DESIGN A SYSTEM TO TRANSFER ALTEMATING CURRENT IN OPTICAL FIBER USING A LIGHT-EMITING-DIODE

Student
Fadhel Abbas Feddal
Abdulkareem Kadhim Ali
Qassim Yahya Qassim

loe.18.022@student.uotechnology.edu.iq
loe.18.028@student.uotechnology.edu.iq
loe.18.003@student.uotechnology.edu.iq

Abstract. This project aims to design, test, and measure a three phase alternating current circuit to transmit optical signal through a 10m plastic optical fiber. Three light emitting diodes (LEDs) were used with wavelengths: 450nm, 540nm, and 630nm based on direct modulation. At each stage, the power level was measured at each phase wavelengths before and after the modulation process. The output power of each phase and wavelength was measured using optical power meter. Further, different parameters were to examine the circuit such as the voltage difference of the alternating current.

INTRODUCTION

1. Overview

Laser power transmission (LPT) is one of the most promising technologies in the long-range wireless power transfer field. LPT research has been driven by the desire to remotely power unmanned aerial vehicles (UAVs), satellites, and other mobile electric facilities. However, the low overall efficiency is the main issue that limits the implement of a high-intensity laser power beam (HILPB) system. As seen from the contemporary understanding of the efficiency of laser power transmission channels, the efficiencies of laser and (PV) array are the main limiting factors to the HILPB system from the perspective of power conversion. Thus, a comprehensive overview of LPT technology is presented from the point of efficiency optimization view in this paper. First, the basic principles of laser power transmission are briefly summarized. Then, a survey of the efficiency optimization methods for the HILPB system with regard to the laser and PV technologies is provided in detail. Additionally, the open issues and challenges in implementing the LPT technology are discussed [1].
WIRELESS power transfer (WPT) is the technology that electrical energy is transmitted from a power source to an electrical load without any electrical or physical connections. Compared to traditional power transfer with a cord, wireless power transfer introduces many benefits such as better operational flexibility, user-friendliness, and product durability. Therefore, WPT technology is ideal in applications where conventional conduction wires are prohibitively inconvenient, expensive, hazardous, or impossible [1]. Nowadays, WPT technology is attracting more and more attention and evolving from theories toward commercial products, from low-power smartphones to high-power electric vehicles, and the wireless-powered products will come to a 15 billion market by 2020 . The development of WPT technology is advancing toward two major directions, i.e., near-field techniques, which have a typical transmission distance from a few millimeters to a few meters, and far-field techniques, where the coverage is greater or equal to a typical personal area network [2].
The former consists of two techniques: capacitive power transfer (CPT), and inductive power transfer (IPT) , while the latter can be further sorted into microwave power transfer (MPT) and laser power transfer LPT [3]. The key advantages of CPT are high power transfer up to several kilowatts, Transfer power through metal objects without generating significant eddy currents losses, Use metal plates to transfer power to reduce cost, are Suitable for small size applications, and can be used in large size applications such as EV. The potential disadvantages of CPT are

limited efficiency at the range of 70%-80% but it can reach 90%in some applications, Short transmission distance which is usually within the hundred of mm range, The challenge comes from the conflict among the transfer distance and power as well as the capacitance value. The advantages of IPT are High efficiency which is higher than 90% is possible, High power transfer of up to several kilowatts, Good galvanic isolation, Suitable for applications from low-power smartphones to high-power EV. The potential disadvantages of IPT are Limited transmission distance with varies from cm to m, the significant eddy current loss is generated in nearby metals which limits its application area. The key advantages of MPT are long effective transmission distance up to several km, suitable for mobile applications, potential to transfer several kilowatts of power. The potential disadvantages are low efficiency less than 10% for high power applications(such as transfer several kW power or more), complex implementation. The key advantages of LPT are long effective transmission distance up to several km, flexible device, suitable for mobile applications, potential to transfer several kw power. The potential disadvantages are low efficiency around 20% or less, the line to sight to the receiver [4, 5].

To date, both the CPT and IPT can offer the capability of supporting high power transfer above kilowatt level with high efficiency in the close distance. However, the transferred power of these technologies attenuates quickly with the increase of the transmission range. Thus the power transfer distance is largely limited. Because of the ease and low cost of implementation, these near field WPT technologies have found niche applications in everyday life, such as wireless charging of consumer electronics, electric vehicles (EV), robot manipulation, and biomedical implanted devices [4, 5].

2. Problem statement

When the electrical signal is modulated with the optical wave, the electrical signal is distorted due to the large difference between the frequency value of the electrical signal equal to 60Hz and the frequency of the light wave which equals 400 -500THz for the wavelengths used, Therefore, this will affect the received optical signal in the (LDR) optical sensor. Also, when the optical signal spreads in the optical fibers, it is exposed to a deterioration in the intensity of the optical signal, which also reduces the received signal in the optical sensor.

3. Introduction

LiFi is one of the newest communication technologies that aim to improve upon current technology by making use of visible light communication as opposed to the radio waves used by WiFi. Its introduction actually serves a dual purpose as it aims to provide overhead illumination to households as well as facilitate the transfer of data [5].

