systems by** Krause, Wasynczuk, Sudhoff, 2nd Edition, Wiely Interscince.
2. " Generalized theory of electrical machines", **Dr. P.S Bimbhra Khanna Publishers.**

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02105) RENEWABLE ENERGY SOURCES

UNIT I SOLAR PHOTO VOLTAIC POWER SYSTEM: The PV cell, Module and array, equivalent electrical circuit, open circuit and short circuit current, i-v and p-v curves, array design

UNIT II SOLAR THERMAL SYSTEM: Energy collection, solar power plant, synchronous generator, commercial power plants

UNIT III ENERGY STORAGE: Battery, types of batteries, equivalent electrical circuit, performance characteristics, lead- acid battery, battery design, battery charging, charging regulators, battery management, flywheel.

UNIT-IV FUNDAMENTAL OF WIND TURBINES: Historical back ground, power contained in wind, thermodynamics of wind energy, efficiency limit for wind energy conversion, maximum energy obtainable for a thrust-operated converter, types of wind energy conversion devices, some relevant definitions, aerodynamics, design of wind turbine rotor, power speed, torque-speed characteristics, wind turbine control systems, control strategy.

UNIT-V GRID CONNECTED AND SELF EXCITED INDUCTION GENERATOR OPERATION: constant voltage, constant frequency generation, reactive power compensation, variable voltage, variable frequency generation, effect of wind generator on the network.

UNIT-VI GENERATION SCHEMES WITH VARIABLE SPEED TURBINES: Classification of schemes, operating area, induction generators, doubly fed induction generator, wound field synchronous generators, the permanent magnet generators.

UNIT-VII THE INTEGRATION OF WIND FORMS IN TO THE POWER SYSTEM: Reactive power compensation-Static Var compensator- Static synchronous compensator-STATCOM and FSIG stability, HVAC connections, HVDC connections-LCC-HVDC, Vsc-HVDC, Multi terminal HVDC,HVDC Transmission-opportunities and challenges

UNIT-VIII HYBRID ENERGY SYSTEMS: Diesel generator and photo-voltaic system, wind-diesel hybrid system, wind-Photo voltaic systems.

References:

1. **" Wind and solar Power Systems Design, analysis & Operation"** Mukund R. Patel CRC Taylor & Fracis- 2nd edition
2."**Wind Electrical Systems"** S.N.Bhadra, D. Kastha, S. Banerjee Oxford University press.
3 **"Wind energy generation modeling and control",** . Anaya-Lara, Jenkins et al John Wiley & Sons ,Ltd

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02201) FACTS CONTROLLERS AND THEIR APPLICATIONS

UNIT-I:

Basic Types of FACTS Controllers; Brief Description and Definitions of FACTS Controllers; Methods of Controllable Var Generation-Variable Impedance Type Static Var Generators-Thyristor Controlled and Thyristor Switched Reactor (TCR and TSR), Fixed Capacitor Thyristor Controlled Reactor Type Var Generator, Switching Converter Type Var Generator; Hybrid Var Generators: Switching Converter with TSC And TCR.

UNIT-II:

Static Var Compensators: SVC and STATCOM- Transient Stability Enhancement and Power Oscillation Damping; Comparison between STATCOM and SVC: V-I and V-Q Characteristics, Transient Stability, Response Time, Capability to Exchange Real Power, Operation with Unbalanced AC System, Loss Versus Var Output Characteristic, Physical Size and Installation, Merits of Hybrid Compensator.

UNIT-III:

Variable Impedance Type Series Compensators-GTO, Thyristor-Controlled Series Capacitor-(GCSC), Thyristor-Switched Series Capacitor(TSSC), Thyristor-Controlled Series Capacitor(TCSC), Basic Operating Control Schemes For GCSC,TSSC and TCSC.

UNIT-IV:

Switching Converter Type Series Compensators-Static Synchronous Series Capacitor(SSSC), Transmitted Power Versus Transmission Angle Characteristic, Control Range and VA Rating, Capability to Provide Real Power Compensation, Internal Control; External Control for Series Reactor Compensators.

UNIT-V:

Voltage and Phase Angle Regulation, Power Flow Control by Phase Angle Regulators, Real and Reactive Loop Power Flow Control; Approaches to Thyristor –Controlled Voltage and Phase Angle Regulators (TCVRs and TCPARs)-Continuously Controllable Thyristor Tap Changers.

UNIT-VI:

Introduction, The Unified Power Flow Controller-Basic Operating Principles, Conventional Transmission Control Capabilities, Independent Real and Reactive Power Flow Control. Control Structure, Basic Control System for P and Q Control; Hybrid Arrangements: UPFC With a Phase Shifting Transformer.

UNIT-VII:

Introduction, Basic Operating Principle and Characteristics of IPFC, Control Structure, Practical and Application Considerations, Generalized and Multifunctional FACTS controllers.

UNIT-VIII:

NGH-SSR Damping Scheme- Basic Concept, Design and Operation Aspects; Thyristor –Controlled-Braking Resistor (TCBR)-Basic Concept, Design and Operation Aspects.

