MORSE CODE SECURITY SYSTEM VIA VISIBLE LIGHT COMMUNICATION USING MATLAB

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ABSTRACT

The wireless communication technology involves the transmission of information over a distance without the help of wires and the transmitted distances can be a few metres until hundred metres. Unfortunately, the major issue in wireless communication is the limited of radio frequency spectrum which cause the field of optical wireless communication has been rapidly developed during the recent years. The visible light communication (VLC) is an alternative solution to overcome the problem of wireless spectrum limitation. It was selected due to several characteristic such as large bandwidth than entire radio frequency. The VLC are also low power consumption, low cost and licence free operated. In this project the VLC system is used to send the numeric Morse code for the security system code. The project involves the development of the VLC transmitter unit and the receiver unit. The super bright white light emitting diodes (LEDs) are used to transmit the numeric Morse code using visible light as a transmitting medium. The receiver detected the dot, dash and space for the Morse code and represented by the three different LED colour. MATLAB coding has been implemented to translate the numeric Morse code as a security system and operates independently. Friendly MATLAB GUI has been developed by using MATLAB coding. The receiver unit translated the signal and been displayed at the GUI to ensure the system are working properly. The measurement of transmitter and receiver have been analysed between both circuits to see the performance of VLC system. Moreover, the analysis is done for various distance between transmitter and receiver to define the maximum operation distance. However, the maximum distance between the transmitter and receiver is limited to 12 cm. This VLC system can be an alternative technology that can be implemented in the existing security system.

ABSTRAK

Teknologi komunikasi tanpa wayar melibatkan penghantaran maklumat dari suatu jarak tanpa bantuan wayar dan jarak penghantaran adalah dari beberapa meter sehingga ratusan meter. Namun begitu, isu utama dalam komunikasi tanpa wayar adalah spektrum frekuensi radio yang terhad dan menyebabkan bidang komunikasi tanpa wayar optik telah berkembang pesat dalam beberapa tahun kebelakangan ini. Komunikasi cahaya tampak atau *Visible Light Communication (VLC)* ialah satu penyelesaian alternatif bagi masalah had spektrum tanpa wayar. Ianya dipilih kerana terdapat beberapa ciri-ciri penting seperti jalur lebar yang besar daripada keseluruhan frekuensi radio. Di samping itu, VLC juga mempunyai penggunaan kuasa dan kos yang rendah dan tidak perlu lesen untuk mengendalikannya. Dalam projek ini sistem VLC digunakan untuk menghantar kod Morse berangka bagi kod sistem keselamatan. Projek ini melibatkan pembangunan unit pemancar VLC dan unit penerima. Diod pemancar cahaya putih (LED) yang sangat terang digunakan untuk menghantar kod Morse berangka menggunakan cahaya yang boleh dilihat sebagai medium penghantaran. Penerima mengesan 'dot', 'dash' dan 'space' untuk kod Morse yang diwakili oleh LED berlainan warna. Pengekodan MATLAB telah dilaksanakan untuk menterjemahkan kod Morse berangka sebagai satu sistem keselamatan dan beroperasi sendiri. MATLAB GUI mesra pengguna telah dibina dengan menggunakan pengekodan MATLAB. Unit penerima menterjemahkan isyarat yang diterima dan mempamerkan di GUI untuk memastikan sistem beroperasi dengan betul. Pengukuran litar pemancar dan penerima telah dianalisis untuk melihat prestasi sistem VLC. Selain daripada itu, analisis dilakukan untuk pelbagai jarak antara pemancar dan penerima untuk menentukan jarak maksimum pengoperasian. Namun begitu, jarak maksimum antara pemancar dan penerima adalah terhad kepada 12 cm. Sistem VLC ini boleh menjadi satu teknologi alternatif yang boleh dilaksanakan dalam sistem keselamatan yang sedia ada.

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LIST OF ABBREVIATIONS

VLC	-	Visible Light Communication
IR	-	Infrared
RF	-	Radio Frequency
cm	-	Centimeter
km	-	Kilometer
nm	-	Nanometer
THz	-	Tera Hertz
GHZ	-	Giga Hertz
LED	-	Light Emmiting Diode
LDR	-	Light Depending Resistor
V	-	Volt
A	-	Ampere
mW	-	Miliwatt
Db	-	Desibel

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CHAPTER 1

INTRODUCTION

This chapter introduced an overview of the Morse code security system via visible light communication by using MATLAB. The project background, aim, objectives, scope of the project and the structure of thesis are explained in this chapter.

1.1 Project Background

Wireless communications is the fastest growing segment of the communications technology from satellite transmission, radio, and television broadcasting to the mobile telephone, wireless communication has revolutionized the way societies function [1]. The wireless communication system availability is one of the communication technology that have high demand has also increasing as well as reduced device cost and size which would make it more portable and user friendly.

The benefit of this technology that can provide users to connect a wide range of computing and telecommunication devices easily and simply without has to purchase and connect any cables. There are various types of technologies or standards such as IrDA, Bluetooth, Radio Frequency (RF) and IEEE 802.11. All of these technologies compete in certain section and depend on the application context.

However, due to the limited unlicensed bandwidth and increasing traffic radio spectrum is becoming increasingly congested [2].

On the other hand, optical wireless communication provides a cost-effective, flexible solution to the emerging challenges that system and service providers are facing [3]. Flashes of light have been used to transmit information for centuries. In 1880, Alexander Graham Bell demonstrated an invention called photophone, which used light waves to transmit voice information. Transmitting modern computer or network data using light follows the same principle because it used binary code which it is easy to transmit information with light [4].

Visible light communications (VLC) is a wireless communication system which conveys information by modulating light that is visible to the human eye. The VLC has grown rapidly with the growth of visible-light, light emitting diodes (LEDs) for illumination. In achieving visible light communication is to switch the LED lighting on and off at a speed higher than is perceptible to the human eye. A photodiode has ability to recognize the rapid on-off modulation. This simple principle makes possible visible light communication technology that supports both illumination and wireless communication using LED [5].

The VLC is the idea of using LEDs where the dual functionality offered by visible light devices has created a whole range of interesting applications including home networking, car to car communication, high speed communication in airplane cabin and others. The system performance analysis and simulations has been carried out using the MATLAB [6].

1.2 Problem Statement

There is various type of security system available in the market. The devices in the market are expensive and have a complicated operation system. Today's technology has brought some changers in the security system development. One of the technologies used for security system is the wireless communication system. However the wireless communication suffers from many restrictions due to the inherent limitations of the wireless media and existing wireless communication protocols.

The visible light communication (VLC) is also one of the wireless communication technologies that uses light which visible to humans. The VLC has a few advantages over other standard wireless transmission such as larger visible light spectrum which ranges from 428 THz to 750 THz. This spectrum range is the vast potential of unused and unregulated which it can improves the channel utilization.

The aim of this project is to develop a new security system using the Morse code transmitted by the white light emitting diode (LED) using the visible light communication. At the receiver part, the Morse code signal that has been received is translated by using the MATLAB software coding.

