DESIGN AND DEVELOPMENT OF FILTER AND ANTENNAS INTEGRATIONS AT 2.45 GHZ FOR WIRELESS LOCAL AREA NETWORK (WLAN) APPLICATIONS

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DEDICATION

This thesis is dedicated to God Almighty, my family, my teachers and all those who helped me during the course of my studies.

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ABSTRACT

This thesis presents design and development of filter and antennas integrations at 2.45 GHz for WLAN applications. Antenna and band pass filter are two main components of RF front end systems. Due to long transmission path, the losses between the antenna and bandpass filter affect the performance of the overall RF systems. To reduce the losses and to reduce the size of the RF front end system, these two components are integrated to a single structure that has both the filtering and radiating properties. Two filtering antennas namely Design 1 and Design 2 are proposed. Design 1 is the integration of hairpin band pass filter and micro strip patch antenna. Design 2 is the integration of hairpin band pass filter and dipole antenna. The methodology used to design the filtering antennas is the filter synthesis method. In this method the last stage of the hairpin band pass filter is replaced/merged with the antenna. All designed structures were simulated using Computer Simulation Technology (CST) Microwave studio. The main advantage of the filter synthesis method is that the resulting structure has reduced size and more suited for narrow band antennas. Other advantages include sharp selectivity and good out of band gain suppression. In order to compare the performances of Design 1 and Design 2 their performances are compared to conventional patch and dipole antennas. Simulation results show that design 1 has achieved a size reduction of 35 % compared to cascaded structure of bandpass filter with patch antenna whereas design 2 has achieved a size reduction of about 25 % compared to cascaded bandpass filter with dipole antenna. The filtering antennas are successfully designed, simulated and optimized for the WLAN applications.

ABSTRAK

Tesis ini mempersembahkan reka bentuk dan pembangunan integrasi penapis dan antena pada 2.45 GHz untuk aplikasi WLAN. Penapis dan antena adalah dua komponen utama sistem RF bahagian hadapan. Oleh kerana laluan transmisi yang panjang, kehilangan laluan diantara penapis dan antena mempengaruhi prestasi keseluruhan sistem RF. Untuk mengurangkan kehilangan dan mengurangkan ukuran saiz sistem RF bahagian hadapan, kedua komponen ini disatukan dengan struktur tunggal yang mempunyai sifat penapisan dan pemancar. Dua antena penapisan iaitu Reka Bentuk 1 dan Reka Bentuk 2 dicadangkan. Reka bentuk 1 adalah penggabungan penapis jalur pin rambut dan antena jalur mikro. Reka bentuk 2 adalah penyatuan penapis jalur pin rambut dan antena dipol. Metodologi yang digunakan untuk merancang antena penapisan adalah kaedah sintesis penapis. Dalam kaedah ini tahap terakhir penapis jalur pin rambut diganti / digabungkan dengan antena. Semua struktur yang dirancang disimulasikan menggunakan studio Microwave Technology Simulation Technology (CST). Kelebihan utama kaedah sintesis penapis ialah struktur yang dihasilkan mempunyai ukuran yang lebih kecil dan lebih sesuai untuk antena jalur sempit. Kelebihan lain termasuk selektiviti tajam dan penekanan tinggi di luar jalur. Untuk hasil penambahbaikan Reka Bentuk 1 dan Reka Bentuk 2 dibandingkan dengan antena mikro jalur dan dipole konvensional. Hasil simulasi menunjukkan bahawa Reka Bentuk 1 telah mencapai pengurangan ukuran sekitar 35% berbanding penapis jalur dan antena jalur mikro yang digabung secara siri manakala Reka Bentuk 2 mencapai pengurangan ukuran sekitar 25% berbanding dengan penapis jalur dan antena dipol secara siri. Antena penapisan berjaya dirancang, disimulasikan dan dioptimumkan untuk aplikasi WLAN.

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LIST OF ABBREVIATIONS

BW	-	Bandwidth
BER	-	Bit error rate
CST	-	Computer Simulation Technology
E	-	Electric field
FBW	-	Fractional Bandwidth
LNA	-	Low noise amplifier
H	-	Magnetic field
RF	-	Radio frequency
SNR	-	Signal to noise ratio
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

1.1 Introduction

RF and Microwaves is a very active area of research and development for the last decades. A lot of research has been done to make RF communication systems more efficient and effective. The performance of the overall RF systems depends mainly on the RF front end. A typical RF front end receiver circuit comprises of an antenna, bandpass filter, low noise amplifier, mixer and local oscillator **[1]**. Block diagram of a typical RF front end receiver is given in Figure 1.1.

