Faculty of Electrical and Electronic Engineering Technology

Development Data Transmission Using Visible Light Communication (VLC) System (LI-FI)

HARITH HAKIMI BIN HARRY

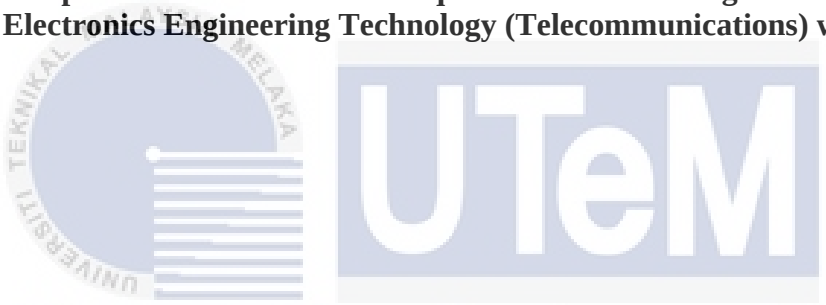
Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

2023

Development Data Transmission Using Visible Light Communication (VLC) System (LI-FI)

HARITH HAKIMI BIN HARRY

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

2023

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI TEKNOLOGI KEJURUTERAAN ELEKTRIK DAN ELEKTRONIK

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Development Data Transmission Using Visible Light Communication (VLC) System (LI-FI)

Sesi Pengajian : SESI 1 2022/2023

Saya Harith Hakimi Bin Harry 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: AE10, TAMAN DESA KENANGA, 43500 SEMENYIH SELANGOR

Tarikh: 13 JANUARY 2023

(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: 27/01/2023

*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 Data Transmission Using Visible Light Communication (VLC) System (LI-FI)" 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 : HARITH HAKIMI BIN HARRY

Date : 13 JANUARY 2023

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	:	Fauzi bin Hj. Abdul Wahab
Date	:	27/01/2023

DEDICATION

I strongly want to dedicate this project to my loving and supportive parents, Harry Bin MD Ali and Che Rofisah Binti Murad, who has always been the source of inspiration and strength throughout my journey to completing this project. I would also like to dedicate this project to my siblings, who continuously motivate me to improve as a person in the future. I love and have the most profound appreciation for Encik Fauzi Bin Haji Abdul Wahab, my gentle and kind-hearted supervisor, for his encouragement and advice. Finally, I want to express my gratitude to Allah S.W.T. for blessing my life much more than I deserve.

ABSTRACT

Nowadays, the radio spectrum is a finite resource that is quickly depleting. The government is considering repurposing different radio frequencies, including the satellite communications bands next to GPS, due to a need for commercial spectrum to promote broadband wireless communications. As a result, Li-Fi is an alternative to avoid this problem. VLC or Li-Fi stands for Visible Light Communication. VLC, also known as Li-Fi, is a data communication technology that employs a visible light source as a signal transmitter, air as a transmission medium, and a signal-receiving device. The transmitters commonly Light Emitting Diodes (LEDs), while the receiver's main element is a photodetector, usually a photodiode. In short-range applications, it can complement radio waves with VLC or Li-Fi to achieve higher data rates and wider bandwidth. This project is to make a transmission system that uses Li-Fi as a transmitter medium combined with Arduino as the microcontroller. This project will have two part, which is the source part and the receiver part. The result of this project is that when the transmitter sends messages to text, the receiver can read the message that comes from the transmitter without data loss. Also, the receiver can display the message on LCD that it received from the transmitter. VLC or Li-Fi is an alternative to replace Wi-Fi.

ABSTRAK

Pada masa kini, spektrum radio adalah sumber terhad yang cepat habis. Kerajaan sedang mempertimbangkan untuk menggunakan semula frekuensi radio yang berbeza, termasuk jalur komunikasi satelit di sebelah GPS, kerana keperluan spektrum komersial untuk mempromosikan komunikasi tanpa wayar jalur lebar. Hasilnya, idea Li-Fi menjadi alternatif yang mengelakkan masalah ini. VLC atau Li-Fi adalah singkatan dari Visible Light Communication. VLC, juga dikenali sebagai Li-Fi, ialah teknik komunikasi data yang menggunakan sumber cahaya yang boleh dilihat sebagai pemancar isyarat, udara sebagai medium penghantaran dan peranti penerima isyarat. Pemancar biasanya adalah Diod Pemancar Cahaya (LED), manakala elemen utama penerima ialah pengesan foto, yang biasanya fotodiod. Dalam aplikasi jarak pendek, kami boleh melengkapkan gelombang radio dengan VLC atau Li-Fi untuk mencapai kadar data yang lebih tinggi dan lebar jalur yang lebih luas. Projek ini adalah untuk menjadikan sistem penghantaran yang menggunakan Li-Fi sebagai medium pemancar bergabung dengan Arduino sebagai pengawal mikro. Projek ini akan mempunyai dua bahagian, iaitu bahagian sumber dan bahagian penerima. Hasil projek ini ialah apabila pemancar menghantar teks mesej, penerima dapat membaca mesej yang datang daripada pemancar tanpa kehilangan data. Juga, penerima dapat memaparkan mesej pada LCD yang diterima daripada pemancar. VLC atau Li-Fi ialah alternatif untuk menggantikan Wi-Fi.

