

Contents

<i>About the Authors</i>	<i>xiii</i>
Chapter 1: A Survey of RF and Wireless Technology	1
1.1 A Short History of Wireless Communication	1
1.2 Where We Are	3
1.3 Conclusion	16
1.4 References	16
Chapter 2: Communication Protocols and Modulation	17
2.1 Baseband Data Format and Protocol	17
2.2 Baseband Coding	25
2.3 RF Frequency and Bandwidth	29
2.4 Modulation	31
2.5 RFID	49
2.6 Summary	50
2.7 References	50
Chapter 3: Transmitters	51
3.1 RF Source	51
3.2 Modulation	59
3.3 Amplifiers	61
3.4 Filtering	62
3.5 Antenna	63
3.6 Summary	64
3.7 References	64
Chapter 4: Receivers	65
4.1 Tuned Radio Frequency	65
4.2 Superregenerative Receiver	66
4.3 Superheterodyne Receiver	68
4.4 Direct Conversion Receiver	70
4.5 Digital Receivers	72
4.6 Repeaters	73

4.7 Summary	73
4.8 Reference	73
Chapter 5: Radio Propagation	75
5.1 Mechanisms of Radio Wave Propagation	75
5.2 Open Field Propagation	77
5.3 Diffraction	79
5.4 Scattering	81
5.5 Path Loss	81
5.6 Multipath Phenomena	83
5.7 Flat Fading	84
5.8 Diversity Techniques	87
5.9 Noise	90
5.10 Summary	93
5.11 References	93
Chapter 6: Antenna Fundamentals I	95
6.1 Electromagnetic Waves	95
Example 6.1 A Quarter-Wave Matching System	104
6.2 Polarization	105
6.3 The Short Dipole	106
Example 6.2 Dipole Input Impedance and Efficiency	115
6.4 The Small Loop	115
Example 6.3 Loop Impedance and Efficiency	118
6.5 Directionality, Efficiency, and Gain	119
6.6 References	121
Chapter 7: Antenna Fundamentals II	123
7.1 Bandwidth and Quality Factor, Q	123
Example 7.1 Effects of Coil Q and Loading	125
Example 7.2 SWR Bandwidth of a Lumped-Element Resonator	128
Example 7.3 Parallel-Tuned Loop SWR Bandwidth	129
7.2 Impedance Matching and System Efficiency	130
Example 7.4 L -Section Matching	131
Example 7.5 Matching the Series-Tuned Loop	132
7.3 Reception	134
7.4 Ground Effects	137
Example 7.6 Field Plots for the Horizontal Dipole	141
7.5 Improvements	145
7.6 References	146

Chapter 8: Basics of Wireless Local Area Networks	
8.1 Networks Large and Small	
8.2 WLANs from LANs	
8.3 802.11 WLANs	
8.4 HiperLAN and HiperLAN 2	
8.5 From LANs to PANs	
8.6 Capsule Summary	
8.7 Further Reading	
WEP Attacks	
Bluetooth	
Trellis-Coded Modulations	
Standards	
Chapter 9: Outdoor Networks	
9.1 Neither Snow nor Rain nor Heat nor Gloom of Night . . .	
9.2 Line-of-Sight Sites	
9.3 Outdoor Coverage Networks	
9.4 Point-to-Multipoint Networks	
9.5 Point-to-Point Bridges	
9.6 Long Unlicensed Links	
9.7 Safety Tips	
9.8 Capsule Summary	
9.9 Further Reading	
Chapter 10: Voice Over Wi-Fi and Other Wireless Technologies	
10.1 Introduction	
10.2 Ongoing 802.11 Standard Work	
10.3 Wi-Fi and Cellular Networks	
10.4 WiMax	
10.5 VoWi-Fi and Bluetooth	
10.6 VoWi-Fi and DECT	
10.7 VoWi-Fi and Other Ongoing 802.x Wireless Projects	
10.8 Conclusion	
10.9 References	
Chapter 11: Security in Wireless Local Area Networks	
11.1 Introduction	
11.2 Key Establishment in 802.11	
11.3 Anonymity in 802.11	
11.4 Authentication in 802.11	
11.5 Confidentiality in 802.11	

