

MICROWAVE HAIRPIN FILTER DESIGN

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To my beloved father and mother

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ABSTRACT

The scope of this project presented analyze, simulation, fabricate and measurement for microwave hairpin filter design. Hairpin Filter is one of the most popular microwave frequency filters because of it is compact and does not require grounding. The filter is designed at center frequency of 2.44 GHz with a fractional bandwidth of 3.42%. This frequency is presenting for wireless LAN application and operates in the ISM band (Industrial, Scientific and Medical) application. There are several step to design this filter that including by determine filter specification, order of filter, low pass filter prototype elements, low pass to band pass transformation, physical dimension (width, spacing, length) and wavelength guide. All calculation to design hairpin filter were done using Mathcad software. The simulation of the filter will be done using Microwave office and fabricate on FR4 substrate by using etching process. Improvement technique will be introduced to get better response for scattering parameter.

ABSTRAK

Projek ini menampilkan merekabentuk, simulasi, analisis dan pengukuran untuk penapis jenis *Hairpin*. Penapis *Hairpin* adalah salah satu diantara penapis gelombang mikro frekuensi yang paling terkenal kerana bentuknya sangat padat dan tidak mempunyai penamatan bumi. Penapis ini adalah direkabentuk pada frekuensi 2.44GHz dengan jalur lebar 3.42%. Frekuensi jalur penapis ini adalah untuk aplikasi LAN tanpa wayar dan beroperasi dalam jalur ISM. Terdapat beberapa langkah untuk merekabentuk penapis ini di antaranya adalah menentukan spesifikasi penapis, bilangan peringkat, penukaran lurus bawah ke lurus jalur, elemen penapis lurus bawah prototaip, dimensi fizikal (lebar, jarak dan panjang) dan panjang gelombang berpandu. Semua pengiraan dilakukan menggunakan perisian *Mathcad*. Rekabentuk penapis dan simulasi menggunakan perisian *Microwave Office* dan di fabrikasi pada papan substratum FR4 dengan menggunakan proses punaran. Teknik penambahbaikan diperkenalkan untuk mendapatkan lebih baik respons untuk parameter serakan.

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LIST OF TERM

A - Worsening

BW - Bandwidth

f_0 - Center Frequency

f_L - Lower Cut-off Frequency

f_H - Higher Cut-off Frequency

Z_{in} - Input Impedance

Z_0 - Characteristics Impedance

R_{in} - Input Resistance

R_0 - Characteristic Resistance

ϵ_r - Relative Dielectric Constants

ϵ_{eff} - Dielectric

ϵ_0 - Wavelength

h - Substrate Height

t - Thickness

L - Length

w - Width

s - Space

Gaps - Internal Between

Lumped - Lumped of Earth

PCB - Printer Board Circuit

CHAPTER I

INTRODUCTION

1.1 Introduction

Bandpass filters are used as frequency selective devices in many RF and microwave applications. Filters are realized using lumped or distributed circuit elements. However with the advent of advanced materials and new fabrication techniques, microstrip filters have become very attractive for microwave applications because of their small size, low cost and good performance. There are various topologies to implement microstrip bandpass filters such as end-coupled, parallel coupled, hairpin, interdigital and combline filters. This project will present the design of a hairpin microstrip bandpass filter. The basic design specifications that will be used for this bandpass filter are center frequency and bandwidth while Microwave Office software will be used for simulation. The working frequency for this band pass filter is 2.4 GHz.

WLAN operates in the ISM frequency band covering 2.4 GHz to 2.4835 GHz. The filters are designed to have a passband from 2.4 GHz to 2.4835 GHz with a minimum attenuation of -25dB at 2.5 GHz and a passband ripple of 0.2 dB. The minimum attenuation of -25dB at 2.5 GHz is chosen to prevent interference from Broadband Radio Service (BRS). BRS operates in the frequency range 2.5 GHz to 2.69 GHz. The filters are designed using Microwave Office design software and

implemented on FR4 substrate with dielectric constant (ϵ_r) of 4.7, loss tangent ($\tan \delta$) of 0.019 and substrate height (h) of 1.6mm.

1.2 Objectives

The objectives of this project are:-

1. To design and simulation hairpin filter for 2.44 GHz operating frequency this is suitable for ISM (Industrial, Scientific and Medical) band application by using microwave office.
2. To fabricate and measurement the microstrip filter on the FR4 board by using etching technique.
3. To compare between simulation and measurement result.

1.3 Problem Statement

Nowadays filters in the market are more complex. The hairpin filter is better than other filters because it is compact and does not require grounding. This filter also produces high frequency a wide band filter

1.4 Scopes Of Work

A several scope of work has been determined are:-

1. To calculate hairpin filter using MathCAD software.
2. To design and simulation hairpin filter by using Microwave office or ADS software.
3. To fabricate the hairpin filter on the FR4 board.
4. To use the etching technique and measure filter.