ACKNOWLEDGEMENTS

I want to express my gratitude to Encik Fauzi Bin Hj Abdul Wahab, my supervisor, for their excellent guidance, unwavering support, and patience during my Bachelor's degree program. 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 my study. An honorable mention also goes to Harry Bin MD Ali and Che Rofisah Binti Murad for all their motivation and understanding.

Finally, I thank all my friends, classmates, colleagues, and faculty members. Others who are omitted 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 ABBREVIATIONS

VLC	-	Visible Light Communication
PWM	-	Pulse-Width Modulation
LED	-	Light-Emitting Diode
PV	-	Photovoltaic
LCD	-	Liquid Crystal Display
APD	-	Avalanche Photodiode
PD	-	Photodiode
Wi-Fi	-	Wireless Fidelity
Li-Fi	-	Light Fidelity
LDR	-	Light Dependent Resistors
VPPM	-	Variable Pulse Position Modulation
OOK	-	On-Off Keying
CSK	-	Color Shift Keying
TTL	-	Transistor-Transistor Logic
IDE	-	Integrated Development Environment
V	-	Voltage
Mbps	-	Megabits Per Second
Gbps	-	Gigabytes Per Second
Kbps	-	Kilobits Per Second
Bps	-	Bits Per Second
VCC	-	Common Collector Voltage
GND	-	Ground

CHAPTER 1

INTRODUCTION

1.1 Background

We now can foresee a period of peak data when the radio spectrum will be so overcrowded that the amount of data used for wireless services will be limited [1]. However, Li-Fi technology is being developed to increase the data rate, efficiency, and power consumption. Li-Fi is a bidirectional network solution that gives users an experience similar to Wi-Fi. The demand for connectivity will grow dramatically as we progress into the future [2]. We will require a network with a higher spectral capacity to meet these demands. We can use a spectrum 100000 times larger than radio frequency with Li-Fi. Li-Fi is now capable of delivering unprecedented amounts of data and bandwidth. Optical wireless communication incorporates infrared, ultraviolet, and visible light transmission [3]. Li-Fi, however, is unique in that the same light energy used to illuminate may also be utilised to communicate. Li-Fi's operation is straightforward but effective. When a continuous current is delivered to an LED light bulb, photons are emitted, resulting in lighting. Because LED bulbs are semiconductors, the wind and the illumination may change rapidly, which the photodetector can detect. The LED bulb can transmit high-speed information using this technology [4].

1.2 Problem Statement

We are rapidly approaching peak data in many worldwide cities, especially Malaysia. The problem arises when the service provider can no longer meet the user demands for wireless internet and telephony by the available radio frequency spectrum. Because of limited spectrum availability and interference, radio waves can only support a specific bandwidth. The radio spectrum is bursting at the seams, making it more difficult to obtain radio capacity to support media applications. [5]. Wi-Fi networks are usually insecure. Its lack of security is due to its extensive signal range. The problem with Wi-Fi connections is that signals are often unstable. That is because radio frequencies are still susceptible to external interference [5]. Also, the availability of Wi-Fi is limited to some locations, such as aeroplanes, chemical and power factories, and hospitals. Radio waves cannot be used [5]. The problem with Wi-Fi connections is that signals are often unstable. That is because radio frequencies are still susceptible to external interference. So, Li-Fi is one of the solutions that meet the requirement.

1.3 Project Objective

The main aim of this project is to develop data transmission using visible light communication. Specifically, the objectives are as follows:

a) To design and construct a Visible Light Communication system that consists transmitter unit and a receiver unit.

b) To develop modulation for modulating and sending the data through the LED and develop a LDR system to receive and demodulate data.

c) To develop the receiver part that can receive messages from the transmitter and display the message.

d) To analyse and optimise the complete system.

1.4 Scope of Project

This research focuses on data transmission using visible light communication. In achieving

a) The transmitter uses Arduino mega as the microcontroller to connect with a keypad to write the message before transmitting.

b) Data that comes from the keypad will be modulated before the transmission.

c) Develop an ultrabright LED system capable of functioning as a transmitter module.

d) LDR system that can receive a message from the ultrabright LED module.

e) Arduino mega will demodulate the data received from the LDR module sensor.

f) Data that has demodulated goes through LCD and displays the message.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Li-Fi is identified as a critical strategy to address growing issues of user activities in transferring data and information in today's society because it outperforms Wi-Fi in terms of bandwidth, efficiency, availability, and security. As the world becomes more rapid, so does the need for fast data transmission.

Moreover, to study and understand more about Li-Fi technology [6] and data transmission using visible light communication [10]. For strategic planning and development, data transmission using visible light communication VLC system Li-Fi.

Besides, this chapter contains information and research collected from the internet, books, and journal papers.

