DUAL BAND MICROSTRIP FILTER

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This Report Is Submitted In Partial Fulfilment of Requirement for the Bachelor Degree of Electronic Engineering (Wireless Communication) With Honours

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Special dedication to my family, my kind hearted supervisor En. Azahari bin Salleh and to all my dearest friends.

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ABSTRACT

This project proposed a novel dual-band microstrip parallel-coupled SIR-BPF based on the traditional single-band coupled theory. The scope of this project presented analyze, simulation, fabricate, and measurement for parallel-coupled SIR-BPF design. Parallel-Coupled SIR-BPF is one of the popular methods to design dual-band microstrip filter because of the simplicity and compactness. The filter is designed at center frequencies of 1.3 GHz and 2.8 GHz bandwidth 25 MHz and 55 MHz. this frequency is presenting for wireless video transmitter application and Worldwide Interoperability for Microwave Access (WiMAX). There are several step to design this filter that including by determine filter specification, order of filter, bandpass filter prototype elements, bandpass transformation, physical dimensions calculations (width, spacing, length), and wavelength guide. The simulation of the dual-band microstrip filter will be done using Advance Design System 2008 software. The fabrication process will do on FR4 substrate by using etching process. Improvement technique will be introduced to get better response for scattering parameter (S_{11} and S_{21}). Simulation results of this dual band filter shows that the values of S_{21} are -0.004 dB for low frequency and -0.006 dB for high frequency. Moreover, for values S_{11} are -31.172 dB for low frequency and -16.09 dB for high frequency.

ABSTRAK

Projek ini menampilkan dwi-jalur mikrostrip selari ditambah pula SIR-BPF berdasarkan teori jalur tunggal. Projek ini juga, menampilkan merekabentuk, simulasi, analisis dan pengukuran untuk penapis dwi-jalur mikrostrip selari. Pasangan selari SIR-BPF adalah cara yang popular dalam mereka penapis dwi-jalur mikrostrip disebabkan kemudahan litar dan lebih saiz yang lebih kecil. Penapis ini direka untuk menapis isyarat yang berfrekuensi 1.3 GHz (Penghantar Video Tanpa Wayar) dan 2.8 GHz (WiMAX). Terdapat beberapa langkah untuk merekabentuk prototaip, dimensi fizikal (lebar, jarak dan panjang) dan pengiraan. Simulasi penapis ini dilakukan menggunakan program Advance Design System 2008. Proses fabrikasi pula, dilakukan menggunakan substratum FR4 dengan menggunakan proses punaran. Teknik penambahbaikan diperkenalkan untuk mendapatkan respons yang lebih baik untuk parameter serakan (S_{11} dan S_{21}). Keputusan untuk simulasi menunjukkan nilai untuk S_{21} adalah -0.004 dB untuk frekuensi rendah dan -0.006 dB untuk frekuensi tinggi. Selain itu, bacaan untuk S_{11} adalah -31.172 dB untuk frekuensi rendah dan -16.09 dB untuk frekuensi tinggi.

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LIST OF ABBREVIATIONS

BPF	-	Bandpass Filter
SIR	-	Step Impedance Resonator
S-PARAMETER	-	Scattering Parameter
ADS	-	Advance Design System
mm	-	millimeter
GHz	-	Giga Hertz
MHz	-	Mega Hertz
dB	-	Decibel

CHAPTER I

INTRODUCTION

1.1 Project Background

Recent advances in wireless communication systems have increased the demand for dual-band radio frequency circuits. Filters in electric circuits have played an important role since the early stages of telecommunication, and have progressed steadily in accordance with the advancement of communication technology. In the early stages of filter development, filter design concentrated on passive electrical circuits composed of appropriate combinations of inductor, L and capacitor, C. The LC resonator being a linear resonant system, many early researchers believed that resonant systems based on physical principles other than lumped/distributed-element electrical circuits could achieve filter performance. Dual-band operation can be implemented by switching between two independent single-band circuits, or developing a single circuit with dual-band function [1]. The first approach requires a switching circuit, increasing insertion loss and power consumption, whereas the second approach needs dual-band components such as dual-band filters.

The microstrip filter is popular in dual-band filters design because it has a planar structure, and is easy to connect with other devices. Dual-band microstrip filter design can be classified into four types.

The first method can be called twin-filter method. This type of dual-band microstrip filter is obtained by combining two individual single-band filters via a common input/output port [2–5]. This type of dual-band filter is easy to realize, because signals of the two bands pass through different resonators, allowing the two individual single-band filters to be designed independently.

