

PERFORMANCE ANALYSIS OF TRIANGULAR LATTICE PLANAR ARRAY FOR MIMO SYSTEM

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**PERFORMANCE ANALYSIS OF TRIANGULAR LATTICE
PLANNAR ARRAY FOR MIMO SYSTEM**

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**This report is submitted in partial fulfilment of the requirements
for the degree of Bachelor of Electronic Engineering with Honours**



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Faculty of Electronic and Computer Engineering

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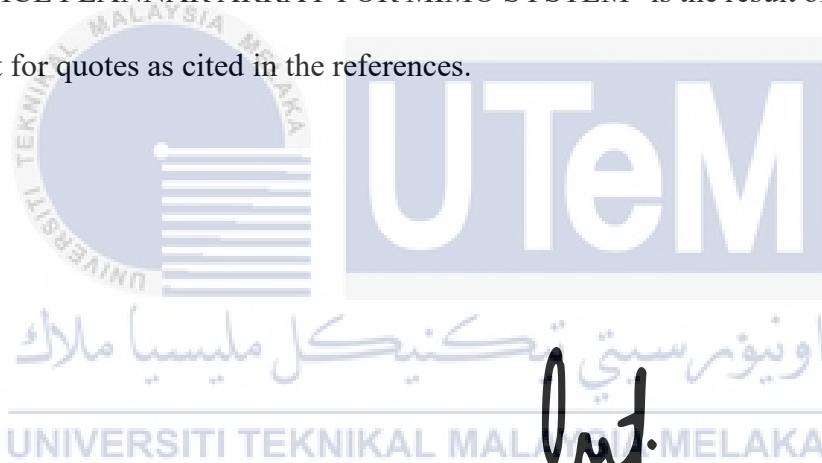
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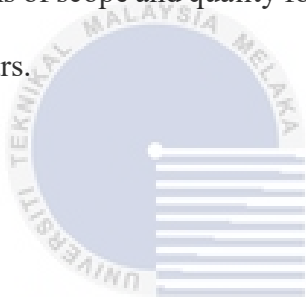
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DEDICATION

To my family, supervisor and friends



ABSTRACT

Massive MIMO has been recognized as one of the most promising technologies to fulfil 5G network needs because it provides directive beams with extremely high antenna gains. To obtain better data rates or reliable links, antenna arrays with large number of elements have been used to provide high multiplexing gain with high directivity. However, increasing number of elements could lead to grating lobes or high lateral lobes inside the visible region as well as resulting in large surface size. Most of the designed array solutions for massive MIMO rely on square or rectangular array structures with a uniform lattice. Thus, this project aims to propose an irregular elements array by exploiting triangular lattice to overcome aforementioned drawbacks. Triangular lattice planar arrays will be modelled in multi-elements array arrangements in MATLAB to analyse the performance in terms of directivities, half power beam width (HPBW), gain and side lobes. Then, the results will be validated with CST (Computer simulation technology) simulation and comparison will be made with regular rectangular lattice. The purpose of this project is to assess the benefit of adopting a triangular lattice to improve overall performance of massive MIMO and will provide significant advantages with respect to the regular lattices.

ABSTRAK

MIMO telah diiktiraf sebagai teknologi yang memenuhi keperluan rangkaian 5G kerana ia menyediakan pancaran arahan dengan keuntungan antena yang sangat tinggi. Untuk mendapatkan kadar data yang lebih baik atau pautan yang boleh dipercayai, tatasusunan antena dengan bilangan elemen yang besar telah digunakan untuk memberikan keuntungan pemultipleksan yang tinggi dengan kearaharah yang tinggi. Walau bagaimanapun, peningkatan bilangan elemen boleh menyebabkan lobus parut atau lobus sisi tinggi di dalam kawasan yang boleh dilihat serta mengakibatkan saiz permukaan yang besar. Kebanyakan penyelesaian tatasusunan yang direka untuk MIMO bergantung pada struktur tatasusunan segi empat sama dengan kekisi seragam. Oleh itu, projek ini bertujuan untuk mencadangkan tatasusunan unsur yang tidak teratur dengan mengeksploitasi kekisi segi tiga untuk mengatasi kelemahan yang dinyatakan di atas. Tatasusunan satah kekisi segitiga akan dimodelkan dalam susunan tatasusunan berbilang elemen dalam MATLAB untuk menganalisis prestasi dari segi arahan, lebar pancaran separuh kuasa (HPBW), keuntungan dan lobus sisi. Kemudian, simulasi CST (Computer simulation technology) akan dibandingkan dengan kekisi segi empat Tujuan projek ini adalah

