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An Analysis of Self-Powered Implantable Medical Electronics and Emerging Implantable Energy Harvesters

Jayalani M[1], Velusamy P[2]

[1]Assistant Professor ,[2]Final Year M.E. VLSI Design , Department of Electronics and Communication Engineering, Al-Ameen Engineering College (Autonomous), Erode – 638 104, Tamilnadu, India

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KEYWORDS
Wavelength division multiplexing (WDM), Free space optical (FSO), SOP (state of polarization, PI (polarization interleaving), Polarization extinction ratio (PER)

ABSTRACT:
Wavelength division multiplexing (WDM) is a possible choice for future Free space optical networks, as it can enable ultra-high bandwidth and high velocity systems using compact, lightweight, and low-power optical equipment. This study looks at how polarisation diversity and a revised back to zero advanced modulation scheme can improve the efficiency of a 16 x 20 Gb/s WDM-FSO system. Using a WDM system with a channel spacing of 50 GHz, a high-speed system is achieved to meet the large bandwidth needs of mobile networks in FSO. A polarisation interleaving mechanism is incorporated in the system to suppress polarisation crosstalk and non - linearities among neighboring WDM channels.

I. INTRODUCTION

The expansion of internet connections and traffic in a range of new services has put a strain on traditional radio systems' low-speed design. Free space optical communication shares properties with other widely used technologies such as fibre optics and wireless communication [1]. Free Space Optical (FSO) transmission has received a lot of attention recently because of its advantages over optical cable connection [2]. Many studies have been conducted in the past to meet the high-speed information needs and to provide cost-effective design [3].Furthermore, FSO renders communication more secure due to less interception of P2P (point to point) laser transmissions. Large bandwidth and capacity, license-free operation, low power operation, and elimination of trenching, permits, and other costs associated with optical fibre transmission are all advantages of FSO communications[4] -[5]. FSO is a prominent possibility for geographical regions in India where optical fibre installation is not viable, and it has received interest due to its uses and multiple advantages. Atmospheric degrading conditions including medium rain, mild rain, fog, high rain, mist, and others [6] that enervate the connection and cause the network transmission to be shut down are variables that influence the performance of FSO.Many studies have been conducted or proposed to reduce the consequences of atmospheric destabilization, as well as numerous ways to reduce turbulence effects [7-8].

In [9], the impact of beam width on free space communication is examined in the context of atmospheric disturbance. For the open space optical channel, OFDM advance modes, aperture balancing, diversity, and FSO signal augmentation are also examined. At ultra-narrow channel spacings and high bandwidth, wavelength division multiplexing has been used to boost FSO capacity. WDM-based access networks support a large number of users and are built on spectrum slices.

WDM (wavelength division multiplexing) is adaptive and reliable in that it can provide wide coverage across atmospheric instabilities in FSO. Bidirectional transmission and capacity multiplication describe the WDM (wavelength division multiplexing) as adaptive and reliable.

As a result, a high-speed FSO system-based polarisation interleaved wavelength division multiplexing (PIWDM) architecture is proposed in this research goal. The most effective strategy is to meet high-speed data demands, hence the system was designed and demonstrated for 20 Gbps. Different polarisation states are used in the system to reduce interchannel and polarisation

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crosstalk, resulting in better outcomes. Furthermore, prior to the FSO channel, super dense channel spacing of 50 GHz is provided between neighbouring channels to increase system bandwidth efficiency.

II. THEORY OF POLARIZATION DIVERSITY

The laser intensity is polarised in many, but not all, systems. This is a state of linear polarisation in which the electric field oscillates along a path that is orthogonal to the laser intensity propagation. Fiber lasers, on the other hand, do not produce a consistent directional electrical field. However, the laser output is not always unpolarized, as it might have the same powers in two polarizations at the same time without any amplitude correlation. The state of polarisation is not stable for a variety of reasons, including temperature changes and random flips between different directions.Some form of polarisation fixing mechanism is usually required to generate the pure single-direction fluctuation of electrical field vector. The polarisation extension ratio (PER), defined as the ratio of powers in various polarisation directions and derived by recording the orientation-dependent power transmission of a polarizer, is commonly used to quantify the degree of specific state of polarisation. By fixing the polarisation of adjacent channels, polarisation diversity is an efficient way to reduce the effect of inter-channel nonlinear effects. The approach is expanded to developing WDM systems with orthogonally polarised bit streams in two nearby channels.

