4G LTE DIRECTIONAL ANTENNA DESIGN AND ANALYSIS FOR WIRELESS BACKHAUL

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

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : 4G LTE DIRECTIONAL ANTENNA DESIGN AND ANALYSIS FOR WIRELESS BACKHAUL

Sesi Pengajian : 2022/2023

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DEDICATION

I dedicate this work to my creator, my strong pillar, my source of inspiration, knowledge, and understanding. He was the source of all things during this task. To my beloved father and mother, Mr Shamsudin bin Kaling and Mrs Asmah binti Muslim and siblings, Muhammad Maizal Hairi bin Shamsudin and Nurina Najwa binti Shamsudin. This is dedicated to each and every one of you. May Allah continue to bless you all.

ABSTRACT

The existing antenna in 4G LTE router are suffering with low gain antenna that connect to the base station (BS). To overcome this problem, a directional antenna was introduced and integrate as an external antenna to boost up the quality of connectivity thus improve the overall of internet speed. This project presents the design and analysis of Yagi Disc Antenna with different number of director's elements appropriate for band 3 in 4G LTE mobile communication system which operating at frequency of 1.8 GHz. The design of this antenna was first simulated by using CST software. After the result obtained, then it was fabricated and measured it performace. The antenna comprises of two elements which are driven and parasitic that consists of reflector and directors. The purpose of this project is to investigate and analyze the effect of antenna performance with changes in the number of director's elements. The material of these elements is made of aluminium because it has a good reflector. The performance of the antenna was measured in several ways which are using Vector Network Analyzer (VNA), Anechoic Chambers and perform a field test to show how well it truly worked.

ABSTRAK

Antena sedia ada dalam penghala 4G LTE mengalami masalah dengan antena gandaan rendah yang bersambung ke stesen pangkalan (BS). Untuk mengatasi masalah ini, antena berkearah telah diperkenalkan dan diintegrasikan sebagai antena luaran untuk meningkatkan kualiti sambungan sekali gus meningkatkan keseluruhan kelajuan internet. Projek ini membentangkan reka bentuk dan analisa Antena Cakera Yagi dengan bilangan elemen pengarah yang berbeza yang sesuai untuk jalur 3 dalam sistem komunikasi mudah alih 4G LTE yang beroperasi pada frekuensi 1.8 GHz. Reka bentuk antena ini dimulai dengan menggunakan perisian CST. Selepas keputusan diperolehi, barulah ia disimulasi dan diuji prestasinya. Antena terdiri daripada dua elemen iaitu pemacu dan parasit yang terdiri daripada pemantul dan pengarah. Tujuan projek ini adalah untuk mengkaji dan menganalisis kesan prestasi antena dengan perubahan dalam bilangan elemen pengarah. Bahan elemen ini diperbuat daripada aluminium kerana ia mempunyai pantulan yang baik. Prestasi antena diukur dalam beberapa cara yang menggunakan Penganalisis Rangkaian Vektor (VNA), Bilik Kepuk Tidak Bergema dan ujian lapangan untuk menunjukkan sejauh mana ia benar-benar berfungsi.

ACKNOWLEDGEMENTS

Foremost, to my supervisor, Assoc. Prof. Dr. Imran bin Mohd Ibrahim of the Faculty of Electronics and Computer Engineering (FKEKK) Universiti Teknikal Malaysia Melaka (UTeM), I would like to convey my heartfelt appreciation for his patience, encouragement, passion and vast expertise. His advice was invaluable to me during the preparation of my thesis. I couldn't have wish for a better adviser and mentor for my degree program.

Special thanks to my colleagues, Angkhana A/P Tong, as well as my loving father, mother, siblings, and friends, who provided moral support while I was finishing my degree. Last but not least, thank you to everyone who helped make this project a success.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

4G	:	4th Generation
LTE	:	Long Term Evolution
WCDMA	:	Wideband Code Division Multiple Access
HSPA	:	High Speed Packet Data
3GPP	:	3rd Generation Partnership Project
GSM	:	Global System for Mobile communication
UE	:	User Equipment
DL	:	Downlink
LTE-A	:	Long Term Evolution Advance
MS	:	Mobile Station
BS	:	Base Station
CST	:	Computer Simulation Technology
RF	:	Radio Frequency
HPBW	:	Half Power Beam Width
SWR	:	Standing Wave Ratio
VSWR	:	Voltage Standing Wave Ratio
eNB	:	Evolved Node B
LoS	:	Line of Sight

VNA	:	Vector Network Analyzer
F/B	:	Front to Back
RSRP	:	Reference Signal Received Power
RSRQ	:	Reference Signal Received Quality
SINR	:	Signal to Interference Noise Ratio
RSSI	:	Received Signal Strength Indicator
ϵr	:	Relative Permittivity
Ω	:	Ohm
λ	:	Lambda
Γ	:	Reflection Coefficient
μ	:	Micro
tan δ	:	Loss Tangent
Mbps	:	Mega bit per second

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an overall overview of the project, which includes project background, problem statement, objectives, scope of the project, project planning and chapter outline.

