DESIGN A MICROSTRIP HAIRPIN BANDPASS FILTER FOR GPS APPLICATION

NORBAIZURA BINTI DAHALAN

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) with Honours

Faculty of Electronic and Computer Engineering
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Signature	:………………………………..
Supervisor"s Name	: EN. AZAHARI BIN SALLEH
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Dedicated to my family, lectures and to all my friends,
My appreciation to all of you for providing me assistance and encouragement throughout my final year project in Universiti Teknikal Malaysia Melaka (UTeM)

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Assalamualaikum w.b.t

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I wish to express my appreciation for my project supervisor, Mr Azahari Bin Salleh for his excellent supervision, advices, suggestion, and comment throughout the completion and implementation of this project.

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ABSTRACT

This project is mainly focused on development of microwave filter by using bandpass filter principle. The reason of this project is to develop the microwave used widely in the application and to provide the graduate engineer with knowledge about the potential of the microwave technique to implement practical microwave. Microwave frequencies generally operate at frequencies between 300 MHz and 300 GHz. Filter is highly desirable in communication systems. It functions to pass through the desired frequencies within the range and block the unwanted frequencies. In addition, filters are also needed to remove out the harmonics that are present in the communication system. This thesis presents the design of a hairpin bandpass filter. The main objective of this project is to design bandpass filter of reduced size and enhanced bandwidth. This filter are designed by using the specification as using the Chebyshev response of 0.5 dB ripples and hairpin filter for frequency 1.575 GHz. It was found that the optimum designed filter has a centre frequency of 1.575 GHz, exhibits excellent return loss in the passband of less than -20 dB. Consequently, the proposed filter is not only of compact size, it also exhibits excellent good return loss by using the AWR and CorelDRAW software.

ABSTRAK

Projek ini yang utama difokuskan pada pembangunan gelombang mikro dengan menggunakan prinsip penapis jalurlulus. Projek ini adalah bertujuan untuk mengembangkan lagi bidang gelombang mikro yang mana sering digunakan secara meluas di dalam aplikasi dan untuk menghasilkan graduan jurutera dengan pengetahuan tentang potensi teknik gelombang mikro untuk melaksanakan ianya secara praktikal. Umumnya, gelombang mikro berfungsi pada frekuensi di antara 300 MHz dan 300 GHz. Ini juga menceritakan tentang peranti penapis yang sangat diperlukan dalam sistem komunikasi. Ia berfungsi bagi membenarkan satu julat frekuensi yang dikehendaki. Di samping itu, penapis juga diperlukan untuk membuang harmonic yang tidak dikehendaki dalam sesebuah sistem komunikasi. Tesis ini membentangkan rekabentuk penapis jenis penyalun „hairpin‟. Objektif utama projek ini adalah untuk merekabentuk penapis penyalun rambut (hairpin) dengan pengurangan saiz dan lebar jalur lebih luas. Penapis penyalun rambut direka dengan spesifikasi seperti bertatarajah dalam rekaan penyalun rambut dengan menggunakan tindakbalas Chebyshev dengan ripple 0.5dB pada frekuensi 1.575 GHz. Kehilangan kembali yang sangat baik dalam penapis iaitu kurang daripada -20 dB. Penapis ini bukan saja bersaiz padat tetapi mempunyai kehilangan kembali yang lebih rendah dengan menggunakan perisian AWR dan CorelDRAW.

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AWR	Microsoft Office RF/Microwave
GPS	Global Positioning System
RL	Return loss
IL	Insertion Loss
PR	Power Reflected
EM	Electromagnetic

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CHAPTER I

INTRODUCTION

This chapter will discuss the overview process that involved for this project; the aims and specific project background, problem statements, objective of the project and work scope. The end of this chapter the thesis outline will be listed.

