

Index

- Airy function 191–192, 198
- amplitude amplification 364,
370–371, 373, 375, 377
- arbitrary time-varying magnetic
field approximation 106

- Bessel functions, modified 54, 63,
67, 130, 143, 398, 419
- boundary 4, 23, 34–39, 120–124,
127–128, 131–135, 138,
144–146, 155, 157, 160,
164–166, 173, 189, 192,
195–198, 209–210, 213–214,
218, 227, 229, 235, 237, 245,
249–251, 257–258, 277,
279–284, 287–290, 292,
294–295, 297–303, 306,
309–311, 317, 324–325,
328–329, 331, 333–334,
337–344, 346, 351, 358,
360, 365–367, 371, 379,
392, 395, 418, 427
- flat 146, 151
- inner 265, 272
- lower 172–173, 404–405
- runaway 340
- stationary 304
- temporal 190
- uniformly moving 279, 281, 283,
285, 287
- upper 172, 174, 405–406
- waveguides 438–439
- boundary conditions 13, 16, 25,
27, 120, 169, 190–191, 193,
200, 278–280, 287, 291,
320, 365–366, 393, 397,
400, 439
- boundary influence 36, 129–131,
142, 155, 231, 426
- boundary movement 278, 283,
287–288, 293, 299, 338, 342,
347, 350
- uniform 297, 302
- boundary movement velocity 293,
338
- boundary-value problem 210,
320–321
- boundary velocity 279–281, 284,
287, 289–290, 292, 295–299,
309–310, 338, 340, 342, 345,
354, 364
- Brillouin waves 336, 342, 364,
441–443, 445–446
- Brillouin waves approach 434,
447

- cluster velocity 377–378, 382,
385–386
- cold plasma 343, 355, 357, 365,
368
- core medium, time-varying 407
- core permittivity 409, 414, 434,
439, 444

- dielectric 2, 121, 123, 151, 157,
162, 181, 191, 193, 209, 216,

- 224–225, 227, 245, 302, 341, 377–378, 401, 414
- dielectric half-space 211, 213, 215, 217, 219, 221, 223
- dielectric layer
 - collapsing 303, 305, 307, 309–310
 - linear 182–183
- dielectric medium 317, 334
- dielectric permittivity 73, 76, 125, 190
- dielectric permittivity jump 75–76
- dielectric waveguide 317, 394–395, 400, 418, 433–435, 437–439, 441, 443–445, 447
- dielectric waveguides, time-varying 396

- eigen-frequencies 273, 319, 435, 443, 445, 448
- eigen-frequency approach 444, 447
- eigen-functions 320
- eigen-waves 108, 433, 435, 441
- electric field vector 257, 263, 306
- electromagnetic field
 - free-space 20
 - initial 225, 260
 - non-stationary 318
 - primary 112
 - transient 355
- electromagnetic field evolution 132, 438
- electromagnetic field
 - transformation 57, 191
- electromagnetic oscillations 102–103, 145, 441, 443
- electromagnetic problems
 - boundary value 260, 269, 438
 - initial-boundary value 434
- electromagnetic transients 210, 212, 214, 216, 218, 220, 222, 224, 226, 228, 230, 232, 234, 236, 238, 240, 242, 244, 246, 248, 250, 252, 254, 256, 258, 260, 262, 264, 266, 268, 270, 272, 274, 324, 418
- influence of medium plane
 - boundaries on 119–120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202
- electromagnetic wave
 - diffraction 146
 - in isotropic plasma 99, 101
 - propagation 169
- electromagnetic waves
 - amplification 189
 - plane 162
 - plane harmonic 125
 - scattering 224, 292
 - secondary 355
 - source of 281, 339
 - transformation of 60, 94, 102, 190, 225
 - transmitted 381
- equation kernels 32, 100, 147
- integral 44, 101
- equations, inhomogeneous 21

- FDTD, *see* finite difference time domain
- field asymptotic 167–168
- field discontinuities 131, 179, 306
- field evolution 433, 435, 437, 439, 441, 443, 445, 447

