

Contents

1	New Analytical Solutions of Selected Electromagnetic Problems in Wave Diffraction Theory	1
	Leonid Pazynin	
1.1	Introduction	1
1.2	Wave Propagation Near an Irregular Impedance Structure	3
1.2.1	Wave Propagation Over a Plane Surface of Variable Conductivity	3
1.2.2	A Field of Linear Magnetic Current in a Plane Waveguide with Smoothly Varying Impedance of Its Walls	7
1.3	The Cycle Slipping Phenomenon and the Degeneracy of Waveguide Modes	21
1.3.1	Introduction	21
1.3.2	Problem Formulation and Solution	24
1.3.3	The Watson Transformation	31
1.3.4	A Numerical Experiment	35
1.4	Pulsed Radiation from a Line Electric Current Near a Planar Interface	40
1.4.1	Problem Formulation	41
1.4.2	Reduction to Single Integrals	44
1.4.3	The Field in the First Medium	48
1.4.4	The Field in the Second Medium	51
1.4.5	Discussion and Conclusion	52
1.5	Transition Radiation of a Longitudinal Magnetic Dipole in the Case of Diffuse Interface	54
1.5.1	Problem Formulation and Solution	54
1.5.2	The Criterion of the Interface ‘Sharpness’	61
1.6	The Biisotropic Epstein Transition Layer	63
1.6.1	Equations for the Electromagnetic Field in a Biisotropic Medium	63

1.6.2	Problem Formulation and Solution	65
1.6.3	Analysis of the Reflected and Transmitted Fields	68
1.7	Negative Refraction in Isotropic Double-Negative Media	71
1.7.1	Negative Refraction Phenomenon in Homogeneous Double-Negative Media	71
1.7.2	A Model of Smoothly Inhomogeneous Flat-Layered Double Negative Medium. Solution of the Problem of Transmission of a Plane Wave.	73
1.7.3	Analysis of the Expressions for Fields	76
1.8	Distorting Coatings as an Alternative to Masking Coatings	78
1.8.1	Transformation Optics, Masking Coatings, Distorting Coatings	78
1.8.2	Radical Distortion of Radar Image by Applying a Special Coating on the Metamaterial Surface	79
1.9	Conclusion	83
	References	85
2	Dyadic Green's Function for Biaxial Anisotropic Media	91
	Leonid Pazynin, Seil Sautbekov and Yuriy Sirenko	
2.1	Introduction.	91
2.2	Formulation of the Problem.	92
2.3	Initial Representation for Dyadic Green's Function.	93
2.4	Transformation of the Original Representation. Singular Part of Dyadic Green's Function	94
2.5	Regular Part of Dyadic Green's Function	96
2.6	The Physical Solution.	98
2.7	Conclusion	101
	References	102
3	Operator Fresnel Formulas in the Scattering Theory of Waveguide Modes	103
	Igor Petrusenko and Yuriy Sirenko	
3.1	Introduction.	103
3.2	The Mode-Matching Technique in the Problem of a Waveguide Step-like Discontinuity	106
3.2.1	The Classical Mode-Matching Technique: An Example of Application.	106
3.2.2	The Mode-Matching Technique in the Problem of a Step Discontinuity in a Waveguide: Standard Approach	108
3.2.3	New Formulation of the Problem of Scattering of Waveguide Modes	114
3.3	Matrix Operator Formalism in the Scalar Mode Analysis	114

3.4	Generalized Mode-Matching Technique in the Step Discontinuity Problem	119
3.4.1	Derivation of the Operator Fresnel Formulas	119
3.4.2	Reciprocity Principle and Energy Conservation Law in the Operator Form.	123
3.4.3	Correctness of the Matrix-Operator Model.	127
3.5	Justification of the Truncation Technique for Solving Operator Equations.	129
3.5.1	Construction of Projection Approximations for the Fresnel Formulas	130
3.5.2	Unconditional Convergence of the Truncation Technique	133
3.5.3	Rate of Convergence of the Approximations of Scattering Operators	135
3.6	Mittra Rule for Scattering Operators.	139
3.7	Novel Matrix Models for the Problem of a Step Discontinuity in a Waveguide	143
3.8	The Conservation Laws in Operator Form for Two Classes of Mode Diffraction Problems	148
3.9	Universality of the Operator Fresnel Formulas	155
3.9.1	Step-Like Discontinuity in a Waveguide	155
3.9.2	Generalized Operator Fresnel Formulas for Resonant Discontinuities.	157
3.10	Matrix Scattering Operators.	159
3.10.1	Properties of Reflection and Transmission Operators.	159
3.10.2	Basic Operator Properties of the Generalized Scattering Matrix	164
3.11	Conclusion	172
	Appendix A: Vectors and Their Spaces	175
	Appendix B: Infinite Systems of Linear Algebraic Equations	179
	Appendix C: Operator Forms of the Energy Conservation Law Under Time Reversal	184
	References	185
4	Two-Dimensionally Periodic Gratings: Pulsed and Steady-State Waves in an Irregular Floquet Channel	187
	Lyudmyla Velychko	
4.1	Introduction.	187
4.2	Fundamental Equations, Domain of Analysis, Initial and Boundary Conditions	189
4.3	Time Domain: Initial Boundary Value Problems	192
4.4	Exact Absorbing Conditions for the Rectangular Floquet Channel	194
4.5	Some Important Characteristics of Transient Fields in the Rectangular Floquet Channel	197