1.1 Project Background

A microwave filter is an electromagnetic circuit that consists of two ports network. It controls the frequency at certain point or region in a microwave system, by providing transmission at frequencies within the passband of the filter and attenuation at its stopband of the filter [1]. Filters are easily found in applications such as microwave communication, wireless communication, global positioning system and measurement system [1]. Bandpass filter is widely used in the telecommunication system, be it in receiving or transmitting devices, to filter out unwanted frequency. There are plenty of ways to design the filter, and most attractive among them is microstrip filter due to the compact structure and fairly easy to be manufactured [2]. There has been much research on hairpin resonator. The main purpose of all these project is to make the filters more compact in size and shape [3]. The conventional filter was too space consuming. The concept of miniaturize hairpin resonator was design for Global Positioning System (GPS) that nowadays are most familiar.

1.2 Problem Statement

Filter is one of the most important components in an electronic circuit. The problem statement of this project is to analyze what will be faced when there is no filter circuit in GPS system. Without an automatic filter tuning circuit, it can"t keep the cut-off frequency of the filter constant and structure will run with unwanted signal. The conventional filter is built in concept integrates lumped element which have a large size, so we solve to reduce the size of bandpass filter by using hairpin resonator.

1.3 Objective

The objective of this project is to design, simulate and fabricate a microstrip hairpin bandpass filter that operating at frequency 1575.60 MHz for Global Positioning Application (GPS) with bandwidth 12%, insertion loss >-1 dB and return loss < -20dB.

1.4 Work Scope

The project is designing a suitable microstrip bandpass filter structure for GPS application with frequency LI is 1575.60 MHz. The configuration is modified to reduce the size of the fractal filter. The Microsoft Office RF Design (AWR) is used to design and simulate the conventional filter. For hardware implementation and fabrication, Coral DRAW is used for actual printed circuit layout. The parameters performances of the filter are analyses in term of return loss < -20dB, insertion loss >-3dB, and bandwidth 12% and so on to have the optimum configuration microstrip bandpass filter for GPS. The project scopes are as following:

(a) Literature reviews of band pass filter design and software"s that are available.
(b) Design microstrip band pass filters with using mathematical software.
(c) Simulating the designed filters with AWR software.

(d) Analyze the characteristics and performance of the designed filters to determine the ideal filter structure and become the optimum design where the parameters in term of loss < -20dB, insertion loss >-3dB, and bandwidth 12%

(e) Fabricate optimum design filter into respective multilayer with FR4 substrate

(f) Configurations simulate and measured the performance of the filter.

1.6 Thesis Outline

The report consists of six chapters. Chapter I present the objective, problem statements, objective, project scope and thesis outlines.

Chapter II discusses the basic theory on Global Positioning System (GPS) that are the main application have been choose for designing this project. It also explained the location of this project onto the GPS system.

Chapter III presents about the filters that relevant to this project. These include S-parameters application in microwave circuits, a brief discussion on the subject and equations concerning the theory were presented. Filter synthesis technique method were described together with discussion on filter response. This chapter also covers theories of resonator miniaturization, hairpin filter realization and characteristics of internal coupled resonator.

Chapter IV presents design methodology, specification and the discussion on the tools involved for circuit simulation.

Chapter V discusses the result and analysis of the findings. These include the study of resonator behaviour and all parameter variations that affect filter performance as whole. Discussion and comparison of the filter performances are made, for the single and multilayer configurations.

Finally, chapter VI covers the project conclusion of the thesis and discussion deep details on recommendation and possible future work that can be done to enhance the application of miniaturize resonator and improve the performance.

CHAPTER II

GLOBAL POSITIONING SYSTEM (GPS)

There are several types of system that involved in user needed that used a filter in their structure, such as GPS system, W-LAN system, GPS system, Infra-red system and others. In this project, the GPS system application is used for the designing the filter. In this chapter will discusses the basic theory on Global Positioning System (GPS) that are the main application have been choose for designing this project. It also explained the location of this project onto the GPS system.

2.1 GPS Overview

GPS is fully operational and meets the criteria established in the 1960s for an optimum positioning system. The system provides accurate, continuous, worldwide, three-dimensional position and velocity information to users with the appropriate receiving equipment. GPS also disseminates a form of Coordinated Universal Time (UTC). The satellite constellation nominally consists of 24 satellites arranged in 6 orbital planes with 4 satellites per plane. A worldwide ground control/monitoring network monitors the health and status of the satellites. This network also uploads navigation and other data to the satellites. GPS can provide service to an unlimited number of users since the user receivers operate passively (i.e., receive only).