Whereas WiFi technology effects data transfer on radio waves, LiFi takes the next revolutionary step in wireless evolution and embeds and transfers data in visible light beams, thereby allowing LiFi to take full advantage of the vastly greater light spectrum bandwidth capacity that is provided by the light spectrum. Data is captured in modulated light frequencies of a solid-state LED light source and is then transmitted and received by LiFi-enabled devices. A photosensitive detector demodulates the light frequency signal and converts it back into an electronic data stream and – in so doing – allows for faster-than-ever, more secure, bi-directional wireless communication. Since data is transmitted through light, then that must mean that LiFi does not work in the dark, Not necessarily. If the light is completely turned off, there is no LiFi. But LiFi enabled LED lights can be dimmed low enough that a room will appear dark and still transmit data. There is a consistent performance between 10 and 90 percent illumination. Currently, LiFi can still effectively perform at light levels down to 60 Lux [6].

4 Principle of Operation

4.1. The direct modulation (DM)

The transmitted signal generated from the direct modulation is shown in the following scheme:

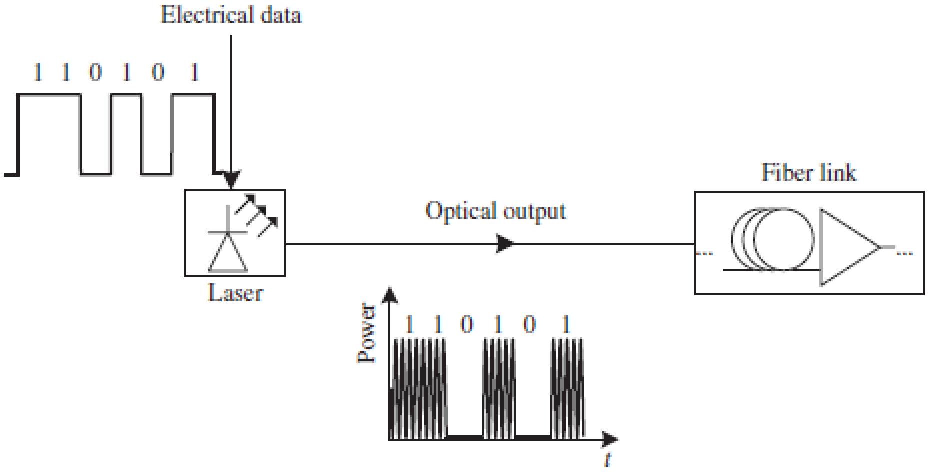

Figure 1: The Direct modulation of semiconductor laser [1]

As shown in the figure 1, the electrical data modulate the drive current of the laser, when the “1” of electrical data is present, the laser is turned on and, therefore, the electrical impulsion is encoded onto the presence of optical. Signal in the fiber link. This modulation present a great amount of chirp that defined as a rapid variation in the instantaneous frequency of the laser caused by the refractive index changes in the active layer due to the carrier density population [6]. Where the chirp and dispersion effect of the fiber will introduce pulse broading. For that, the performance of this modulation class still limited for data rate (< 10 Gb/s) and short distance [7].

METHODOLOGY

In order to find a new way to transmit the electric current, the li-fi system is used, and instead of entering the data into the system, an alternating electric current is entered so that the electric current is included with the optical wave using the LED.

