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RESEARCH ARTICLE

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COMPARISON OF OPTICAL WIRELESS AND FREE SPACE OPTICS CHANNELS FOR INTER SATELLITE OPTICAL WIRELESS SYSTEM (ISL) USING QPSK MODULATION

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ABSTRACT

An improved performance of optical wireless transmission system obtained from wireless system which deployed the lengthy fibres. Inter satellite optical wireless communication (IsOWC) is one of the important applications of free space optics (FSO) technology will be deployed in space in the near future for providing power efficient and high bandwidth allocation facilities unlike present microwave satellite system . This paper explores the digitally implemented QPSK system in inter satellite link for free space optics and optical wireless channel (OWC). This proposes a transmission link model to dissipate the minimum power, minimum bit error rate (BER) and high quality factor (Q-factor). We have taken bit rate of 2.5Gbps for both channels corresponds wavelength range to OWC is 800nm and for FSO is 1550nm and compare the performance in term of eye diagram. The simulated model developed using optisystem have integrated system for both OWC and FSO channels.

Keywords—FSO, OWC, IsOWC, Quadrature phase shift keying (QPSK), Q-factor, BER, Inter satellite link (ISL).

1 INTRODUCTION

Laser communication link is a rapidly developing technology that has recently found applications in several areas including all indoor and outdoor optical networks and free space optical (FSO) links. [3]. Laser communication links in space are Laser sources are capable of transmitting data up to rate of 1 Gbps and at thousands of kilometres without any error. This has forces us to adapt optical communication technology in our space satellite systems; hence for these reasons inter satellite optical links (OISL) has developed [6]. ISL link based on line of sight (LOS). To connect satellites of same orbit as well as of different orbits, IsOWC system is to be employed. To sends the data for thousands of kilometres using small payload size optical communication is to be required.. The first inter satellite link communication using optical link was successfully achieved on March 2003 between advance relay and technology mission satellite (ARTEMIS) & SPOT-4 [5]. An IsOWC system offers a high bandwidth, small size, low power and Low cost compare to microwave satellite systems [5]. Laser exhibits narrow beam width compare to RF system [1]. In IsOWC system the main focus is to dissipate minimum power and to obtain minimum BER.

2 SYSTEM MODEL

IsOWC system uses a laser beam as a wireless connectivity between transmitter and receiver for carrying information and propagation medium is free space. IsOWC system is not much different for free space optics and fibre optics communication where the difference relies in propagation medium. Thus the selection of modulation technique is a vital role in the design process of the system [4]. Modulation technique is one of the most significant processes in ISL system where the RF electrical signal is applied to methods are of two types: direct modulation and external modulation. In direct modulation the amplitude of laser beam suffers from a laser frequency chirp effects degrade the performance of the system. This can be eliminated by using external modulation scheme that is used to modulate the phase of optical carrier [2] This is proposed model for ISL system. Basic model of the system consist of 3 main parts transmitter, receiver and propagation medium. For IsOWC system, the coverage distance required is of the order of thousands of kilometres, thus it uses only LOS system.

Transmitter consists of pseudo- random bit sequence (PRBS) generator followed by an optical transmitter. The output of the transmitter given to the propagating channel, which consists of transmitter telescope, the wireless communication channel and the receiver telescope. The output of the receiver telescope is given to the optical QPSK receiver, which coherently detects the optical signal using a local oscillator (laser). It uses a balanced-detection technique and produces the information signals in the electrical domain. Then the electrical signal is amplified, filtered using a low pass filter and given to the input of an M-array threshold detector. Then the PSK decoder is used to produce binary sequences. Hence, the bit error rate (BER) analyzer is used to observe the BER, eye diagram, eye opening etc.

2.1 PROPAGATING CHANNELS

There are two type of channels which are used i.e. for propagating medium in inter satellite optical wireless communication.

1 optical wireless channel
2 free space optics channel

2.1.1 OPTICAL WIRELESS CHANNEL (OWC)

Optical wireless communication is a type of communication system that uses the atmosphere as a communication channel. It is not much different than the FSO channel but the difference realise only in the propagation medium [8]. OWC system is attractive to provide broad band services due to their inherent wide bandwidth, easy deployment and no license requirement.