The odd and even number channels are multiplexed into separate branches with orthogonal polarisation states (SOPs). To keep channels orthogonal, polarizations are modified using linear polarisation controllers. In PI systems, the basic mechanism of suppression is that both cross phase modulation and four wave mixing are entirely dependent on the state of polarisation of adjacent channels, and SOPs are orthogonal. Inter channel collisions produce smaller phase shifts and better results as an outcome.

III. SYSTEM SETUP

A prominent and complete simulation suit, Optiwav e Optisystem, is used to realise spectrum sliced free space optical communication.Figure 1 depicts the proposed WDM free space optical network at 20 Gbps employing modified return to zero

(MDRZ) in downstream. Novelty of the system is use of polarization interleaving in WDM FSO to combat with the polarization and inter-channel crosstalk. System proposed is symmetrical and also centralized lightwave that supports 16 WDM channels in this work.

Internal structure of modified return to zero (MDRZ) system is depicted in Figure 2. A laser light wave source at 193.1 THz frequency and 0 dBm input power is used. In order to investigate the impact of nonlinear deficiencies on the system, the polarisation of even and odd channels is modified. The linear polarizer transmits only the linear polarisation component that is parallel to the polarizer's transmission axis and rejects the orthogonal part. Odd channels from 1 to 15 have the same polarisation and the state of polarisation (SOP) in a linear polarizer is set to 0 degrees. Even channels 2-16 have 90 degree polarisation, which is orthogonal to odd ones.The investigated range for the proposed link is 9 Km. All WDM channels are modulated in central office with MDRZ modulation. From this point, downstream communication in Free space optical network initiates. The modulated MDRZ -WDM

signals are accumulated with the two multiplexer of configuration 8 x 1, as well as the mu ltiplexed signal is transmitted over 9 km

FSO link.

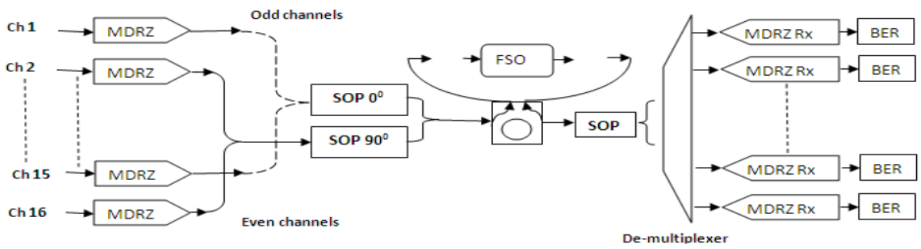

Figure 1 Proposed polarisation interleaved WDM FSO system block diagram

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After transmission of 9 km, signal is de-multiplexed by 1 x 16 wavelengths with frequency spacing of 50 GHz as shown in figure 3.4.

The photo-detectors in the receiver section receive the drive with a time delay. By taking into account shot, thermal, and ASE (Amplifier spontaneous noise) distortions, a p-i-n photodetector with 100 percent responsivity and 10 nA dark current is installed in the receiver. For re-sampling, re-shaping, and re-amplification of collected signal, a 3-R regenerator is used. The bit error rate analyzer is a decision-making element that calculates the received signals' final quality factor, bit error rate (BER), signal to noise ratio (SNR), and other parameters. The eye diagram analyzer is followed by a PIN photodiode, a low pass filter, and a PIN photodiode.

