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Performance analysis of Free Space Optical transmission system

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Abstract - In this paper, the free space optical (FSO) transmission system is analyzed for various optical wavelengths in clear weather condition. The clear weather condition indicates that there is no attenuation to the flow of data from transmitter section to receiver section. The source used for the system is Continuous Wave (CW) Laser and at the receiver end, PIN photo detector is used to analyze the FSO transmission system for different modulation formats with bit rate of 6 Gbps and fixed distance of 1 km. The transmitter and receiver should also be in Line of Sight (LOS) for proper transmission and reception. The low pass Gaussian filter is used to filter the output from PIN photo detector in receiver section. It is investigated that the FSO system with RZ format gives better Q-Factor and minimum BER value for different optical wavelengths on comparing with other formats as discussed in this paper. The power of optical source for different wavelengths is kept minimum to avoid any additional loss.

Keywords— Free Space Optical (FSO) transmission, Quality Factor (Q-Factor), Bit Error Rate (BER), Continuous Wave (CW) laser, Line of Sight (LOS), Mach-Zehnder Modulator (MZM).

I. Introduction

In FSO transmission system the data in form of bits per second is transmitted in FSO channel from starting point i.e. source to terminating point i.e. destination [1] [2]. The optical source is laser used to carry the data and at the destination the data is received by photo detector. This type of system delivers the wireless connection for workplaces, administrative centers, campus, public buildings, hilly areas etc. [3]. There is no signal interference as the system gives license free optical wavelength bands [4] [5]. The transmitter should be in proper LOS with receiver section to achieve successful communication[6].

II. Methodology

The figures 1 below shows the methodology of the FSO system in which the data in the form of bits is encoded and modulate over the optical signal from laser and transmitted to the free space channel. The free space channel acts as the medium for transmission of the data successfully to the receiver section. The success of the data transfer depends on the outer environment that is the different weather conditions.

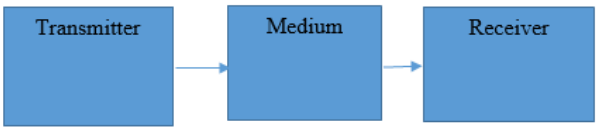

Figure 1. Block diagram of FSO transmission system

Now for the successful transmission of the data the source and destination should also be in LOS. The optical data received at the receiver by photodetector coverts it into electrical type. The output is further transfer to filter (low pass) to check its quality and finally the quality and sharpness of the data is checked by bit error analyzer in the form of Q-Factor and BER.

III. Design set up

The free space optical transmission design set up consists of continuous wave (CW) laser, modulation formats, PRBS generator and Mach-Zehnder (MZ) modulator at the transmitter side which is used to transmit the signals. The FSO transmission system is aimed to transmit the data with bit rate of 6 Gbps in free space channel having LOS with photo detector at the receiver. In this design set up different modulation formats like

Return to Zero (RZ), Non-return to Zero (NRZ), Triangular and Sine has been used along with the MZ modulator. This data in gigabits per second is transmitted over the free space at distance 1 km. The wave length used for the transmission are 1510 nm, 1550 nm, 1600 nm and 1635 nm. The outputs of transmitted data is converted to another form by PIN photo detector are verified through the BER analyser. The table 1 below shows the different parameters used in set up for free space communication.

Table 1. Different parameters used in design set up.

Parameters used	Values
Bit Rate	6
Power	1 mW
CW Laser wavelength	1510 nm,1550 nm, 1600 nm and 1635 nm
Free space distance	1 km
Type of Filter	Low Pass Gaussian Filter
Photo Detector	PIN

The figure 2 shows the simulative design set up for FSO system in RZ format with wavelength of 1510 nm and a distance of 1 km. In this design set up, the different optical wavelengths like 1510 nm, 1550 nm, 1600 nm and 1635 nm have been used to send the data over the distance 1 km. The data with bit rate of 6 Gbps is transmitted from transmitter to receiver using RZ format.

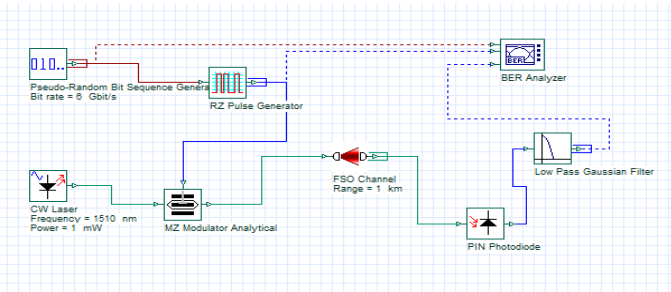

Figure 2. Simulative design set up for FSO transmission system

IV. Result and Discussions

The other modulation formats like NRZ, Triangular and Sine along with Mach Zehnder (MZ) modulator are also used for different optical wavelengths in this research work with bit rate of 6 Gbps. The BER analyzer is used at the receiving end to analyze the output in terms of Q-Factor and BER. The figure 3 below shows the eye diagram at the optical wavelength of 1510 nm by using RZ format in FSO transmission system. The Q-Factor obtained is 8.41.

