

PERFORMANCE OF IsOWC WITH VARIOUS MODULATION TECHNIQUES

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ABSTRACT

Inter-satellite optical-wireless communication systems (IsOWC) is one of the imperative utilizations of Free Space Optics/Wireless Space Optics (FSO/WSO) innovation which is an optical communication technology using light propagating in free space to transmit data between two different points. IsOWC system consists of transmitter and receiver communicating with optical wireless communication. Optical Communication systems have developed from long fiber to intense remote framework. This has subsequently come about in the use of optical remote correspondence framework in space interchanges. As the number of satellites circling Earth increment year by year, a system between the satellites gives a technique for them to impart with each other. This is imperative for satellites to send data to one another moreover to transfer the data from one satellite to another satellite, at that point to the ground stations. By utilizing laser satellite communication, the satellites can be associated with information rates up to a few Gbps. This objective will present the optical wireless communication (IsOWC) join execution centering on information exchange between Low Earth Orbit satellites by using various PSK techniques. The performance execution counting input power, range, amplifier and photo detector gain on an ISL were examined.

Keywords: *Inter satellite optical wireless communication (IsOWC), Inter satellite link (ISL), optical wireless communication (OWC), Bit error rate (BER)*

I INTRODUCTION TO IsOWC

An optical fiber is a cylindrical shaped dielectric waveguide (non conducting waveguide) that transmits light along its axis, by the procedure of total internal reflection. The process of communicating using fiber-optics involves the following basic steps: creating the optical signal involving the use of a transmitter, relaying the signal along the fiber, ensuring that the signal does not become too distorted or weak, receiving the optical signal and converting it into an electrical signal [1]. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals. Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications.

However, infrastructure development within cities was relatively difficult and time-consuming and fiber-optic systems were complex and expensive to install and operate. Due to these difficulties, fiber-optic communication systems have primarily been installed in long-distance applications, where they can be used to their full transmission capacity, offsetting the increased cost. There are a few orbits accessible for satellites to live and that are Low Earth orbit (LEO), Medium Earth orbit (MEO), highly elliptical orbit (HEO) and Geosynchronous orbit (GEO). Inter satellite link communication is very beneficial [2, 3]. Low-Earth Orbit (LEO) is the region of space around the Earth below an altitude of 2,000 kilometers. LEO satellites take around two to four hour to rotate around the earth. LEO is used for multi satellite constellation and in that constellation multiple satellites are used to perform a single task. The MEO (medium earth orbit) ranges from 10000 to 20000 Km and it has time period of four to twelve hours and it can be used for remote sensing purpose. For communication purpose like telephone services and for broadcasting Geosynchronous orbits (GEO) are used that have an altitude of around 36000 Km. It takes a day to revolve around the Earth and seems to be stationary at any point of the earth.

For the IsOWC system the low Earth orbit is an important parameter as the signal is transmitted from earth station to the satellite. So range of the Low Earth Orbit is important factor that is taken in consideration while designing the system [4]. For LEO satellites, a gathering of satellites can be sent to space with a typical mission and direct communication link between them will permit faster communication and make the satellites less dependent on a ground station. Satellite groups of stars, for example, Iridium satellites have as of now use between satellite connection in their mission. Between satellite connections can likewise be utilized between satellites at various orbits, from GEO to LEO satellites for example [5].

The advanced modulation plans are researched for the Inter-satellite optical remote correspondence for the better execution. In portable satellite correspondence, the most generally utilized computerized balance frameworks have been PSK, DPSK and diverse types of QPSK. At the point when the phase of the carrier wave is changed with reference of the modulating signal then the resultant adjustment plan is termed as Phase Shift Keying. Offset quadrature phase shift keying (OQPSK) is a variation of phase movement keying modulation utilizing 4 diverse estimations of the stage to transmit. Differential Phase Shift Keying (DPSK) is an optical balance position in which event of π phase change between progressive bits speaks to logic 1 and when there is no stage change then it speaks to logic 0. The signal optical power stays fixed in DPSK plan [6, 7].

