# Electrical Engineering Science

*(ECE/EEE/IT/TC/BM/ML and other allied branches)*

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1. **Transient Stability Enhancement**: High speed fault clearing, reduction of transmission system reactance, regulated shunt compensation, dynamic braking, reactor switching, independent pole operation of circuit breakers, single pole switching, steam turbine fast valving, generator tripping, controlled system separation and load shedding, high speed excitation systems, discontinuous excitation control, control of HVDC transmission links, power system stabilizers, potential energy function, kinetic energy and the total energy, potential energy function for SVC, SSSC and UPFC, a new control algorithm for improving transient stability and damping of oscillations, case Studies of Discrete Control for Stability Improvement.

2. **Power Oscillation Damping (Dynamic Stability Enhancement)**: Introduction, basic issues in the damping of lowfrequency oscillations in large power systems, system modelling for small signal stability, design of damping controllers, modal transformation of swing equations, damping of power oscillations using series and shunt FACTS controllers, case study of damping controllers in UPFC.

3. **Criteria and Methods for Voltage Security (Stability) Assessment**: voltage security, definitions and criteria, contingency evaluation, loadability limit computation, secure operation limit determination, eigen analysis for instability diagnosis, examples from a real-life system, real-time issues.

4. **Instability Mechanisms and Countermeasures to Voltage Instability**: types of countermeasures, classification of instability mechanisms, examples of short-term voltage instability, countermeasures to short-term instability, case studies of long-term voltage instability, corrective actions against long-term instability.

5. **Insulation co-ordination for AC transmission and distribution systems**: Introduction, Classification of dielectric stress, Voltage-time characteristics, Factors affecting switching overvoltages, Methods of controlling switching surges, Factors affecting lightning overvoltages entering substations, Methods of controlling lightning overvoltages.

6. **Protection Systems with Phasor Inputs**: Introduction, differential protection of transmission lines, distance relaying of multiterminal transmission lines, adaptive protection, intelligent islanding, supervisory load shedding.

7. **Data Mining Techniques and Its Application in Power Industry**: Introduction, fundamentals of data mining, correlation, classification and regression, available data mining tools, data mining based market data analysis, data mining based power system security assessment, case studies.


**Reference Books:**


1. **IGBT Applications:** DC to DC conversion, DC to AC conversion, AC to DC conversion, Soft switching converters, IGBT circuit simulation, Applications of IGBT converters.

2. **AC to AC converters:**
   
   (a) **Phase-Controlled Cycloconverters:** Introduction, single-phase, phase-controlled dual converter, three-phase to single-phase cycloconverters, three-phase to three-phase Cycloconverter, examples.
   
   (b) **Envelope Cycloconverters:** single-phase cycloconverter operation, three-phase-to-single-phase cycloconverter, three-phase-to-three-phase four-wire envelope cycloconverter, three-phase-to-three-phase, three-wire envelope cycloconverters, examples.

3. **Matrix Converters:** principle of the matrix converter, matrix converter switches, matrix converter circuit, switching control strategies for PWM matrix converters in three-Phase motor applications, study of simulated results.

4. **Controller Design:**
   
   (a) **Sliding Mode Control:** Introduction, Variable Structure Systems, Control of the Boost Converter, Control of the Buck-Boost Converter, Control of the C’uk Converter, Control of the Zeta Converter, Control of the Quadratic Buck Converter, Multi-variable Case, Control of the Boost-Boost Converter, Control of the Double Buck-Boost Converter, Σ – Δ Modulation.

5. **Approximate Linearization in the Control of Power Electronics Devices:** Introduction, Linear Feedback Control, Buck Converter, Boost Converter, Buck-Boost Converter, C’uk Converter, Zeta Converter, Quadratic Buck Converter, Boost-Boost Converter.


7. **Power electronics in battery management systems:** Application of power electronics in rechargeable batteries, Battery charge management, Cell balancing, SOA of battery power electronics.


**Reference Books:**


1. (a) **Multilevel Topologies**: Introduction, Generalized Topology with a Common DC Bus, Converters Derived from the Generalized Topology, Symmetric Topologies without a Common DC Link, Summary of Symmetric Topologies, Asymmetric Topologies.

