

Contents

Preface — V

Introduction — 1

Chapter 1

Parameters of antennae — 4

- 1.1 Radiation power density and radiation intensity — 4
 - 1.1.1 Radiation power density — 4
 - 1.1.2 Radiation intensity — 5
- 1.2 Directivity and gain — 6
 - 1.2.1 Directivity — 6
 - 1.2.2 Gain — 6
- 1.3 Beam solid angle — 7
- 1.4 Antenna field zones — 7
- 1.5 Radiation pattern — 9
 - 1.5.1 Description of antenna pattern — 10
 - 1.5.2 HPBW — 11
 - 1.5.3 FNBW — 12
 - 1.5.4 Directivity estimation — 12
 - 1.5.5 Sidelobe level — 12
 - 1.5.6 The difference among the decibels — 13
- 1.6 Effective length and effective area — 14
 - 1.6.1 Effective length — 14
 - 1.6.2 Effective area — 15
- 1.7 Antenna impedance — 16
 - 1.7.1 Input impedance — 16
 - 1.7.2 Voltage standing wave ratio — 17
- 1.8 Bandwidth — 19
- 1.9 Polarization of the antenna — 19
- 1.10 Equivalent isotropically radiated power — 20
- 1.11 Friis transmission equation — 21
- 1.12 Receiving antenna — 23
 - 1.12.1 Receiver voltage — 23
 - 1.12.2 Antenna factor — 23
- References — 25

Chapter 2

Polarization theory — 26

- 2.1 Polarization characteristics of the wave — 26
 - 2.1.1 Plane electromagnetic wave electric field vector — 26

2.1.2	Linear polarization — 27
2.1.3	Circular polarization — 28
2.1.4	Elliptically polarization wave — 29
2.2	Polarization ellipse dip angle — 30
2.3	Axial ratio — 31
2.4	Polarization ratio — 32
2.4.1	Linear polarization ratio — 32
2.4.2	Circular polarization ratio — 33
2.5	Circular polarization component synthesis — 34
2.5.1	Elliptic equation derivation — 34
2.5.2	Synthesis of orthogonal circular polarization waves — 36
2.6	Polarization loss — 37
2.6.1	Polarization ratio and polarization efficiency — 38
2.6.2	Axial ratio and polarization efficiency — 39
2.7	Cross-polarization — 41
2.7.1	Cross-polarization identification — 42
2.7.2	Cross-polarization isolation — 44
2.7.3	Cross-polarization calculation of antenna — 44
2.8	Circular polarization antenna — 45
	References — 48

Chapter 3

Crossed dipole circularly polarized antenna — 49

3.1	Crossed dipole antenna principle — 49
3.1.1	Dipole antenna — 49
3.1.2	Crossed dipole antenna — 51
3.2	Balun-fed self-phased crossed dipole antenna — 53
3.2.1	Balun feed structure — 53
3.2.1.1	$\lambda/4$ choke sleeve — 54
3.2.1.2	Split coax balun — 54
3.2.1.3	Folded balun — 55
3.2.1.4	Half-wavelength balun — 56
3.2.1.5	Coaxial taper balun — 57
3.2.1.6	Natural balun — 58
3.2.2	Gain and beam width control methods — 58
3.2.2.1	Crossed dipole antenna radiation characteristics — 58
3.2.2.2	Effects on spacing of the dipoles and reflector on gain and beam width — 59
3.2.2.3	Declinate arms for beam widening — 60
3.2.3	Design example of self-phase-shifted crossed dipole antenna — 63
3.2.3.1	Antenna structure — 63

- 3.2.3.2 Effect of bending angle on antenna performance — 64
- 3.2.3.3 Results — 69
- 3.3 Printed self-phased crossed dipole antenna — 70
- 3.3.1 Design process of compact printed crossed dipole antenna — 70
- 3.3.2 Antenna parameter analysis — 75
- 3.3.3 Antenna measurement and discussion — 76
- 3.4 Broadband crossed dipole CP antenna — 78
- 3.4.1 Broadband principle of CP antenna with crossed dipole — 79
- 3.4.2 Design example of broadband crossed dipole CP antenna — 79
- References — 84

