Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF VISIBLE LIGHT COMMUNICATION SYSTEM USING ARRAYED LED TECHNIQUE FOR WIRELESS CONNECTIVITY.

RIDZWAN AFIF BIN RAZALI

Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

2021

DEVELOPMENT OF VISIBLE LIGHT COMMUNICATION SYSTEM USING ARRAYED LED TECHNIQUE FOR WIRELESS CONNECTIVITY.

RIDZWAN AFIF BIN RAZALI

A project report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

Faculty of Electrical and Electronic Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJURUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DEVELOPMENT OF VISIBLE LIGHT COMMUNICATION SYSTEM USING ARRAYED LED TECHNIQUE FOR WIRELESS CONNECTIVITY

Sesi Pengajian: 2021/2022

Saya Ridzwan Afif bin Razali mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

Disahkan oleh:

(TANDATANGAN PENULIS)
Alamat Tetap: NO. 68, JALAN SRI DAMAK 53, TAMAN SRI ANDALAS, 41200, KLANG, SELANGOR D.E

(COP DAN TANDATANGAN PENYELIA)
FAUZI BIN ABDUL WAHAB
Pensyarah
Jabatan Teknologi Kejuruteraan Elektronik dan Komputer
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
Universiti Teknikal Malaysia Melaka

Tarikh: 1/3/2022

Tarikh: 16/03/2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this project report entitled “Development of Visible Light Communication System using arrayed LED technique of wireless connectivity“ is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : 

Student Name : RIDZWAN AFIF BIN RAZALI

Date : 1/3/2022

APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

Signature	:	
Supervisor Name	:	ENCIK FAUZI BIN HJ ABDUL WAHAB
Date	:	16/03/2022
Signature	:	
Co-Supervisor Name (if any)	:	DR. MD ASHADI BIN MD JOHARI
Date	:	16/3/2022

DEDICATION

I strongly want to dedicate this project to my loving and supportive parents, Razali bin Daud and Faridah Binti Ismail, who have always been source of inspiration and strength throughout my journey on completing this project. I would also like to dedicate this project to my siblings, who are continuously motivating me to improve as a person in the future. I have nothing but love and the deepest appreciation to Encik Fauzi Bin Haji Abdul Wahab, my gentle and kind-hearted supervisor, for his encouragement and advise. Finally, I want to express my gratitude to Allah S.W.T. for blessing my life much more than I deserve.

ABSTRACT

Over the last decade, optical wireless communication (OWC) has attracted a lot of attention. OWC is seen as an alternative as well as a promising interdependent communication approach to the traditional radio frequency (RF) approach, which uses a controlled and licenced electromagnetic spectrum band spanning 30 kHz to 300 GHz [1]. There are crises arising within the RF spectrum as a result of an exponential expansion in wireless data traffic and smart mobile devices. This rise causes a spectrum crisis, resulting in congestion and low maximum data rates compared to OWC. Due to the advantages of Visible Light Communication technology over conventional lighting technologies, the use of LED technology has increased in recent years. One of these advantages is its potential to quickly switch on and off, allowing data to be transmitted using light as a channel. This project's designed transmitter and receiver are tested in simulation with the software OptiSystem for the optical part and Proteus for the electrical part, and the prototype is then produced. Different types of electrical modulator, different distance of FSO Channels and different numbers of LED will be tested in the OptiSystem simulation. Both the transmitter and receiver units will also simulated in Proteus. Arduino Nano is used to create the final prototype for the optical and electrical parts. The project's findings were analysed and compared. The constructed VLC system has been tested in two conditions. First is by varying the distance between transmitter and receiver units. The second condition is by varying the illumination intensity of LEDs. To be conclude, the higher the number of LEDs used for data transmission and the closer the distance between transmitter unit and receiver unit, the better the performance of the system.