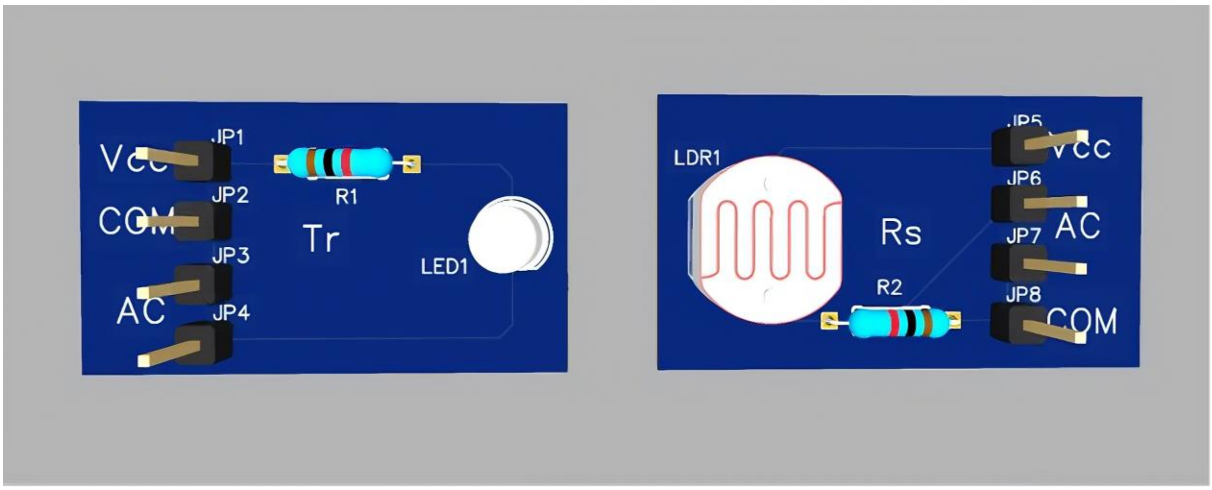

Figure 2: The PCB design of a system

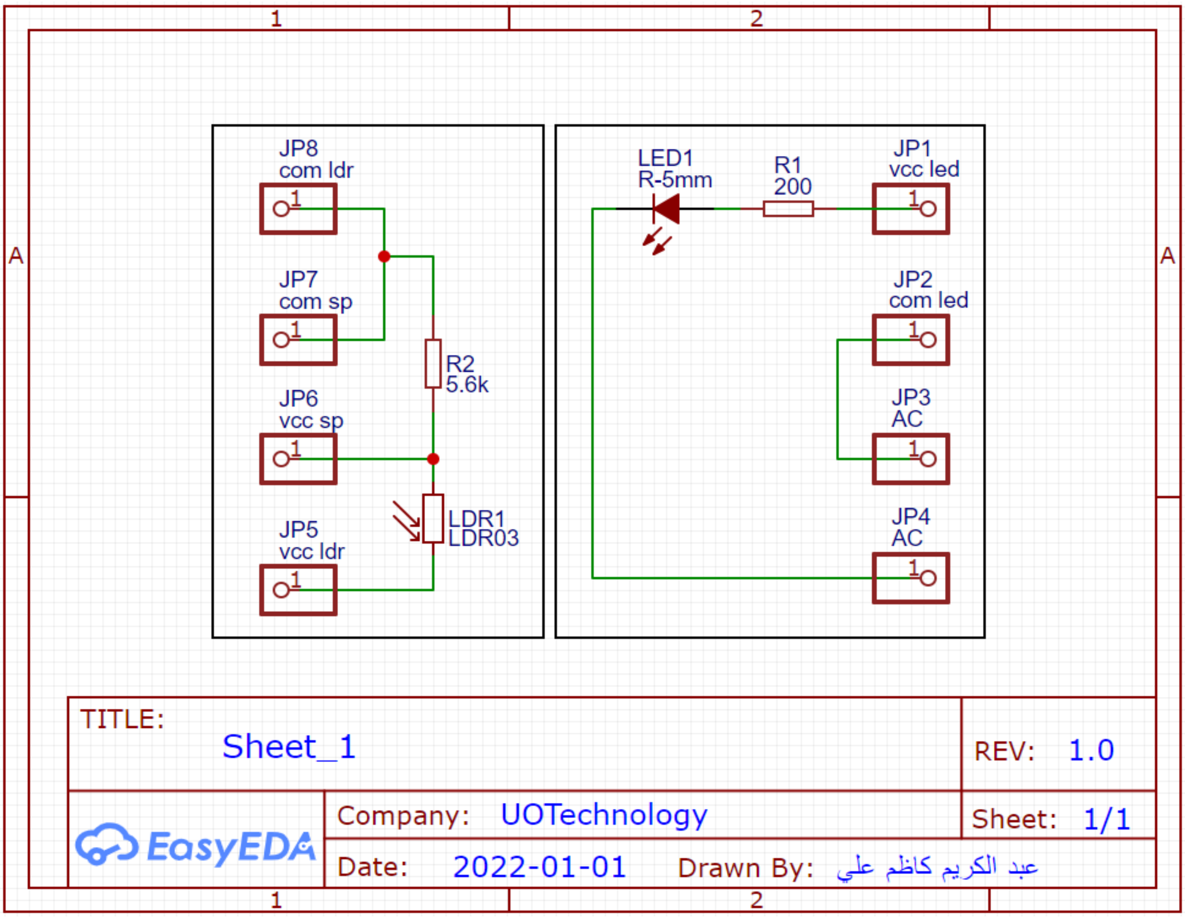

Figure 3: The design of a Transmitter and receiver system for single channel (model No.1)

