MICROSTRIP ANTENNA ARRAY FOR SATELLITE COMMUNICATION OPERATING AT 12GHZ

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A project report submitted in fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical-Electronics & Telecommunication)

Faculty of Electrical Engineering
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NOVEMBER 2009

With love to my parents, Haji Ramli Hambali and Hajjah Rosemini Joji,
Angah, Achik and Adik Haji…

ACKNOWLEDGEMENT

In the name of Allah S.W.T, the Most Gracious, Most Merciful in giving us strength and patience in accomplishing this project successfully. This work was written in faith, support, advice and help from many people.

I would like to express my sincere gratitude and appreciation to my supervisor, Associate Prof. Dr. Mohamad Kamal A. Rahim, for his support, guidance and encouragement in the duration of the work preparation until its completion.

A special thanks to a number of people, who for one reason or another, helped to make this happen: Azreen, Wan Mustafa, Saiful, Rina, Faezah, coursemates, researchers, neighbours and friends. I am also very thankful to Fakulti Kejuruteraan Elektrik, Universiti Teknologi Malaysia, Universiti Teknologi MARA and STRIDE for the technical support

Last but not least, my deepest appreciation and love goes to my parents and brothers who have always be with me during my sorrow and happiness.

Thank you.

ABSTRACT

Studies on the microstrip antenna array has been conducted with the objective to design, simulate and fabricate the microstrip antenna array operating at 12GHz, Ku band downlink. Microstrip antenna is well known for its low cost, compact and mechanically robust. This project explores the capability of the microstrip antenna array at a higher frequency for the satellite communication. Specification is defined and the designed antenna should be able to operate with minimum gain of 20dBi, <-10 return loss, 3 to 5 percent bandwith with circular polarization. Simulation started with the basic single element antenna in getting the correct geometrical parameters and feeding technique. Simulation was done step by step prior obtaining the final design of antenna. The final design which complies to the specification was selected for fabrication and measurement, whereby in this case (16x16) array was selected. Fabrication was done successfully, however the performance comparison shows some variation between simulation and antenna measurement. There are many factors contributing to the variation which has been discussed in Chapter 5 of this writings. This project work has shown a big potential of microstrip antenna array in satellite communication, at a higher frequency. Further effort and follow ups will enhance the performance of the microstrip antenna and lessen the impact of the shortcomings.

ABSTRAK

Objektif projek adalah untuk merekabentuk, melakukan simulasi dan fabrikasi antenna yang berfungsi dalam jalur Ku *(Ku band downlink)* pada frekuensi 12GHz. *Microstrip Antenna* telah diketahui umum melibatkan kos yang rendah, kompak dan kurang dipengaruhi gangguan mekanikal. Projek ini adalah eksplorasi kebolehan *microstrip antenna* pada frekuensi tinggi. Spefikasi yang ditentukan adalah melibatkan *gain, return loss, bandwidth* dan polar. *Gain* minimum hendaklah mencapai 20dBi, *return loss* minimum pada -10dB, *bandwidth* 3 hingga 5 peratus dan antenna hendaklah beroperasi secara *circular*. Simulasi bermula dengan antenna yang mempunyai satu elemen sahaja, bertujuan untuk memperolehi ukuran *patch* dan *feeding* teknik yang betul. Simulasi berperingkat dijalankan sebelum mendapatkan rekabentuk terakhir antenna. Rekabentuk terbaik yang memenuhi spesifikasi akan dipilih untuk fabrikasi dan pengukuran. Bagi projek ini rekabentuk terbaik ialah (16x16) *array.* Fabrikasi telah berjaya dijalankan, walaubagaimanapun terdapat perbezaan pada keputusan pengukuran berbanding simulasi. Perbezaan ini disebabkan banyak faktor yang akan diperbincangkan dalam Bab 5. Projek ini telah membuktikan bahawa *microstrip antenna array* mempunyai potensi yang tinggi dalam aplikasi komunikasi satelit pada frekuensi tinggi. Kajian yang lebih terperinci diperlukan untuk memperbaiki mutu dan kebolehan *microstrip* antena dan sekaligus mengurangkan kelemahan antena ini.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

f	-	Operating frequency
f_c	–	Cut off frequency
Z_o	-	Characteristic impedance
ε_r	-	Dielectric constant
ε_{eff}	-	Effective dielectric constant
ε_o	-	Dielectric constant in free space
μ_o	-	Permeability in free space
h	-	Thickness of the substrate
δ	-	Loss tangent
λ_o	-	Wavelength in space
c	-	Velocity of light in free space
W_f	-	Feed Width
L	-	Patch length
W	-	Patch width

CHAPTER 1

INTRODUCTION

1.1 Project Background

An antenna serves as the transition between the RF front-end circuitry and the radiation and propagation of electromagnetic waves in free space. Antennas play a critical role in microwave and other wireless applications systems. Planar oriented antennas, such as microstrip patch and printed dipole have attracted significant attention among antenna engineers due to the tremendous benefits they bring to modern wireless systems in comparison to more conventional designs.

