DUAL BAND ACTIVE MICROSTRIP MONOPOLE ANTENNA FOR WIRELESS LOCAL AREA NETWORK

ABDULRAHMAN ABDULLAH AL-MALSI

UNIVERSITI TEKNOLOGI MALAYSIA

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To my beloved Father, Mother, brothers, Sisters and wife

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ABSTRACT

An active antenna with simultaneous transmit and receive function, integrate an active devices onto a printed antenna to improve its performance or combine functions within the antenna itself. Such antenna are of increasing interest, as system designers require more complex functions to be implemented in reduced space. This thesis discusses the integration of active antennas by combining receive functions into one single antenna. Two main components in the design are passive dual band microstrip monopole antenna and active device (low noise amplifier). All the simulations are done using the CST Microwave Software and Advance Design System (ADS). The terminology of "active integrated antenna" indicates specifically that the passive antenna elements and the active circuitry are integrated on the same substrate. Two different set of frequencies have been allocated for the WLAN application. One is at 2.4 GHz band and the other at 5.8GHz band. Two different set of frequencies need two different set of antenna. It can be solved by using one antenna for two different systems. Basically the design of transmit or receive passive microstrip monopole antenna the gain is not constant over a desired frequency band. The implementation of amplifier (low noise amplifier) in a passive antenna structure increases the antenna gain and improves the noise performance. The antenna will be designed for receiver type of amplifying active integrated microstrip monopole antenna for WLAN applications in IEEE 802.11b/g/a systems. The antenna will be fabricated on the FR4 microstrip board with εr= 4.7 and $\tan\theta$ = 0.019.The best value of the return loss at operation frequencies (ISM band) just will be less than -10 dB especially after intergrades the LNA to the antenna, and also the gain just will be greater than 10 dB and noise characteristics of the antenna will be enhanced(2~3dB).

ABSTRAK

Antena aktif dengan fungsi pemancaran dan penerimaan pada waktu yang sama, mengintegrasikan peralatan aktif kepada antena tercetak untuk meningkatkan keupayaan atau menggabungkan pelbagai fungsi kepada antena itu sendiri. Antena sedemikian amat diminati, di mana perekabentuk sistem memerlukan fungsi-fungsi yang lebih kompleks untuk digabungkan dalam ruang yang terhad. Kertas ini membincangkan integrasi antena aktif dengan menggabungkan fungsi-fungsi penerimaan dalam satu antena. Dua komponen utama dalam rekabentuk ialah antena mikrostrip monopole pasif dengan dua jalur dan peralatan aktif (penguat rendah hingar). Semua simulasi dilakukan melalui CST MICROWAVE SOFTWARE dan Advance Design System (ADS). Terminologi "antena diintegrasi aktif" menunjukkan elemen antena pasif dan litar aktif diintegrasikan pada substrat yang sama secara spesifikasi. Dua set frekuensi yang berlainan diperuntukkan untuk aplikasi WLAN. Pertama ialah jalur 2.4 GHz dan yang satu lagi ialah jalur 5.8 GHz. Dua set frekuensi yang berlainan memerlukan dua set antena yang berbeza. Ia hanya boleh diselesaikan dengan menggunakan satu antena dengan dua sistem berlainan. Secara asas gandaan pemancaran atau penerimaan rekabentuk antena monopole mikrostrip pasif tidak tetap pada jalur frekuensi yang dikehendaki. Penggunaan penguat (penguat rendah hingar) dalam struktur antena pasif meningkatkan gandaan antena dan memperbaiki keupayaan hingar. Antena direkabentuk untuk penerima bagi menguatkan antena monopole mikrostrip diintegrasi aktif untuk aplikasi-aplikasi WLAN dalam sistem-sistem IEEE 802.11b/g/a. Antena akan difabrikasi pada papan mikrostrip FR4 dengan $\varepsilon r = 4.7$ dan $\tan\theta = 0.019$. Nilai kehilangan balikan yang terbaik pada frekuensi-frekuensi operasi (jalur ISM) memadai kurang dari -10 dB terutamanya selepas integrasi penguat rendah hingar pada antena, dan juga gandaan mesti melebihi 10 dB dan sifat hingar antena akan dikuatkan (2~3 dB).

