

**CHARACTERIZATION OF LOW-LEVEL  
MODULATION TECHNIQUES FOR INDOOR VISIBLE  
LIGHT COMMUNICATION (VLC) SYSTEM**

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**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**CHARACTERIZATION OF LOW-LEVEL MODULATION  
TECHNIQUES FOR INDOOR VISIBLE LIGHT  
COMMUNICATION (VLC) SYSTEM**

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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**

**2018**

BORANG PENGESAHAN STATUS LAPORAN  
PROJEK SARJANA MUDA II

Tajuk Projek : Characterization of Low-level Modulation Techniques for Indoor Visible Light Communication (VLC) System

Sesi Pengajian : 2017/2018

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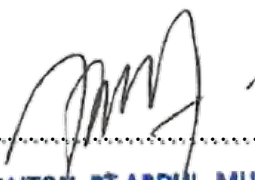
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## **DEDICATION**

I dedicated this thesis to my beloved parents who have been alongside with me all the time. Their caring and patience have made me who I am today. They flourished my life with unconditional love and support, giving guidance toward success and protecting me along the thorny path. Their attitude and kindness have affected me from young. Thanks for everything that my parents have done to me and I am much appreciated it.

## ABSTRACT

Technology is another expression of industrial art which comprise of skills, techniques, methods and processes to develop or manufacture a product or provide service to help the life of human getting easier. During the past recent years, we have encountered a bombastic advancement in technology especially in wireless communication system. We are now on the road to the fifth generation of wireless system that would definitely change the way we communicate currently. Optical Wireless Communication (OWC) has risen to become a reliable replacement to the current radio frequency transmission. Visible Light Communication (VLC) is one of the key technologies that falls within the category of OWC and indicate the dawn of 5G. This technology has been proposed for the past decade and the research and development (R&D) keep going until today in order to achieve a better objectives. Such objectives are higher transmission speed, larger capacity and security improvement. Modulation techniques are important to achieve those objectives and some of the them will be discussed in detail. This project is mainly focused on low-level indoor VLC system so the modulation schemes are limited to the certain techniques such as pulse position modulation. Most of their properties and both advantages and disadvantages will be listed out to make comparison among various modulation techniques. At last, the modulation technique with the highest transmission speed will be chosen as an ideal method for future prototype.

## ABSTRAK

Teknologi adalah satu sektor perindustrian yang mengandungi kemahiran, teknik, kaedah dan proses untuk membangun, menghasilkan produk atau menyediakan perkhidmatan untuk membantu kehidupan manusia menjadi semakin senang. Sepanjang tahun-tahun kebelakangan ini, kita telah mengalami kemajuan besar dalam teknologi terutamanya dalam sistem telekomunikasi tanpa wayar. Kita sedang berada di atas jalan yang mengarah ke generasi kelima dalam sektor komunikasi tanpa wayar dan ini akan mengubah cara kita berkomunikasi pada masa kini. Optical Wireless Communication (OWC) telah meningkat sebagai salah satu pengganti yang boleh dipercayai selain daripada frekuensi radio yang digunakan semasa. Sistem Visible Light Communication (VLC) adalah salah satu teknologi penting yang dapat menunjukkan kedatangan 5G. Teknologi ini telah dicadangkan sejak sedekad lalu dan penyelidikan dan pembangunan (R&D) terus berjalan hingga hari ini untuk mencapai objektif yang lebih baik. Objektif tersebut adalah kelajuan transmisi yang lebih tinggi, peningkatan kapasiti dan peningkatan keselamatan. Teknik modulasi adalah penting untuk mencapai objektif tersebut dan akan dibincang secara terperinci. Projek ini akan memberi tumpuan kepada sistem VLC dalaman yang bertahap rendah, oleh itu, skema modulasi adalah terhad kepada beberapa teknik tertentu. Kebanyakan sifat mereka dan kedua-dua kelebihan dan kelemahan akan disenaraikan untuk membuat perbandingan antara pelbagai teknik modulasi.



