A DUAL BAND HYBRID MIMO DIELECTRIC RESONATOR ANTENNA FOR LONG TERM EVOLUTION APPLICATIONS

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Dedicated, in thankful appreciations to my beloved parents and brothers for giving me endless love, motivations, constant encouragements and supports.

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ABSTRACT

Dielectric resonator antennas (DRAs) are widely used in the last two decades. Comparison with microstrip patch antenna, DRA can provide high bandwidth, low metallic losses and high radiation efficiency. Smaller size of meander line is suggested to replace conventional microstrip line. Multiple-input multiple-output (MIMO) can increase more channel capacity and throughput compared to single port. In this project, a dual band MIMO hybrid DRA for LTE applications is proposed. This hybrid technique will be consisted of DRA and meander-typed antenna as radiators which can operate at LTE band 8 (880-960 MHz) at f_r = 900 MHz, LTE band 2 (1.85-1.99 GHz), 3 (1.71-1.88 GHz), and 9 (1.7499-1.7849 GHz) at f_r = 1.8 GHz respectively. A triple band is obtained in the simulations of HFSS software with additional 2.3 GHz for LTE Band 30 (2.305-2.360 GHz). The MIMO prototype has bandwidth up to 6.53 % at Port 1 and 12.68 % at Port 2, with isolation ranging - 6.10 dB to - 22.76 dB at 0.9, 1.5, 1.8 and 2.5 GHz.

ABSTRAK

Antena resonator dielektrik (DRA) digunakan secara meluas dalam dua dekad yang lalu. Berbanding dengan antena tampalan mikrojalur, DRA mempunyai jalur lebar yang tinggi, kehilangan logam rendah dan kecekapan radiasi yang tinggi. Saiz antena berliku-liku yang lebih kecil dicadangkan untuk menggantikan konvensional antena mikrojalur. Berbilang input berbilang output (MIMO) boleh meningkatkan lebih banyak kapasiti saluran dan penghantaran berbanding dengan port tunggal. Dalam projek ini, berbilang input berbilang output bagi dua band hibrid DRA untuk aplikasi LTE dicadangkan. Teknik hibrid ini akan terdiri daripada antena DRA dan radiator seperti antena berliku-liku supaya boleh beroperasi di band LTE 8 (880-960 MHz) pada f_r = 900 MHz, Band LTE 2 (1.85-1.99 GHz), 3 (1.71-1.88 GHz) dan 9 (1.7499-1.7849 GHz) pada f_r = 1.8 GHz masing-masing. Dalam simulasi perisian HFSS, tiga band didapati dengan tambahan 2.3 GHz untuk LTE Band 30 (2.305-2.360 GHz). Prototaip MIMO mempunyai jalur lebah sehingga 6.53% di Port 1 dan 12.68% di Port 2, dengan pengasingan antara - 6.10 dB hingga - 22.76 dB pada 0.9, 1.5, 1.8 dan 2.5 GHz.

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LIST OF ABBREVIATIONS

BW	-	Bandwidth
CDRA	-	Cylindrical DRA
DL	-	Downlink
FDD	-	Full-duplex Division
GHz	-	Giga Hertz
GSM	-	Global System for Mobile Communication
GSMA	-	Global System Mobile Association
HFSS	-	High Frequency Structure Simulator
HSDPA	-	High Speed Downlink Packet Access
LTE	-	Long Term Evolution
MIMO	-	Multiple-input Multiple-output
MHz	-	Mega Hertz
OFMDA	-	Orthogonal Frequency Division Multiple Access
SC-FDM	-	Single Carrier Frequency Division Multiple Access
UP	-	Uplink
UV	-	Ultraviolent
TDD	-	Time-duplex Division
SMA	-	Subminiature Version A
TV	-	Television
1G	-	First Generation
3D	-	Three-dimension
3G	-	Third Generation
4G	-	Fourth Generation

LIST OF SYMBOLS

℃	-	Degree Celsius
c	-	Speed of light, $3\ x\ 10^{8}\ ms^{-1}$
cm	-	Centimeter
dB	-	Decibel
dBi	-	Decibel-isotropic
ε_r	-	Permittivity
f_r / f / freq.	-	Frequency
mm	-	Millimeter
S11	-	Input Return Loss
S22	-	Output Return Loss
S12/S21	-	Isolation
$\tan\delta$	-	Tangent Loss
λ	-	Wavelength
Ω	-	Ohm
%	-	Percentage

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Evolution of mobile network technology from 1G to 4G has brought numerous benefits to humans in terms of callings, texting and speed of surfing through the Internet. In telecommunication, the latest standard wireless communication, that is, Long Term Evolution (LTE) is widely used in mobile devices such as smartphones, laptops and tablets due to its high speed transmission, data rates and spectrum efficiency. The operating frequency ranges from 400 MHz up to 4 GHz [1] with bandwidth (BW) from 1.4 to 20 MHz. The significance of LTE has been highlighted by the forecasts of GSMA Intelligient in 2014. It predicts that 64 % of the world's population will be covered by 4G-LTE network by the end of 2020. Therefore, a high performance, low profile and small size of antenna is preferred.

