PERFORMANCE ANALYSIS OF TRIANGULAR LATTICE PLANAR 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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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 Bachelor of Electronic Engineering with Honours.

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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 dibandingan 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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Thank you to god had help and gave me this opportunity to complete this Final Year Project with ease and successfully,

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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
εr	:	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

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

Where

N: number of elements along y-axis

M: number of elements along x-axis

In1 and Im1: excitation coefficient of each element along y-axis and x-axis

d: spacing between elements

β: progressive phase shift between elements

k: propagation constants= 2π/λ

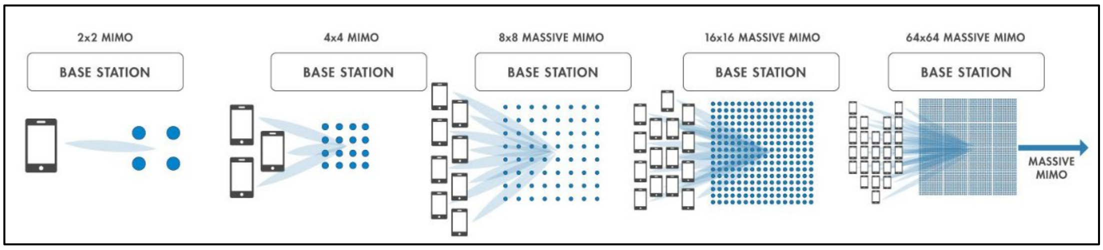

Figure 1.1 Massive MIMO

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.