Electromagnetics

Vectors analysis: Vector algebra, vector calculus - divergence, gradient, curl, Laplacian; Coordinate systems - Cartesian, cylindrical and spherical; Electrostatics: Coulomb's law, Gauss's law, electric scalar potential, Laplace and Poisson's equations, conduction and polarization, boundary conditions, resistance and capacitance; Magnetostatics : Biot-Savart law, Ampere's law, magnetic vector potential, Lorentz force, magnetization, boundary conditions, magnetic energy and inductance; Electrodynamics : Maxwell's equations, Faraday's induction, displacement current, Plane wave propagation in free space and in materials; Poynting vector, reflection and transmission of plane waves at media boundary, Transmission lines, Smith chart;

Applications of electromagnetics in the 21st century. Numerical Methods: ODE solvers, Euler, Runge-Kutta. Review of Basic Electromagnetics: Electrostatics, Magnetostatics, Wave Equations. Numerical Techniques: Method of Moements, Finite Difference Method, Finite Element method, Charge Simulation Method, Monte carlo method. Time Varying Electromagnetic Fiels: Eddy currents & skin depth, introduction to wavelets, families of wavelets. Microwaves, Optics, Micromagnetics, Bio-electromagnetics. Tutorials and demonstration on PC, programming assignments.

Suggested Books:

1. *M.N.O. Sadiku, "Numerical Techniques in Electromagnetic," 2nd Ed., CRC Press.*
2. *E. Weber, "Electromagnetic Fields," Dover, 1951.*
3. *P. P. Silvester, and R. L. Ferrari, "Finite Elements for Electrical Engineers," Cambridge University Press 1996.*
4. *J. Kiusalaas, "Numerical Methods in Engineering with Python," Cambridge.*
5. *J. D. Kraus and D. A. Fleisch, "Electromagnetics: with Applications," McGraw Hill, 1999.*
6. *D. K. Cheng, 'Field and Wave Electromagnetics,' Addison-Wesley series, 1989.*

Signals & Systems

Introduction and Basics: Signals and Systems; Classification of Signals, System Properties; Linear Algebra Basics-Vectors, Orthogonality, Eigenvalues and Eigenvectors; Probability and Random Signals: Random variables; probability density functions (PDFs); Moments and Cumulants; Multivariate distributions; Time averages, Ensemble averages, Autocorrelation functions, Crosscorrelation function; Estimation of parameters of random signals; Linear prediction; Auto- regressive model; Nonlinear models of signals; Analysis of Nonstationary signals; Continuous Signals and Systems: Laplace Transform, Transfer Functions, Causality and Stability, Poles/Zeros; Differential Equations, Steady State and Transient Responses, and Convolution Integral; Discrete- Time Signals and Systems: LTI Systems; Z-transform; Digital filters; Difference Equations; Causality and stability; Convolution and Correlation; Discrete Fourier Transform (DFT), FFT and Window Function; Frequency Analysis of Signals and Systems; Data Acquisition: Sampling theorem; Sampling of Bandpass Signals; Quantization; A/D conversion; D/A conversion; Sampling and Reconstruction; Interpolation and Decimation; Digital Filter Design: Butterworth, Elliptic, Chebyshev low-pass filters. Filter Realizations; Conversion to high-pass, band-pass, band-stop filters. Discrete-time filters: IIR and FIR. Linear phase filters. Frequency sampling filters.

Suggested Books:

1. A. Papoulis and S. U. Pillai, "Probability, Random Variables, and Stochastic Processes," McGraw Hill, 2001.

2. A. V. Oppenheim, A. S. Willsky and H. Nawab, "Signals and Systems," 2nd Ed., Prentice-Hall, 1996.

Analog Communications

Introduction: Signals, Fourier Series, Complex Fourier Spectrum, Fourier Transform, Convolution, Parseval's Theorem, Linear Systems; Analog Modulation: Concept Of Modulation, Amplitude modulation: Double-Sideband Suppressed Carrier, Double-Sideband Full Carrier, Single Sideband and vestigial sideband modulation; Demodulation: Carrier Recovery in AM, coherent Demodulation, Envelope Detector, Square-Law Demodulator; Integrated Circuit Modulators And Demodulators, Superheterodyne Receiver; Angle Modulation: Frequency Modulation, Phase Modulation, Narrow Band Angle Modulation, Wideband FM, Modulators, Demodulators, Broadcast FM And Stereo, QAM; Effects Of Noise In Analog Modulation Systems. Sampling, Pulse amplitude modulation, pulse width modulation, pulse position modulation, PCM.

Suggested Books:

1. J. G. Proakis and M. Salehi, "Fundamentals of Communication Systems," Prentice Hall, 2004.

2. S. Haykin, "Communication Systems," John Wiley & Sons, 5th Ed., 2009.

Digital Communication

Introduction to Digital Communications, Nyquist Sampling Theorem, Information Sources, Random process, Quantization, Pulse Code Modulation, Delta Modulation, Signal Space Representation: Orthogoal expansion of signals, Gram-Schmidt Procedure, Representation of digitally modulated signals; Digital Transmission over the AWGN Channel, Matched Filters, ML and MAP Receivers, Power Density Spectra and Probability of Bit Error; Modulation for Bandwidth- Limited Channels: Intersymbol interference, Equalization, error performance; Passband Digital Transmission via Carrier Modulation: BPSK, QPSK, MPSK, BFSK, MFSK, CPFSK, OQPSK, MSK, GMSK and Continuous phase modulation, , Communication over fading channels, Spread spectrum systems: direct sequence modulation and frequency hopping Case study — code division multiple access (CDMA); Multichannel and multicarrier systems: OFDM; Introduction to information theory: Entropy, Channel Capacity in AWGN;

Suggested Books:

1. J. G. Proakis and M. Salehi, "Fundamentals of Communication Systems," Prentice Hall, 2004.

2. S. Haykin, "Communication Systems," John Wiley & Sons, 5th Ed., 2009.

Antenna System

Fundamental: Concepts of antenna parameters, Radiation from Wires and Loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop, Aperture Antennas: Huygens' principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, Fourier transform method in aperture antenna theory, Horn and Reflector Antennas: Radiation from sectoral and pyramidal horns, design concepts, prime focus parabolic reflector and casse grain antennas Microstrip Antennas: Basic characteristics, feeding methods, methods of analysis, design of rectangular and circular patch antennas, Antenna Arrays: Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays, synthesis of antenna arrays using Schelkunoff polynomial method, Fourier transform method, and Woodward-Lawson method.

