PERFORMANCE CHARACTERISATION BETWEEN OPTICAL WIRELESS COMMUNICATION AND ULTRAVIOLET COMMUNICATION FOR INDOOR APPLICATION

IZZAH HAZIRAH BINTI ZAINAL

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

PERFORMANCE CHARACTERISATION BETWEEN OPTICAL WIRELESS COMMUNICATION AND ULTRAVIOLET COMMUNICATION FOR INDOOR APPLICATION

IZZAH HAZIRAH BINTI ZAINAL

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

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Performance Characterisation between Optical Wireless Communication and Ultraviolet Communication for indoor application

Sesi Pengajian : 2021/2022

Saya IZZAH HAZIRAH BINTI ZAINAL 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)

(COP DAN TANDATANGAN PENYELIA)

DR. ZAITON BT. ABDUL MUTALIP
Senior Lecturer
Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya, 76100 Durian Tunggal
Melaka, MALAYSIA

Alamat Tetap: No 146 Jalan IM2 Bandar Indera Mahkota 25200 Kuantan Pahang

Tarikh : 20 Jun 2022

Tarikh : 21 Jun 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 the thesis of Performance Characterisation Between Optical Wireless Communication and Ultraviolet Communication for Indoor Application is the result of my own work except for quotes as cited in the references.

Signature : ....

Author : IZZAH HAZIRAH BINTI ZAINAL

Date : 20 JUNE 2022

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : ....

Supervisor Name : TS DR ZAITON BINTI ABDUL MUTALIP

Date : 21 JUNE 2022

DEDICATION

I dedicate this thesis to the people who have been beside me throughout this journey which are my parents. I also dedicate this thesis to my siblings and friends who cheer me up when I feel down. This is for you.

ABSTRACT

Wireless communication technologies become one of the biggest technology that are considered to be suitable for radio frequency in various type of applications including indoor application. This research studies is to know the suitability of wireless technology for indoor application to compliment 5G and 6G advancement. Two types of technology which are Optical Wireless Communication (OWC) and Ultraviolet Wireless Communication (UVC) are observed based on On-Off Keying (OOK) modulation technique. The power distribute by LED in fixed size room and various amount of LEDs are compared between those two technology. The minimum illuminance for OWC is 0.36lx while for UVC is 90lx. Bit Error Rate (BER) for both technologies are same which in the range of 10^{-9} that complement ITU-T standard. For eye diagram result, the eye pattern generated for both technologies are different in terms of eye opener. OWC is chosen to be the technologies that suitable for indoor applications due to its benefits. The ideas of this project is to make sure the safety and security of signal which are critical in optical and ultraviolet frequency communication.

ABSTRAK

Teknologi komunikasi tanpa wayar merupakan salah satu teknologi terbesar yang mempertimbangkan kesesuaian frekuensi radio dalam pelbagai jenis aplikasi termasuklah aplikasi di dalam kawasan tertutup. Penyelidikan ini dilakukan untuk melihat kesesuaian teknologi tanpa wayar yang boleh digunakan di kawasan tertutup bagi memenuhi kemajuan 5G dan 6G. Terdapat dua teknologi yang diselidik iaitu komunikasi optik tanpa wayar dan komunikasi ultraviolet. Keduanya akan dikaji menggunakan teknik modulasi kekunci tutup dan buka. Pengagihan kuasa yang dikeluarkan oleh LED dan diletak di dalam bilik yang mempunyai saiz sama akan dibandingkan untuk dua teknologi tersebut. Pencahayaan minimum yang di keluarkan bagi teknologi optikal adalah 0.36lx manakala untuk komunikasi ultraviolet adalah 90lx. Kadar ralat bit bagi kedua-dua teknologi adalah sama dimana ia berada dalam julat 10^{-9} *yang ditetapkan dalam standard ITU-T. Bagi keputusan rajah mata, corak yang dikeluarkan untuk kedua-dua teknologi adalah berbeza dari segi bukaan rajah mata tersebut. Teknologi optik tanpa wayar dipilih sebagai teknologi yang sesuai digunakan di kawasan tertutup disebabkan oleh faedah yang ada pada teknologi tersebut. Cadangan projek ini adalah untuk memastikan keselamatan isyarat yang merupakan perkara penting untuk optik dan frekuensi komunikasi ultraviolet.*

