CIRCULAR POLARIZED CYLINDRICAL DIELECTRIC RESONANT ANTENNA FOR 5G APPLICATIONS

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DEDICATION

This project is dedicated to me and all the other engineers who are pursuing or have pursued a postgraduate course while working full time. It was a challenge to try to juggle between work and studies, however with determination and hard work it finally came to an end successfully. Setting your mind strongly towards your goals will enable you to achieve great things.

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ABSTRACT

This study compared two different excitation methods and three different designs of a Circular Polarized Cylindrical Dielectric Resonant Antenna (DRA) which operates at the 5G frequency bands which are the C-Band range of 3.5 GHz. Due to the expansion of 5G and advancements in Internet of Things (IoT) technologies, more and more wireless digital electronic devices which are agile with minimal power consumption are required. As the 5G spectrum moves into higher frequency ranges, previous antenna design methods such as microstrip patch antenna using metallic substrate suffer from significant losses. In addition to that, the profile and dimension of the antennas also needs to be minimized to be fitted inside various miniature devices. Numerous articles are now available on the design of microstrip patch antennas for 5G application. However, studies into dielectric resonant antenna for 5G applications are still upcoming and that will be the main discussion of this paper. The objective of this paper is to simulate and design a cylindrical dielectric resonant antenna which is circularly polarized and compare the radiation effects that it produces via different types of excitation methods used. A cylindrical DRA fed via slot aperture coupled technique has been proposed. In order to make the cylindrical DRA circularly polarized, the slot underneath the DRA has been modified into a U-shaped slot and the DRA has been modified to include a hollow cylindrical space in the centre to improve its bandwidth and gain. It has been found that the inclusion of a hollow space in the centre of DRA and modification of the slot produces a circularly polarized DRA with 270 MHz bandwidth for the centre frequency of 3.5 GHz. The design of this structure can be proposed for 5G application in the C-Band spectrum.

ABSTRAK

Kajian ini membandingkan dua kaedah pembekalan yang berbeza dan tiga reka bentuk Antena Resonan Dielektrik Silinder (DRA) yang beroperasi pada jalur frekuensi 5G yang merupakan julat C-Band 3.5 GHz. Disebabkan oleh perkembangan 5G dan kemajuan teknologi Internet of Things (IoT), semakin banyak peranti elektronik digital tanpa wayar yang lincah dengan penggunaan kuasa minimum diperlukan. Ketika spektrum 5G bergerak ke julat frekuensi yang lebih tinggi, kaedah reka bentuk antena sebelumnya seperti antena patch microstrip yang menggunakan substrat logam mengalami kerugian yang ketara. Selain itu, profil dan dimensi antena juga perlu diminimumkan untuk dipasang di dalam pelbagai peranti miniatur. Banyak artikel kini terdapat mengenai reka bentuk antena patch mikrostrip untuk aplikasi 5G. Walau bagaimanapun, kajian mengenai antena resonan dielektrik untuk aplikasi 5G masih akan datang dan itu akan menjadi perbincangan utama kajian ini. Objektif kajian ini adalah untuk mensimulasikan dan merancang antena resonan dielektrik silinder yang terpolarisasi bulat (Circular) dan membandingkan kesan radiasi yang dihasilkannya melalui pelbagai jenis kaedah pembekalan yang digunakan. DRA silinder yang diumpankan melalui teknik cantuman bukaan slot telah dicadangkan. Untuk menjadikan DRA silinder terpolarisasi secara bulat, slot di bawah DRA telah diubah menjadi slot berbentuk U dan DRA telah diubah suai untuk memasukkan ruang silinder berongga di tengah untuk meningkatkan lebar jalur (Bandwidth) dan Gain. Hasil kajian mendapati bahawa ruang berongga di tengah DRA dan modifikasi slot menghasilkan DRA terpolarisasi bulat dengan lebar jalur 270 MHz untuk frekuensi tengah 3.5 GHz. Reka bentuk struktur ini dapat dicadangkan untuk aplikasi 5G dalam spektrum C-Band.

