

COMPUTER- AIDED DESIGN OF MICROWAVE CIRCUITS

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Preface

With the introduction of hybrid microwave integrated circuits (MICs), computer-aided design (CAD) techniques have become an essential tool for microwave circuit designers. The circuit design process has become increasingly complex because a large variety of active and passive components are now available for use at microwave frequencies and the increased complexity of modern systems demands more precise and accurate design of circuits and subsystems. Also the hybrid MIC approach provides a very limited possibility of trimming or adjusting the circuit after it has been fabricated.

The area of computer-aided circuit design — including computer-aided microwave circuit design — has undergone rapid advances in recent years. Although there are a number of books available on the CAD of electronic circuits at lower frequencies, there is no book dealing with the CAD of microwave circuits. Since the area of CAD of microwave circuits has now matured, a book on this topic is expedient; the present book is an endeavour in this direction. It is designed to provide a detailed exposition of the concepts and techniques used in the computer-aided analysis and design of microwave circuits.

Any CAD process consists of three important segments, namely, i) modelling, ii) analysis, and iii) optimization. This book discusses these three aspects vis-a-vis microwave circuits. We discuss modelling

of various constituents of microwave circuits. These include transmission lines, discontinuities, lumped elements, planar components, and semiconductor devices. Network representation suitable for analysis is introduced and matrix techniques for analysis of microwave circuits are discussed. Sensitivity analysis and various optimization techniques are presented.

The book is divided into five parts. In Part I, the first chapter describes the evolution of microwave circuits and introduces the concept of the computer-aided circuit design. Chapter Two is a review of the various representations used for microwave circuits.

Modelling of active and passive components is a crucial part of any circuit design; this is discussed in the eight chapters that make up Part II. At microwave frequencies, there is a need to characterize precisely not only the constituent components, but also the associated parasitic reactances. This book contains seven chapters devoted to characterization of various transmission structures, discontinuities, lumped elements, planar components, and semiconductor devices. Sensitivities of various components are useful in tolerance analysis and optimization of circuits. A chapter is devoted to the characterization of the sensitivities of transmission structures. Accurate characterizations of some of these elements (for instance semiconductor devices) is obtained by measurement of S-parameters over the frequency range of interest. Computer-aided measurement techniques using network analyzers are commonly employed. One chapter is devoted to these techniques including six-port measurement concepts.

Circuit analysis is the most important component of the computer-aided design approach. Part III deals with various methods used for analysis. Microwave circuit analysis is usually carried out in terms of S-matrices. Various chapters deal with the evaluation of the S-matrix of the overall network using the known S-matrices for the individual components, the sensitivity analysis, the tolerance analysis, and the time-domain analysis. All these analyses involve solutions of matrix equations, techniques for which are discussed in a separate chapter.

There are several techniques available for optimization of microwave circuits. Both direct search and gradient methods have been used. Basic concepts in optimization, one-parameter optimization, and multi-parameter optimization techniques are discussed in the three

chapters in Part IV. Methods discussed include pattern search, Rosenbrock's method, simplex method, Newton-Raphson method, Davidon-Fletcher-Powell method, and a method for optimizing least square objective functions.

Part V includes two chapters describing CAD programs. A microwave circuit analysis program (MCAP) developed at IIT Kanpur is described. The final chapter, contributed by Mr. Les Besser of Compact Engineering, is a review of some commercially available programs.

Several algorithms have been included in this book in Chapter Thirteen and in later chapters. These have been written in an ALGOL type language and could be skipped over in the first reading when the reader is not familiar with this type of language.

This book evolved from a set of lecture notes first prepared for a graduate course on CAD of microwave circuits offered at IIT Kanpur in the spring semester of 1978. Part of the material has been used subsequently for a course on microwave circuits. Work on CAD of microwave integrated circuits carried out at IIT Kanpur formed a part of a project sponsored by the Department of Electronics (Government of India, New Delhi) and contributed to the contents of this book. Parts of this material were used for a series of seminars delivered at Eidgenössische Technische Hochschule, Zurich in summer 1979 and appeared as an internal publication (Bericht Nr. 79-10) of the Mikrowellen Laboratorium there.

The proposed book will serve microwave circuit designers and graduate students in microwaves. It could be used as a supplementary text for courses on microwave circuits and computer-aided network analysis and design. Part V on CAD programs may be read without going through the rest of the book. Chapter 19 on MCAP could be used directly for analysis of microstrip and stripline circuits.

