DESIGN AND DEVELOPMENT OF MIMO ANTENNA FOR POINT-TO- POINT APPLICATION

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"To my beloved parents, Ghanim and Shereen,

who have sacrificed so much for me.

To my sister Marwa,

who have been role model to me all of my life.

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ABSTRACT

A Multiple-Input-Multiple-Output (MIMO) Microstrip Patch Antenna 4 ports has been designed and implemented. The proposed antenna consists of four ports and a four Array Microstrip Patch Antenna ground plane extruded on the substrate. The overall size of the proposed substrate is $220 \times 220\ mm^2$. The antenna is fabricated on an inexpensive FR4 a dielectric constant of$\varepsilon_r = 4.5$, loss tangent of tan δ=0.019, with thickness of substrate that is 1.6-mm and the thickness of patch is *0.035 mm*. The measured results represents that the proposed antenna obtained a reasonable bandwidth from 2.4 GHz that could cover point-to-point application defined by 10-dB return loss. Furthermore, The S-Parameters of antenna are simulated and measured. In this project, design structure of the MIMO antenna four ports and substrate has been employed to broaden the bandwidth. Since MIMO antenna, high gain and directivity can be achieved. Simulation by using CST microwave studio program and measurement on the final prototype antenna were carried out and compared. A MIMO system characteristic evaluation of a four port MIMO antenna operating at 2.4GHz is performed. A four port antenna operating in point-to-point applications is designed, the antenna shows good pattern diversity low correlation coefficient.

ABSTRAK

A Multiple-Input-Multiple-Output (MIMO) Mikrojalur Patch Antena 4 pelabuhan telah dirancang dan dilaksanakan. Antena yang dicadangkan terdiri daripada empat pelabuhan dan empat Array Mikrojalur Patch Antenna satah bumi tersemperit pada substrat. Saiz keseluruhan substrat yang dicadangkan adalah 220 × 220 mm 〖〗 ^ 2. Antena ini direka pada FR4 murah yang ofε_r dielektrik berterusan = 4.5, kerugian tangen daripada tan δ = 0.019, dengan ketebalan substrat iaitu 1.6 mm dan ketebalan patch adalah 0.035 mm. Hasil diukur mewakili antena yang dicadangkan diperolehi lebar jalur yang munasabah daripada 2.4 GHz yang boleh meliputi titik-ke-titik permohonan ditakrifkan oleh 10 dB kerugian pulangan. Tambahan pula, The S-Parameter antena adalah simulasi dan diukur. Dalam projek ini, struktur reka bentuk antena MIMO empat pelabuhan dan substrat telah digunakan untuk meluaskan jalur lebar. Sejak MIMO antena, keuntungan tinggi dan directivity boleh dicapai. Simulasi dengan menggunakan CST program studio gelombang mikro dan pengukuran pada antena prototaip akhir telah dijalankan dan dibandingkan. Sistem MIMO penilaian ciri empat pelabuhan MIMO antena beroperasi pada 2.4GHz dilakukan. Sebuah antena empat pelabuhan yang beroperasi di titik-ke-titik aplikasi direka, antena menunjukkan kepelbagaian corak baik pekali korelasi yang rendah.

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LIST OF SYMBOLS

h	-	Dielectric substrate thickness
L	-	Length
W	-	Width
Γ	-	Reflection coefficient
$Z0$	-	Characteristic impedance
Z_L	-	Load impedance
λr	-	Free-space wavelength
V_0^-	-	Reflected volta
V_0^+	-	Incident voltage
εr	-	Dielectric constant of the substrate
t	-	Patch thickness
c	-	Speed of light 3x 10-8 m/s
G	-	Conductance
Π	-	Pi
η	-	Efficiency
G	-	Gain
D	-	Outer diameter of SMA connector
d	-	Inner diameter of SMA connector
W1	-	width of feed line

LIST OF ABBREVIATIONS

FCC	-	Federal Communication Commission
UWB	-	Ultra-wideband
PD	-	Phase Difference
CP	-	Circular polarization
MPA	-	Microstrip Patch Antenna
Ω	-	Ohm
dB	-	Decibel
CST	-	Computer Simulation Software
FR4	-	Fire Retardant Type 4
BW	-	Bandwidth
BW%	-	Bandwidth percentage
PCB	-	Printed Circuit Boards
Hz	-	Hertz
GHz	-	Giga Hertz
mm	-	Millimetre
RF	-	Radio Frequency
IEEE	-	Institute of Electrical and Electronic Engineers
VSWR	-	Voltage Standing Wave Ratio
RL	-	Return Loss
HPBW	-	Half Power Beam Width
EM	-	Electromagnetic
UV	-	Ultraviolet

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CHAPTER 1

INTRODUCTION

A MIMO antenna operates at 2.4 GHz for point-to-point communication microwave link, has been proposed in this project. This first chapter discusses the background of the project providing the project overview, problem statement, objective, scope of the study and the methodology taken to achieve the objectives.