2.2 Li-Fi technologies

Li-Fi stands for light-based data transmission. The following are five important reasons to support li-fi and understand the value of this technology [6].

1. Distance - The distance light may penetrate water limits LiFi's usefulness. Beyond 200 metres, significant amounts of light do not travel. Beyond 1000 metres, there is no light.
2. Cost - Saves energy and money
3. Traffic Update
4. Telivsion Interaction

2.3 Principle of Visible Light Communication

Visible Light Communication (VLC) is a new technology that attempts to improve communication by using light. Aims are to offer to provide high internet connectivity, especially indoors environment. It modulates the intensity of existing solid-state lighting infrastructure, which light-emitting diodes can supply (LEDs) [10]. VLC has several significant benefits compared to typical radio frequency-based access networks, including around 300 THz of license-free bandwidth carried on visible wavelengths, 10,000 times greater than the radio's available capacity, which is also significantly overcrowded [7].

VLC is the communication channel that employs visible light as an optical carrier for data transmission and illumination between 400 THz (780 nm) and 800 THz (375 nm). It uses fast light pulses to convey data wirelessly. White LEDs have recently been used as efficient light sources to displace incandescent light bulbs and fluorescent lamps [10].

2.4 Li-Fi addresses Wi-Fi issues

The following is how Li-Fi tackles the Wi-Fi above issues [9]:

1. Capacity: The light spectrum in visible form is 10,000 times bigger than the spectrum of radio frequencies. In addition, the light sources are already installed. As a consequence, Li-Fi provides higher bandwidth while using existing equipment.
2. Efficiency: LED lights are more energy efficient and consume less power.
3. Availability: Light sources can be found all around the planet. As a result, accessibility is not an issue. LEDs are all that is required to replace light bulbs around the world.
4. Security: Light, of course, does not penetrate through walls and thus, data transmission using light waves is more secure.

2.5 Difference between Li-Fi and Wi-Fi technologies

Feature	Li-Fi	Wi-Fi
Full form	Light Fidelity	Wireless Fidelity
Operation	Li-Fi with the aid of LED lights, Li-Fi transports data via light.	With the assist of a WiFi router, Wi-Fi delivers data via radio waves.
Interference	There are no interference difficulties as if there are with radio frequency waves.	Will have interference issues from nearby access points(routers)
Technology	Present IrDA compliant devices	WLAN 802.11a/b/g/n/ac/ad standard compliant devices
Applications	For data transfer and internet surfing, it is used in aircraft, submarine excursions, operating rooms in hospitals, offices, and homes.	Wi-Fi kiosks or Wi-Fi hotspots are commonly used for internet browsing.
Merits (advantages)	There is less interference, it can flow through salty sea water, and it operates in dense areas.	There is more interference, it cannot flow through sea water, and it only operates in a less dense environment.
Privacy	Light is blocked by barriers in Li-Fi, making data transport more secure.	Since the RF signal in Wi-Fi cannot be blocked by barriers, measures must be used to ensure safe data transfer.
Data transfer speed	About 1 Gbps	WLAN-11n offers 150Mbps, about 1-2 Gbps can be achieved using WiGig/Giga-IR
Frequency of operation	10 thousand times frequency spectrum of the radio	2.4GHz, 4.9GHz and 5GHz
Data density	Works in high dense environment	Works in less dense environment due to interference related issues
Coverage distance	About 10 meters	About 32 meters (WLAN 802.11b/11g), vary based on transmit power and antenna type
System components	The whole Li-Fi system will consist of a light driver, an LED bulb (lamp), and a photodetector.	Subscriber devices (laptops, PDAs, and desktops) are referred to as stations, and routers must be installed.

Table 1: Difference between Li-Fi and Wi-Fi technologies [8]

2.6 Related Project

2.6.1 Data Transmission System Using LI-FI Technology

The proposed work by Emmanuel Ifada, Nasir Faruk, Nazmat Surajudeen, and A. Abdulkarim (2019) is about building the Li-Fi system using off-the-shelf electronic components. The proposed method is based on an embedded system with a dual-core Advanced Virtual RISC (AVR) microcontroller (ATmega16L) that is connected to input/output circuits that include a Light Emitting Diode (LED) also consisting of a photodiode and an LM358N operational amplifier. The sample data in the text sent was also monitored. The system's speed, efficiency, security, and capacity were evaluated and found to be outstanding, thanks to the usage of JAVA programming to develop a user (Receiver PC) interface.

The Arduino microcontroller creates the interface for encoding and decoding data supplied by the flashing LED in the transmitter circuit and received by the photodiode in the receiver circuit. The Arduino's GPIO pins provide a signal to the transmitter, which is subsequently sent to the PC via USB. This signal controls the transistor that acts as a switch for the LED's power source. The photodiode turns light into an electrical signal, which is then sent into the microcontroller through the signal filtered and amplified by the operational amplifier. Because the signal is analogue after amplification, it undergoes an ADC operation before being sent to the Arduino. The decrypted message (text) is then gathered and displayed on the receiving PC [26].