DESIGN OF INTEGRATED FILTER-ANTENNA FOR WIRELESS COMMUNICATIONS

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BORANG PENGESAHAN STATUS LAPORAN
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Dedicated to my beloved family especially my parents, supervisor, lecturers, all my friends.

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ABSTRACT

This report presents the design and development of an integrated rectangular patch antenna and T-shape resonator filter, which utilizes cascaded techniques. The reduction of the overall design size in front-end subsystems as well as in manufacturing cost was contributed by integrated method. As starting point in developing processes, the basic concept of filter with the characteristics of the circuit transformation of low pass prototype network for filter, antenna and integrated filter and antenna was applied. Then, next procedure applying Chebyshev band pass for filter, antenna and integrated filter and antenna at selected frequency based on single- and dual-band. The final design process were developed using planar structure based on T-shape resonator filter and rectangular patch antenna. Integrated method using coupling technique was developed in order to combined T-shape resonator filter and rectangular patch antenna. There are two software were used in design and development of integrated rectangular patch antenna and T-shape resonator filter. It is Advanced Design System (ADS) software, and CST Studio Suite software. All designs in this project were simulated, manufactured and measured. The experimental result has shown good results with the simulated results. The reduction of the overall size, low in cost, ease to fabricate and the use of standard printed circuit board process were main benefits of integrated rectangular patch antenna and T-shape resonator filter. This prototype of microwave filters is suitable and is an alternative solution for WLAN applications without an addition of external common impedance network on the systems. A study for integrated of filter-antenna with dual-band for 2.4 GHz and 5.8 GHz wireless local area (WLAN) is presented. The proposed integrated antenna system will be consists of a rectangular with notch dual-band and a microstrip dual-band T-shape resonator low pass filter. As expected to be final result, it should capable to provide wider bandwidth, good selectivity, high suppression in the stop band and directional radiation patterns within the two interested frequency band.

ABSTRAK

Laporan ini membentangkan reka bentuk dan pembangunan integrasi antena tampalan segi empat tepat dan penapis penyalun bentuk-T yang menggunakan kaedah lata. Pengurangan saiz keseluruhan rekabentuk dan kos pembuatan dalam bahagian depan sistem subdi sumbangkan oleh kaedah integrasi. Sebagai satu titik permulaan, konsep asas penapis dengan ciri-ciri transformasi litar rangkaian prototaip untuk penapis laluan rendah, antena dan integrasi penapis dan antena telah diaplikasikan. Selepas itu, prosedur seterusnye mengaplikasikan lulus jalur untuk penapis Chebyshev, antena dan integrasi penapis dan antena pada frekuensi yang dipilih berdasarkan tunggal- dan dwi-jalur. Proses rekabentuk terakhir telah dibangunkan dengan menggunakan struktur satah berasaskan penapis penyalun bentuk-T dan antena tampalan segiempat tepat. Kaedah integrasi menggunakan teknik gandingan telah dibangunkan untuk gabungkan penapis penyalun bentuk-T dan antena tampalan segiempat tepat. Terdapat dua perisian yang telah digunakan dalam reka bentuk dan pembangunan integrasi penyalun bentuk-T penapis dan penapis antena lulus jalur. Ia adalah perisian Advance System Design (ADS) dan perisian CST Studio Suite. Semua reka bentuk dalam projek ini telah disimulasikan, dihasilkan dan diukur. Keputusan eksperimen telah menunjukkan keputusan yang baik dengan simulasi yang telah dilakukan. Pengurangan saiz keseluruhan reka bentuk, kos yang rendah, fabrikasi yang mudah dan menggunakan proses biasa papan litar yang bercetak adalah manfaat utama integrasi antenna tampalan segiempat tepat dan penapis penyalun bentuk-T. Prototaip penapis gelombang mikroini adalah sesuai dan penyelesaian alternatif untuk aplikasi WLAN tanpa rangkaian impedans luaran yang biasa di dalam sistem. Pembelajaran untuk integrasi penapis antenna dengan dwi-jalur untuk 2.4 GHz dan 5.8 GHz WLAN telah ditunjukkan. Cadangan system integrasi antenna akan mengandungi segiempat tepat dengan takuk dwi-jalur dan penapis jalurmikro dwi-jalur penyalun bentuk-T. Keputusan yang dijangkakan, sepatutnya ia berkebolehan untuk menyediakan jalur lebar yang lebih lebar, pemilihan yang bagus, penindasan yang tinggi dalam jalur henti dan bentuk radiasi berarah di dalam dua frekuensi jalur yang dikehendaki.

