PRINTED MICROWAVE WIDEBAND PASSIVE BALUN

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Dedicated to my beloved parents, family, and friends
who have always been there for me.

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ABSTRACT

Balun is an important component in a wireless communication system, particularly in a microwave circuit. Its ability to accept an unbalanced input and produce balanced output makes it applicable in various wireless communication application. In this thesis, balun is used as a transformer and an impedance match for a wideband application. Planar balun is chosen over other types of balun because it has some good qualities such as low insertion loss and wide bandwidth. Coplanar waveguide and coplanar strip lines are used to design the balun. The balun transform the unbalanced CPW feed line to balanced CPS feed line. The baluns are design to operate at centre frequency of 3 GHZ. The impedance match between the cable and the balun is obtained using Chebyshev and Binomial multisection impedance transformer. An analysis using MathCAD of balun performance using the two impedance matching theories for three, four and five sections transformers are made. Results show that Chebyshev response has wider wideband bandwidth compare to Binomial response and the more the number of sections, the larger the bandwidth. The wideband transition from CPW to CPS is accomplished through slots in between the two structures. A rectangular slot is introduced to compare the results with other types of slot found in the literature review. The balun is intended to be used for spiral antenna.

ABSTRAK

Balun ialah komponen penting sistem komunikasi wayarles terutamanya dalam litar gelombang mikro. Ia berupaya menerima masukan tak seimbang dan menghasilkan keluaran seimbang. Oleh itu, ia digunakan dengan meluasnya. Tesis ini membentangkan rekabentuk balun yang digunakan sebagai pengubah dan padanan galangan bagi aplikasi jalur lebar. Balun satah dipilih berbanding konfigurasi lain kerana ia mempunyai kualiti bermutu seperti kehilangan sisipan rendah dan lebarjalur luas. Pandu gelombang sesatah dan talian jalur sesatah digunakan dalam rekabentuk balun ini. Balun ini mengubah talian CPW kepada talian CPS. Balun direkabentuk untuk berkendali pada 3 GHz. Padanan galangan antara kabel dan balun diperoleh menggunakan pengubah galangan berbilang bahagian Chebyshev dan Binomial. Analisis prestasi balun menggunakan MathCAD telah dibuat bagi tiga hingga lima bahagian pengubah. Didapati bahawa sambutan balun Chebyshev mempunyai lebarjalur lebih luas berbanding Binomial. Selain itu, lebarjalur bertambah dengan pertambahan bahagian. Transisi jalurluas daripada CPW kepada CPS berjaya diperolehi menggunakan alur di antara kedua-dua struktur. Alur segiempat tepat dimasukkan sebagai perbandingan. Balun ini sesuai untuk antena seperti antena pilin.

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f_0	-	center frequency
ε_r	-	dielectric constant
h	-	substrate thickness
RL	-	return loss
W	-	width of substrate
t	-	thickness of conducting strip
ε	-	permittivity
ε_{re}	-	effective dielectric constant
Z	-	characteristic impedances
η	-	wave impedance in free space
c	-	speed of light
E	-	electric fields
Γ	-	reflection coefficient
T	-	transmission coefficient
Γ_m	-	maximum allowable reflection coefficient impedance

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TABLE OF ABBREVIATIONS

CPW	Coplanar Waveguide
CPS	Coplanar Strip
EM	Electromagnetic
GHz	Giga hertz
RF	Radio frequency
MIC	Microwave integrated circuit
TEM	Tranverse Electromagnetic Mode
VSWR	Voltage Wave Standing Ratio
dB	Decibel

CHAPTER I

INTRODUCTION

1.1 Introduction

This chapter presents the objective, problem statement, scope of project, project background and thesis organization.

1.2 Objective of Project

The objective of this project is to design two printed microwave wideband passive baluns, each having different impedance transforming characteristics using MathCAD [1] and Sonnet Suite softwares [2].