II SYSTEM DESCRIPTION

The optical wireless comprises of transmitter, spread medium and collector i.e. receiver. Figure 1 demonstrates the fundamental piece chart of an IsOWC framework where the transmitter is in the primary satellite and the receiver is in the second satellite. The free space between the satellites is the OWC station that is use to transmit the light signal [8].

The IsOWC transmitter receives data from the satellite's Telemetry, Tracking and Communication (TT&C) system. The data that usually transmitted by a satellite are such as the satellite position and attitude tracking, captured image for remote sensing satellite, or even voice data for telephone network relaying satellite.

So, this is the block diagram of inter satellite optical wireless communication in which different modulation techniques are used and to check the performance of this model this is designed in the OptiSystem software.

In this, the IsOWC simulation and modeling done in OptiWave OptiSystem software. We have studied the comparison of various PSK modulations and analyses the performance for low earth orbit satellite communication [9, 10]. From the IsOWC model and simulation results, it can be concluded that the received error increases as the distance between the satellites increase. Even so, optical wireless signal can travel further than using RF system. It can also be concluded that the IsOWC system can perform better by having an amplifier to travel further transmission at 1550 nm. 1550nm is used to reduce the effect of scattering and for its compatibility with existing devices. It has been shown from simulation results that DPSK shows better BER in all cases that we studied in this chapter because DPSK is simpler than all and lesser spectral contents [11, 12].

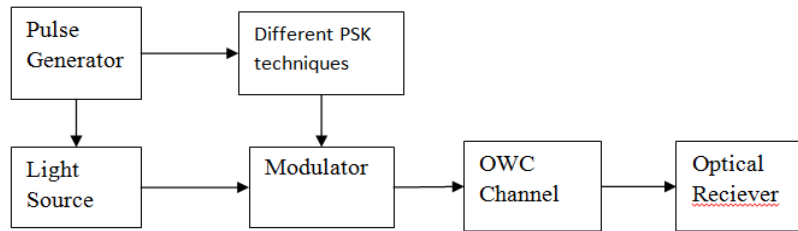


Figure 1 Block Diagram of IsOWC with QAM [10]

The simulation models inter-satellite links between satellites as shown in Figure 5.2. OptiwaveOptiSystem software is used to simulate the model. The circuit using OptiSystem of an inter satellite link between two adjacent satellites [13, 14]. Therefore in order to analyze the IsOWC system, communication between two satellites is used. In the chosen model satellite 1 is the transmitter and the satellite 2 is the receiver. The propagating medium is the optical wireless channel. Quadrature Amplitude Modulation technique is chosen. The transmitter includes a laser source, a telescope and a tracking system. The receiving module includes a telescope, photo detector and a tracking system. The transmitter converts the electrical signals into optical signals by using the laser [15, 16].

Table 1: System Parameters used in the Simulation

Parameters	Values
Techniques used	PSK, OQPSK, DPSK
IsOWC Wavelength	1550 nm
Bit Rate	2.5 Gbits/s
Modulator/Demodulator Frequency	50 GHz
Transmitter Aperture Diameter	15 cm
Reciever Aperture Diameter	15 cm
Attenuation/Additional Losses	0 Db

III GRAPHICAL RESULTS

For low earth orbit satellites, comparing PSK, OQPSK and DPSK modulation in terms of BER. Less bit-error rate (BER) which leads to better performance of the system. So from the graphical representation it can be concluded that which modulation is best for low earth orbiting satellites.

3.1 Range Vs BER

In this, distance is set from 1500 km to 2000 km because Low-Earth Orbit (LEO) is the region of space around the earth below an altitude of 2,000 kilometers. The input optical power is maintained at 10dBm and the transmit wavelength is 1550 nm.