Microstrip patch antennas were first proposed in the early 1970s and since then, a lot of activity in this area of antenna engineering has occurred, probably more than in any other field of antenna research and development. The microstrip antenna is probably the simplest yet most popular planar antenna. In its simplest form, the patch antenna can be realized by etching a rectangular metal pattern on a dielectric substrate. It has several well-known advantages over other antenna structures, including their low profile and hence conformal nature, light weight, low cost of production, robust nature, and

compatibility with microwave monolithic integrated circuits (MMICs) and optoelectronic integrated circuits (OEICs) technologies. Because of these merits, forms of the microstrip patch antenna have been utilized in many applications such as in satellite communication, mobile communication base stations, and even mobile communication handset terminals. Microstrip antenna is one of the common antenna elements in telecommunications and radar applications. Microstrip antenna has the advantage of light weight, low volume, low profile, low fabrication cost (can be made of FR4 board), supports multiple polarization, easy integration with microwave integrated circuits (MICs), capable of multi - frequency operations and mechanically robust.

Besides the advantages, microstrip patch antenna has its own disadvantages in bandwidth limitation (i.e narrow bandwidth), has low radiation efficiency, low gain, suffer from spurious radiation of feeds and junctions, poor end fire radiator, low power handling capability and vulnerable to surface wave excitation.

The aim of the project is to explore the capability of the microstrip antenna in satellite communication with concern of its advantages and disadvantages.

1.2 Objectives

This research is concentrating on the concept and application of microstrip antenna in satellite communication. The studies will include the single element as the fundamental and continue with the antenna array design. The bottom line is to design, simulate and fabricate the microstrip antenna array for satellite communication operating at 12GHz, Ku band downlink respected to the specification. It is expected that the design should lessen the drawback effects of the antenna in satellite communication application

1.3 Scope of Project

This research mainly concentrates on the design, simulation and fabrication of the microstrip antenna array at 12 GHz Ku band downlink with <-10 dB return loss, gain better than 20dBi and linear polarization. There are nine elements in the scope to be carried out as per below details:

- Literature on the concept of microstrip patch antenna. Review on previous work related to microstrip patch antenna
- Single element antenna design and simulation
- Design and simulation of patch microstrip antenna array operating at frequencies 12GHz

- Analysis of the properties and performance of the patch microstrip antenna (single unit and antenna arrays) based on the simulation result for benchmarking.
- Optimization of the antenna design to fulfill antenna specification or performance requirements.
- Fabrication of the selected antenna design
- Test and measurement of the fabricated antenna
- Analysis, discussion and assessment on the antenna array properties and performance according to specification and performance requirement.
- Final report and presentation

1.4 Thesis Outline

This thesis is organized into six chapters. Chapter 1 provides an overview on the background of the project, the objective, scope of project and motivation.

Chapter 2 covers the literature review on the research works conducted on the design and implementation of various microstrip antenna designs. The focus is on the current work on the proximity coupled feeding techniques. This chapter highlights the advantages and disadvantages of proximity coupled microstrip antenna.

Chapter 3 focuses on the antenna design methodology which covers the calculation of antenna parameters and step by step design procedures.

Chapter 4 discusses on antenna simulation software (Microwave Office) and antenna fabrication process, antenna measurement setup and measured results.

Chapter 5 focuses on the presentation of the simulated and measured results together with antenna performance analysis.

Lastly, Chapter 6 summarizes the all the works that has been performed during the project execution. Conclusion is rolled to inclusive of achievements, shortcomings and future work recommendation.

1.5 Summary

The motivation of this project is to explore and enhance the operational capability of the microstrip antenna array specifically for operation in the Ku band, operating at 12 GHz downlink. By applying the microstrip design and considering the advantages, it is expected to have better gain with lower costs, light, less mechanical limitation distraction, more innovative and compatible antenna in satellite communication.

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