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LIST OF SYMBOLS

Zo	-	Characteristic Impedance
ZL	-	Load Impedance
Zin	-	Input Impedance
RL	-	Return Loss
S11	-	S parameter from port 1 to port 1
λ	-	Wavelength
λg or λd	-	Dielectric guided wavelength
λo	-	Free space wavelength
tan δ	-	Dielectric loss tangent
f	-	Frequency
fc	-	Resonant Frequency
εreff	-	Effective dielectric constant
εo	-	Dielectric constant of free space
εr or εd	-	Relative Dielectric constant / permittivity
W or a	-	Conductor width
W/L	-	Patch conductor width over length ratio
h	-	Height of dielectric layer
I	-	Current
V	-	Voltage
pF / F	-	Piko Farade / Farade
T	-	Reflection coeffic

LIST OF ABBREVIATIONS

ADS	-	Advanced Design System
AIA	-	Active Integrated Antenna
AIA with LNA	-	Active Integrated Antenna with Low Noise Amplifier
BW	-	Bandwidth
CAD	-	Computer Aided Design
dB	-	Decibel
GHz	-	Giga Hertz
MHz	-	Mega Hertz
L	-	Length
LAN	-	Local Area Network
RF	-	Radio Frequency
W	-	Width
Z0	-	Characteristic Impedance
G	-	Gain
LNA	-	Low Noise Amplifier
ISM	-	Industrial Science Medical
MIC	-	Microwave Integrated Circuit
MMIC	-	Monolithic Microwave Integrated Circuit
VSWR	-	Voltage Standered Wave Ratio
RL	-	Return Loss
HPBW	-	Half Power Beam Width
DBS	-	Direct Broadcast Services
EM	-	Electromagnetic
UV	-	Ultraviolet
NF	-	Noise Figure
MOM	-	Method of Moment

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Antenna design has become one of the most active fields in the communication studies. In the early years when radio frequency was 'found', simple antenna design was used as an apparatus to transmit electrical energy or radio wave through the air in all direction. Wireless technology has expanded rapidly not only for commercial but also for military purposes. Wireless technology provides less expensive alternative and a flexible way for communication.

Antenna is one of the important elements in the RF system for receiving or transmitting the radio wave signals from and into the air as the medium. One of the types of antenna is the microstrip antenna. The microstrip antenna has been said to be the most innovative area in the antenna engineering, thanks to its low material cost and its easiness of fabrication which the process can be made inside universities or research institutes [1].

Wireless communications continue to enjoy exponential growth in the cellular telephony, wireless Internet, and wireless home networking arenas. The wireless networks include wireless local area networks (WLAN). The IEEE 802.11 group has been responsible for setting the standards in WLAN. One major technology exists in the

industrial ISM bands: 2.4-2GHz.4835 GHz, 5.15 GHz -5.35 GHz, and 5.725 GHz -5.825 GHz. Therefore the antenna is required to operate at two or more frequency bands in WLAN systems. Some of the desired features for these antennas include broad bandwidth, simple impedance matching to the feed line and low profile [2]. The terminology of "active integrated antenna" indicates specifically that the passive antenna elements and the active circuitry are integrated on the same substrate. Due to the mature technology of microwave integrated circuit (MIC) and monolithic microwave integrated circuit (MMIC), the active integrated antenna (AIA) became an area of growing interest in recent years

Incorporation of active devices functions directly into active integrated antenna reduces the size, weight, and cost of many microwave systems [4]. Active integrated antenna can be categorized by the function of active devices they integrate. Depending on the function of the active device, the active integrated antennas can be categorized into the oscillator type, the amplifier type and the frequency conversion type [3] [5] [6] [7].

In this work, design the passive dual band microstrip antenna for wireless commutation applications in 2.4 GHz and 5.8 GHz (ISM band) bands. Low noise amplifier is integrating with the passive antenna for the purpose of enhancement the gain of the antenna and improves noise characteristics. Cost and size are reduction by using single patch microstrip antenna.

1.2 Problem Statement

A WLAN access point device in the market commonly consists of a transceiver that uses one antenna for one frequency band. The use of one antenna for one frequency band increase the overall size of the access point device and the use of the monopole will have omni-directional radiation pattern. The use of microstrip antenna will be an

alternative to the omni-directional monopole antenna which the microstrip antenna can be used in certain cases depends on the environment.