References:

1. **Concepts and Technology of Flexible AC Transmission Systems** - Understanding FACTS: Narain G. Hingorani, Laszlo Gyugyi - Standard Publishers Distributors - IEEE Press – First Edition – 2001.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02202) RELIABILITY ANALYSIS OF POWER SYSTEMS

UNIT I : Generating System Reliability Analysis – I
Generation system model – Capacity outage probability tables – Recursive relation for capacitive model building – Sequential addition method – Unit removal – Evaluation of loss of load and energy indices – Examples.

UNIT II : Generating System Reliability Analysis – II
Frequency and Duration methods – Evaluation of equivalent transitional rates of identical and non-identical units – Evaluation of cumulative probability and cumulative frequency of non-identical generating units – 2-level daily load representation - Merging generation and load models – Examples.

UNIT III : Transmission System Reliability Analysis
System and load point reliability indices – Weather effects on transmission lines – Weighted average rate and Markov model – Common mode failures.

UNIT IV : Distribution System Reliability Analysis – I (Radial Configuration)
Basic Techniques – Radial networks – Evaluation of Basic reliability indices, performance indices - Load point and system reliability indices – Customer oriented, loss and energy oriented indices – Examples.

UNIT V : Distribution System Reliability Analysis - II (Parallel Configuration)
Basic techniques – Inclusion of bus bar failures, scheduled maintenance – Temporary and transient failures – Weather effects – Common mode failures – Evaluation of various indices – Examples.

UNIT VI : Substations and Switching Stations
Effects of short-circuits - Breaker operation – Open and Short-circuit failures – Active and Passive failures – Switching after faults – Circuit breaker model.

UNIT VII : Plant and Station Availability
Generating Plant Availability – Derated states and auxiliary systems – allocation and effect of spares – Protection systems – Problems.

UNIT VIII : Evaluation of Reliability Worth
Introduction – Implicit and Explicit evaluation of reliability worth – customer interruption cost evaluation – Basic evaluation approaches – cost valuation methods – customer damage functions – reliability worth assessment of HLI, HLII, distribution function zone and stations.

References:

1. **Reliability Evaluation of Power Systems**, Roy Billinton and Ronald N. Allan Plenum Press, New York and London, 2nd Edition, 1996.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02203) POWER QUALITY

Unit 1: Introduction:

Introduction of the Power Quality (PQ) problem, Terms used in PQ: Voltage, Sag, Swell, Surges, Harmonics, over voltages, spikes, Voltage fluctuations, Transients, Interruption, overview of power quality phenomenon, Remedies to improve power quality, power quality monitoring

Unit 2: Long Interruptions

Interruptions – Definition – Difference between failure, outage, Interruptions – causes of Long Interruptions – Origin of Interruptions – Limits for the Interruption frequency – Limits for the interruption duration – costs of Interruption – Overview of Reliability evaluation to power quality, comparison of observations and reliability evaluation.

Unit 3: Short Interruptions

Short interruptions – definition, origin of short interruptions, basic principle, fuse saving, voltage magnitude events due to re-closing, voltage during the interruption, monitoring of short interruptions, difference between medium and low voltage systems. Multiple events, single phase tripping – voltage and current during fault period, voltage and current at post fault period, stochastic prediction of short interruptions.

Unit 4: Voltage sag – characterization:

Voltage sag – definition, causes of voltage sag, voltage sag magnitude, monitoring, theoretical calculation of voltage sag magnitude, voltage sag calculation in non-radial systems, meshed systems, voltage sag duration. Three phase faults, phase angle jumps, magnitude and phase angle jumps for three phase unbalanced sags, load influence on voltage sags.

Unit 5: PQ considerations in Industrial Power Systems:

Voltage sag – equipment behaviour of Power electronic loads, induction motors, synchronous motors, computers, consumer electronics, adjustable speed AC drives and its operation. Mitigation of AC Drives, adjustable speed DC drives and its operation, mitigation methods of DC drives.

Unit 6: Mitigation of Interruptions and Voltage Sags:

Overview of mitigation methods – from fault to trip, reducing the number of faults, reducing the fault clearing time changing the power system, installing mitigation equipment, improving equipment immunity, different events and mitigation methods. System equipment interface – voltage source converter, series voltage controller, shunt controller, combined shunt and series controller.

Unit 7: Fundamentals of Harmonics

Harmonic Distortion – Voltage verses Current distortion – Harmonics verses Transients – Harmonic Indexes – Harmonic Sources from Commercial Loads – Harmonic Sources from industrial Loads – locating harmonic sources – System response characteristics – effects of harmonic distortion – inter harmonics.

Unit 8: Power Quality Monitoring:

Monitoring Considerations – Historical Perspective of Power Quality measuring Instruments – Power Quality measurement Equipment – Assessment of Power Quality Measurement Data – Application of Intelligent Systems – Power Quality Monitoring Standards.

