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Optimization of Various Parameters for High-Efficiency Light-Fidelity (LI-FI)

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Abstract- Light Fidelity (LiFi) is a Visible Light Communication (VLC) based technology that making a light as a media of communication replacing the cable wire communication. LiFi is evolve to overcome the rate speed in Wi-Fi, while using LiFi the rate speed can reach until 14 Gbps. This paper presents an introduction of the LiFi technology including its performance at different parameter. The result of this paper can be used as a reference and knowledge to develop some of the LiFi technology. Li-Fi has evolved with the tremendous growing technology. This paper presents a communication system based on Light fidelity (Li- Fi). In this paper, simulation of the transmitter- receiver system has been done. The major contribution of the work is in the optimization of various parameters. We achieved received signal power density and 3D power distribution along with signal to noise ratio at receiver end with variation of perpendicular distance between receiver and transmitter i.e. height and with variation of incidence angle of light i.e. the angle between the horizontal plane and light rays. All simulation work is done of MATLAB 2018a software version.

Keywords- VLC, Light fidelity, Li-Fi, MATLAB, LED, Photodiode.

I. INTRODUCTION

1. Visible light communication and Li-Fi:

LiFi known as light fidelity was introduced first time by Prof. Harald Haas on July 2011 at TED Global Talk. LiFi is based on Visual Light Communication (VLC) that using light emitting diodes (LEDs) to fully networked wireless system. LiFi enables the electronic device to connect to the internet with no wire. In order to make a communication line between nodes, a LiFi will need a transceiver to transmit and receive the data.

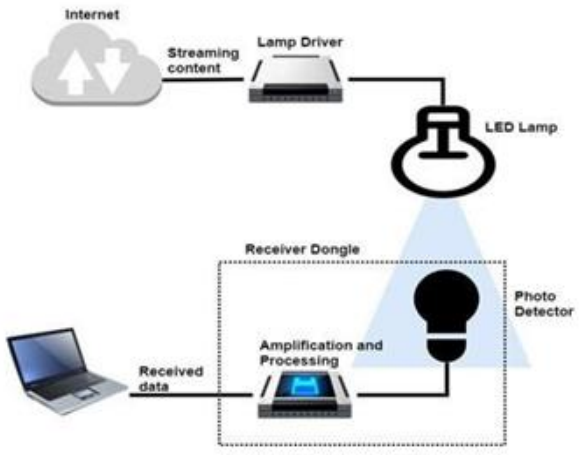

Fig 1. Basic Concept Diagram LiFi.

According to figure 1(a), LiFi technology consists of LED Lamp as the media transmission and photo. Detector as a receiver of transmitted data. Lamp driver is needed to make LED working properly. While amplification and processing are responsible to manage the signal that comes from the photo detector.

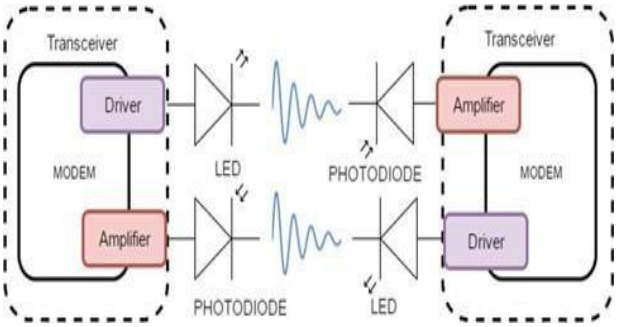

Fig 2. Transceiver LiFi based on VLC.

2. Li-Fi system with working principle & features:

Basic concept for working principle in LiFi Technology is pointing into: Transceiver and Light as a media transmission. Figure 1(b) is a basic concept block diagram for LiFi. This basic concept indicates as a duplex communication. The rates of LiFi is 14Gbps using three off- the- shelf laser diodes (red, green, and blue) and predict the rate until 100Gbps when the whole visible spectrum is used.