1.3 Objectives

The objectives of this project are:

a) To design and develop a security system sending numeric Morse code via the VLC system.
b) To translate and analyse the numeric Morse code signal by using MATLAB against voltage, current, power, loss and distance.

1.4 Scope of the project

The project involves the implementation of hardware and software. The hardware part concentrates on the transmitter and receiver circuit for Morse code signal transmission process via VLC. The software implementation involves the MATLAB programming for the process of translating the Morse code signal. The limitation of this project, only the numeric Morse code signals has been translated.

1.5 Significant of the project

The significant of the project is for developing new application of Visible Light Communication in security system. The project based on the Morse code signal has been sent by white LED and received at the receiver. The received signal was sent to the MATLAB Graphical User Interface (GUI) and has been translated and displayed the numeric code. There is no combination password or any physical keypad that makes this system more secure. Other than that the knowledge of VLC technology and MATLAB programming has been improved after doing this project.

1.6 Thesis Structure

This thesis is about implementation of Morse code signal transmission system via VLC with the used of MATLAB in Morse code translation process. The thesis is divided into five chapters and organized as follows. Chapter 1 discussed a brief introduction of the research including project background, problem statements objectives, scope of the project, significant of the project and thesis structure.

Chapter 2 presented the literature of the project consist type of wireless communication technology, introduction of VLC communication and current VLC project review. This chapter discussed all the description of system and identification in general which related to the project.

Chapter 3 treated the methodology of this project. It consists of system planning, system design, system implementation and system operation. This chapter contain of the implemented project circuits and has been followed ‘Projek Sarjana’ (PS) activities.

Chapter 4 contains the result and analysis for the overall project. The analysis is based on parameters which have been designed, measurements of VLC transmitter and receiver circuits. The calculation, the waveform for each circuit has been developed and the maximum distance for the system has been measured.

Finally, Chapter 5 includes the conclusion and summary of the project. There are also several recommendations for improvement in developing a better VLC Morse code system in the future.

CHAPTER 2

LITERATURE REVIEW

This chapter will explain the previous project based on journals that were related to the implementation of this project.

2.1 Wireless Communication Technology

The wireless communication technology or simply called wireless affects almost every aspect of our routine life and continue to expand. Wireless communication is to transfer information over a distance without the use of electrical conductors or wires. The distance involved may be short from a few meters as in television remote control until hundred metres for radio communication. The distances involved may be short from a few meters as in television remote control until thousands or millions of kilometres long for radio communications

In the last few years, wireless communication system availability is also increasing as well as reduced device cost and size which would make it more portable and user friendly. The term wireless is often describing any types of device or technology that can communicate without using any wire connection as the transmission medium [7].

2.1.1 Infrared (IR)

IR wireless is one of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The infrared light has the same characteristic as the visible light because it is side by side to visible light on the light spectrum. Figure 2.1 shows the IR wavelength spectrum has a very wide range from 0.78 μm to 1 mm and it is divided as near infrared, mid infrared and far infrared. Near infrared is closest in wavelength to visible light and far infrared is closer to the microwave region of the electromagnetic spectrum.

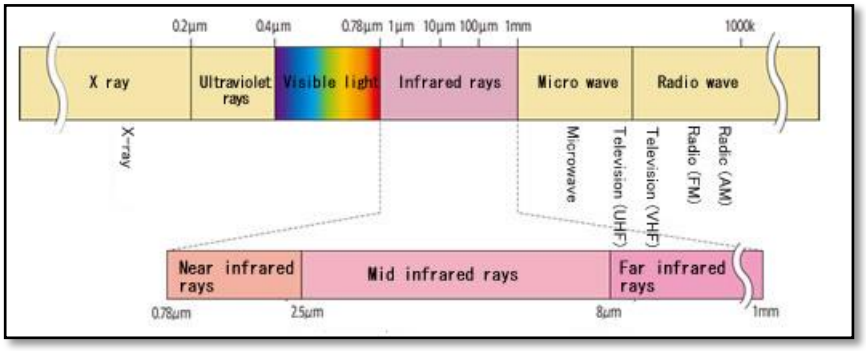

Figure 2.1: IR wavelength spectrum.

Infrared is less susceptible to interference from other source of visible light that makes it much better medium for data transmission for short range transmission. The transmission system required two components which are the emitter and the detector. The emitter is to transmit the signal and the detector function to receive the signal. The two types of transmission for infrared transmission is directed that need the line-of sight or diffusion use the reflection technique [8]. Figure 2.2 shows the direct transmission of infrared between two personal computers (PC). One PC consists of emitter for transmitting signal and the other PC has detector to receive the signal. This system operates in light of sight mode meaning that there must be visually unobstructed straight line through space between the emitter and detector.

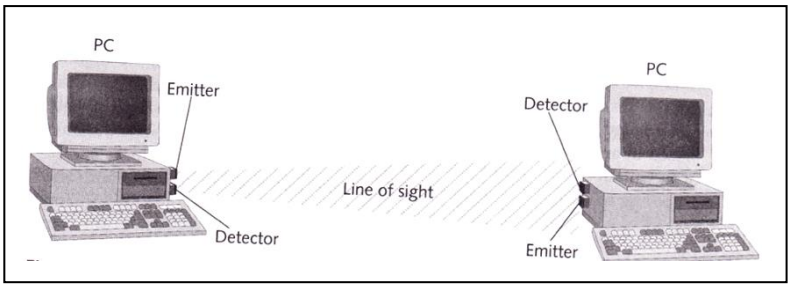

Figure 2.2: Direct transmission using infrared between two PC.

2.1.2 Bluetooth

Bluetooth is a wireless standard where the Bluetooth device communicates by using radio modules or transceiver and then being encoded onto microprocessor chips. Bluetooth wireless technology is a short-range communications technology intended to replace the cables connecting portable or fixed devices while maintaining high levels of security. The key features of Bluetooth technology are robustness, low power, and low cost.

The Bluetooth specification defines a uniform structure for a wide range of devices to connect and communicate with each other. Figure 2.3 shows the functional component of Bluetooth system. It consists of an antenna, a radio unit, a link control unit, a support unit for link management and host terminal interface. All these components are needed as the functional component to complete Bluetooth system unit. The frequency for Bluetooth system is 2.4 GHz that works within 10 meters [9].