- field time behavior 224
- field vector 237–238
- finite difference time domain (FDTD) 119–120, 169, 185, 187–188
- FMC, *see* frequency multiplication coefficient
- frequency
 - complex 266, 268
 - critical 337, 344, 363
 - cutoff 326, 331, 335–336
 - gyrotropic 99, 104
 - normalized 179, 426, 430
 - vibration 332–333
- frequency multiplication coefficient (FMC) 370–371, 377, 381
- frequency multiplication
 - effectiveness 384, 386
- Fresnel coefficients 223, 254–255
- Fresnel formulae 215, 225, 227–229, 238–239, 298

- Gaussian pulse 181–183
- Gaussian pulse signals 182–183
- generalized functions 4, 16, 27, 34, 396–397
 - theory of 10, 21
- generalized parameter 81–82, 84, 86, 89, 95–96, 98
- generalized wave equation 10–11, 13, 15, 17–19, 396
- Green's function 21–22, 24–25, 27, 32, 68, 318–319, 398–399
- gyrotropic plasma 102–103, 105, 107, 109, 111, 113

- half-restricted time-varying
 - medium 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145
- harmonic wave 76–77, 79, 81, 83, 85, 87, 89, 189, 191, 400
- harmonic wave transformation 407, 409, 411, 413, 415
- Hurst's index 88–90, 94–96

- infinite medium problem 218
- initial-boundary problem 146, 259
- initial-boundary-value problem 99, 120, 146
- integral equation method/approach 76, 99, 173, 191, 193, 200, 225, 261, 278, 395
- inverse wave 84, 128, 138–141, 235, 237, 240, 250
- isotropic plasma 99, 101

- Laplace transform 261, 263, 269, 347, 403, 435, 439, 441
 - inverse 151, 264–265, 435–436, 440–441, 444
- late-time analysis 120, 169
- late-time approximation 129, 132, 134, 201
- linear medium, time-varying 82
- Lipschitz–Hankel functions 132
- Lipshitz–Hankel functions 200
- Lyapunov exponent 94, 97–98

- magnetic field
 - arbitrary time-varying 106
 - extrinsic 59, 99
 - slow time-varying external 102
 - static 46

- magnetic induction 13–15
- magnetizing field 102–103, 105, 107, 109, 111, 113
- Maxwell's equations 4, 11–12, 15–16, 21, 23, 25, 120, 169, 190, 260, 269, 321–322, 365, 368, 393, 396, 439
 - fundamental solutions to 21, 23, 25
- medium
 - conductive 145
 - immovable 279–280, 282
 - motionless 336–337
 - medium boundary 10, 119–122, 144–145, 189, 193, 195, 212, 233, 237, 239, 241–242, 246, 250, 257–258, 277–280, 282, 284, 286, 288, 290, 292–302, 304, 306, 308, 310, 317, 328, 355
 - moving 302, 354, 364
 - non-stationary 121, 229
 - non-stationary conductive 141
 - medium parameters 10–11, 57, 59–60, 63, 68, 77, 89, 94, 125–127, 138, 183, 185–190, 225, 261, 277, 283, 395, 416–417, 423
 - time jump in 63
 - time jump of 76, 403
 - time modulation of 59, 189
 - medium permittivity 121, 125, 162, 186–187, 260, 335, 429, 432
 - medium plane boundaries 119–120, 122, 124, 126, 128, 130, 132, 134, 136, 138, 140, 142, 144, 146, 148, 150, 152, 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200, 202
- metallic waveguide 1, 317–318, 320, 322, 324, 326, 328, 330, 332, 334, 338, 340, 342, 344, 346, 348, 350, 352, 354–370, 372, 374, 376, 378, 380, 382, 384, 386
- modulation frequencies 184, 392
 - temporal medium 184
 - time-spatial medium 184
- monochromatic waves 2, 76, 151, 230, 246, 254, 288, 328
- moving boundaries 9, 277–281, 283, 291, 339, 341, 343, 350, 365
- moving dielectric 335–336, 338
- moving medium 21, 279–280, 317–318, 320, 322, 324, 326, 328, 330, 332, 334, 337–340, 342, 344, 346, 348, 350, 352, 354, 356, 358, 360, 362–366, 368, 370, 372, 374, 376, 378, 380, 382, 384, 386
- moving plasma bunch 355, 358, 374
- moving semi-infinite medium 341
- non-dispersive medium 19–20
- non-dispersive time-varying medium 60–61, 63, 65, 67, 69, 71, 73, 75
- non-linear and time-varying medium 168–169, 171, 173, 175, 177, 179, 181, 183, 185, 187
- non-linear dielectric layer 180–182, 188
- non-linear dielectric waveguide 416–417, 419, 421, 423, 425, 427, 429, 431
- non-linearity 172, 181, 183, 188, 429–430, 432–433