According to [3] LiFi and VLC used a similar medium as a data communication that is light. The difference between LiFi and VLC is VLC has a unidirectional, point-to-point light communication at low data rates. While the

LiFi technology is fully networked, bidirectional, and high-speed wireless communication. Others said LiFi is the incorporation of Wi-Fi and VLC Professor Haas highlighted the following key problems of Wi-Fi that need to be overcome in the near future:

- **Capacity:** The radio waves used by Wi-Fi to transmit data are limited as well as expensive. With the development of 3G and 4G technologies, the amount of available spectrum is running out.
- **Efficiency:** There are 1.4 million cellular radio masts worldwide. These masts consume massive amounts of energy, most of which is used for cooling the station rather than transmission of radio waves. In fact, the efficiency of such stations is only 5%.
- **Availability:** Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants and in hospitals.
- **Security:** Radio waves can penetrate through walls. This leads to many security concerns as they can be easily intercepted.

Li-Fi addresses the aforementioned issues with Wi-Fi as follows:

- **Capacity:** The visible light spectrum is 10,000 times wider than the spectrum of radio waves. Additionally, the light sources are already installed. Hence Li-Fi has greater bandwidth and equipment which is already available.
- **Efficiency:** LED lights consume less energy and are highly efficient.
- **Availability:** Light sources are present in all corners of the world. Hence, availability is not an issue. The billions of light bulbs worldwide need only be replaced by LEDs.
- **Security:** Light of course does not penetrate through walls and thus data transmission using light waves is more secure.

II. PHYSICAL MODEL

The proposed indoor white LED lighting setup fo Characterization calculation is shown in Figure2 (a) & Figure2 (b). Since we consider line-of-sight LED characterization for optical wireless channel, a white LED was installed at the center of the ceiling.

In order to get better illumination of room, 4 pieces of LEDs were closely packed. The size of the room was 5m x 5m x 3m as given in Figure 2 (a) & Figure 2 (b) and the measuring distance between LED and the Lux meter was kept at the distance of 2.4mas the receiver was placed on a table as a working plane.

1. Optimization of Various Height:
We then simulated the program code to analyze the variation of SNR and received power density of receiver with respect to height variation from 0.5m to 5 m

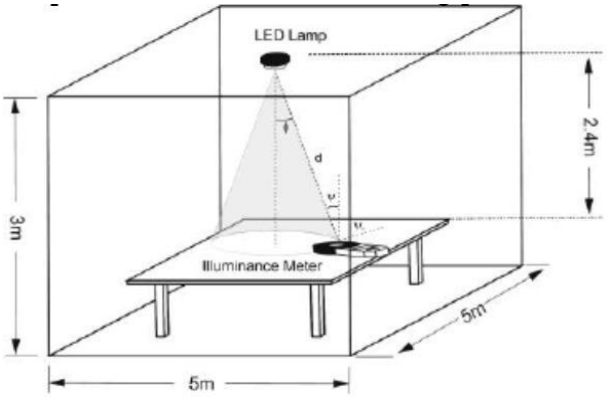

Fig 3. The Room Set-up.

2. Optimization of Various Incidence angle:
We then simulated the program code to analyze the variation of SNR and received power density of receiver with respect to incident variation from (1-89)o.

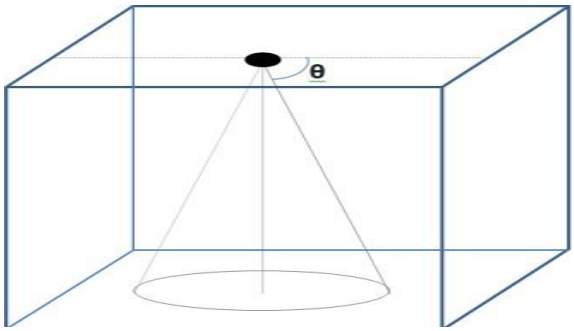

Fig 4. The Room Set-up.

III. IMPLENTATION

1. Matlab Simulation:
For obtaining the illumination and power distribution models over the plane, MATLAB programs were used. The various parameters needed for simulation are listed in Table. 4.

The viewing angle of the receiver was 120 □ , the semi-angle at half power is taken at 60 □ . The 4 pieces of 2.4 w LEDs produced approximately 358 lumens, And they gave 7W of total optical power and that was taken as the transmitted power of LED.