ABSTRAK

Sepanjang dekad yang lalu, komunikasi tanpa wayar optik (OWC) telah menarik banyak perhatian. OWC dipandang sebagai alternatif dan juga pendekatan komunikasi saling bergantung yang menjanjikan kepada pendekatan frekuensi radio tradisional (RF), yang menggunakan jalur spektrum elektromagnetik terkawal dan berlesen yang merangkumi 30 kHz hingga 300 GHz [1]. Terdapat krisis yang timbul dalam spektrum RF sebagai hasil dari pengembangan eksponensial dalam lalu lintas data tanpa wayar dan peranti mudah alih pintar. Kenaikan ini menyebabkan krisis spektrum, mengakibatkan kesesakan dan kadar data maksimum yang rendah berbanding OWC. Oleh kerana kelebihan teknologi Komunikasi Cahaya Terlihat berbanding teknologi pencahayaan konvensional, penggunaan teknologi LED telah meningkat dan bertambah sejak beberapa tahun yang lalu. Salah satu kelebihannya adalah potensinya untuk menyala dan tidak menyala secara berkelip dengan pantas, membolehkan data dihantar melalui cahaya sebagai saluran. Pemancar dan penerima projek yang dirancang ini diuji secara simulasi dengan perisian OptiSystem untuk bahagian optik dan Proteus untuk bahagian elektrik, dan prototaip kemudian dihasilkan. Pelbagai jenis modulator elektrik, jarak Saluran FSO dan bilangan LED yang berlainan akan diuji dalam simulasi OptiSystem. Kedua-dua unit pemancar dan penerima juga akan disimulasikan di Proteus. Arduino Nano digunakan untuk membuat prototaip akhir untuk bahagian optik dan elektrik. Penemuan projek ini telah dianalisis dan dibandingkan. Sistem VLC yang dibina diuji dalam dua keadaan. Pertama, mengubah jarak antara unit pemancar dan penerima. Syarat kedua ialah dengan mempelbagaikan keamatan pencahayaan LED. Kesimpulannya, semakin tinggi bilangan LED yang digunakan untuk penghantaran data dan semakin dekat jarak antara unit pemancar dan unit penerima, semakin baik prestasi sistem.

ACKNOWLEDGEMENTS

I want to express my gratitude to Encik Fauzi Bin Hj Abdul Wahab, my supervisor, and Encik Md Ashadi Bin Md Johari, my co-supervisor, for their excellent guidance, unwavering support, and patience during my Bachelor's degree programme. Their vast knowledge and wealth of experience have aided me throughout my academic career and daily life.

I would also like to express my gratefulness to Universiti Teknikal Malaysia Melaka (UTeM) and my siblings for their financial assistance in helping me to complete the project during a challenging time.

My highest appreciation goes to my parents and family members for their love and prayer during the period of my study. An honourable mention also goes to Reza Afdzal Bin Razali for all the motivation and understanding.

Finally, I would like to thank all my friends, classmates, fellow colleagues and the faculty members. Others who are not included here but have been cooperative and helpful throughout my tough time are also not forgotten.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Vpp	-	Voltage Peak-to-Peak
V	-	Voltage
W	-	Watt

LIST OF ABBREVIATIONS

VLC	-	Visible Light Communication
OWC	-	Optical Wireless Communication
Li-Fi	-	Light Fidelity
RF	-	Radio Frequency
LED	-	Light Emitting Diode
LoS	-	Line of Sight
APD	-	Avalanche Photodiode
FSO	-	Free Space Optic
OOK	-	On-Off Keying
NRZ	-	Non-Return-to-Zero
PAM	-	Pulse Amplitude Modulation
FM	-	Frequency Modulation
PM	-	Phase Modulation
FSK	-	Frequency-Shift Keying
PSK	-	Phase-Shift Keying
OFDM	-	Orthogonal Frequency Division Multiplexing
PCB	-	Printed Circuit Board

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Lighting is on the verge of being fully restructured, thanks to the advancement of solid-state devices for lighting. This innovation brings with it plenty of benefits and opportunities that have the potential to turn the wireless communications industry for the better. Fluorescent lamps and incandescent are increasingly being replaced by solid-state LEDs. LEDs are ideal for their long lifetime, ability to turn on and off at a very high pace, low heat generation and high energy efficiency. A new communication technology known as Visible Light Communication (VLC) which has the ability to quickly switch between various levels of luminous intensity has given rise to a new communication technology. LED lamps are now being widely used for data transmission as well, thanks to this technology. It uses light pulses to transmit data and at the same time, it can also provide illumination for the users.