The authors are grateful to Mr. Les Besser for contributing Chapter 20. Discussions with several colleagues at IIT Kanpur and at Eidgenössische Technische Hochschule Zurich are thankfully acknowledged. Facilities extended by the Department of Electrical Engineering and the Advanced Center for Electronic Systems at IIT Kanpur are acknowledged. The typing of the manuscript has been handled efficiently by Mr. C.M.

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Contents

Part I Introduction

Chapter 1

MICROWAVE CIRCUITS AND COMPUTER-AIDED DESIGN	3
1.1 EVOLUTION OF MICROWAVE CIRCUITS	3
1.2 COMPUTER-AIDED DESIGN APPROACH	8
1.3 OUTLINE OF THE BOOK	14
REFERENCES	19

Chapter 2

MICROWAVE NETWORK REPRESENTATION	25
2.1 ABCD PARAMETERS	26
2.2 SCATTERING PARAMETERS	30
2.2.1 Definition and General Properties	30
2.2.2 Relationship with Other Representations	33
2.3 TRANSFER SCATTERING MATRIX REPRESENTATION	36
APPENDIX 2.1 ABCD, S-AND T-MATRICES FOR SOME OF THE COMMONLY USED TWO-PORTS	39
REFERENCES	43

Part II Modelling of Circuit Elements

Chapter 3

CHARACTERIZATION OF TRANSMISSION STRUCTURES	47
3.1 COAXIAL LINES	49
3.2 WAVEGUIDES	53
3.2.1 Rectangular Waveguides	53
3.2.2 Circular Waveguides	55

5506697

3.3	STRIPLINES	57
3.4	MICROSTRIP LINES	60
3.5	SLOT LINES	65
3.6	COPLANAR LINES	67
3.7	COUPLED STRIPLINES	72
3.8	COUPLED MICROSTRIP LINES	76
	REFERENCES	85

Chapter 4

SENSITIVITIES OF TRANSMISSION STRUCTURES	91
4.1 INTRODUCTION	91
4.1.1 Definitions	91
4.1.2 Applications of Sensitivity Analysis	92
4.1.3 Tolerance Analysis of Transmission Lines	93
4.2 COAXIAL LINES	95
4.3 WAVEGUIDES	97
4.4 STRIPLINES AND MICROSTRIP LINES	100
4.4.1 Striplines	100
4.4.2 Microstrip Lines	102
4.5 SLOT LINES AND COPLANAR LINES	106
4.5.1 Slotlines	106
4.5.2 Coplanar Lines	112
4.6 COUPLED STRIPLINES AND COUPLED MICROSTRIP LINES	117
4.6.1 Coupled Striplines	117
4.6.2 Coupled Microstrip Lines	120
REFERENCES	126

Chapter 5

CHARACTERIZATION OF DISCONTINUITIES-I	
<i>Coaxial Lines and Waveguides</i>	129
5.1 INTRODUCTION	129

20000000

5.2	COAXIAL LINE DISCONTINUITIES	131
5.2.1	Capacitive Gaps in Coaxial Lines	131
5.2.2	Steps in Coaxial Lines	135
5.2.3	Capacitive Windows in Coaxial Lines	136
5.2.4	T-Junction or Stub in Coaxial Lines	139
5.3	RECTANGULAR WAVEGUIDE DISCONTINUITIES	139
5.3.1	Posts in a Waveguide	139
5.3.2	Strips in Waveguides	149
5.3.3	Diaphragms or Windows in Waveguides	152
5.3.4	Steps in Waveguides	159
5.3.5	Right-Angled Bends or Corners in Waveguides	166
5.3.6	T-junctions	169
5.3.7	Circular and Elliptical Apertures in Waveguides	173
	REFERENCES	177

Chapter 6

CHARACTERIZATION OF DISCONTINUITIES -II

	<i>Striplines and Microstrip Lines</i>	179
6.1	STRIPLINE DISCONTINUITIES	181
6.1.1	Open-End	183
6.1.2	Round-Hole	184
6.1.3	Gap	185
6.1.4	Step in Width	186
6.1.5	Bend	186
6.1.6	T-junction	188
6.2	MICROSTRIP DISCONTINUITIES	189
6.2.1	Open-End	190
6.2.2	Gap	191
6.2.3	Notch	192
6.2.4	Step in Width	192
6.2.5	Right-angled Bend	195
6.2.6	T-junction	195
6.2.7	Cross-junction	197
	REFERENCES	200