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LIST OF ABBREVIATION

ADS	-	Advanced Design System Software
EM	-	Electromagnetic
TE	-	Transverse Electric
TEM	-	Transverse Electromagnetic
TM	-	Transverse Magnetic
TX	-	Transmit
AUT	-	Antenna Under Test
CST	-	Computer Simulation Technology
dB	-	Decibel
GHz	-	Gigahertz
RF	-	Radio Frequency
RL	-	Return Loss
RX	-	Receiver
VNA	-	Vector Network Analyzer
WLAN	-	Wireless Local Area Network

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A Wireless Local Area Network (WLAN) links two or more devices using some wireless distribution method and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network in a specific range of frequency. In order to gives comfortable and compactness in wireless communication system, both filter and antenna are need designed together. To achieve this purpose, both filter and antenna must meet perfectly the requirement which is get optimum desired return loss for both elements by using suitable impedance matching. The concept of integration filter and antenna combine together into one module is to reduce the overall size of element and to improve the performance which is the transition loss in both elements located in the RF front-end subsystems as shown.

1.2 PROBLEM STATEMENT

Nowadays technology on the receiver/transmitter diplexer is designed with the filter and antenna in separate modules. In microwave band, this is normally

a distributed filter and is implemented using transmission line resonators. The transmission line filters are not compact, and in many applications where size is an issue. This results in a large size and a high cost as well as performance (loss).

1.3 OBJECTIVE

The main objectives of the project are as follows:

1) To design dual-mode integrated filter-antenna at frequency 2.4 GHz and 5.8 GHz that suitable for WLAN applications.
2) To analyze the characteristic of integrated filter-antenna such as S-parameter, radiation pattern, directivity and bandwidth.
3) To fabricate and validate the proposed concept.

1.4 SCOPE OF PROJECT

The scope of this project is to design for integrated of filter-antenna with dual-band for 2.4 GHz and 5.8 GHz which is based on the IEEE 802.11 for WLAN standard. The Filter-antenna is simulated by using software Advanced Design System Software (ADS) for ideal simulation and the Computer Simulation Technology (CST) software with the FR4 board. The antenna will be optimized to fulfill the specification and the performance requirements of the Filter-antenna. The compact integrated of filter-antenna is fabricated by using FR4 board with dielectric constant, ε_r= 4.6 and tangent loss of substrate, tan δ = 0.019. Besides, the thickness of substrate, h = 1.6mm and thickness and thickness of copper, t = 0.035mm. Chemical etching technique will be used for the fabrication process. After the fabrication of filter-antenna is done, the filter-antenna will be measured by using Antenna Training Kit (TX and RX), FieldFox RF Analyzer, Vector Network Analyzer (VNA) and others.

1.5 METHODOLOGY

The flow chart of this project was as shown in the Figure 1.1. This project was start with the literature review through journals and books in order to identify the aspects that related to the integrated filter-antenna. Before design the integrated filter-antenna, the design process will start with design the single filter, single filter, single filter-antenna and lastly dual-band filter-antenna. Initial stage, the designing are simulate use Agilent advances design system (ADS), the follow simulate by using CST software. After the simulation design for the dual-band filter-antenna antenna is done and the result is desirable, the antenna will be fabricated by using FR4 board with chemical etching technique. Next, measurement for the prototype antenna will be done.