untuk membandingkan kekisi segi tiga untuk meningkatkan prestasi keseluruhan MIMO dan akan memberikan kelebihan yang ketara berkenaan dengan kekisi biasa.



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TABLE OF CONTENTS

Declaration	
Approval	
Dedication	
Abstract	i
Abstrak	ii
Acknowledgements	iv
Table of Contents	v
List of Figures	ix
List of Tables	xii
List of Symbols and Abbreviations	xiii
CHAPTER 1 INTRODUCTION	1
1.1 Background of Project	1
1.2 Problem Statement	4
1.3 Objectives	5
1.4 Scope of Project	5
1.5 Thesis Outline	5

CHAPTER 2 LITERATURE REVIEW	7
2.1 Multiple Input Multiple Output	7
2.2 Massive Multiple Input Multiple Output	9
2.2.1 Frequency for 5G MIMO	10
2.2.2 MIMO suitable for 3G and 4G?	10
2.2.3 Why using MIMO	11
2.3 Planar Array	12
2.3.1 Array Factor	13
2.4 Technique	13
2.5 Method Used in Feeding Technique	14
2.6 Literature Review Conclusion	14
CHAPTER 3 METHODOLOGY	16
3.1 Introduction	16
3.2 Project Flowchart	17
3.3 Software	19
3.3.1 Matlab Software	19
3.3.2 CST Software	20
3.4 Parameter	21
3.4.1 Directivity	21
3.4.2 Gain	22

3.4.3	Half Power Beam Width (HPBW)	22
3.4.4	Side Lobes	23
3.5	Calculation	24
3.5.1	Determination of the actual length (L) of the patch	24
3.5.2	Determination of the width (W) of the patch	24
3.5.3	Determination of the length extension (L)	25
3.5.4	Determination of the effective dielectric constant (ϵ_{eff})	25
3.5.5	Determination of the effective length of the patch (L_{eff})	25
3.5.6	Determination of the ground plane dimensions	26
3.6	Modelling in MATLAB	26
3.7	Designing Antenna in CST	29
3.8	Fabrication Process	34
3.8.1	Cutting Process	35
3.8.2	Printing Process	35
3.8.3	UV Exposure Process	36
3.8.4	Developing Process	37
3.8.5	Etching Process	37
3.8.6	Solder Process	38
3.8.7	Measurement Process	38
CHAPTER 4 RESULTS AND DISCUSSION		40

4.1	Radiation Pattern Analysis Sub-Array	40
4.2	Analysis in MATLAB	42
4.3	Analysis in CST	46
4.3.1	4x4 Triangular Lattice Array Antenna	46
4.3.2	8x8 Triangular Lattice Array Antenna	48
4.3.3	16x16 Triangular Lattice Array Antenna	51
4.3.4	Analysis on Various Design of Antenna	53
4.4	Fabrication and Measurement	56
CHAPTER 5 CONCLUSION AND FUTURE WORKS		60
5.1	Conclusion	60
5.2	Future Works	61
REFERENCES		62

