TUNABLE MICROWAVE FILTER DESIGN USING DEFECTED GROUND STUCTURE

JACINTA A/P SAVERIDASS

A project report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Engineering (Electronic-Wireless Communications)

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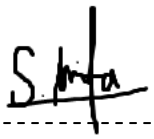
DR. BADRUL HISHAM BIN AHMAD
Deputy Dean (Research And Development)
Faculty Of Electronics And Computer Engineering (FKEKK)
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka.

DECLARATION

I hereby declare that this project report entitled "Tunable Microwave Filter Design Using Defected Ground Structure" is based on my original work except for citations and quotations which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

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Supervisor : Dr. BADRUL HISHAM AHMAD

Date : 15 JUNE 2012

Specially dedicated to
my beloved parents for their caring support and to all my lecturers who guided me throughout completing this design.

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ABSTRACT

Tunable bandstop filters using defected ground structure (DGS) was designed. The DGS section is obtained by etching the conventional ground plane. Transmission line with DGS has a characteristic of slow-wave propagation and bandstop with low loss in passband. To adjust the stopband, voltage controlled variable capacitor diodes (VVC) are equipped on the DGS section. The electrical method is proposed to provide tunable bandstop filters using DGS with VVC diodes. The center frequency of the filter is varied as the reverse bias voltage is changed. The stopband of the proposed filter expected to have wide tunable range. DGS unit can lead to deeper suppression and wider tunable bandwidth. This project is designed using ADS 2008. The design was created based on design specifications especially when designing the dimension of DGS structure. Two types of materials were discussed but RT/Duroid 5880 was used only as reference for the simulation. An active component which is varactor diode is used to obtain the tuning characteristic of bandstop filter. Good agreements between the simulated and measured results are expected

ABSTRACT

Tunable bandstop filters dengan defected ground structure (DGS) telah didesign. Bahagian DGS boleh didapati dengan mempunarkan lapisan bawah substrat. Talian penghantaran dengan DGS mempunyai cirri-ciri perambatan gelombang signal yang perlahan dan banstop yang mempunyai kehilangan tenaga kecil. Diode jenis voltage controlled variable capacitor (VVC) digunakan pada bahagian DGS untuk meyelaraskan stopband. Kaedah elektronik dicadangkan bagi memperoleh tunable bandstop filters mengunakan DGS dengan diode VVC. Frekuensi tengah filter divariasikan dengan mengubah voltan reverse bias. stopband yang didesign dijangka mempunyai julat boleh laras yang besar. Unit DGS boleh memperoleh signal penindasan yang mendalam dan julat jalur lebar boleh laras yang besar. Projek ini didesign menggunakan ADS 2008. Design project direka dengan panduan spesifikasi design terutamanya semasa design dimensi struktur DGS. Dua jenis substrat dibincangkan tetapi hanya RT/Duroid 5880 digunakan sebagai panduan simulasi. Komponen aktif iaitu diod varactor diode digunakan bagi memperoleh ciri boleh laras bandstop filter. Keputusan daripada simulasi dan ukuran dijangka mempunyai keserasian yang amat baik.

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LIST OF SYMBOLS / ABBREVIATIONS

c_p	specific heat capacity, J/(kg·K)
h	height, m
K_d	discharge coefficient
M	mass flow rate, kg/s
P	pressure, kPa
P_b	back pressure, kPa
R	mass flow rate ratio
T	temperature, K
v	specific volume, m^3
α	homogeneous void fraction
η	pressure ratio
ρ	density, kg/m^3
ω	compressible flow parameter
ID	inner diameter, m
MAP	maximum allowable pressure, kPa
MAWP	maximum allowable working pressure, kPa
OD	outer diameter, m
RV	relief valve

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Mobile and wireless communication services is now facing challenges in expanding compact and high quality RF filters. Defected Ground Structure (DGS) has been one of the options used for microwave circuit applications to produce bandstop filter with low loss, slow-wave propagation and compact filter design. DGS can be obtained by etching conventional ground plane. The stopband can be made adjustable by adding varactor diode on the DGS section.