(b) **Diode-Clamped Multilevel Converter**: Introduction, Converter Structure and Functional Description, Modulation of Multilevel Converters, Voltage Balance Control, Effectiveness Boundary of Voltage Balancing in DCMC Converters.

2. (a) **Flying Capacitor Multilevel Converter**: Introduction, Flying Capacitor Topology, Modulation Scheme for the FCMC, Dynamic Voltage Balance of the FCMC.

(b) **Cascade Asymmetric Multilevel Converter**: Introduction, General Characteristics of the CAMC, CAMC Three-Phase Inverter, Comparison of the Five-Level Topologies.


6. **Direct Torque Control (DTC) of AC Machines**: Preliminary Remarks, Basic Concept and Principles of DTC, DTC of Induction Motor with Ideal Constant Machine Model, DTC of Induction Motor with Consideration of Iron Loss, DTC of Induction Motor with Consideration of both Iron Losses and Magnetic Saturation, Modified Direct Torque Control of Induction Machine with Constant Switching Frequency, Direct Torque Control of Sinusoidal Permanent Magnet Synchronous Motors (SPMSM).

7. **Non-Linear Control of Electrical Machines Using Non-Linear Feedback**: Introduction, Dynamic System Linearization using Non-Linear Feedback, Non-Linear Control of Separately Excited DC Motors, Multiscalar model (MM) of Induction Motor, MM of Double Fed Induction Machine (DFIM), Non-Linear Control of Permanent Magnet Synchronous Machine, Problems.

Reference Books:


14PHDEE004: Energy Management Engineering


**Reference Book:**

14PHDEE005: MICRO ELECTRONICS AND CONTROL SYSTEMS

1. **VLSI Design**: VLSI Design level system, design examples CAD tools for VLSI Design, Design steps CIF representation, Design Styles, placement, routing, and simulation. Circuit extraction, design rule, checking algorithms. Testability and fault tolerances.

2. **High Speed VLSI Design**


4. **Control Systems**: Design of compensators: Introduction to phase lag, lag-lead, lead, PID controllers, design of lag, lag-lead, lead and PID controllers using time domain and frequency domain methods. Design of PID controller – Zeigler Nichole’s method.
   Discrete time Control Systems: State space representation of discrete –time systems, solving discrete time state space equations, the pulse transfer function matrix, discretisation of continuous time state space equations, controllability, observability, design via pole placement, design of state observer, Transient andsteady state response analysis, design based on the root locus method, design based on the frequency response method, analytical design method.

5. **Nonlinear Control Systems**: Stability analysis of nonlinear control systems: Lure's criteria, popov's method, circle criteria and its application.


**Reference Books:**

14PHDEE006: Linear Algebra


Reference Book:

14PHDEC001: VLSI Design and Embedded Systems

**MOS Inverters**: Static Characteristics: Introduction, Resistive-Load Inverter, Inverters with n_Type MOSFET Load, CMOS Inverter.


**Semiconductor Memories**: Introduction, Dynamic Random Access Memory (DRAM), Static Random Access Memory (SRAM), Nonvolatile Memory, Flash Memory, Ferroelectric Random Access Memory (FRAM).

**Single stage Amplifier**: CS stage with resistance load, diode connected load, current source load, triode load, CS stage with source degeneration, source follower, common-gate stage, cascade stage, choice of device models.

**Differential Amplifiers & Current Mirrors**: Basic difference pair, common mode response, Differential pair with MOS loads, Gilbert cell. Basic current mirrors, Cascade mirrors, active current mirrors.


**Test Generation for Combinational Logic Circuits**: Fault Diagnosis of Digital Circuits, Test Generation Techniques for Combinational Circuits, Detection of Multiple Faults in Combinational Logic Circuits.

**Built-In Self Test**: Test Pattern Generation for BIST, Output Response Analysis, Circular BIST, BIST Architectures.

**Embedded Hardware Design and Development**: EDA Tools, How to use EDA tool, Schematic Design-Place wire, Bus, Port, Junction, Creating part Numbers, Design Rule Check, Bill of materials, Netlist Creation, PCB Layout Design-Building Blocks, Component Placement, PCB track routing.
**Embedded Firmware Design and Development:** Embedded Firmware Design Approaches, Embedded Firmware Development Languages

**Real-Time Operating System (RTOS) based Embedded System Design:**
Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS.

