

Remote Sens. **2013**, *5*, 367-373; doi:10.3390/rs5010367

OPEN ACCESS

Remote Sensing

ISSN 2072-4292

www.mdpi.com/journal/remotesensing

New Book Received

Microwave and Millimeter-Wave Remote Sensing for Security Applications. By Jeffrey A. Nanzer, Artech House, 2012; 372 pages. Price £109.00, ISBN 978-1-60807-172-2

Shu-Kun Lin

MDPI AG, Kandererstrasse 25, CH-4057 Basel, Switzerland; E-Mail: lin@mdpi.com

Received: 10 January 2013 / Accepted: 10 January 2013 / Published: 17 January 2013

The following paragraphs are reproduced from the website of the publisher [1]:

Microwave and millimeter-wave remote sensing techniques are fast becoming a necessity in many aspects of security as detection and classification of objects or intruders becomes more difficult. This groundbreaking resource offers you expert guidance in this burgeoning area. It provides you with a thorough treatment of the principles of microwave and millimeter-wave remote sensing for security applications, as well as practical coverage of the design of radiometer, radar, and imaging systems. You learn how to design active and passive sensors for intruder detection, concealed object detection, and human activity classification. This detailed book presents the fundamental concepts practitioners need to understand, including electromagnetic wave propagation in free space and in media, antenna theory, and the principles of receiver design. You find in-depth discussions on the interactions of electromagnetic waves with human tissues, the atmosphere and various building and clothing materials. This timely volume explores recently developed detection techniques, such as micro-Doppler radar signatures and correlation radiometry. The book is supported with over 200 illustrations and 1,135 equations.

Table of Contents

Chapter 1 Introduction 1

1.1 Security Sensing 1

1.1.1 Needs for Remote Security Sensing 1

1.1.2 Advantages of Microwave and Millimeter-Wave Remote Sensors 2

1.2 Overview of Remote Sensing Techniques 3

1.2.1 Radiometry 3

- 1.2.2 Radar Systems 4
- 1.2.3 Imaging Systems 4
- 1.2.4 Interferometric Angular Velocity Measurement 5
- 1.2.5 Microwave and Millimeter-Wave Remote Sensing in Related Fields Z
- 1.3 The Microwave and Millimeter-Wave Spectrum 7
 - 1.3.1 Frequency Designations 7
 - 1.3.2 Propagation of Microwave and Millimeter-Wave Radiation 8
- 1.4 Examples of Remote Security Sensors 9
 - 1.4.1 Active Imaging for Contraband Detection 10
 - 1.4.2 Passive Imaging for Contraband Detection 10
 - 1.4.3 Detection of Human Presence 12
 - 1.4.4 Discrimination of Humans and Classification of Human Activity 18
 - 1.4.5 Through-Wall Detection 19
 - 1.4.6 Biological Signature Detection 20
- References 20

Chapter 2 Electromagnetic Plane Wave Fundamentals 27

- 2.1 Maxwell's Equations 27
 - 2.1.1 The Constitutive Parameters 30
- 2.2 Time-Harmonic Electromagnetic Fields 31
 - 2.2.1 The Wave Equation 32
 - 2.2.2 Plane Waves 33
 - 2.2.2.1 Phase Velocity 34
 - 2.2.2.2 Relationship Between E and H 35
 - 2.2.3 Energy and Power 37
- 2.3 Wave Polarization 38
 - 2.3.1 Linear Polarization 39
 - 2.3.2 Elliptical Polarization 40
- References 42

Chapter 3 Electromagnetic Waves in Media 43

- 3.1 Plane Wave Propagation in Unbounded Media 44
 - 3.1.1 Good Conducting Media 46
 - 3.1.2 Good Dielectric Media 47
 - 3.1.3 Wave Impedance in Media 48
 - 3.1.4 Complex Permittivity and Dispersion 48
- 3.2 Plane Wave Propagation in Bounded Media 51
 - 3.2.1 Reflection and Transmission of Normally Incident Waves 52
 - 3.2.2 Reflection and Transmission of Arbitrarily Incident Waves 54
 - 3.2.2.1 Transverse Electric (Perpendicular) Incidence 54
 - 3.2.2.2 Transverse Magnetic (Parallel) Incidence 57
 - 3.2.3 Power Reflection and Transmission 58

- 3.2.4 Total Transmission and Total Reflection 60
- 3.2.5 Layered Media 61
- 3.3 Electromagnetic Propagation in Specific Media 63
 - 3.3.1 Atmospheric Propagation Effects 63
 - 3.3.2 Propagation Through Building Materials 69
 - 3.3.3 Propagation Through Clothing and Garment Materials 70
 - 3.3.4 Dielectric Properties of Explosives, Plastics, and Metals 71
 - 3.3.5 Dielectric Properties of Human Tissue 72
- References 81

