
A Review on Free Space Optical Communication System

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Abstract:

Introduction: Optical wireless solutions are becoming increasingly popular due to their potential for high-speed data transmission. However, atmospheric turbulence can significantly degrade signal performance in Free Space Optical (FSO) communication channels. To ensure efficient data transmission, selecting the optimal modulation scheme is crucial. This study focuses on evaluating different modulation techniques to determine the most effective approach for FSO systems.

Objectives: The primary objective of this research is to examine the best modulation technique for FSO communication systems operating in an FSO channel. The study aims to compare the energy efficiencies, bandwidth efficiencies, Bit Error Rate (BER), and Signal-to-Noise Ratio (SNR) of four modulation schemes: On-Off Keying (OOK), Binary Phase Shift Keying (BPSK), Differential Phase Shift Keying (DPSK), and Quadrature Phase Shift Keying (QPSK).

Methods: A comparative analysis was conducted by evaluating the performance of the selected modulation schemes under standard FSO conditions. The study initially assessed their performance in the absence of atmospheric turbulence, focusing on energy and bandwidth efficiency, BER, and SNR. Additionally, the impact of turbulence was analyzed using a Gamma-Gamma turbulence channel to observe intensity scintillation effects on BER performance.

Results: Numerical studies revealed that BPSK and QPSK outperform OOK and DPSK in terms of BER performance and power consumption. Under turbulent conditions modeled by the Gamma-Gamma channel, the BER performances of BPSK and QPSK were nearly identical. BPSK, in particular, demonstrated strong resistance to turbulence, making it a highly suitable modulation scheme for FSO communication.

Conclusion: FSO communication systems can benefit from using BPSK due to its superior resistance to atmospheric turbulence. The study highlights that among the evaluated modulation schemes, BPSK and QPSK offer the best performance in terms of BER and power efficiency, making them the preferred choices for reliable FSO communication.

Keywords: Free Space Optics (FSO), Optical Wireless Communication, Modulation Techniques, On-Off Keying (OOK), Binary Phase Shift Keying (BPSK), Differential Phase Shift Keying (DPSK).

1. Introduction

Due to its unique qualities, such as exceptionally high capacity, easy implementation, tariff-free available bandwidth, and lower power consumption, WOC communication is described the next barrier for high-speed broadband service. FSO connectivity is ideal for densely inhabited urban regions where road digging is inconvenient. Terrestrial FSO lines can be utilised for short-range (a few metres) or long-range (a few kilometres) communication . Short-range links connect lans sections that are

located within the site or in multiple buildings of the organisation to give social connections to end users.

Long-range FSO networking devices connect wireless systems to existing metropolitan area fibre rings or expand up to existing metro area fibre rings. These connections do not reach end users, but they do provide services to underlying infrastructure. Indoor WOC systems are FSO communication systems that can be placed within a building. With the expansion of technology including portable devices, such as computers, personal digital

assistants, mobile telephonic gadgets, and etc, this short-range interior WOC system is becoming more popular.

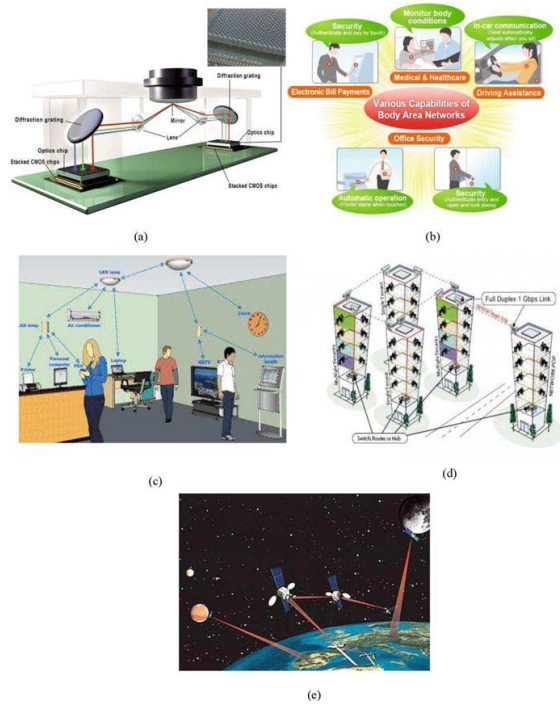


Fig.1. WOC applications include (a) chip-to-chip communication, (b) wireless body area networks, and (c) wireless sensor networks