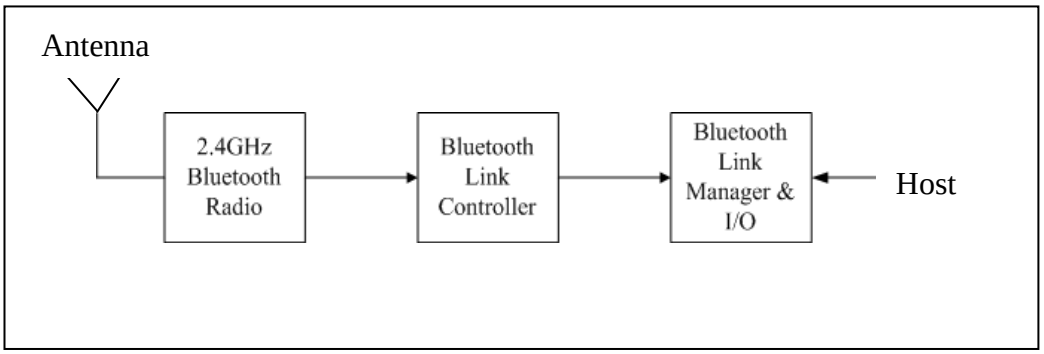

Figure 2.3: The functional component of Bluetooth.

2.1.3 Radio Frequency (RF)

Radio frequency (RF) communication is the most common type of wireless technology. RF communication has less limitation and can travel at long distance and not impeded by any surrounding object or obstacle. It is more flexible and does not require line-of-sight communication.

RF technology can be categorized as narrowband and spread spectrum. Narrowband includes microwave transmission which uses high frequency radio waves can operates in the maximum distance of 50 km [10]. The RF system consists of RF transmitter and RF receiver that must be operated on the same frequency to be functioned. Figure 2.4 shows the example of RF in remote control system. A four channel encoder and decoder are used in this system. The input signals at the transmitter side are taken through four buttons while the outputs are monitored by LEDs corresponding to each input button. An antenna is needed at both transmitter and receiver units. It is used to send signal from RF transmitter and to receive the signal at the RF receiver.

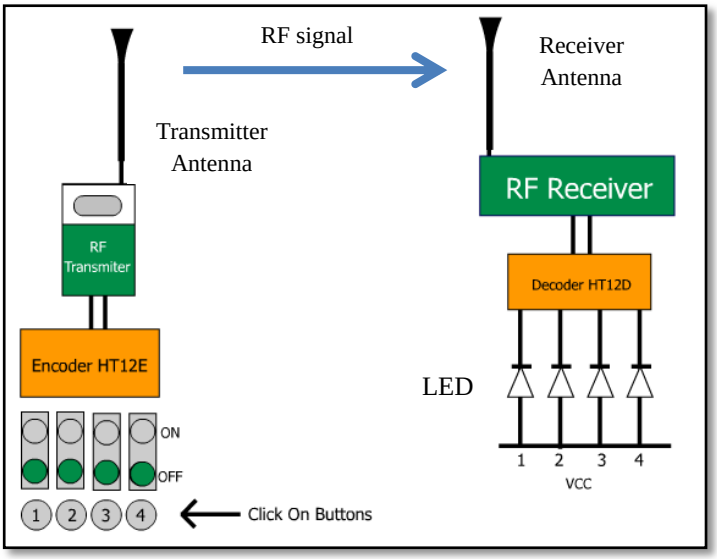

Figure 2.4: The component of RF in remote control system.

2.2 Introduction of Visible Light Communication (VLC)

Visible light communication (VLC) is a new field of optical wireless communication using visible light. This system carries information by modulating light in the visible spectrum of 400 nm to 700 nm that is principally used for illumination. The communication signal is encoded on top of the illumination light. The VLC has grown rapidly with the growth of visible-light light emitting diodes (LEDs) for illumination. In achieving visible light communication is to switch the LED lighting on and off at a speed higher than is perceptible to the human eye [11].

Typical transmitters used for visible light communication are visible light LEDs and receivers are photodiodes. A photodiode has ability to recognize the rapid on-off modulation. White LEDs have recently been used as efficient light sources replacing incandescent light bulbs and fluorescent lamps. An LED light is used as a data transmitter for the visible light communication. This simple principle makes possible visible light communication technology that supports both illumination and wireless communication system.

The motivation to use the illumination light for communication system is to save energy by exploiting the illumination to carry information and at the same time use the technology that is green that eliminates most drawbacks of transmission via electromagnetic waves in comparison of radio frequency (RF) [11].

2.2.1 Visible Light Spectrum

Visible light or the visible spectrum is the portion of the electromagnetic spectrum that can be detected by the human eye. Electromagnetic radiation in this range of wavelength is referred as light. A typical human eye will respond to wavelengths from 390 to 750 nm [12]. Visible light is produced by vibrations and rotations of atoms and molecules as well as by electronic transitions within atoms and molecules. The colours that can be produced by visible light of a narrow band of wavelengths or monochromatic light are called pure spectral colours.

Visible spectrum is a small part of the electromagnetic spectrum that includes its visible components. Figure 2.5 shows the electromagnetic spectrum with the colours associated with the particular pure wavelengths. The division is between infrared and ultraviolet. Red light has the lowest frequencies and longest wavelength meanwhile violet has the highest frequencies and shortest wavelengths.

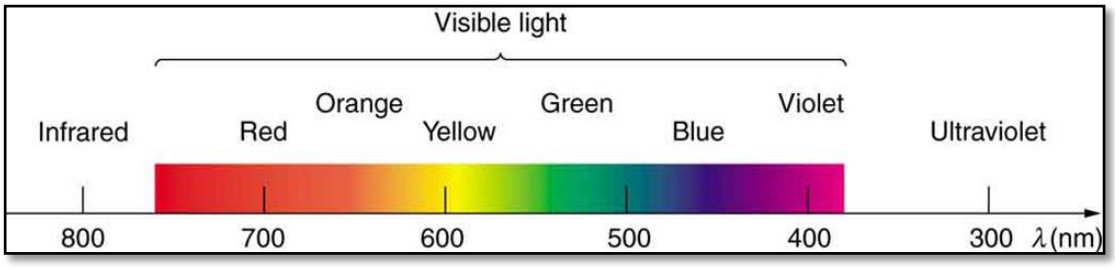

Figure 2.5: The visible light spectrum.

2.2.2 VLC Properties

Visible light communication has properties where the communication distance using visible light communication is typically between 1 to 50 meters. This distance is short due to the fact that visible light communication is basically line-of-sight communication. It means that communication is interrupted when there is an object between a transmitter and a receiver. Its data rate is typically between kilobits per second to 10 megabits per second. It is caused by the performance of either white LEDs or receiving photo sensors. The disadvantageous properties of visible light communication may limit the use of this system for many other applications [13].

2.3 Morse Code

Morse code is a method of transmitting string information into a series of dots and dash encrypting a message between two entities and so making communication possible between two parties. It is also known as a series of on-off tones, lights, or clicks that can be directly understood by a skilled listener or observer without special

equipment. Figure 2.6 shows the international Morse code for letters and numbers [14]. Each character (letter or numeral) is represented by a unique sequence of dots and dashes. For example to produce the numeric number one we need to send ‘dot’, ‘dash’, ‘dash’, ‘dash’ and ‘dash’.