The system utilizes the concept of one-way time of arrival (TOA) ranging. Satellite transmissions are referenced to highly accurate atomic frequency standards onboard the satellites, which are in synchronism with a GPS time base. The satellites broadcast ranging codes and navigation data on two frequencies using a technique called code division multiple access (CDMA); that is, there are only two frequencies in use by the system, called L1 (1,575.42 MHz) and L2 (1,227.6 MHz). Each satellite transmits on these frequencies, but with different ranging codes than those employed by other satellites.

2.2 GPS System Segment

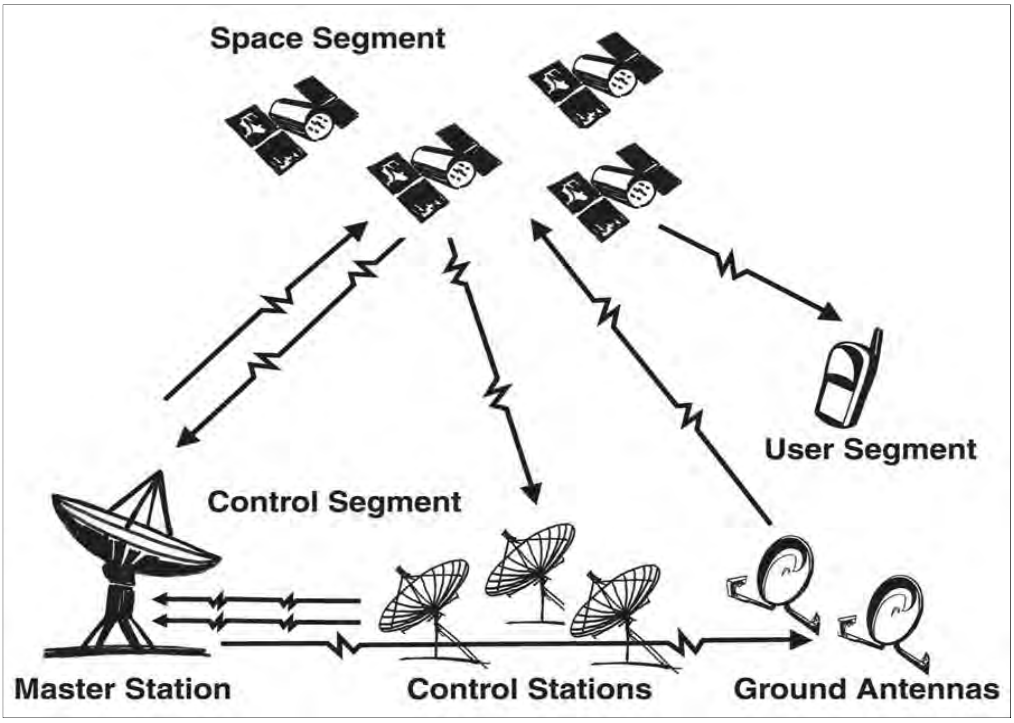

Figure 2.1: Three Segment of GPS System [4]

GPS is comprised of three segments: satellite constellation, ground-control/monitoring network, and user receiving equipment. Formal GPS JPO programmatic terms for these components are space, control, and user equipment segments, respectively as shown in Figure 2.1, The satellite constellation is the set of satellites in orbit that provide the ranging signals and data messages to the user equipment. The control segment (CS) tracks and maintains the satellites in space [4]. The CS monitors satellite health and signal integrity and maintains the orbital configuration of the satellites. Furthermore, the CS updates the satellite clock corrections and ephemerides as well as numerous other parameters essential to determining user PVT. Finally, the user receiver equipment (i.e., user segment) performs the navigation, timing, or other related functions (e.g., surveying). There are three segments of GPS which is space segment, control segment and user segment.

(a) The space segment (satellites)
Broadcast radio signals toward users on the Earth and receive commands from the ground

(b) The control segment
Monitors the space segment and send commands to satellites

(c) The user segment
Receivers record and interpret the radio signals broadcast by the satellites

For this project just focus a primary signal at 1.575 GHz (L1 band). The basic GPS diagram is a transmitter, satellite and receiver part. For GPS system, both part transmitter and receiver are including the use of filter.