Chapter 4

Circularly polarized microstrip antenna — 87

- 4.1 Principle and solutions of microstrip CP antenna — 88
- 4.1.1 Single probe feed — 90
- 4.1.2 Microstrip line feed — 91
- 4.1.3 Aperture coupling — 92
- 4.1.4 Microstrip proximity coupling — 93
- 4.1.5 Multifed network — 94
- 4.1.5.1 3 dB bridge — 94
- 4.1.5.2 Phase-shifted power divider — 94
- 4.2 Single probe-fed circularly polarized MSA — 96
- 4.2.1 A single probe-fed square patch with truncated corners MSA — 96
- 4.2.2 A single probe-fed slot-loaded MSA — 98
- 4.2.3 A single probe-fed slot-loaded dual-band MSA — 102
- 4.2.4 A single probe-fed stub loaded MSA — 106
- 4.3 Single-probe feed-stacked CP MSA — 109
- 4.3.1 Dual-layer square patch CP antenna with truncated corners — 111
- 4.3.1.1 Broadband stacked square patch CP antenna with truncated corners — 111
- 4.3.1.2 Dual-band stacked square corner cut CP patch antenna — 115
- 4.3.2 Stacked quasi-square patch CP antenna — 118
- 4.3.3 Stacked circular slot CP patch antenna — 120
- 4.4 Microstrip-fed CP MSA — 125
- 4.4.1 Microstrip-fed CP MSA — 125
- 4.4.2 Microstrip proximity coupled CP MSA — 129
- 4.4.3 CPW-fed CP MSA — 134
- 4.4.4 Aperture-coupled CP antenna — 137
- 4.5 Multifed CP MSA — 142
- 4.5.1 A broadband CP H-sharped aperture-coupled MSA — 142
- 4.5.2 Multiple L-shaped probe-fed CP MSA — 145

- 4.5.2.1 CP MSA with different feeds — **145**
- 4.5.2.2 Engineering realization of quad-feed CP MSA — **151**
- References — **156**

Chapter 5

Helix antenna — 159

- 5.1 Basic structure of helix antenna — **159**
- 5.2 Axial-mode helix antenna — **161**
 - 5.2.1 Principle of CP — **161**
 - 5.2.2 Phase difference — **162**
 - 5.2.3 Radiation pattern — **163**
 - 5.2.4 Antenna design — **163**
 - 5.2.5 Main parameters analysis — **170**
 - 5.2.5.1 The effects of the pitch angle with fixed length — **170**
 - 5.2.5.2 The effects of helix diameter with fixed length — **171**
 - 5.2.5.3 The effects of the number of turns — **172**
- 5.3 Modified axial-mode helix antenna — **173**
 - 5.3.1 Tapered-end helix antenna — **175**
 - 5.3.2 Conical helix antenna — **176**
 - 5.3.3 Nonuniform helix antenna — **177**
- 5.4 Helix antenna with reflective cavity — **178**
- 5.5 Normal mode helix antenna — **183**
- 5.6 Multiarm helix antenna — **187**
- References — **191**

Chapter 6

Quadrifilar helix antennas — 194

- 6.1 Principle of quadrifilar helix antenna — **194**
 - 6.1.1 Structure of the quadrifilar helix antenna — **194**
 - 6.1.2 Radiation field of QHA — **197**
- 6.2 Parameters analysis of the QHA — **198**
 - 6.2.1 The effect of axis length and number of turns on the performance of the QHA — **199**
 - 6.2.1.1 The effect of axial length and number of turns on 3 dB beamwidth — **199**
 - 6.2.1.2 The effect of axial length and number of turns on axial ratio — **199**
 - 6.2.1.3 The effect of axial length and number of turns on front-to-back ratio — **200**
 - 6.2.2 The effect of rotation angle on the performance of the QHA — **201**
 - 6.2.2.1 The effect of rotation angle on impedance — **202**
 - 6.2.2.2 The effect of rotation angle on gain, front-to-back ratio and beamwidth — **203**

6.2.2.3	The effect of rotation angle on axial ratio —	204
6.2.3	The effect of radius and pitch ratio on the pattern of the QHA —	204
6.3	Realization of the QHA —	204
6.3.1	Self-phase-shifting QHA —	205
6.3.1.1	Self-phase-shifting structure —	206
6.3.1.2	Balanced feed structure —	206
6.3.1.3	Self-phase-shifting QHA with infinite barron feed —	207
6.3.1.4	Self-phase-shifting QHA with slotted balun feed —	208
6.3.2	QHA with phase-shifting network feed —	211
6.3.2.1	Phase-shifting network —	211
6.3.2.2	Sense of rotation of QHA circular polarization —	214
6.3.2.3	Design example —	214
6.4	Research direction of QHA —	216
6.4.1	Miniaturization of QHA —	216
6.4.1.1	Meandering method —	217
6.4.1.2	Folding method —	219
6.4.1.3	Dielectric loading method —	221
6.4.2	Wideband QHA —	223
6.4.3	Dual-band QHA —	224
	References —	227

