



**Faculty of Electronic and Computer Engineering**

**DESIGN OF COMPACT TRI-POLARIZED ANTENNA FOR  
MULTIPLE INPUT MULTIPLE OUTPUT (MIMO) SYSTEM**

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**Master of Science in Electronic Engineering**

**2016**

**DESIGN OF COMPACT TRI-POLARIZED ANTENNA FOR MULTIPLE INPUT  
MULTIPLE OUTPUT (MIMO) SYSTEM**

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**A thesis submitted  
in fulfillment of requirements for the degree of Master of Science  
in Electronic Engineering**

**Faculty of Electronic and Computer Engineering**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2016**

## DECLARATION

I declare that this thesis entitled “Design of Compact Tri-Polarized Antenna for Multiple Input Multiple Output (MIMO) System” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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## APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature : .....

Supervisor Name : .....

Date : .....

## **DEDICATION**

To my beloved family

## ABSTRACT

In recent years, wireless communication system such as radar, navigation system, video conferencing, medical application and others has been widely developed. In order to meet the miniaturization requirements of portable communication equipment, an antenna with compact size has received much attention. Regardless of the application, most of the modern wireless communication systems require high data rate and channel capacity. With these provocations, Multiple Input Multiple Output (MIMO) system was introduced to provide efficient performance and combat multipath effect. The objective of this project was to design, simulate, and fabricate a compact tri-polarized antenna for MIMO system with operating frequency of 2.4GHz. In this project, antennas were designed by using inverted suspended method where the FR4 substrate and copper ground plane were separated with an air gap layer. Modified L-probe fed was used for all antenna designs where the strip line was printed on the upper side of the FR4 substrate and connected to the coaxial probe for ease of fabrication. The rectangular patch was printed at the lower side of the FR4 substrate. First of all, single polarizations for linear polarized (Design A) and circular polarized antennas (Design B) were designed. Then, dual-polarized antennas (Design C) were designed. Lastly, a compact tri-polarized antenna (Design D) was designed with a combination of three different polarizations; including linear polarization (LP), left-handed circular polarization (LHCP) and right-handed circular polarization (RHCP). All the antenna designs were simulated by using Computer Simulation Technology (CST) software. Single-polarized antenna, dual-polarized antenna and tri-polarized antenna were successfully designed and achieved design specifications. Based on the simulation and measurement results, the designed antennas covered frequency of 2.4GHz with reflection coefficient below -10dB. The simulated bandwidths of the designed antenna were more than 200MHz for the broadband specification. The simulated axial ratio result was used to determine the performance of polarizations, in which the axial ratio for linear polarized was above 3dB and the axial ratio for circular polarized was below 3dB. Overall, the reflection coefficient, total efficiency, directivity, gain, axial ratio, and bandwidth of compact tri-polarized antenna showed good responses. The measurement results were almost similar to the simulation results. Therefore, this compact broadband tri-polarized antenna that is capable of performing in three different polarizations is suitable to be applied in MIMO system that requires polarization diversity.

## ABSTRAK

*Dalam tahun kebelakangan ini, sistem komunikasi wayarles seperti radar, sistem navigasi, persidangan video, aplikasi perubatan dan sebagainya telah berkembang dengan pesat. Dalam usaha untuk memenuhi keperluan pengecilan peralatan komunikasi mudah alih, antena dengan saiz kompak telah menarik perhatian. Tidak kira apa-apa aplikasi, kebanyakan sistem komunikasi tanpa wayar yang moden memerlukan katar data dan kapasiti yang tinggi. Dengan provokasi ini, sistem Multiple Input Multiple Output (MIMO) telah diperkenalkan untuk membekalkan prestasi yang cekap dan menentang kesan pelbagai arah. Objektif projek ini adalah untuk mereka bentuk, mensimulasi dan menfabrikasikan antena tiga-polarisasi yang padat untuk sistem MIMO dengan frekuensi yang beroperasi pada 2.4GHz. Dalam projek ini, antena direka dengan menggunakan kaedah terbalikkan substrat, di mana FR4 substrat dan kepingan tembaga telah dipisahkan dengan lapisan udara. L-probe yang telah diubahsuaikan digunakan untuk semua antena, di mana garisan jalur dicetak pada lapisan atas FR4 substrat dan bersambung dengan coaxial probe untuk tujuan memudahkan fabrikasi. Patch yang bersegi empat pula dicetak pada lapisan bawah FR4 substrat. Mula-mulanya, polarisasi tunggal seperti linear polarisasi (Design A) dan polarisasi putaran (Design B) antena direka. Seterusnya, dual-polarisasi (Design C) antena dengan konfigurasi yang berlainan direka. Akhir sekali, antena tiga-polarisasi (Design D) yang padat direka dengan gabungan tiga jenis polarisasi, termasuk linear polarisasi, polarisasi putaran arah kiri dan polarisasi putaran arah kanan. Semua antena yang direka adalah disimulasikan dengan menggunakan CST perisian. Polarisasi tunggal, dual-polarisasi dan tiga-polarisasi telah berjaya direka dan memenuhi spesifikasi reka bentuk. Berdasarkan keputusan simulasi dan pengukuran, antenna yang direka melingkungi frekuensi 2.4GHz dengan koefisien pantulan di bawah -10dB. Simulasi lebar jalur setiap port untuk antenna tiga-polarisasi yang padat adalah lebih daripada 200MHz untuk spesifikasi broadband. Keputusan simulasi nisbah paksian digunakan untuk menentukan prestasi polarisasi, di mana nisbah paksian untuk linear polarisasi di atas 3dB dan nisbah paksian untuk polarisasi putaran adalah di bawah 3dB. Secara keseluruhannya, koefisien pantulan, jumlah efisiensi, directivity, gain, nisbah paksian, dan lebar jalur untuk antena tri-polarisasi yang padat telah menunjukkan keputusan yang baik. Keputusan pengukuran juga hampir sama dengan keputusan simulasi. Oleh itu, antena tiga-polarisasi yang padat dengan tiga polarisasi yang berlainan adalah sesuai untuk diaplikasikan dalam sistem MIMO yang memerlukan polarisasi diversiti.*

## ACKNOWLEDGEMENTS

First of all, I wish to express my deepest gratitude to my supervisor, Prof. Madya Dr. Mohamad Zoinol Abidin Bin Abd. Aziz from Faculty of Electronic and Computer Engineering (FKEKK) who has been providing me knowledge and also helping me in completing this master project. His ideas, suggestions, advices and guidance are very useful for me to complete my report. Besides, I would like to express my deepest gratitude to my co-supervisor, Prof Madya Dr. Badrul Hisham Ahmad who also from Faculty of Electronic and Computer Engineering has supporting me along the master project.

Special thanks to University Technical Malaysia Melaka (UTeM) for supporting in obtained the information and material in the development for my master project. I also thank the Ministry of Education Malaysia (MOE) for PJP/2013/FKEKK (1C) / S01129 research grant.

I would also like to express my greatest gratitude to Mr. Sufian and Mr. Imran from laboratory of Faculty of Electronic and Computer Engineering for their assistance and efforts during the measurement and fabrication in the lab.

Lastly, my thanks and appreciation also goes to all of my family, friends, and siblings who were supporting me in completing this master project either in directly or indirectly, and have aided me through the difficult and crucial time. Though I had a tough time, with the help of others, I have managed to finish my project on time. Producing this master project has truly been an informative and remarkable experience for me.

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