1.1 Project Overview

Antenna is a fundamental component of any wireless communication system. The development of wireless and satellite communications has spurred the creation of wide range of antenna shapes and sizes; each has its own advantages and limitations. Wireless communication has experienced an enormous growth since it allows users to access network services without being connected to a wired infrastructure. The major wireless system that has experienced the most rapid evolution and wide popularity is the standard developed by IEEE for wireless local area network (WLAN), identified as IEEE802.11. WLAN point-to-point application is based on IEEE802.11b,g standards and operates in ISM band (2.4GHz).

Point-to-point communication considered as backbone for the antennas since they are expected to provide the wireless transmission between those devices. Besides being able to achieve good signal to noise ratio and immunity to noise, they should have portray compact structure, and can be easily constructed and mounted on various devices.

Some point-to-point application that's required high performance the weight, size, shape, unit cost, ease of installation are constraints, any antenna is very much required to meet these needs, so Microstrip antenna is preferred. Currently Microstrip antenna is growing fast in the segments in the telecommunications industry and it may become the chosen medium for antenna design in the future. And as any material Microstrip antenna has several advantages, and many disadvantages like low gain and narrow bandwidth [1].

Microstrip antenna has become the simplest yet most popular planar antenna. In its easiest form, the patch can be introduced by etching a rectangular metal pattern on a substrate. Nevertheless, we must note here that Microstrip patch antennas were first proposed in the early 1970s and from that time, a lot of studies in this area of antenna engineering has been done, probably more than in any other field of antenna research and development [2].

For point-to-point wireless communication applications, it is desirable that the antenna has a narrow beam width, which is hard to achieve using single element. For that array antenna can achieve such goals, where array antenna beam width and side lobes depends mainly on the number of elements and spacing between them.

Using multiple-input multiple-output (MIMO) Wireless communication systems enables increased spectral efficiency for a given total transmit power

Increased capacity is achieved by introducing additional spatial channels that are exploited by using space-time coding.

1.2 Problem Statement

- In order to Increase the capacity of a wireless communication channel a single antenna element is not enough, this issue could be solve using MIMO.
- By having multiple antennas in a closely packed system, the problem of mutual coupling is a very challenging issue.
- In order to improve the mutual coupling, normally the antenna elements are spaced farther apart to reduce their effect on each other. However, this results in increasing the size of the structure.
- Designing a MIMO antenna for point-to-point communication, which requires antenna with high gain, precise directivity and high efficiency, is also challenging work.

1.3 Project Objective

The objective of this project is as followed:

- To design, fabricate and measure a MIMO Antenna 4 ports operating at 2.4 GHz (for point-to-point communication).
- To analyze the characteristic of MIMO antenna which consist of combination of four elements microstrips Patch antenna (MPA) at each port.

1.4 Scope of the Project

The scope of this project is to study proposed MIMO antenna design to increase the capacity of the point-to-point communication channel. The project started with the Simulation of radiation pattern and return loss and bandwidth response by using Computer Simulation Technology (CST), then by Design, fabrication and prototype measurement. Finally, the results of actual antenna and simulated design compared. There are eight elements in the scope to investigate as per below details:

- Literature on the concept of MIMO antenna. Review on previous work related to point-to-point communication antenna's design.
- Single element antenna design and simulation
- Design and simulation of the MIMO antenna.
- Fabrication of the selected antenna design.
- Test and measurement of the fabricated antenna
- Compare the results between simulated and fabricated designs.

1.5 Project Organization

This thesis organized in six chapters. The first chapter is an introduction, which provides information regarding the project background, problem statement, objective and scope of work and the layout of the project.

The second chapter summarizes the literature and among the topics that are discussed , Microstrip antenna overview, single rectangular and square patch antenna

design, rectangular and square patch array antennas design, basic antenna and array antenna theory and its properties.

In the third chapter, is the methodology, in which the methods employed, and the software used for this project been shown in details.

The fourth chapter presents all the design specifications and results obtained from manual calculation and simulation respectively. The simulation results and subsequent analysis discussed.

In the fifth chapter, the fabrication method, results and analysis of the measurement and comparison between the simulation and measurement results discussed.

In the sixth chapter, conclusion and recommendations, this chapter concludes the finding of the project and provides recommendations for future work.

1.6 Summary

Brief introduction on the project and its scopes been presented, some relevant project backgrounds been shown to give a clear view on the direction of the project, and the outline of this thesis been described.

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