## ACKNOWLEDGEMENTS

Firstly, I would like to thank my parents who always give full support to me without any complaint.

Secondly, I would like to give thousand gratitude to my supervisor, Dr. Zaiton binti Abdul Mutalip who provided a lot of guidance and information during the research. She guided me with her professional knowledge on communication field and lent me a hand when I facing difficulties on research process.

Thirdly, I would like to say thank you to my fellow friends who always provide help either financially or mentally. They also help in releasing my stress during the project.

Lastly, thank you very much given to all the people that provide help during this Final Year Project. Your assistance is appreciated.

## TABLE OF CONTENTS

<b>Declaration</b>	<b>i</b>
<b>Approval</b>	<b>i</b>
<b>Dedication</b>	<b>i</b>
<b>Abstract</b>	<b>i</b>
<b>Abstrak</b>	<b>ii</b>
<b>Acknowledgements</b>	<b>iii</b>
<b>Table of Contents</b>	<b>iv</b>
<b>List of Figures</b>	<b>viii</b>
<b>List of Tables</b>	<b>xv</b>
<b>List of Symbols and Abbreviations</b>	<b>xvi</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Project Background	1
1.2 Problem Statement	3
1.3 Objectives	3

1.4 Scope of Work	3
1.5 Methodology	4
1.6 Thesis Organization	4
<b>CHAPTER 2 BACKGROUND STUDY</b>	<b>6</b>
2.1 Introduction	6
2.2 Wireless Communication	7
2.2.1 Bluetooth	7
2.2.2 Wireless Fidelity (Wi-Fi)	10
2.2.3 WiMAX	11
2.3 Optical Wireless Communication	12
2.3.1 Infrared	13
2.3.2 Ultraviolet	14
2.3.3 Visible Light	14
2.4 Modulation Techniques	18
2.4.1 Single Carrier Modulation	18
2.4.1.1 On-Off Keying	18
2.4.1.2 Pulse Position Modulation	19
2.4.2 Multiple Carrier Modulation	20
2.5 Main Components	22
2.5.1 Carrier Signal Generator	23

2.5.2 Light Emitting Diodes (LED)	24
2.5.3 Photodetector	25
2.5.4 Amplifier	26
2.5.5 Display Unit	27
2.6 Summary	27
<b>CHAPTER 3 METHODOLOGY</b>	<b>29</b>
3.1 Introduction	29
3.2 Research Methodology Flow Chart	30
3.2.1 Detail Description of the Research Methodology	30
3.3 OptiSystem	31
3.3.1 Introduction	31
3.3.2 Design Concept	31
3.3.3 Circuit Construction	33
3.3.3.1 Circuit Without Modulator	33
3.3.3.2 On-off Keying Modulation	36
3.3.3.3 Optical Amplitude Modulation	40
3.3.3.4 Mach-Zehnder Modulator	42
3.3.3.5 Electrical Amplitude Modulation	44
<b>CHAPTER 4 RESULTS AND DISCUSSION</b>	<b>46</b>
4.1 Introduction	46

4.2 Signal without Modulation	46
4.3 On-off Keying	48
4.4 Optical Amplitude Modulation	60
4.5 Mach-Zehnder Modulator	72
4.6 Electrical Amplitude Modulation	82
4.7 Summary	90
<b>CHAPTER 5 CONCLUSION AND FUTURE WORKS</b>	<b>93</b>
5.1 Conclusion	93
5.2 Recommendation	94
<b>REFERENCES</b>	<b>95</b>

## LIST OF FIGURES

Figure 2.1 : Example of applications that connected using Bluetooth.	8
Figure 2.2 : The Bluetooth connection of multiple devices called Piconet.	9
Figure 2.3 : Wimax transmission.	11
Figure 2.4 : The position of Infrared (IR) in electromagnetic spectrum.	13
Figure 2.5 : Wavelength of the three energies radiated from the sun.	14
Figure 2.6 : The visible light that made up from 7 different colors with different wavelength.	15
Figure 2.7 : Data transmission in binary form.	16
Figure 2.8 : The working theory of a VLC system.	17
Figure 2.9 : OOK modulation techniques using Manchester Coding.	19
Figure 2.10 : A PPM waveform with data and clock.	19
Figure 2.11 : Carrier signal that generated from Wein Bridge Oscillator.	23
Figure 2.12 : An LED and its inner components.	24
Figure 2.13 : A PIN photodetector.	25
Figure 2.14 : A DMX signal amplifier.	26
Figure 2.15 : An oscilloscope displaying a waveform.	27

