DESIGN OF RECONFIGURABLE DEFECTED GROUND STRUCTURE FOR MICROWAVE RESONATOR

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This report submitted in partial fulfilment of the requirements for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honours

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UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
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I hereby, declared this report entitled "DESIGN OF RECONFIGURABLE DEFECTED GROUND STRUCTURE FOR MICROWAVE RESONATOR" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Electronics and Computer Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering (Wireless Communication). The member of the supervisory committee is as follow:

………………………………

DR. ZAHRILADHA B ZAKARIA

(Official Stamp of Supervisor)

DEDICATION

"In the Name of Allah, the most Beneficent, the Most Merciful"

Special dedication to my beloved parents,

Sulaiman B. Ishak & Hinum Bt. Lebai Hassan

My supporting brothers and sisters,

Darmadi B. Sulaiman

Dian Bt. Dominic

Mohd Husny B. Sulaiman

Mohd Hafis B. Sulaiman

Nur Farahana Bt. Ramli

Norsuhaida Bt. Sulaiman

Abu Hanifah B. Sulaiman

Muhammad Fadhil B. Abdul Rasit

To my supervisor **Dr Zahriladha B. Zakaria***,*

My friends and my fellow lecturers

Thank you for all your care, support and believe in me

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ABSTRACT

Defected Ground Structure (DGS) has been used widely and they have shown increasing potential due to its drastic development for the several applications in this recent year. This project presents the reconfigurable DGS resonator fabricated on coplanar waveguide (CPW) technology. The objective of this project is to reconfigure the resonant frequencies operates at 3.5 GHz and 5.2 GHz by employing the Dumbbell-shaped DGS design on the ground plane. In order to implement, the capabilities of DGS to reconfigure at an arbitrary frequencies have been investigated. Four sets of DGS have been designed, simulated, measured and analysed. The first and second set is without PIN diode, while the rest two set is reconfigured with the PIN diode. The scope of work is divided into few parts which are research analysis, simulation, optimization, fabrication and measurement analysis of results. The DGS design is reconfigured by PIN diode operating at frequency of 3.45 and 5.54 GHz with return loss of -16.71 and -12.96 dB. The bandwidth is 1.53 and 2.28 GHz with corresponding loaded Q of 2.25 and 2.42. These indicate good return loss as the DGS transmits power above 90%. This DGS is operates from 2.39 GHz to 7.07 GHz frequency. This type of DGS is useful for applications when the undesired signal need to be removed such as radar and wideband systems. All simulated and measured frequency responses in very good agreement with each other.

ABSTRAK

Struktur Bumi Terdefek (DGS) telah digunakan dengan meluas dan mereka telah membuktikan penambahan potensi drastiknya dalam perkembangan untuk beberapa aplikasi dalam beberapa tahun terkini. Projek ini membentangkankan kebolehubahan pengayun DGS yang difabrikasi ke atas teknologi sesatah pandu gelombang (CPW). Projek ini bertujuan untuk menyusun atur pengayun frekuensi pada frekuensi 3.5 GHz dan 5.2 GHz dengan menggunakan rekabentuk Dumbbell DGS pada satah bumi. Dalam tujuan untuk melaksanakannya, keupayaan DGS untuk menyusun atur pengayun frekuensi pada sembarang frekuensi telah disiasat. Empat set DGS telah direkabentuk, disimulasi, diukur dan dianalisis. Set pertama dan kedua adalah tanpa diod PIN, manakala dua set selebihnya disusun atur dengan diod PIN. Skop kerja dibahagikan kepada beberapa bahagian iaitu analisis kajian, simulasi, pengoptimuman, fabrikasi dan analisis keputusan pengukuran. Rekabentuk DGS disusun atur oleh diod PIN yang beroperasi pada frekuensi 3.45 dan 5.54 GHz dengan kehilangan kembali pada -16.10 dan -18.83 dB. Jalur lebar adalah 1.53 dan 2.28 GHz dengan kesamaan Q terbeban adalah 2.25 dan 2.42. Ini menunjukkan kehilangan kembali yang bagus dengan hantaran kuasa DGS di atas 90%. DGS ini beroperasi pada frekuensi 2.39 GHz sehingga 7.07. Jenis DGS ini boleh digunakan pada aplikasi apabila isyarat yang tidak diingini hendak dibuang seperti radar dan sistem jalur lebar. Kesemua sambutan frekuensi simulasi dan pengukuran berada dalam keadaan yang baik antara satu sama lain.