**Reference Books:**

14PHDEC002: Signal Processing


Signal Modeling: Least squares method, Padé approximation, Prony's method, finite data records, stochastic models, Levinson-Durbin recursion; Schur recursion; Levinson recursion.


Multirate Digital Signal Processing: Introduction, Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, Filter design and implementation for sampling rate conversion, Multistage implementation of sampling rate conversion, Sampling rate conversion of band-pass signals, Sampling rate conversion by an arbitrary factor, Applications of multirate signal processing.

Linear Prediction and Optimum Linear Filters: Representation of a random process, Forward and backward linear prediction, Solution of normal equations, Properties of the linear error-prediction filters, AR lattice and ARMA lattice-ladder filters, Wiener filters for filtering and prediction.


Reference Books:


14PHDEC003: Communication Systems


Arrays: Array factor for linear arrays, Uniformly excited equally spaced linear arrays, Pattern multiplication, Directivity of linear arrays, Non-uniformly excited equally spaced linear arrays, Mutual coupling, Multidimensional arrays, Phased arrays, Feeding techniques, Perspectives on Arrays.

Broadband antennas: Travelling wave antennas Helical antennas, Biconical antennas Sleeve antennas, and Principles of frequency independent antennas, Spiral antennas, and Log - periodic antennas.

Aperture antennas: Techniques for evaluating gain, Reflector antennas - Parabolic reflector antenna principles, Axi-symmetric parabolic reflector antenna, Offset parabolic reflectors, Dual reflector antennas, Gain calculations for reflector antennas, Feed antennas for reflectors, FiECS representations, Matching the feed to the reflector, General feed model, Feed antennas used in practice.


Digital modulation techniques: Digital modulation formats, Coherent binary modulation techniques, Coherent quadrature - modulation techniques, No-coherent binary modulation techniques, Comparison of binary and quaternary modulation techniques, M-ray modulation techniques, Power spectra, Bandwidth efficiency, M- ary modulation formats viewed in the light of the channel capacity theorem, Effect of inter symbol interference, Bit versus symbol error probabilities, Synchronization, Applications.

Coding techniques: Convolutional encoding, Convolutional encoder representation, Formulation of the convolutional decoding problem, Properties of convolutional codes: Distance property of convolutional codes, Systematic and nonsystematic convolutional codes, Performance Bounds for Convolutional codes, Coding gain, Other convolutional decoding algorithms, Sequential decoding, Feedback decoding, Turbo codes.
Reference books:
14PHDEC004: Wireless and Mobile Networks


Wireless LANs: Network components, design requirements, Architectures, IEEE-802.11x, WLAN protocols, 802.11p and applications.

WMANs, IEEE-802.16: Architectures, Components, WiMax mobility support, Protocols, Broadband networks and applications, WWANs, cellular networks, Satellite Network, Applications.


Reference books
Reliable Design and Fault Diagnosis Hazards: Fault Detection in Combinational Circuits, Fault-Location Experiments, Boolean Differences, Fault Detection by Path Sensitizing, Detection of Multiple Faults, Failure-Tolerant Design, Quadded Logic

Capabilities, Minimization, and Transformation of Sequential Machines: The Finite- State Model, Further Definitions, Capabilities and Limitations of Finite – State Machines, State Equivalence and Machine Minimization, Simplification of Incompletely Specified Machines.


Combinational Basics: Boolean Functions and Boolean Algebra, Binary Coding, Combinational Components and Circuits, Verification of Combinational Circuits.

Number Basics: Unsigned and Signed Integers, Fixed and Floating-point Numbers.

Sequential Basics: Storage elements, Counters, Sequential Datapaths and Control, Clocked Synchronous Timing Methodology.

Memories: Concepts, Memory Types, Error Detection and Correction.

Processor Basics: Embedded Computer Organization, Instruction and Data, Interfacing with memory.

Reference Books:

2. Charles Roth Jr., “Digital Circuits and logic Design”,

14PHDEC005: Digital System Design


14PHDEC006: Modelling & Analysis of Dynamic Systems

**Introduction:** Rationale, Analysis of Dynamic Systems, Classification of Variables, Classification of Systems, Computer Tools.

**Translation of Mechanical Systems:** Variables, Element Laws, Interconnection Laws, Obtaining the Systems Model.

**Standard Forms for System Models:** State – Variable Equation, Input-Output Equation, Matrix formulation of state – variables.