11.6 Data Integrity in 802.11.....	272
11.7 Loopholes in 802.11 Security.....	274
11.8 WPA	275
11.9 WPA2 (802.11i).....	287
Chapter 12: System Planning	295
12.1 System Design Overview	295
12.2 Location and Real Estate Considerations.....	296
12.3 System Selection Based Upon User Needs	301
12.4 Identification of Equipment Requirements.....	303
12.5 Identification of Equipment Locations	305
12.6 Channel Allocation, Signal-to-Interference, and Reuse Planning.....	311
12.7 Network Interconnect and Point-to-Point Radio Solutions.....	315
12.8 Costs	318
12.9 The Five C's of System Planning	319
Chapter 13: System Implementation, Testing, and Optimization	321
13.1 Real-World Design Examples	321
13.2 Example One: Local Coffee House.....	321
13.3 Example Two: Office LAN Deployment.....	322
13.4 Example Three: Community WISP.....	331
13.5 Example Four: Mobile Broadband Network	344
13.6 Chapter Summary.....	348
Chapter 14: Next Generation Wireless Networks	349
14.1 Why "Next" Generation?	349
14.2 First Generation Wireless Networks: Wireless Access	350
14.3 Second Generation Wireless Networks: Mobile Access	351
14.4 Third Generation Wireless Networks: Wireless and Mobile Access to High-Bandwidth Services	356
14.5 Fourth Generation Wireless Networks and Beyond: Universal Access in a Multinetwork Environment	364
14.6 Conclusion.....	372
14.7 References	373
Chapter 15: Mobile Ad Hoc Networks	377
15.1 Physical Layer and MAC	379
15.2 Routing in Ad Hoc Networks.....	392
15.3 Conclusion.....	402
15.4 References	403

Chapter 16: Wireless Sensor Networks	
16.1 Applications.....	
16.2 Plant Network Layouts.....	
16.3 Plant Network Architecture.....	
16.4 Sensor Subnet Selection	
16.5 Functional Requirements.....	
16.6 Technical Trade-offs and Issues	
16.7 Conclusion.....	
16.8 References	
Chapter 17: Reliable Wireless Networks for Industrial Applications	
17.1 Benefits of Using Wireless	
17.2 Issues in Deploying Wireless Systems	
17.3 Wireless Formats	
17.4 Wireless Mesh Networks.....	
17.5 Industrial Applications of Wireless Mesh Networks.....	
17.6 Case Study: Water Treatment	
17.7 Conclusion.....	
Chapter 18: Software-Defined Radio	
18.1 What Is Software-Defined Radio?.....	
18.2 Aspects of Software-Defined Radio	
18.3 History and Evolution of Software-Defined Radio	
18.4 Applications and Need for SDR.....	
18.5 Architectures	
18.6 Implementation Issues.....	
18.7 Case Study: A Close Look at a CDMA2000 and UMTS SDR Receiver.....	
18.8 Conclusion.....	
18.9 References	
Chapter 19: The Basics of Radio Frequency Identification Technology	
19.1 The Automatic Identification Manufacturers (AIM), Pittsburgh, PA.....	
19.2 What Is RFID?.....	
19.3 Wireless Communication and the Air Interface	
19.4 RFID System Components.....	
19.5 RFID System Categories	
19.6 Areas of Application for RFID.....	
19.7 Standardization.....	
19.8 Conclusion.....	
19.9 References	