The second approach is the notch-adding method which involves adding transmission zeros or notches to a wideband bandpass filter. Thus, a wide passband is separated into two narrower passbands. The transmission zeros can be created by connecting open stubs in parallel [6, 7] or cascading a bandstop filter [8]. To completely determine the responses including both passbands and stopband, the characteristic function with dual-bandpass behavior is first obtained by analytical derivation [9], synthesis [10–12] or optimization [13–15] to meet the specifications. The open stubs and quarter-wave transmission lines, which conform to the inductor-capacitor (LC) resonators and inverters obtained from the characteristic function, are applied to generate the necessary notch [12]. The notch can also be introduced by placing coupled resonators suitably such that more than one coupling paths are generated, and cancel out at the specified frequencies [8–11, 13–15]. The required coupling matrix is derived from the above characteristic function in advance. These two methods generally require large size for the great quantity of resonators.

The third method, which is often favored for its compactness, is to employ stepped impedance resonators (SIRs) [16]. For convenience, this approach may be called the SIR method. The electrical lengths and impedance ratio are used to control the fundamental and spurious resonance frequencies to meet the central frequencies of the two bands. Therefore a single set of resonators can introduce dual-band responses. In addition to the central frequency, important specifications of a filter include the type of frequency response, bandwidth and passband ripple. These characteristics are determined by the external quality factors and the coupling coefficients when using traditional coupled filter theory. Thus, the key point to developing a SIR dual-band filter is finding appropriate physical parameters to satisfy the required external quality factors and coupling coefficients at both bands simultaneously [17–22]. Since two physical parameters are necessary to obtain every desired external quality factor or coupling coefficient, two-dimensional searching or trial and error is often used. Obtaining the required values of physical control parameters is time consuming. Besides, it does not guarantee suitable values that meet the specifications.

The last approach is the Parallel-Coupled SIR-BPF method which is introduced because of the simplicity, low cost, and high performance. This method is upgraded from basic SIRs method by adding some extra coupled resonator sections to a single circuit filter [23] increases the degrees of freedom in extracting coupling coefficients, but does not reduce the difficulty of finding values for the external quality factors in the original SIR method.

1.2 Problems Statements

A low cost of manufacturing and design in microwave subsystem is the most highlighted issues today. That's why the proposed filter design used Parallel-Coupled SIR-BPF method because notch-filter method generally required large size for the great quantity of resonators which means the cost in order to produce the filter is higher than using the proposed method. Parallel-Coupled SIR-BPF method is easy to realize, because signals of the two bands pass through different resonators, allowing the two individual single-band filters to be designed independently. SIRs method is more compact and required fewer resonators than other methods. Furthermore, the problem of the demand for high performance, high efficiency, low loss and excellent reproducibility microwave always high will be overcome by use the coupled lines which generate the transmission zero.

1.3 Objectives

The objective of this project is to design a dual band microstrip filter using Parallel-Coupled SIR-BPF method and FR4 as substrate. Furthermore, this filter is target to operate at 1.3 GHz (Wireless Video Transmitter) and 2.8 GHz (WiMAX).

1.4 Scope Of Project

The scopes of this project are:

- Design and Fabricate the dual band filter by using Parallel-Coupled SIR-BPF method and FR4 as a substrate.

- Analyze the performance of the filter from s parameter (S_{11} and S_{21}) by using Advance Design System (ADS) software.
- Do parametric analysis is performed on the structure to determine the optimum dimensions to obtain the desired frequency response.
- Finally, assure the filter to be operates at 1.3 GHz and 2.8 GHz.

1.5 Thesis Outline

This thesis represent by five chapters. The following outline of the Deisgn and analysis of dual-band microstrip filter project in chapter by chapter. For chapter 1 its discuss about the brief overview about the project such as introduction, objectives, problem statements, and scope of the project. Moreover, in chapter 2 its discuss about the fundamental of the dual band filter and the reasons for the chosen of the filter design method. Besides that, chapter 3 discuss about the step by step procedure for designing a dual band microstrip filter. It presents a requirement in designing a dual band microstrip filter by using Parallel-Coupled SIR-BPF. This chapter describes the method in designing and also will included literature reviews, specification of design, design and simulation, filter analysis, fabrication, and testing. Last but not least is chapter 4, this chapter describes about the projects findings such as analysis result and result discussion. The results are represented by figures, tables, and graphs. Finally, Chapter 5 which discuss about conclusions and recommendation for this project.