Optical communication is a type of light communication in the range of the electromagnetic spectrum which are Infrared, Visible Light, and Ultraviolet Light that are used to transmit signals in the transmission system. All these systems that operate in the visible band are referred to VLC. VLC is a comparatively modern technology in the field of communication. To resolve the problem occurs in Radio Frequency (RF) technology such as radio interference from other services, this form of wireless communication is recommended. There are calamities occurring within the Radio Frequency band which are exponential growth in wireless data traffic and advanced mobile devices.

Recent standardization and development of various RF technologies are also insufficient to mitigate these ongoing problems. Optical Wireless Communication (OWC) is viewed as a replacement for traditional RF communication, which operates within a controlled and licensed electromagnetic spectrum band ranging from 30 kHz to 300 GHz. Meanwhile, the OWC spectral band is operating between 300 GHz and 30 000 THz and the best part is that it is free from regulation [1].

The major point behind this project is to modulate LEDs that send electromagnetic waves in visible light wavelengths so that devices in the same place, such as a room, can communicate. The transmitter and receiver units for the VLC system will be developed in this project. The prototype's performance will be evaluated by varying the gap distances between transmitter and receiver units and the illuminating strength by taking into account the attenuation effect caused by the factor of the environment.

1.2 Problem Statement

Current wireless networking technology, which uses the Radio Frequency (RF) Spectrum, has many disadvantages and weakness, including distortion and high latency problems. The RF Technology is also lack of security because there is no privacy as the signal that transmit the data travels through solid surfaces and it can be interrupted momentarily [2][3]. The scramble for spectrum in RF wireless communication systems is increasing at an alarming rate on a yearly basis. This issue has lead to an increase in data traffic which is primarily caused by an exponential increase in communication devices. The global mobile data traffic is predicted to be increased more than sevenfold between 2017 and 2022. Plus, in RF communication systems, power consumption is extremely high compared to the OWC technology [4].

It also gives side effects and negative impacts to the human being. Studies shows that the radio frequency has been found to have a negative impact on pacemakers that have been inserted into patients that have heart problem. The electromagnetic exposure has a high risk of causing the pacemaker to fail or even cease working. In addition, since the human brain is the most susceptible to radio frequency radiation, the whole nervous system of the elderly is potentially exposed to this radiated energy, resulting in neurological symptoms such as Alzheimer's disease, enzyme disorders, and free radicals that reduce brain metabolism [5].

Furthermore, the common VLC system employs a single LED, resulting in a small data coverage area in a compressed space such as a hall. Because of the lack of light and illumination, data transferred by a single LED is often restricted in space and has a shorter wavelength radius.

1.3 Project Objective

The objectives of the project are written as belows:

a) To design and construct a Visible Light Communication system which consists of transmitter unit and receiver unit by using arrayed LED Technique as the light source.

b) To analyze the data transmission and performance of Visible Light Communication system under various conditions such as distance between transmitter unit and receiver unit and illumination intensity.

1.4 Scope of Project

The scope of this project are as follows:

a) Construction and development of simulation/software and prototype/hardware both will be done which consists of transmitter unit and receiver unit.

b) In simulation, the electronic part will be designed using Proteus Software and the optical part will be analyzed and designed using OptiSystem Software.

c) Design will be tested in both hardware and software. The result of input inserted to transmitter and output from receiver will be compared for both hardware and software.

d) Once it has been accomplished, it will be further compared and tested under various conditions. The change of distance between transmitter and receiver unit and the change of level for illumination intensity will be analyzed.

e) Arrayed LED technique will be used as the light source in the transmitter. Meanwhile receiver will consist of Illumination Sensor.

1.5 Thesis Outline

The research effort on the development of a VLC system using arrayed LED technique for wireless connectivity using fundamental modulation method is separated into five chapters in this thesis. The second chapter will concentrate on the literature review and past research on wireless optical communication, VLC data transmission system, LED light characteristics, and photodetector. The technologies for wireless data transfer used by the past researchers are also explained and compared in this chapter. Next, the third chapter will explain about the methodolgy that will be used to complete the system in software and hardware step by step. The depiction of methods, knowledge, modelling, and implementing the VLC system into a modelling tool, as well as the constructions required, will be examined in this chapter. The analysis and discussion of approaches employing the proposed VLC system will be covered in Chapter 4, which will be supported by graphs and tabulated data. The thesis' primary conclusions are summarised in Chapter 5 and recommendations for further research are proposed.