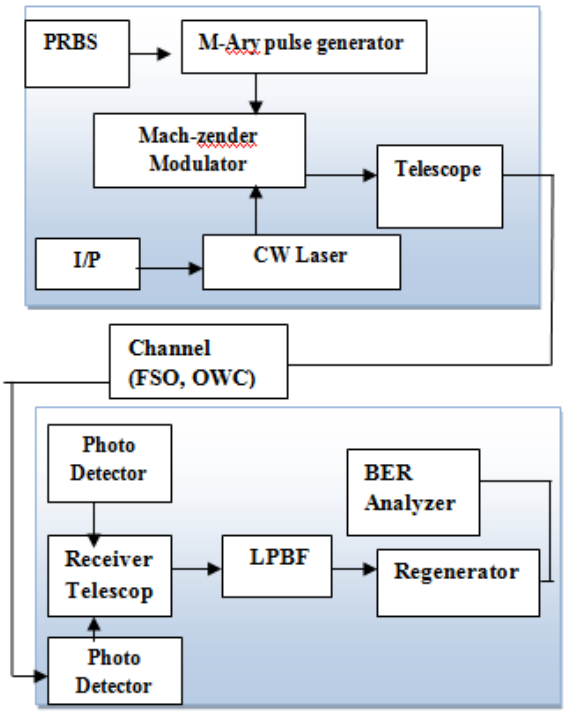

Figure 1. IsOWC System Block Diagram [2]

2.1.2 FREE SPACE OPTICS (FSO)

Free space means air, outer space, vacuum or something similar and free space optics communication meaning that the transmission of modulated or visible light or infrared beams through the atmosphere to obtain optical communication [7]. FSO system has another advantage that FSO is that it is unaffected by electromagnetic interference and radio frequency interference which increasingly plague radio based communication system.FSO communication system will be most secure and high speed medium of data transmission

3. SIMULATION PARAMETERS

The Proposed IsOWC system as shown in figure is designed and simulated for optical signal of wavelength 800nm for OWC and 1550nm for FSO channel using QPSK modulation. The selection of optical wavelength for FSO and OWC system especially ISLs is primarily based on optical transmission windows, eye safety reasons, of course

expenses, atmospheric effects, the availability of receiver and transmitter components as well depending on the desired applications [3]. The parameters are considered as per the practical scenario of IsOWC and the telecommunication standardisation sector of the international telecommunication union (ITU-T) [5].

Table 1. Simulation parameters of IsOWC System

Parameter	Value
Wavelength	800nm –OWC 1500nm-FSO
Bit rate	2.5Gbps
Targeted BER	10^{-9}
Link distance	3800km
Sequence length	64
Samples per bit	128
Modulation	QPSK
Laser frequency	193.2 THz
Laser power	2 and 3 dBm
Transmitter aperture diameter	15cm
Receiver aperture diameter	15cm
Optical QPSK receiver power	11dbm
Responsively of PIN,A/W	1
Dark current, nAmp	10

For Proposed model of IsOWC system using OWC channel having bit rate of 2.5 Gbps. Input power is 2 and 3 dBm is applied with wavelength of 800nm and 1550nm for OWC and FSO channels.

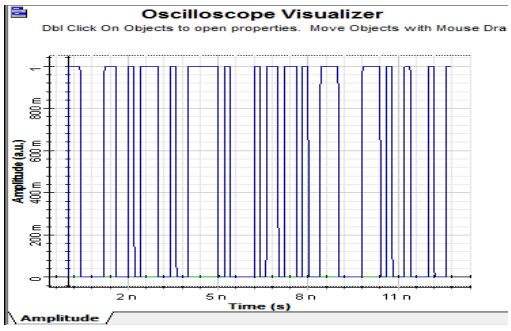

Figure 2. Output of electrical signal for IsOWC system using OWC channel

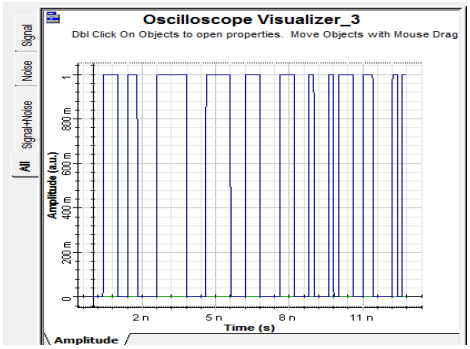

Figure 3. Output of electrical signal for IsOWC system using FSO channel

Figure 2 and 3 shows the electrical signal for OWC and FSO channels using oscilloscope visualizer. Optisystem can propagate the signal and noise separately, so in oscilloscope visualizer, to visualize electrical signals in time domain with an oscilloscope.

The eye diagrams of OWC and FSO channel are shown in figure 4 and 5.

