DESIGN, FABRICATE AND TESTING OF 2X2 ARRAY ANTENNA AT IMT 2000 BAND

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"I, hereby declare that this thesis entitled, Design, Fabricate and Testing of 2x2 Array Antenna at IMT 2000 Band based on my own research, ideas and effort except for works that have been cited clearly in the reference."

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DEDICATION

To

My Beloved Parents,

En Nik Aziz Nik Daud & Pn Che Maziah Che Yusoff,

My Brother and Sister

And All BENT Pioneer Friends

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ABSTRACT

The aim of the project is to design a 2x2 array microstrip patch antenna operating at International Mobile Telecommunication (IMT 2000) Band whereby the frequency spectra is 1.885GHz to 2.172GHz. Since the microstrip patch antenna has various shapes, this project will focus for rectangular shape antenna and the feed network that connect through out the array is branching network power divider. The antenna is designed to become a base station for 3Gs system to replace the conventional antenna that mount on the building and communication tower. The 2x2 array antenna was designed using Microwave Office 2004 and achieved the bandwidth 4.65 % (VSWR 1.2:1). The antenna cover the frequency spectra of IMT 2000 from 1.885 GHz to 2.172 GHz The antenna was designed using FR4 board with dielectric substrate, $\varepsilon_r = 4.7$, loss tangent 0.019 and thickness 1.6 mm.

ABSTRAK

Projek ini bertujuan untuk merekabentuk 2x2 antena tatasusun menggunakan teknologi mikrostrip di mana antena ini akan beroperasi pada frekuensi 1.885GHz hingga 2.172GHz iaitu adalah merupakan frekuensi yang telah ditetapkan untuk *International Mobile Telecommunication (IMT 2000) Band.* Projek ini akan mengunakan bentuk antena segiempat tepat walaupun terdapat pelbagai lagi bentuk yang lain dan *feed network* yang digunakan adalah *Wilkinson power divider.* Rekaan antena ini adalah untuk digunakan sebagai *base station* untuk sistem 3G bagi menggantikan rekaan lama antena yang di letakkan diatas bumbung bangunan atau menara komunikasi. Satu antena tatasusun 2x2 telah direka dengan menggunakan perisisan Microwave Office 2004 telah mencapai lebar jalurnya sebanyak 4.65% (VSWR 1.2:1). Antena tersebut mampu untuk beroperasi di dalam julat frekuensi *IMT 2000 band* iaitu 1.982 GHZ hingga 2.172 GHz. Antena ini dibina dengan menggunakan lapisan substrat FR4 yang mempunyai pekali dialektrik 4.7, kehilangan tangen 0.019 dan ketebalan 1.6 mm.

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E	-	Euclidean space
r	-	Ruler
D	-	Hausdorff dimension
Z_{in}	-	Input impedance
VSWR	-	Voltage Wave Standing Ratio
G	-	Gain
D	-	Directivity
dB	-	decibel
HPBW	-	Half Power Beamwidth
FNBW	-	First Null Beamwidth
BW	-	Bandwidth
f_H	-	High Frequency
f_L	-	Low Frequency
f_o	-	Resonant Frequency
Z_L	-	Load impedance
Z_0	-	Input Impedance
v_0	-	Light Velocity ($3\times10^8 m$)
ε_r	-	Relative permittivity
d	-	Substrate thickness
$\tan\delta$	-	Tangent Loss of Substrate
W	-	Antenna Width
ε_{eff}	-	Effective dielectric constant

$\Delta\ell$	-	The fringing field
L	-	Antenna Length

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CHAPTER I

INTRODUCTION

The aim of this thesis is to design a 2x2 array microstrip patch antenna for use with the IMT 2000 band base station. The inspiration using microstrip patch element, instead of conventional dipole element, in the antenna design is to explore the many advantages and the features offers by microstrip. The antenna design is evaluated based on return loss, VSWR, bandwidth, gain, directivity, side lobes level and radiation pattern.

1.1 Problem Statement

The basis of mobile business is the convergence of technologies. Today people are able to communicate with one another via voice, text, images and data through uniform systems. People are living and working in new ways that require mobile access to offices, leisure activities and homes. Mobile works and mobile play have become major trends that increasingly influence our daily activities. With this ever-increasing demand for mobile communication, telecommunication service providers are putting up more base stations to enhance network coverage and to increase capacity. However as the number of base station antennas installed on building structures increases, the

aesthetic appearance of these buildings and its surroundings will be adversely affected as illustrated in Figure 1.0. Consequently there is a need to develop base station antennas that are compact in size so that they can be concealed from the public vision.