A ·–	J ·–––	S ···	1 ·———–
B –···	K –·–	T –	2 ··–––
C –·–·	L ·–··	U ··–	3 ···––
D –··	M ––	V ···–	4 ····–
E ·	N –·	W ·––	5 ·····
F ··–·	O –––	X –··–	6 –····
G ––·	P ·––·	Y –·––	7 ––···
H ····	Q ––·–	Z ––··	8 –––··
I ··	R ·–·	0 –––––	9 ––––·

Figure 2.6: The international Morse code

2.4 Current VLC Project

This topic discussed about the current VLC project that have been produced in the market and the technologies used. The function and the operation system of the equipment will also be stated for deeper understanding about VLC.

2.4.1 Indoor Navigation System for the Visually Impaired using Visible Light Communication and Compensated Geomagnetic Sensing

The paper with title ‘Indoor Navigation System for the Visually Impaired using Visible Light Communication and Geomagnetic Sensing was written by Madoka Nakajima and Shiniciro Haruyama in year 2013.

This paper showed an indoor navigation system that utilizes visible light communication technology which employs LED lights and geomagnetic correction

method. The aim of this project is to support visually impaired person travelling indoors. They design the indoor navigation system combining three methods of positioning VLC, creation of indoor map data and compensated geomagnetic sensing.

As shown in Figure 2.7, the system is composed of LED lights, a smartphone with integrated receiver and headphones. The indoor navigation system is obtained by using positional information base (LBS platform). The visible light LED is sent from the LED light using VLC and received by the receiver. The smartphones obtains the visible light ID from receiver via Bluetooth with the positional information. The positional information base through Wi-Fi and the guidance content are synthesized in previously recoded audio file and sent to the headphones.

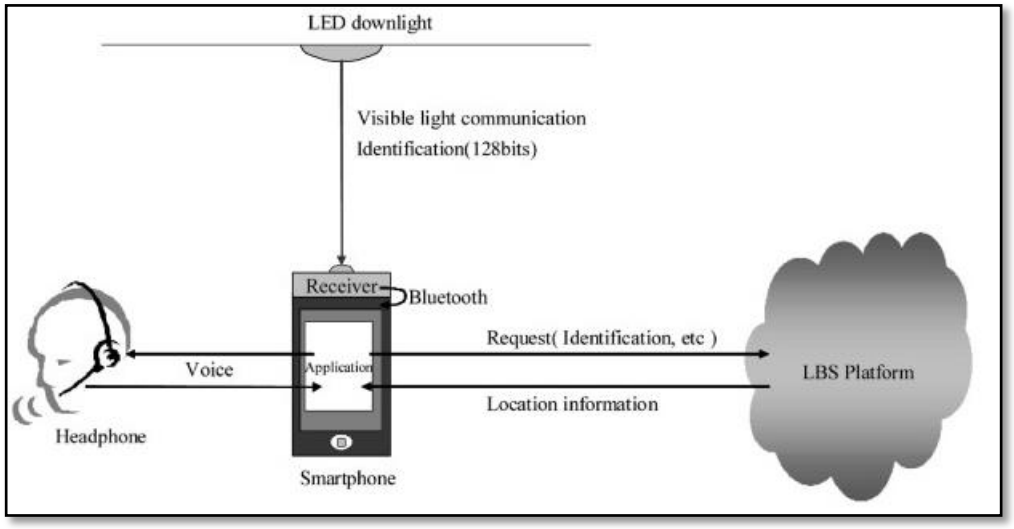

Figure 2.7: Indoor Navigation System for the Visually Impaired using VLC

The result of this project is the distance to the destination was found correctly but not the direction of movement where the guidance should synchronize with the walking speed of the impaired person. In conclusion, they conclude that this system is effectual system for visually impaired person with the guidance of positional information and travel direction [15].

2.4.2 Visible Light Communication using Mouse Sensor

The paper with title ‘Visible Light Communication using Mouse Sensor was written by Chung Lin Chan, Jing Yeu Chen and Hsin Mu Tsai in year 2014.

This paper is about VLC system that utilizes a low resolution LED panel as the transmitter and an image sensor with the use of a computer mouse as the receiver. The aim of this project is to encode the digital information to be transmitted in the form of a series of fast moving patterns presented on the LED panel, and the receiver can reconstruct the transmitted data from the output of the mouse sensor for achieving a higher data rate.

As shown in Figure 2.8, are the components of mouse VLC design. It consists of transmitting and receiving laptop connected with UART. At the transmitting side the laptop is connected with LED panel and with mouse sensor for both laptops. In their system, instead of capturing the appearance of the surface under the mouse, with the help of a proper lens, the mouse sensor captures images of a transmitting LED panel. The digital information is encoded into the movements of the patterns displayed on the LED panel, and these movements of the mouse sensor that is from a moving surface under the mouse.

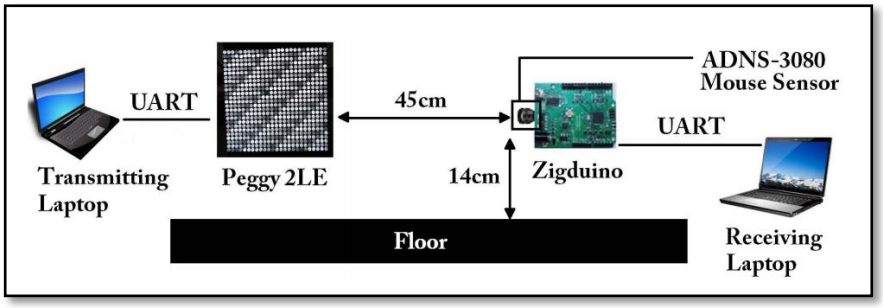

Figure 2.8: The mouse VLC system.

The result of this project, they utilize an ordinary mouse sensor as the receiver. The transmitter uses moving patterns shown on a LED array to represent digital information, and the receiver can reconstruct the transmitted digital information from the output of the mouse sensor. They also manage to achieve a data rate of 74 bit/s with a byte error rate at 0.1%. [16].

2.4.3 New Position Detection Method using Image Sensor and Visible Light LEDs

The paper with title 'New Position Detection Method using Image Sensor and Visible Light LEDs was written by Toshiya Tanaka and Shiniciro Haruyama in year 2009.

This paper is about using an image sensor and visible light LEDs as a new positioning method. The colour LEDs are used to detect position. This system used visible light sources such as visible light LED illumination which is indispensable for indoors. An image sensor and an accelerometer are used to estimate the position of a receiver. Figure 2.9 shows the new position detection component. The position detector system finds three colours light following red, green and blue. An image is taken by the image sensor to define colours then it is converted from red, green and blue (RGB) to hue saturation lightness (HSV). This is done to obtain value image and threshold by the most lightness or not because the LEDs are very bright and the most lightness area can be light. The acceleration sensor measured the error margin accuracy in the position detector.