**Rotational Mechanical System:** Diagram Block, Combining the blocks to solve Modeling, Running Simulink using MATLAB, Repetition Inputs.

**Electrical System:** Variables, Element Laws, Interconnection Laws, Obtaining the Systems Model, Computer Simulation.

**Analysis of Liner Models:** Linearization of element law, Linearization of the Model, Computer Simulation, Piecewise Linear System.


**Transfer Function Analysis:** I/O Model, Resistive Circuits, Obtaining the state-variable model, Op-Amps, Computer Simulation.

**Developing as Linear Model:** Basic consideration, Transformation of function, Transformation of Properties, 1st order system, The step function Impulse, Transform Inversion, Additional Transform properties.

**Electromechanical System:** Variables, Element Laws, Interconnection Laws, Obtaining the Systems Model, Computer Simulation.

**Thermal System:** Dynamic Models of thermal system. Analysis of thermal system.

**Hydraulic System:** Modeling and Analysis of Hydraulic systems. Computer simulation.

**Reference Books:**

Classification of signals, Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG etc - . Difficulties in biomedical signal acquisition, Computer Aided Diagnosis. Origin of bio potentials ECG, EEG - Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals.

Cardio vascular applications : Basic ECG - Electrical Activity of the heart, ECG data acquisition, ECG parameters & their estimation - QRS detection techniques, Arrhythmia types and analysis , Data Compression: Lossless & Lossy methods ,wavelet transform method, Heart Rate Variability - Time Domain measures , Heart Rhythm representation , Spectral analysis of heart rate variability.

Neurological Applications: The electroencephalogram - EEG rhythms & waveform, characteristics , Origin of EEG, Event detection of EEG, and disorders - Epilepsy, sleep disorders, Evoked potentials- Auditory evoked potential, Somatosensory Evoked potential, Visual evoked potential, Event related potential, Modeling EEG- parametric and nonparametric methods , EEG segmentation , Joint Time-Frequency analysis and correlation analysis of EEG channels , coherence analysis of EEG channels.

References:
7. Enderle, “Introduction to Biomedical Engineering,” 2/e, Elsevier, 2005
14PHDIT002: BIOMEDICAL IMAGE PROCESSING & APPLICATIONS

Image Pre-processing
Pixel brightness transformations, geometric transformations, local preprocessing.

Segmentation Algorithms
Thresholding, edge based segmentation, region based segmentation, matching, Hough transforms, supervised and unsupervised evaluation

Advanced Segmentation Algorithms
Mean shift segmentation, active contour models, geometric deformable models, level sets and geodesic active contours, graph cut segmentation

Shape representation
Region identification, B-spline representation, region based shape representation, convex hull.

Image Understanding
Image understanding control strategies hierarchical, bottom up control, model based control, combined control, point distribution models, fitting models to data, active appearance models, classification based segmentation, semantic image segmentation and understanding.

3D Vision
Shape from texture, shape from motion, 3D objects and models, volumetric representation and modeling, surface modeling, visualizing 3D views from 2D views.

Morphological Operations
Dilation, erosion, skeletons and object marking, morphological reconstruction, morphological segmentation and watersheds.

Texture
Statistical texture description, co-occurrence matrices, texture description wavelet approaches.

Reference Books
2. Geoff Dougherty, Digital Image Processing for Medical Applications, Cambridge university Press, 2010 (only part-III ch-9, 10, 11, 12)
Chapter 1. Measurement, Instrumentation and Calibration

Chapter 2. Mechanical transducers
**Temperature measurement**- Introduction, Basics of temperature measurement, Absolute thermodynamics or Kelvin scale, bimetallic element.

**Pressure, Force and Torque**-
Basics of pressure measurement- Manometers, Ring-balance Manometer, Bell-type Manometer. Thin plate Diaphragms, Membranes, Corrugated Diaphragms and Capsules. Bellows element, Bourdon tube elements, Basics of force measurements-Helical spiral springs, cantilever beams, Beams held at ends, Diaphragm elements, Column-type load cells, proving ring type load cells.
Basics of torque measurement- Torsion bar, Flat spiral spring.
Basics of flow measurement- Pitot-static tube, flow obstruction elements, centrifugal force element, static vane systems, rotating vane systems, Rota meter float system. Displacement to pressure system transducer, seismic displacement transducers.

