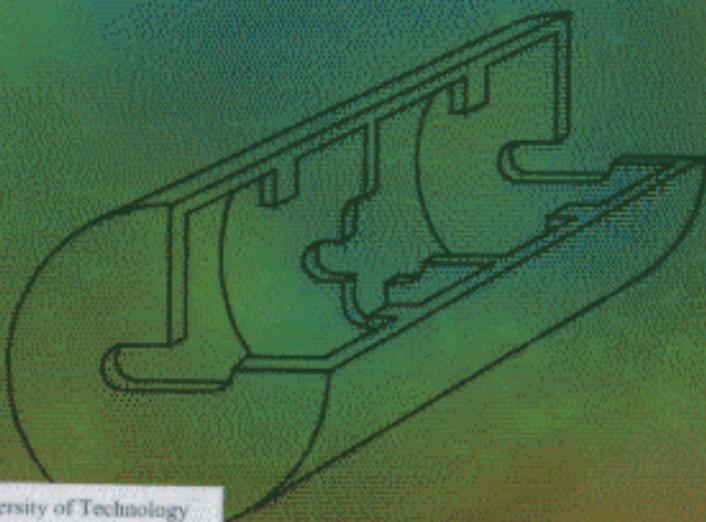




ADVANCED MODAL ANALYSIS

**CAD Techniques for Waveguide
Components and Filters**



Suranaree University of Technology



31051000624482

**Giuseppe Conciauro
Marco Guglielmi
Roberto Sorrentino**

Contents

Preface

xi

1 Electromagnetic field expansions in waveguides	1
1.1 TE and TM modes in hollow waveguides	1
1.2 TEM modes in hollow waveguides	5
1.3 Properties of the modal vectors	6
1.4 The rectangular waveguide	7
1.5 LSM and LSE modes	9
1.6 The circular waveguide	15
1.7 The coaxial waveguide	17
Bibliography	21
2 Cavity resonators	23
2.1 Introduction	23
2.2 Electric and magnetic eigenvectors	24
2.2.1 Electric eigenvectors	25
2.2.2 Magnetic eigenvectors	27
2.2.3 Relation between the electric and magnetic solenoidal eigenvectors	30
2.3 Forced oscillations in resonant cavities	30
2.3.1 The interior problem	31
2.3.2 Resonance in ideal cavities	32
2.3.3 Resonance in real cavities	33
2.4 Admittance matrix of waveguide components	35
2.5 Cylindrical cavities	37
2.6 Spherical cavity	40
2.7 Scalar and vector potentials (Coulomb gauge)	41
2.8 Potential Green's functions	43
2.9 Hybrid representation of cavity fields	46
Bibliography	54

3 Mode matching analysis of planar discontinuities	55
3.1 The microwave network formalism	55
3.2 Cascading admittance matrices	60
3.3 Circuit model of a uniform waveguide length	61
3.4 The step junction	63
3.5 Scattering matrix of the step junction	66
3.6 Cascading admittance and coupling matrices	67
3.7 Admittance matrix of the step junction	68
3.8 Computation of the coupling matrix	69
3.8.1 Coupling matrix between rectangular waveguides	70
3.8.2 Numerical computation of the coupling matrix	72
3.9 Offset step junction	73
3.10 Thin diaphragm	75
3.11 Thick diaphragm	77
3.12 Stub	78
3.13 The program BGCANA	80
Bibliography	85
4 Modal analysis of three-dimensional microwave structures	87
4.1 Introduction	87
4.2 GAM of a rectangular cavity	90
4.2.1 Apertures at opposite sides	92
4.2.2 Apertures at the same side	93
4.2.3 Apertures on adjacent sides	94
4.3 Alternative formulations	96
4.4 H-plane corner	99
4.5 H-plane T-junction	103
4.6 H-plane cross-junction	105
4.7 H-plane mitered bend	106
4.8 E-plane corner. Expansion in TE and TM modes.	107
4.9 E-plane corner. Expansion in LSE modes	110
Bibliography	113
5 The BI-RME method	115
5.1 Introduction	115
5.2 Modes of arbitrarily shaped waveguides	116
5.2.1 TM modes	119
5.2.2 TE modes	125
5.2.3 Symmetries	133
5.2.4 Basis functions and matrix calculation	136

5.2.5 Accuracy control and selection of internal modes	140
5.2.6 Examples	143
5.3 Coupling matrix of a step junction	149
5.3.1 Calculation through the BI-RME method	150
5.3.2 Examples	153
5.4 Modes of arbitrarily shaped 3-D resonators	155
5.4.1 Mode determination	158
5.4.2 Calculation of the Q -factor	164
5.4.3 Basis functions and matrix calculation	164
5.4.4 Notes on symmetries and mode selection	170
5.4.5 Example	172
Bibliography	173
6 Wideband modelling by the BI-RME method	177
6.1 Introduction	177
6.2 Pole expansion of the admittance matrix	178
6.2.1 Calculation of $A_{pq}^{(rs)}$ and $B_{pq}^{(rs)}$	180
6.2.2 Poles and residues	184
6.2.3 Choice of accuracy factor	189
6.3 The code ANAPLAN-W®	189
6.3.1 Examples	190
6.4 Examples of 3-D analyses	191
6.5 Analysis of E-plane Metal Insert Filters	195
6.5.1 Theory	195
6.5.2 Example	202
6.5.3 The program MIF	202
Bibliography	206
7 Integral equations	209
7.1 General formulation in one dimension	209
7.1.1 Inductive step	213
7.1.2 Capacitive step	216
7.1.3 Multiple aperture formulation	220
7.1.4 Applications: the program INDFILT	226
7.2 General formulation in two dimensions	232
7.2.1 Extraction of the frequency dependence	238
7.2.2 Solution of the integral equation	239
7.2.3 Offset steps	240
7.2.4 Applications: the program TWODIM	241
Bibliography	243

8 Alternative computation of admittance parameters	245
8.1 General junction formulation	245
8.1.1 Y-junction	247
8.1.2 H-plane Y-junction	252
8.1.3 E-plane Y-junction	253
8.1.4 C-junction	255
8.1.5 T-junction	263
8.2 Formulation for planar waveguide steps	266
8.3 Improving the computational efficiency	269
8.3.1 Frequency extraction	269
8.3.2 Cascading waveguide steps	274
8.4 Applications	277
Bibliography	284
9 Coupling integrals	287
9.1 Circular waveguide steps	287
9.2 Circular to rectangular steps	300
9.3 Circular coaxial waveguide steps	302
9.4 Elliptical waveguide steps	310
9.5 Rectangular coaxial waveguide steps	318
9.6 Arbitrary waveguide steps	328
Bibliography	332
A Quasi-static 2-D Green's functions	335
A.1 Eigenfunction expansions	335
A.2 Closed-form expressions, circular domain	337
A.3 Rapidly converging expressions for the rectangular domain	338
Index	339