EUROPEAN ACADEMIC RESEARCH
Vol. XI, Issue 6/ September 2023

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Analysis and Modelling of Optical Concentrator for Reliable Infrared Communication

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Abstract

This "study describes the development of optical concentrator for reliable infrared communication. We use ray tracing simulator software for the design implementation and results . In particular a compound parabolic concentrator is selected for the said purpose. A diode is modeled as 1 mm by 1mm using a cylindrical design. Finally the simulation is carried out for illumination and flux results. The results reveal that concentrator efficiently focuses the rays on absorber and it can work with an angular view range from -10 to 10 degree.

Keywords: parabolic concentrator, optical wireless communications, photo detectors

1. INTRODUCTION

Communication history is old as human history, in every era communication Was a big problem for people that how to send their message to their love one's.so people used different ways to send their messages. Such as human messenger, pigeon and fire etc. In 1200 BC fire was used to send a message at a far distance. In1790 Clande Cappe used optical telegraph by varying the direction of the signaling arms, more over a message can be send at a distance in mint [1]. In 1880 Bell and Tainter invented photo phone actually he used Selenium to convert reflection of sun light in to electrical signal. In modern era Gfeller and Bepst work in indoor OWC by using diffuse emission in IR band, since that OWC become more popular as a replacement of traditional broad band technology (RF) [2, 3]. Wireless devices totally change the way we live, socialize and worked. Basics principle of OWC is optical beam transmit the data through atmosphere [4]. when we compare WC with RF there are several advantages in OWC components are cost effective, operate in low power, no fear of harmful radiation (VLC), unregulated spectrum and free of license, optical power is save for skin and eye, OWC can be easily utilize in place where highly security is concerned because light wave cannot pass, from the wall [5, 6]. OWC does not required a complex infrastructure. OWC as utilize the light wave to transmit the information in atmosphere the wave length can be in infrared (IR) 750-1600nm, visible light (VL) 390-750nm, and ultra-violate (UV) 200-280nm. IR is short range application, transmitter and receiver should be in line of sight (LOS). When ultra-violate(UV) is utilize in OWC it has many risks regarded to skin and eye. Visible light communication can provide light and data transmission simultaneously, this unique feature make it desire able choice, VLC with white LED provide this terminus feature, the unique response of LED makes them enable to utilize in OWC. Optical wireless system can be divided in to four classes such as personal communication, indoor communication system, outdoor communication system, and hybrid OW/RF system [7]. Personal communication system is used to deliver services at more personal level in a very short time such as financial data or secure payments etc. standard for personal communication system has been set by Infrared Data Association (IrDA) and IEEE. Personal communication is also involving a point-to-point links [8].

Like visible light infrared laser light can also use for transmission, infrared band lays between 750-1600 nm but the problem with these frequencies are invisible for human eye it is actually Laser transmition.IR transmission is secure as it cannot penetrate wall so no issue of interference but IR have some drawbacks as well IR radiation cannot increase above the certain level as it has some issue regarding to eye safety.

For two-way VLC communication system, LED panel can be used for down link transmission for uplink LEDs are not preferred as they are not comfortable for eye, the other option IRED which can transmit non visible range, however their optical power is limited for eye safety stander, to improve reception a concentrator is a solution however analysis and modeling of optical concentrator is a challenge for which an investigation is required.

This paper deals with a concentrator design for reliable IR communication. The compound parabolic concentrator is selected for the said purpose which is content of section II. Section III is based on the results of proposed concentrator and section IV is the conclusion.

II Compound Parabolic Concentrator Design

A working CPC, formulated by utilizing Tracepro, is shown in. Figure 1. The same dimensions of the concentrator are depicted in Figure 2. its aperture diameter is 2.4mm and the receiver diameter is 1.2mm.

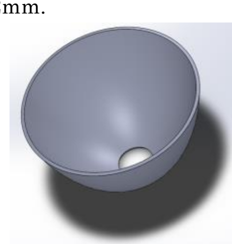


Fig 1. Design of CPC

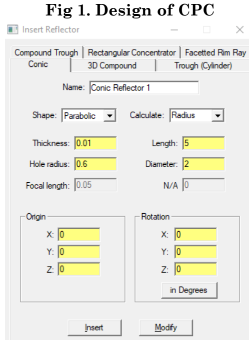


Fig. 2 Parameter for CPC in Tracepro

To analyze the optical performance of flux on absorber surface, a ray-tracing software trace pro had been utilized. The Concentrator converges the rays on the absorber surface. Simulation is achieved by employing the Monte Carlo ray-tracing method in the Trace Pro. Trace pro assigned different material properties like plastic glass and other material for concentrator and also for the absorber. More over other setting can be used to make absorber perfect.