References:

1. "**Understanding Power Quality Problems"** by Math H J Bollen. IEEE Press.
2. **Electrical Power Systems Quality'' by** Roger C. Dugan, Mark E. Mc. Granaghan, Surya Santoso and H. Wayne Beaty,"Mc. Graw Hill, Second Edition.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02204)STATIC AND DIGITAL POWER SYSTEM PROTECTION

UNIT-I: **Introduction to Static Relays**

Advantages of static relays - Basic construction of static relays – Level detectors – Replica impedance-mixing circuits-general equation for two input phase and amplitude comparators – Duality between amplitude and phase comparator.

UNIT-II:

Amplitude Comparators: Circulating current type and opposed voltage type rectifier bridge comparators – Direct and Instantaneous comparators.

Phase Comparators: Coincidence circuit type block spike phase comparator, techniques to measure the period of coincidence – Integrating type – Rectifier and vector product type phase comparators.

UNIT-III: Multi –Input Comparators

Conic section characteristics – Three input amplitude comparator – Hybrid comparator – Switched distance schemes – Polyphase distance schemes-Phase fault scheme – Three phase scheme – combined and ground fault scheme

UNIT-IV: Static Relays

Introduction-Instantaneous over current relay – Time over current relays - Basic principles- Definite time and Inverse definite time over current relays.

Static Differential Relays-Analysis of static differential relays – static relay schemes- Dual bias transformer differential protection – Harmonic restraint relay.

Static Distance Relays- Static impedance – reactance - MHO and angle impedance relay sampling comparator – realization of reactance and MHO relay using a sampling comparator.

UNIT-V: Power Swings

Effect of power swings on the performance of Distance relays - Power swing analysis – Principle of out of step tripping and blocking relays – Effect of line length and source impedance on distance relays.

UNIT-VI: Microprocessor Based Protective Relays-I

Over current relays – Impedance relays – Directional relay – Reactance relay (Block diagram and flow chart approach only).

UNIT-VII: Microprocessor Based Protective Relays-II

Generalized mathematical expression for distance relays - Measurement of resistance and reactance – MHO and offset MHO relays – Realization of MHO characteristics – Realization of Offset MHO characteristics (Block diagram and flow chart approach only) Basic principle of Digital computer relaying.

UNIT-VIII: Numerical Relays:

Advantages of Numerical Relays- Numerical network- Digital Signal processing – Estimation of Phasors – Full Cycle Fourier Algorithm – Half Cycle Fourier Algorithm- practical considerations for selection of Algorithm –Discrete Fourier Transform

References:

1. **Power system Protection static relay**, T.S.Madhava Rao, Tata McGraw Hill, 2^{nd} Edition, 1989.
2. **" Power System Protection and Switchgear",** Bhuvanesh A Oza, Nirmal kumar C Nair et.al. Mc Graw Hill
3. **Power system Protection and Switchgear**, Badri Ram and D.N.Vishwakarma, Tata McGraw Hill, First Edition -1995.

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Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02205) MODERN POWER ELECTRONICS

Unit-I High-Power Semiconductor Devices: Introduction, High-Power Switching Devices, Diodes, Silicon-Controlled Rectifier (SCR), Gate Turn-Off (GTO) Thyristor, Gate-Commutated Thyristor (GCT), Insulated Gate Bipolar Transistor (IGBT), Other Switching Devices, Operation of Series-Connected Devices, Main Causes of Voltage Unbalance ,Voltage Equalization for GCTs, Voltage Equalization for IGBTs

Unit-II Two-Level Voltage Source Inverter: Introduction, Sinusoidal PWM , Modulation Scheme ,Harmonic Content, Overmodulation,Third Harmonic Injection PWM, Space Vector Modulation , Switching States , Space Vectors, Dwell Time Calculation, Modulation Index , Switching Sequence, Spectrum Analysis, Even-Order Harmonic Elimination, Discontinuous Space Vector Modulation.

Unit-III Cascaded H-Bridge Multilevel Inverters: Introduction, H-Bridge Inverter, Bipolar Pulse-Width Modulation, Unipolar Pulse-Width Modulation, Multilevel Inverter Topologies, CHB Inverter with Equal dc Voltage, H-Bridges with Unequal dc Voltages, Carrier Based PWM Schemes, Phase-Shifted Multicarrier Modulation, Level-Shifted Multicarrier Modulation, Comparison Between Phase- and Level-Shifted,PWM Schemes , Staircase Modulation.

Unit-IV Diode-Clamped Multilevel Inverters: Introduction, Three-Level Inverter , Converter Configuration, Switching State ,Commutation, Space Vector Modulation, Stationary Space Vectors , Dwell Time Calculation, Relationship Between *V_ref* Location and Dwell Times, Switching Sequence Design, Inverter Output Waveforms and Harmonic Content , Even-Order Harmonic Elimination, Neutral-Point Voltage Control, Causes of Neutral-Point Voltage Deviation , Effect of Motoring and Regenerative Operation, Feedback Control of Neutral-Point Voltage, Other Space Vector Modulation Algorithms, Discontinuous Space Vector Modulation, SVM Based on Two-Level Algorithm, High-Level Diode-Clamped Inverters, Four- and Five-Level Diode-Clamped Inverters, Carrier-Based PWM.

