Empirical Performance Comparison of ISI Minimizing Techniques (OFDM vs Polarization Interleaving) based on IS-OWC WDM System

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Abstract – This research is intended to have the experimental performance comparison of two inter-symbol interference minimizing techniques, Orthogonal frequency division multiplexing and Polarization Interleaving in an inter-satellite optical wireless channel 8x1 wavelength division multiplexed system. Results of the experiments can be observed with the help of BER, SNR vs Range, SNR vs transmitter and receiver pointing errors, received signal power vs range graph reports for both the techniques. Comparison and conclusion has been made on the basis of above mentioned graphical reports.

Key Words: BER, ISI, SNR, IS, OWC, WDM, OFDM, QAM, QPSK etc.

1. INTRODUCTION

In telecommunication, inter-symbol interference (ISI) is a form of distortion of a signal in which one symbol interferes with succeeding symbols. This is an undesirable phenomenon because the preceding symbols acts as noise, therefore making the communication system less dependable. The pulse spreading outside its fixed time interval roots it to interfere with its adjacent pulses. ISI is usually caused by multipath propagation or the inherent linear or non-linear frequency response of a communication channel causing consecutive symbols to "blur" together.

The presence of ISI in the system introduces errors in the decision device at the receiver output. Therefore, in the design of the transmitting and receiving filters, the ambition is to minimize the effects of ISI, and thus deliver the digital data to its terminus with the minimum error percentage conceivable.

In this research, we have made our major concern in enhancing the overall performance of an Is-OWC WDM system. From the various methodologies of reducing the inter-symbol interference in an optical communication link, we have performed an empirical research on the two ISI minimising and system performance enhancing techniques such as orthogonal frequency division multiplexing and Polarization Interleaving, both implemented with the WDM system having an Is-OWC link.

By having the detailed analysis of previous work done in the field of Is-OWC link implemented with WDM system, taking into consideration, the work done by Sushank Chaudhary, having an experimental evaluation of the performance comparison of a 4 QAM and 4 QPSK in OFDM based Is-OWC system. Manbir kaur, performance analysis of optical orthogonal frequency division multiplexing transmission systems. We aim towards the negligible error inter-satellite transmission with highest capacity as possible.

1.1 Optical Orthogonal Frequency Division Multiplexing

The term "optical" has been prefixed with the name of the digital modulation scheme OFDM because this system is made a hybrid optical OFDM system on combining the optical transmitters and receivers and providing a suitable interface to it. The system consists of an FFT/IFFT computation, QAM/QPSK sequence generator and decoder, D/A and A/D converters and Mach-zehnder optical modulator. The signal processing in OFDM receives benefit of the efficient low computation complexity algorithm of FFT/IFFT. Furthermore, the cyclic prefix code property makes the system resistant to ISI caused due to the chromatic dispersion and polarization mode dispersion.

1.2 Polarization Interleaving

To alleviate the impact of inter-channel non linearities in a communication system, polarization Interleaving plays a vital role. In this method, the neighbouring bits in a channel are orthogonally polarized. Channels are separately categorized as even and odd channels and are multiplexed together being in two separate even and odd branches.

The states of polarization of both the branches are adjusted with the help of polarization controllers such that they are orthogonal. The signal at both the branches are combined with the help of a device called as polarization combiner or polarization inter-leaver. This device is used to create a WDM signal having orthogonally polarized channels mutually.

At the receiver end, polarization splitter device is used to regain the message signal employed before the WDM de-mux.

2. System designs

The schematic block diagrams of both the systems are shown below whose performance comparison have been done.

2.1 Hybrid Is-OWC OFDM WDM system design

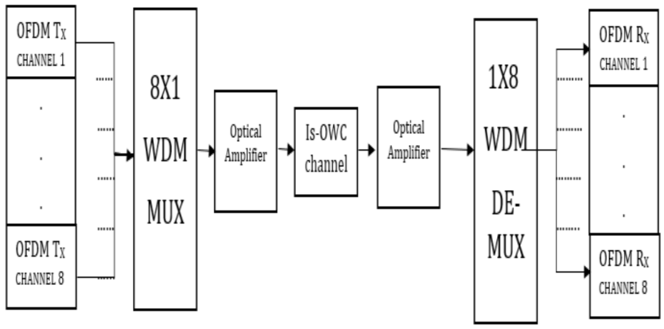


Fig. 1 Block diagram of an Is- OWC OFDM WDM SYSTEM

The block diagram shown above is our designed system module which contains an eight channel OFDM transmitters each having a bit rate of 20 Gbps i.e 20x8 Gbps, are multiplexed with the help of an 8x1 WDM MUX. The optical signal obtained from the mux is amplified with an Optical amplifier. The transmitted signal is passed via an Is-optical wireless channel having a range of 10,000 km and antenna aperture as 15cm, 20cm respectively. The obtained signal is post amplified and fed to the 8x1 WDM de-mux and the desired information from the received signal is extracted with the help of receivers.