Chapter 7

Circularly polarized frequency-independent antenna — 229

7.1	The principle of frequency-independent antenna —	230
7.2	Plane Archimedes spiral antenna —	231
7.2.1	Antenna structure —	231
7.2.2	Electrical characteristics —	233
7.2.3	Design examples —	236
7.2.3.1	A broadband low-profile Archimedes plane spiral antenna —	236
7.2.3.2	Miniature planar helix antenna loading curved sawtooth —	241
7.2.3.3	Ultra-wideband low-profile hybrid back-cavity plane spiral antenna —	244
7.3	Planar equiangular spiral antenna —	247
7.3.1	Antenna structure —	247
7.3.2	Electrical properties —	249
7.3.3	Design examples —	251
7.3.3.1	Annular equiangular spiral filled with edge-absorbing material —	251
7.3.3.2	A planar equiangular helix antenna with high power capacity —	254
7.4	Conical logistic-spiral antenna —	255
7.4.1	Antenna structure —	255
7.4.2	Electrical properties —	256

- 7.4.2.1 Impedance — **256**
- 7.4.2.2 Working bandwidth — **257**
- 7.4.2.3 Polarization — **257**
- 7.4.2.4 Directivity — **258**
- 7.4.3 Design examples — **259**
- 7.5 Other types of frequency-independent circular polarization antenna — **263**
- 7.5.1 Log-periodic CP antenna — **264**
- 7.5.1.1 Basic structure of log-periodic antenna — **264**
- 7.5.1.2 Example of log-periodic CP antenna — **266**
- 7.5.2 Sinusoidal circularly polarized antenna — **268**
- 7.5.2.1 Basic structure of sinusoidal circularly polarized antenna — **268**
- 7.5.2.2 Examples of sinusoidal circularly polarized antennas — **271**
- References — **273**

Chapter 8

Circularly polarized horn antennas — 275

- 8.1 Circular polarizer types — **275**
- 8.1.1 Screw circular polarizer — **276**
- 8.1.2 Diaphragm circular polarizer — **276**
- 8.1.3 Baffle circular polarizer — **277**
- 8.1.4 Dielectric plate circular polarizer — **279**
- 8.1.5 Resonant cavity circular polarizer — **280**
- 8.2 Common horn antenna — **281**
- 8.2.1 Dual-mode conical horn antenna — **281**
- 8.2.2 Multimode conical horn antenna — **282**
- 8.2.3 Corrugated horn antenna — **283**
- 8.2.3.1 Small flare angle horn — **283**
- 8.2.3.2 Large flare angle horn — **284**
- 8.2.3.3 Axial groove corrugated horn — **285**
- 8.3 Circularly polarized horn antenna design — **285**
- 8.3.1 Design of baffle circular polarizer — **286**
- 8.3.2 Design of dual-mode conical horn antenna — **290**
- 8.3.3 Simulation results of the dual circularly polarized dual-mode conical horn antenna — **292**
- References — **294**

Chapter 9

Omnidirectional circularly polarized antenna — 296

- 9.1 OCP antennas using circular arrays of directional circularly polarized antenna elements — **297**

- 9.1.1 A conformal omnidirectional circularly polarized antenna using patch antennas — **297**
- 9.1.2 A broadband OCP antenna — **298**
- 9.2 OCP antennas using circular arrays of omnidirectional antenna elements with linear polarizations — **299**
 - 9.2.1 OCP antenna using slant or bended dipoles — **301**
 - 9.2.2 OCP antenna with helix antennas — **305**
 - 9.2.3 OCP antenna utilizing bended monopoles — **309**
- 9.3 Other forms of OCP antennas — **313**
 - 9.3.1 OCP antennas based on zero-order resonant antennas — **313**
 - 9.3.2 OCP antennas based on omnidirectional cone antennas fed by CP waves — **315**
- References — **317**

Chapter 10

Circularly polarized radial line array antenna — **319**

- 10.1 Structure and basic principle of radial antenna — **319**
 - 10.1.1 Structure of radial line antenna — **319**
 - 10.1.2 Radial transmission mode — **320**
 - 10.1.3 Concentric ring array theory — **322**
- 10.2 Design of circularly polarized radial line array antenna — **324**
 - 10.2.1 Antenna geometry — **324**
 - 10.2.2 Relationship between the slow wave structure and the waveguide structure — **325**
 - 10.2.3 Aperture field distribution — **327**
 - 10.2.4 Derivation of position alignment of gap — **328**
 - 10.2.5 Realization of dual-circular polarization radial slot array antenna — **330**
 - 10.2.6 Circularly polarized radial line helical array antenna — **336**
- References — **337**

Index — **339**