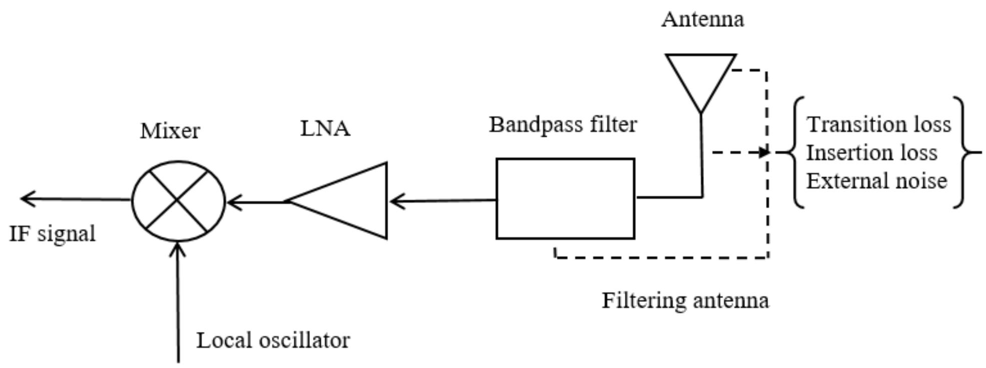

Figure 1.1 Block diagram of RF front end receiver

Antenna and bandpass filter are the two key components of the RF front end circuitry. Antenna is used to receive or transmit the RF signal and bandpass filter is used to remove the unwanted signals. The signal from the antenna to bandpass filter has to travel through the transmission path. The losses i.e. transition loss, insertion loss and external noise degrades the overall system performance. Also there is an increasing trend towards simplicity and miniaturization of the RF systems. So to reduce the losses between antenna and bandpass filter and to reduce the system size and cost, these two main components can be integrated into a single structure, which has both the radiating and filtering properties at 2.45 GHz, for Wireless local area network (WLAN) application.

The integrated structure of bandpass filter and antenna has both the filtering and radiating properties. The filtering properties include sharp roll offs and good out of band gain suppression and radiating properties include good shaped radiation pattern and gain. The design of integrated structure of bandpass filter and antenna simplifies the RF front end system as shown in Figure 1.2.

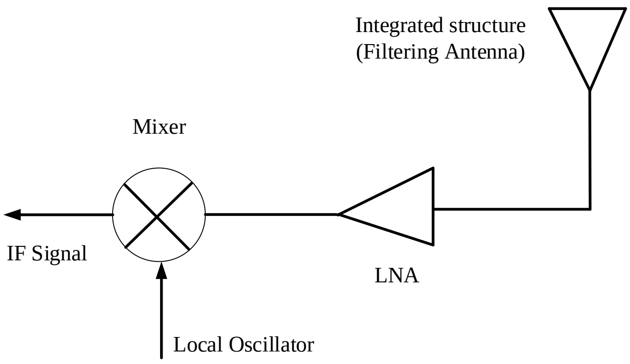

Figure 1.2 Block diagram of RF front end with integrated structure

1.2 Problem Statement

The bit error rate (BER) performance and the signal to noise ratio (SNR) of the system depends mainly on the RF front end. Therefore the quality of signal can be improved by enhancing the performance of RF front end system. One possible way is to integrate the filter and antenna into a single structure that results in reduced losses due to long transmission path between the antenna and the bandpass filter **[1]**. To integrate the filter and antenna come with some challenges like low out of band gain suppression, no sharp selectivity, complex geometry and large size.

Some research has been done that make use of the high profile stack structure to compensate for the pass band gain of the filtenna **[2]**. But this method makes the structure complex and increases the size of the overall front end. Moreover, if the bandpass filter and antenna are simply integrated, in a cascaded fashion, the size is still large. So there is a need to design an efficient integrated structure of band pass filter and antenna that has small size, good out of band gain suppression, sharp selectivity and good radiation pattern.

1.3 Project Objectives

The main aim of this project is to design and develop an integrated structure of band pass filter and antenna that has small size, good out of band gain suppression, sharp selectivity and good radiation pattern. So the following research objectives are listed below:

(a) To design a band pass filter that has sharp selectivity and low insertion loss (> -3dB).

(b) To design filtering antenna by merging the designed band pass filter and micro strip patch antenna (Design 1).

(c) To design an integrated structure by merging the bandpass filter with the dipole antenna (Design 2).

(d) Performance comparisons of objective (b) and objective (c) with conventional patch and dipole antennas respectively.

1.4 Project Scope

Project scope covers a literature review to develop understanding of the project and the simulation of the design in Computer Simulation Technology (CST) software. Hence the scopes of the project are listed below:

(a) Design of the bandpass filter with low insertion loss (> -3dB) and sharp selectivity. For this hairpin bandpass filter is chosen. The hairpin band pass filter is simple compact size and allows for sharp roll offs **[3]**.

(b) Design of the Filtering antenna (filtenna) using filter synthesis method. The designed filtenna will have sharp selectivity, good out of band gain suppression of <-10dB and compact size. Hairpin bandpass filter and micro strip patch antenna will be used **[4]**.

(c) Design of an integrated structure by merging of dipole antenna and hairpin bandpass filter. The resulting structure will have sharp selectivity, good out of band gain suppression of <-10dB and reduced size.

(d) To validate the performance of the designs, Computer Simulation Technology (CST) will be used to evaluate the performance in terms of S_{11} and S_{21} parameters.

1.5 Summary

Chapter 1 presented an introduction of the project. Antenna and bandpass filter are two main components of RF front end systems. The integrated structure of antenna and bandpass filter results in reduced losses, size and cost. Integrated structure of antenna and bandpass filter must possess both radiating and filtering characteristics. Project objectives mainly include design and simulation of the integrated structures design 1 (patch and hairpin bandpass filter) and design 2 (dipole and hairpin bandpass filter) at 2.45 GHz, that have both good filtering and radiating characteristics.

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