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LIST OF ABBREVIATIONS

DGS	-	Defected Ground Structure
CPW	-	Coplanar Waveguide
CPW-TL	-	Coplanar Waveguide Transmission Lines
PBG	-	Photonic Band Gap
LTCC	-	Low Temperature Co-fire Ceramic
LTCF	-	Low Temperature Co-fire Ferrite
SIW	-	Substrate Integrates Waveguide
UWB	-	Ultra-Wideband
WLAN	-	Wireless Local Area Network
WiMAX	-	Wireless Maximum
RF	-	Radio Frequency
UV	-	Ultraviolet
ADS	-	Advanced Design System
RLC	-	Resistance Inductance Capacitance
LC	-	Inductance Capacitance
LPF	-	Low Pass Filter
MIC	-	Microwave Integrated Circuit
RF	-	Radio Frequency
3D	-	Three Dimension
2D	-	Two Dimension
TEM	-	Transverse Electromagnetic
TE	-	Transverse Electric
EM	-	Electromagnetic

SMA - SubMiniature version A / Sub Multi Assembly

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CHAPTER 1

INTRODUCTION

1.1 Project Background

The increasing development of wireless applications introduces new requirements for transceiver architecture that feature excellent microwave performance and enhanced integration density. Since 1998, photonic band gap (PBG) structures and defected ground structures (DGS) have attracted the interest of many researchers [1]-[3].

The used of DGS technology into coplanar waveguide transmission lines (CPW-TL) compared to conventional transmission lines have many advantages such as to allow a simple reconfiguration and it is a very compact solution [4]. Furthermore, high performance, compact size and low cost often meet the stringent requirements of modern microwave communication systems. There have been some new technologies such as Low-temperature co-fire ceramic technology (LTCC), Low-temperature co-fire ferrite (LTCF) and some new structures such as Photonic band gap (PBG), DGS, Substrate integrates wave-guide (SIW) and so on to enhance the whole quality of system [5].

In recent years, there have been several new concepts applied to distributed microwave circuits. One such technique is *defected ground structure* or DGS, where the ground plane metal of a microstrip, stripline, or coplanar waveguide circuit is intentionally modified to enhance performance.

The name for this technique simply means that a “defect” has been placed in the ground plane which is typically considered to be an approximation of an infinite, perfectly-conducting current sink. Furthermore, a ground plane at microwave frequencies is far removed from the idealized behavior of perfect ground. The additional perturbations of DGS not render as defective even though it is alter the uniformity of the ground plane [6].

1.2 Problem Statement

In fact, the conventional DGS produce the frequency response fixed at certain notch frequency. This way makes the DGS unable to act as reconfigurable for any microwave resonator. In order to overcome, this conventional DGS has been implementing with active diode as the reconfigurable component. Another problem statement is Ultra Wideband (UWB) face interferences of other signal such as WiMAX system and Wireless Local Area Network (WLAN) radio signal. In order to overcome, the DGS reconfigurable concept have been implement into the UWB system by obtaining the resonant frequency at 3.5 GHz which is for WiMAX system and 5.2 GHz for IEEE 802.11a lower band of WLAN system [8], [20], [21].

1.3 Objective of Project

The objective of this project is to design the DGS structure that can be reconfigured at any desired resonant frequencies. In order to implement, the capabilities of DGS to reconfigure at an arbitrary frequencies have been investigated. Thus, the resonant frequency that reconfigured by PIN diode has been focuses [7]. This project have potential to be applied into the UWB application such to remove the undesired frequencies that interfere the UWB systems.

1.4 Scopes of Project

The scope of work is divided into few parts which are research analysis, simulation, optimization, fabrication, measurement analysis of results. The research processes are based on the review studies of DGS technology and it evolution in this recent year. Furthermore, the DGS development becomes popular year from year due to it renaissance implementation by the most researchers. Thus, the simulation process including the design of layout, simulation and optimize the frequency response. The simulation tools have been used is Advanced Design System 2011 (ADS) software and the DGS-shaped design that have been choose is Dumbbell-shaped design.