LIST OF FIGURES

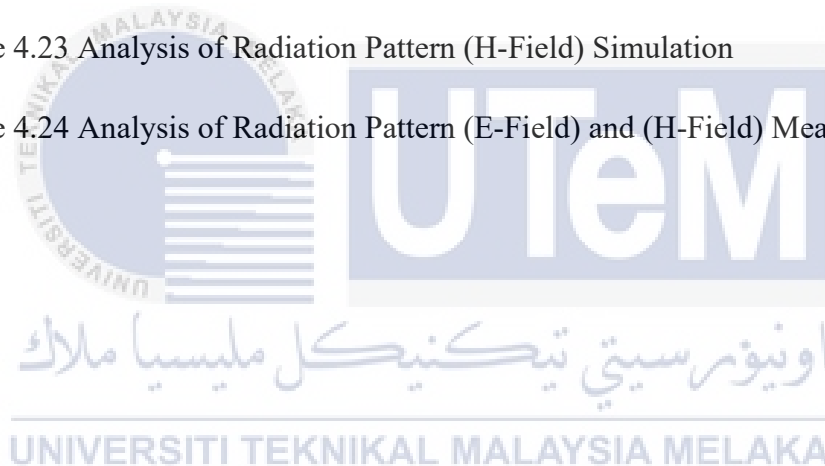
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Figure 1.1 Massive MIMO	2
Figure 2.1 MIMO System	8
Figure 2.2 Massive MIMO	9
Figure 2.3 Multi-User Multiple Input Multiple Output	10
Figure 2.6 Planar Array configurations	13
Figure 3.1 Project Flowchart	18
Figure 3.2 MATLAB	19
Figure 3.3 CST Software	20
Figure 3.4 Half Power Points on the major lobe and HPBW	23
Figure 3.5 Directional antenna radiation pattern	23
Figure 3.6 Modelling MATLAB Flowchart	27
Figure 3.7 MATLAB Coding for Modelling the spacing between elements	28
Figure 3.8 Spacing between Elements	29

Figure 3.9 Design Antenna in CST	33
Figure 3.10 Fabrication Process Flowchart	34
Figure 3.11 Cutting Process	35
Figure 3.12 Design to be print	35
Figure 3.13 Printed Design and Board with UV paper	36
Figure 3.14 Developed Board	37
Figure 3.15 Etching Manually	37
Figure 3.16 Solder SMA	38
Figure 3.17 Gain Results	39
Figure 3.18 Board in Anechoic Chamber	39
Figure 4.1 Polar Plots of an Antenna Pattern 4x4	41
Figure 4.2 Polar Plots of an Antenna Pattern 8x8	41
Figure 4.3 Polar Plots of an Antenna Pattern 16x16	42
Figure 4.4 MATLAB Design 4x4	43
Figure 4.5 MATLAB Design 8x8	43
Figure 4.6 MATLAB Design 16x16	44
Figure 4.7 Array Antenna 4x4 Arrangement	47
Figure 4.8 S11 Parameter for 4x4 Array Antenna	47
Figure 4.9 3D Radiation Pattern of 4x4 Array Antenna	48
Figure 4.10 Polar view of antenna $\phi = 90^\circ$	48
Figure 4.11 Array Antenna 8x8 arrangement	49
Figure 4.12 S11 Parameter for 8x8 Array Antenna	49
Figure 4.13 3D Radiation Pattern of 8x8 Array Antenna	50

Figure 4.14 Polar View of Antenna at $\phi = 90^\circ$	50
Figure 4.15 Array Antenna 16x16 Arrangement	51
Figure 4.16 S11 Parameter for 16x16 Array Antenna	51
Figure 4.17 3D Radiation Pattern of 16x16 Array Antenna	52
Figure 4.18 Polar View of Antenna at $\phi = 90^\circ$	52
Figure 4.19 Anechoic Chamber	56
Figure 4.20 Far-Field Measurement	56
Figure 4.21 S11 Results using Vector Network Analyzer	57
Figure 4.22 Analysis of S11 Parameter Simulation	57
Figure 4.23 Analysis of Radiation Pattern (H-Field) Simulation	58
Figure 4.24 Analysis of Radiation Pattern (E-Field) and (H-Field) Measurement	59



