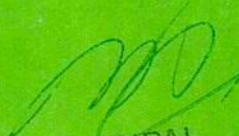
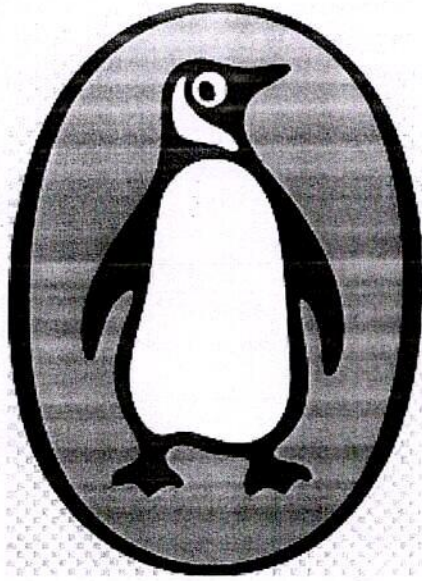


ANTENNAS AND WAVE PROPAGATION CONCEPTS



Dr.N.ASHOK KUMAR


PRINCIPAL
KASIREDDY NARAYANREDDY COLLEGE
OF ENGINEERING AND RESEARCH
Abdullapur (V), Abdullapurmet (M),
R.R. District-501 505:



PUBLISHED BY

PENGUIN INDIA

© Publishers

Office No.1, Krishnasagar
Society, Nr. Shivsagar Sharda Mandir
Road, Ahmedabad-380007

PRICE : RS. 299/-

2019

ISBN : 9781656691880

The text of this publication, or any part thereof, should not be reproduced or transmitted in any form or stored in any computer storage system or device for distribution without the prior written permission of the publisher with whom the rights are reserved.

Note: While every care and precautions have been taken regarding the contents and data of this book, the publisher does not hold responsibility for any error or omissions. Any dispute will be subject to Nagpur Jurisdiction only.

Project By : PENGUIN INDIA PUBLISHERS & PRINTERS PVT. LTD. DELHI

PRINCIPAL
KASIREDDY NARAYANREDDY COLLEGE
OF ENGINEERING AND RESEARCH
Abdullapur (V), Abdullapurmet (M)
R.R. District-501 505.

TABLE OF CONTENTS

Unit - I : Fundamentals of Radiation

Chapter - 1 Fundamentals of Radiation (1 - 1) to (1 - 90)

Introduction to Antenna	1 - 2
Definitions of Antenna	1 - 2
1.2.1 Basic Antenna Elements	1 - 2
1.2.2 Important Properties of Antenna	1 - 2
1.2.3 Classification of Antennas	1 - 3
1.2.4 Functions of Antenna	1 - 3
1.2.5 Types of Antenna	1 - 4
Isotropic Radiator	1 - 6
Basic Antenna Parameters	1 - 6
1.4.1 Radiation Pattern	1 - 7
1.4.1.1 Directional and Omnidirectional Patterns	1 - 8
1.4.1.2 Field Radiation Pattern	1 - 8
1.4.1.3 Power Radiation Pattern	1 - 10
1.4.2 Radian, Steradian and Beam Solid Angle (Ω_A)	1 - 11
1.4.3 Radiation Intensity [$U(\theta, \phi)$]	1 - 12
1.4.4 Directive Gain [$G_D(\theta, \phi)$] and Directivity [D]	1 - 12
1.4.5 Directivity and Resolution	1 - 14
1.4.6 Power Gain [$G_P(\theta, \phi)$] and Radiation (or Antenna) Efficiency	1 - 14
1.4.7 Front to Back Ratio (FBR)	1 - 15
1.4.8 Antenna Beamwidth	1 - 16
1.4.9 Antenna Beam Efficiency (ϵ_M)	1 - 17
1.4.10 Antenna Bandwidth ($\Delta\omega$)	1 - 18
1.4.11 Input Impedance of Antenna	1 - 18
1.4.12 Self and Mutual Impedance of Antenna	1 - 20