Unit-V DC-DC Switch-mode converters: Introduction, control of dc-dc converter, Buck converter, boost converter, buck-boost converter, cuk dc-dc converter, full-bridge dc-dc converter, dc-dc converter comparison.

Unit-VI Switching DC power supplies: Introduction, linear power supplies, overview of switching power supplies, dc-dc converters with electrical isolation, control of switch mode dc power supplies, power supply protection, and electrical isolation in the feedback loop, designing to meet the power supply specifications.

Unit-VII Resonant converters: Introduction, classification of resonant converters, basic resonant circuit concepts, load-resonant converters, resonant-switch converters, zero-voltage-switching, resonant-dc-link inverters with zero-voltage switching's, high frequency-link integral-half cycle converters.

Unit-VIII Power conditioners and uninterruptible power supplies: Introduction, power line disturbances, Introduction to Power Quality, power Conditioners, uninterruptible power supplies, Applications.

References:

1. **Power electronics circuits, Devices and applications** — M.H. Rashid PHI –I edition –1995.
2. **"Power Electronics converters, Applications and Design"** Ned Mohan, Tore M. Undeland and William P. Robbins, A John Wiley & Sons, Inc., Publication 3rd Edition.
3. **"High-Power Converters And Ac Drives"** Bin Wu, A John Wiley & Sons, Inc., Publication(Free down load from rapidshire.com).

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02206) POWER ELECTRONIC CONTROL OF DC DRIVES

UNIT – I 1- Controlled Bridge Rectifier with DC Motor Load:
Separately excited DC motors with rectified single-phase supply, single-phase semi converter and single phase full converter for continuous and discontinuous modes of operation, power and power factor

UNIT – II 3-Controlled Bridge Rectifier with DC Motor Load:
Three-phase semi converter and Three phase full converter for continuous and discontinuous modes of operation, power and power factor, Addition of Free wheeling diode, Three phase double converter

UNIT-III Three phase naturally commutated bridge circuit as a rectifier or inverter: Three phase controlled bridge rectifier with passive load impedance, resistive load and ideal supply, Highly inductive load and ideal supply for load side and supply side quantities, shunt capacitor compensation, three phase controlled bridge rectifier inverter

UNIT – IV Phase controlled DC Motor drives:
Three phase controlled converter, control circuit, control modeling of three phase converter, Steady state analysis of three phase converter control DC motor drive, Two quadrant, Three phase converter controlled DC motor drive, DC motor and load, converter

UNIT – V Design of controllers for DC Motor drives:
Current and speed controllers, current and speed feedback, Design of controllers, Current and speed controllers, Motor equations, filter in the sped feed back loop speed controller, current reference generator, current controller and flow chart for simulation, Harmonics and associated problems , sixth harmonics torque

UNIT – VI Chopper controlled DC motor drives:
Principle of operation of the chopper, Four- quadrant chopper circuit, Chopper for inversion, Chopper with other power devices, model of the chopper, input to the chopper, steady state analysis of chopper controlled DC motor drives, rating of the devices, Pulsating torque

UNIT – VII Closed loop operation of Chopper fed DC motor drives:
Speed controlled drive system, current control loop, pulse width modulated current controller, hysterisis current controller, modeling of current controller, design of current controller

UNIT – VIII Dynamic Simulation of chopper fed DC motor drives
Dynamic simulations of the speed controlled DC motor drives, Speed feedback speed controller, command current generator, current controller, System simulation

References:

1. **"Power Electronics and motor control" by** W. Shepherd, L. N. Hulley, D. T.W .Liang, II Edition, Cambridge University Press
2. **" Electric motor drives modeling, Analysis and control"** R. Krishnan, I Edition, Prentice Hall India

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02207) SPECIAL ELECTRICAL MACHINES

Unit-I Why electric machines continue to naturally grow, Status of electric motors, A.C. Motors Brushless PM motors, Stepping motors, Switched reluctance motors, Servo motors, Progress in electric machines technology, Mechatronics, Microelectromechanical systems, super conductivity, Solid state converters, Energy conservation, Power quality, Recyclable electric machines.

Unit-II High power density machines: Permanent magnet transverse flux motor, Permanent magnet disc type motors, Permanent magnet motors with concentrated non-overlapping coils, Motors for refrigeration compressors, Induction motors with cryogenic cooling system.

Unit-III High speed machines: Requirements, Microturbines, Compressors, Aircraft generators, High speed multimegawatt generators, Directed energy weapons, airborne radar, Megawatt, airborne generator cooling system, Comparison of cooling techniques for high speed electric machines, Induction machines with cage rotors, Induction machines with solid rotors.