Chapter 3. Passive electrical transducer
Introduction, Resistive transducers- resistance thermometers, hot wire resistance transducers, Resistive displacement transducer, Resistive strain transducer, resistive pressure transducer, resistive optical radiation transducers.
Inductive transducers- Inductive thickness transducers, Inductive displacement transducers, Movable core-type Inductive transducers, eddy current type Inductive transducers.
Capacitive transducers- Capacitive thickness transducers, capacitive displacement transducers, capacitive moisture transducers.

Chapter 4. Active Electrical Transducers
Introduction, thermoelectric transducers, thermoelectric phenomenon, common thermocouple systems, piezoelectric transducers, piezoelectric phenomenon piezoelectric materials, piezoelectric force transducers, piezoelectric strain, piezoelectric torque transducers, piezoelectric pressure transducers, piezoelectric acceleration transducers.
Magnetostrictive transducers- Magnetostrictive force transducers, Magnetostrictive acceleration transducers, Magnetostrictive torsion transducers, Hall Effect transducers, and application of Hall transducer.
Electromechanical transducers-Tachometers, variable reluctance tachometers
Electrodynamic vibration transducers, Electromagnetic pressure electromagnetic flowmeter.
Photoelectric transducers- photoelectric phenomenon, photoelectric transducers, Photo volatile transducers, Photo emissive transducers.
Ionization transducers- Ionization vacuum gauges, ionization displacement transducers, nuclear radiation transducers, radioactive vacuum gauge, radioactive thickness gauge, radioactive level gauges.
Digital transducers- Digital displacement transducers, Digital tachometers, transducer oscillators.
Electrochemical transducers- basics of electrode potentials, reference electrodes, indicator electrodes, measurement of PH, measurement of bioelectric signals.

Text Books:

Reference Books:
2. Instrument transducers: An Introduction to their Performance and Design- Neubert, Hermann K.P
Unit 1

Unit 2

Unit 3

Unit 4

Unit 5
High Performance Liquid Chromatography: Scope of HPLC, Column efficiency in liquid chromatography, Instruments for liquid chromatography, Partition chromatography Absorption chromatography, Ion-exchange chromatography size-Exclusion chromatography, thin layer chromatography: Properties of Supercritical Fluids, Supercritical fluid chromatography Supercritical fluid extraction.

Unit 6

Unit 7
Blood pH measurement, blood pCO2 and pO2 measurement, complete blood gas analyzer, paramagnetic oxygen analyzer, infrared gas analyzer.
Environmental Pollution Monitoring: Air pollution monitoring instruments, carbon monoxide, sulphur dioxide, nitrogen oxides, hydrocarbons, ozone water pollution monitoring instruments.

**Unit 8**

**TEXT BOOK:**

**REFERENCE BOOKS:**
Introduction to sensing
Introduction, brief history of sensing, Passive infrared sensing, sensor systems, frequency band allocations for the electromagnetic spectrum, acoustic spectrum

Active Ranging and Imaging Sensors

Target and Clutter Characteristics
Introduction, Target cross –section, Radar cross-sections(RCS), RCS of Simple shapes, Radar cross section of complex Targets, Effect of Target, RCS of living creatures, fluctuations in Radar Cross-section, Radar Stealth, Target cross section in Infrared, Acoustic Target Cross-section, clutter, Orepass Radar Development, Detecting Targets in clutter, Target Detection with Air Surveillance Radar

Tracking Moving Targets
Tracking While Scan, The Coherent Pulsed Tracking Radar, Range-Gated Pulsed Doppler Tracking, Coordinate Frames, Antenna Mounts and servo systems, On-Axis Tracking, Tracking in Cartesian Space, fire Control Radar

Radio Frequency Identification Tags and Transponders

Text Book
1. Introduction to Sensors for Ranging and Imaging, Dr.Graham Brooker, Yes Dee Publishing Pvt. Ltd ,2012

Reference Books
1. Introduction to Remote sensing , James B Campbell, Third Edition, Taylor and Francis
2. Principles of Remote sensing, ITC Educational Text Book Series 2
3. Introduction to sensor systems,Shahen A. Hovanessian
14PHDIT006: Robotics and Automation  (will be uploaded shortly)