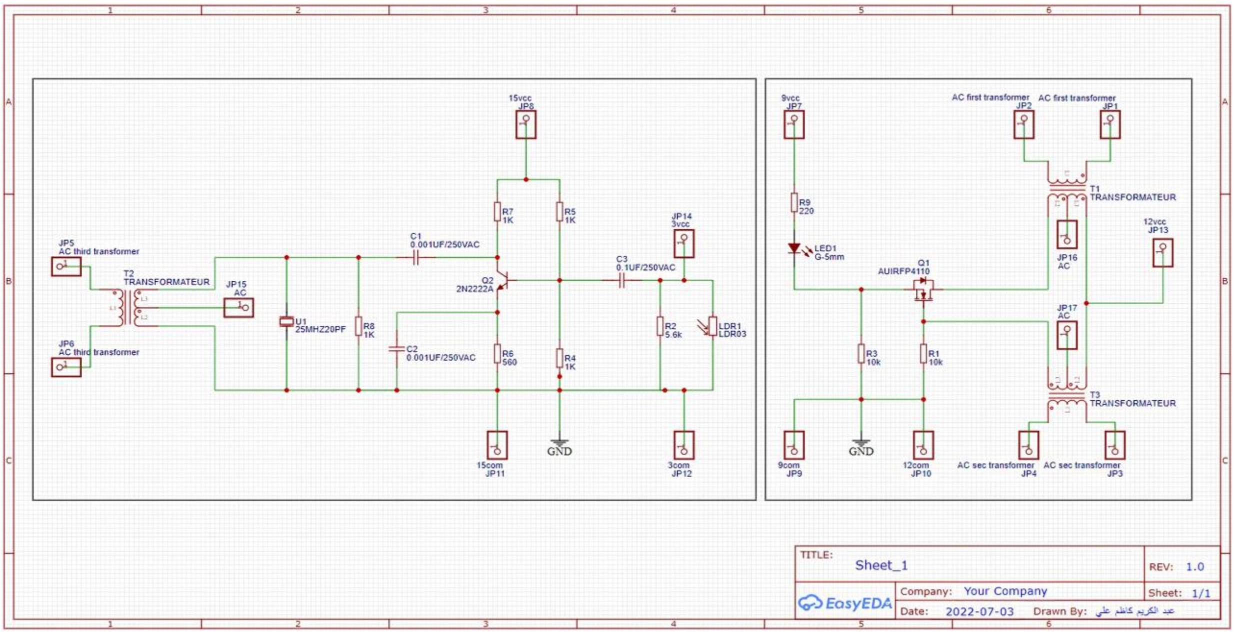

Figure 4: The design of a Transmitter and receiver system for single channel (model No.2)

RESULTS AND DISCUSSION

Figure (5) shows the power of a photon for each wavelength before the alternating current is included and after the alternating current is included in the transmitter circuit in the alternating current transmission system in the optical fiber using the LED.

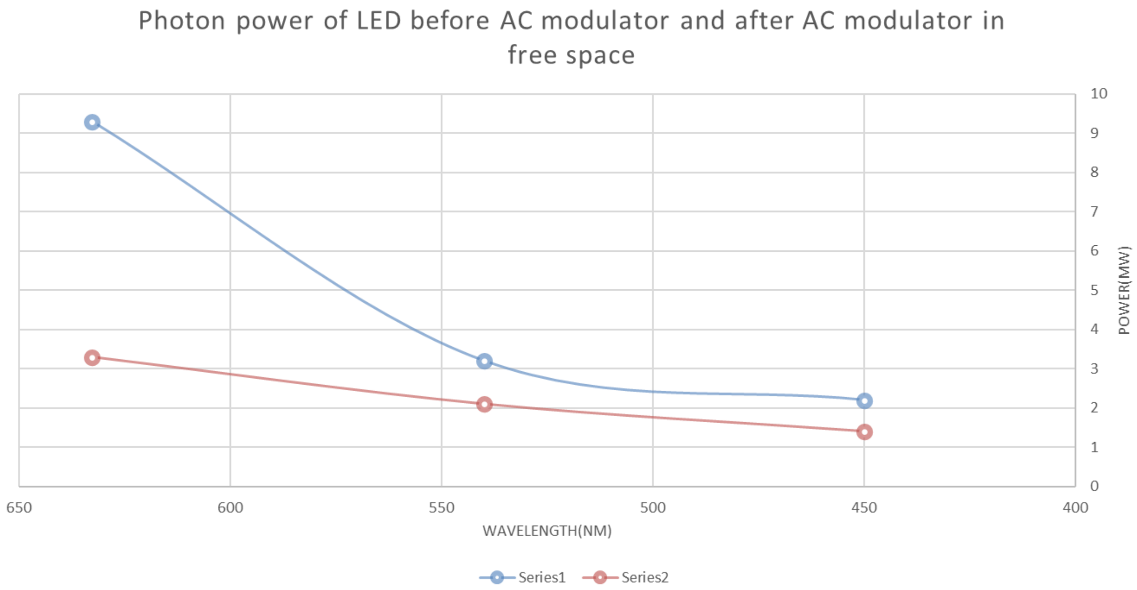

Figure 5: Photon power of LED before AC modulator and after AC modulator

Figure (6) shows the power of a photon for each wavelength during the single phase is modulated and during the three-phase generator is modulated in the transmitter circuit in the alternating current transmission system in the optical fiber using the LED.