2.2 Is-OWC WDM system with polarization-interleaving

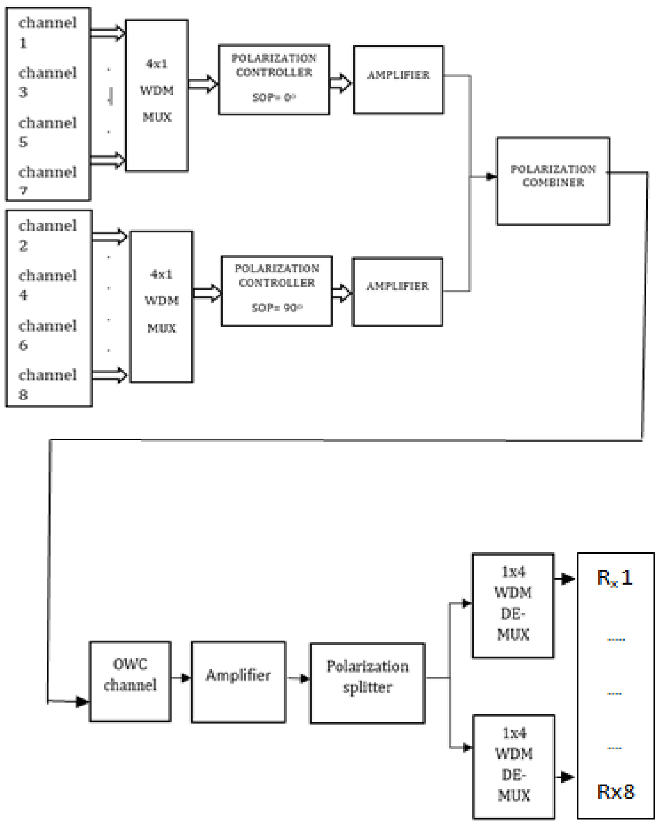


Fig.2 Block diagram of Is-OWC WDM system with polarization-interleaving

The above depicted block diagram is the implementation of polarization interleaving with 8x1 WDM. The system parameters here are similar to that of the OFDM system i.e range of transmission, antenna aperture, input power of laser and bit rate. As shown in the fig:2, even and odd group of channels are separated and multiplexed by using 4x1 WDM MUX for each. Output signal from each branch is fed to the polarization controller. The state of polarization is set to 0° for odd channels and 90° for even channels so that these signals can be orthogonal. Pre and post amplification has also been employed here. At the receiver side, a device used for splitting the polarization of the obtained signal is employed known as polarization splitter. Setting its angle = 0° for odd channels and 90° for even channels respectively. The signal from the polarization splitter is fed to 1x4 WDM for each odd and even channel receivers and the desired signal is obtained with the help of the optical receivers.

Table -1: System parameters taken into consideration

s.no.	Parameter	OFDM	Polarization Interleaving
1.	Input power	30dbm	30dbm
2.	Bit-rate	20x8=160gbps	20x8=160gbps
3.	channels	8	8
4.	Distance for transmission	10,000km	10,000km
5.	Antenna aperture	15 cm, 20cm	15cm, 20cm
6.	Circuit complexity	More	Very less
7.	T_x & R_x pointing error	1, 2, 3 micro radian (sweep iteration)	1, 2, 3 micro radian (sweep iteration)
8.	Laser line width	10 MHz	10 MHz
9.	Resolution bandwidth	0.1 THz	0.1 THz
10.	Reference bit-rate	5 Gbps	-
11.	No. of subcarriers	64	-
12.	Position array	256	-
13.	No. of FFT points	128	-
14.	Cyclic prefix	1 to 8 bits	-

3. Results

On the basis of the performed simulations of both the designed systems using optisystem 15, results of the received output signal were observed. Results were observed in different forms such as the electrical constellation diagram, BER, Eye diagram, SNR, received signal power compared to the range of transmission as well as pointing error.

Results obtained from the hybrid system of **OFDM** are shown below.