Chapter 7

LUMPED ELEMENTS IN MICROWAVE CIRCUITS	205
7.1 BASIC CONSIDERATIONS	205
7.2 DESIGN OF LUMPED ELEMENTS	206
7.2.1 Resistors and Inductors	207
7.2.2 Capacitors	213
7.3 MEASUREMENTS OF LUMPED ELEMENT PARAMETERS	220
REFERENCES	226

Chapter 8

TWO-DIMENSIONAL PLANAR COMPONENTS	229
8.1 BASIC CONCEPTS	231
8.2 GREEN'S FUNCTION APPROACH	237
8.3 EVALUATION OF GREEN'S FUNCTIONS	242
8.3.1 Method of Images	243
8.3.2 Expansion of Green's Function in Eigenfunctions	244
8.3.3 Green's Functions for Various Configurations	247
8.4 SEGMENTATION AND DESEGMENTATION	251
8.5 NUMERICAL METHODS FOR ARBITRARY SHAPES	253
8.6 SCALING FOR PLANAR CIRCUITS	256
8.6.1 Frequency Scaling	257
8.6.2 Impedance Scaling	257
8.6.3 Designs of Stripline Type Circuits from a Microstrip Type Planar Circuit (and Vice Versa)	257
REFERENCES	259

Chapter 9

MODELS FOR MICROWAVE SEMICONDUCTOR DEVICES	263
9.1 SCHOTTKY-BARRIER AND POINT-CONTACT DIODES	264

9.2	VARACTOR DIODES	267
9.3	PIN DIODES	268
9.4	BIPOLAR TRANSISTORS AND MESFETS	269
9.4.1	Bipolar Transistors	269
9.4.2	MESFETs	277
9.5	GUNN AND IMPATT DIODES	285
9.5.1	Gunn Diodes	285
9.5.2	Impatt Diodes	289
	REFERENCES	293

Chapter 10

MEASUREMENT TECHNIQUES FOR MODELLING		295
10.1	MICROWAVE NETWORK ANALYZERS	296
10.1.1	Network Analyzer	296
10.1.2	Automatic Network Analyzer	301
10.1.3	Six-Port Network Analyzer	303
10.2	SYSTEM ERROR MEASUREMENT AND CORRECTION	307
10.2.1	General Considerations	307
10.2.2	One-port Device Measurements	311
10.2.3	Two-port Measurements	313
10.2.4	Three-port and Multiport Measurements	317
10.2.5	Characterization of Connectors	319
10.3	DATA REDUCTION TECHNIQUES	321
	REFERENCES	323

Part III Analysis

Chapter 11

EVALUATION OF CIRCUIT PERFORMANCE		329
11.1	CIRCUITS CONSISTING OF TWO-PORTS	330
11.1.1	Use of Symmetry in the Circuit Analysis	330
11.1.2	Analysis of Cascaded Two-Ports	333
11.1.3	Analysis of Arbitrarily Connected Two-Ports	337

11.2	ARBITRARILY CONNECTED NETWORKS	338
11.2.1	Analysis Using Connection Scattering Matrix	338
11.2.2	Multiport Connection Method	341
11.2.3	An Example	343
11.2.4	Analysis by Subnetwork Growth Method	347
11.3	CIRCUITS CONSISTING OF TWO-DIMENSIONAL PLANAR COMPONENTS	353
11.3.1	Segmentation Method	353
11.3.2	Desegmentation Method	359
	REFERENCES	369

Chapter 12

	SENSITIVITY ANALYSIS OF MICROWAVE CIRCUITS	371
12.1	FINITE DIFFERENCE METHOD	373
12.3	ADJOINT NETWORK METHOD	373
12.2.1	Tellegen's Theorem in Wave Variables	374
12.2.2	The Adjoint Network	376
12.2.3	Comparison with the Direct Method	380
12.2.4	Evaluation of Gradients for Subnetwork Growth Method	382
12.3	EVALUATION OF DIFFERENTIAL SCATTERING MATRICES	388
12.3.1	Sensitivity Invariants for Scattering Matrices	388
12.3.2	Differential S-Matrices for Typical Components	392
12.4	AN EXAMPLE OF EVALUATION OF SENSITIVITIES	393
12.5	LARGE CHANGE SENSITIVITIES	397
	APPENDIX 12.1 DIFFERENTIAL SCATTERING MATRICES FOR SOME TYPICAL COMPONENTS	402
	REFERENCES	401