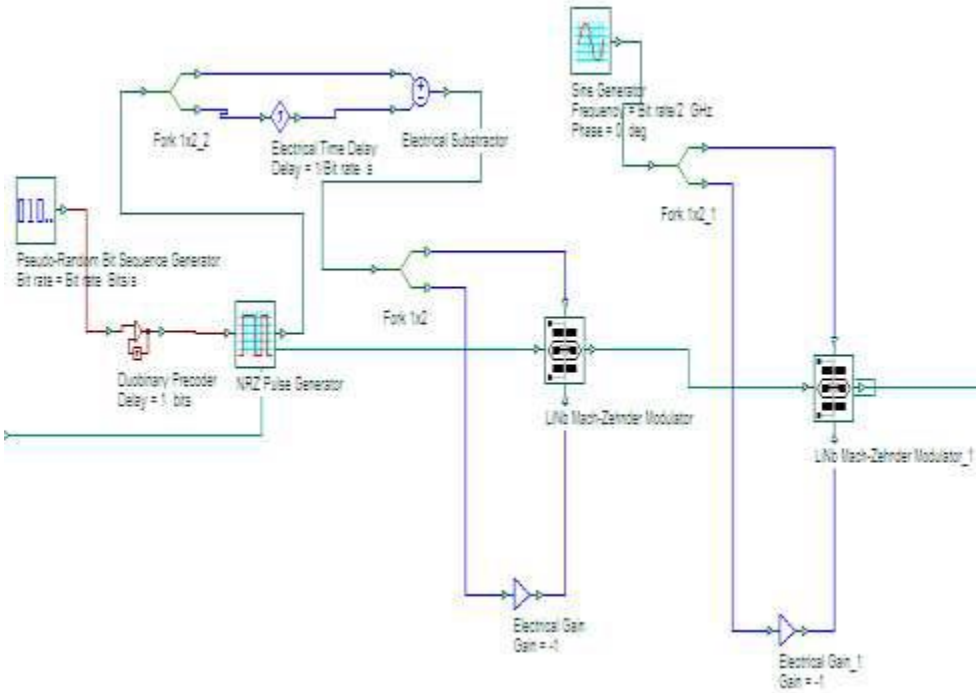

Figure 2 Internal structure of modified return to zero

Internal structure of modified return to zero (MDRZ) system is depicted in Figure 2

IV. RESULTS AND DISCUSSIONS

In order to design a polarization crosstalk suppressed systems, a free space optical network employing polarizat ion interleaving is proposed. A system consists of 16 wavelengths and each wavelength is modulated with MDRZ modulation for down stream at central office. Two WDM multiplexers are used in order to separately combine the 8-8 wavelengths. Even wavelengths and odd wavelengths are combined differently with these two multiplexers. Then odd channels are fed to polarizat ion rotator that pass only horizontal polarization signals and even channels are projected to orthogonal polarizer. Polarizations combined and signal sent over 9 km long stretch of FSO and followed by 1 x 16 de-multiplexer. Received wavelengths are received with receiver that consists of photodetector, low pass filter and BER analyzer.

First and foremost, the investigation of proposed system has been done by taking different distances into consideration. Loop length is varied from 1 km to 9 km with the gaps of 2 km as depicted in Figure 3.

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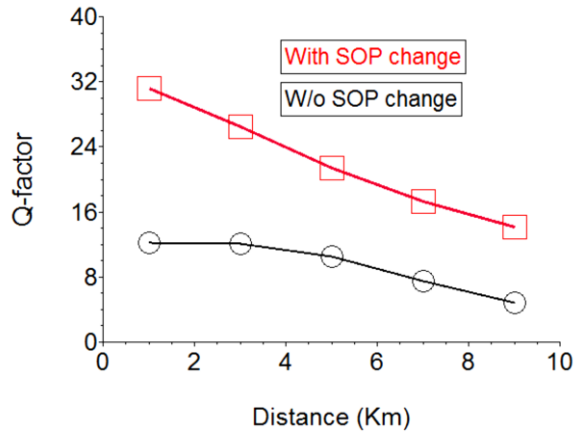

