

Contents

PREFACE	xi
1. A BRIEF PREVIEW <i>by</i> R. MITTRA	1
References	5
2. WIRE ANTENNAS <i>by</i> G.A. THIELE	7
2.1. Introduction	7
2.2. Integral Equations for Wire Antennas	8
2.2.1. A Volume Equivalence Theorem	8
2.2.2. Pocklington's Integral Equation	9
2.2.3. Hallen's Integral Equation	14
2.3. Method of Moments	15
2.3.1. Galerkin's Method	16
2.3.2. Point-matching	17
2.4. Bases	18
2.4.1. Entire-domain Bases	19
2.4.2. Sub-domain Bases (Segmentation)	21
2.4.3. Some Common Basis Functions	23
2.4.4. A Basis Transformation Method	24
2.4.5. Piecewise-sinusoidal Basis: Reaction-matching	29
2.4.6. Characteristic Mode Currents: an Eigenvalue Problem	36
2.4.7. The Stability Problem	37
2.5. Calculation of Antenna Characteristics	38
2.5.1. Current Distribution, Impedance and Lumped Loading	38
2.5.2. Radiation Patterns, Gain and Efficiency	40
2.6. The Yagi-Uda Array	41
2.6.1. The Integral Operator	42
2.6.2. Matrix Formulation	43

2.6.3. Far-zone Radiation	46
2.6.4. Current Distributions	48
2.6.5. Array Input Impedance	49
2.7. Electrically Small Antennas	52
2.7.1. Multiturn Loop Antenna	53
2.7.2. TEM-line Antenna with Loading	57
2.8. Modeling of Wire Antennas on Metallic Bodies	61
2.8.1. Monopole or Circular Slot in the Base of a Cone	62
2.8.2. Small Loops of TEM Line on an Aircraft	67
2.9. Conclusions and Acknowledgment	69
2.10. Exercises	70
Appendix I. Fields of a Magnetic Frill Current	72
Appendix II. Calculation of Characteristic Mode Currents	80
Appendix III. Fortran IV Program for Wire Antennas on Metallic Bodies	84
References	93
3. NUMERICAL SOLUTION OF ELECTROMAGNETIC SCATTERING PROBLEMS <i>by</i> P. C. WATERMAN	
3.1. Introduction	97
3.1.1. General Discussion	97
3.1.2. Computational Aspects	97
3.2. Theory	98
3.2.1. Matrix Formulation	98
3.2.2. Evaluation of the Transition Matrix	101
3.2.3. Application to Special Geometries	104
3.2.4. Results for Finite Cylinders and a Cone-Sphere	108
3.3. Organization of the Computer Program	113
3.3.1. Introduction	113
3.3.2. Glossary of the Subroutines	114
3.3.3. The Input Routine	115
3.3.4. Calculation of End Points and Spacing for Integration	116
3.3.5. The First Control Routine	117
3.3.6. Associated Legendre Functions	119
3.3.7. Bessel Functions	119
3.3.8. Recursion Relationships for Bessel and Neumann Functions	120
3.3.9. Generating the Body Shape	120

3.3.10. First Matrix Printout	121
3.3.11. Printout of an Array	121
3.3.12. Generating the Q Matrix and the T Matrix	121
3.3.13. Normalizing Matrices	123
3.3.14. Conditioning Matrices	123
3.3.15. Printing the $[T]$ Matrix	124
3.3.16. Final Control Routine	124
3.3.17. Multiplying a Matrix Times a Vector	125
3.3.18. Core Dump	125
3.3.19. Storage Arrangements	125
Appendix I. The Fortran IV Program Listing	128
References	157
4. INTEGRAL EQUATION SOLUTIONS OF THREE-DIMENSIONAL SCATTERING PROBLEMS <i>by</i> A.J. POGGIO and E.K. MILLER	
4.1. Introduction	159
4.2. The Integral Equations of Electromagnetic Theory	160
4.2.1. The Derivation of Space-frequency Domain Integral Equations	160
4.2.2. The Derivation of Space-Time Domain Integral Equations	177
4.2.3. Tabulation of Integral Equations	182
4.3. Numerical Solution Methods	184
4.3.1. Frequency Domain Solutions	185
4.3.2. Time-domain Solutions	199
4.3.3. Additional Considerations	206
4.4. Applications	211
4.4.1. Frequency-domain Examples	211
4.4.2. Time-domain Examples	239
4.5. Concluding Remarks	260
References	261
5. VARIATIONAL AND ITERATIVE METHODS FOR WAVEGUIDES AND ARRAYS <i>by</i> C. P. WU	
5.1. Scattering from an Infinite Grating of Metallic Strips	266
5.2. Variational Principle, Method of Moments and Iterative Methods	270
5.2.1. Variational Principle	270
5.2.2. Method of Moments	271
5.2.3. Iterative Methods	273