Figure 2.16 : Multiple types of modulation techniques.	28
Figure 3.1 : Research methodology flow chart.	30
Figure 3.2 : A design concept without the modulator.	33
Figure 3.3 : The properties of user defined bit sequence generator.	34
Figure 3.4 : The properties of NRZ pulse generator.	34
Figure 3.5 : The properties of LED.	35
Figure 3.6 : The properties of PIN type photodetector.	36
Figure 3.7 : The VLC system with OOK modulation technique.	37
Figure 3.8 : The properties of user defined bit sequence with OOK modulation.	37
Figure 3.9 : Properties of sine generator.	38
Figure 3.10 : Properties of electrical amplifier.	38
Figure 3.11 : Properties of Free Space Optical channel.	39
Figure 3.12 : Properties of Gaussian optical fiber.	39
Figure 3.13 : The properties of transimpedance amplifier.	40
Figure 3.14 : The properties of low pass Bessel filter.	40
Figure 3.15 : Transmitter end of optical AM VLC system.	41
Figure 3.16 : Receiver end of optical AM VLC system.	42
Figure 3.17 : Transmitter end of Mach-Zehnder VLC system.	43
Figure 3.18 : The receiver end of Mach-Zehnder VLC system.	43
Figure 3.19 : Transmitter end of electrical AM VLC system.	44
Figure 3.20 : Receiver end of electrical AM VLC system.	44
Figure 4.1 : Signal from NRZ pulse generator to splitter 1x2.	47
Figure 4.2 : Pulse displayed on oscilloscope visualizer 2.	47

Figure 4.3 : Two display units reading the output.	47
Figure 4.4 : Results on oscilloscope visualizer and RF spectrum analyzer.	48
Figure 4.5 : Information source generator side and electrical power meter visualizer.	48
Figure 4.6 : The oscilloscope 1 display after the RZ pulse generator.	49
Figure 4.7 : The oscilloscope 1 display after the NRZ pulse generator.	49
Figure 4.8 : The optical time domain visualizer 1 between the LED and FSO channel.	50
Figure 4.9 : Signal displayed on optical time domain visualizer 1.	50
Figure 4.10 : Transmission between FSO channel and Gaussian optical filter.	51
Figure 4.11 : Signal displayed on optical time domain visualizer 2.	51
Figure 4.12 : Signal with 10cm transmitter aperture diameter.	52
Figure 4.13 : Signal with 15cm transmitter aperture diameter.	52
Figure 4.14 : Signal with 20cm transmitter aperture diameter.	53
Figure 4.15 : Signal with 15cm receiver aperture diameter.	53
Figure 4.16 : Signal with 10cm receiver aperture diameter.	53
Figure 4.17 : Signal with 5cm receiver aperture diameter.	54
Figure 4.18 : Signal from Gaussian optical filter to photodetector PIN.	55
Figure 4.19 : The reading of optical power meter.	55
Figure 4.20 : Oscilloscope visualizer 4 measuring the output signal from photodetector PIN.	55
Figure 4.21 : Signal from transimpedance amplifier to low pass Bessel filter.	56
Figure 4.22 : The reading of the electrical power meter visualizer.	56
Figure 4.23 : The signal displayed on oscilloscope visualizer 3.	56
Figure 4.24 : Signal from low pass Bessel filter to 3R regenerator.	57