Unit-IV Types of novel motors: written pole motor, Piezoelectric motors, bearing less motor, Slot less motors, Coreless stator permanent magnet brushless motors, Disc type coreless motors, Cylindrical type motors with coreless stator winding, Integrated starter generator, Integrated electromechanical drives, Induction motors with copper cage rotor.

Unit-V Electric motors for medical and clinical applications: Electric motors and actuators, Material requirements, Control, Implanted blood pumps, Motorized catheters, Plaque excision, Capsule endoscopy, minimally invasive surgery, Challenges.

Unit-VI Low speed HTS machines: Applications, Requirements, HTS synchronous motor for ship propulsion rated at 5MW, Test facility for 5 MW motors, HTS motor for ship propulsion rated 36.5 MW, Superconducting synchronous generators, Dynamic synchronous condenser, HTS synchronous generators developed by Siemens, Japanese HTS machines, Bulk HTS machines, HTS synchronous generator built in Russia, HTS d.c. homopolar generator,

Unit-VII High speed HTS generators, First prototype of high speed superconducting generators, Homopolar generators with stationary, superconducting winding, Design of HTS rotors for synchronous generators, Market readiness.

Unit-VIII Generators for portable power applications: Miniature rotary generators, Mini generators for soldiers at battlefields and unmanned vehicles, Coreless stator disc type micro generators, Energy harvesting devices.

References:

"Advancements in Electric Machines" by J. F. Gieras, Springer publication (free download from rapidshare.com)

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Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02208) POWER ELECTRONIC CONTROL OF A.C. DRIVES

UNIT I Introduction to Induction motor Drives: Induction machine Torque production, Equivalent circuit analysis – Speed-Torque Characteristics with Variable voltage, constant frequency operation, Variable frequency operation, constant v/f operation, Variable stator current operation ,Induction motor characteristics in constant torque and field weakening regions

UNIT II Scalar control of Induction motor drives: Voltage fed inverter control, Open loop volts/Hz control, speed control slip regulation, speed control with torque and flux control, current controlled voltage fed inverter drive, current-fed inverter control, Independent current and frequency control, Speed and flux control in Current-Fed inverter drive, Volts/Hz control of Current-fed inverter drive, Efficiency optimization control by flux program

UNIT III Slip power recovery Induction motor drives: Static Kramer Drive, Phasor diagram, Torque expression, Speed control of a Kramer Drive, Static Scherbius Drive, modes of operation

UNIT IV Vector and adaptive control of Induction Motor Drives: Principles of Vector control, Vector control methods, Direct method of vector control, Indirect method of vector control, Adaptive control principles, Self tuning regulator ,Model referencing control, sliding mode control

UNIT V Introduction to Synchronous machine drives: Wound field machine, equivalent circuit, developed torque, salient pole machine characteristics, synchronous reluctance machine, sinusoidal PM machines, trapezoidal PM machines

UNIT VI Control of Wound-field Synchronous motor and SRM drives: Brush and brushless dc excitation, LCI drives and its control, scalar and vector control of cycloconverter drives, current vector control of SyRM drive, constant d^e- axis control, fast torque response control, maximum torque/ampere control, maximum power factor control

UNIT VII Control of PM Synchronous motor drives: Vector control of PMSM**,** control strategies, Constant torque angle control, Unity power factor control Constant mutual flux linkage control, flux weakening operation, speed controller design, sensorless control

UNIT VIII: Control of BLDC motor drives: PMBDCM drive scheme, dynamic simulation, commutation-torque ripple, phase advancing, normalized system equations, Half wave PMBDCM drives, sensor less control, design of speed and current controllers.

References:

1. **"Electric Motor Drives, Modeling, Analysis and Control " by** R. Krishnan , Prentice Hall edition – 2002
2. **" Modern Power Electronics and AC Drives"** B. K. Bose,, Prentice Hall edition– 1st edition

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02209) DIGITAL CONTROL SYSTEMS

UNIT I:
Introduction - Advantages of Digital control systems - Practical aspects of the choice of sampling rate and multirate sampling - Basic discrete time signals - Quantization – Sampling theorem - Data conversion and Quantization - Sampling process - Mathematical modeling - Data reconstruction and filtering of sampled signals – zero - order hold.

UNIT II:
z - transform and inverse z - transform, Relationship between s - plane and z - plane - Difference equation - Solution by recursion and z - transform - pulse transfer functions of the zero - order Hold and relationship between G(s) and G(z)– Bilinear transformation .

UNIT III:
Digital control systems - Pulse transfer function - z transform analysis of open loop, closed loop systems - Modified z Transform - transfer function - Stability of linear digital control systems - Stability tests.

UNIT IV:
Root loci - Frequency domain analysis - Bode plots - Gain margin and phase margin - Design of Digital Control Systems based on Root Locus Technique.

UNIT V:
Cascade and feedback compensation by continuous data controllers - Digital controllers - Design using bilinear transformation - Realization of Digital PID controllers.