3.1 Transmitted signal power spectrum (OFDM)

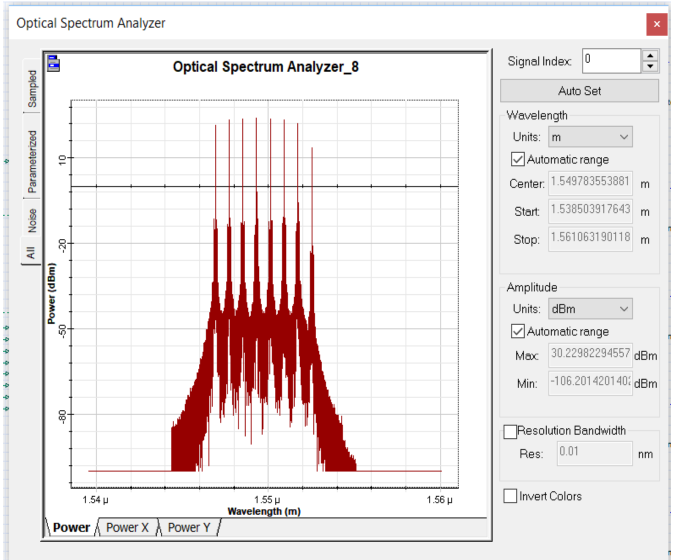
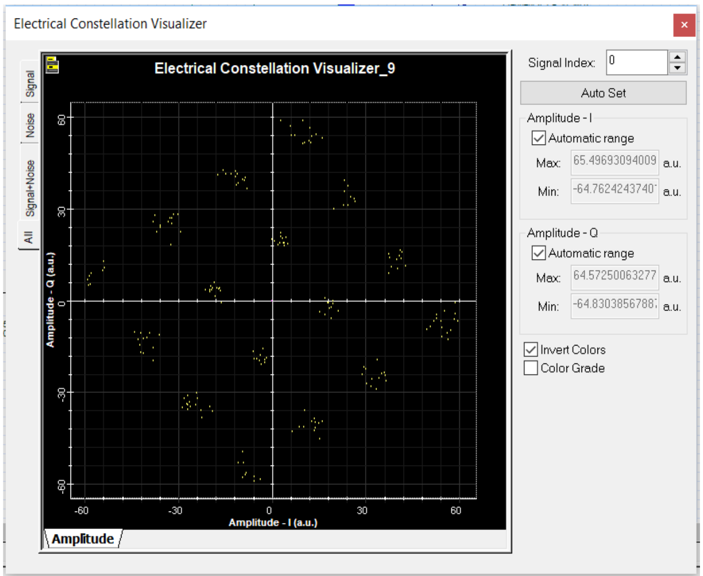
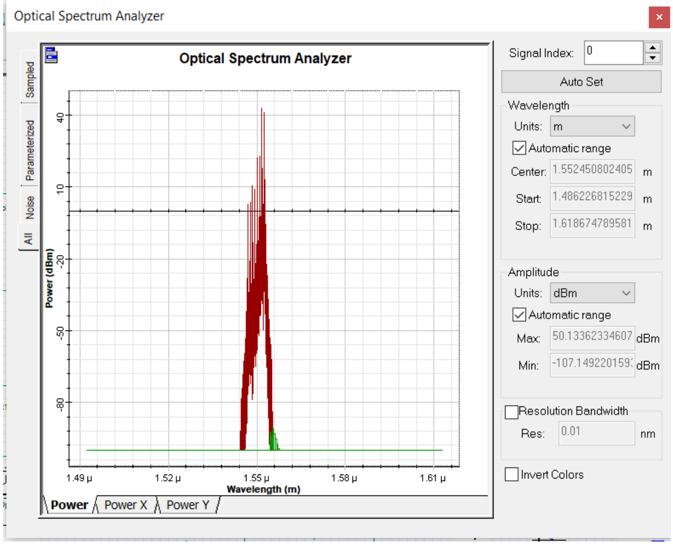