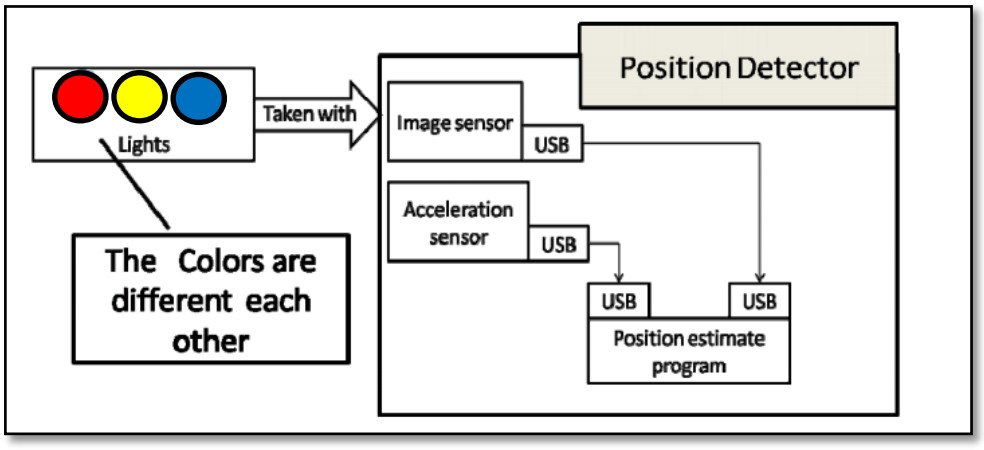

Figure 2.9: The Position Detection Method components

In the result, they manage to achieve position accuracy of less than 5 cm using the purpose method. They applied it to a robot and demonstrated that accurate position control of a robot was feasible [17].

CHAPTER 3

METHODOLOGY

This chapter discussed the methods that have been used in this project. This project consists of two important parts which are the hardware and MATLAB programming coding development. In hardware development the LED driver circuit and photodetector circuit were constructed. MATLAB programming was used to translate the received Morse code. All the project implementation flow has been shown starting with PS activities and the overall system operation of this project.

3.1 System Planning

The system planning consists of hardware and programming development for this VLC project. The first part was hardware development of the LED driver circuit as VLC as transmitter and then photodetector circuit as the receiver. The second part was code development which MATLAB were used for translating and display the numeric Morse code signal. Figure 3.1 showed the system overview of this project. Button at the transmitter circuit was used to send the Morse code signal by controlling on and off the lights in the LED driver circuit. Then, the photodetector circuit detected these signal. The signal then been processed at the personal computer (PC) and translated to numeric code by MATLAB coding developed in the PC.

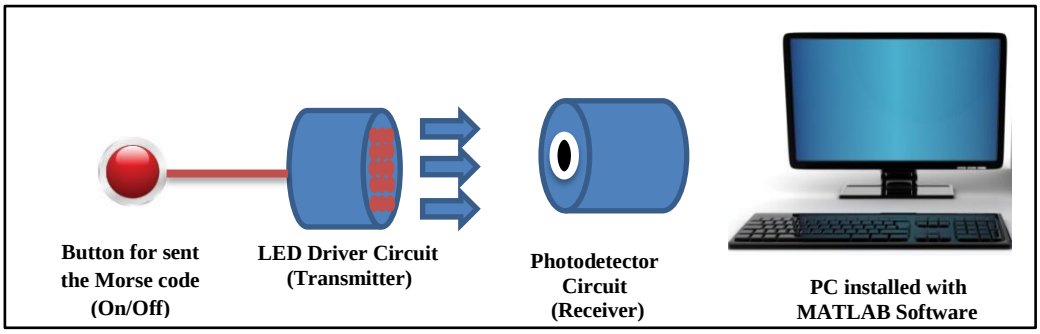

Figure 3.1: The system overview of this project.

In the *Projek Sarjana 1* (PS1) it is consist of the system planning and system design. Figure 3.2 is a flowchart of PS1. This part was focused on the hardware design and development of the transmitter and receiver circuit. The LED driver circuit were used as transmitter and the photodetector circuit as the receiver. Next, the chosen circuit design was routed in the printed circuit board (PCB). Then the next process of B is done in *Projek Sarjana 2* (PS2).

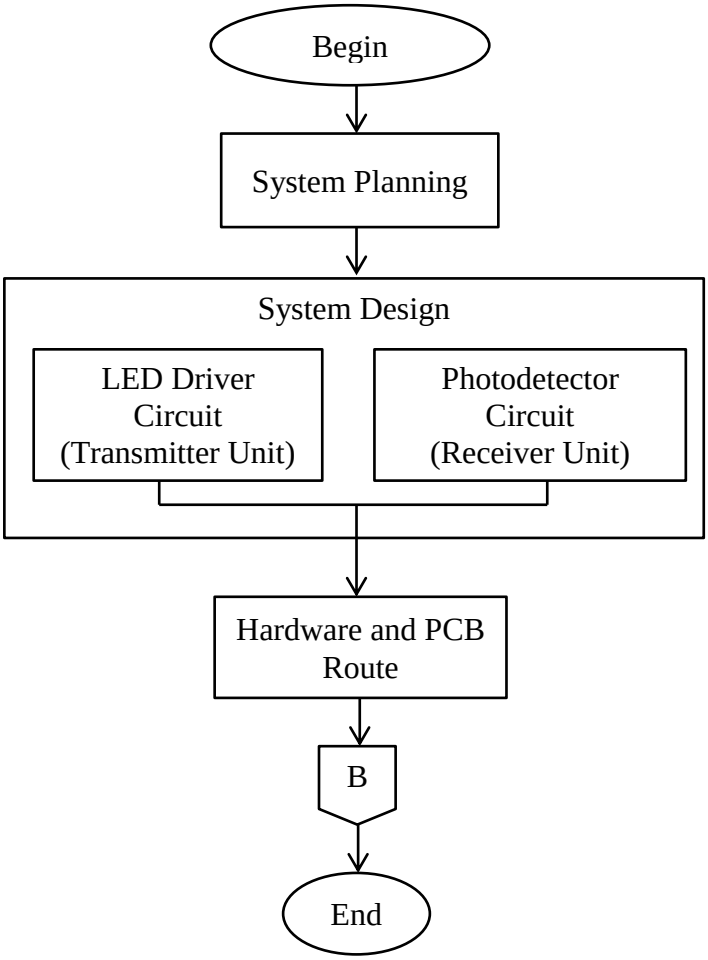

Figure 3.2: Flowchart of PS1.

In the PS2 it consists of software development and system implementation. The flowchart of PS2 was shown in Figure 3.3. This part software development was focused on the MATLAB programming and interface. When the MATLAB programming and interface is finished, the system was tested to translate the received Morse code. When the system is successfully working, the Morse code signal was translated correctly. The system debug is needed when the translation process was failed.