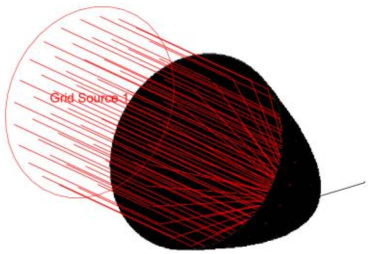
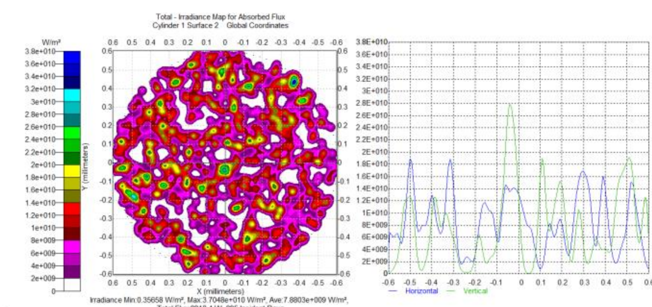


Fig. 3 Simulation of concentrator

III. SIMULATION RESULTS

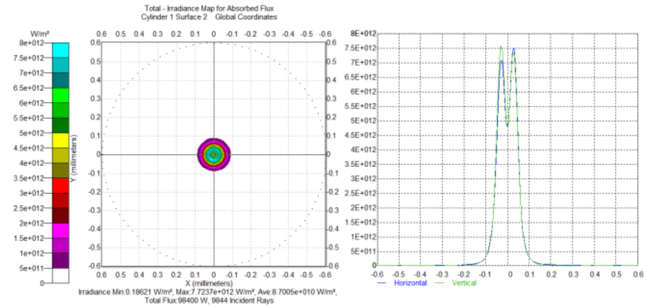
2D irradiance map of absorber without concentrator at a 0^{o} angle with 10000 random rays from grid are shown in Fig 4 (a). The average flux on absorber surface is 7.8×10^{9} W/m^{2}. Figure 4 (b) shows its profile. The blue line represents flux on the horizontal axis and the green line illustrates flux on a vertical axis.



(a) (b)

Fig 4 (a) 2D irradiance map without concentrator at absorber surface. (b):irradiance profile

2D irradiance map of absorber concentrator at a 0^{o} angle with 10000 random rays from grid are shown in Fig 5 (a). The average flux on absorber surface is 8×10^{10} W/m^{2}. Figure 4 (b) shows its profile. The blue line represents flux on the horizontal axis and the green line illustrates flux on a vertical axis.



(a) (b)

Figure 5 (a) 2D irradiance map with concentrator at absorber surface.(b):irradiance profile

V. CONCLUSION

In this research we designed a compound parabolic concentrator using Trace pro. The parameter of design were selected based on the photo diode dimensions, used in OWC systems. For irradiance at absorber simulation was carried out using 10000 random rays both with and without concentrator. The results of irradiance at absorber without concentrator was about 7×10^9 W/m². Similarly the result of irradiance at absorber with concentrator was about 8×10^9 W/m²/ The value is 10 times more than without concentrator and hence it improves the range and quality of OWC signal.

REFERENCES

[1] Ameer, S. A. A., & Shahad, H. A. (2017). Characteristics Review of Optical Concentrators

[2] Borah, D. K., Boucouvalas, A. C., Davis, C. C., Hranilovic, S., & Yiannopoulos, K. (2012). A review of communication-oriented optical wireless systems. *EURASIP Journal on Wireless Communications and Networking*, *2012*(1), 91.

[3] Boucouvalas, A. C. (1996). Indoor ambient light noise and its effect on wireless optical links. *IEE Proceedings-Optoelectronics*, *143*(6), 334-338

[4] Elgala, H., Mesleh, R., & Haas, H. (2011). Indoor optical wireless communication: potential and state-of-the-art. *IEEE Communications Magazine*, *49*(9), 56-62.

[5] Ghassemlooy, Z., & Hayes, A. R. (2003). Indoor optical wireless communication systems–part I. In *Quantum Beam Ltd. Review*.

[6] Henderson, R., & Schulmeister, K. (2003). *Laser safety*. CRC Press.

[7] Ho, K. P., & Kahn, J. M. (1995). Compound parabolic concentrators for narrowband wireless infrared receivers. *Optical Engineering*, *34*(5), 1385-1396.

[6] Hranilovic, S. (2006). *Wireless optical communication systems*. Springer Science & Business Media.

[7] Kahn, J. M., & Barry, J. R. (1997). Wireless infrared communications. *Proceedings of the IEEE*, *85*(2), 265-298.

[8] Koonen, T. (2018). Indoor optical wireless systems: technology, trends, and applications. *Journal of Lightwave Technology*, *36*(8), 1459-1467.