5.3. Step Discontinuity in Circular Waveguides (Mode Conversion Applications)	273
5.4. Transition Between a Straight and a Continuously Curved Waveguide	279
5.4.1. Waveguide Modes in Curved Waveguides	279
5.4.2. Formulation of the Integral Equation	281
5.4.3. Application of the Moments Method	284
5.4.4. Special Computational Problems	284
5.5. Dielectric Slab-covered Waveguide Antenna	286
5.6. Double Discontinuity Problems	292
5.6.1. Coupled Integral Equations for Double Discontinuity Problems	293
5.6.2. Band Rejection Filter in Coaxial Waveguides	295
5.7. Concluding Remarks	298
Appendix. Convergence Test and the Relative Convergence Problem	300
References	303
6. SOME NUMERICALLY EFFICIENT METHODS	
<i>by R. MITTRA and T. ITOH</i>	
6.1. Introduction	305
6.2. Analysis of Microstrip Lines	306
6.2.1. Introduction and Description of the Problem	306
6.2.2. Formulation of a Boundary Value Problem in Spectral Domain	307
6.2.3. Modified Residue Calculus Technique	309
6.2.4. Numerical Computation	312
6.2.5. Numerical Results	315
6.3. Diffraction Grating	315
6.3.1. Description of the Problem	315
6.3.2. Formulation in the Spectral Domain	317
6.3.3. MRCT Method of Solution	319
6.3.4. Numerical Procedure	322
6.3.5. Numerical Results	322
6.4. Dielectric Step in a Waveguide	324
6.4.1. Introduction and Problem Description	324
6.4.2. Formulation of the Problem	326
6.4.3. Method of Solution	328
6.4.4. Numerical Considerations	332
6.4.5. Numerical Results	334

6.5. The Generalized Scattering Matrix Method for Solving Discontinuity Problems	335
6.5.1. Introduction	335
6.5.2. Generalized Scattering Matrix Analysis of a Thick-walled Phase Array	336
6.5.3. Method of Solution for the Thick-walled Phased Array	338
6.5.4. Considerations for the Numerical Calculation	340
6.5.5. Numerical Results	341
References	342
Problems	343
7. INVERSE SCATTERING AND REMOTE PROBING <i>by R. MITTRA</i>	
7.1. Introduction	351
7.2. The Two-dimensional Inverse Scattering Problem	352
7.2.1. Statement of the Problem and Preliminaries	352
7.2.2. Numerical Processing of Pattern Function to Derive Object Shape	353
7.2.3. Summary of Computational Procedure for Inverse Scattering	356
7.2.4. Numerical Results	357
7.3. Remote Probing of Antenna Apertures by Holographic Techniques	360
7.3.1. Description of the Problem	360
7.3.2. Analytical Development	360
7.3.3. Numerical Procedure	361
7.3.4. Numerical Results	362
7.4. Antenna Power Pattern Synthesis	366
7.4.1. Introduction and Description of Problem	366
7.4.2. Formulation of Problem	367
7.4.3. Numerical Considerations	368
7.4.4. Numerical Results	369
7.5. Remote Probing of Inhomogeneous Media	372
7.5.1. Introduction	372
7.5.2. Linear Approach	372
7.5.3. Parameter Optimization Method of Solution	375
7.5.4. Numerical Considerations	376
7.5.5. Numerical Results	381

7.6. Numerical Aspects of Wavefront Reconstruction Using Matrix Methods	385
7.6.1. Introduction	385
7.6.2. Analytical Background	386
7.6.3. Numerical Experiment	387
7.6.4. Numerical Results	389
Appendix A. Optimization Methods	393
Appendix B. The Use of the Fast Fourier Transform Algorithm	395
References	397
Index	399