Suggested Books:

1. *Antenna Theory and Design, Balanis, C. A., 3rd Ed., John Wiley & Sons 2005.*
2. *Antenna Theory and Design, Stutzman, W. L. and Thiele, H. A., 2nd Ed., John Wiley & Sons 1998.*
3. *Microstrip Antenna Design Handbook, Garg, R., Bhartia, P., Bahl, I. and Ittipiboon, A., Artech House 2001.*

Advance Antenna

Adaptive Array Concept: Motivation of using Adaptive Arrays, Adaptive Array problem statement, Signal Environment, Array Element Spacing considerations, Array Performance, Nulling Limitations due to miscellaneous array effects, Narrow band and broad band signal processing considerations Optimum Array Processing: Steady state performance limits and the Wiener solution, Mathematical Preliminaries, Signal Description for conventional and signal aligned arrays, Optimum Array Processing for narrowband applications, Optimum Array Processing for broadband applications, Optimum Array Processing for perturbed propagation conditions Adaptive Algorithms: The least mean square error (LMS) algorithm, the Differential Steepest descent algorithm, the accelerated gradient approach, Gradient algorithm with constraints, Simulation studies. Recursive Methods for Adaptive Error Processing: The weighted Least Square Error Processor, Updated Covariance Matrix Inverse, Kalman Filter methods for Adaptive Array Processing, the minimum variance processor, Simulation studies. Effect of Mutual Coupling on Adaptive Antennas: Accounting for mutual effects for dipole array compensation using open-circuit voltages, compensation using the minimum norm formulation, Effect of mutual coupling-Constant Jammers, Constant Signal, Compensation of mutual coupling Constant Jammers,Constant Signal, Result of different elevation angle.

Suggested Books:

1. *Smart antennas: Adaptive arrays, algorithms and wireless position location, T. S. Rappaport, IEEE Press, 1998.*
2. *Smart antennas for wireless communications, Frank Gross, McGraw-Hill, 2006.*
3. *Adaptive antenna arrays, S. Chandran, trends and applications, Springer, 2009.*

Radar System

Nature of Radar and Applications, Simple form of Radar Equation, Radar Block Diagram and Operation, Prediction of Range Performance, Minimum Detectable Signal, Radar Receivers, Transmitter Power, CW and Frequency Modulated Radar, MTI and Pulse Doppler Radar, Tracking Radar, Detection of Radar Signals in Noise, Airborne Radar, Space borne Radar, Synthesis aperture radar, SHAR and MST radar.

Phased Arrays in Radar and Communication Systems: System requirements for radar and communication antennas, Array characterization for radar and communication systems, Fundamental results from array theory, Array size determination, Time-delay compression. Pattern characteristics of Linear and Planar Arrays: Array analysis, characteristics of linear and planer arrays, scanning to end fire, Thinned arrays. Pattern Synthesis for Linear and Planar Arrays: Linear arrays and planar arrays with separable distributions, circular planar arrays and adaptive arrays. Electronic Scanning Radar Systems: Frequency and phase scanning, Phase design techniques.

Suggested Books:

1. Introduction to Radar Systems, M.I. Skolnik, McGraw hill, 2000.

2. Radar Handbook, M.I. Skolnik, McGraw hill, 2nd edition, 1990.

3. Battacharya, Radar Systems and Radar Aids to Navigation, A.K. Sen and A.B. Khanna Publications, 1988.

4. Phased array antenna handbook, R. J. Mailloux, Artech house, 2005.

5. Array and phased array antennas basics, H. J. Visser, John Wiley and Sons, 2005.

6. Adaptive antennas and phased array for radar and communications, Alan J. Fenn, Artech house, 2007.

RF Packaging and Electromagnetic Compatibility

EMC Requirements for Electronic Systems: Sources of EMI; Aspects of EMC; Radiated susceptibility; Conducted susceptibility; Electrostatic discharge; Design constraints for products; Advantages of EMC design; Transmission line per-unit-length parameters: Wire type structures, PCB structures; High-speed digital interconnects and signal integrity. Non-ideal Behavior of Components: Spurious effects of wires, PCB, component leads, resistors, capacitors, inductors, ferromagnetic materials, electromagnetic devices, MMIC components, digital circuit devices, and mechanical switches. Conducted and Radiated Emissions: Measurement of conducted emissions; Power supply filters; Power supply and its placement; Conducted susceptibility; Simple emission models for wires and PCB leads; Simple radiated susceptibility models for wires and PCB leads. Crosstalk: Three-conductor transmission lines, shielded wires, twisted wires, shielding. System Design for EMC: Safety ground; PCB design; System configuration and design.

Suggested Books:

1. Introduction to Electromagnetic Compatibility, Paul, C.R., Wiley Interscience, 2006.

2. Electromagnetic Compatibility Handbook, Kaiser, K.L., CRC Press.

3. Engineering Electromagnetic Compatibility: Principles, Measurement and Technologies, Kodali, V.P., IEEE Press.

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