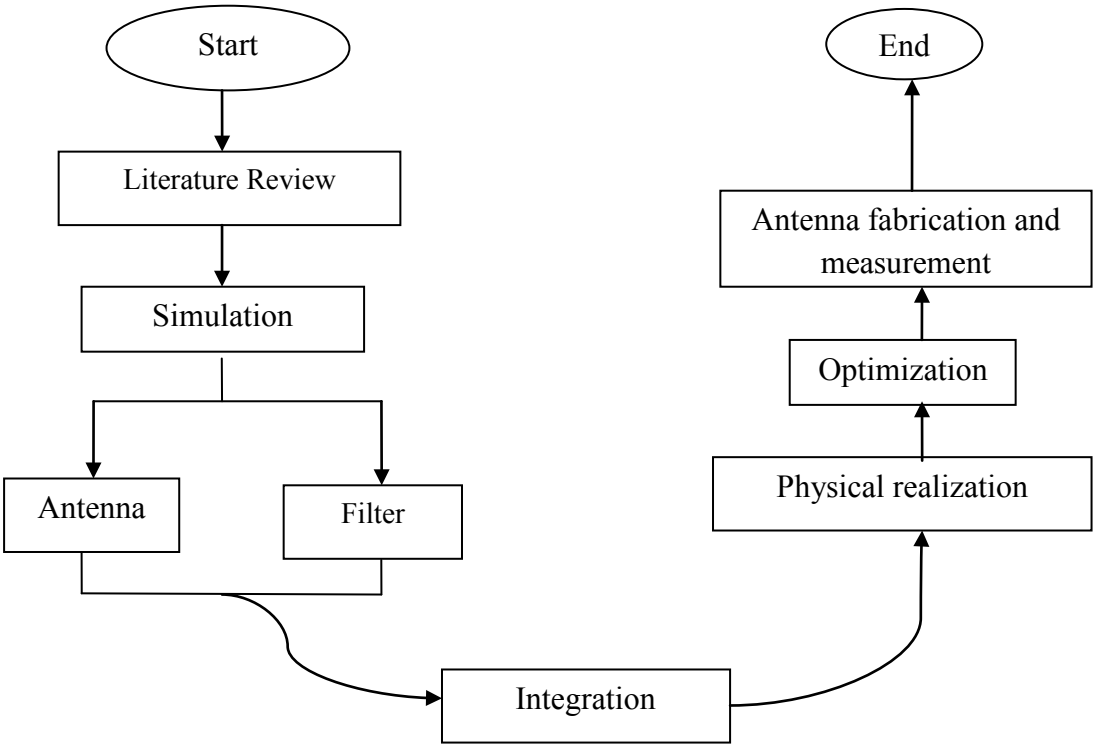

Figure 1.1: Project Flowchart

1.6 ORGANISATION OF THESIS

In this final year project report, the thesis is organized into five chapters. Chapter 1 is about the introduction about the dual-band filter-antenna antenna for the WLAN application, problem statement, objective, scope of work and methodology.

Chapter 2 is covers the background of the basic concept of antenna and filter. Then, discuss about concept lowpass prototype network and how to transform to bandpass circuit. The resonant circuit of this design procedure also discuss here from the single filter and antenna, dual filter and antenna, single-mode integrated filter-antenna, and last dual-mode integrated filter-antenna. Also, some overview of microstrip patch antenna and review of integrated microwave filter-antenna is discussed.

Chapter 3 is discussed about the methodology of this project. The design can classify into three parts, which are single filter and single antenna, single integrated filter-antenna and dual-mode integrated filter-antenna. FR4 board is used in order to design a dual-mode integrated filter-antenna. The design process that involved for the design of dual-mode integrated filter-antenna is included calculations and parametric study. The simulation, fabrication and measurement process are discussed in this chapter.

Next, Chapter 4 is about the result and the discussion for the result that obtained from the simulation or measurement.

In Chapter 5, the conclusion of this project will be discussed and a few suggestions for future work to the dual-mode integrated filter-antenna are proposed.

CHAPTER 2

LITERATURE REVIEW

This chapter is discussed on the literature review for the topic of design of integrated filter-antenna for wireless communication. Firstly, the background of the integrated filter-antenna that discussed by compared with the conventional separated antenna and filter systems. Then, the basic antenna parameters also discussed in this chapter, which included radiation pattern, bandwidth, return loss, directivity, and bandwidth have been highlighted in this chapter.

2.1 Background

A Wireless Local Area Network (WLAN) links two or more devices using some wireless distribution method and usually providing a connection through an access point to the wider internet. This gives users the mobility to move around within a local coverage area and still be connected to the network in range of frequency as shown in Figure 2.1. In order to gives comfortable and compactness in wireless communication system, both filter and antenna are need designed together. To achieve this purpose, both filter and antenna must meet perfectly the requirement which is get optimum desired return loss for both elements by using suitable impedance matching.

The concept of integration filter and antenna combine together into one module is to reduce the overall size of element and to improve the performance which is the transition loss in both elements located in the RF front-end subsystems as shown in Figure 2.2. There have been numerous studies of literature about the evolution of filter-antenna from the single-mode until to dual-band applications. Therefore, many method had been apply which presented by [1][2][3], it using edge-fed gap-coupling mechanism to produce single-mode filter-antenna. In addition, there a design filter-antenna using coplanar wave guide (CPW) has been presented in [4] to improve band-edge selectivity and good stop-band suppression. In [5] it implements filter-antenna as system-on package (SOP), by using this concept it able to support higher frequency up to 66 GHz, also can provide high gain, and fan-beam radiation pattern.