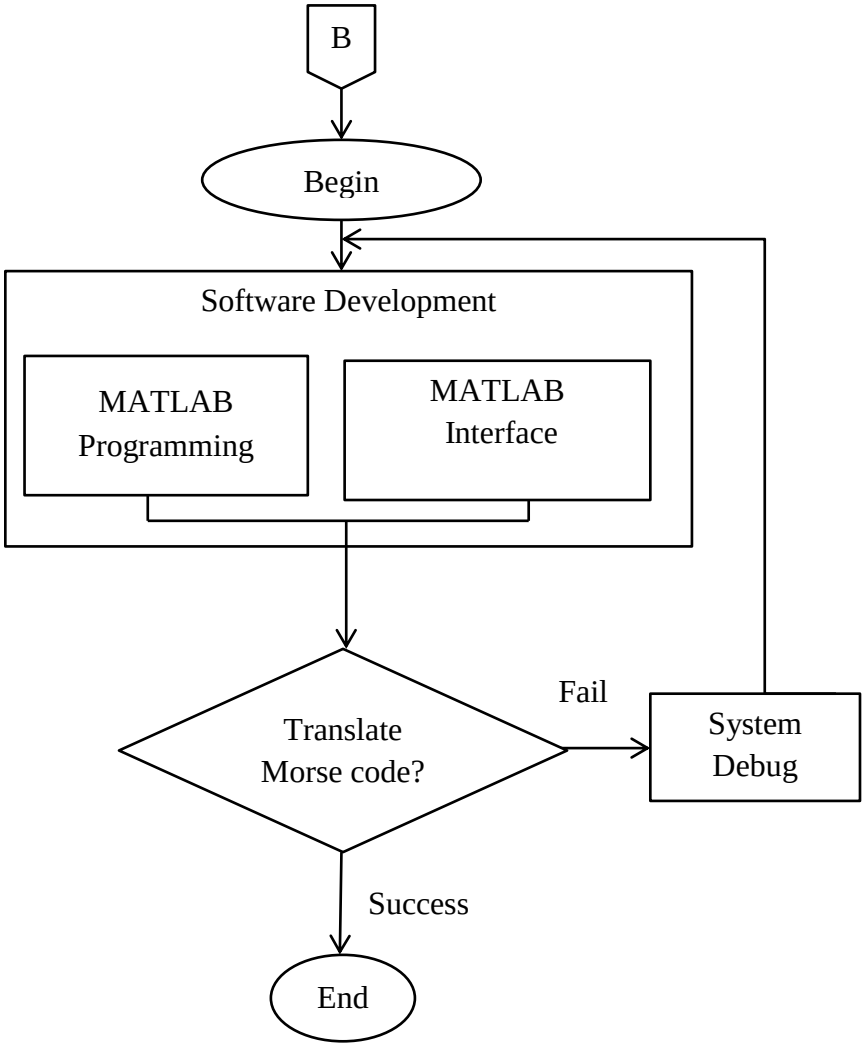

Figure 3.3: Flowchart of PS2

3.2 System Design

This subtopic discussed the designed circuit that has been used in this project. The system design is divided into transmitter section and receiver section. Figure 3.4 shows the block diagram of the component used the Morse Code Security System via VLC by using MATLAB. The transmitter and a receiver have been designed for the VLC system. The transmitter section consists of LED driver circuit for sending Morse code signal. At the receiver section were include the photodetector circuit as receiver and the MATLAB software. The receiver function is to detect the Morse code signal. Then, the signal was translated and displayed in numeric code by MATLAB software.

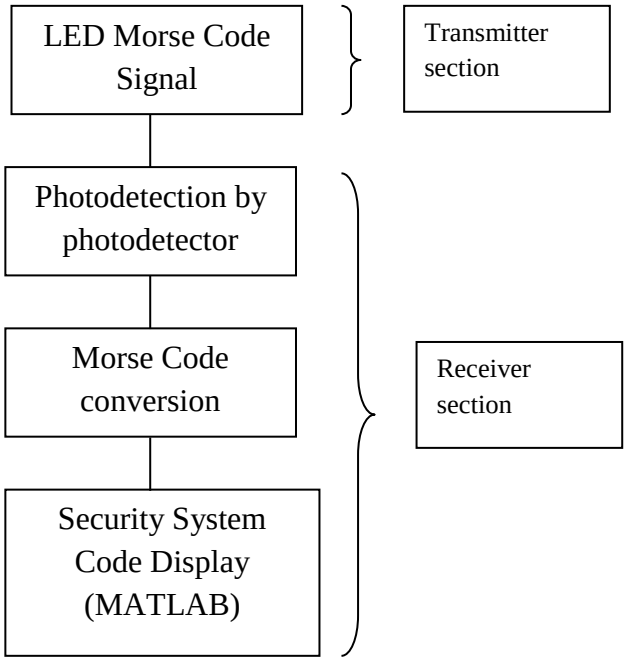

Figure 3.4: Block diagram of the component in this project

3.2.1 Transmitter Unit

The transmitter unit used white LED driver circuit to transmit the Morse code signal using visible light communication concept. This circuit consist of 15 super bright white led connected to the 9 V battery as the power supply. It has five rows of LED which each row have three LED parallel connected with 90 ohm resistors. The process of sending and controlling the Morse code signal is done by switching the lights on and off using the push button. Figure 3.5 shows the white LED driver schematic circuit.

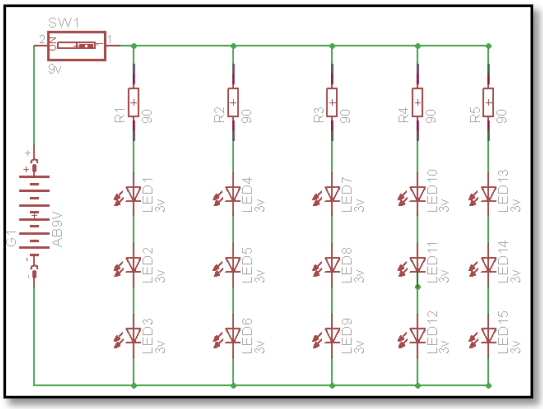

Figure 3.5: White LED driver schematic circuit

When the schematic circuit design has no errors the process of routing the electronics components has been done by converting schematic to the board. Figure 3.6 shows the components layout on PCB board for white LED driver circuit.

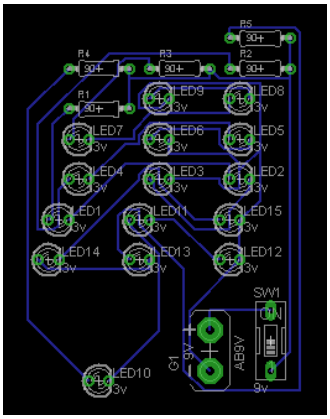

Figure 3.6: White LED PCB layout

3.2.2 Receiver Unit

The receiver unit has three LDR sensor and each parts represent a different signal for the Morse code. The receiver functioned to receive the VLC signal from the white LED driver circuit. The receiver circuit has been connected with PIC 16F877A to analyse and provide 3 different outputs. The output signal represented by using three colours LED and connected to PC input. The green LED represents the dash, yellow LED represents the dot and the red LED represents the space between dot and dash.