LIST OF TABLES

Table 3.1 Parameter Setup for Antenna Design	30
Table 4.1 Comparison the parameter for Triangular Lattice model with Rectangular Lattice Planar Array [1]	44
Table 4.2 Comparison the parameter for Triangular Lattice model in MATLAB and CST Simulation	53



LIST OF SYMBOLS AND ABBREVIATIONS

MIMO	:	Multiple Input Multiple Output
HPBW	:	half-power beam width
MUMIMO	:	Multiple User Multiple Input Multiple Output
SIR	:	Signal-to-Interference Ratio
CST	:	Computer Simulation Technology
BS	:	Base Station
LTE	:	Long Term Evolution
HSPA	:	High Speed Packet Access
HSDPA	:	High-Speed Digital Packet Access
AF	:	Array Factor
EM	:	Electromagnetic
L	:	Length
W	:	Width
h	:	height of the dielectric substrate
ϵ_r	:	dielectric constant
f	:	Frequency
VNA	:	Vector Network Analyzer
dB	:	Decibel

CHAPTER 1

INTRODUCTION



1.1 Background of Project

Large scale antenna arrays have been researched for a variety of purposes, but the current focus is on massive MIMO with a myriad of tiny and active antennas. Technology of Massive MIMO was selected as one of the most promising technologies. Technologies to meet the requirements of the 5G network given their highly focused beams and strong antenna gain [1]. The analysis of the performance of planar arrays having an irregular periodic lattice is conducted and applied to massive multiple-input and multiple-output (5G) MIMO systems. Improving massive MIMO 5G performance in terms of directivity, gains, and half-power beam width (HPBW) by using a triangular lattice [2].

The project will investigate using the array factor theory. The spacing between element gives on the properties of large antenna arrays (planar arrays). The number of

elements, element spacing, amplitude, and phase of the applied signal to each element depends on array factor. All of the elements are identical which array factor is influenced by antenna type. The antenna array is aligned along either x and y-axis or z-axis. A uniform array is defined by uniform spaces containing identical elements of equal magnitude and linearly increasing phase from element to element. [2]. The array factor (AF) for the planar array is expressed by

$$AF = \sum_{n=1}^N I_{n1} \left[\sum_{m=1}^M I_{m1} e^{j(m-1)(kd_x \sin\theta \cos\phi + \beta_y)} \right] e^{j(n-1)(kd_y \sin\theta \cos\phi + \beta_x)} \quad (1)$$

Where

N: number of elements along y-axis

M: number of elements along x-axis

I_{n1} and I_{m1} : excitation coefficient of each element along y-axis and x-axis

d: spacing between elements

β : progressive phase shift between elements

k: propagation constants = $2\pi/\lambda$

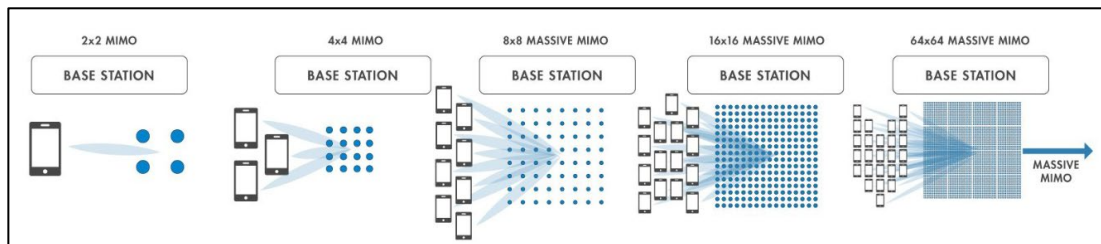


Figure 1.1 Massive MIMO

MIMO technology sends and receives data on two polarities of the radio wave at simultaneously. This dual-polarized technology doubles the network's capacity as

