
**ELECTROMAGNETIC
WAVES** **PIER 35**

Progress

In

Electromagnetics

Research

© 2002 EMW Publishing. All rights reserved.

No part of this publication may be reproduced. Request for permission should be addressed to the Publisher.

All inquiries regarding copyrighted material from this publication, manuscript submission instructions, and subscription orders and price information should be directed to: EMW Publishing, P. O. Box 425517, Kendall Square, Cambridge, Massachusetts 02142, USA. FAX: 1-617-354-9597.

For up-to-date information, visit web site at <http://www.emwave.com>.

This publication is printed on acid-free paper.

ISSN 1070-4698

ISBN 0-9668143-1-2

Manufactured in the United States of America.

**ELECTROMAGNETIC
WAVES** **PIER 35**

Progress

In

**Electromagnetics
Research**

Chief Editor: J. A. Kong

Media of Waves

EMW Publishing
Cambridge, Massachusetts, USA

CONTENTS

Chapter 1. ELECTROMAGNETIC WAVE INTERACTION WITH STRATIFIED NEGATIVE ISOTROPIC MEDIA

J. A. Kong

1	Introduction	2
2	Backward Waves in Negative Isotropic Media	3
3	Reflection and Transmission by a Negative Isotropic Medium	4
4	Reflection and Transmission by Stratified Media	9
	4.1 Reflection Coefficients	11
	4.2 Propagation Matrices and Transmission Coefficients	12
	4.3 Reflection and Transmission by a Slab Medium	14
5	Guided Waves In Stratified Media	17
	5.1 Guidance Conditions	17
	5.2 Fields of Guided Waves	21
	5.3 Coupling of Guided Waves	22
6	Linear Antennas In Stratified Media	24
	6.1 Integral Formulation	24
	6.2 Linear Antenna Between Two Negative Isotropic Slabs	28
	6.3 Linear Antenna in Front of a Negative Isotropic Slab	30
7	Dipole Antennas In Stratified Media	34
	7.1 Hertzian Electric and Magnetic Dipoles	34
	7.2 Integral Formulation for Dipoles in Stratified Media	36
	7.3 Dipoles Between Two Negative Isotropic Slabs	44
	7.4 Dipoles in Front of Stratified Isotropic Media	46
	7.5 Dipoles in Front of a Negative Isotropic Slab	47
	7.6 Dipoles In Front of Negative Isotropic Slab Backed by a Perfect Conductor	51
	References	52

Chapter 2. DYADIC GREEN'S FUNCTIONS IN MULTILAYERED STRATIFIED GYROELECTRIC CHIRAL MEDIA

L. W. Li, S. B. Yeap, M. S. Leong, T. S. Yeo, and P. S. Kooi

1	Introduction	54
----------	-------------------------------	-----------

2	General Formulation For Unbounded Gyroelectric Chiral Medium	56
2.1	General Formulation of DGFs	57
2.2	Analytical Evaluation Of The h Integral	63
3	General Formulation For Planar, Layered Gyroelectric Chiral Media	66
3.1	Scattering Dyadic Green's Functions	67
4	Determination of the DGFs' Scattering Coefficients ..	69
4.1	Recurrence Formulae Of DGFs' Scattering Coefficients ..	70
4.2	Specific Applications: Three Cases	72
5	Conclusion	75
	Acknowledgment	76
	Appendix A. Integration of h	76
	References	77

Chapter 3. SCATTERING FROM A FREQUENCY SELECTIVE SURFACE SUPPORTED BY A BIANISOTROPIC SUBSTRATE

G. Kristensson, M. Åkerberg, and S. Poulsen

1	Introduction	84
2	General Case — Arbitrary Scatterer	85
2.1	Integral Representation in an Isotropic Medium	87
2.2	Plane Wave Expansion of the Green's Dyadic	88
2.3	Expansion Relations	91
2.4	Propagation in the Stratified Region	93
3	Special Case — Flat Metallic Screen	97
3.1	Transmittance and Reflectance	98
4	Special Case — FSS	99
4.1	Integral Equation for the Surface Current	100
4.2	Galerkin's Procedure	102
4.3	The Reflection and Transmission Coefficients	103
5	Results	108
6	Conclusion and Discussion	110
	Acknowledgment	110
	Appendix A. Power Flow	110
	References	112

Chapter 4. DYADIC GREEN'S FUNCTION FOR AN UNBOUNDED ANISOTROPIC MEDIUM IN CYLINDRICAL COORDINATES

K. Li, S.-O. Park, and W.-Y. Pan

1	Introduction	116
2	Formulation of the Problem	116
3	Integration over the Longitudinal and Transverse Fourier Variables	119
4	Derivation of the Delta-Type Source Singularity	121
5	Conclusion	124
	References	124

Chapter 5. ANALYTICAL TECHNIQUE TO EVALUATE THE ASYMPTOTIC PART OF THE IMPEDANCE MATRIX OF MICROSTRIP DIPOLE ON A UNIAXIAL SUBSTRATE

K. Li, S.-O. Park, H. Lee, J. Ma, B.-C. Kim, and H.-D. Choi

1	Introduction	128
2	Theory	128
3	Integral Transform Technique	131
4	Evaluation of the Integral I_{mn}^c	133
5	Computations and Comparisons	135
6	Conclusion	137
	References	137

Chapter 6. ELECTROMAGNETIC SCATTERING OF A THIN CIRCULAR LOOP ENCLOSED BY A SPHERICAL CHIRAL RADOME SHELL: A METHOD OF MOMENTS ANALYSIS