Monopole antenna has widely been used as the antenna for wireless access point because it has been a standard type of antenna for wireless devices (walkie-talkie, mobile phones, etc) and its design is less complicated than other type of antenna. omni-directional means radiation at all angles. Two different set of frequencies have been allocated for the indoor WLAN application. One is at 2.4 GHz band and the other at 5.8GHz band. Two different set of frequencies need two different set of antenna. It can be solved by using one antenna for two different systems. The integration of two bands of frequencies can reduce the incompatibility to each other. The array antenna size is large; to make the antenna size small is by designing one patch at 2.4GHz and 5.8GHz bands. The implementation of amplifier (low noise amplifier) in a passive antenna structure increases the antenna gain and improves the noise performance.

1.3 Objectives

The objectives of this project are as follows:

i. To design, simulate, fabricate and measurement the performance of the passive dual band microstrip monopole antenna at ISM band (2.4GHz and 5.8 GHz).

ii. To integrate the designed passive dual band microstrip monopole antenna with active device LNA (low noise amplifier) to increase the gain and improve noise characteristics.

1.4 Scope of Work

The project focuses on the development of the antenna to meet the satisfied performance that can be used in WLAN system. The scope of this project comprises the design, simulation and fabrication between a passive dual band microstrip monopole antenna and active microstrip monopole antenna by low noise amplifier. The passive dual band microstrip monopole antenna design for wireless commutation applications in 2.4 GHz and 5.8 GHz(ISM band) bands.

When the low noise amplifier is integrated with the passive antenna the antenna, the gain, noise characteristics is enhancement. The antenna is designed using CST software to obtain the overall simulation performance of the antenna. The antenna will be designed for receiver type of amplifying active integrated microstrip antenna for WLAN application 2.4 GHz and 5.8 GHz bands. The antenna will be fabricated on the FR4 microstrip board with ε_r= 4.7 and tanθ = 0.019.

The best value of the return loss at operation frequencies (ISM band) will be less than -10 dB especially after intergrades the LNA to the antenna, and also the gain and noise characteristics of the antenna will be enhanced.

1.5 Research Methodology

A Theoretical and experimental design approach was utilized to optimize the antenna structure, the strategy implemented for simplifying the design and development procedures in this research work can be divided into the following points:

1. Initial concept
    - Literature review
    - Problem statement
    - Design conceptual understanding
2. Design and simulation stage
    - Design consideration based on previous research results
    - Decide the input parameters of the antenna
    - Design the passive part of the antenna using antenna design software (CST MICROWAVE STUDIO)
3. Prototype stage
    - Fabrication of the passive part of the designed antenna
    - Combining the passive and active part of the proposed antenna
4. Measurement stage
    - Measurement of the properties of the fabricated antenna
5. Analysis and conclusion stage
    - Comparison between measurement results and the simulation results and draw a conclusion

1.6 Specification

i. Antenna patch : FR4 materials $\varepsilon r = 4.7$,
    - h (substrate thickness) = 1.6 mm
    - T (conductor thickness) = 0.035 mm

ii. Antenna resonate frequency at 2.4 GHz and 5.8 GHZ

iii. Use LNA : MGA 21108

iv. Input impedance is 50 ohm

v. Antenna has Rx function

vi. Passive antenna Bandwidth more than 17% AT 2.4GHZ AND 26% AT 5.8GHZ

1.7 Thesis Outline

This thesis consists of five chapters describing all the work done in the project. The thesis outline is generally described as follows.

Chapter 1: This chapter explains the introduction of the project. Brief general background is presented. The objectives of the project are clearly phased with detailed. The research scope implementation plan and methodology are also presented.

Chapter 2: This chapter discusses literature review.

Chapter 3: This chapter gives an overview of the antenna design methodology with the fundamental process in the design, simulate, fabricate and measurement procedures.

Chapter 4: This chapter discusses and analyzes the results of antenna prototype measurement compared to the simulation result. The antenna application in the real environment and comparison with monopole also presents in this chapter.

Chapter 5: This chapter presents the conclusion based on the analysis and comparison of results in chapter 4. The recommendations for future works are also presented.