Chapter 20: UWB Spectrum and Regulations	485
20.1 Regulatory Testing of UWB Devices	485
20.2 UWB Regulatory Terminology	485
20.3 Testing Infrastructure.....	487
20.4 Regulatory Overview.....	496
20.5 UWB Waiver Impact on Technical Requirements.....	516
20.6 International Regulatory Status of UWB Devices.....	517
20.7 References	519
Chapter 21: Interference and Coexistence	521
21.1 Protecting Other Services in Band	522
21.2 Ensuring Coexistence	532
21.3 Detection and Avoidance.....	533
21.4 Responding to Changing Needs	538
21.5 Finding the Balance.....	538
21.6 References	539
Chapter 22: Direct Sequence UWB	541
22.1 Direct-Sequence UWB	541
22.2 Binary Signaling with DS-UWB	542
22.3 <i>M</i> -ary Biorthogonal Signaling with DS-UWB.....	543
22.4 Properties of Good Codes.....	546
22.5 Binary Codes	550
22.6 Ternary Codes.....	552
22.7 Processing Gain.....	554
22.8 DS-UWB Advantages versus Nonspread Spectrum Methods.....	555
22.9 Transmitter Structure.....	556
22.10 Receiver Structure	558
22.11 Simulation Results.....	559
22.12 References	560
Chapter 23: Multiband Approach to UWB	561
23.1 Introduction and Overview.....	561
23.2 Detailed Motivation for Multiband UWB Transmission Schemes.....	564
23.3 Multipath Energy Collection in Sequenced Multiband Receivers	570
23.4 Local Oscillator Generation Aspects.....	574
23.5 Regulatory Implications of Multiband UWB Transmissions.....	576
23.6 Conclusion.....	581
23.7 References	582

Chapter 24: History and Background of Cognitive Radio Technology	
24.1 The Vision of Cognitive Radio.....	
24.2 History and Background Leading to Cognitive Radio	
24.3 A Brief History of SDR.....	
24.4 Basic SDR	
24.5 Spectrum Management.....	
24.6 U.S. Government Roles in Cognitive Radio.....	
24.7 How Smart Is Useful?	
24.8 References	
Chapter 25: The Software-Defined Radio as a Platform for Cognitive Radio	
25.1 Introduction	
25.2 Hardware Architecture	
25.3 Software Architecture.....	
25.4 SDR Development and Design.....	
25.5 Applications.....	
25.6 Development.....	
25.7 Cognitive Waveform Development	
25.8 Summary	
25.9 References	
Chapter 26: Cognitive Radio: The Technologies Required	
26.1 Introduction	
26.2 Radio Flexibility and Capability	
26.3 Aware, Adaptive, and CRs.....	
26.4 Comparison of Radio Capabilities and Properties	
26.5 Available Technologies for CRs	
26.6 Funding and Research in CRs	
26.7 Timeline for CRs	
26.8 Summary and Conclusions.....	
26.9 References	
Chapter 27: Spectrum Awareness	
27.1 Introduction	
27.2 The Interference Avoidance Problem.....	
27.3 Cognitive Radio Role	
27.4 Spectral Footprint Minimization	
27.5 Creating Spectrum Awareness.....	
27.6 Channel Awareness and Multiple Signals in Space.....	

27.7 Spectrally Aware Networking	699
27.8 Overlay and Underlay Techniques	700
27.9 Adaptive Spectrum Implications for Cognitive Radio Hardware.....	702
27.10 Summary: The Cognitive Radio Toolkit	702
27.11 References	703
Appendix: Propagation Energy Loss 704	
Chapter 28: Direct-Sequence and Frequency-Hopping Spread Spectrum.....	707
28.1 Direct-Sequence Spread Spectrum.....	708
28.2 Frequency Hopping	721
28.3 Conclusion.....	730
28.4 References	731
Chapter 29: RF Power Amplifiers.....	733
29.1 Power Amplifier Class of Operation.....	733
29.2 Conclusion.....	750
29.3 References	750
Chapter 30: Phase-Locked Loop Techniques in Modern Communications Systems	751
30.1 Phase-Locked Loop Techniques for Frequency Synthesizers	751
30.2 Sub-blocks in PLL.....	761
30.3 The Voltage Controlled Oscillator (VCO).....	767
30.4 Application: A Fully Integrated Dual-Mode Frequency Synthesizer for GSM and WCDMA Standards	796
30.5 References	798
Chapter 31: Orthogonal Frequency-Division Multiplexing (OFDM).....	803
31.1 Fundamentals of OFDM.....	805
31.2 Effect of OFDM on Wireless Environment.....	807
31.3 Coding for OFDM Systems.....	807
31.4 Interleaving.....	808
31.5 The Peak-to-Mean Envelope Power Ratio Problem.....	809
31.6 Channel Estimation	811
31.7 Synchronization.....	813
31.8 Conclusion.....	814
31.9 References	815
Index.....	819