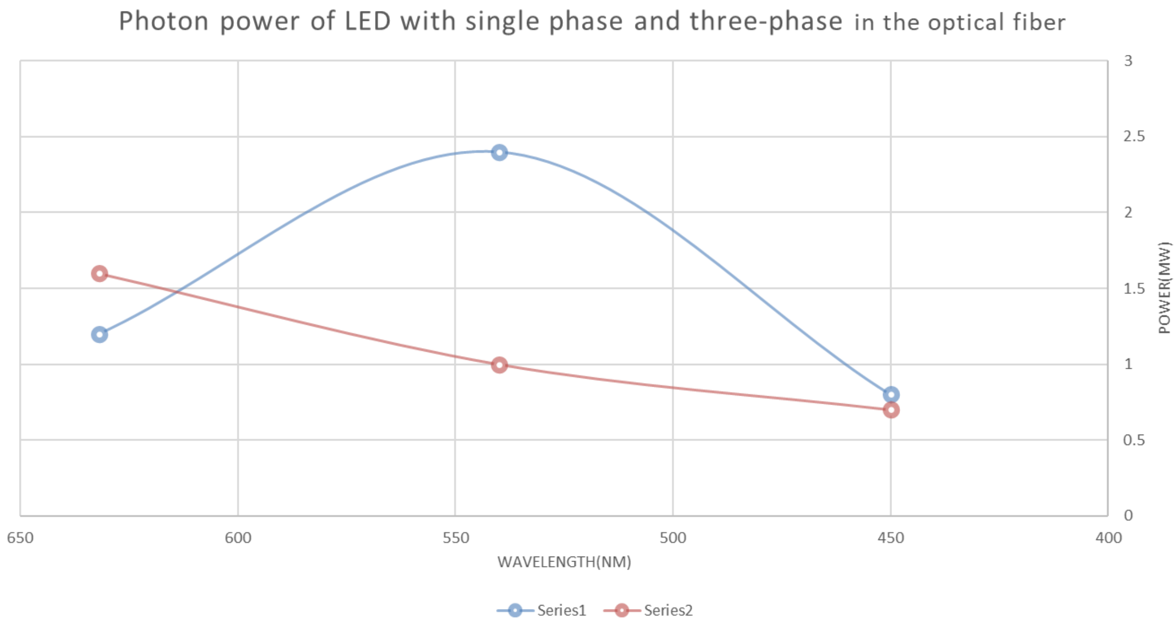

Figure 6: Photon power of LED before AC modulator and after AC modulator

The values are measured using a digital photon power meter shown in Figure (7). The results are obtained by operating the transmitter circuits shown in Figure (7.b) and each circuit is fed with a voltage of 9 volts, and the power is measured for each 5 mm LED, then the current is entered The alternator is connected to the transmitter circuit by connecting the 6-220 volt transformer with each circuit as shown in Figure (7.c) and the power is calculated for each LED and the signal is tracked using an oscilloscope for all chanel and for (input and output signal) as showen in figures (7.a) to (7.f).

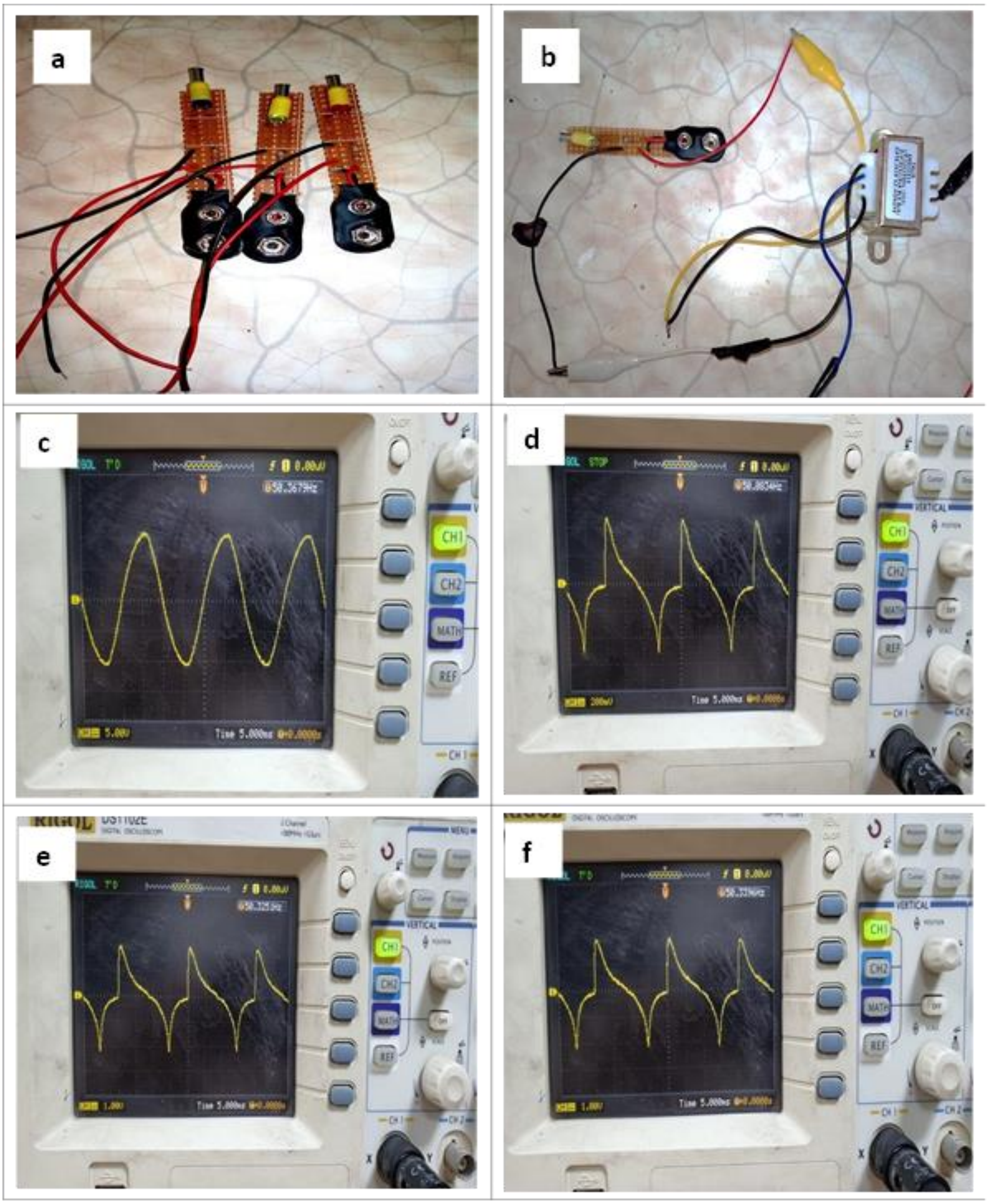

Figure 7: Single phase transmission(a) LED circuits, (b) Single phase transmitter, (c) Input signal, (d) Output signal of blue LED, (e) Output signal of green LED, (f) Output signal of red LED