Table 1. Simulation Parameters.

Room	Size	5m x 5 m x 3m
Source	Location of LED	2.5 m,2.5m,3m
	Semi angle at half power	60 °
	Transmitted power	7 W
	Centre luminous intensity	21.4 to 1401 lx
Receiver	Receiver plane above the floor	0.6 m
	Receiver active area	1.5 cm^2
	Half Angle FOV	70 °

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IV. RESULT

1. Optimization of Various Heights:

Simulated plots for the distribution of received power at various heights of 0.50 m, 1.00 m, 2.00 m, 3.00 m, 4.00m and 5.00m are shown from Figure4.1 (a) to Figure4.1(f) with incident angle 7.5o (constant)

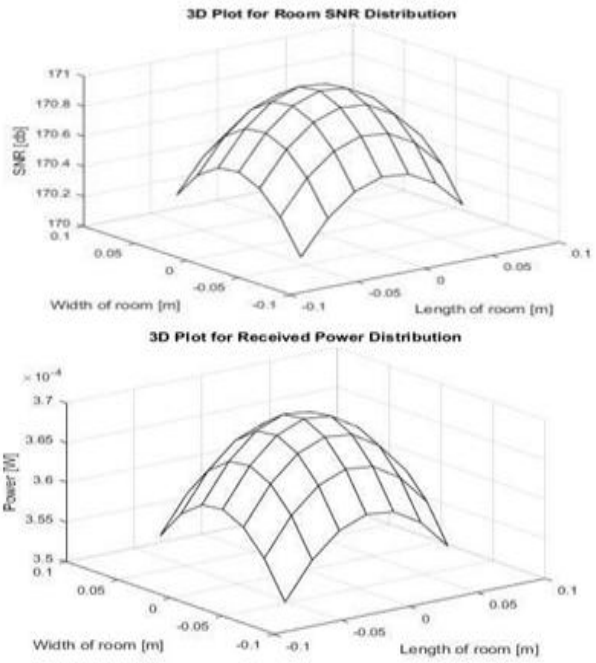

Fig 5. Curves for SNR and received power at distance of 0.50 m.

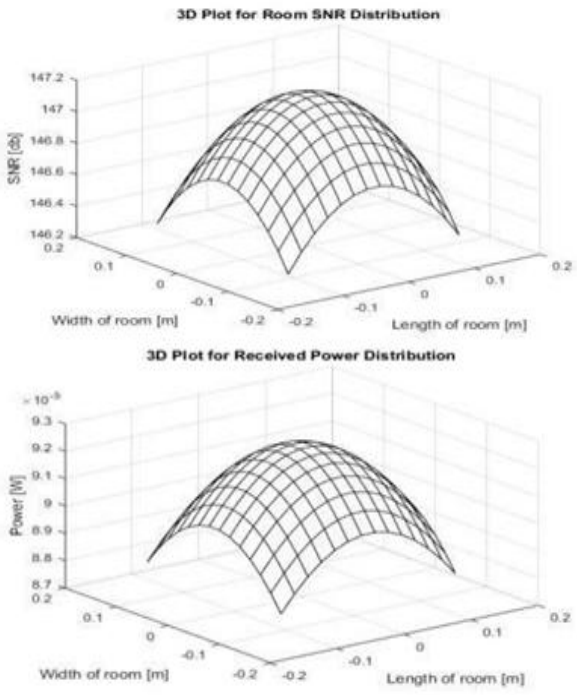

Fig 6. Curves for SNR and received power at distance of 1.00 m.