1.4.12.1 Self Impedance of Antenna	1 - 20
1.4.12.2 Mutual Impedance of Antenna	1 - 20
1.4.13 Radiation Resistance (R_{rad})	1 - 21
1.4.14 Effective Length or Effective Height L_{eff}	1 - 21
1.4.15 Effective Aperture or Effective Area [A_e]	1 - 22
1.4.15.1 Relationship between Directive Gain, Radiation Resistance and Effective Length	1 - 23
1.4.15.2 Different Types of Antenna Apertures	1 - 24
1.4.16 Antenna Temperature [T_A]	1 - 25
1.4.17 Equivalent Noise Temperature of Antenna	1 - 27
1.4.18 Antenna Polarization	1 - 27
1.4.19 Antenna Field Zones	1 - 28
1.5 Radio Communication Link - Friis Transmission Formula	1 - 38
1.6 Introduction to Radiation	1 - 39
1.7 Sources of Radiation and Radiation Mechanism	1 - 40
1.7.1 Single Wire	1 - 41
1.7.2 Two Wires	1 - 41
1.7.3 Dipole	1 - 42
1.8 Potential Functions and Electromagnetic Fields	1 - 42
1.8.1 Heuristic Approach	1 - 43
1.8.2 Maxwell's Equations Approach	1 - 44
1.9 Potential Functions for Time Varying Fields	1 - 46
1.10 Radiation from Alternating Current Element	1 - 47
1.10.1 Significance of Field Components	1 - 52
1.11 The Hertzian Dipole - Relation between a Current Element and Electric Dipole	1 - 53

2.6.5	Feed Methods of Microstrip Antenna	2 - 39
2.6.6	Applications of Microstrip Antennas	2 - 41
	Loop Antenna	2 - 42
2.7.1	Field Pattern of Small Loop Antenna	2 - 43
2.7.2	Comparison of Small Loop and Short Dipole	2 - 45
	2.7.2.1 Far Fields of the Short Magnetic Dipole	2 - 46
2.7.3	General Case of Loop Antenna	2 - 47
2.7.4	Radiation Resistance of Loop Antenna	2 - 49
2.7.5	Directivity of Loop Antenna	2 - 51
2.7.6	Salient Features of Loop Antenna	2 - 53
2.7.7	Applications of Loop Antenna	2 - 53
2.7.8	Expression for Induced E.M.F. in Loop	2 - 54
	Numerical Tools	2 - 55
2.8.1	Separation of Variables Method	2 - 56
2.8.2	Finite Difference Method	2 - 57
	2.8.2.1 Methods to be used for Application of Finite Difference Approximations to Given Problem	2 - 60
2.8.3	Method of Images	2 - 61
	2.8.3.1 The Image Theory	2 - 61
	2.8.3.2 Method of Images for Point Charges	2 - 62
2.8.4	Moment Method or Method of Moments (MOM)	2 - 63
	2.8.4.1 Charge Distribution Calculation using Method of Moments	2 - 64
2.8.5	Finite Element Method (FEM)	2 - 66
	o Marks Questions with Answers	2 - 71

Unit - III : Antenna Arrays

Chapter - 3 Antenna Arrays (3 - 1) to (3 - 58)