2.3 GPS Receiver Architecture

The GPS system has been fully operational with 24 satellites in its constellation since 1994. It is used by millions of people, both civilian and military, every day. The fundamental concept of using code-division multiple access (CDMA) for time-delay measurement (yielding range) while allowing all satellites to share the same carrier frequency 1.57542 GHz has not changed in the past 30 years. Each GPS satellite uses a unique 1,023-chip orthogonal code (Gold code) to spread the low-speed binary phase shift keying (BPSK, 20 ms per bit) navigation data bitstream. The chipping clock rate is 1.023 MHz, and therefore the sequence of 1,023 chips repeats every millisecond.

The GPS receiver generates a local copy of the same Gold code, which is then cross-correlated with the incoming signal. When the receiver code phase aligns with the incoming signal code phase, there is a +30 dB improvement in the SNR, and the BPSK navigation bit stream can then be easily detected. Roughly speaking, you can use the local code time offset, where the correlation is maximized to estimate the time difference between the received signal and the signal transmitted by the satellite. The range is directly proportional to time; therefore, with four satellite ranges, and knowing the positions of the satellites, you can navigate.

The Receiver for the GPS system consist of LNA with high front-end gain, a active type I/O down conversion mixer, and baseband circuits which perform amplification and filtering [4]. As shows in Figure 2.2, the hairpin bandpass filter that design in this project are located at the block of PPF. The bandpass filter are used to remove unwanted signal of frequency that"s capture from the receiver antenna.

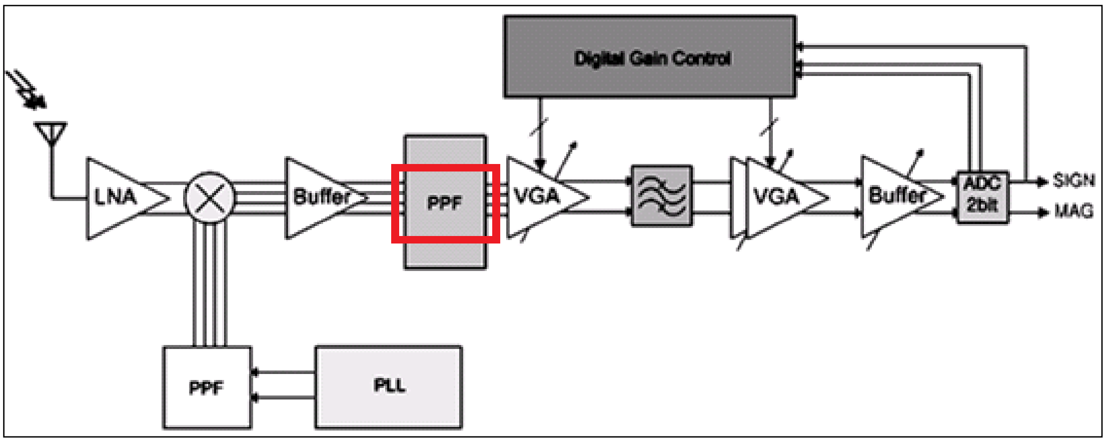

Figure 2.2: GPS Receiver Architecture [4]

CHAPTER III

FILTER THEORY

This chapter is represents about the filters that relevant to this project. These include S-parameters application in microwave circuits, a brief discussion on the subject and equations concerning the theory were presented. Filter synthesis technique method were described together with discussion on filter response. This chapter also covers theories of resonator miniaturization, hairpin filter realization and characteristics of internal coupled resonator.

3.1 Introduction

Filters are used for the rejection of unwanted signal frequencies but permitting good transmission of wanted frequencies. An automatic filter tuning circuit keeps the cut-off frequency of the filter constant despite the environmental variations in the supply voltage and temperature [2]. In this chapter, an explanation about microwave filter theory and scattering parameters are given. In addition, basic theory of microstrip transmission line is also given.

Most microwave systems consist of many active and passive components that are difficult to design and manufacture with precise frequency characteristics. In contrast, microwave passive filters can be designed and manufactured with remarkably predictable performance. As a result, microwave systems are usually