1.5 Project Methodology

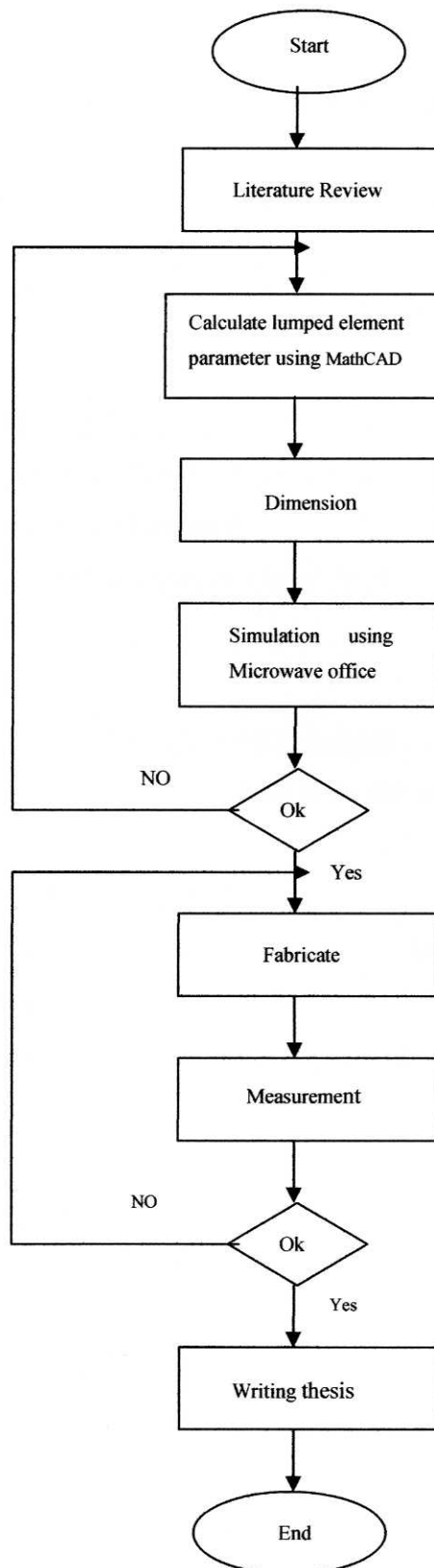


Figure 1.1: Project Methodology Flowchart

This project will involve 4 major phase:-

1st phase: Literature Review

- Gather the information about the project via Internet, journals, magazines, published work and reference books.
- Study of the software implementation (Microwave Office and MathCAD).
- Make research to know more detail about designing hairpin filter according all parameters

2nd phase: Calculation and analysis

- Analyzed and calculated all parameters that related to designing the Step impedance hairpin resonance.
- Using MathCAD software to calculate physical dimension and all parameters hairpin filter.

3rd phase: Software Implementation development

- Used software Microwave Office to do simulation and designing filter.

4th phase: Hardware development

- Then proceed to designing microstrip filter using etching technique and measure using spectrum analyzed.
- Lastly, compare between simulation and measurement results.

CHAPTER II

LITERATURE REVIEW

2.1 Background Study

The use of microstrip in the design of microwave components and integrated circuits has gained tremendous popularity since the last decades because microstrips can operate in a wide range of frequencies. Furthermore, microstrip is lightweight, ease of fabrication and integration and cost effective. Many researchers have presented numerous equations for the analysis and synthesis of microstrip. However, along with the sophistication comes with a high price tag, copy protection schemes and training requirements that create difficulties for exploratory usage in an academic environment. Therefore, a low cost, user-friendly, open source system software package is needed that can be used as an effective training aid on microstrip filters design.

The hairpin filter is one of the most popular low microwave frequency filters because of it is compact and does not require grounding. Its form is derived from the edge-coupled resonator filter by folding back the ends of the resonators into a “U” shape. This reduces the length and improves the aspect ratio of the microstrip significantly as compared to that of the edge-coupled configuration. There are many substrates with various dielectric constants that are used in wireless applications. Those with high dielectric constants are more suitable for lower frequency applications in order to help minimize the size. Its design on FR4 laminates is very

difficult to do because of the relatively poor performance of the laminate at the microwave region. The laminate properties of the FR4 become nonlinear unlike more expensive microwave laminates. The motivation to use FR4 in the low microwave frequencies is its cost

2.2 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 reflection the incident power, while in a dissipative filters are used in most applications. The most conventional description of a filter is by its frequency characteristic such as lowpass, highpass, bandpass or bandstop. Typically frequency responses for these difference types are show in figure1. In additional, an ideal filter displays zero insertion loss, constant group delay over the desire passband and infinite rejection elsewhere. However, in practical filters deviate from these characteristics and the parameters in the introduction above are a good measured of performance.

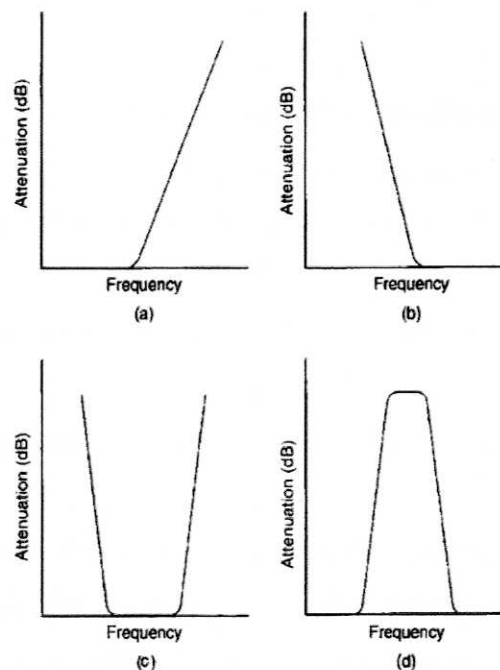


Figure 2.1: Basic Filter Response (a) Lowpass, (b) Highpass, (c) Bandpass, (d) Bandstop.