Contents

Foreword ix

Part 1. Theoretical introduction 1

Chapter 1. Electromagnetic field of antennas 3
A: Purpose of Part 1 3
B: Maxwell's equations—physical viewpoint 4
1: Maxwell's equations. 4
2: Simple (or perfect) media 4
3: Propagation of the electromagnetic field. 5
4: Conductive media 6
5: Anisotropic media 6
C: Sinusoidal time dependence 7
1: Sinusoidal fields 7
2: Complex fields. 7
3: Rules for calculation 9
4: Maxwell's equations. 9
5: Extension to the products of complex vectors 11
D: Maxwell's equation—mathematical aspects 16
1: Electromagnetic theory. 16
2: Magnetic distribution 17
3: Bicomplex field 18
4: Use of distribution theory. 19
E: Radiation of electromagnetic sources 24
1: Source and radiation field. 24
2: Scalar Helmholtz equation 25
3: Calculating the radiation field 28
4: Application to antennas 31
5: Far fields 37
6: Supplementary information 39

Chapter 2. Waves and rays 43
A: Propagation of electromagnetic waves 43
1: Electromagnetic waves 43
2: Homogeneous plane waves 43
3: Various extensions 44
4: The electromagnetic field and the Fourier Transform (FT) . 51

B: Approximation of geometrical optics 59
1: Locally plane waves 59
2: Rays 61
3: Field transport 65
4: Homogeneous media 67
5: Application to reflectors 70
C: Physical optics approximations 72
1: General points 72
2: Relationship to geometrical optics 73
3: The field at the foci 74

Chapter 3. Introduction to diffraction theory 76
A: General points 76
1: The role of electromagnetic diffraction 76
2: Solving diffraction problems 77
B: Two canonical examples 78
1: Cylinder of revolution (Rayleigh, 1881) 78
2: Conductive half-plane (Sommerfeld, 1896) 80
C: Indirect method 84
1: Induced current 84
2: Physical optics approximation 85
3: Radiating cells 87
4: Applications 88
D: Diffraction through apertures 89
1: The aperture problem 89
2: Image principle 90
3: Thin plane screen 92
4: Babinet's principle 93
B: Geometrical theory of diffraction (GTD) 95
1: Principles 95
2: Construction of rays 96
3: Diffraction coefficients 96
4: Diffraction by an edge 96
5: Diffraction by a convex body 99

Bibliography to Part 1 101

Part 2. General properties of antennas 105

Chapter 4. Transmitting antennas 107
A: Introduction to transmission 107
B: Far-field radiation 108
1: General properties 108
2: Translation theorem 109
3: Superposition theorem 110
4: Representations of the vector radiation characteristic . . . 111

C: Radiated power 112
1: Active and reactive power. 112
2: Gain and directivity. 113
3: Input impedance—radiation resistance 115
D: The elementary source case 119
Bibliography to Chapter 4. 121

Chapter 5. Examples of applications 122
A: Introduction 122
B: Linear structures 122
1: Statement of the problem 122
2: Basic formula 123
3: Travelling wave antennas 124
4: Standing-wave antennas 131
5: Discontinuous distribution 135
C: Planar structures 137
1: General formulae. 137
2: Examples 139
3: Non-uniform apertures. 140
4: Calculation of directivity 141

Chapter 6. Introduction to antenna synthesis 143
A: General points. 143
B: Examples 144
1: Woodward's method 144
2: Using the Laplace transform. 145
3: Dolph–Tchebycheff's method 146
C: Introduction to superdirectivity. 147
Bibliography to Chapter 6. 149

Chapter 7. Receiving antennas 150
A: Introduction to reception theory 150
B: Antenna response to an incident plane wave 150
1: Stating the problem 150
2: Calculation of $I(S)$ 152
3: Determining the equivalent generator 154
C: Antenna coupling. 155
1: Matrix representation 155
2: Calculation of the coupling parameters 157
3: Study of a specific case. 159
D: Power balance. 160
1: General formula 160
2: Influence of the load 161
3: Influence of polarization 162
4: Directive properties of receive antennas 163

E: Equivalent areas 163
1: Definition 163
2: Applications 164
F: Behaviour of an antenna in the presence of noise 165
1: Noise 165
2: Noise temperature 166
3: Applications 168
Bibliography to Chapter 7 168

Chapter 8. Numerical methods 170
A: Introduction 170
B: Integral formulation principle 171
1: Diffraction by a metallic body 171
2: Radiation from an antenna 173
C: Introduction of numerical solution. 180
1: Method of moments. 180
2: Direct numerical solution 181
3: Determining the characteristic modes of the structure . . . 182
4: Determining the poles in a complex plane 182
D: An elementary example—the thin linear antenna. 183
Bibliography to Chapter 8 186

Chapter 9. Experimental methods 187
A: Introduction 187
B: Realization of a laboratory model 187
1: Principle of similarity 187
2: Simulation of radiation conditions in free space 189
C: Local measurement of electromagnetic fields 190
1: Measurement probes 190
2: Measurement techniques 191
D: Direct measurement 192
1: Stating the problem 192
2: Antenna subjected to a plane wave 193
3: Disturbance of conditions of normal operation 195
E: Indirect measurement 196
1: Principle 196
2: Practical solutions 196
Bibliography to Chapter 9 198

Appendices 199
Appendix 1: Bicomplex algebra 199
Appendix 2: Stationary phase method. 200
Appendix 3: Distributions 201

Index 215