- non-stationarity 168, 189, 277–278, 280, 282, 284, 286, 288, 290, 292, 294, 296, 298, 300–302, 304, 306, 308, 310, 322, 324, 343, 363
- non-stationary boundary value problem 418
- non-stationary eigen-functions 318–319, 321, 323
- non-stationary electromagnetic problem 10, 59
- non-stationary medium 27, 94, 126–127, 194, 196, 230, 251, 417

- optical frequency plasmon pulses 393
- orthogonal vector spherical functions 260, 269
- oscillatory approach 433–434, 437–438, 444, 446

- partial spherical waves 259, 261, 263, 265, 267
- permittivity time jump 230, 239, 409
- phase velocity 18, 74–75, 135, 144, 164, 263, 265, 272, 280–281, 298–299, 310, 336–337, 397, 419, 424
 - internal 309–311
- plane dielectric resonator 328–329, 331, 333
- plasma
 - cold isotropic 19, 46, 49, 335, 357
 - half-restricted 343–344
 - over-critical 257
 - stationary 100, 146, 151, 157, 254
 - time change of 251, 253, 255, 257
 - time-varying 251
 - under-critical 257
- plasma boundary 157, 160–162, 252, 258, 343, 351–353
 - moving 350–351, 353
 - plane motionless 346
- plasma bunch 354–355, 357, 359, 361, 363–365, 367, 369–370, 378
- plasma bunch phase velocity 358
- plasma bunch velocity 356, 376, 378
- plasma cluster 379
 - stratified 378–379, 381, 383, 385
- plasma density 99, 101, 103, 146, 152, 154–155, 157, 159–160, 162, 257, 343, 372–373, 375–376, 378–379, 386
 - step-wise change of 99, 101
- plasma dispersion 343, 352–353, 377–378
- plasma frequency 19, 99–101, 146, 152, 154, 157–158, 160, 216, 252, 254, 256–257, 343, 345, 357, 365, 370, 378, 401
- plasma half-space 147, 149, 151, 153, 155, 157, 159, 161
- plasma ignition 269, 271, 273
- plasma oscillation field 112–113
- plasma oscillations 103, 112–114, 254
- plasma permittivity 252, 254
- plasma plane boundary 256
- plasma polarization 154
- plasma slabs 378–379
- plasma sphere 269, 271
- plasma velocity 354, 357–358, 377
- point harmonic source 246, 249

- point source radiation 229, 245, 247, 249, 251
- quantum electronics 119, 168, 392
- refractive index 191–192, 195–197, 279, 362, 392–393
- resolvent construction 121, 209
- resolvent kernel 404–405
- resolvent light cone 122, 125
- Riemann surface 232, 234–236, 349–350, 440–441
- solid medium parameters, time jumps of 11
- spatial-time coordinates 136, 446
- stationary boundary value problems 27
- tensor equation 22–23
- tensor function 25
- time harmonic dependence 264, 271
- time-spatial coordinates 193, 197
- time-spatial region 34, 193, 348
- time-spatial structure, triple asymmetry in 189, 191, 193, 195, 197, 199
- time-spatial zones 197, 300, 404, 418
- time variations, arbitrary 264, 416
- time-varying parameters 9–10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34–36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 59–60, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100, 102, 104, 106, 108, 110, 112, 114, 169, 183
- arbitrary 119, 168
- time-varying systems, linear 90–91, 93–95, 97
- transverse wavenumber 407, 410, 414
- vector, time-spatial 41, 402, 423
- vector eigen-functions 320–321
- vector functions 10, 227–228, 321
 - spherical 261, 263, 269
 - transverse spherical 260, 269
- Volterra integral equations 27, 34, 120, 169, 343, 397, 399, 401
- wave amplitude 75, 83, 94, 155, 245, 251, 288, 305, 308, 310, 352
 - direct 88–90
 - internal 306
 - secondary 85–87
- wave equations 16, 24, 394
- wave frequency 190, 215, 288, 290, 309, 336, 351, 354, 368
 - initial 265, 331, 431
 - reflected 298, 308, 340
- wave numbers 281, 319, 335, 350–351, 355–356, 360, 363, 367–368, 379
- wave phase velocity 63, 264, 281, 287, 289, 292, 305, 336, 354, 364, 439
- wave propagation 190
- wave splitting 66, 68, 94, 235