Figure 4.25 : The signal displayed on oscilloscope visualizer 2.	57
Figure 4.26 : Various display units connected to the 3R regenerator.	58
Figure 4.27 : Results on oscilloscope visualizer and RF spectrum analyzer.	58
Figure 4.28 : BER analyzer showing the eye diagram and Q factor.	58
Figure 4.29 : BER analyzer showing the eye diagram and minimum BER.	59
Figure 4.30 : RF spectrum zoomed to 160kHz.	59
Figure 4.31 : Signal travelling from NRZ pulse generator.	60
Figure 4.32 : Pulse displayed on oscilloscope visualizer 1.	61
Figure 4.33 : Signal travel from electrical amplifier to amplitude modulator.	61
Figure 4.34 : Pulse displayed on oscilloscope visualizer 2.	62
Figure 4.35 : Reading on electrical power meter visualizer.	62
Figure 4.36 : Signal generated by sine generator to the LED.	62
Figure 4.37 : Signal displayed on oscilloscope visualizer 3.	63
Figure 4.38 : Signal transmitted from LED.	63
Figure 4.39 : Waveform on optical time domain visualizer 1.	63
Figure 4.40 : Signal transmitted from the amplitude modulator.	64
Figure 4.41 : Signal displayed on optical time domain visualizer.	64
Figure 4.42 : Reading on optical power meter.	64
Figure 4.43 : The signal travel through FSO channel.	65
Figure 4.44 : The signal displayed on optical time domain visualizer 2.	66
Figure 4.45 : The signal measured after Gaussian optical filter.	66
Figure 4.46 : Signal displayed on optical time domain visualizer 3.	66
Figure 4.47 : Reading on optical power meter 1.	67

Figure 4.48 : The signal travelling from Photodetector PIN.	67
Figure 4.49 : Signal displayed on oscilloscope visualizer 4.	67
Figure 4.50 : Reading on electrical power meter visualizer 1.	68
Figure 4.51 : Signal travelling from transimpedance amplifier.	68
Figure 4.52 : Signal displayed on oscilloscope visualizer 5.	68
Figure 4.53 : Various display units connected to low pass Bessel filter.	69
Figure 4.54 : Results on oscilloscope visualizer and RF spectrum analyzer.	69
Figure 4.55 : Reading on electrical power meter visualizer 2.	70
Figure 4.56 : BER analyzer showing the eye diagram and Q factor.	70
Figure 4.57 : RF spectrum zoomed to 160kHz.	71
Figure 4.58 : BER analyzer showing the eye diagram and minimum BER.	72
Figure 4.59 : Information and carrier signal modulated in Mach-Zehnder modulator.	73
Figure 4.60 : Information signal displayed on oscilloscope visualizer 1.	73
Figure 4.61 : Information signal displayed on oscilloscope visualizer 2.	74
Figure 4.62 : Reading on electrical power meter visualizer 1.	74
Figure 4.63 : Carrier signal displayed on oscilloscope visualizer 3.	74
Figure 4.64 : Carrier signal displayed on optical time domain visualizer.	75
Figure 4.65 : Signal travelling in free space.	76
Figure 4.66 : Signal displayed on optical time domain visualizer 1.	76
Figure 4.67 : Reading on optical power meter 2.	76
Figure 4.68 : Signal displayed on optical time domain visualizer 3.	77
Figure 4.69 : Signal displayed on optical time domain visualizer 2.	77
Figure 4.70 : Reading on optical power meter 1.	77

