

---

# Contents

Preface	xiii
Acknowledgments	xv
Introduction	xvii

<b>Chapter 1. Fundamentals of Antennas</b>	<b>1</b>
1.1 Basis Parameters and Definitions of Antennas	1
1.1.1 Input Impedance and Equivalent Circuits	2
1.1.2 Matching and Bandwidth	3
1.1.3 Radiation Patterns	4
1.1.4 Polarization of the Antenna	6
1.1.5 Antenna Efficiency	9
1.1.6 Directivity and Gain	10
1.1.7 Intermodulation	13
1.2 Important Antennas in This Book	15
1.2.1 Patch Antennas	15
1.2.2 Suspended Plate Antennas	17
1.2.3 Planer Inverted-L/F Antennas	18
1.2.4 Planer Dipoles/Monopoles	20
1.3 Basic Measurement Techniques	21
1.3.1 Measurement Systems for Impedance Matching	21
1.3.2 Measurement Setups for Far-Zone Fields	22
1.3.3 Measurement Systems for Intermodulation	26
1.4 System Calibration	28
1.5 Remarks	28
References	29
 <b>Chapter 2. Base Station Antennas for Mobile Radio Systems</b>	 <b>31</b>
2.1 Operational Requirements	32
2.2 Antenna Performance Parameters	33
2.2.1 Control of Antenna Parameters	36
2.3 The Design of a Practical Base Station Antenna	44
2.3.1 Methods of Construction	44
2.3.2 Array Design	51
2.3.3 Dimensioning the Array	51
2.3.4 Multiband and Wideband Arrays	62
2.3.5 Feed Networks	67

2.3.6	Practical Cost/Performance Issues	68
2.3.7	Passive Intermodulation Products and Their Avoidance	69
2.3.8	Use of Computer Simulation	71
2.3.9	Arrays with Remotely Controlled Electrical Parameters	72
2.3.10	Antennas for TD-SCDMA Systems	78
2.3.11	Measurement Techniques for Base Station Antennas	80
2.3.12	Array Optimization and Fault Diagnosis	83
2.3.13	RADHAZ	86
2.3.14	Visual Appearance and Planning Issues	87
2.3.15	Future Directions	91
	References	93
<b>Chapter 3.</b>	<b>Antennas for Mobile Communications: CDMA, GSM, and WCDMA</b>	<b>95</b>
3.1	Introduction	95
3.1.1	Requirements for Indoor Base Station Antennas	95
3.1.2	Requirements for Outdoor Base Station Antennas	96
3.2	Case Studies	98
3.2.1	An Eight-Element-Shaped Beam Antenna Array	98
3.2.2	A 90° Linearly Polarized Antenna Array	106
3.2.3	A Dual-Band Dual-Polarized Array	111
3.2.4	A Broadband Monopolar Antenna for Indoor Coverage	117
3.2.5	A Single-Feed Dual-Band Patch Antenna for Indoor Networks	122
3.3	Conclusion	126
3.4	Acknowledgment	126
	References	127
<b>Chapter 4.</b>	<b>Advanced Antennas for Radio Base Stations</b>	<b>129</b>
4.1	Benefits of Advanced Antennas	130
4.2	Advanced Antenna Technologies	131
4.3	Three-Sector Reference System	132
4.4	Three-Sector Omnidirectional Antenna	134
4.5	Higher Order Receive Diversity	137
4.5.1	Field Trial	138
4.6	Transmit Diversity	139
4.7	Antenna Beamtilt	139
4.7.1	Case Study	146
4.8	Modular High-Gain Antenna	148
4.8.1	Case Study	150
4.8.2	Field Trial	153
4.9	Higher Order Sectorization	154
4.9.1	Case Study	156
4.10	Fixed Multibeam Array Antenna	157
4.10.1	Field Trials	161
4.10.2	Migration Strategy	165
4.11	Steered Beam Array Antenna	167
4.12	Amplifier Integrated Sector Antenna	168
4.12.1	Case Study	169
4.13	Amplifier Integrated Multibeam Array Antenna	171
4.14	Conclusion	173
	References	174

<b>Chapter 5. Antenna Issues and Technologies for Enhancing System Capacity</b>	<b>177</b>
5.1 Introduction	177
5.1.1 Mobile Communications in Japan	177
5.1.2 Wireless Access System	179
5.2. Design Considerations for Antennas from a Systems Point of View	182
5.3 Case Studies	184
5.3.1 Slim Antenna	184
5.3.2 Narrow HPBW Antenna with Parasitic Metal Conductors	188
5.3.3 SpotCell (Micro-Cell) Antenna	194
5.3.4 Booster Antenna	196
5.3.5 Control of Vertical Radiation Pattern	196
5.4 Conclusion	202
References	202
<b>Chapter 6. New Unidirectional Antennas for Various Wireless Base Stations</b>	<b>205</b>
6.1 Introduction	205
6.2 Patch Antennas	207
6.2.1 Twin L-Shaped Probes Fed Patch Antenna	207
6.2.2 Meandering-Probe Fed Patch Antenna	210
6.2.3 Differential-Plate Fed Patch Antenna	212
6.3 Complementary Antennas Composed of an Electric Dipole and a Magnetic Dipole	219
6.3.1 Basic Principle	220
6.3.2 Complementary Antennas Composed of Slot Antenna and Parasitic Wires	221
6.3.3 Complementary Antennas with a Slot Antenna and a Conical Monopole	221
6.3.4 New Wideband Unidirectional Antenna Element	222
6.4 Conclusion	236
6.5 Acknowledgment	237
References	237
<b>Chapter 7. Antennas for WLAN (WiFi) Applications</b>	<b>241</b>
7.1 Introduction	241
7.1.1 WLAN (WiFi)	241
7.1.2 MIMO in WLANs	243
7.2 Design Considerations for Antennas	245
7.2.1 Materials, Fabrication Process, Time to Market, Deployment, and Installation	246
7.2.2 MIMO Antenna System Design Considerations	249
7.3 State-of-the-Art Designs	255
7.3.1 Outdoor Point-to-Point Antennas	255
7.3.2 Outdoor Point-to-Multiple-Point Antennas	260
7.3.3 Indoor Point-to-Multiple Point Antennas	260
7.4 Case Studies	264
7.4.1 Indoor P2MP Embedded Antenna	265
7.4.2 Outdoor P2P Antenna Array	270
7.4.3 Dual-Band Outdoor P2P Antenna Array	270
7.4.4 Outdoor P2P Diversity Grid Antenna Array	276

7.4.5	Outdoor/Indoor P2MP HotSpot/HotZone Antenna	279
7.4.6	MIMO Antenna Array	282
7.4.7	Three-Element Dual-Band MIMO Antenna	286
7.5	Conclusion	287
	References	288
<b>Chapter 8.</b>	<b>Antennas for Wireless Personal Area Network (WPAN) Applications: RFID/UWB Positioning</b>	<b>291</b>
8.1	Introduction	291
8.1.1	Wireless Personal Area Network (WPAN)	292
8.1.2	Radio Frequency Identification (RFID)	296
8.1.3	Ultra-Wideband (UWB) Positioning	305
8.2	Antenna Design for RFID Readers	313
8.2.1	Design Considerations	313
8.2.2	Case Study	318
8.3	Antenna Design for Indoor Mono-Station UWB Positioning System	341
8.3.1	Design Considerations	341
8.3.2	Case Study: Six-Element Sectorized Antenna Arrays	341
8.4	Conclusion	346
	References	347
<b>Index</b>		<b>349</b>