UNIT VI:
State equations of discrete data systems, solution of discrete state equations, State transition Matrix: z - transform method. Relation between state equations and transfer functions.

UNIT VII
Concepts on Controllability and Observability - Digital state observer: Design of the full order and reduced order state observer - Pole placement design by state feed back.

UNIT VIII:
Design of Dead beat Controller - some case studies - Stability analysis of discrete time systems based on Lyapunov approach.

References:

1. **Discrete Time Control Systems by** K. Ogata, PHI/Addison - Wesley Longman Pte. Ltd., India, Delhi, 1995.
2. **Digital Control Systems**, B.C Kuo 2nd Edition, Oxford Univ Press, Inc., 1992.
3. **Digital control of Dynamic Systems**, .F. Franklin, J.D. Powell, and M.L. Workman, Addison - Wesley Longman, Inc., Menlo Park, CA , 1998.
4. **Digital Control and State Variable Methods**, Gopal, Tata McGraw Hill, India, 1997.
5 **Digital Control Systems**, . C. H. Houpis and G.B. Lamont, McGraw Hill, 1985.
6. **Fundamentals of Linear State Space Systems**, John S. Baey, Mc. Graw – Hill, 1st edition
7. **Control System Design**, Bernard Fried Land Mc. Graw – Hill, 1st edition
8. **Continuous and Discrete Control Systems**, Dorsay,McGraw - Hill.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02210) OPTIMAL CONTROL

UNIT I

An overview of optimization problem - concepts and terms related to optimization - constrained and unconstrained problems and their solutions using different techniques.

UNIT II

Convex set and convex function - convex optimization problem - quadratic optimization problem - Karush - Kuhn - Tucker (KKT) necessary and sufficient conditions for quadratic programming problem.

UNIT III

Interior point method for convex optimization - linear programming - primal and dual problems and basic concept of multi - objective optimization problem.

UNIT IV

Concept of functional, different types of performance indices, Euler - Lagrange equation.

UNIT V

Calculus of variation to optimal control problem - Fundamental concepts, functionals of a single function, functional involving several independent functions, necessary conditions for optimal control, linear regulator problems.

UNIT VI

Linear quadractic regulator, remarks on weighting matrices, solution of Riccati equation.

UNIT VII

Frequency domain interpretation of linear quadratic regulator, robustness studies.

UNIT VIII

Dynamic programming, Pontrygin’s minimum principle, time optimal control, concept of system and signal norms, statement of problem and its solution.

References:

1. **Introduction to optimum design**, Jasbir S. Arora, Elesevier, 2005.
2. **Engineering optimization : Methods and applications**, A Ravindran, K.M. Ragsdell, and G.V. Reklaitis,Wiley India Edition.
3. **Optimal Control Theory an Introduction**, Donald E.Kirk, Prentice - Hall Network series - First edition.
4. **Optimal control systems**, D.S. Naidu CRC Press.
5. **An Introduction**, Arturo Locatelli, Optimal control Birkhauser Verlag.
6. **Systems and Controll**, S.H.Zak Indian Edition , Oxford Univ, 2003.
7. **An introduction to continuous optimization**, Niclas Anreasson, Anton Evgrafov and Michael Patriksson Overseas Press (India) Pvt. Ltd.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02211) NONLINEAR CONTROL THEORY

UNIT I:
Linear versus nonlinear systems - Describing function analysis: Fundamentals, common nonlinearities (saturation, dead - zone, on - off non - linearity, backlash, hysteresis) and their describing functions.

UNIT II:
Describing function analysis of nonlinear systems. Reliability of describing method analysis. Compensation and design of nonlinear system using describing function method.

UNIT III:
Phase plane analysis: Phase portraits, Singular points characterization. Analysis of non - linear systems using phase plane technique.

UNIT IV:
Existence of limit cycles. Linearization: Exact linearization, input - state linearization, input - output linearization.

UNIT V:
Concept of stability, stability in the sense of Lyapunov and absolute stability. Zero - input and BIBO stability. Second (or direct) method of Lyapunov stability theory for continuous and discrete time systems.

UNIT VI:
Aizerman's and Kalman's conjecture. Construction of Lyapunov function - Methods of Aizerman, Zubov, Variable gradient method. Lure problem.

UNIT VII:
Popov's stability criterion, generalized circle criterion, Kalman - Yakubovich - Popov Lemma. Popov's hyperstability theorem.

UNIT VIII:
Concept of variable - structure controller and sliding control, reaching condition and reaching mode, implementation of switching control laws. Reduction of chattering in sliding and steady state mode. Some design examples of nonlinear systems such as the ball and beam, flight control, magnetic levitation and robotic manipulator etc.

References:

1.**Applied Nonlinear Control**, J. E. Slotine and Weiping LI Prentice Hall,
2. **Nonlinear Systems by** Hassan K. Khalil Prentice Hall, 1996.
3. **Nonlinear Systems Analysis by** Sankar Sastry,Stability and Control.
4**. Nonlinear Systems Analysis**, M. Vidyasagar, Prentice - Hall International editions,1993.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02212) ADAPTIVE AND LEARNING CONTROL

UNIT I

Introduction - use of Adaptive control - definitions - essential aspects – classification - Model Reference Adaptive Systems - different configurations - classification - mathematical description - Equivalent representation as a nonlinear time varying system - direct and indirect MRAC.