1.2 Project Background

In this era of pandemic, there are lot of society who are being affected by the Covid-19 virus especially among the students. They have been impressed with the new norm of learning that is through online which requires good internet access to smooth their learning process. From the Sun Daily News, students have complained that their internet access is limited especially those who living in rural areas because the base station is located far from their homes [1]. The development of communication

technology has grown up remarkably and driven the orientation of wireless communication systems. Nowadays, certain wireless communication systems including Long Term Evolution (LTE) as well as its service applications are recently becoming increasingly popular and high demand. This is owing to the multiple advantages such as providable communication services with inexpensive cost at anytime and anyplace for the users [2]. LTE system can solve this problem by supporting higher data rates, higher capacity, and lower latency [3]. Figure 1.1 shows the network architecture of 4G LTE in which co-exist with the WCDMA and HSPA networks that will also continue to evolve within 3GPP [4].

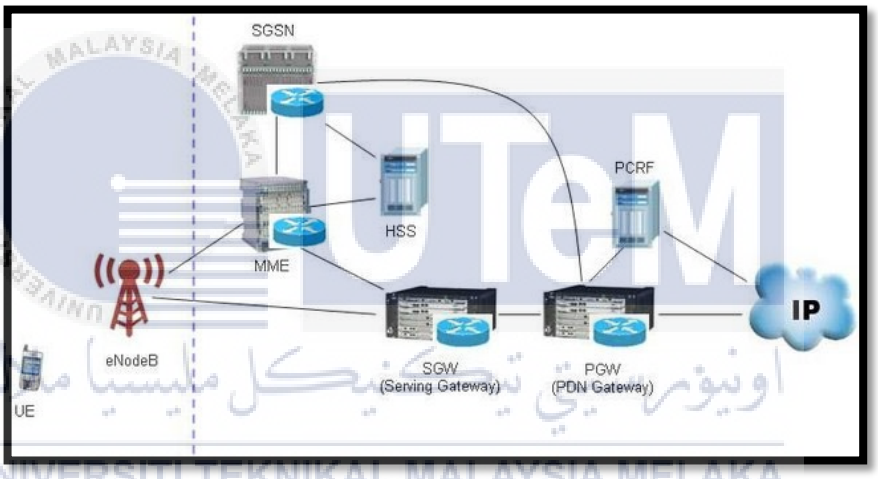

Figure 1.1: 4G LTE Network Architecture

The majority of network operators around the world have launched commercial LTE systems in the 1.8 GHz spectrum. Band 3 (1800 MHz) deployments represent greater than 48% of all LTE networks globally. LTE 1800 technology band 3 has gained a lot of interests among wireless broadband operators. This is primarily due to the 1.8 GHz bandwidth it is already being used for GSM [5]. Operators have several motivations for deploying band 3 LTE 1800. In term of coverage area, LTE1800 technology provide twice as large compared to deployments in LTE 2600 technology.

Besides, the spectrum reframing from GSM1800 to LTE 1800 is very cost effective [6]. With the clear majority of band 3 4G networks using a 20 MHz channel width as shown in Figure 1.2 [7], most stand-alone networks provide up to 150 Mbps UE DL data rate with clean channel conditions, and up to 400 Mbps in LTE-A Pro.

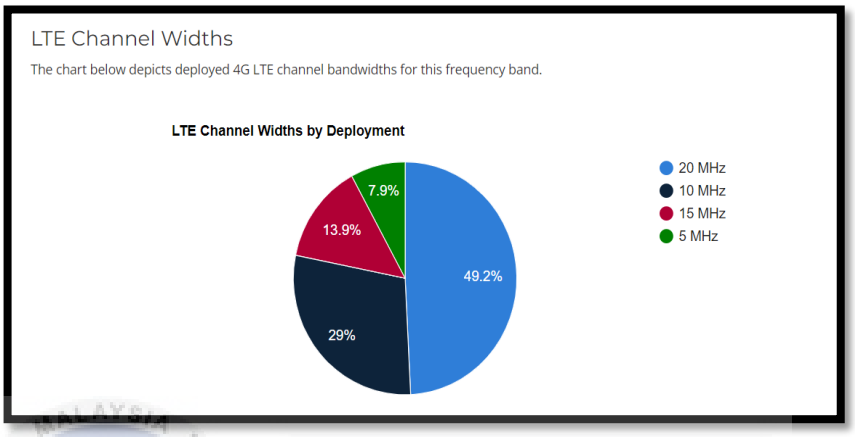

Figure 1.2: LTE Channel Widths

However, the application of such wireless communication technology is generally constrained by the distance between the mobile station (MS) of user and the site coverage to base station (BS). So, the received power was becoming low caused by several losses on the broadcasting signals between base station and mobile station [8].

In case of using a 4G Wi-Fi router, there are often encountered by low signal throughputs due to the weak receiving signal and the distance between mobile station and base station [9]. Therefore, the users generally requires an antenna with high gain to improve the power of receiving signal from base station. A Yagi antenna is one sort of antennas for boosting the gain of recipient signal and has reduced return loss value [10]. In this project, a yagi disc antenna is suitable to be used due to this antenna provides balanced traveling-wave structure, which has high directivity, front-to-back