Antenna Array	3 - 2
Various Forms of Antenna Array	3 - 3
3.2.1 Broadside Array	3 - 3
3.2.2 End Fire Array	3 - 3
3.2.3 Collinear Array	3 - 3
3.2.4 Parasitic Array	3 - 4
3.3 Array of Point Sources	3 - 5
3.4 Two Point Sources with Currents Equal in Magnitude and Phase	3 - 5
3.5 Two Point Sources with Currents Equal in Magnitude but Opposite in Phase	3 - 7
3.6 Two Point Sources with Currents Unequal in Magnitude and with any Phase	3 - 9
3.7 n-Element Uniform Linear Arrays	3 - 10
3.8 Array of n Elements with Equal Spacing and Currents Equal in Magnitude and Phase - Broadside Array	3 - 12
3.8.1 Properties of Broadside Array	3 - 14
3.9 Array of n Elements with Equal Spacing and Currents Equal in Magnitude but with Progressive Phase Shift - End Fire Array	3 - 20
3.9.1 Properties of End Fire Array	3 - 21
3.10 Hansen Woodyard Array - End Fire Array with Increased Directivity	3 - 28
3.10.1 Directivity of End Fire Array with Increased Directivity	3 - 31
3.11 Pattern Multiplication Method	3 - 32
3.12 Binomial Array	3 - 34
3.12.1 Design of Binomial Array	3 - 36
3.13 Effect of Uniform and Non-uniform Amplitude Distributions	3 - 37
3.13.1 Fundamentals of Tchebyscheff Polynomials	3 - 38
3.13.2 Dolph Pattern Method of Obtaining Optimum Pattern using Chebyshev Polynomial	3 - 41

PRINCIPAL
KASIREDDY NARAYANAREDDY COLLEGE
OF ENGINEERING AND RESEARCH
Abdullapur (V), Abdullapurmet (M),
R.R. District-501 505.

Unit - IV : Special Antennas

Chapter - 4 Special Antennas (4 - 1) to (4 - 52)

4.1	Frequency Independent Antenna	4 - 2	4.5.2	Active Antenna	4 - 21
4.1.1	Rumsey's Principle	4 - 2	4.5.3	Dielectric Antennas	4 - 21
4.2	Spiral Antenna - Equiangular Spiral Antenna	4 - 3	4.5.3.1	Applications of Dielectric and Dielectric Loaded Antennas	4 - 21
4.3	Log Periodic Antenna	4 - 5	4.6	Electromagnetic Bandgap Structures and its Application	4 - 23
4.3.1	Log Periodic Dipole Array (LPDA)	4 - 6	4.7	Introduction to Antenna Measurements	4 - 25
4.4	Helical Antennas - Broadband Antenna	4 - 11	4.7.1	Need of Antenna Measurements	4 - 24
4.4.1	Helical Antenna Structure and Helical Geometry	4 - 11	4.7.2	Drawbacks in Antenna Measurements	4 - 24
4.4.2	Normal or Perpendicular Mode of Radiation	4 - 13	4.7.3	Methods to Overcome Drawbacks in Measurement of Antenna Parameters	4 - 24
4.4.3	Axial or End Fire Mode of Radiation	4 - 15	4.7.4	Useful Techniques for Antenna Measurements	4 - 24
4.4.4	Salient Features of Helical Antenna	4 - 16	4.7.5	Sources of Errors in Antenna Measurements	4 - 24
4.4.5	Applications of Helical Antenna	4 - 16	4.8	Basic Concept of Antenna Measurements	4 - 21
4.5	Modern Antennas	4 - 17	4.8.1	Reciprocal Relationship between Transmitting and Receiving Properties of Antenna	4 - 27
4.5.1	Reconfigurable Antenna	4 - 17	4.8.2	Near Field and Far Field	4 - 28
4.5.1.1	Reconfiguration Techniques	4 - 18	4.8.3	Co-ordinate System for Antenna Measurement	4 - 28
4.5.1.2	Classification of Reconfigurable Antennas	4 - 18	4.9	Antenna Ranges (Instrument Ranges)	4 - 29
4.5.1.3	Electrically Reconfigurable Antennas	4 - 19	4.9.1	Reflection Ranges	4 - 30
4.5.1.4	Optically Reconfigurable Antennas	4 - 19			

PRINCIPAL
KASIREDDY NARAYANREDDY COLLEGE
OF ENGINEERING AND RESEARCH
ABDULLAPUR (V), ABDULLAPURMET (M),
R.R. District-507 505