UNIT II

Continuous time MRAC systems - Model Reference Adaptive System Design based on Gradient method, Design of stable adaptive controllers based on Kalman - Meyer - Yakubovich Lemma, Lyapunov theory, Hyper stability theory - Narendra's error model approach.

UNIT III

Discrete time MRAC systems - Hyper stability approach - Narendra's error model approach - Introduction - stability theorem - Relation to other algorithms - hybrid adaptive control.

UNIT IV

Self Tuning Regulators (STR) - different approaches to self tuning - Recursive parameter estimation - implicit STR - Explicit STR.

UNIT V

STR design based on pole - placement technique and LQG theory - Gain scheduling. - Stability of adaptive control algorithms.

UNIT VI

Adaptive control of a nonlinear systems - Adaptive predictive control - Robustness of adaptive control systems - Instability phenomena in adaptive systems.

UNIT VII

Concept of learning control systems. Different types of learning control schemes. LTI learning control via parameter estimation schemes. Convergence of learning control.

UNIT VIII

Case Studies: Robotic manipulators, Aerodynamic curve identification, Electric drives, Satellite altitude control.

References:

1. **Adaptive control**, K.J.Astrom and Bjorn Wittenmark Pearson Edu., 2nd Edn.
2. **Sankar Sastry by** Adaptive control.
3. **Adaptive Control System - Techniques & Applications**, V.V.Chalam Marcel Dekker Inc.
4. **Adaptive control systems**, Miskhin and Braun MC Graw Hill
5 **Filtering and Signal Processing** . Karl Johan Åström, Graham Clifford Goodwin, P. R. Kumar, Adaptive Control,
6. **Adaptive control.** G.C. Goodwin
7. **Stable Adaptive Systems**. Narendra and Anna Swamy

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Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02213) RELIABILITY OPTIMIZATION

Unit I:

Partially redundant systems-Standby redundant systems-redundancy concepts-perfect switching-imperfect switching-standby redundancy calculations-Component versus unit redundancy-Weakest-Link Technique-Mixed Redundancy-Redundancy Optimization-Double Failures and Redundancy.

Unit II:

Systems Model-Statement of the various optimization problems- Heuristic Methods applied to optimal systems reliability-A heuristic method : Sharma And Venkateswran's Approach, Aggrawal's Approach, Mishra's Approach, Ushakov's Approach, Nakagawa and Nakashima's Approach.

Unit III:

Dynamic programming applied to optimal systems reliability-Basic dynamic programming approach-Dynamic programming approach using Lagrange multipliers-The discrete maximum principle applied to optimal systems reliability-Sequential unconstrained minimization technique(SUMT) applied to optimal systems reliability-Generalized reduced gradient method(GRG) applied to optimal Systems reliability.

Unit IV:

Method of Lag range multipliers-single constraint problem-single linear constraint problem-two linear constraint problem-Generalized Lagrangian function method applied to optimal systems reliability-Generalized Lagrangian problem-computational procedures.

Unit V:

KUHN-TUCKER conditions in optimal systems reliability- KUHN-TUCKER conditions- KUHN-TUCKER conditions for the two linear constraint problem.

Unit VI:

The geometric programming applied to optimal systems reliability-Introduction-Formulation of the problem-Stochastic Programming-Sequential, Non-Sequential and Chance- Constrained Stochastic Programming-Examples.

Unit VII:

Integer programming applied to optimal systems reliability-Introduction-The partial Enumeration method-The Gomory Cutting plane method-The branch and bound method-The Geoffrion Implicit Enumeration method.

Unit VIII:

Other methods applied to systems reliability optimization problems-Introduction-A classical approach-Parametric method-Linear programming-Separable Programming.

References:

1 **Optimization of Systems Reliability**, . F. A. Tillman, C. V. Hwang & W. Kuo, Marcel Dekker Inc.

2. **Engineering Optimization Theory and Practice**, S. S Rao, New Age International Publications, Third edition.

3**. Reliability Engineering,** E. Balagurusamy, Tata McGraw-Hill Publishing Company Limited.

4. **Operations Research Theory and Appliactions**, . J. K. Sharma, Macmillan Publications, 4th Edition.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02214) NEURAL AND FUZZY SYSTEMS

Unit – I: Introduction to Neural Networks
Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN.

Unit- II: Essentials of Artificial Neural Networks
Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN – Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application

Unit–III: Feed Forward Neural Networks
Introduction, Perceptron Models: Discrete, Continuous and Multi-Category, Training Algorithms: Discrete and Continuous Perceptron Networks, Perceptron Convergence theorem, Limitations of the Perceptron Model, Applications. Multilayer Feed forward Neural Networks Credit Assignment Problem, Generalized Delta Rule, Derivation of Backpropagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements.

