
Contents

1	Introduction	1
I	Motivation	1
II	The Architecture	3
II.1	Problem Partitioning	3
II.2	Network Representations	4
II.3	Methodological Hybridization	5
III	Organization of the Book	6
	References	9
2	Representations of Electromagnetic Fields	13
I	Introduction	13
II	Maxwell's Equations	14
II.1	Maxwell's Equations in Time-Dependent Form	14
II.2	Maxwell's Equations in the Frequency Domain	17
II.3	Maxwell's Equations in the \bar{s} -Domain	18
II.4	Constitutive Relations	18
II.5	Boundary Conditions	20
III	Theorems and Concepts for Electromagnetic Field Computation	21
III.1	Energy and Power	22
III.2	Field Theoretic Formulation of Tellegen's Theorem	26
III.3	Uniqueness Theorem	27
III.4	Equivalence Theorem	28
IV	Field Potentials	32
V	Separation of Variables: The Scalar Wave Equation	35
V.1	The Scalar Wave Equation in Cartesian Coordinates	37
V.2	The Scalar Wave Equation in Spherical and Polar Coordinates	40
V.3	The Scalar Wave Equation in Cylindrical Polar Coordinates	41

XII Contents

VI	Sturm–Liouville Problems	43
VI.1	Source–Free Solutions: Eigenvalue Problem	43
VI.2	Source–Driven Solutions: Green’s Function Problem	49
VI.3	Relation Between the Spectral (Characteristic) Green’s Function and the Eigenvalue Problems	54
VII	Radiation and Edge Condition	56
VII.1	Radiation Condition	56
VII.2	Edge Condition in Two Dimensions	58
VIII	Reciprocity and Field Equivalence Principles	59
VIII.1	Reaction in Electromagnetic Theory	59
VIII.2	Lorentz Reciprocity Theorem	60
References		67
3	Wave–Guiding Configurations	69
I	Introduction	69
II	The Transverse Field Equations	70
II.1	Source–Free Case	70
II.2	Source–Excited Case	72
III	TE and TM Potentials	74
IV	Modal Representations of the Fields and Their Sources	77
V	Scalarization and Modal Representation of Dyadic Green’s Functions in Uniform Regions	80
V.1	Mode Functions	81
VI	Fields in Source-Free, Homogeneous Regions	82
VII	Green’s Functions for the Transmission-Line Equations	83
VIII	Modal Representations of the Dyadic Green’s Functions in a Piecewise Homogeneous Medium	85
IX	Modal Representations of the Dyadic Green’s Functions in an Inhomogeneous Medium	91
X	Network–Oriented Formulation of the Characteristic Green’s Functions	93
X.1	Alternative Representations	99
XI	1D Characteristic Green’s Function and Eigenfunction	104
References		123
4	Two–Dimensional Problems	125
I	Introduction	125
II	Electric Line Source in a PEC Parallel Plate Waveguide	125
II.1	Constituent One–Dimensional Problems: x -Domain	126
II.2	Problems in the z -Domain	131

II.3	Two-Dimensional Waveguide:(Finite x)–(Bilaterally Infinite z)–Domain	141
III	Electric Line Source in Radial–Angular Waveguides	150
III.1	Introduction	150
III.2	Constituent 1D Problems	151
III.3	Eigenvalue Problem in the ρ –Domain	152
III.4	Spectral Green’s function problem in the ρ –domain	153
III.5	Two–Dimensional Green’s Functions: Alternative Representations	153
	References	155
5	Network Representation of Electromagnetic Fields	157
I	Introduction	157
II	Method of Moments	159
II.1	Expansion Set	161
III	Regions of Zero Volume: the Connection Network	164
III.1	The Connection Network	164
III.2	Tellegen’s Theorem for Discretized Fields	166
III.3	Testing of the Field Continuity Equations	166
III.4	Independent Quantities	167
III.5	Tellegen’s Theorem and its Implications	168
III.6	Application to Orthonormal Bases	168
III.7	Canonical Forms of the Connection Network	169
IV	Network Representations for Regions of Finite Volume	171
IV.1	Foster Representation of the Transmission Line Resonator	172
IV.2	Green’s Function and Multiport Foster Representation	176
IV.3	The Canonical Foster Representation of Distributed Circuits	178
V	Regions Extending to Infinity: Radiation Problems	180
V.1	The Cauer Canonic Representation of Radiation Modes	183
V.2	The Complete Equivalent Circuit of Radiating Electromagnetic Structures	185
VI	Solving the Entire Field Problem via Tableau Equations	186
VI.1	Primary and Secondary Fields	186
VI.2	Choice of Primary and Secondary Fields for a Subregion	189
VI.3	A Constraint on the Choice of Primary and Secondary Fields	189
VI.4	Topological Relationships: Operator Form	190
VI.5	The Tableau Equations for Fields: Operator Form	191
VI.6	Solving the Entire Field Problem via Tableau Equations: Discretized Form	191
VI.7	Field Discretization	192
VI.8	The Tableau Equations for Discretized Fields	195

XIV Contents

References	197
Appendix	199
Index	209

Electromagnetic Field Computation by Network Methods

Felsen, L.B.; Mongiardo, M.; Russer, P.

2009, XIV, 214 p. 58 illus., Hardcover

ISBN: 978-3-540-93945-0