Several types of novel antennas were introduced as radiating element in the past few decades ago such as horn antenna, Yagi-Uda antenna, microstrip patch antenna (MPA), dielectric resonator antenna (DRA) and others. However, MPA and DRA have received a great attentions [2] due to their simple properties, inexpensive and the capability to be embedded in modern wireless products.

In 1939, R.D. Richmyer has demonstrated that certain dielectric materials can radiate in the same way as metallic cavities radiate. They are known as dielectric resonator. Due to the properties of energy storage in the early stage, they are used in microwave circuit for filter network and oscillator [3]. It allows a high permittivity dielectric constant, which ranges from 4 to 140 [4]. The idea of using dielectric resonator as an antenna had not been widely accepted until the original paper on cylindrical DRA was published in 1983 [2], [5]. The analysis of DRA as radiating element leads the research on theoretical and experiments. The resonance frequency of DRA will not be shifted from designated frequency by the change of temperature. It makes DRA to become more popular due to this fantastic properties.

DRA is available in various shape as shown in Figure 1.1 [6]. Multiple feeding methods such as microstrip feed line, coaxial probe, aperture coupling have been introduced in DRA design. A rectangular shape is widely used because it is easy to design, fabricate and control bandwidth as shown in Figure 1.1 (a). DRAs can be designed in smaller size as its size is inversely proportional to square root of dielectric permittivity [7]. The higher the permittivity, the smaller size of DRA but reduced bandwidth.

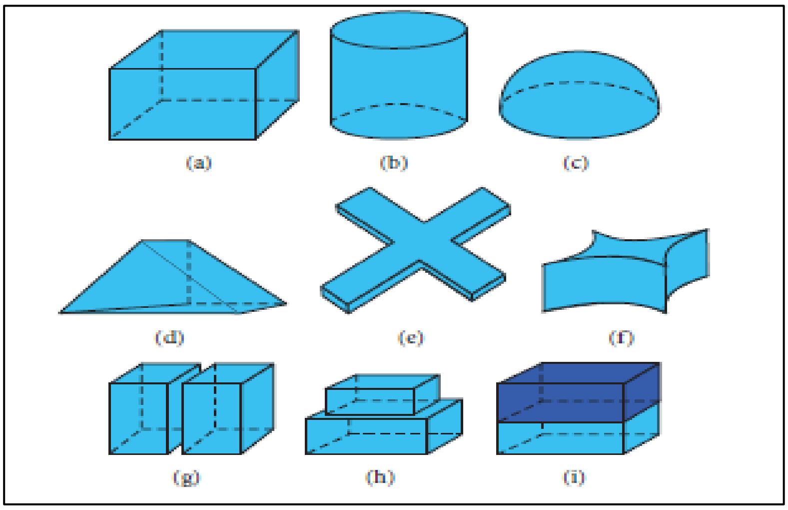

Figure 1.1 Various shapes of DRA [6]

A single DRA element can also be fed by either single port or multiple ports which is known as multiple-input multiple-output (MIMO). At least two antennas utilized at each transmitter and receiver are considered as MIMO. This technology is utilized for preventing multipath fading to improve channel capacity, data rates, link reliability and network coverage. The focus of the world today is the use of a MIMO system [8]. Digital TV and mobile communications are some of the MIMO applications in our daily lives.

In DRA design, either single band or multi-band frequency can be designed. Multi-band frequency is superior than single band because when there is available of different band frequencies, a lower frequency will be chosen. This is because lower frequency has a better coverage than higher frequency due to its long generating signals.

LTE is the standard technology used for mobile communication devices due to its advanced speed. The speed of download data is from 5 to 12 megabits per second is faster than older 3G networks speed which is around 800 to 950 kilobits per second [9]. LTE use different frequency spectrum with specified uplink and downlink range for each LTE frequency band as shown in Figure 2.5 and Figure 2.6.

1.2 Problem Statement

Microstrip patch antenna suffers from low gain, low radiation efficiency and narrow bandwidth (typically 2-5 %) compared to DRA [10]. Therefore, DRA is chosen in this project due to its numerous advantages over it. The second problem statement comes for the design of conventional linear monopole antenna. Meander line antenna can be realized by bending it to decrease the size of antenna [11]. The last problem statement is limitation channel throughput of single port. Hence, MIMO is designed to provide higher channel capacity and high data rates [8].

1.3 Objectives

There are four objectives listed below in this project.

1) To design a single port DRA operating at 1.8 GHz.

2) To design a single port meander line operating at 0.9 GHz.

3) To design, fabricate and test a dual band single port hybrid DRA operating at 0.9 GHz and 1.8 GHz.

4) To design, fabricate and test a dual band MIMO hybrid DRA operating at 0.9 GHz and 1.8 GHz.

1.4 Scope of Project

The scope of this project is to study dielectric resonator antenna and meander line as radiators to achieve a dual band frequency, 0.9 GHz and 1.8 GHz respectively in LTE applications by using hybrid technique. The shape of DRA is rectangular and microstrip feeding line is used as feeding technique throughout this whole project. All the simulations are done by using High Frequency Structure Simulator (HFSS) software.

1.5 Summary

This chapter gives brief descriptions of DRA as radiating element. Its advantages are highlighted compared to microstrip patch antenna. The function of multi-band frequency, MIMO and basic information of LTE technology are described.

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