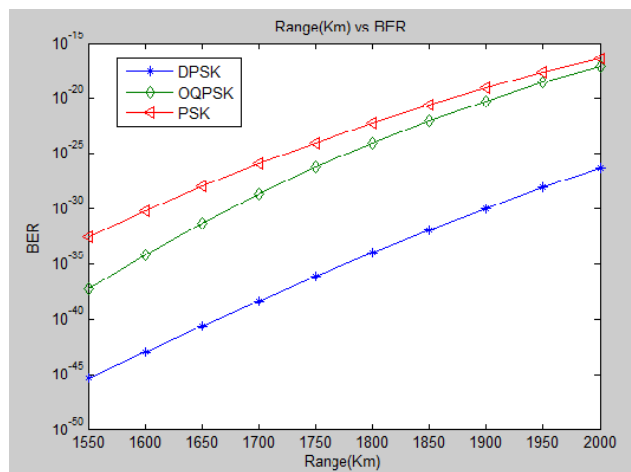


Figure 2 Range Vs BER

From the graph, it can be seen that as the range increases BER increases for all three modulations. But it can be concluded from the graph that at minimum distance or at maximum distance better BER achieved in the case of DPSK. At distance 2000 km, the IsOWC can only be received at BER 10^{-27} , 10^{-18} and 10^{-17} and at minimum distance i.e. 1550 km according to graph received BER at 10^{-47} , 10^{-38} and 10^{-33} . So it can be observed that DPSK has better BER as compared to PSK and OQPSK.

3.2 Photo detector Gain Vs BER

In this, distance is maintained at 2000 km because Low-Earth Orbit (LEO) region is the region of space around the earth below an altitude of 2,000 kilometers. The input optical power is maintained at 10 dBm and the transmit wavelength is 1550 nm. But Avalanche photo detector gain is set from 1.5 dB to 5.5 dB.

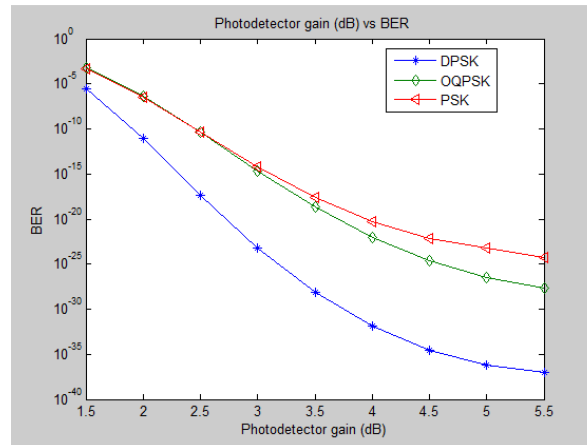


Figure 3 Photo detector gain Vs BER

From the graph, it can be seen that as the Photo detector gain increases BER decreases for all three modulations. BER decreases i.e. higher Q-factor is obtained. By default the value of photo detector gain is 3dB and from the graph it can be observed that below 3dB not acceptable BER is achieved and as studied it also not linear after 6dB i.e. increase or decrease simultaneously. But it can be concluded from the graph that at minimum gain or at maximum gain better BER achieved in the case of DPSK.

At gain 5.5 dB, the IsOWC can only be received BER at 10^{-25} , 10^{-29} and 10^{-38} and at minimum gain i.e. 1.5dB according to graph received BER at 4.9×10^{-4} , 6.3×10^{-4} and 2.9×10^{-6} . So it can be observed that DPSK has better BER as compared to PSK and OQPSK.

3.3 Laser Power Vs BER

In this, distance is maintained at 2000 km because Low-Earth Orbit (LEO) region is the region of space around the earth below an altitude of 2,000 kilometers and the transmit wavelength is 1550 nm. But input power is set from 6 dBm to 14 dBm. The input power is given through CW laser's power which then passes to the receiver followed by the Optical Wireless channel.