L.-W. Li and W.-X. Zhang

1	Introduction	142
2	General Formulations for Electromagnetic Radiated Fields	143
	2.1 DGFs for Source in Region 1	146
	2.2 DGFs for Source in Region 3	147
3	Determination of Unknown Current Coefficients	148
4	Electromagnetic Fields in the Far Zones	151

5	Numerical Results	152
5.1	Use of Incident Field	152
5.2	Effects of Chiral Parameters	156
6	Conclusion	159
	Acknowledgment	159
	Appendix A. Determination of Parameters	160
	References	161

Chapter 7. A SPATIAL-DOMAIN METHOD OF MOMENTS ANALYSIS OF A CYLINDRICAL-RECTANGULAR CHIROSTRIP

L.-W. Li, T.-X. Zhao, M.-S. Leong, and T.-S. Yeo

1	Introduction	166
2	Formulation of the Problem	168
2.1	The Chiral Substrate	168
2.2	Dyadic Green's Functions	168
2.3	Galerkin's Method of Moments Procedure	173
2.4	Far-Field Radiation Patterns	176
3	Numerical Results and Discussion	177
4	Conclusions	179
	References	180

Chapter 8. EXCITATION AND RECEPTION OF ELECTRO-MAGNETIC, MAGNETOSTATIC AND SPIN WAVES IN FERRITE FILMS

S. V. Zagriadski and S. Choi

1	Introduction	184
2	Excitation of Waves in Ferrite Layers and Waveguides by High-Frequency Magnetic Field	187
3	Self-Consistent Electrodynamic Problem of Excitation and Reception of Waves in Ferrite Films by Transmission Lines of an Arbitrary Type	191
4	Application of the Theory to Magnetostatic Wave Filters and Delay Lines	201
4.1	Characteristics of MSW Filters and Delay Lines with Strip-Line Transducers	202
4.2	Influence of Higher Modes of Transmission Line on Amplitudes of Excited Magnetostatic Waves	208

4.3 Influence of Width Modes of Ferrite Film on Amplitudes of Excited Magnetostatic Waves	210
5 Conclusion	213
Acknowledgment	214
Appendix A. Eigenwaves of Magnetization for Magne- tostatic Waves	214
A.1 Surface Magnetostatic Waves (SMSW)	214
A.2 Forward Volume Magnetostatic Waves (FVMSW)	215
References	215

Chapter 9. FIRST-ORDER MATERIAL EFFECTS IN GYROMAGNETIC SYSTEMS

D. Censor and M. D. Fox

1 Introduction	218
2 The Perturbation Method	220
3 A Simple Plane Wave Example and Boundary Considerations	223
4 Gyromagnetic Media	225
5 A Note on Superposition	230
6 Application to Plane Waves in Gyromagnetic Media ..	231
7 A Simple Vector Spherical Wave Example	233
8 Application to Vector Spherical Waves in Gyromag- netic Media	236
9 Concluding Remarks	241
Appendix A.	242
Appendix B.	245
Acknowledgment	248
References	248

Chapter 10. MODEL OF DIELECTRIC CONSTANT OF BOUND WATER IN SOIL FOR APPLICATIONS OF MICROWAVE REMOTE SENSING

D. A. Boyarskii, V. V. Tikhonov, and N. Yu. Komarova

1 Introduction	251
2 Model of Dielectric Properties of Bound Water in Soil	253
3 Model of Permittivity of Wet Soils	257

4	Comparison of Model Calculations and Experimental Data	259
5	Conclusion	267
	Acknowledgment	267
	References	267

Chapter 11. PROPAGATION OF ELECTROMAGNETIC WAVES IN A SLAB WITH NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY

Y. Zhang, T. M. Grzegorzczuk, and J. A. Kong

1	Introduction	272
2	Formulation of the Problem	273
	2.1 Layered Green's Function and Boundary Conditions ...	273
	2.2 Symmetry Properties of the Green's Functions	276
3	Current Source with Gaussian Distribution	277
4	Conclusions	283
	Appendix A.	284
	A.1 Boundary Conditions	284
	A.2 Fresnel Reflection Coefficients	285
	A.3 Electromagnetic Fields for a Slab with $(-\epsilon_0, -\mu_0)$ and a Gaussian Distributed Current Source	285
	References	286

Chapter 12. COMPUTATION OF SCATTERING FROM ANISOTROPICALLY COATED BODIES USING CONFORMAL FDTD

H.-X. Zheng, X.-Q. Sheng, and E. K.-N. Yung

1	Introduction	288
2	Formulations	288
3	Numerical Results	291
4	Conclusions	296
	References	296

Chapter 13. ELECTROMAGNETIC PULSE PROPAGATION IN DISPERSIVE MEDIA

P. Hillion

1	Introduction	300
---	--------------------	-----

2	B-I Problems for Maxwell's Equations	300
2.1	Mathematical Background	300
2.2	Constraints Imposed by Initial Conditions	303
2.3	Constraints on Boundary Conditions	304
3	Electromagnetic B-I Problems	307
3.1	Pulse Propagation in a Half-Space	307
3.2	Pulse Propagation in a Sheet	309
4	Discussion	309
	Appendix A.	311
	Appendix B.	312
	Appendix C.	312
	References	313

Chapter 14. NUMERICAL STUDIES OF LEFT HANDED METAMATERIALS

C. D. Moss, T. M. Grzegorzczuk, Y. Zhang, and J. A. Kong

1	Introduction	316
2	FDTD Model	318
3	Results	321
3.1	Determining Frequencies of LH Behavior	321
3.2	Phase Data in an LH Metamaterial Slab	324
3.3	Index of Refraction Calculated with an LH Metamaterial Prism	330
4	Conclusion	333
	Acknowledgment	333
	References	333