ACKNOWLEDGEMENTS

First and foremost, my most humble gratitude to our God, Allah S.W.T. Only with His blessings and perseverance that was bestowed upon me in making this undergraduate journey possible. My special gratitude and appreciations to my FYP main supervisor, Dr Zaiton Binti Abdul Mutalip who been an inspiration and mentor throughout my degree journey. Her guidance and encouragement in my research had refined my knowledge in the wireless technology and system engineering. My sincere gratitude to my family for their support, love and prayers throughout my degree journey. Words cannot express their sacrifices and support that had led me to what I am today. I am also very thankful to all my friends and colleagues who had contributed directly or indirectly in completing my thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Wireless devices are increasing day by day because of its user friendly which consumer can access real-time information other than it can helps in reducing the usage of cables. WiFi is something everyone know and people cannot live without it. Device connectivity provides ecosystems in which one device can act as an entry point to others. Using the system's continuous data gathering, a device may collectively function to deliver insights to users. IoT solutions have the potential to enhance business verticals while also influencing other elements of our everyday lives such as health, safety, productivity, and entertainment [1]. Optical wireless communication (OWC) is known to have wide bandwidth and license-free frequency spectrum as shown in [2]. OWC suitable for radio frequency in many applications including indoor application. The optical spectrum is described as electromagnetic radiation with wavelengths from 10nm and frequencies range from 300 GHz to 3000 THz. Ultraviolet communication (UVC) is included under OWC but with difference bandwidth and omni-directional links with low background noise [3].

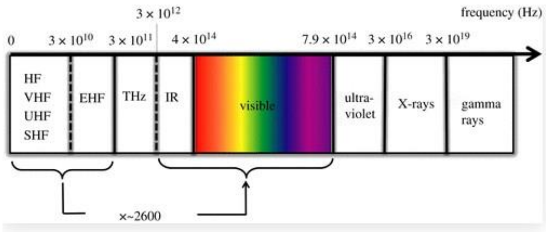

Figure 1.1: Optical spectrum

Because of the low signal attenuation at low carrier frequencies, the signal that need to be transmit may pass through opaque obstacles such as walls and it diffract on it. Even though the carrier frequency might be low it has smaller bandwidth and consequently data speeds [1]. Increasing the carrier frequency and reducing the wavelength can make better bandwidth and data rates across a shorter connection range with less penetration and diffraction.

1.2 Objective

The project is focus on exploring the performance of optical wireless communication and ultraviolet communication by using On-Off Keying modulation schemes. Optical Wireless Communication OWC is known to have license-free unregulated wide bandwidth to serve ultra-high transmission rate while ultraviolet wireless communication UVC has large spectrum than optical spectrum. Indoor application has obstacles that can cause data loss for optical wireless communication OWC since it need point to point system. Ultraviolet wireless communication UVC is band that is virtually noiseless compared to optical wireless communication OWC so it can be enable more secure communication at once it will transmit the data faster and stable. On-Off Keying OOK modulation will be used in the project by using MATLAB software to compare the performance both system in the same environment and to analyze which wireless communication is suitable for indoor application.

1.3 Problem Statement

Due to the rapid expansion in wireless technology, optical wireless communication OWC and ultraviolet wireless communication UVC become uprising promising technology. Optical wireless communication OWC break in the optical line of sight Line-of-sight (LOS) link that can be major cause loss of data. When it comes to indoor application, it has lot of obstacles including smokes, furniture, etc. It does have some of suitable link configuration for both application such as line-of-sight LOS, non line-of-sight Non line-of-sight (NLOS) and diffuse link. Even though ultraviolet wireless communication UVC channel response have different behavior for different room size, it also had harmful effect if human expose for too long. Between optical wireless communication OWC and ultraviolet wireless communication UVC which one is more suitable to use for indoor application?

1.4 Scope of Project

The scope of project is to simulate both optical wireless communication and ultraviolet wireless communication based on on-off keying configuration. Then the performance in terms of bit error rate, transmission power, environmental noise measurement and signal-to-noise ratio are evaluated.The size of room is fix to 4x4x4 and used LED as the transmitter. Based on the performance characterization, the suitability of the system for indoor environment will be proposed

1.5 Sustainability

This project is considered to be a green technology because the component used which is LED in the project is one of the efficient lighting source and consumed less electricity compared to the normal fluorescent light. optical wireless communication and ultraviolet wireless communication system are compatible to the radio frequency wireless technology in many applications. Based on the vision of IR4.0, both system can help to overcome the spectrum crunch in radio frequency Radio Frequency (RF) communications. This helps to meet the growing demand for high-speed communication links between consumer electronics, sensors and the infrastructure. The project has commercial value especially in the communication and data transmission field as it offers high- speed wireless communication as a complementary solution for overcrowded RF and WIFI system.

1.6 Report Structure

This report consists of five (5) main chapters. Chapter 1 is introduction where it is more to describe about this project that includes introduction of the project, objectives, problem statement, scope, sustainability and summary of the project. Chapter 2 is literature review that involved with the background research of application. Next, methodology is explained in chapter 3 that includes technical design of electronic component and coding that use in this project. In chapter 4, there are results and discussion on outcome of the project. Last chapter which is chapter for conclusion and suggestion on how to improve and added in the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explains more on how the project is needed by the user to utilise in their work. Some research on the component specifications is made to complete the job successfully. Other than that, this chapter needs to consider how the initiative will aid in the improvement of user performance.