Indoor WOC links allow for flexible connecting within a facility where establishing a physical cable connection is difficult. The transmitter is made up of lasers or light-emitting leds, and the reception is made up of photodetectors. When contrasted to communication equipment or copper wires wires, these devices and their drive pathways are far less expensive. Furthermore, unlike electromagnetic radiation, which can cause disruptions, indoor WOC is fundamentally safe technology, as photons can not permeate walls and so give a high level of protection against spying. These optical wavelengths either belong to the visible spectrum of light or to the infrared spectrum, which has a very wide (THz) bandwidth. These gadgets are also useful for mobile terminals systems because they require extremely little power.

2. LinkConfigurationsTypes

An indoor optical link's categorization is determined by two key factors: I the broadcaster beam direction, or degree of directional cues, and (ii) the detector's FOV, or whether the recipient's view is broad or narrow. Directional LOS, quasi LOS, dispersed, and

multi-beam quasi diluted links are the four basic types of link configurations based on this.

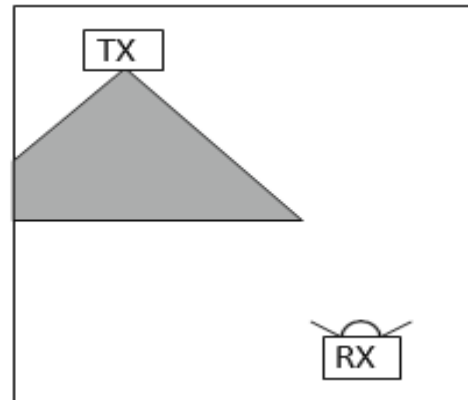


Fig.2 LOS link with many beams that is not directed

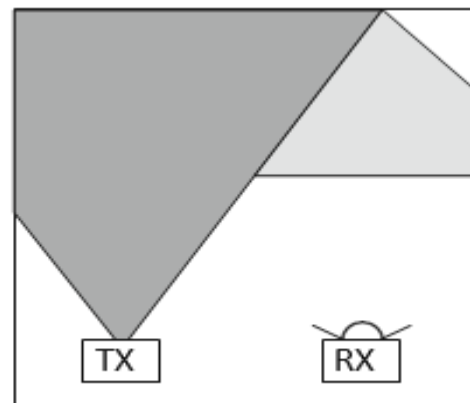


Fig.3 Diffusedlink[14]

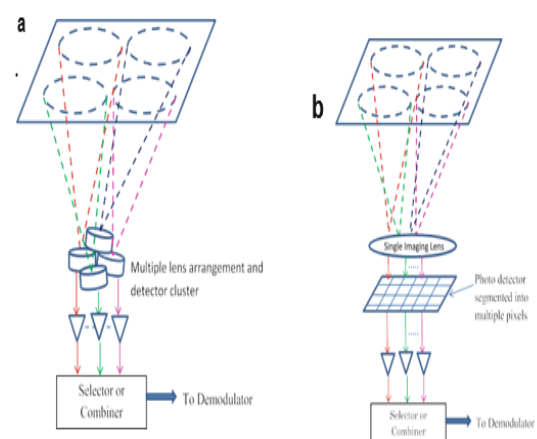


Fig 4: Links with several quasi-diffused beams. (a) A receiver with a multi-lens setup. (b) Transmitter with a single lens configuration

Table 1 Indoor WOC and Wi-Fi systems are compared.