The alternator is then connected to the transmitter circuit by connecting the Three-Phase Generator with each circuit as shown in Figure (8.a) and the signal is tracked using an oscilloscope for all chanel and for (input and output signal) as showen in figures (8.b) to (8.g). One of the problems that occurred was that the power meter had some noise and there were external effects such as heat and light scattered around the device, and also when the power values of each LED were taken when alternating current was included, two values were obtained for each LED because the LED was working As a puls source, the mean value of each LED was taken.

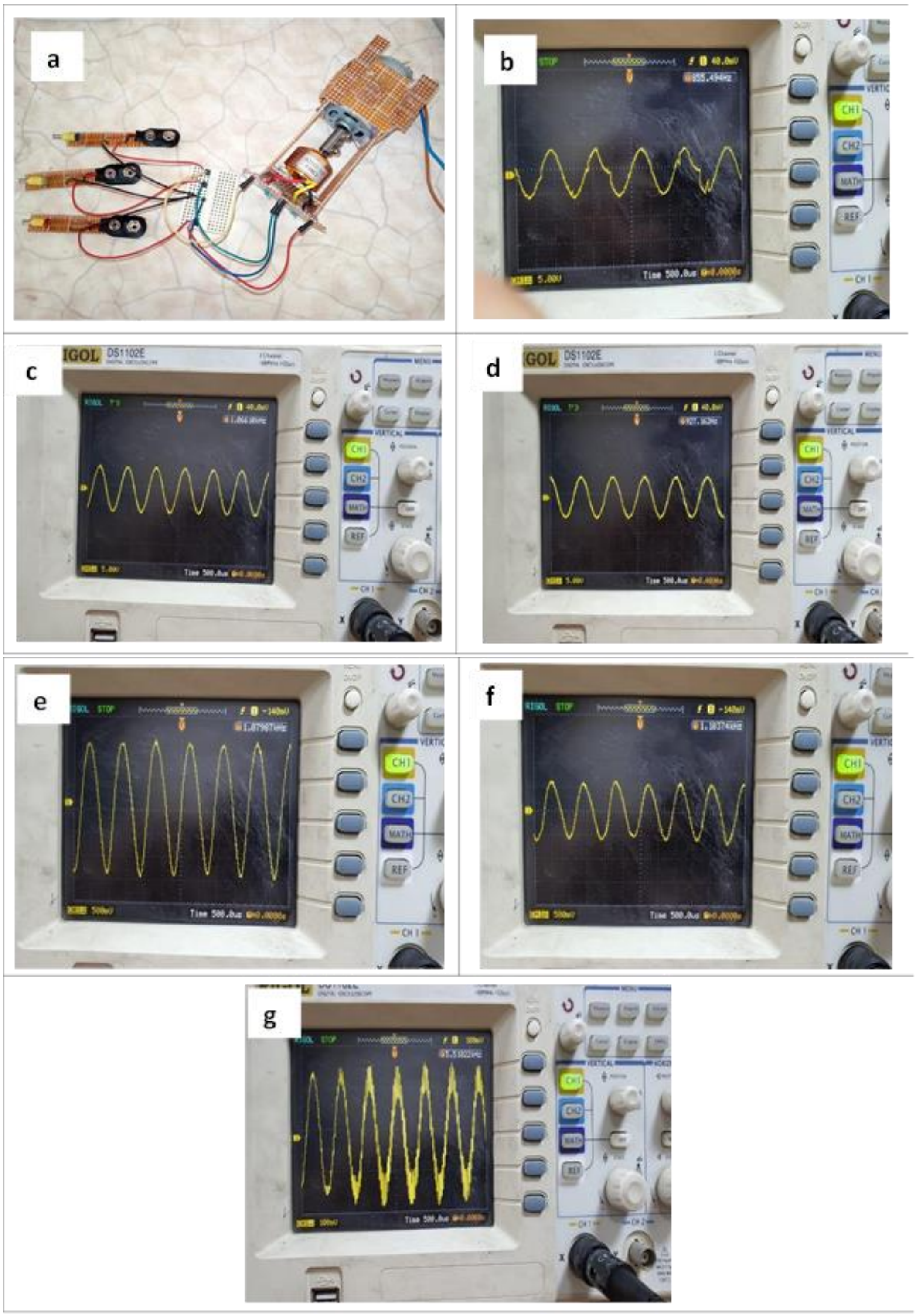

Figure 8: Three-phase input – output signal (a) Three phase circuit, (b) Input signal of red LED, (c) Input signal of green LED, (d) Input signal of blue LED, (e) Output signal of blue LED, (f) Output signal of green LED, (g) Output signal of red LED.