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DRA	-	Dielectric Resonant Antenna
CDRA	-	Cylindrical Dielectric Resonant Antenna
IoT	-	Internet of Things
MPA	-	Microstrip Patch Antenna
5G	-	5^{th} Generation
LTE	-	Long Term Evolution
LOS	-	Line of Sight

CHAPTER 1

INTRODUCTION

1.1 Overview

Due to the need for higher cellular broadband speed and bandwidth, a successor to the existing 4G technological standard was required. Hence the fifth-generation cellular broadband standard, also known as 5G was developed and started to be deployed in selected parts of the world in 2019.

Among the areas which require and would greatly benefit from the upgrade to 5G standards are the Internet of Things (IoT) and Big Data since it will improve on the rate and amount of data processing and computing which can be done on a given period.

The key highlights of 5G standard is its ability to process higher data rates (100 -1000 times) with low latency [1] which is essential in high resolution video broadcast, high mobility gaming, massive Internet of Things (IoT) and lifeline communications

In line with the development of 5G frequency spectrum, the Dielectric Resonant Antenna (DRA) is being focused more and more in the antenna design sector for its distinctive properties [9] such as low loss at higher frequencies as compared to a regular microstrip patch antenna.

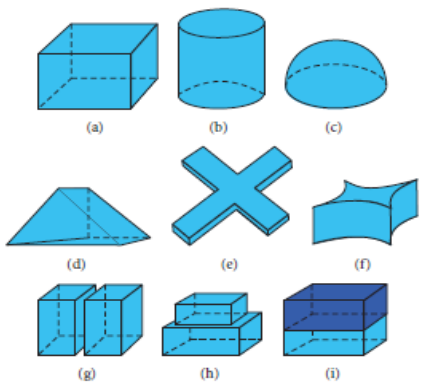

Figure 1.1 Assortments of DRA Types [3]

1.2 Problem Statement

Commonly used patch antenna solutions have several limitations when resonating at higher frequencies and even so on millimeter wave bands. Among some of the issues with these devices at higher frequencies are low gain, low radiation efficiency and narrowband behavior. These issues along with high cross polarization potential prove to be a hindrance on the development of antennas for uses on 5G applications which radiate at the C-Band range of 3.5 GHz and also the Millimeter Wave Band of 26 GHz.

For DRA's one of the issues which are regularly faced is the cross polarization due to improper excitation methods and substrate isolation. Hence this study will consider the multiple issues and drawbacks faced in the design and fabrication of DRA's.

Another common problem with conventional types of microstrip patch antennas used is that they suffer from metallic losses at higher frequency ranges which affects their radiation properties and efficiencies. This is even more significant in the current scenario whereby frequency bands for the 5G applications are moving towards higher frequency bands.

In addition to that, there is also a need on the existing antenna designs to provide higher gain and bandwidth to support widescale usage. Regular patch antennas have limitations in achieving higher bandwidth without compromising on the gain of the device.

1.3 Objectives of the Study

Followings is the statement of objective proposed for this study: -

- To design and simulate a cylindrical dielectric resonant antenna via aperture coupling excitation method at @ 3.5 GHz.
- To perform a comparison on 3 different types of cylindrical dielectric resonant antennas design in terms of its bandwidth and gain.

- To achieve a circular type of signal polarization on the final selected design by way of modification to the aperture slot.

A feasibility study has been performed regarding the objective statement and it has been evaluated that the objective is achievable. Hence the project will be carried out in accordance with the objective stated.

Figure 1.2 Cylindrical Dielectric Resonant Antenna

1.4 Project Scope

The scope and research of this project will be limited to:

No.	Design specifications	Value
1	Operating frequency of DRA	3.5 GHz

2	Excitation Method 1 Excitation Method 2	Microstrip Feed Aperture Coupling
3	Software	CST Studio Suite
5	Minimum Bandwidth	100 MHz
6	Minimum Gain	3 dB
7	DRA Substrate Permittivity Loss Tangent	Custom 10.2 0.0022

The values obtained for all the design types from the CST simulations will then be compared to come up with the most efficient design type.

1.5 Significance of the Project

This project is carried out to prove that Dielectric Resonator Antennas are suitable and carries numerous advantages in terms of design and size for 5G applications.

As 5G implementation is expected to be started in this year, readiness in terms of consumers antenna design and optimization are essential in anticipation of it. Although most antennas used for mobile technologies are using the linear type of polarization, this project focuses on the circular type of polarization which is better in maintaining communication even when there are considerable obstructions on the line of sight (LOS).

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