Property	Spectrum licensing		Penetration through walls		Multipath fading	Multipath dispersion
Wi-Fi radio	Yes		Yes		Yes	Yes
IR/VLC	No		No		No	Yes
Implication for IR/VLC	Approval not required	World wide compatibility	Inherently secure	Carrier reuse in adjacent rooms	Simple link design	Problematic at high data rates

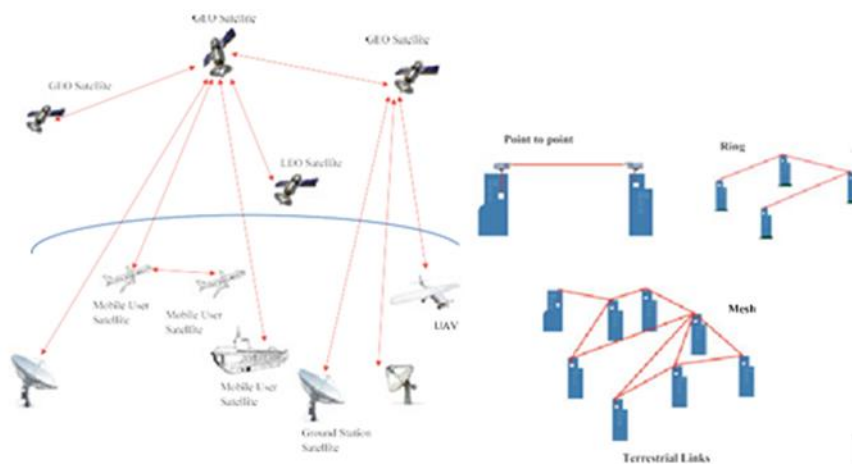


Fig. 5 FSOcommunicationlinksApplications

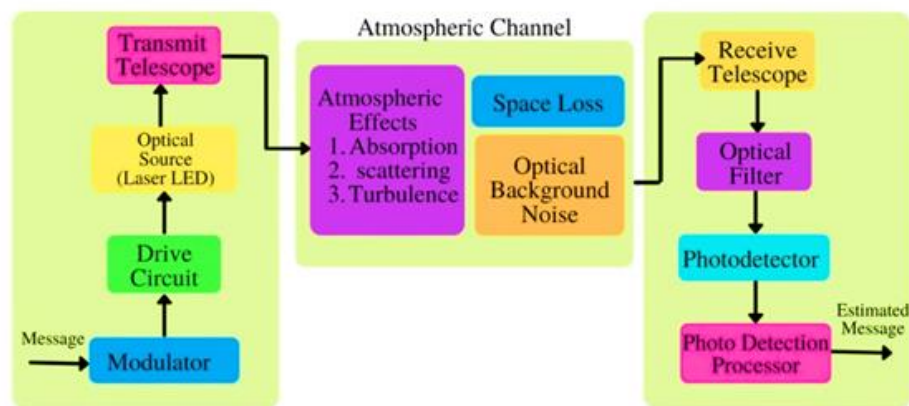


Fig.6 FSOcommunicationlinkBlockdiagram

2.1. SubcarrierModulation

Unlike the OOK system, it does not need a thresholding technique, and it uses less bandwidth than the PPM technique. Because optical SIM inherits the advantages of a more established RF technology, it simplifies the implementation procedure. Simultaneous transfer of several data streams across an optical link is possible using the

SIM technology. Subcarrier multiplexing is accomplished by employing frequency-division multiplexing (FDM) to combine different modulating electric subcarrier signals, which are then utilised to control the intensity of a steady light beam that functions as the optical signal. The SIM objective lens for the FSO link is depicted in Figure 1.16. The drawback of this multiplex system is the

receiver's tight synchronisation and design intricacy.

Figure 1.17 depicts the most frequently used modulator techniques in FSO systems. The selection of an appropriate modulation technique