In this project, the DGS unit effect on the frequency response suppression and the width of the tunable bandwidth are investigated. Active devices are placed on the DGS section to obtain tunable stopband between certain range of frequencies which are specified for the DGS filter design. The DGS dimension was varied in order to investigate and observe the exact operating frequencies of the specific dimension design. The design is added with continuous tuning capabilities using varactor diodes to optimize the function of a banstop filter to suppress unwanted signals at desired frequencies. This project was mainly focused on the bandstop characteristic which has tuning range within 1GHz-2GHz with low loss characteristics.

1.2 Problem Statement

In RF filter designing, the conventional bandstop filter has much complex design with narrow stopband and high return loss. Compared with a conventional bandstop filter, a bandstop filter using DGS provides similar Q-factor with smaller size and simple structure, it can be fabricated on a printed circuit board with low cost and better return loss can be achieved.

1.3 Objectives

The objectives of this project are specified to implement this project based on these guidelines in order to measure the achievement of this project during accomplishment. Below are the main objectives of this project:

i. To design and develop tunable bandstop filter with Defected Ground Structure (DGS) using active devices.
ii. To obtain tunable center frequency between 1GHz-2GHz.
iii. To obtain high Q-factor with low loss characteristics.
iv. To improve the depth and width of the stopband through the effect of DGS unit

1.4 Scope

The scope of this project is to use dumbbell shape DGS unit to obtain the bandstop filter design. Diode model of SMV-1247-079 is used to develop a tunable bandstop filter. Duroid5880 dielectric substrate was investigated to be used during designing process since it has high resistance over high frequency application with low loss and low dielectric constant with tight tolerance control and it was also compared to FR4 to make final decision on the suitable material that can be used to fabricate the design. VVC diode with low resistance and inductance is used to achieve high Q characteristics.

1.5 Organization of Report

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

Chapter 2 presents the brief theory of bandstop filters and related literature review in designing tunable bandstop filters with DGS element which are on the technology of microstrip, theory of resonator, loaded and unloded Q, microwave board, characteristic of filter, varactor diode and defected ground structure (DGS).

Chapter 3 describes the methodology of the project which includes the flowchart of project methodology, design procedure which are calculation, designing, analysis of simulation results, design specification of the tunable bandstop filter, material properties of RT/Duroid 5880 and component properties of varactor diode (SMV-1405-079).

Chapter 4 presents the simulation and measurement results. The results obtained are analyzed and discussed. This chapter explains the designing of 50Ω transmission line, designing of defected ground structure and results of design simulation using ADS 2008.

The final chapter concludes the report and recommendations for further work are given. This chapter describes the current achievement and state of this project and the future plan that need to be achieved in order to obtain a complete project results that are targeted at the beginning of this project.

CHAPTER 2

LITERATURE REVIEW ON BANDSTOP FILTER AND TUNABLE BANDSTOP FILTER WITH DEFECTED GROUND STRUCTURE

2.1 Chapter Overview

The beginning of this chapter describes the fundamental theory on microwave filter. The following section discusses on literature review of tunable bandstop filter with defected ground structure (DGS).

2.2 Technology of Microstrip

Microstrip is used to convey microwave frequency signal through fabrication on printed circuit board. Microstrip consist of three layer where the top conducting layer is separated with ground conducting layer by dielectric substrate with certain value of dielectric constant depending on the substrate material. Microstrip has many advantages where it is compatible with microwave active devices that can be easily mounted on the substrate. Besides that, the cost of using microstip is much low and it has lighter weight and reduced volume.

Microstrip lines are among the most frequently used planar transmission lines where it can be fabricated through photolithographic process and integrated with any active or passive devices [1]. Photolithographic is a process done to remove thin film

layer or bulk of substrate which is also known as “optical lithography” used in microfabrication [1].