Fig: 3 transmitted signal power spectrum of OFDM

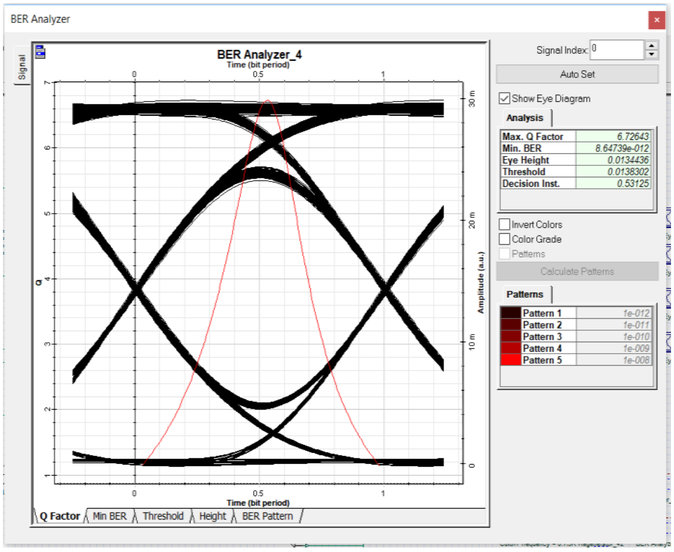
3.2 Received signal electrical constellation diagram (OFDM)



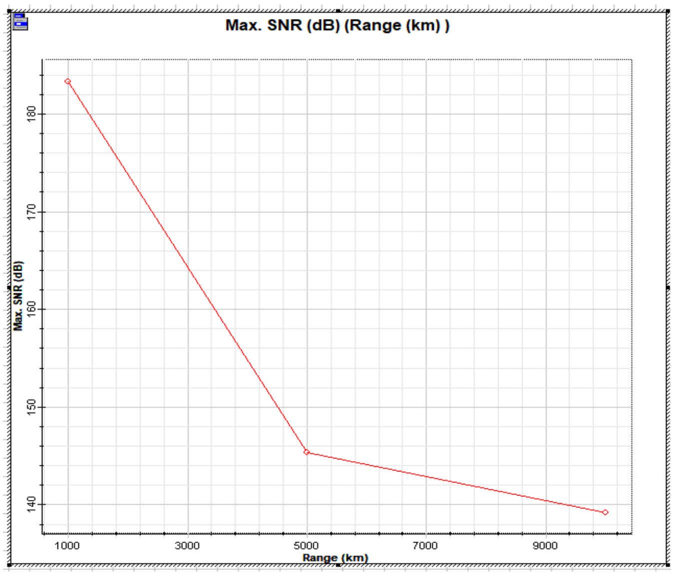
3.3 Transmitted signal power spectrum for (polarization interleaving)