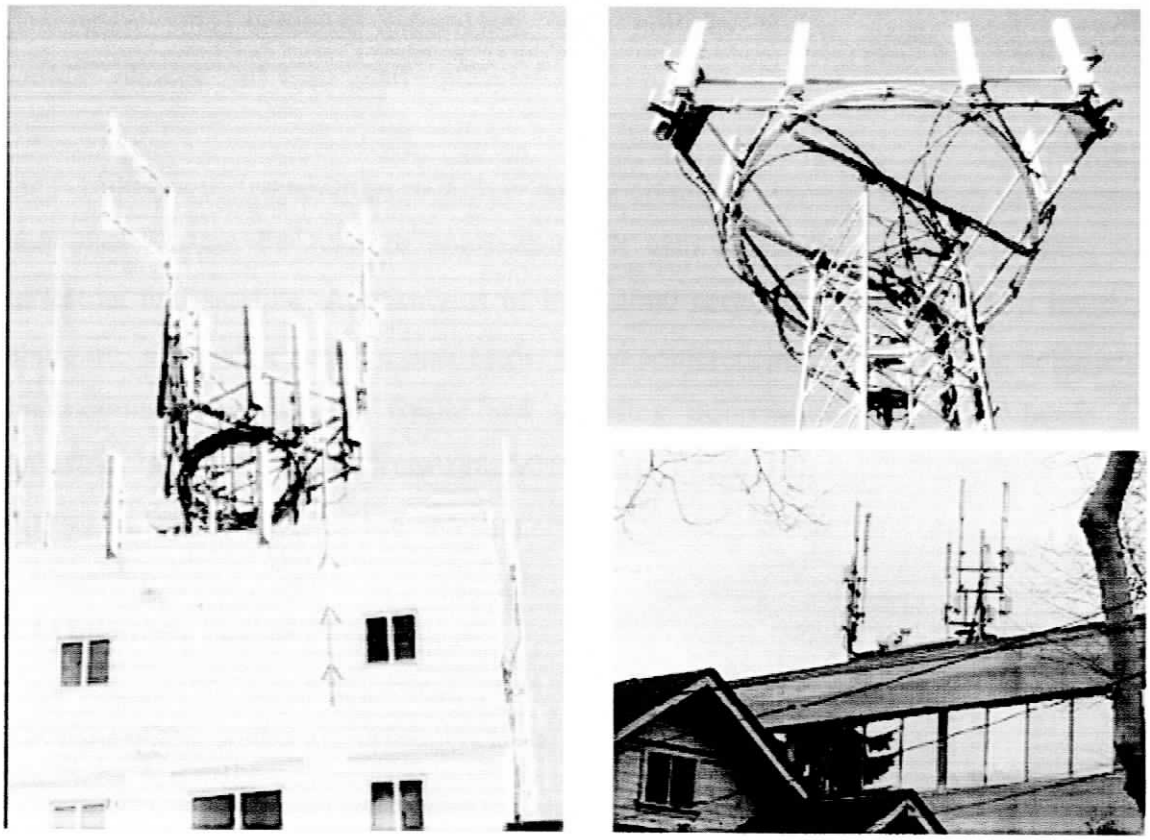

Figure 1.0: Base station antennas mounted on buildings and communication tower

The motivation of this thesis is therefore to design a compact size base station antenna that could be easily disguised on buildings and communication towers. The base station antenna will be designed using microstrip patch elements to achieve this objective. A brief overview on IMT-2000 network is described in the next section.

1.2 Introduction to IMT-2000 Network

International Mobile Telecommunications-2000 (IM T-2000) is simply a term used by the International Telecommunications Union (ITU) to refer to many third generation (3G) wireless technology, that provide higher data speed between mobile phones and base antennas.

IMT-2000 has the capabilities to deliver data at up to 2M bits/sec for indoor applications and 384Kbits/sec for outdoor applications. It also allows world wide roaming via terrestrial and satellite. Applications of IMT 2000 network includes wireless internet, audio on demand, electronic post cards, video conferencing, secure mobile commerce transactions and providing traffic and traveling information. Frequency bands for terrestrial IMT-2000 covers from 1885MHz to 2170MHz [15].

1.3 Objectives Project

The aims of this project are as listed below:

- To understand the concepts and techniques used for achieving high performance microstrip array antenna
- To design and develop high performance 2x2 array antenna using Microwave Office 2000 software so that it will operating at IMT 2000
- To study of the antenna characteristic due to its advantages and disadvantages
- The designed array antenna specifications would include:
  - o Return loss < -10dB
  - o Bandwidth ≈ 10% at VSWR ≤ 2

1.4 Scope of work

The implementation of this project requires understanding the concept of antenna and array antenna system and the technique that using. The array feed network will be designed based on the branching network power divider. The patch element also will be design based on rectangular patch. The design would have to be simulated using relevant softwares. Results obtained would require analysis. The 2x2 array antenna will then be fabricated. The results obtained from the fabricated array would be analyzed and compared with the simulation results.

1.5 Layout of Thesis

The thesis is divided into six chapters.

Chapter I is Introduction, which provides information regarding the project background, objectives, scope of project, project contribution and the layout of the thesis.

Chapter II is Antenna Fundamental System. In this chapter, the basic antenna fundamentals will be discussed due to its characteristic and parameters.

Chapter III discusses the microstrip concept such as factors affecting microstrip design. They include microstrip discontinuity and losses, feeding methods and analysis methods and also covered about the rectangular patch since this project is using the rectangular patch array.

Chapter IV is Design Methodology and Software, in which the methods employed and the software needed for this project will be explained. This chapter also explains the design procedures, the parameters table and the equations needed for the design of the rectangular patch antenna and 2x2 patch array antenna. The Microwave circuit layout and S11 simulation response are also shown.

Chapter V will cover on fabrication and measurement of fabricated antenna. The measurement result also will be analyzed and discussed in this chapter.

Chapter VI will conclude this report with a critical review and recommendations for future work.