Chapter 4 Antennas 85

- 4.1 Electromagnetic Potentials 86
 - 4.1.1 Electromagnetic Potentials Due to Electric Current Density J 86
 - 4.1.2 Electromagnetic Potentials Due to Magnetic Current Density J_m 88
 - 4.1.3 Infinitesimal Dipole Radiation 89
 - 4.1.4 Far Field Radiation 90
 - 4.1.5 Infinitesimal Dipole Far-Field Radiation 94
- 4.2 Antenna Parameters 95
 - 4.2.1 Radiated Power Density and Total Radiated Power 95
 - 4.2.2 Antenna Pattern 96
 - 4.2.3 Antenna Pattern Beamwidth 97
 - 4.2.4 Antenna Solid Angles 99
 - 4.2.5 Directivity 99
 - 4.2.6 Gain 101
 - 4.2.7 Aperture Area and Pattern Solid Angle 102
 - 4.2.8 Antenna Temperature and Noise Power 103
 - 4.2.9 Polarization 103
- 4.3 Properties of Wire Antennas 104
 - 4.3.1 Infinitesimal Dipole 104
 - 4.3.2 Long Dipole 105
- 4.4 Aperture Antennas 107
 - 4.4.1 Image theory 108
 - 4.4.2 The Equivalence Principle 109
 - 4.4.3 Radiation from a Rectangular Aperture 111
 - 4.4.4 Radiation from a Circular Aperture 115
- 4.5 Antenna Arrays 117
 - 4.5.1 Linear Array Theory 118
 - 4.5.2 Planar Arrays 121
 - 4.5.3 Array Beamwidth 122
 - 4.5.4 Phased Arrays 123
 - 4.5.5 Array Architectures 125
 - 4.5.5.1 Signal Feeds 125

- 4.5.5.2 Beam Steering 127
- 4.6 Common Microwave and Millimeter-Wave Antennas 128
 - 4.6.1 Horn Antennas 128
 - 4.6.2 Slot Antennas 131
 - 4.6.3 Microstrip Antennas 132
 - 4.6.4 Reflector Antenna Systems 134
 - 4.6.5 Lens Antenna Systems 136
- References 137

Chapter 5 Receivers 139

- 5.1 General Operation of Receivers 140
- 5.2 Receiver Noise 143
 - 5.2.1 Sources of Receiver Noise 144
 - 5.2.1.1 Thermal Noise 144
 - 5.2.1.2 Shot Noise 145
 - 5.2.1.3 Flicker Noise 146
 - 5.2.2 Equivalent Noise Bandwidth 146
 - 5.2.3 Thermal Noise at Millimeter-Wave Frequencies 148
- 5.3 Noise Figure and Noise Temperature 150
 - 5.3.1 Noise Figure 150
 - 5.3.2 Noise Temperature 152
 - 5.3.3 Noise Figure of an Attenuator 153
 - 5.3.4 Noise in Cascaded Systems 154
 - 5.3.5 ADC Noise 157
- 5.4 Receiver Linearity 160
 - 5.4.1 Gain Compression 162
 - 5.4.2 Intermodulation Products 164
 - 5.4.3 Third Order Intercept Point 166
 - 5.4.4 Intercept Point of a Cascade 168
 - 5.4.5 Dynamic Range 168
 - 5.4.6 Spurious Free Dynamic Range 170
- References 171

Chapter 6 Radiometry 173

- 6.1 Radiometry Fundamentals 174
 - 6.1.1 Brightness 174
 - 6.1.2 Brightness and Distance 176
 - 6.1.3 Flux Density and Source Distribution 178
 - 6.1.4 Effect of the Antenna 179
- 6.2 Blackbody Radiation 180
 - 6.2.1 Planck's Blackbody Radiation Law 180
 - 6.2.2 Approximations of Planck's Law 184

- 6.2.3 Band-Limited Integration of Planck's Law 185
- 6.3 Applied Radiometry 187
 - 6.3.1 Source Resolution 188
 - 6.3.1.1 Resolved Source 188
 - 6.3.1.2 Unresolved Source 189
 - 6.3.2 Received Power as a Convolution 190
 - 6.3.3 Emissivity and Radiometric Temperature 191
 - 6.3.3.1 Emissivities of Human Skin and Common Materials 192
 - 6.3.3.2 Radiometric Temperature in an Environment 194
- 6.4 Radiometer Receivers 196
 - 6.4.1 Sensitivity 197
 - 6.4.2 Total Power Radiometer 200
 - 6.4.2.1 Total Power Response 200
 - 6.4.2.2 Sensitivity 201
 - 6.4.3 Interferometric Correlation Radiometer 206
 - 6.4.3.1 Spatial Point Source Response 207
 - 6.4.3.2 Sensitivity 212
- 6.5 Practical Considerations 215
 - 6.5.1 Receiver Instabilities 215
 - 6.5.2 Dicke Radiometer 215
 - 6.5.3 Radiometer Calibration 217
- 6.6 Scanning Radiometer Systems 218
 - 6.6.1 Spatial Resolution 219
 - 6.6.2 Dwell Time 222
 - 6.6.3 Measurement Uncertainty 223
 - 6.6.3.1 One-Dimensional Scanning 223
 - 6.6.3.2 Two-Dimensional Scanning 225
- References 226