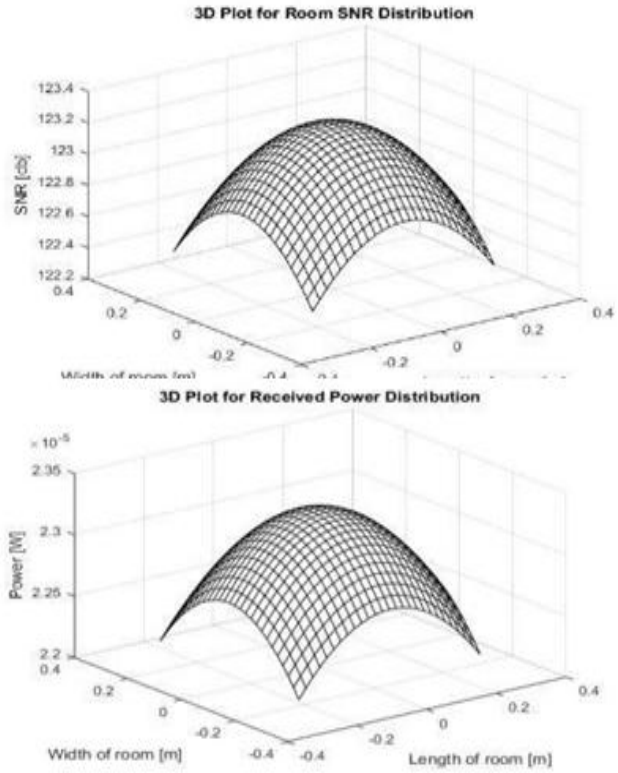

Fig 7. Curves for SNR and received power at distance of 2.00 m.

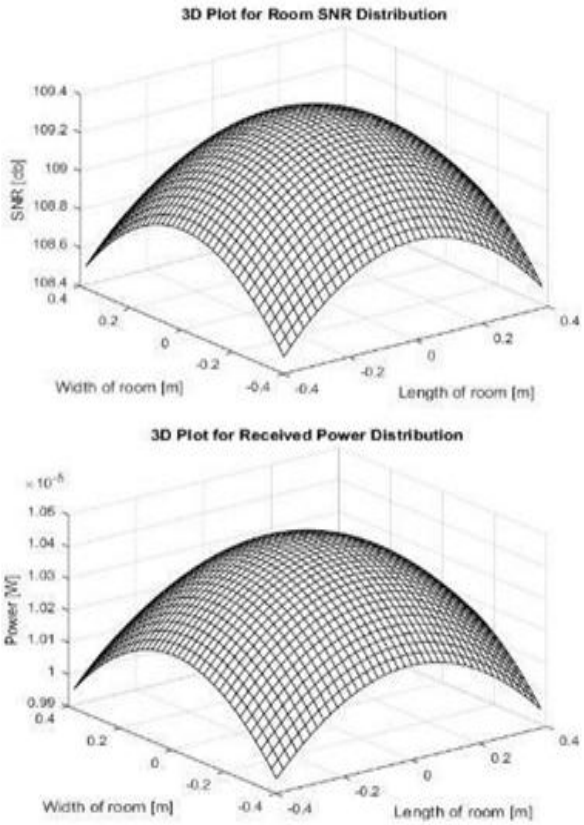

Fig 8. Curves for SNR and received power at distance of 3.00 m.

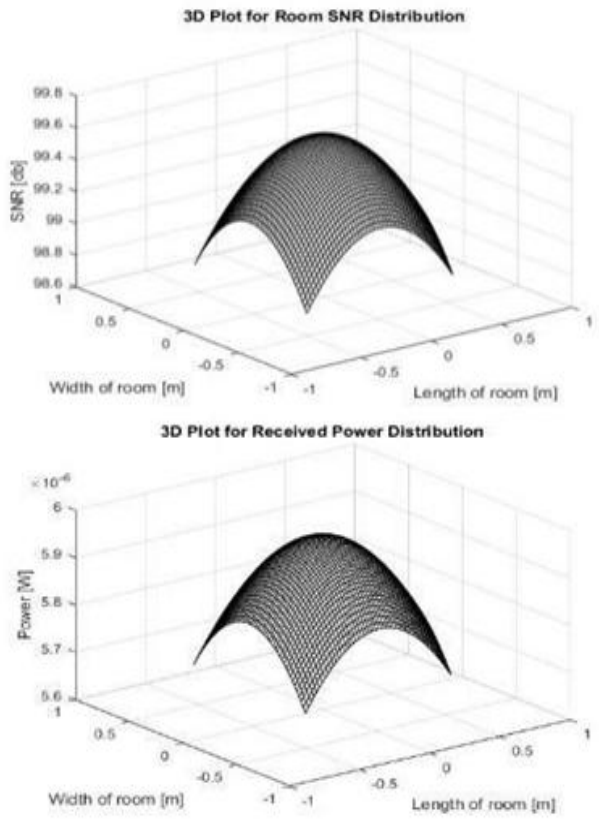

Fig 9. Curves for SNR and received power at distance of 4.00 m.