Figure 3 Representation of Q factor versus distance

To evaluate the results, Q factor is noted from Eye diagram analyzer. Figure 4.6 represents the graphical representation of Q factor versus distance for with and without polarization interleaving in WDM-FSO. It is reported that with the increase in the link length, there is significant reduction in Q factor of the signal. Also, two different scenarios are proposed by considering the polarization

interleaving and without polarization interleaving. Q factor decreases due to numerous factors such as the attenuation, pulse broadening, crosstalk among different channels etc. However, in this work, analysis is accentuated on polarizat ion crosstalk that emerges in multi-channel WDM systems and plays a vital role in signal degradation. It is evident from the investigation that because of the different states of polarization in even and odd channels of the proposed system, Q factor is obtained well in case of with PI

system than without polarizat ion interleaved system. This is due to the fact that different states of polarizat ions, minimize the interaction of signals between different wavelengths. This phenomenon led to a significant enhancement in Q factor and it is seen tha t when polarization interleaving is eliminated, Q factor decrease sharply and valid for 8 km distance as compared to with polar ization

interleaved system as given in Table 1.

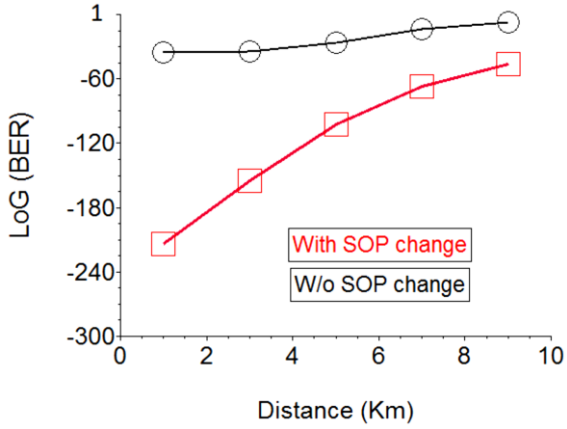

Figure 4 LoG (BER) versus distance of WDM FSO system

Figure 4 represents the LoG (BER) values when link length is varied from 1 km to 9 km. It is evident that as distance prolongs, there is increase in bit errors. Bit error rate is an important measure to evaluate the system performance. In proposed system that incorporates polarization interleaving, exhibits less errors as compared to without interleaved WDM free space optical network.

Modified return to zero advanced modulation format is employed in the system to suppress the crosstalk between WDM channels.

However, MDRZ has done another task of inter symbol interference suppression due to two different phases. Other problem is al so exists that is the inter channel interference in WDM FSO. LoG (BER) is more in without polarizat ion interleaved system and thus polarization inter leaving is recommended to use for better results. Distance is considered for the evaluation of the systems in terms of Q factor and BER. However, the next study is on the effect of input power on the system performance. Results such as Q factor, LoG (BER) and signal to noise ratio are accessed for investigation. So, in the proposed WDM free space optical network, launched power is varied from the laser source from 0 dBm to 4 dBm with the difference of 1 dBm. Figure 5 depicts the variation of Q factor with the launched power for with and without polarizat ion interleaved system. From the results as given in Table 2, it is observed that with the more power coupling into FSO, Q factor tends to increase. Increase in launched power serve as a power budget in the system.

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However it is also seen that high power input initiates the nonlinear effects due to the variation in power of adjacent channels. But, in this setup power is limited to 4 dBm and this power level do not initiates the nonlinear effects.

Figure 6 represents the LoG (BER) versus launched power in the system. It is observed that power increase, improves the BER and provide less BER for high powers that are launched in optical fiber.

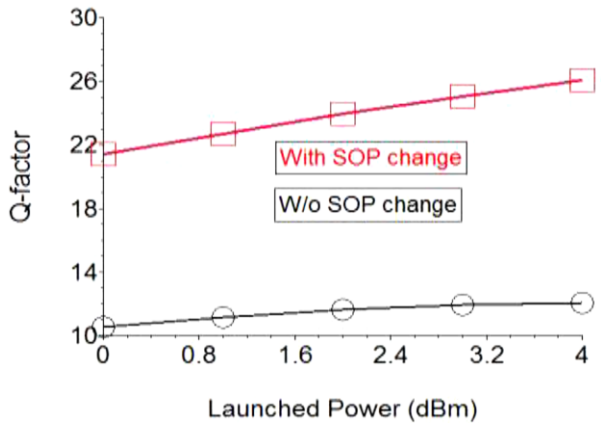

Figure 5 Representation of launched powers versus Q factor of WDM FSO system employing with and without polarization interleaving