2.2 Optical Wireless Communication

Optical wireless communication OWC is light that transmits from one point to another in free space or it also called Free Space Optics (FSO) [4]. Wireless communication is essential and has become part of our lives where it helps to connect people all around the world through the internet and devices. Light can transmit data faster and efficiently through the air rather than through glass with a greater incident angle. Optical wireless communication OWC has benefits, including people who can use it for free without any license. It is not dangerous to humans since it does not emit any harmful light. Unfortunately, optical wireless communication OWC have stringent alignment requirements and severe weather-related impacts [5]. Data will be interrupted if there is an obstacle in front of the receiver because it is sensitive to shadow and has limited by front-end photodiode capacitance. Figure 2.1 below shows the structure of OWC system where it includes a laser that generates a light source and transmits it to atmospheric channel before filtering the signal in telescope.

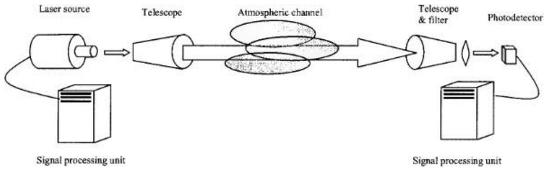

Figure 2.1: OWC schematic system

There is much more application that OWC can be used in such as indoor, outdoor, underwater, industry and airport. The history started with the first telegraph and electrical telegraph developed in 1830s by Samuel Morse to use for long distance communication [6]. After years of invented new technology, it has few types of communication technology based on its suitability. Under OWC itself, it has different communication such as; [7]

i. Satellite communication

Satellite communication has the big role to transmit signal all over the world and designed specifically to use in telecommunications including TV, radio broadcasting, planes and ships. It is also used for military purposes or as military weapon. They are in charge of providing these services to a certain location of the planet. The satellites' power and bandwidth are determined by the preferred footprint size, the complexity of traffic control protocol methods, and the cost of ground stations.

ii. Infrared communication

Infrared (IR) is a form of information transmission that uses light that is invisible to the naked eye. This indicates that it is located between microwaves and visible light on the electromagnetic spectrum. To receive the light beam, infrared communication requires a transmitter and a photo receiver [7]. Because any disruption to the light will prevent the photo receiver from receiving it, IR can only work when there is a clear line of sight.

iii. Broadcast radio

An omnidirectional antenna broadcasts a sent signal over a large coverage area in a broadcast radio channel. A directional transmitting antenna is used in a point-to-point radio channel to focus the wave into a small beam that is directed toward a single receiving location. In either instance, a remote receiving antenna picks up the sent electromagnetic wave and converts it to an electric current [8].

iv. Microwave communication

Antennas can focus microwave signals in the same way that a laser beam concentrates light into a narrow beam. Signals are sent straight from the source to the receiver. The range of a reliable microwave signal does not extend much beyond the visible horizon. Cities would be crisscrossed by microwave transmissions transmitting crucial signals if microwave signals were visible to the naked eye. Any type of data that can be communicated over telephone wires or coaxial cables can be transmitted as efficiently over a microwave circuit as it can over the wires and cables it supplements.

v. Wi-Fi

Wi-Fi internet is a wireless electronic network with a low power consumption. These can be found in nearly every shopping mall, restaurant or even in public places. A physical wired network is, in essence, connected to a router. As a result, low-power wireless network is created. It is possible to join a variety of devices to the local network using this method. However, criminals and hackers have been known to target public wireless internet connections. As a result, it is critical that both users and providers implement password security measures when connecting to these networks [9].

vi. Global Positioning System (GPS)

The Global Positioning System (GPS) is a space-based radio navigation system that consists of a constellation of satellites that broadcast navigation signals and a network of ground stations and satellite control stations that monitor and regulate the system.

GPS attracted a wide range of users throughout the world by providing a system that overcame the constraints of several existing navigation technologies [9].

Indoor application become much crucial as an outdoor application since most of the work happen either at home or office. OWC-based indoor positioning functionality is also in great demand. The method to accept the signal has generated much interest, where multiple transmitters are used and positioning information is provided by estimating the channel gain of each transmitter [8]. Before apply communication technology for indoor application, OWC has some types of communication types of depending on the distance.

- Ultra-short range: for nm/mm distance of communication.
- Short range: Wireless body area network (WBAN) and wireless personal area network (WPAN) and bluetooth which do not need to consume too much power and low in data transfer.
- Medium range: when the data transmits between two points and usually used for wireless local area networks (WLANs).
- Long range: suitable for inter-building connection since it can transmit data faster than short range communication.
- Ultra-long range: used for space communication such as inter-satellite [9].