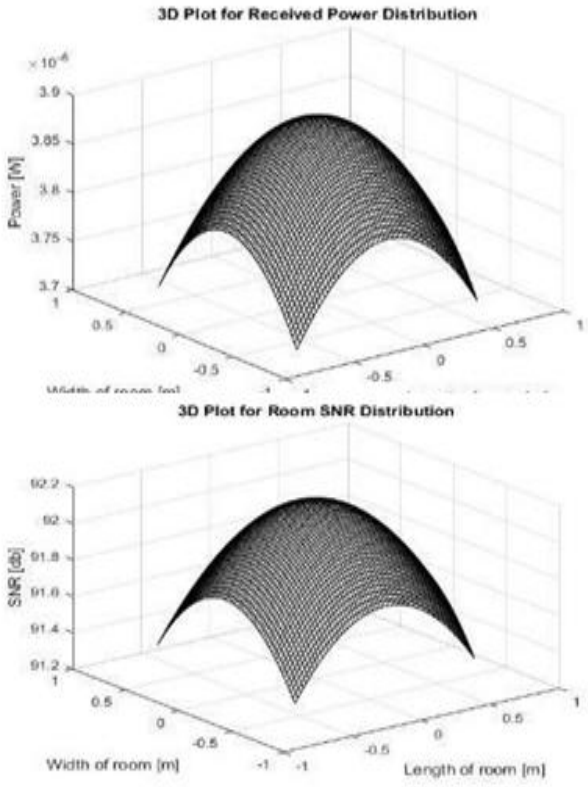

Fig 10. Curves for SNR and received power at distance of 5.00 m.

2. Optimization of Various Incidence angle:

Simulated plots for the distribution of received power at various Incidence angle of 10o, 20o, 30o, 40o, 50o, 60o, 70o and 80o are shown from Figure4.2(a) to Figure4.2() with height of room 2.5m (constant).

