



Introduction to Optical Waveguide Analysis

Solving Maxwell's Equations
and
the Schrödinger Equation

KENJI KAWANO
TSUTOMU KITOH

CONTENTS

Preface / xi

1	Fundamental Equations	1
1.1	Maxwell's Equations / 1	
1.2	Wave Equations / 3	
1.3	Poynting Vectors / 7	
1.4	Boundary Conditions for Electromagnetic Fields / 9	
Problems	/ 10	
Reference	/ 12	
2	Analytical Methods	13
2.1	Method for a Three-Layer Slab Optical Waveguide / 13	
2.2	Effective Index Method / 20	
2.3	Marcatili's Method / 23	
2.4	Method for an Optical Fiber / 36	
Problems	/ 55	
References	/ 57	

3 Finite-Element Methods

59

- 3.1 Variational Method / 59
- 3.2 Galerkin Method / 68
- 3.3 Area Coordinates and Triangular Elements / 72
- 3.4 Derivation of Eigenvalue Matrix Equations / 84
- 3.5 Matrix Elements / 89
- 3.6 Programming / 105
- 3.7 Boundary Conditions / 110
- Problems / 113
- References / 115

4 Finite-Difference Methods

117

- 4.1 Finite-Difference Approximations / 118
- 4.2 Wave Equations / 120
- 4.3 Finite-Difference Expressions of Wave Equations / 127
- 4.4 Programming / 150
- 4.5 Boundary Conditions / 153
- 4.6 Numerical Example / 160
- Problems / 161
- References / 164

5 Beam Propagation Methods

165

- 5.1 Fast Fourier Transform Beam Propagation Method / 165
- 5.2 Finite-Difference Beam Propagation Method / 180
- 5.3 Wide-Angle Analysis Using Padé Approximant Operators / 204
- 5.4 Three-Dimensional Semivectorial Analysis / 216
- 5.5 Three-Dimensional Fully Vectorial Analysis / 222
- Problems / 227
- References / 230

6 Finite-Difference Time-Domain Method

233

- 6.1 Discretization of Electromagnetic Fields / 233
- 6.2 Stability Condition / 239
- 6.3 Absorbing Boundary Conditions / 241

Problems / 245

References / 249

7 Schrödinger Equation 251

7.1 Time-Dependent State / 251

7.2 Finite-Difference Analysis of Time-Independent State / 253

7.3 Finite-Element Analysis of Time-Independent State / 254

References / 263

Appendix A Vectorial Formulas 265

Appendix B Integration Formula for Area Coordinates 267

Index

273