The photodetector circuit operated voltage is 5 V. The voltage regulator used is LM7805 which provided voltage output of 5 V. A voltage regulator has been used to convert the voltage into other voltage levels and regulate the voltage from any value to the fixed-voltage output 5 V. It has three output pin which represent the unregulated voltage, ground and the regulated voltage.

The schematic of photodetector circuit is shown in Figure 3.7 consists of the LDR1, LDR2 and LDR 3 as the sensor that detected transmitted signal. Each LDR circuit has relay to control the circuit by opening and closing contacts with the PIC circuit. The output from the PIC circuit is presented by the green LED (D1), yellow LED (D2) and red LED (D3). This output is also connected to the serial port PC input.

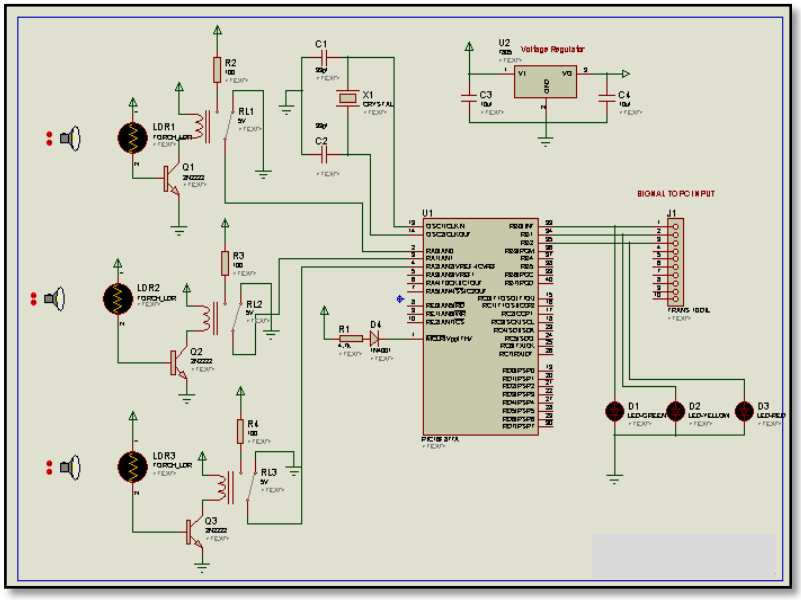

Figure 3.7: The schematic of photodetector circuit.

When the schematic circuit design has no errors the process of routing the electronics components have been done by converting schematic to the board. Figure 3.8 shows the components layout on PCB LDR sensor circuit board and PIC 16F877A in Figure 3.9

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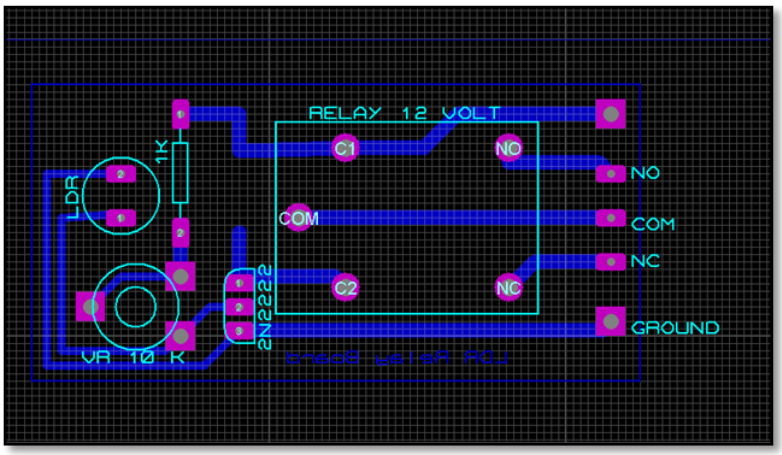

Figure 3.8: LDR PCB layout

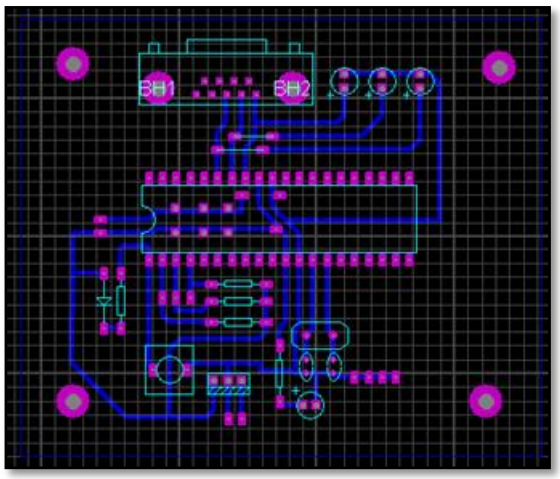

Figure 3.9: PIC PCB layout.

3.2.3 MATLAB software

MATLAB software is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include math and computation, algorithm development

modelling, simulation and prototyping, data analysis, exploration and visualization scientific, engineering graphics and application development including graphical user interface building [18].

In this project MATLAB for graphical user interface (GUI) has been built for displayed the translation of the numeric Morse code signal received as shown in Figure 3.10. The MATLAB GUI has been built with buttons, menus, text boxes, axes and other more. Based on the figure, it shows that the MATLAB GUI is consists of three main sections. The first section display Morse code signal then the translation section for numeric Morse code. The last section was the verification of the Morse code detected for the security system.

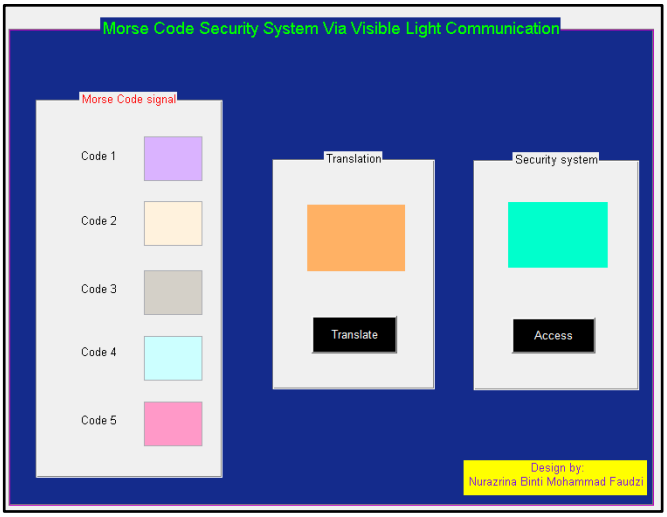

Figure 3.10: MATLAB GUI.

3.3 System Implementation

In this part of system implementation all the circuit discussed in the system design has been developed. This process involved the development of LED driver circuit, photodetector circuit and the MATLAB GUI. Figure 3.11 shows the system overview of this project. This implemented circuit is done by referring to the flowchart that has been shown in Figure 3.2 and Figure 3.3.