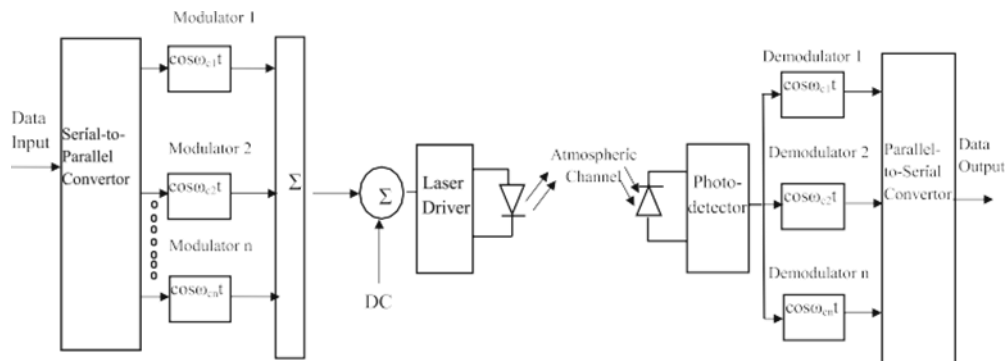


Fig.7 SIMforFSOlink

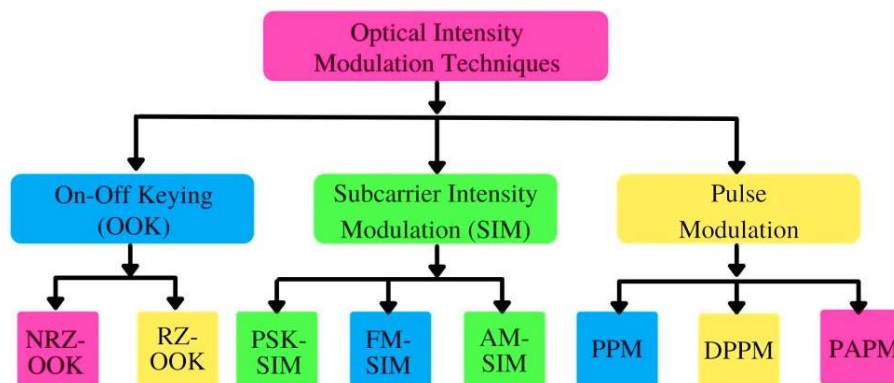


Fig.8 In the FSO system, there are several modulation techniques.

2.2 Outdoor FSOCommunication

For data to be transmitted from one place to another, FSO communication needs a line-of-sight link between the sender and receiver. The message signal from the source is modified on the optical signal, which is then permitted to propagate toward the reception over the atmospheric route or space available rather than directed optical fibres. The

transmission of a laser system through the air and into free space is involved in ground-to-satellite and satellite-to-ground communications. As a result, these connections are a mix of earthly and interplanetary linkages. The main applications of FSO links are depicted in Figure 1.8.

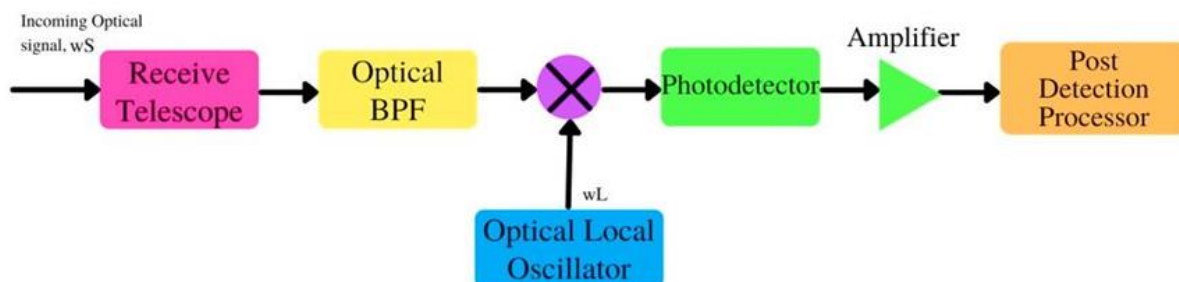


Fig.9 Coherent optical communication system block diagram

2.3 Coherent Detection

The incoming signal is combined with a locally produced coherent carrier wave from a specific frequency in an efficient detection receiver. The photodetector amplifies and turns the optical signal to electrical signal by combining the incoming weak light beam with the strong LO signal.

3. Conclusions:

As a response, the BPSK has changed. In this situation, the evaluation of the above-mentioned modulating scheme evaluation was finished successfully. Even when atmospheric interruptions are taken into consideration, BPSK and QPSK modulating perform much better in terms of BER than OOK and DPSK modulation, according to both analytical and empirical investigations. After account for atmospheric variations, the mean BER efficiency of the modulation techniques indicates a direct decrease. In both low and high turbulence, the BER performance of the BPSK and QPSK versions is almost identical. Experiments have shown that BPSK has good turbulent resistance in a variety of turbulence conditions. QPSK surpasses the competition by a factor of 2 in terms of spectrum efficiency.

Conflict of interests

The authors declare that they have no conflicts of interest.

Availability of data and materials

Not applicable

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