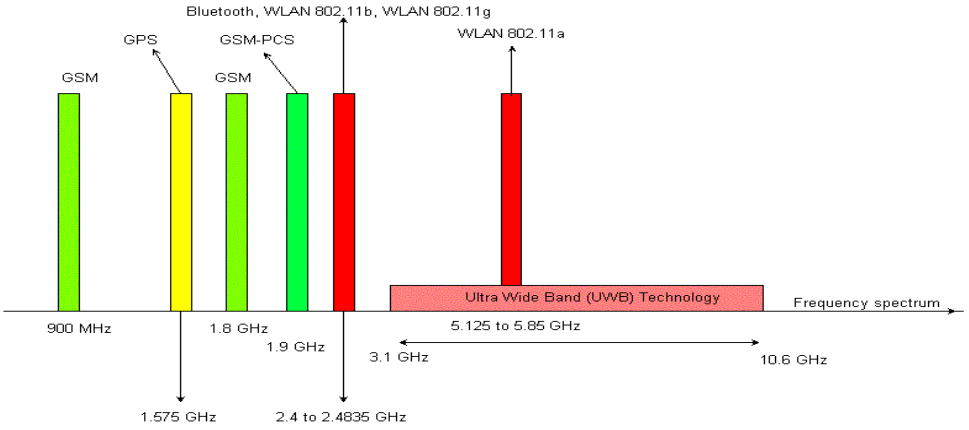

Figure 2.1: Distribution of frequency spectrum in wireless communication system.

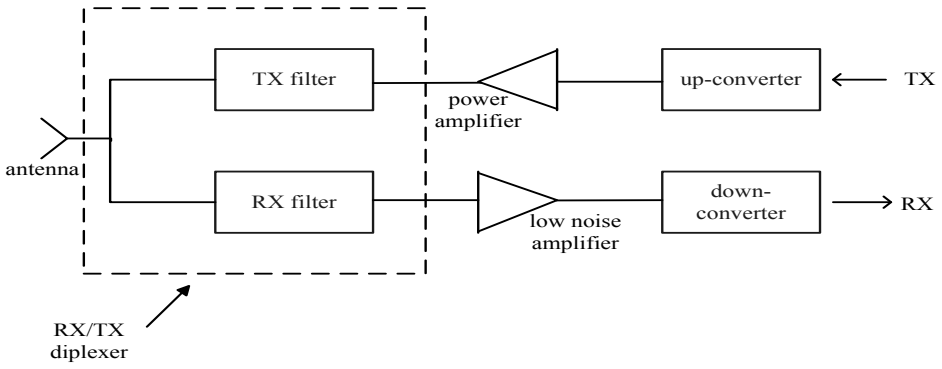

Figure 2.2: Block diagram of the RF front end of wireless communication systems in the base station.

2.1.1 Basic Concept of Antenna

Antenna is an electrical device that able to coverts electric power into electromagnetic waves and vice versa. These devices use to transmit and receive electromagnetic wave. Typically, most antennas are resonant devices which to handle efficiently under specific given narrow frequency band [15].

2.1.2 Basic Concept of Filter

Filter is the most importance components in a huge variety of electronic systems, such as satellite communications, cellular radio, satellite communications, radar and etc. Filter work to emphasize the received signal in certain frequency ranges and reject signals that out of frequency range. Its means only interested signal frequency that can pass through the filter response for example in radio base station, satellite communications and radar systems [6]. Moreover, filters are required to have different specifications (such as return loss, insertion loss, bandwidth, as well as frequency range) which depend on the need of certain applications. However, to design filter the network synthesis is needed as a tool in designing processes. From network synthesis, it can provides the designer with a prototype network is transformed into a variety of microwave networks by using the most suitable transmission line which typically uses stripline, microstrip, coaxial resonator, or waveguide [7].

In order to design microwave filter, there have been several developed over the last few decades, most of the design procedures for microwave filters are still based on Cohn's paper [8]. There are three steps in order to design microwave filter which are:

1) Begin with common mathematical models, and then an equivalent circuit prototype is designed.
2) After that, covert the prototype elements into real filter structure, by estimates are calculated for the physical layout of the filter dimension.
3) Lastly, get optimize value on the filter response by the physical layout. In this case, inductors, capacitors and resistors are remaining as passive elements. [9]

The basic ladder filters that are normally used can be dividing into 4 types [10]:

i. Butterworth filters;
ii. Chebyshev filters;
iii. Elliptical filters;
iv. Linear phase filters.

There is another type of filter which called as Quasi-elliptic filter, is the combine features of elliptical and Chebyshev filters. The advantages of this type of filter are better selectivity rather than Butterworth and Chebyshev. In term of loss and attenuation, Butterworth and Chebyshev is good. In addition, it is easier to synthesize than elliptic. Four types of filters that can be designed based on the ladder filter are lowpass filter, highpass filter, bandpass filter and bandstop filter. Figure 2.3 shows the response of each prototype filter in an ideal condition.