Chapter 13

TOLERANCE ANALYSIS	407
13.1 WORST-CASE ANALYSIS	408
13.2 STATISTICAL TOLERANCE ANALYSIS	423
13.2.1 Method of Moments	423
13.2.2 Monte-Carlo Analysis	426
APPENDIX 13.1 SOME RESULTS FROM PROBABILITY THEORY AND STATISTICS	427
REFERENCES	430

Chapter 14

TIME DOMAIN ANALYSIS OF MICROWAVE CIRCUITS	433
14.1 TRANSIENT ANALYSIS OF TRANSMISSION LINES	434
14.2 LAPLACE TRANSFORM METHOD	441
14.3 COMPANION MODEL APPROACH	450
14.4 STATE VARIABLE APPROACH	456
REFERENCES	460

Chapter 15

MATRIX SOLUTION TECHNIQUES	463
15.1 GAUSSIAN ELIMINATION	464
15.2 PIVOTING	469
15.3 L-U FACTORIZATION AND F-B SUBSTITUTION	470
15.3.1 L-U Decomposition	471
15.3.2 Forward Elimination and Back Substitution	475
15.4 SPARSE MATRIX TECHNIQUES	478
15.4.1 Reordering of Equations	479
15.4.2 Data Structures for Reordering	486
15.4.3 L-U Factorization and F-B Substitution	491
15.4.4 Remarks on Sparse Matrix Techniques	498
REFERENCES	499

Part IV Optimization

Chapter 16

INTRODUCTION TO OPTIMIZATION	505
16.1 BASIC CONCEPTS AND DEFINITIONS	507
16.2 OBJECTIVE FUNCTIONS FOR CIRCUIT OPTIMIZATION	515
16.2.1 General Considerations	515
16.2.2 Least <i>pth</i> Approximation	516
16.2.3 Minimax Approximation	518
16.3 CONSTRAINTS	520
16.3.1 Transformation of Constraints	520
16.3.2 Penalty for Constraint Violation	522
16.3.3 Sequential Unconstrained Minimization Technique	522
16.4 ONE-DIMENSIONAL OPTIMIZATION TECHNIQUES	523
16.4.1 Elimination Methods	524
16.4.2 Interpolation Methods	530
REFERENCES	540

Chapter 17

DIRECT SEARCH OPTIMIZATION METHODS	543
17.1 PATTERN SEARCH METHODS	543
17.1.1 Hooke and Jeeves Methods	544
17.1.2 Powell's Method	546
17.1.3 Razor Search Method	548
17.2 ROTATING COORDINATES METHOD	550
17.3 THE SIMPLEX METHOD	553
REFERENCES	561

Chapter 18

GRADIENT METHODS FOR OPTIMIZATION	563
18.1 STEEPEST DESCENT METHOD	563
18.2 GENERALIZED NEWTON-RAPHSON METHOD	566
18.3 DAVIDON-FLETCHER-POWELL METHOD	567

18.4	OPTIMIZATION OF LEAST SQUARE OBJECTIVE FUNCTIONS	572
	REFERENCES	575

Part V CAD Programs

Chapter 19

	A MICROWAVE CIRCUIT ANALYSIS PROGRAM (MCAP)	579
19.1	PROGRAM DESCRIPTION	581
19.1.1	Flow Chart	581
19.1.2	Description of Subroutines	581
19.1.3	An Example	583
19.2	INSTRUCTIONS FOR USERS	586
19.3	PROGRAM LISTING	594
	REFERENCES	617

Chapter 20

	CAD PROGRAMS FOR MICROWAVE CIRCUITS	619
	<i>(contributed by Les Besser, Compact Engineering Inc., USA)</i>	
20.1	INTRODUCTION	619
20.2	INTEGRATED DESIGN AND MANUFACTURING SYSTEM CONCEPT	620
20.3	SUMMARY OF MICROWAVE CAD PROGRAMS	625
20.3.1	HANDY-COMPACT Circuit Analysis on HP-41C Handheld Calculator	626
20.3.2	MICRO-COMPACT Circuit Optimization on HP-9845 B/T Desktop Computer	628
20.3.3	SUPER-COMPACT	632
20.3.4	Lumped Element Matching Synthesis with AMPSYN	637
20.3.5	Transmission Line Matching Network Synthesis with CADSYN	639
20.3.6	FILSYN	643
	REFERENCES	648
	INDEX	651

Part I

Introduction
