ANALYSIS OF LOW PASS FILTER USING BOWTIE DEFECTED GROUND STRUCTURE (DGS) AT 10 GHz FOR RADAR APPLICATION

WAN NOOR AINI BINTI WAN MAKHZAN

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MOHD AZLISHAH BIN OTHMAN
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal
Melaka

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Special Dedicate:

To my beloved family members for their true love, prayers and encouragement. Then to my supervisor that guide and give moral support to me and to all my colleagues for your help and support throughout my educational journey.

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ABSTRACT

This report describes the design of Low-pass filter using bowtie Defected Ground Structure (DGS). The designing of low-pass filter begins from lumped element in which the filter will be built using capacitors and inductors. This project has three main phases which are designing phase, fabricating phase and measuring phase. The low-pass filter using bowtie Defected Ground Structure (DGS) is required to operate at 10 GHz for radar application. As a comparison, the design of different bowtie DGS were analyzed to identify the better performance of the low-pass filter. In this report there will be an overview on how to design, fabricate and measure the filter that meet the specification. The applications and software which will be used in designing the filter will be described. Finally the results of simulated and measured filter is analyzed and discussed. At the same time, future work and improvements to the accuracy and the performance of the filters are discussed.

ABSTRAK

Laporan ini menerangkan rekabentuk penapis lulus rendah menggunakan 'bowtie Defected Ground Structure' (DGS). Penapis laluan rendah direka bermula daripada 'lumped element' di mana penapis itu akan dibina menggunakan kapasitor dan pengaruh. Projek ini mempunyai tiga fasa utama iaitu fasa mereka bentuk, fasa fabrikasi dan fasa eksperimen. Penapis laluan rendah menggunakan 'bowtie Defected Ground Structure' (DGS) diperlukan untuk beroperasi pada frekuensi 10 GHz bagi aplikasi radar. Sebagai perbandingan, reka bentuk ‘bowtie’ DGS yang berbeza telah dianalisis untuk mengenalpasti prestasi yang lebih baik untuk penapis laluan rendah. Dalam laporan ini akan ada gambaran mengenai bagaimana untuk mereka bentuk, fabrikasi dan eksperimen penapis yang memenuhi spesifikasi. Aplikasi dan perisian yang akan digunakan dalam mereka bentuk penapis akan diterangkan. Akhirnya keputusan prestasi penapis yang telah disimulasi dan diukur telah dianalisis dan dibincangkan.Tambahan pula, kerja-kerja masa depan dan penambahbaikan kepada ketepatan dan prestasi penapis dibincangkan.

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CHAPTER 1

INTRODUCTION

This chapter will explain about the introduction of the project, the objectives of the project, problem statement and also the scope of the work.

1.1 Introduction

Nowadays, diversity of communications using radio frequency causing microwave filter that represents the class of electronic filters designed to operate on signals in the frequency range of megahertz to gigahertz. Several communications used in this frequency range are radio, television, wireless communication and others.

RF filters are used for a variety of applications from audio to RF and across the entire frequency spectrum [2]. So, these RF filters will function to allow the required frequency to passthrough the circuit and reject frequencies that are not needed. The basic concept of a filter can be explained by examining the frequency dependent nature of the impedance of capacitors and inductors. An ideal filter is a linear 2-port network that provides perfect transmission of signal for frequencies in a certain passband region, infinite attenuation for frequencies in the stopband region and a linear phase response in the passband (to reduce signal distortion).

Filters are used in all frequency ranges and are categorize into four basic types of filters [1]:

i. Low-pass filters (LPF) – transmit all signals below the cut-off, $\omega_c$to pass from source to the load.
ii. High-pass filters (HPF) – pass all signal with frequencies above the ω_c and reject signal with frequencies below ω_c.
iii. Band-pass filters (BPF) – allows frequencies through within a given pass band.
iv. Band-reject filter (BRF) - rejects signals within a certain band. It can be particularly useful for rejecting a particular unwanted signal or set of signals falling within a given bandwidth.