Figure 4.71 : Signal travels along the receiver end.	78
Figure 4.72 : Signal displayed on oscilloscope visualizer 5.	79
Figure 4.73 : Reading on electrical power meter visualizer 2.	79
Figure 4.74 : Signal displayed on oscilloscope visualizer 4.	79
Figure 4.75 : Results on oscilloscope visualizer and RF spectrum analyzer.	80
Figure 4.76 : Reading on electrical power meter.	80
Figure 4.77 : BER analyzer showing the eye diagram and Q factor.	81
Figure 4.78 : BER analyzer showing the eye diagram and minimum BER.	81
Figure 4.79 : Circuit of transmitter connected various display units.	82
Figure 4.80 : Signal displayed on oscilloscope visualizer.	83
Figure 4.81 : Reading on electrical power meter visualizer.	83
Figure 4.82 : Signal displayed on oscilloscope visualizer 1.	83
Figure 4.83 : Reading on optical power meter.	83
Figure 4.84 : Signal displayed on optical time domain visualizer.	84
Figure 4.85 : The signal travelling through free space.	85
Figure 4.86 : Signal displayed on optical time domain visualizer 1.	85
Figure 4.87 : Reading on optical power meter 1.	85
Figure 4.88 : Signal displayed on optical time domain visualizer 2.	86
Figure 4.89 : Circuit of receiver connected to various display units.	86
Figure 4.90 : Signal displayed on oscilloscope visualizer 2.	87
Figure 4.91 : Reading on electrical power meter visualizer 1.	87
Figure 4.92 : Signal displayed on oscilloscope visualizer 3.	87
Figure 4.93 : Signal displayed on oscilloscope visualizer 4.	88

Figure 4.94 : Results on oscilloscope visualizer 5 and RF spectrum analyzer.	88
Figure 4.95 : Reading on electrical power meter visualizer 2.	89
Figure 4.96 : BER analyzer showing the eye diagram and Q factor.	89
Figure 4.97 : BER analyzer showing the eye diagram and minimum BER.	90

## LIST OF TABLES

Table 2.1 : Comparison among 3 standards of IEEE 802.11 protocols taken from Digi International Inc.	10
Table 2.2 : Various type of communication technologies between wireless and optical wireless.	27
Table 4.1 : Comparison of power(W) among signals by varying aperture diameter of transmitter and receiver.	54
Table 4.2 : Comparison among multiple modulation techniques.	91

## LIST OF SYMBOLS AND ABBREVIATIONS

AM	:	Amplitude modulation
BER	:	Bit error rate
IoT	:	Internet of things
IR	:	Infrared
LED	:	Light emitting diode
OFDM	:	Orthogonal frequency division multiplexing
OOK	:	On-off keying
OWC	:	Optical wireless communication
PAM	:	Pulse amplitude modulation
PPM	:	Pulse position modulation
PWM	:	Pulse width modulation
RF	:	Radio frequency
UV	:	Ultraviolet
VLC	:	Visible light communication

# CHAPTER 1

## INTRODUCTION

### 1.1 Project Background

In the past decades, the world's telecommunication technology has shown a dramatic improvement in both wired and wireless field. The increasing demand for high-speed internet has bombarded the market and lead to the need for further innovation, research and development in new emerging technologies which capable to deliver ultra-high data rates to the users. This rapid growth resulted in traffic congestion which can be seen clearly from wireless communication. The increasing demand has overflowed with the limited bandwidth and such situation arise in high-density areas such as airport and commercial office. In order to overcome this situation, visible light communication (VLC) is one of the preferred solutions due to its universality and performance [1].

VLC has many advantages over the other technologies such as infrared (IR) and ultraviolet (UV). Example of the advantages are radio frequency (RF) interference-free, no side effect to human health and has higher security [2]. All these advantages have pushed the development of VLC as an alternative choice to replace or work together with other wireless communication technologies.

This technology has been proposed a few years ago but facing some commercial problems due to the lack of reliable lighting source. This problem has seen to be solved after the use of light emitting diode (LED) become so common. LED has chosen to be the ideal light source due to its high flickering and longer life-time than the other conventional lighting devices such as fluorescent lamps and incandescent bulbs. LED used for illumination purpose are simultaneously used for wireless data transmission [3].

Data transmission rate is getting more vital when more people are demanding higher quality internet services. Visible light occupies the spectrum from 380nm to 750nm which corresponds to the frequency spectrum of 430THz to 790THz. The deficiency of bandwidth in RF communication can be solved by the VLC system because of its large bandwidth [5].

VLC can be a very good communication fabric for the Internet of Thing (IoT) with a LED enhanced with photodiodes. In this situation, the LED light source can act as both transmitter and receiver. This shows that VLC is a sustainable and green technology with the potential to revolutionize approaches to how we are going to use lights in the future [4].