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Software VNA and Microwave Network Design and Characterisation

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Software VNA and Microwave Network Design and Characterisation

To Guoping, William and Richard

Foreword

Software VNA and Microwave Network Design and Characterisation is a unique contribution to the microwave literature. It fills a need in the education and training of microwave engineers and builds upon well-established texts such as *Fields and Waves in Communication Electronics* by S. Ramo, J. Whinnery and T. Van Duzer, *Foundations for Microwave Engineering* by R.E. Collin and *Microwave Engineering* by D. Pozar. The 'virtual vector network analyser' that can be downloaded from the CD supplied with the book enables those without access to a real instrument to learn how to use a vector network analyser. The many design examples provide opportunities for the reader to become familiar with the Software VNA and the various formats in which frequency responses can be displayed. They also encourage 'virtual experiments'.

Design formulas for many devices are given, but the underlying theory that can be found in other texts is not covered to avoid repetition. A circuit theory or field theory approach is available and this encourages the user to link the two. A novel feature of the book is the introduction and application of a two-port chart that complements the well-known Smith chart, widely used for one-port circuits. The two-port chart enables the frequency response of transmission parameters to be displayed as well as reflection parameters. The range of devices introduced in the book includes stubs, transformers, power dividers/combiners, couplers, filters, antennas and amplifiers. Nonideal behaviour, e.g. the effects of dielectric, conductor and radiation losses, is included for many devices. The devices can be connected to form microwave circuits and the frequency response of the circuit can be 'measured'. The lower frequency limit in the Software VNA is 1 Hz and circuits containing both lumped and distributed devices can be characterised.

Assuming a knowledge of transmission lines, circuits and some electromagnetic theory, Software VNA is suitable for introduction at the final-year undergraduate level and postgraduate levels. Students would be stimulated by the opportunity to 'measure' their own devices and circuits. Experienced microwave engineers will also find Software VNA useful.

L.E. Davis
University of Manchester

Preface

In addition to conventional textbooks, the advances in computer technology and modern microwave test instruments over the past decade have given electrical engineers, researchers and university students two new approaches to study microwave components, devices and circuits. The Vector Network Analyser (VNA) is one of the most desirable instruments in the area of microwave engineering, which can provide fast and accurate characterisation of microwave components, devices or circuits of interest. On the other hand, a commercial microwave circuit simulation software package offers a cost-effective way to study the properties of microwave components and devices before they are used to construct circuits and the properties of the circuits before they are built for testing. However, mainly due to their costs, VNAs and microwave circuit simulators are not widely accessible on a day-to-day basis to many electrical engineers, researchers and university students. This book together with the associated software is intended to fill in the gap between these two aspects with (i) an introduction to microwave network analysis, microwave components and devices, microwave circuit design and (ii) the provision of both device and circuit simulators powered by the analytical formulas published in the literature.

The purpose of the associated software named Software VNA is fourfold. First, it functions as a VNA trainer with a lower frequency limit of 1 Hz and a upper frequency limit of 1000 GHz, providing to those who have not seen or used a VNA before the opportunity to have personal experience of how a VNA would operate in practice and be used for microwave measurements. Secondly, it provides experienced users with an option to get access to the data on a commercial VNA test instrument for data analysis, manipulation or comparison. Thirdly, it provides the users with a simulator equipped with 35 device builders from which an unlimited number of devices can be defined and studied. Analytical CAD equations, many of which have been experimentally verified, are used as models for simulation, giving no hidden numerical errors. The users may also use the Software VNA to verify the limitations and accuracy of the CAD equations. Finally, it provides the users with a circuit simulator that they can use to build circuits and study their properties.

The book has five chapters. In Chapter 1, the basic theory of network analysis is introduced and network parameters are defined. In Chapter 2, the installation and functions of the Software VNA are described. In Chapter 3, the built-in device models are presented with detailed equations and their limitations. In Chapter 4, circuit design and operation principles for impedance matching, impedance transformation, resonators, power dividers, coupler, filters and amplifiers are summarised, and the design examples of these circuits are given in Chapter 5.

The book and its associated software can be used for teaching in the area of microwave engineering.

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1

Introduction to Network Analysis of Microwave Circuits

ABSTRACT

Network presentation has been used as a technique in the analysis of low-frequency electrical and electronic circuits. The same technique is equally useful in the analysis of microwave circuits, although different network parameters are used. In this chapter, network parameters for microwave circuit analysis, in particular scattering parameters, are introduced together with a Smith chart for one-port networks and a new chart for two-port networks. The analyses of two-port connected networks and a circuit composed of multi-port networks are also presented.

KEYWORDS

Network analysis, Network parameters, Impedance parameters, Admittance parameters, *ABCD* parameters, Scattering parameters, Smith chart, Two-port chart, Connected networks

Network presentation has been used as a technique in the analysis of low-frequency electrical and electronic circuits (Ramo, Whinnery and van Duzer, 1984). The same technique is equally useful in the analysis of microwave circuits, although different network parameters may be used (Collin, 1966; Dobrowolski, 1991; Dobrowolski and Ostrowski, 1996; Fooks and Zakarev, 1991; Gupta, Garg and Chadha, 1981; Liao, 1990; Montgomery, Dicke and Purcell, 1948; Pozar, 1990; Rizzi, 1988; Ishii 1989; Wolff and Kaul, 1998). Using such a technique, a microwave circuit

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