TRANSMITARRAY ANTENNA UNIT CELL CHARACTERISTICS FOR 5G APPLICATIONS

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DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ABSTRACT

The multimedia and the communications in different countries and especially in Malaysia recently has been dedicated the bands of the frequency (700 MHz, 3.5 GHz, and 26/28 GHz) for the using of mobile services of 5G. Meanwhile, the transmit array antenna is providing attention for the previous years because owing a high gain capability in the communication system. Thus, this project study about three different unit cell for transmitarray antenna which are Frequency Selective Surfaces (FSS), Metamaterial and Transmit- Receiver types at 26GHz for 5G applications. Each configuration will be design and simulated using CST Software. Then, the design will be characterised and compared. The results show that FSS unit cell have achieved S21 phase range of 223 degrees for single layer and 247 degrees for two layers. In the following, metamaterial and transmit - receiver unit cell has obtained 80 degree and 200 degrees respectively. As conclusion, all the unit cell is still needs to be further optimised in order to achieve good performances.

ABSTRAK

Multimedia dan komunikasi di setiap negara adalah berbeza dan khususnya di Malaysia baru-baru ini telah ditetapkan jalur frekuensi (700 MHz, 3.5 GHz, dan 26/28 GHz) untuk digunakan bagi perkhidmatan komunikasi mudah alih 5G. Sementara itu, antena “transmitarray” telah diberi perhatian sebelumnya kerana keupayaan mempunyai keuntungan yang tinggi dalam sistem komunikasi. Oleh itu, projek ini mengkaji tentang tiga jenis unit sel berbeza untuk antena “transmitarray” iaitu “Frequency Selective Surfaces (FSS)”, “Metamaterial” dan “Transmit-Receiver” pada 26GHz untuk aplikasi 5G. Setiap konfigurasi akan direka bentuk dan disimulasikan menggunakan Perisian CST. Kemudian, reka bentuk ini akan dicirikan dan dibandingkan diantara satu sama lain. Keputusan simulasi menunjukkan bahawa sel unit FSS berjaya mencapai julat fasa S21 sebanyak 223 darjah untuk lapisan tunggal dan 247 darjah untuk dua lapisan. Seterusnya, sel unit ”metamaterial” dan “transmit – receiver” telah memperolehi julat fasa 80 darjah dan 200 darjah masing-masing. Sebagai kesimpulan, semua sel unit masih perlu dioptimumkan lagi untuk mencapai prestasi yang lebih baik pada masa hadapan.

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LIST OF ABBREVIATIONS

RF	-	Radio frequency
MI	-	Millimetre
5G	-	Fifth generation
FSS	-	Frequency selective surface
TA	-	Transmitarray

LIST OF SYMBOLS

k	-	Propagation constant in free space
R	-	Distance from the feed horn to the element
$\vec{r}_i$	-	Position vector of the element
$\hat{r}$	-	Main beam direction
	-	Operating frequency
	-	Speed of light (^{8})

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CHAPTER 1

INTRODUCTION

1.1 Problem Background

According to the recent assigned in malaysia for the 5G by the Malaysian communications and multimedia commission for the broadband services, a three different bands are going to be available in the service in malaysia, 700MHz 3.5GHz, 26/28GHz for 5G applications in the future [12], a wide change is coming to be available in the utilities of wireless communications with the ability to perform the 5G since the antenna is the basic and sufficient for the radio frequency to any type of devices. Meanwhile the antenna could play a necessary enhance the 5G applications. For moving to the 5G the serious challenge is represent is how to deal with bandwidth and the big carrier frequency while the deal with the new bands which could be the bandwidth frequency is mostly larger 10 times than the present band 4G [13]. The huge amount of the spectrum at millimetre wave frequency are attract more concern of cellular utilities supporters to use this underutilized band as useful modern technology for 5G, it required a wideband antenna in order to maintain the issues regarding to high propagation loss this also require a high gain to overcome this issue.[14][15]. Dielectric lens and horn antenna determined as a traditional techniques, they are heavy and huge. The planar antenna arrays basically are the suitable choice in the modern technology but they suffering from loss in transmission lines when it is designed for millimetre wave frequency. Between the different ways technologies which are operation as special feeding, the transmitarray antenna could provide a high efficiency and wide broadband performance [16]. The required of modern transmitarray antenna had increased because this type of antennas are have advantages such as low profile, light weight, low cost, high gain, the transmitarrays fabrication is very easy because transmitarrays did not need for a complex feeding network [17]. We have many types of transmitarray antenna but among the varying types we have three different transmitarray antenna and the most common design is receiver-transmitter due the insertion loss is very high by radiating parameter [18]. The frequency selective surface could provide high bandwidths [19], furthermore the two layer of frequency selective surface could change and enhance the characteristics of transmitarray antenna such as control the phase range to performance full 360 degree and high transmission coefficient magnitude S21.