The values are measured using a digital photon power meter. The results are obtained by operating the transmitter circuits and the plastic optical fiber was connected with LED in transmitter circuits shown in Figure (9) and each circuit is fed with a voltage of 9 volts, then the current is entered the alternator is connected to the transmitter circuit by connecting the 6-220 volt transformer with each circuit and the power is calculated for each LED and the signal is tracked using an oscilloscope for all chanel and for output signal as showen in figure (9.b) and (9.c), (While no signal was obtained from the red LED). The current is applied to the alternator is connected to the transmitter circuit by connecting the Three-Phase Generator with each circuit and the plastic optical fiber was connected with LED in transmitter circuits and the signal is tracked using an oscilloscope for all chanel and for output signal as showen in figures (9.d) to (9.f).

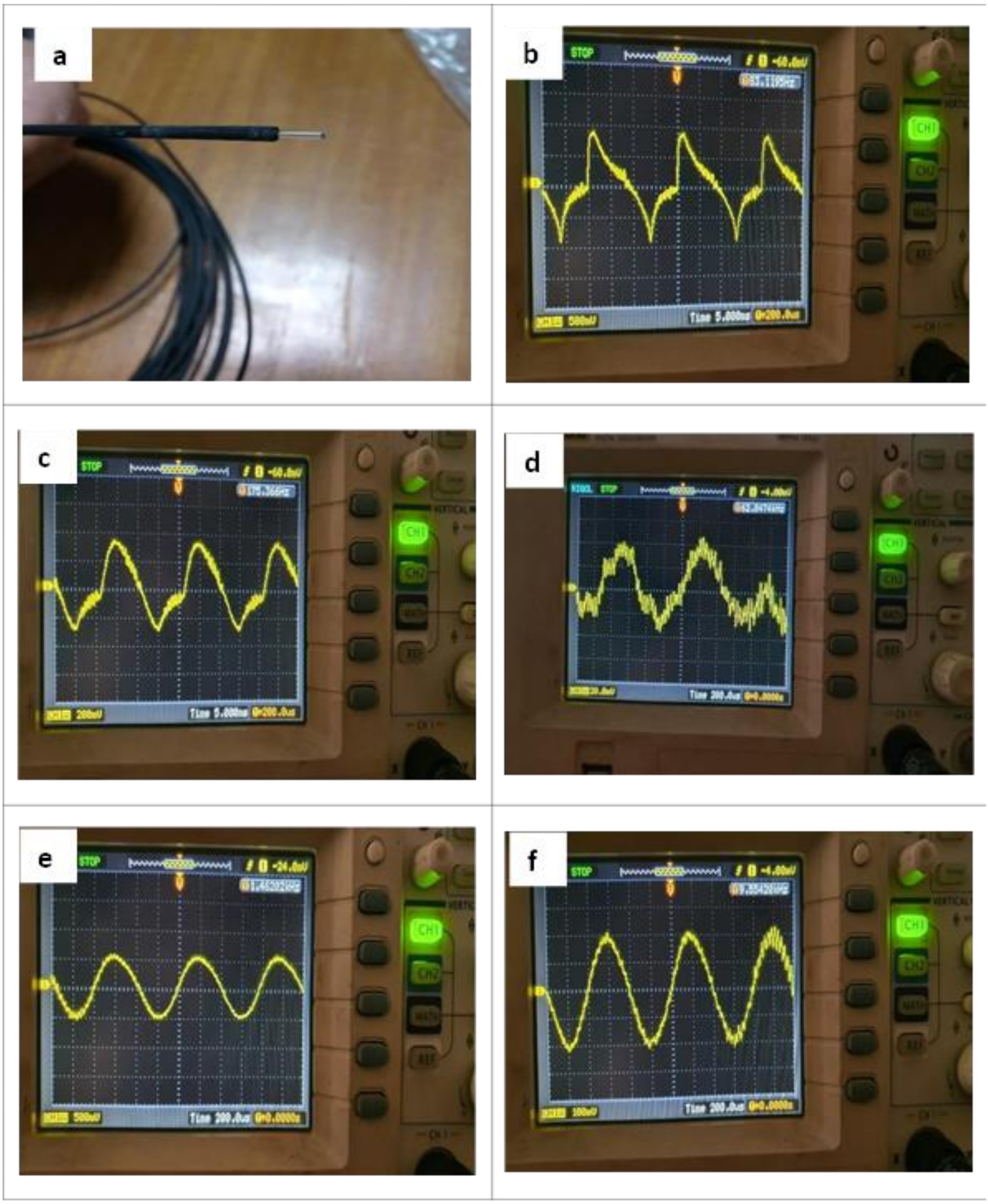

Figure 9: Output signal,(a) 10 m plastic optical fiber, (b) Output of green LED, (c) Output of blue LED, (d) Output of red LED, (e) Output of single phase of green LED, (f) Output of single phase of blue LED.

Where this table represents the value of the output voltage in the first design (before the improvement) and the second design (after the improvement).