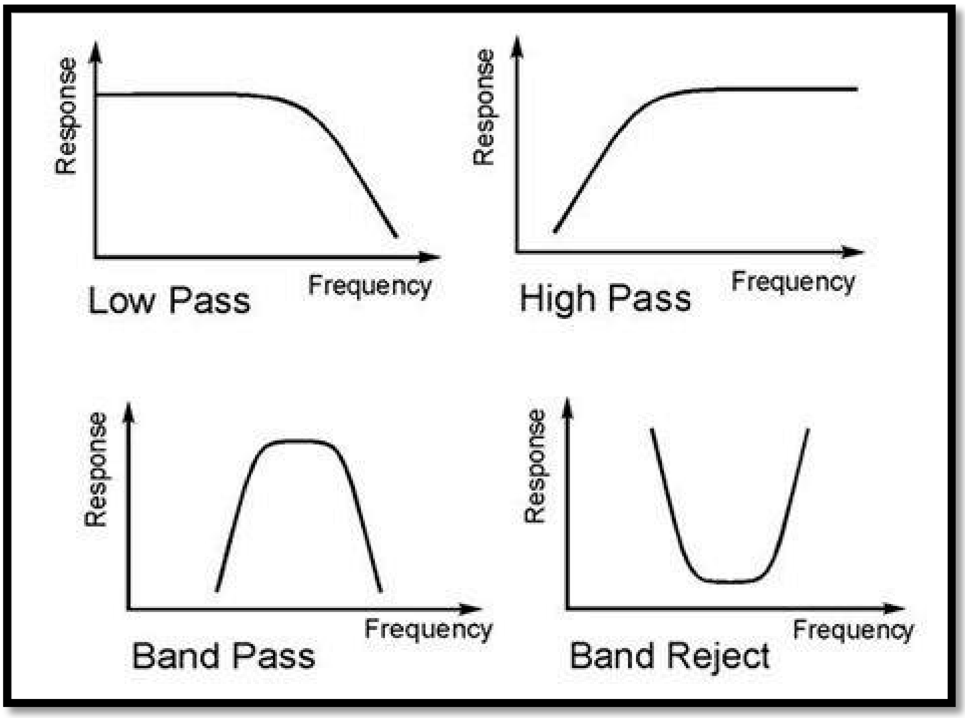

Figure 1.1: Types of filter

Defected Ground Structure (DGS) is a defect on the ground that can change the propagation properties of transmission line with changing the current distribution on the ground side [3]. This technique can be used in microstrip line to high impedance, suppress spurious response, slow-wave characteristics and reduce size of the circuit [6][28]. DGS can help the filter to enhance their performance and help the low-pass filter to generate the frequencies to become narrow [10].

The purpose of this project is to design, simulate as well as to analyze the low pass filter using Bowtie Defected Ground Structure (DGS) at 10GHz for radar application. This low pass filter will designed with stub. A stub is a length of transmission line or waveguide that is connected at one end only. Neglecting transmission line losses, the input impedance of the stub is purely reactive; either capacitive or inductive, depending on the electrical length of the stub [4]. The inductor will represent the short circuit and the capacitor will represent the open circuit. For this project, that use is specifically for 10GHz, matching several stubs is used, spaced along the main transmission line.

1.2 Problem statement

Radar is a system or technique for detecting the position, movement and nature of remote objects by means of radio waves reflected from its surface. Although most radar units use microwave frequencies, the principle of radar is not confined to any particular frequency range.

Existing radars are configuring with separate equipment for transmitters and receivers. A transceiver chip could be integrates both functions, however, would not enable everything to be integrating in one piece of equipment, allowing systems to become more compact.

To handle the transmission signals on the same chip, it needs to be effective to switch between incoming and outgoing signals and reduce the impact on incoming and outgoing signals. However, it is difficult to combine these goals. Possible with the technology to configure goals in one chip will produce a tool for incorporating radar equipment and the wireless communication equipment is more compact.