Unit IV: Associative Memories
Paradigms of Associative Memory, Pattern Mathematics, Hebbian Learning, General Concepts of Associative Memory (Associative Matrix, Association Rules, Hamming Distance, The Linear Associator, Matrix Memories, Content Addressable Memory), Bidirectional Associative Memory (BAM) Architecture, BAM Training Algorithms: Storage and Recall Algorithm, BAM Energy Function, Proof of BAM Stability Theorem Architecture of Hopfield Network: Discrete and Continuous versions, Storage and Recall Algorithm, Stability Analysis, Capacity of the Hopfield Network.

Unit V: Self-Organizing Maps (SOM) and Adaptive Resonance Theory (ART)
Introduction, Competitive Learning, Vector Quantization, Self-Organized Learning Networks, Kohonen Networks, Training Algorithms, Linear Vector Quantization, Stability-Plasticity Dilemma, Feed forward competition, Feedback Competition, Instar, Outstar, ART1, ART2, Applications.

Unit – VI: Classical AND Fuzzy Sets
Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

UNIT VII: Fuzzy Logic System Components
Fuzzification, Membership value assignment, development of rule base and decision making ystem, Defuzzification to crisp sets, Defuzzification methods.

UNIT VIII: Applications

Neural network applications: Process identification, Function Approximation, control and Process Monitoring, fault diagnosis and load forecasting.

Fuzzy logic applications: Fuzzy logic control and Fuzzy classification.

References:

1. **Fuzzy logic, Genetic algorithms**: Neural Networks synthesis and applications by Rajasekharan and Rai – PHI Publication.
2. **Introduction to Artificial Neural Systems** - Jacek M. Zuarda, Jaico Publishing House, 1997.
3. **Foundation, Architectures and Applications**, Neural and Fuzzy Systems - N. Yadaiah and S. Bapi Raju, Pearson Education
4. **Neural Networks** – James A Freeman and Davis Skapura, Pearson, 2002.
5. **Neural Networks** – Simon Hykins , Pearson Education
6. **Neural Engineering** by C.Eliasmith and CH.Anderson, PHI

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY ANANTAPUR ANANTAPUR

Pre-Ph.D ELECTRICAL ENGINEERING

(09PH02215) ADVANCED DIGITAL SIGNAL PROCESSING

UNIT-I:

Short introduction, Analog to digital and Digital to Analog conversion, sampled and Hold circuit, Continuous time Fourier Transforms.

UNIT-II:

Discrete-time signals and systems, Discrete-time Fourier transform- its properties and applications, Fast Fourier Transform (in time-domain and Frequency domain), IDFT and its properties.

UNIT-III:

z- Transform: Definition and properties, Rational z-transforms, Region of convergence of a rational z- Transform, The inverse z- Transform, Z-Transform properties, Computation of the convolution sum of finite-length sequences, The transfer function

UNIT-IV

Digital filter structures: Block Diagram representation, Equivalent structures, Basic FIR Digital Filter structures, Basic IIR Digital Filter structures, Realization of Basic structures using MATLAB, All pass filters, Computational complexity of Digital filter structures.

UNIT V:

IIR Digital filter design: Preliminary considerations, Bilinear transformation method of IIR Filter design, Design of low pass IIR Digital filters, Design of High pass, Band pass and band stop IIR digital filters, Spectral Transformations of IIR filter, IIR digital filter design using MATLAB, Computer aided design of IIR digital filters.

UNIT VI:

FIR digital filter design: Preliminary considerations, FIR filter design based on windowed Fourier series, Computer aided design of Equiripple Linear phase FIR filters, Design of Minimum phase FIR filters, FIR digital filter design using MATLAB, Design of computationally efficient FIR digital filters.

UNIT VII:

Analysis of Finite word length effects: The quantization process and errors, quantization of Fixed point numbers, Quantization of floating point numbers, Analysis of coefficient quantization effects, Analysis of arithmetic round off errors, Low sensitivity digital filters, Reduction of product round off errors using error feedback, Round off errors in FFT algorithms.

UNIT VIII:

The basic sample rate alteration devices, Multi rate structures for sampling rate conversion, Multistage design of decimator and interpolator, The Polyphase decomposition, Arbitrary-rate sampling rate converter, Nyquist Filters and some applications of digital signal processing.

References:

1. **Digital Signal Processing-** S.K. Mitra, Tata McGraw-Hill, Third Edition, 2006.
2. **Principle of Signal Processing and Linear Systems-** B.P. Lathi, Oxford International Student Version, 2009
3. **Continuous and Discrete Time Signals and Systems-** M. Mondal and A Asif, Cambridge, 2007

4 Digital Signal Processing- Fundamentals and Applications- Li Tan, Indian reprint, Elsevier,2008.

5**. Discrete- Time Signal Processing-** Alan V. Oppenheim, Ronald W. Schafer, and John R.Buck, Pearson Education, 2008.