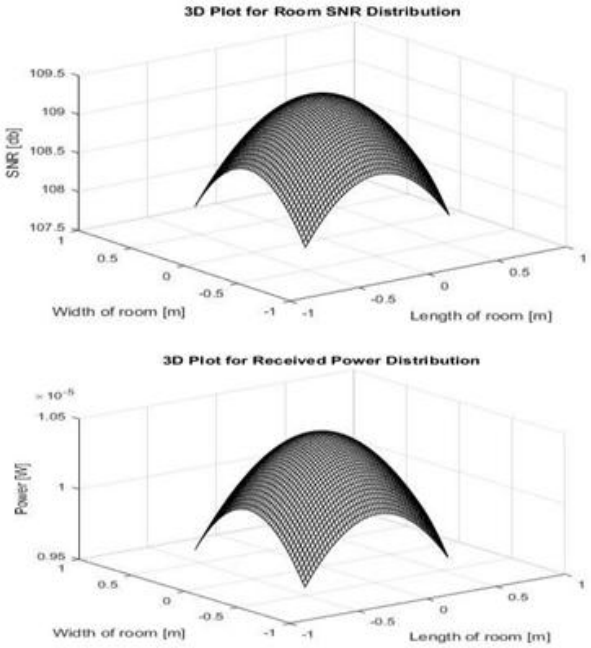

Fig 11. Curves for SNR and received power at angle of 10o

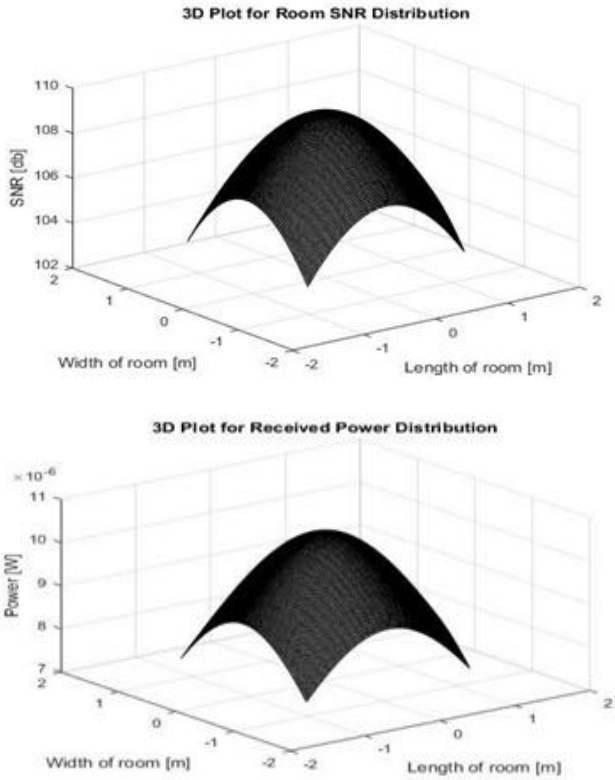

Fig 12. Curves for SNR and received power at angle of 20o

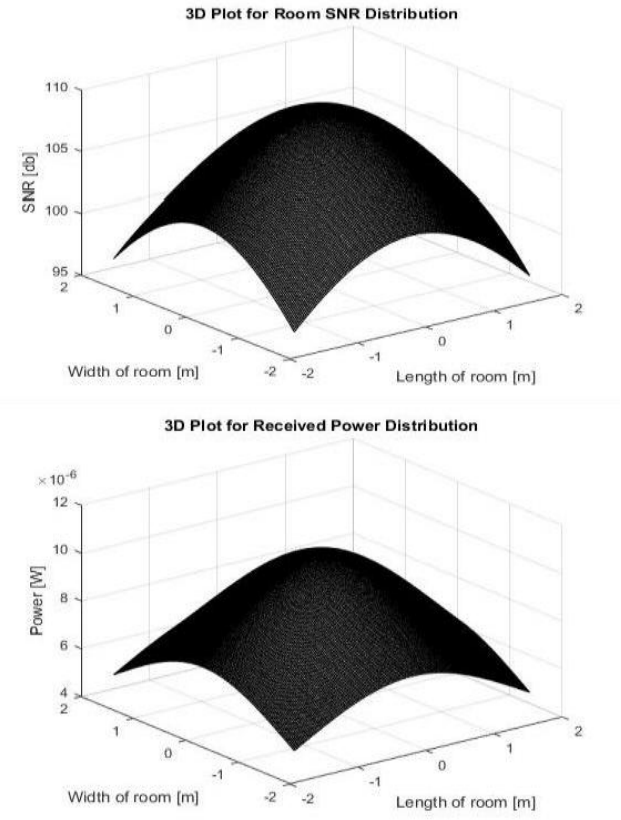

Fig 13. Curves for SNR and received power at angle of 30o

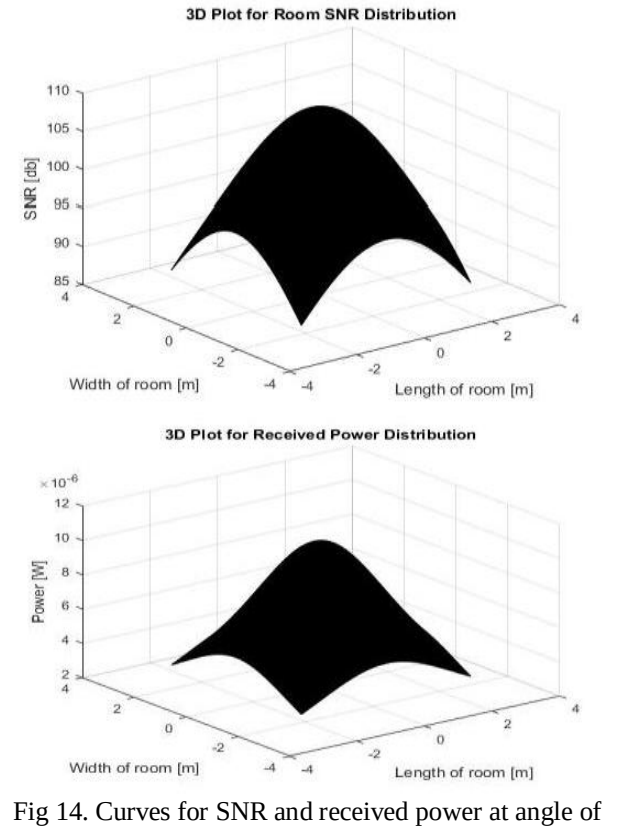

Fig 14. Curves for SNR and received power at angle of 40o

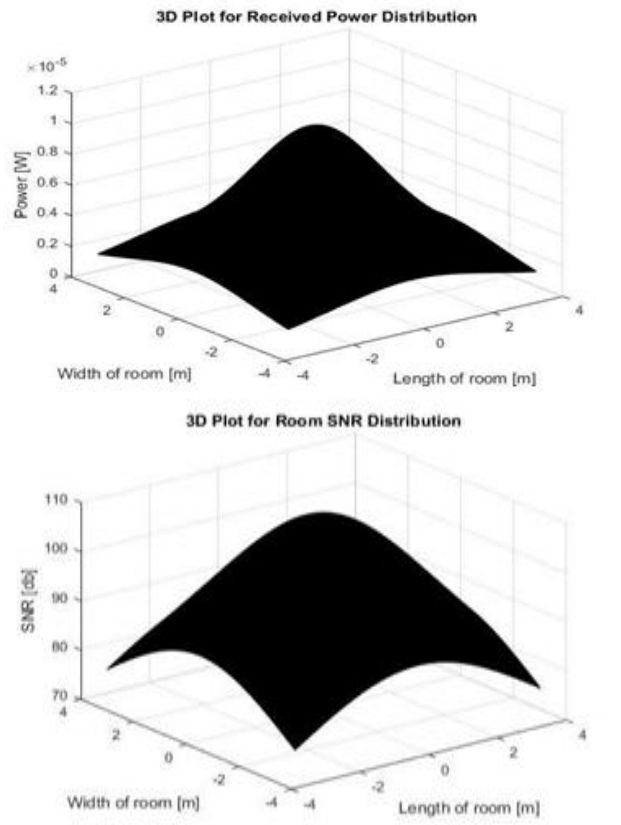

Fig 15. Curves for SNR and received power at angle of 50o