1.3 Objectives

The objectives of this project are listed below:

i. To study and understanding of Low Pass Filter and Bowtie Defected Ground Structure (DGS).

ii. To design, fabricate and analyze the Low Pass Filter with Bowtie Defected Ground Structure.

iii. To understanding the microwave measurement technique.

iv. To gain experience using ADS2011 software to simulate the Low Pass Filter.

1.4 Scope of work

This project will focus on the following scope of work:

i. To design Low-Pass Filter using Open-circuited and short-circuited stubs.

ii. To design, simulate and fabricate Low-Pass Filter with Bowtie Defected Ground Structure (DGS)

iii. To analysis Low-Pass Filter with Bowtie Defected Ground Structure (DGS).

CHAPTER 2

LITERATURE REVIEW

2.1 X Band

Microwaves are radio waves with wavelengths ranging from as long as one meter to as short as one millimetre, or equivalently, with frequencies between 300 MHz (0.3 GHz) and 300 GHz. Microwaves is widely used for point-to-point communication [27]. Small wavelength allows antenna to easily direct them in narrow beams, which can be shown directly on the receiving antenna. If there are other microwave devices in the same frequency are close to it, it will not interfere with each other. High frequency of microwaves gives the microwave band a very large information-carrying capacity. But, the microwaves are limited to line of sight propagation. Which is they cannot pass around hills or mountain.

Microwave radio transmission is commonly used in point-to-point communication systems, radar, radio astronomy, navigation, spectroscopy and more.

In radio communication, electromagnetic waves travel through the air at the speed of light from transmitter to receiver. The communication will operate in their own specific frequency so they will not interfere with each other. To avoid the chaos in the same frequency, government has identified the selected frequency spectrum for different type of communication.

BAND	FREQUENCY RANGE	APPLICATIONS
L	1 to 2 GHz	Satellite, navigation (GPS) cellular phone
S	2 to 4 GHz	Satellite, SiriusXM radio, unlicensed (Wi-Fi, Bluetooth), cellular phones.
C	4 to 8 GHz	Satellite, microwave relay
X	8 to 12 GHz	Radar
Ku	12 to 18 GHz	Satellite TV, police radar
K	18 to 26.5 GHz	Microwave backhaul
Ka	26.5 to 40 GHz	Microwave backhaul
Q	30 to 50 GHz	Microwave backhaul
U	40 to 60 GHz	Experimental, radar
V	50 to 75 GHz	New WLAN, 802.11ad/WiGig
E	60 to 90 GHz	Microwave backhaul
W	75 to 110 GHz	Automotive radar
F	90 to 140 GHz	Experimental, radar
D	110 to 170 GHz	Experimental, radar

Table 2.1: Frequency spectrum band

X band is one of the segments of the frequency spectrum band, which has a frequency range from 8 GHz to 12 GHz. X band used in all radar applications including continuous-wave, pulsed, single-polarization, dual-polarization, synthetic aperture radar, and phased arrays. X band radar mostly used for weather monitoring, air-traffic control, maritime vessel traffic control, defence tracking, and vehicle speed detection for law enforcement. In modern radars, to identify the target and discrimination, the shorter of the wavelength of the X band allows higher resolution images of high resolution radar imaging.

2.2 RF and Microwave Filter

RF filters are used for a variety of applications from audio to RF and across the entire frequency spectrum. So, these RF filters will function to allow the required frequency to pass through the circuit and reject frequencies that are not needed [1].Low-pass filter is chosen to be designed for this project.

Low-pass filter allows signal below the cut-off frequency to pass through from source to the load [30].It also plays an important role in modern communication systems and high frequency measurement equipment [26].Cut-off frequency is defined as the point at output filter falls at 50% or -3dB in the frequency band. The cut-off frequency in X band frequency is 10 GHz.