4.6	Transformation Operator Method	202
4.6.1	Evolutionary Basis of a Signal and Transformation Operators	202
4.6.2	Equations of the Operator Method in the Problems for Multilayered Periodic Structures	206
4.7	Some Important Properties of Steady-State Fields in the Rectangular Floquet Channel	208
4.7.1	Excitation by a <i>TM</i> -Wave	208
4.7.2	Excitation by a <i>TE</i> -Wave	212
4.7.3	General Properties of the Grating's Secondary Field	213
4.7.4	Corollaries of the Reciprocity Relations and the Energy Conservation Law	215
4.8	Elements of Spectral Theory for Two-Dimensionally Periodic Gratings	217
4.8.1	Canonical Green Function	217
4.8.2	Qualitative Characteristics of the Spectrum	219
4.9	Conclusion	223
	References	223
5	The Exact Absorbing Conditions Method in the Analysis of Open Electrodynamical Structures	225
	Kostyantyn Sirenko and Yuriy Sirenko	
5.1	Introduction	225
5.2	Circular and Coaxial Waveguides	228
5.2.1	Formulation of the Model Problem	228
5.2.2	Radiation Conditions for Outgoing Waves	230
5.2.3	Nonlocal Exact Absorbing Conditions	235
5.2.4	Local Exact Absorbing Conditions	237
5.2.5	Equivalence Theorem	241
5.3	Compact Axially Symmetric Structures	245
5.3.1	Formulation of the Model Problem	245
5.3.2	Radiation Conditions for Outgoing Waves	246
5.3.3	Far-Field Zone Problem, Extended and Remote Sources	254
5.3.4	Virtual Feed Lines in Compact Open Structures	259
5.4	Characteristics of Steady-State and Transient Fields in Axially Symmetric Structures	263
5.4.1	Frequency-Domain Prototypes for Initial Boundary Value Problems	263
5.4.2	Electrodynamical Characteristics of Open Axially Symmetric Structures	265
5.4.3	Spectral Characteristics of Open Resonators	269
5.5	Plane Models for Open Electrodynamical Structures	275
5.5.1	The Key Problem	275

5.5.2	Exact Absorbing Conditions for Parallel-Plate Waveguides	277
5.5.3	Exact Absorbing Conditions for Cylindrical Virtual Boundary in Free Space	283
5.5.4	Exact Absorbing Conditions for Rectangular Virtual Boundary in Free Space	286
5.5.5	Frequency-Domain Formalism and Main Characteristics of Open Plane Structures	291
5.6	3-D Vector Models	292
5.6.1	Exact Absorbing Conditions for Regular Hollow Waveguides	294
5.6.2	Radiation Conditions and Exact Absorbing Conditions for Spherical Virtual Boundary in Free Space	300
5.6.3	<i>TM</i> -Excitation: Frequency-Domain Characteristics	306
5.6.4	<i>TE</i> -Excitation: Frequency-Domain Characteristics	310
5.7	Accurate and Efficient Calculations	311
5.7.1	General Questions	311
5.7.2	Nonlocal or Local Conditions?	312
5.7.3	The Blocked FFT-Based Acceleration Scheme	314
5.7.4	Efficiency and Accuracy of the Blocked FFT-Based Acceleration Scheme. Numerical Results	317
5.7.5	Test Problems	320
5.8	Conclusion	322
	References	324
6	High-Power Short Pulses Compression: Analysis and Modeling	327
	Vadym Pazynin, Kostyantyn Sirenko and Yuriy Sirenko	
6.1	Introduction	327
6.2	Exact Absorbing Conditions Method: 2-D Case	329
6.2.1	Planar Structures	329
6.2.2	Axially Symmetric Structures	337
6.3	Energy Accumulation in Direct-Flow Waveguide Compressors	343
6.3.1	Slot Switches	343
6.3.2	Active Compressors Based on Circular and Coaxial Waveguides	348
6.3.3	Distributed Switches and Active Compressors Based on Rectangular Waveguides	352
6.4	Radiation of High-Power Short Pulses	358
6.4.1	Radiation of Compressed Pulses by Simple Antennas	360
6.4.2	Novel Antenna Array Design with Combined Compressor/Radiator Elements	367
6.5	Compression of Frequency-Modulated Electromagnetic Pulses in Hollow Waveguides	371

6.5.1	Transport Operators for Regular Waveguides	373
6.5.2	Pulse Compression in Regular Waveguides	375
6.6	Conclusion	382
	References	383
7	Diffraction Radiation Phenomena: Physical Analysis and Applications.	387
	Seil Sautbekov, Kostyantyn Sirenko, Yuriy Sirenko, Alexey Vertiy and Anatoliy Yevdokymov	
7.1	Introduction.	387
7.2	Periodic Structures and Dielectric Waveguides: Analysis Techniques	389
7.2.1	Plane Models for Infinite Gratings: Time-Domain Representations	389
7.2.2	Plane Models for Infinite Gratings: Frequency-Domain Representations	394
7.2.3	Infinite Gratings as Open Resonators or Open Waveguides.	397
7.2.4	Some Further Comments.	397
7.3	Diffraction Radiation Phenomena	400
7.3.1	Reflecting Gratings in the Field of a Density-Modulated Electron Flow	400
7.3.2	Finite Gratings: Plane and Axially Symmetric Models	408
7.3.3	Near-Field to Far-Field Conversion by Finite Periodic Structures. Plane Models	411
7.3.4	Near-Field to Far-Field Conversion by Finite Periodic Structures. Axially Symmetric Models	416
7.4	Synthesis of Diffraction Antenna Components and Units.	423
7.4.1	Synthesis of Radiators with Predetermined Amplitude-Phase Field Distribution on the Aperture	423
7.4.2	Maintenance of Antenna Operability on Coupling Level	429
7.5	The Low-Side-Lobe Planar Antenna.	432
7.5.1	Radiator's Characteristics	432
7.5.2	Antenna Design	435
7.5.3	Experimental Data	438
7.6	Conclusion	440
	References	440
	Index	443