1.3 Problem Statement

The main reason why baluns are needed is when balanced and unbalanced circuits are adjacent in a system. Most baluns structures are narrowband for specific applications. Wideband impedance matching structures are needed for wideband applications. In some applications, it is necessary to connect the feed terminals on the balanced antennas to the unbalanced coaxial cables that require not only balanced-to-unbalanced transformation circuit, but also an impedance match due to the different characteristic impedances of the antenna and the feed cable. This project innovates two designs of balun using two different types of impedance matching theories; Binomial (or Butterworth) and Chebyshev (or maximally flat). MathCAD files are developed for the designs. The balun performances are verified using EM simulations.

1.4 Project Background

The basis of this project is the wideband balun proposed by J. Thaysen, K. B. Jakobsen and J. Appel-Hansen of the University of Denmark as shown in Figure 1 [3]. Printed balun is chosen because of its good qualities such as low insertion loss and wide bandwidth. It is also realisable using conventional photo techniques. This balun transforms the CPW feed line to CPS output connected to a spiral antenna.

The design of each balun consists of a few components; the coplanar waveguide as the input feed, the balun impedance transformer section where the gradual impedance matching process takes place, the coplanar strip output which is then connected to the antenna as the load. The general block configuration is shown in Figure 2.

Some of the research contributions are as follows:

i. Development of MathCAD files on the design of printed multisection impedance transformers.
ii. Binomial and Chebyshev multisection impedance transformers design cases.

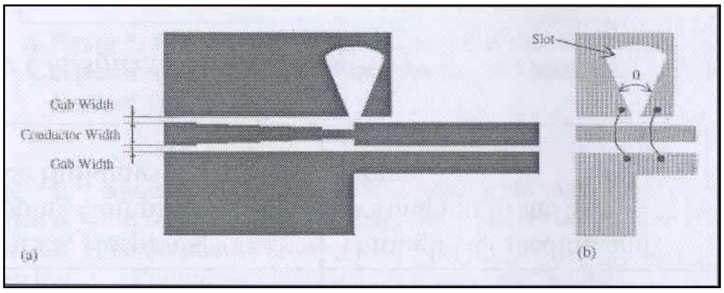

Figure 1: (a) CPW-CPS printed microwave balun, and (b) radial balun [3].

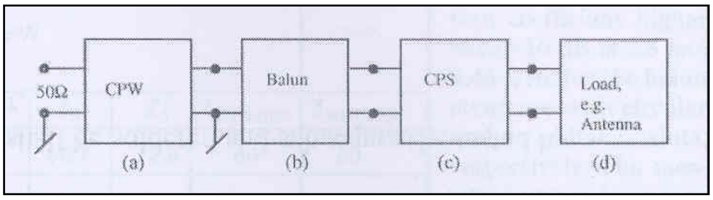

Figure 2: The general block configuration of a balun with (a) a coplanar waveguide input feed (b) balun impedance transformer section, (c) coplanar strip output and (d) antenna as a load [3].

1.5 Scopes of Project

The project scopes are as follows:

- Literature review of transmission line theory, microwave technology and impedance transformers and baluns.
- Design two multisection impedance transformers using MathCAD softwares; Binomial and Chebyshev.
- Simulation of the printed multisection transformers using Sonnet electromagnetic software, as transformers and baluns.
- Analyse the performance of the designed printed multisection transformers and the corresponding baluns.
- Thesis writing.

1.6 Thesis Organization

This thesis is organised into five chapters. Chapter I presents the objective, problem statement, scope of project, project background and thesis organization.

Chapter II presents the literature review and theoretical background which includes the transmission line theory, scattering paramaters and impedance transformers. The mathematical design procedure for the printed impedance multisection transformers are also presented. This includes explanation of the Binomial and Chebyshev responses, and various load impedances used.

In Chapter III, brief discussion of the softwares used are presented. These are MathCAD, for computations of mathematical formulations.equations while Sonnet Suite V9.52 for the electromagnetic simulations of the designed transformers. The design methodology is then presented in detail.

Chapter IV presents all the theoretical and simulation results of the transformers. Discussions and comparations of the Binomial and Chebyshev transformer configurations performances are presented.

Finally, the last chapter concludes the thesis. Suggestions for further developments are also given.

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