- wave vector 65, 109, 114, 230, 233, 244
- waveguide
 - optical 394
 - planar 399
 - rectangular 24–25, 317–318
 - rectangular metal 25–26
- waveguide boundaries 403–405, 409
- waveguide core 392, 397, 399, 401, 407, 409, 411, 413, 415, 419, 421
- waveguide cross-section 320, 322
- waveguide dispersion 317, 324, 334–335, 337, 339, 341, 377–378
- waveguide parameters 375, 377, 382
- waveguide walls 25, 397, 400, 403–404, 408–410, 412, 414, 416, 423–424, 427–428, 431, 438
- waves
 - reverse 82, 157
 - split 67, 77, 306
 - stationary 161–162, 229, 242, 352–353
 - time-reversed 191

“This book presents advanced analytical models based on Volterra integral equations for electromagnetic wave phenomena in dynamically changing environments in a complete, mathematically rigorous but still very clear way. The analyzed problems are presented hierarchically in a very logical structure, and their analytic solutions are suitably illustrated with highly instructive graphs and drawings. The book may serve indisputably as an indispensable reference for academicians, researchers, and students studying electromagnetic wave phenomena in a variety of wavelength ranges, including optical, terahertz, microwave, and other radiations.”

Prof. Marian Marciniak
National Institute of Telecommunications, Poland

“This book comes as a most timely contribution, bringing the collected and systematized knowledge on non-stationary electromagnetic processes in plasma, waveguides, and moving media to the tables of experts working on time-modulated platforms for microwave, photonic, and acoustic devices.”

Prof. Sergei A. Tretyakov
Aalto University, Finland

“This book deals with a modern subject in electromagnetics and ably presents a generalized theory of non-stationary electromagnetics. The theory is validated by applying it to several particular cases of time-varying media problems solved earlier by the authors of the book as well as other researchers. The generalization of the theory should lead to the solution of a large range of problems of this developing field.”

Prof. Dikshitulu Kalluri
University of Massachusetts Lowell, USA

This book is devoted to the investigations of non-stationary electromagnetic processes. The investigations are undertaken analytically mainly using the Volterra integral equations approach. The book contains a systematic statement of this approach for the investigations of electrodynamics phenomena in the time domain and new results and applications in microwave techniques and photonics. Particular consideration is given to electromagnetic transients in time-varying media and their potential applications. The approach is formulated and electromagnetic phenomena are investigated in detail for a hollow metal waveguide, which contains moving dielectric or plasma-bounded medium, and dielectric waveguides with time-varying medium inside a core.



Alexander Nerukh is professor and head of the Department of Higher Mathematics, Kharkov National University of Radioelectronics, Ukraine. His main scientific interests are in radiophysics, transient and non-linear electrodynamics, nanophotonics, and dynamical chaos. He has published more than 330 journal/conference papers and 4 books. Prof. Nerukh is a senior member of the IEEE and a member of the European Microwave Association Member and the Optical Society.



Trevor Benson is professor of optoelectronics and a member of the George Green Institute for Electromagnetics Research at the University of Nottingham, UK. His research interests include experimental and numerical studies of electromagnetic fields and waves, mid-infrared photonics, lasers and amplifiers, and the electromagnetic resilience of aircraft. He is the author or coauthor of more than 800 journal and conference papers.