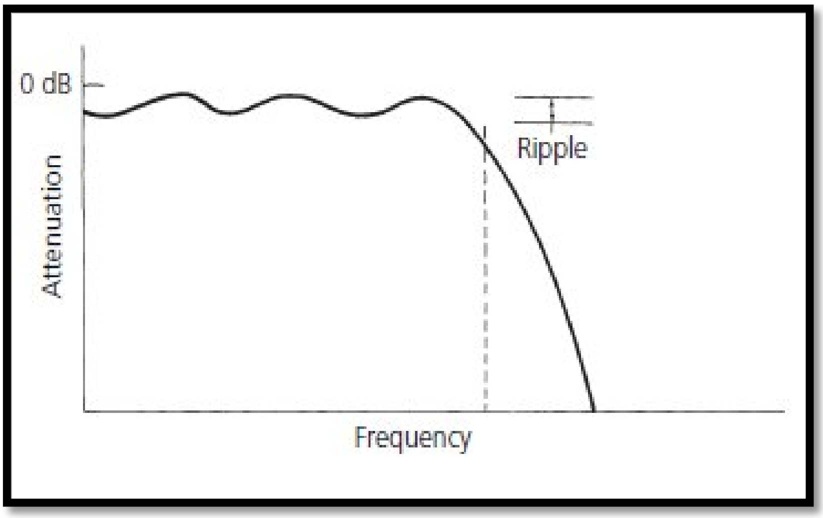

Figure 2.1: Low-pass filter

2.1 Design method prototype

To design a filter, I need to identify the methods to be used. As for that, there are two types of methods that can be used:

i. Image Parameter
ii. Insertion Loss

Filter design using image parameter method consist of a cascade of simpler two-port filter sections to provide the desired cut-off frequencies and attenuation characteristics but do not allow the specification of a frequency response over the complete operating range. The image parameter method of filter design involves the specification of pass band and stop band characteristic for cascade of two-port network [28].

The insertion loss method allows high degree of control over the passband and stopband amplitude and phase characteristics, with a systematic way to synthesize a desired response. Insertion loss method design is divided into four other methods. The methods are [1]:

i. Characterization by Power Loss Ratio
ii. Maximally Flat Low-Pass Filter Prototype
iii. Equal-Ripple Low-Pass Filter Prototype
iv. Linear Phase Low-Pass Filter Prototype

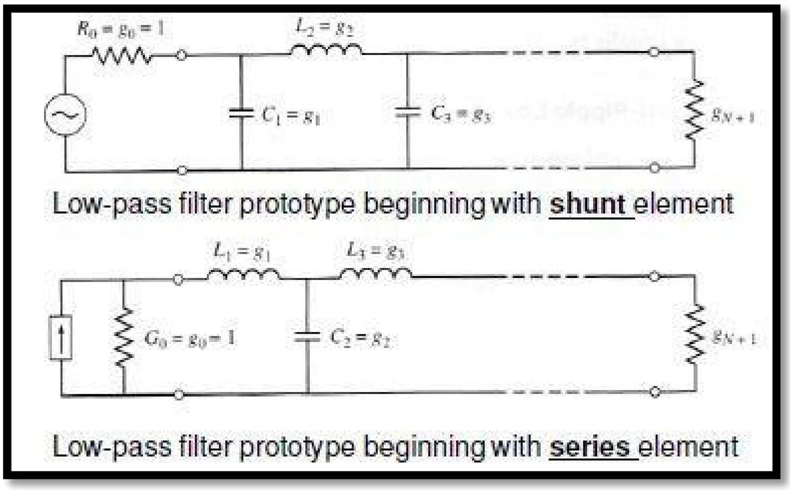

Figure 2.2: Low-pass filter prototype

The low-pass filter designed using capacitor as a shunt element and inductor as a series element [9]. The elements will be numbered from g_s on the generator impedance to the load impedance g_{N+1}, for an N-reactive filter elements [14].Based on the attenuation characteristic table, I can identify the value of N-reactive element for low pass filter prototype [1]-[2].