The basic dimension of a microstrip is shown in the figure below where it has a conducting strip of width, *w,* thickness, *t,* of the microstrip line above the substrate layer with relative dielectric constant ε_r of and substrate thickness of *h*, the bottom of the substrate is a ground (conducting) plane.

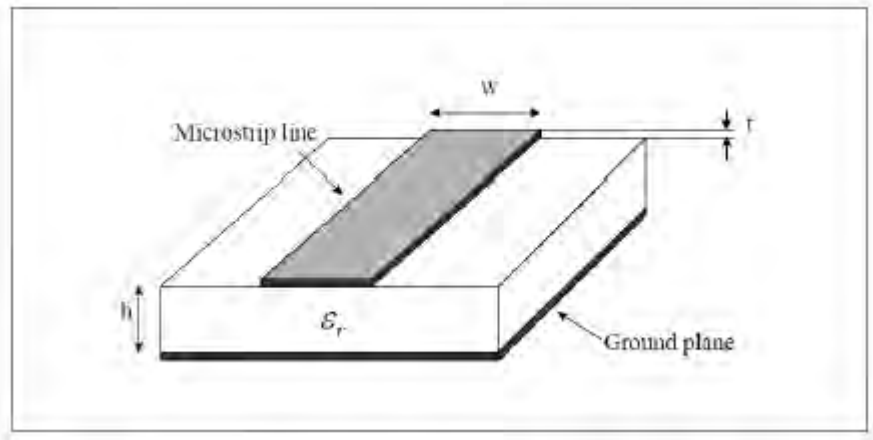

Figure 2.1 General Microstrip Structure [4]

This project is implemented using microstrip since microstrip filter is a high performance filter. Combination of DGS unit on the microstrip technology with active devices produces optimum bandstop filter with desired function. The presence of a DGS under a printed transmission line actually disturbs the current distribution in the ground plane and thus modifies the equivalent line parameter over the defected region [2].

2.3 Theory of Resonator

Basically, the coupling coefficient of coupled RF or microwave resonators, of different structure can have different self-resonant frequencies as shown in Figure 2.2. It can be defined based on the ratio of coupled energy to stored energy where E and *H* represent the electric and magnetic field, respectively [3].

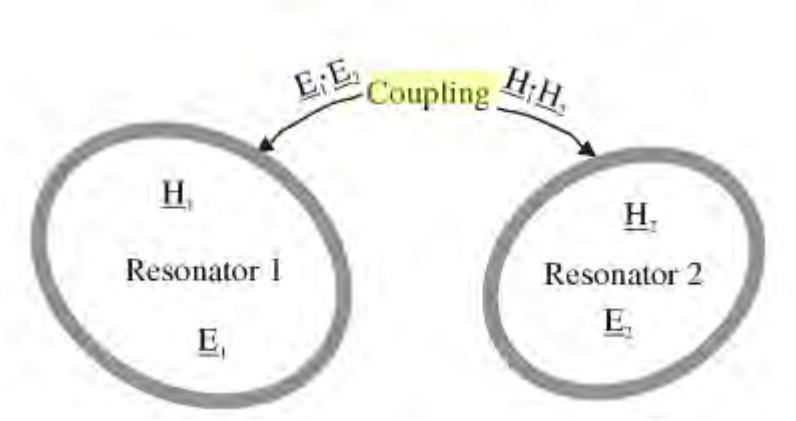

Figure 2.2 General coupled RF or microwave resonators where resonators 1 and 2 can be different in structure and have different resonant frequencies[4].

For this project, the current distribution in the ground plane of microstrip line would lead to an equivalent inductance and capacitance where DGS has characteristic of L-C resonator circuit coupled to the microstrip line. A strong coupling occurs between the line and the DGS around the resonant frequency when RF signal is transmitted through DGS integrated microstrip line [4]. There are two type of coupling which are electric and magnetic coupling. The following session would further discuss on these two types of coupling.