Chapter 7 Radar 229

- 7.1 Radar Fundamentals 230
 - 7.1.1 Configurations and Measurements 231
 - 7.1.2 Range Equation 233
- 7.2 Transmitter Systems 236
 - 7.2.1 Transmitter Functionality 236
 - 7.2.2 Transmitter Noise 239
 - 7.2.3 Millimeter-Wave Oscillators 241
- 7.3 Radar Measurement Sensitivity 243
 - 7.3.1 Measurement Error 243
 - 7.3.1.1 Range Measurement Error 244
 - 7.3.1.2 Frequency Measurement Error 245
 - 7.3.1.3 Angle Measurement Error 245

- 7.3.1.4 Example 245
- 7.3.2 Impact of the Time-Bandwidth Product on Measurement Error 251
- 7.4 Micro-Doppler 253
 - 7.4.1 Micro-Doppler in Security Radar 254
 - 7.4.2 Micro-Doppler Theory 255
 - 7.4.3 Human Micro-Doppler Signature 260
- 7.5 Continuous-Wave Radar 266
 - 7.5.1 Continuous-Wave Doppler 267
 - 7.5.2 Frequency-Modulated CW 271
 - 7.5.3 Multifrequency CW 274
 - 7.5.4 Moving Target Indication Radar 275
- 7.6 High-Range Resolution Radar 279
 - 7.6.1 Pulse Radar 280
 - 7.6.2 Linear Frequency Modulation 282
 - 7.6.3 Stepped-Frequency Modulation 285
- References 286

Chapter 8 Imaging Systems 289

- 8.1 Scanning Imaging Systems 291
 - 8.1.1 Types of Scanning Imagers 291
 - 8.1.2 General Characteristics of Scanning Systems 292
 - 8.1.2.1 Field of View and Spatial Resolution 292
 - 8.1.2.2 Frame Rate 294
- 8.2 Interferometric Imaging Systems 295
 - 8.2.1 Introduction 295
 - 8.2.2 Image Formation 296
 - 8.2.2.1 Visibility Function 297
 - 8.2.2.2 Fourier Transform Relationship of Visibility and Radiometric Temperature 299
 - 8.2.2.3 The Correlation Interferometer as a Spatial Filter 301
 - 8.2.3 Visibility Sampling 303
 - 8.2.4 Two-Dimensional Visibility 308
 - 8.2.5 Image Sensitivity 309
 - 8.2.6 Image Resolution and Field of View 312
 - 8.2.7 Interferometric Imaging Arrays 318
 - 8.2.7.1 Mills Cross Array 319
 - 8.2.7.2 T-Array 321
 - 8.2.7.3 Y-Array 322
 - 8.2.7.4 Circular Arrays 323
- References 325

Chapter 9 Interferometric Measurement of Angular Velocity 329

- 9.1 Interferometer Response to an Angularly Moving Point Source 330

9.1.1 System Beam Pattern	331
9.1.2 Frequency Shift Induced by an Angularly Moving Object	332
9.1.3 Comparison to Doppler Frequency Shift	333
9.1.4 Frequency Uncertainty at Wide Angles	335
9.1.5 Small Angle Approximation	335
9.2 Interferometer Spectral Response	336
9.2.1 General Spectral Response	336
9.2.2 Response with a Sinc Function System Beam Pattern	337
9.2.3 Interferometer Response in the Time-Frequency Domain	341
9.3 Interferometric Measurement of Moving Humans	344
9.3.1 Narrow-Beamwidth Response to a Moving Human	344
9.3.2 Wide-Beamwidth Response to a Moving Human	346
References	349
List of Symbols	351
List of Abbreviations and Acronyms	355
About the Author	357
Index	359

* *Editor's Note:* The brief summary and the contents of the books are reported as provided by the authors or the publishers. Authors and publishers are encouraged to send review copies of their recent books of potential interest to readers of *Remote Sensing* to the Publisher (Dr. Shu-Kun Lin, Multidisciplinary Digital Publishing Institute (MDPI), Kandererstrasse 25, CH-4057 Basel, Switzerland; Tel. +41-61-683-77-34; Fax: +41-61-302-89-18; E-Mail: lin@mdpi.com). Some books will be offered to the scholarly community for the purpose of preparing full-length reviews.

Note

1. The website for this book is: <http://www.artechhouse.com/International/Books/Microwave-and-MillimeterWave-Remote-Sensing-for-Se-1966.aspx>.

© 2013 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).