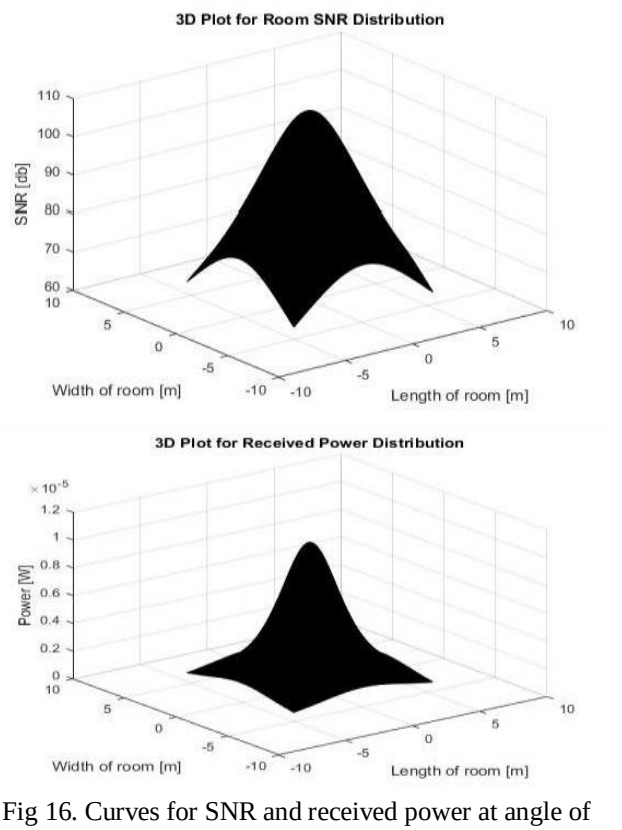

Fig 16. Curves for SNR and received power at angle of 60o

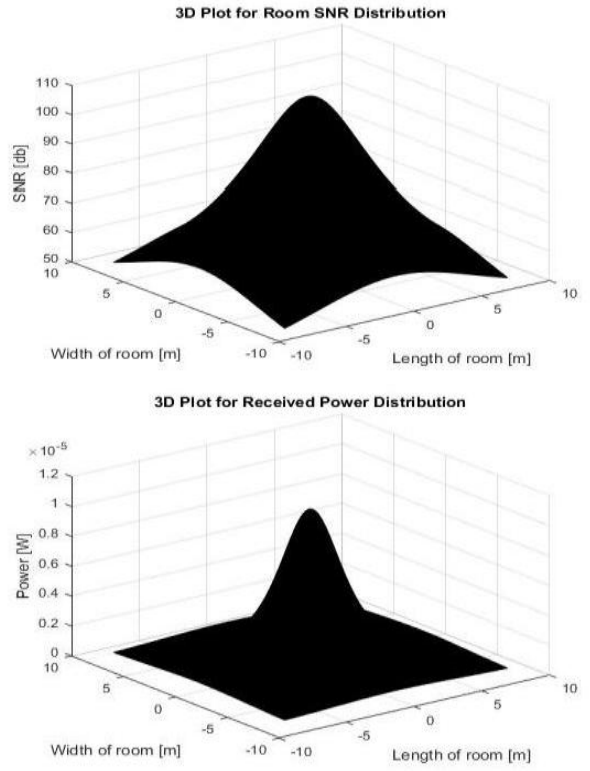

Fig 17. Curves for SNR and received power at angle of 70o

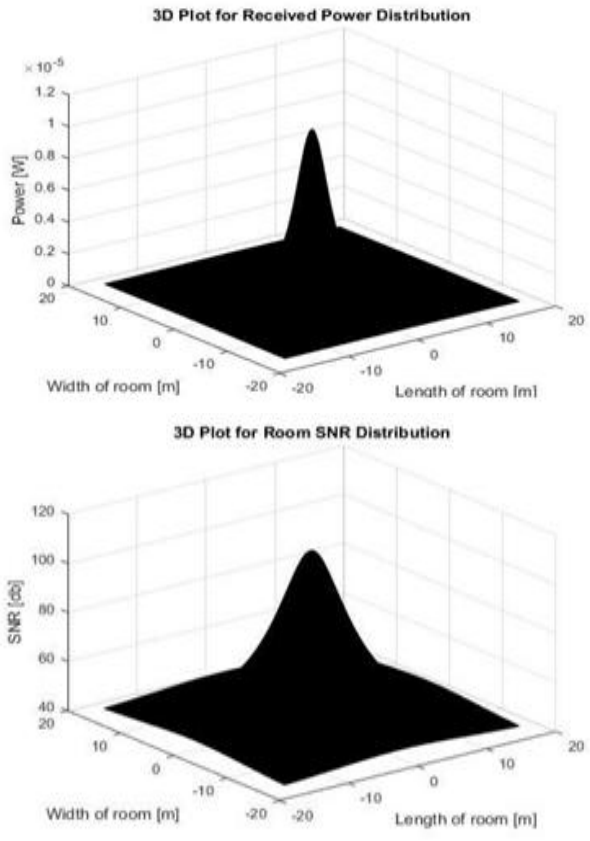

Fig 18. Curves for SNR and received power at angle of 80o

V. CONCLUSION & DISCUSSION

In this paper, we have modeled, measured and simulated the received power distribution for a white LED using a Lux meter. MATLAB program also helped further to investigate the measured values. From the investigation we found a practical way of analyzing the characteristics of a LED suitable for Optical Wireless Communication.

From our studies, we obtained two significant results such as the attenuation of free space channel which was approximately 8 dB/m and the beam divergence of 63.5□ and height of led 3.15m. These results can be used for further research in this area in order to make use of this White LED for Visible light communication

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