The modern technology of transmit array antenna is become very famous due of the ability to attract the scientists among antenna filed because the concept of transmit array antenna is collecting the best elements and properties of lens antenna which is generally depending on the micro strip array and theory and this is depending on array theory [1]. Meanwhile this theory will guide us to high radiation efficiency including perfect gain and also suitable, flexible radiation achievement. The transmitarray antenna is one of suitable option for 5G application because of it is suitable services and features look like high gain for the radiation, flexible radiation, easy to design and fabricate and lightweight [2].

1.2 Problem Statement

The 5G communication system now days become a major concern in the technology society and the new technology is tend to more attenuation typically in 26 GHz and this will require high gain antenna for 5G applications, also high propagation is requirement at high frequency. The different researches on unit cell transmittarray antenna have been figured out with using different designs of unit cell so the antenna required to design in accurate method. In this research we figured out the research on unit cell transmitarray which is carried out three configuration different type the first one is metamaterial which is used to match the metamaterial layers and in this type of trasnmitarray we could control the phase shaft amplitude by change the properties of the metamaterial look like rotation of the receiver patch meanwhile the rotation will applied to the bottom patch of the transmitter and this will not effect on the magnitude [3], the second configuration type is receiver-transmitter transmitarray this type is most common because it is able to connect the layers by screw or vias, furthermore matches between the incident waves and receiver, meanwhile the second layer made up as ground which is used to phase shift and separation. The third configuration is frequency selective surface (FSS) this type contains numbers of layers known as multi-layer which is very common use in transmitarray antenna because it have the ability to achieve and performance full transmission magnitude and phase shift meanwhile the triple layer of (FSS) is also played a necessary role of transmitarray antenna [4]. Thus in this research work we are going to analysis the advantages and disadvantages of each one of three different type of unit cell and recognize the best configuration unit cell of high gain and the lowest attenuation [21].

1.3 Research Objectives

The objectives of the research are :

(a) To design and simulate three different types configuration transmitarray unit cell (Frequency selective surface, receiver-transmitter, metamaterial).

(b) To investigate and optimise each of types of unit cell configuration interms of S21 magnitude.

(c) To compare and summarize each of unit cell performances.

1.4 Scope of research:

The scope of the project can be followed as:

i. simulate and design three unit cell of transmitarray antenna using software CST.
ii. Improve, characterize and analyzed three different each unit performance.
iii. comparison of unit cell results.
iv. Discussion and conclusion of the project.

1.5 Chapter outline

chapter1 contain identify the 5G in summary including the relationship between the modern technology of 5G and the transmitarray antenna unit cell. In this chapter also obtained a summery idea of the three different configuration unit cell and a brief characteristics for each configuration of transmitarray unit cell to provide the 5G applications were also obtained.

Chapter 2 include literature review this chapter identify the unit cell and explain the three different types designs and configuration of unit cell transmitarray (FSS, Receiver-Transmitter, Metamaterial) including studying and analysing structure of each different type of unit cell . Furthermore this chapter obtain the comparison between the three different types configuration of unit cell transmitarray and show the characteristics and advantages of unit cell which could give us chance to understand the unit cell.

Chapter 3 include research methodology which is obtain the plan of the project to introduce and understand the three different type unit cell. Furthermore this chapter explain the practical designs only of each type of transmitarray antenna unit cell regarding to describe each design by using CST studio and show the values, parameter, dimensions.

Chapter 4 including the result, we will explain and show the results of three different type transmitarray unit cell and discuss the results that we find regarding to S21 magnitude and phase shift for each different type of unit cell.

Chapter 5 including conclusion in overall achievements of the report the recommendation future work.

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