against a single-polarized system. This is known as 2X2 MIMO. By combining multiple antennas to send and receive data, more complex MIMO systems may be constructed. 4X4 and 8X8 MIMO is to boost the wireless nodes' processing capacity. Each node must be able to differentiate between the data transmitted by one antenna and those transmitted by another antenna. Typically, Massive MIMO is 16x16 or 64x64, denoting the number of available antennas. As a result, instead of sharing an antenna with a large group of people, it will only be shared by a few. Nokia claims that a 64x64 setup might result in an 8x increase in uplink speeds and a 5x increase in download rates.

A triangular lattice makes it possible to achieve a greater array gain and average sidelobe level reduction, in addition to increased robustness of antenna element impedance change during beam steering by utilizing reduced Mutual Coupling levels. Additionally, a higher minimum spacing between triangle grid components ensures a higher angular resolution, which, in a huge MIMO scenario, gives improved interference resistance and, hence, improved Spectral Efficiency. [3].

Construction of antenna arrays by changing a single antenna element in the x- and y-axes, the radiation pattern distortion and mutual coupling caused by neighboring elements were not taken into account. The irregular antenna arrays are more effective in terms of mutual coupling and channel correlation valuated and compared with the regular arrays and it is determined that when the number of antennas exceeds a specific threshold, the irregular arrays may better than regular arrays. [4].

An important drawback of the MU-MIMO idea is that the number of digital channels limits the number of simultaneous users. Increasing the number of digital channels of array antenna in transmitter base station is complex due to the fact that the design complication increases as the carrier frequency increases, but the connection

period decreases. However, by irregularly arranging the components in accordance with array spatial power distribution will provide the advantages in term of power consumption in which antennas could be built in a way that decrease the power variation throughout the array. This is done to reduce the level of grating lobes by irregularly arranging elements. Shifting from a dense to a sparse irregular antenna array improves the overall system performance, even when a minimal number of antenna elements are employed and the irregularity is produced randomly [5].

1.2 Problem Statement

The large scale of antenna array known as Massive MIMO. In massive MIMO technology, is a crucial component in 5G wireless communication network structure. Base stations is a large number of array antennas work continuously to direct signals to smaller regions of space. [1]. The architecture of the array location, the distance of elements, the radiation pattern features, the inter component separation, and mutual interaction between array components give the eventual performance of any huge MIMO system [2]. Prior works had shown that increasing the number of elements and inter-element spacing will improve direction beams but at the same time led to the increasing in grating lobes or increase lateral lobes. This problem can be even more severe in the case of multi-user communication in terms of Signal-to-Interference Ratio (SIR) [3]. Therefore, this project proposes to study the effect of irregular elements arrangement by exploiting triangular lattice array as opposed to the regular rectangular lattice array in MIMO system. Triangular lattice arrangement is chosen as it allows additional spatial diversity between array elements as well as enables avoiding the premature development of grating lobes [6].

1.3 Objectives

- i. To model the triangular lattices of planar arrays using MATLAB
- ii. To validate the efficacy of performance of the triangular lattice with CST simulations
- iii. To fabricate and measure the design of triangular lattice

1.4 Scope of Project

- i. Planar array is set to operate at 3-6 GHz
- ii. Array elements will be designed up to 256 elements (16 x 16)
- iii. Parameters will be examined in the variations of directivities, half power beam width (HPBW), gain and side lobes.
- iv. Design and simulate using MATLAB and CST software.

1.5 Thesis Outline

There are five (5) chapters in this project that must be completed in order to complete the writing thesis, and the outline must be completed as follows:

The first chapter (1) has an introduction section that gets the project history, the issue description, and therefore the objectives of this project as well as the scope of this project.

As in the second chapter (2), it consists of a review of the literature on the projects discussed, as well as the real title of the project that was completed by previous researchers and is recognized as the current title of the project.