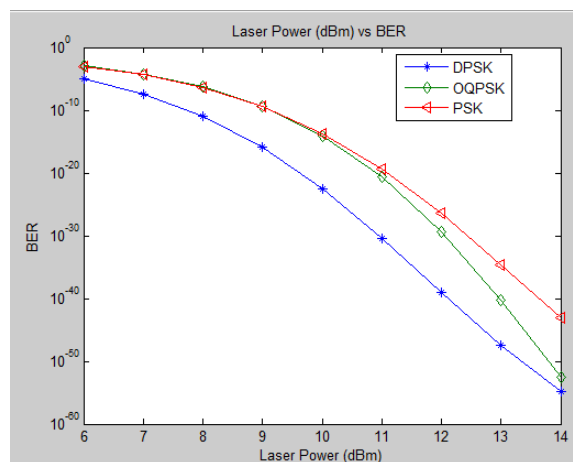


Figure 4 Laser Power Vs BER

From the graph, it can be seen that as the Laser Power increases BER decreases for all three modulations. BER decreases i.e. higher Q-factor is obtained. By default laser power set at 10 dBm. But it can be concluded from the graph that at minimum power or at maximum power better BER achieved in the case of DPSK. As seen from the graph, PSK and OQPSK have approximately same BER from starting but at power 10dBm we can clearly see the difference in both modulation's BER. In case of minimum power, only DPSK give acceptable BER and at the maximum power i.e. 14 dBm all three give better result but DPSK achieved best BER. From PSK and OQPSK, OQPSK give better result after 10 dBm.

At power 14dBm, the IsOWC can only be received BER at 10^{-45} , 10^{-53} and 10^{-55} and at minimum power i.e. 6dBm according to graph received BER at 10^{-4} , 10^{-3} and 10^{-6} . So it can be observed that DPSK has better BER as compared to PSK and OQPSK. BER is less from low power but as we increase power better result achieved.

In this, distance is maintained at 2000 km because Low-Earth Orbit (LEO) region is the region of space around the earth below an altitude of 2,000 kilometers. The input optical power is maintained at 10 dBm and the transmit wavelength is 1550 nm. But Amplifier gain is set from 11 dB to 19 dB.

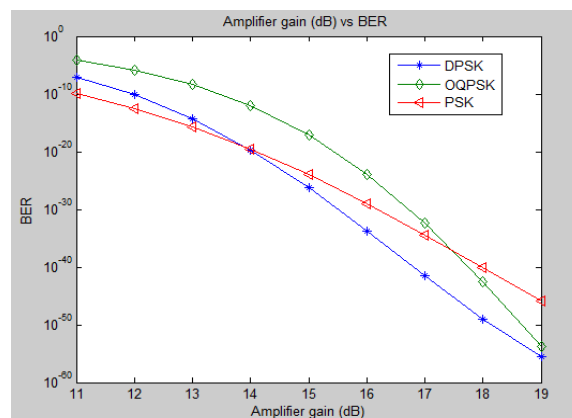


Figure 5 Amplifier Gain Vs BER

From the graph, it can be seen that as the Amplifier gain increases BER decreases for all three modulations. BER decreases i.e. higher Q-factor is obtained. By default the value of amplifier gain is 15dB. But it can be concluded from the graph that at minimum gain better BER achieved in the case of PSK and at maximum gain better BER achieved in the case of DPSK. As seen from the graph, PSK have better BER from starting but at gain 14dB we can clearly see the difference in all modulation's BER. At 14dB PSK results degrade as compare to the DPSK and at 17dB OQPSK cross PSK line and shows better results than PSK but slightly less than DPSK.

At gain 11dB, the IsOWC can only be received BER at 10^{-10} , 10^{-5} and 10^{-8} . So in this case PSK gives better BER as compared to DPSK and OQPSK and at maximum gain i.e. 19dB according to graph received BER at 10^{-46} , 10^{-54} and 10^{-56} . So in this case it can be observed that at maximum gain DPSK has better BER as compared to PSK and OQPSK.

IV CONCLUSION

In this, the IsOWC simulation and modeling done in OptiWave OptiSystem software. We have studied the comparison of various PSK modulations and analyses the performance for low earth orbit satellite communication. From the IsOWC model and simulation results, it can be concluded that the received error increases as the distance between the satellites increase. Even so, optical wireless signal can travel further than using RF system. It can also be concluded that the IsOWC system can perform better by having an amplifier to travel further transmission at 1550 nm. 1550nm is used to reduce the effect of scattering and for its compatibility with existing devices. It has been shown from simulation results that DPSK shows better BER in all cases that we studied in this chapter because DPSK is simpler than all and lesser spectral contents.

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