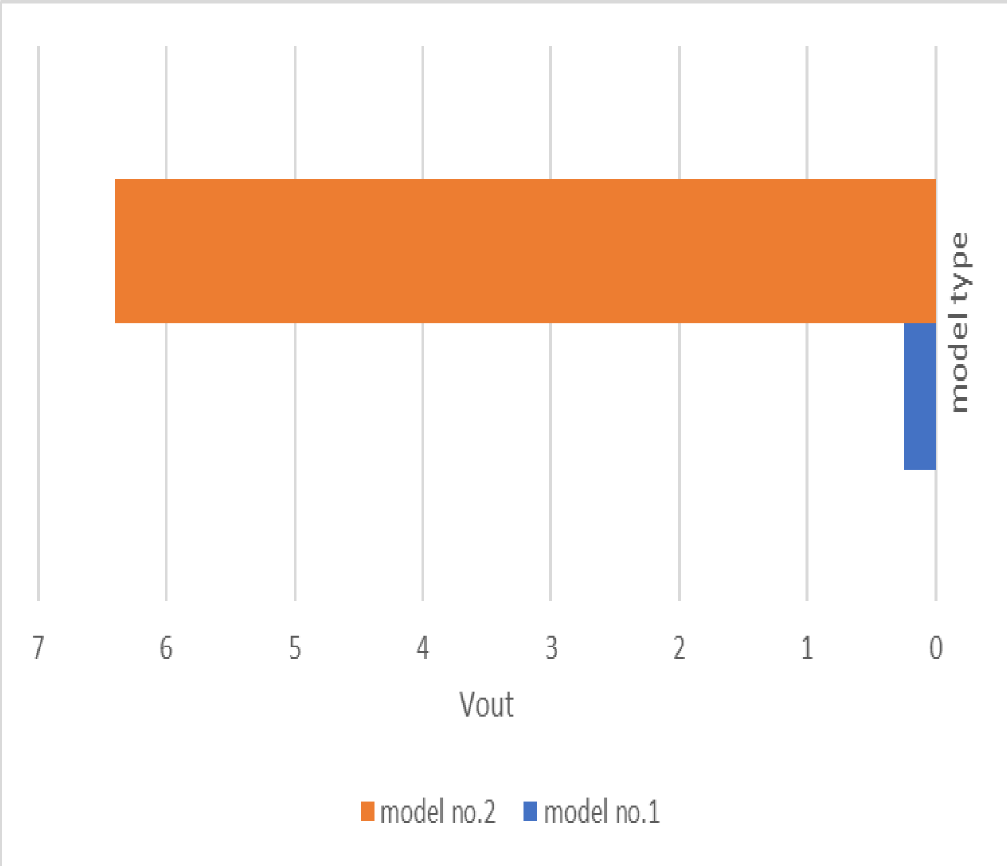

Figure 10: output voltage without crane transformer Where this table represents the value of the output voltage in the first design (before the improvement) and the second design (after the improvement).

CONCLUSIONS

In this project, a design of single and three – phase alternating current based optical signal transmission was proposed. The output signal of different channels (free space and plastic optical fiber) were established and analyzed. It was concluded that signal tramission of blue wavelength has a lower power level compared to green and red light emitting diodes. The diffeculties of this project is to maintain perfect alignment between the LEDs and the plastic optical fiber. Further, more signal loss is found due to waste of signal power due to coupling loss. However, a number of advantages were concluded which they are: low cost design, simple circuit implementation, and suitable controlling of the circuit.

REFERENCES

[1] Bakir H. Ali, “Performance Comparison between Direct and External Modulation using RZ and NRZ Coding”, Journal of electrical engineering, Vol. 19, No. 1, pp. 1 – 8, 2020
[2] Paul O. Idowu1 et al “Comparative Study of Chirp in Direct and External Optical Modulation” International Journal of Computer Science and Information Technology & Security (IJCSITS), Vol.7, No.2, Mar-April 2017.
[3] Baranika, Akalya, Shanthi, C. Balaji, “Wireless Laser Power Transmission: A review of Recent Progress”, International journal of engineering research and technology, Conference Proceeding, Vol. 6, Issue 14, 2018.
[4] S. Hui, W. Zhong, C. Lee, “A critical review of recent progress in mid-range wireless power transfer”, IEEE Trans. Power Electron, Vol. 29, No. 9, 2014.
[5] E. Julka, D. Kumar, “A Review Paper on Li – Fi Technology”, Intenrational Journal of Scientific and Engineering Research, Vol. 6, Issue 2, 2015.
[6] LiFi Companies - LiFi.co, website referencing: *https:// lifi.co*
[7] S. D. S. D. A. M. Anibal Fernandez, "Special issue on LCOS technology,"Journal of Lightwave Technology, vol. 27, no. 9, pp. 1240-1240, 2009.
[8] L. Le, "Assessing the quality of answers autonomously in community question–answering," International Journal on Digital Libraries, vol. 20, no. 4, pp. 351-367, 2019.
[8] X. Lu et al., “Wireless charging technologies, fundamentals standards, and network applications”, IEEE communication survey Tuts., Vol. 18, No. 2, 2016.
[9] C. Park, S. Lee, G. Cho, C. Rim, “Innovative 5m off – distance inductive power transfer systems with optimally shaped dipole coils”,
[10] Shiva Kumar and M. Jamal Deen, ‘fiber optic communications fundamentals and applications’chapter.4, 1st edn, edition. John Wiley & Sons, 2014.