The fabrication part starts from printing the layout into transparent paper, UV exposure on substrate using the UV machine, etching, cutting, drilling, and soldering processes. Thus, the measurement processes have been done by measured the board using the Network Analyzer machine to obtain the frequency response.

The structure consists of a DGS resonator based on coplanar waveguide. The chosen shape of DGS design is Dumbbell-shaped which is the lattice shaped unit DGS shown in Figure 1.1.

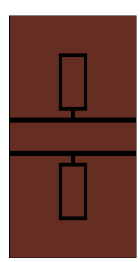

Figure 1.1: Layout of the proposed reconfigurable DGS resonator

1.5 Contribution

The contributions of this project are by applying the new discovery knowledge into the UWB system and for RF and microwave engineering fields. The expansion of this knowledge gives breakthrough to the society needs and country development. Besides, this project development may benefit to the institution and industries in Malaysia as well.

1.6 Report Structure

This report contains five chapters. Chapter 1 describes the background, problem statement, objectives and scope of the project.

Chapter 2 presents the brief theory of DGS and related literature review in designing the Dumbbell-shaped DGS structure.

Chapter 3 describes the methodology of the project which includes the design specification and procedure flow process.

Chapter 4 presents the simulation and measurement results. The results obtained are analysed and discussed.

The final chapter concludes the report and recommendations for further work are given.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a review of past research effort relate to DGS technology, reconfigurable DGS, resonator, coplanar waveguide and the process used in this study. The chapter begins with the discussion of fundamentals of DGS. A review of other relevant research studies is also provided. The review is organized chronologically to offer sight to how past research efforts have laid the groundwork for subsequent studies, including the present research effort. The review is detailed so that the present research effort tailored to the present body of literature as well as to justly the scope and direction of the present research effort.

2.2 Defected Ground Structure (DGS) technology

DGS is an etched periodic or non-periodic cascaded configuration defect in ground of a planar transmission line (e.g., microstrip, coplanar and conductor backed coplanar waveguide) which disturbs the shield current distribution in the ground plane cause of the defect in the ground. This disturbance will change characteristics of a transmission line such as line capacitance and inductance.

In a word, any defect etched in the ground plane of the microstrip can give rise to increasing effective capacitance and inductance [5]. DGS also attractive for band rejection which is remove the unwanted frequency and controllable center frequency through controlling one physical dimension of the DGS pattern [9].

The basic element of DGS is a resonant gap or slot in the ground metal, placed directly under a transmission line and aligned for efficient coupling to the line. Figure 2.1 shows several resonant structures that may be used. Each one differs in occupied area, equivalent RLC ratio, coupling coefficient, higher-order responses, and other electrical parameters. A user will select the structure that works best for the particular application [6].

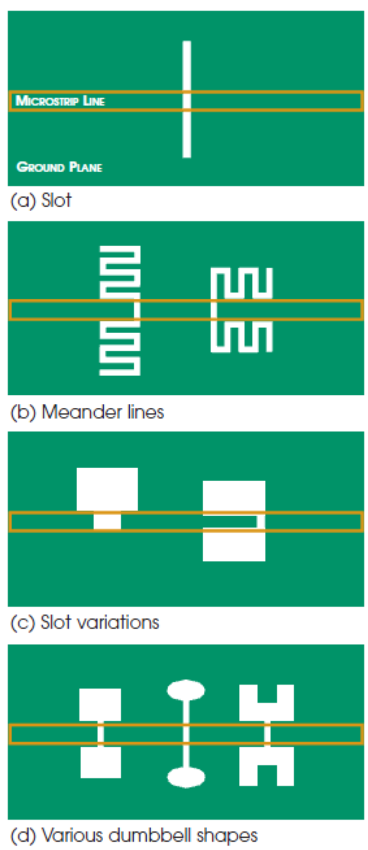

Figure 2.1: Some common configurations for DGS resonant structures [6]