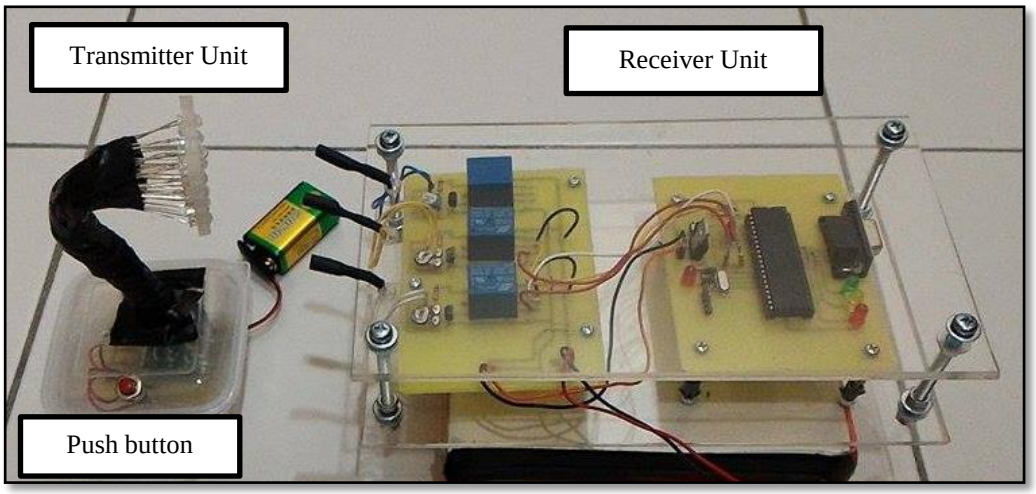

Figure 3.11: The system overview of Morse code security system via VLC.

Based on Figure 3.11, the first circuit that has been developed is the transmitter unit. In order to transmit the Morse code signal, the intensity of the light emitted from white LED has been built using 15 super bright LED. The photodetector circuit consist of three LDR sensors and a microcontroller. These sensors had differentiated the dot, dash and space in the Morse code. The signal was send to PIC 16F877A and the output signal represented by using three colours LED. The green LED represents the dash, yellow LED represents the dot and the red LED represents the space between dot and dash. This circuit is powered by using adapter 12 V. The overall input and output of the photodetector circuit is shown in Figure 3.12. Table 3.1 shows the photodetector input and output circuit with represented Morse code of 'space', 'dash' and 'dot' that has been summarized.

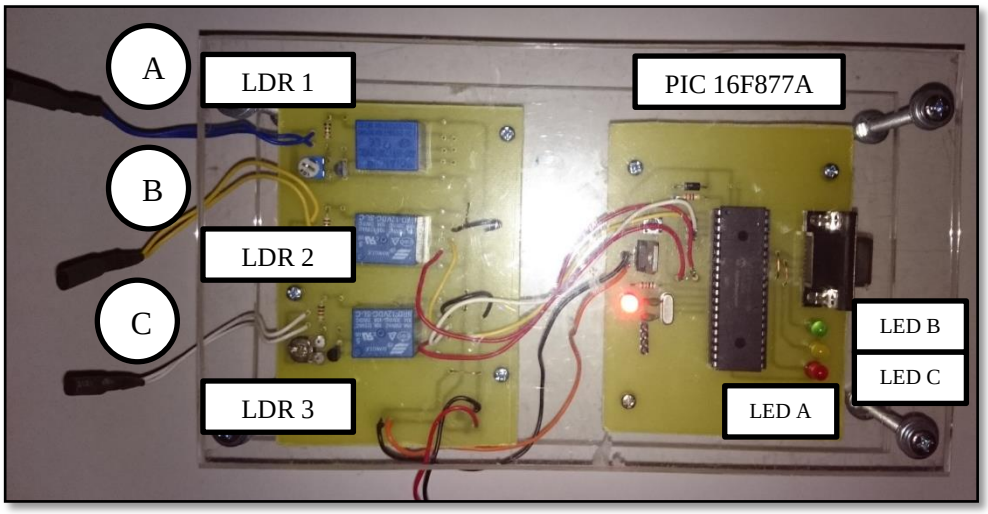

Figure 3.12: The photodetector circuit.

REFERENCES

[1] Andrea Goldsmith. *Wireless Communication.* Cambridge University Press. 2015.

[2] T. L. Singal. *Wireless Communications.* Tata McGraw Hill Education Private Limited. New Delhi. 2010

[3] Z. Ghassemlooy. *Indoor optical wireless communication systems and networks*. John Wiley & Sons, Ltd. 2005

[4] Jorge Olenewa. *Guide To Wireless Communications*. Boston MA. 2014.

[5] Shlomi Arnon, John R.Barry, George K. Karagiannidis, Robert Schober, Mural Uysa. *Advanced Optical Wireless Communication System.* Cambridge University Press. 2012.

[6] Z. Ghassemlooy, W. Popoola, S. Rajbhandari. *Optical Wireless Communications: System and Channel Modelling with MATLAB.* CRC Press. 2012

[7] Farid Dowla. *Handbook Of RF & Wireless Technologies*. USA : Elservier. 2004

[8] Jorge Olenewa and Mark Ciampa. *Wireless# Guide to Wireless Communications*. 2nd. Ed. United States : Thomson Course Technology. 2007

[9] Gary S. Rogers and John Edwards. *An Introduction to Wireless Technology*. New Jersey : Prentice Hall. 2003

[10] Theodore B. Zahariadis. *Home Networking Technologies And Standards.* Norwood, MA. Artech House INC. 2003

[11] Elaine R.S. Hodges. *The Guild Handbook of Scientific Illustration.* Canada. John Wiley & Sons Inc. 2003

[12] Shlomi Arnon. *Visible Light Communication.* United Kigdom. Cambridge University Press. 2015

[13] Cheng Chung Lee. *The Current Trens of Optics and Photonics*. Taiwan. Springer. 2014

[14] *International Morse Code Recommendation ITU-R M 16-77-1*. International Telecommunication Union. October 2009. retrieved December 2011.

[15] M Nakajima, S Haruyama. Proc. IEEE International Conference Communication China (ICCC 2012). *Indoor Navigation System For Visually Impaired People Using Visible Light Communication And Compensated Geomagnetic Sensing*. pp. 524 – 529. 2012

[16] Chung-Lin Chan, Jing-Yeu Chen, Hsin-Mu Tsai. *IEEE International Conference on Internet of Things,Green Computing and Communications and Cyber-Physical-Social* Computing. pp. 328 – 331. 2014

[17] Toshiya Tanaka, Shinichro Haruyama. Second International Conference on Machine Vision (ICMV). *New Position Detection Method Using Image Sensor And Visible Light Leds*. pp. 150 – 153. 2009

[18] Raj Kumar Bansal, Ashok Kumar Goe, Manoj Kumar Sharma. *MATLAB and Its Applications in Engineering*. India. Pearson Education. 2015