Table 2 Values of Q factor vs launched power

Power (dBM)	With PI	W/O PI
0	21.42	10.52
1	22.71	11.17
2	23.93	11.62
3	25.06	11.91
4	26.1	12.06

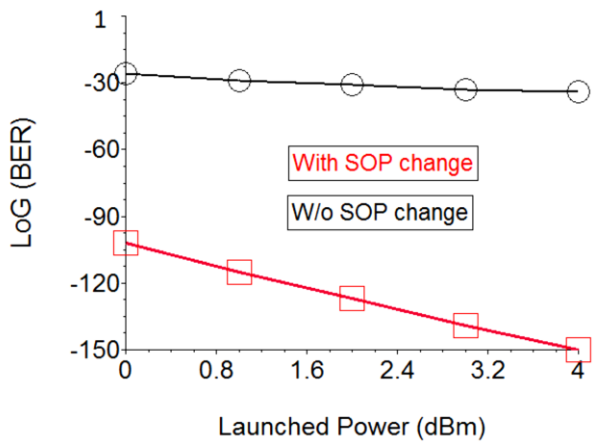

Figure 6 LoG BER versus input power

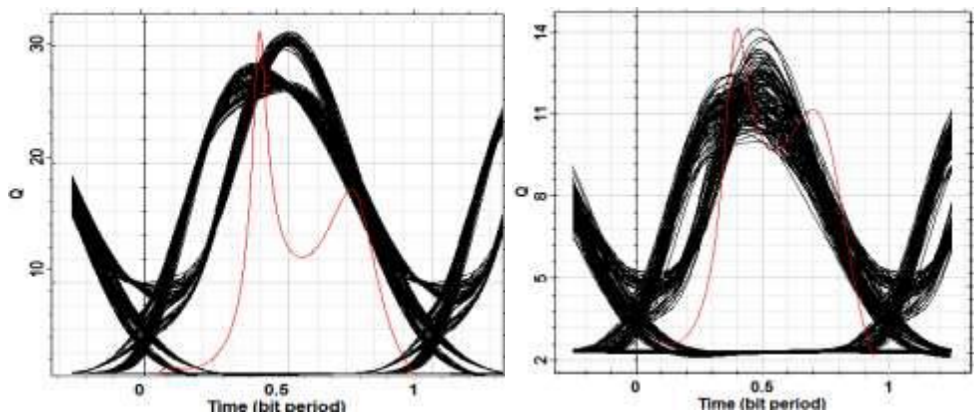

Figure 7 Eye diagrams for polarization interleaved WDM-FSO at (a) 1 km and (b) 9 km

Eye diagram of the system with and without polarization interleaving depicted in Figure at different link lengths. It is reported that Eye opening is more in case of 1 km link distance and closer increase with the increase in the distance. This is due to t he fact that there significant attenuation, dispersion in the free space optical link. It is reported that at 1 km eye height is more as c ompared to 9 km and jitter is also less. More thickly the eye diagram appears , more are the errors and less is the Q factor. So from the analysis it is suggested to use the WDM FSO polarization interleaved system for the future applications.

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V. Conclusion

In this work, a WDM-FSO system to suppress inter channel and polarization crosstalk is proposed. This research explores the performance enhancement of 16 X 20 Gb/s WDM-FSO system incorporating polarizat ion diversity.

It is observed that WDM-FSO with polarization interleaving cause fewer errors and provide enhanced performance as compared to without polarization system. At lower distances and less power levels, Q factor reported minimum and BER is more. Systems using MDRZ and polarization interleaving works successfully for 9 km and polarization crosstalk effects are suppressed. Thus, this is an ultimate solution to WDM free space optical systems to support long distances as well as high data rate.

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