CHAPTER II

LITERATURE REVIEW

This chapter discuss about the fundamental of the dual band filter and the reasons for the chosen of the filter design method.

2.1 Filter

Filters are the most important passive components used in RF and microwave subsystems and instruments to obtain a precise frequency response. In the early years of filter development, significant progress was made in waveguide and planar TEM filters. During the past two decades, filter technology has advanced in the area of emerging applications for both military and commercial markets. Several major developmental categories in filter technology are included performance improvement, development of CAD tools, full wave analysis, new structures and configurations, and advanced materials and associated technologies. Advanced materials/technologies such as high-temperature superconductor substrates, micromachining, multilayer monolithic, low temperature co-fired ceramic, and liquid-crystal polymer are commonly used in the development of advance filters. Some recent applications of filters include dual-band communications, such as wireless local area networks and ultra wideband communication and imaging [24].

Low Pass filters can be designed from the classical lumped element low-pass prototype circuits and may either be fabricated in lumped element form or transformed into equivalent transmission line networks. Band-pass filters require precise transmission characteristics that allow a desired band of signals to pass through the two-port network. Thus, between a transmitter and the transmitting antenna, a band filter may be used to attenuate unwanted signals and harmonic components that may cause interference to other users of the electromagnetic spectrum. Conversely, between an antenna and a receiver, a band pass filter will reject out-of-band signals that may cause interference within the receiver, especially if they are at a high signal level in comparison with the desired signals.

2.1.1 Types Of Filter

Filters may be classified in a number of ways. An example of one such classification is reflective versus dissipative. In a reflective filter, signal rejection is achieved by reflecting the incident power, while in a dissipative filter; the rejected signal is dissipated internally in the filter. In practice, reflecting filter is used in most applications. The most conventional description of a filter is by its frequency characteristic such as lowpass, bandpass, bandstop, or highpass. Typical frequency responses for these different types are shown in figure 2.1. In addition, an ideal filter displays zero insertion loss, constant group delay over the desired pass band, and infinite rejection elsewhere. However, in practice, filters deviate from these characteristics and the parameters in the introduction above are a good measure of performance [25].

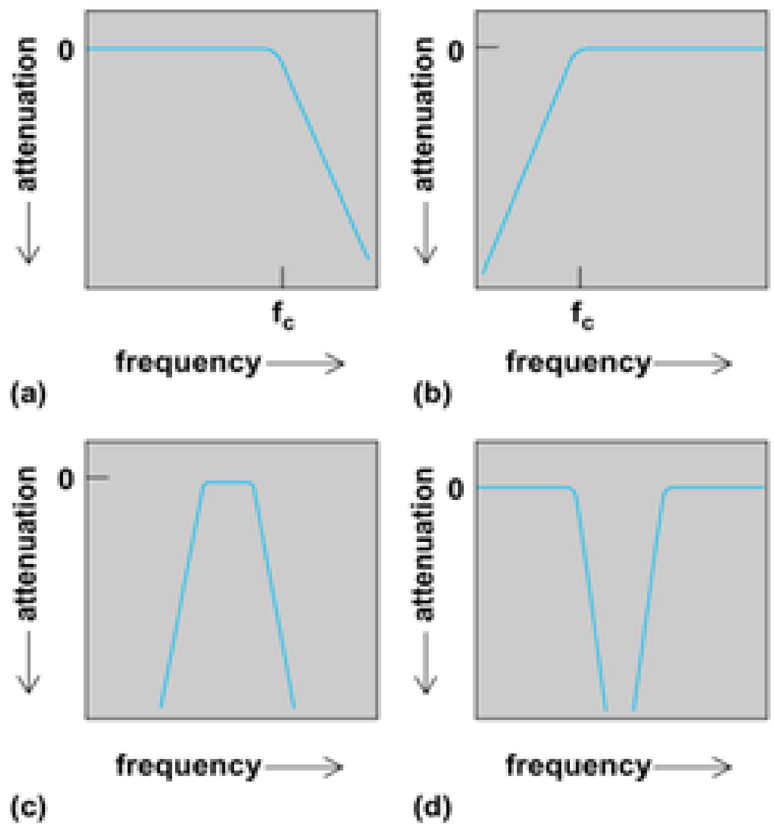

Figure 2.1 Basic filter response (a) Lowpass, (b) Highpass, (c) Bandpass, (d) Bandstop