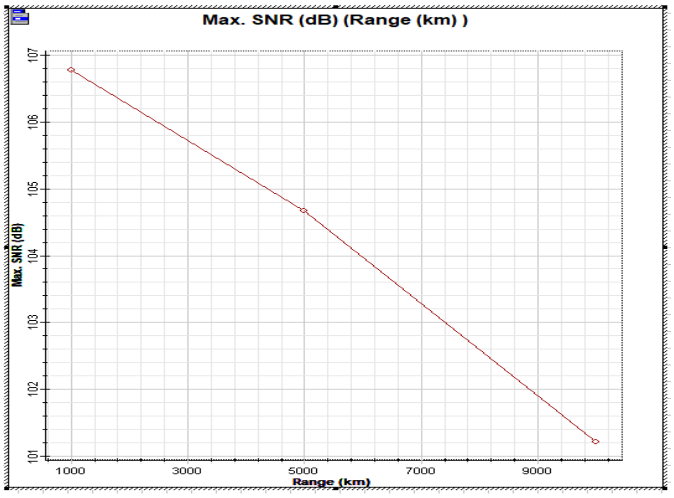
3.4 Received output signal eye diagram



3.5 SNR vs Range comparison for both the techniques (OFDM)



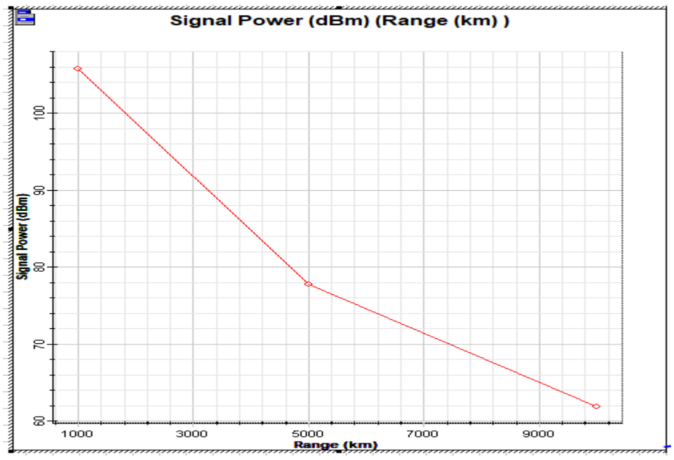
Polarization Interleaving



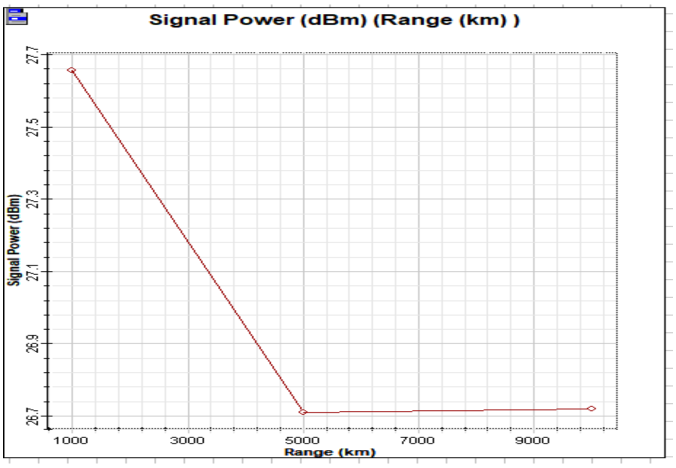
The SNR vs range graphs for both the techniques are depicted above which gives us the result that OFDM system's SNR value is the higher from the polarization technique and bears a good value of SNR at three different points of range i.e on 1000km, 5000km and 10,000 km.

3.6 Received signal power vs Range

OFDM



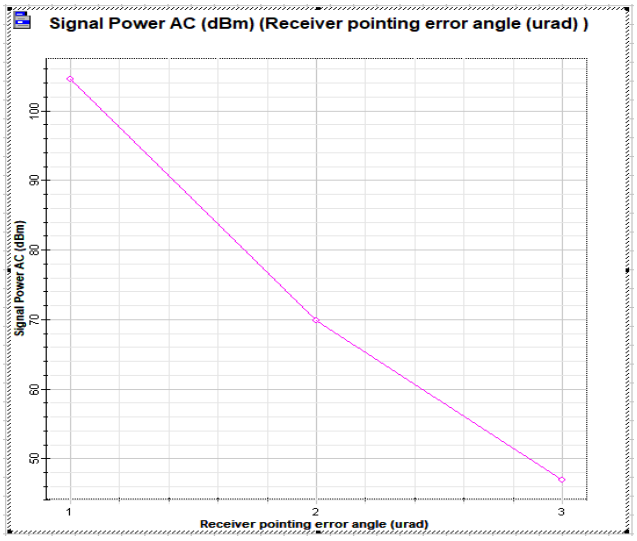
Polarization Interleaving



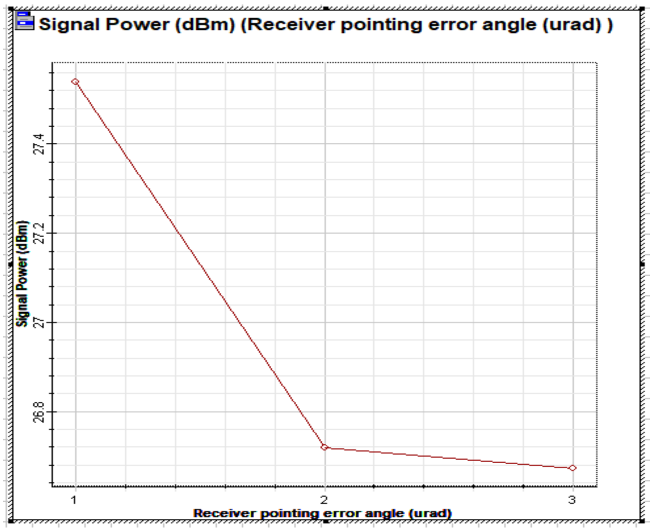
As we can see easily from the first graphical report that the value of received power is very less in polarization interleaving as compared to OFDM. Which is highest 27.7 at 1000km and drops to 26.7 at 5000km.

3.7 Received signal power vs pointing error

OFDM



Polarization Interleaving



The above two graphs show the system efficiency when they are subjected to some values of pointing errors. The lowest value of received power in OFDM system is 46dbm with 3 micro radian pointing error. Whereas in Polarization interleaving it is 25dbm at 3 micro radian pointing error.

4. CONCLUSION

We have observed the comparative graphs for the mentioned parameters of both the techniques. We reached to a conclusion that on the basis of the electrical constellation diagram, SNR vs Range, received signal power vs pointing error, and received signal power vs range graphs. OFDM technique gives better results in signal quality when compared to the Polarization Interleaving providing the same input power, link distance and antenna aperture.

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