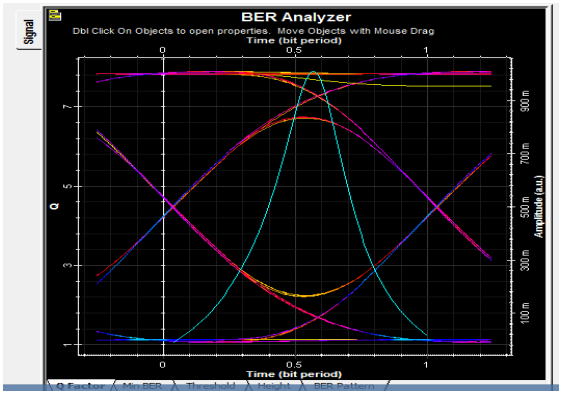

Figure 4. Eye diagram of QPSK using OWC system

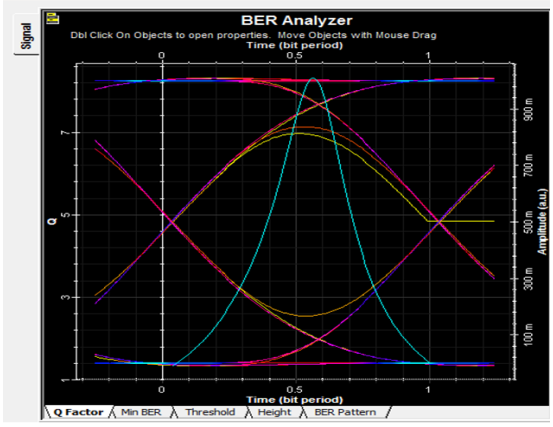

Figure 5. Eye diagram of QPSK using FSO.

From figure 4 and 5, graph clears the comparison of OWC and FSO channel for IsOWC system using QPSK modulation in term of Q- factor and BER. It is clear from the results that system performance is affected by the power variation. The eye diagram for both of channel is compared in term of Q-factor and BER

5 GRAPHICAL RESULTS

5.1.1 Q- factor Vs bit period

Q-Factor is a measurement of signal quality. For the performance of any system higher value of Q- factor is requirement.

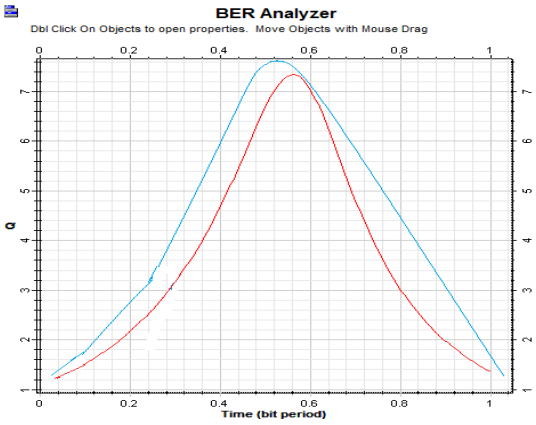

Figure 6. Q- Factor Vs Bit Period

From the graph it is clear that Q factor of FSO is better than OWC system and FSO (In Blue) has high Quality factor than OWC System (In Red).

5.1.2 BER vs. Bit Period

As BER is inversely proportional to Q- factor. Therefore if the system error decreases the BER will thus decrease.

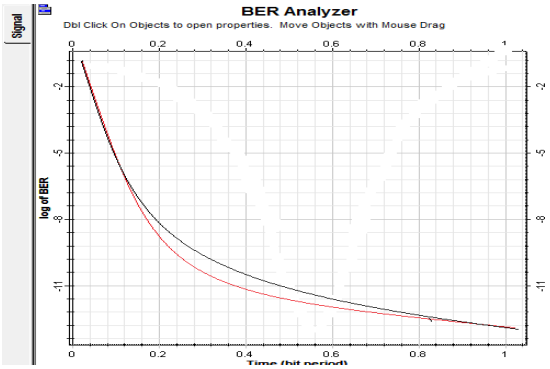

Figure 7. BER vs. Bit period

Graph shows that the BER of FSO channel decrease must increases the Q- Factor. BER of FSO is in red and for OWC BER plot is in blue.

The table shows the comparison of FSO and OWC channel using QPSK modulation.

Table 2. Comparison Table

Parameter	FSO	OWC
Modulation Type	QPSK	QPSK
Max Q – Factor	7.91235	7.26951
Min BER	$1.24739e^{-015}$	$1.7320e^{-013}$

This shows that the BER and Q-factor of FSO channel is better than the OWC Channel, but For greater than thousands of kilometre OWC system is better for inter satellite link.

6 CONCLUSION

The objective of this paper is to optimize the ISL Performance in term of Q- factor and Bit Error Rate. This paper considered the impact of comparison of OWC and FSO channel by QPSK modulation in ISL system using optisystem software and various parameters such as Q-factor, BER, Eye diagram etc. were compared for different categories of channel OWC and FSO. The system may further be analyzed for advance modulation formats and also for high coverage distances.

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