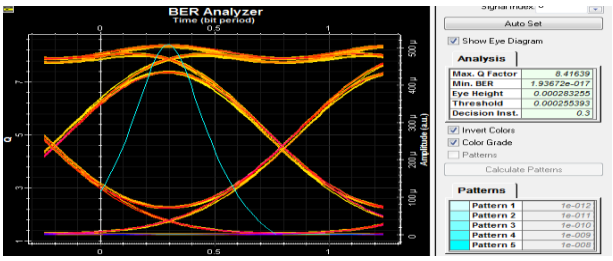

Figure 3. Eye diagram from BER analyzer at wavelength of 1510 nm

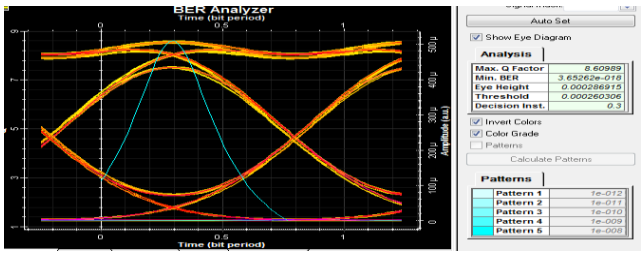

Figure 4. Eye diagram from BER analyzer at wavelength of 1550 nm.

The eye diagram from BER analyzer in the figure 4 shows the Q-Factor and BER values for design set up with RZ format by using the wavelength of 1550 nm with bit rate of 6 Gbps. The value of Q-Factor obtained is 8.60.

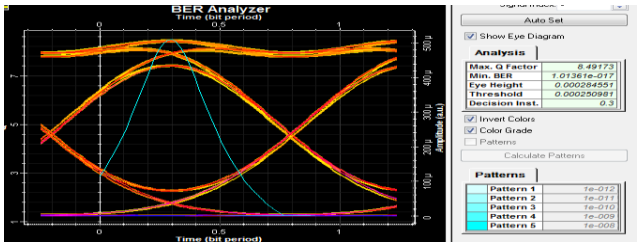

Figure 5. Eye diagram from BER analyzer at wavelength of 1600 nm.

The eye diagram from BER analyzer in the figure 5 shows the Q-Factor and BER values for design set up with RZ format by using the wavelength of 1600 nm and bit rate of 6 Gbps. The value of Q-Factor obtained is 8.49.

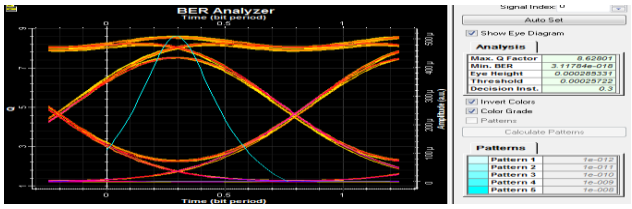

Figure 6. Eye diagram from BER analyzer at wavelength of 1635 nm.

The eye diagram from BER analyzer in the figure 6 shows the Q-Factor and BER values for design set up with RZ format at a wavelength of 1635 nm and bit rate of 6 Gbps. The value of Q-Factor obtained is 8.62.

Table 2. Output of the BER Analyzer for various formats

Laser Wavelength (nm)	RZ format		NRZ Format		Triangular Format		Sine Format	
	Q Factor	BER	Q Factor	BER	Q Factor	BER	Q Factor	BER
1510	8.41	$1.936e^{-017}$	4.55	$2.563e^{-006}$	7.17	$3.657e^{-013}$	8.30	$5.062e^{-017}$
1550	8.60	$3.652e^{-017}$	4.46	$4.085e^{-006}$	7.42	$5.772e^{-014}$	8.01	$5.629e^{-016}$
1600	8.49	$1.013e^{-017}$	4.51	$3.206e^{-006}$	7.22	$2.412e^{-013}$	8.17	$1.487e^{-016}$
1635	8.62	$3.117e^{-018}$	4.51	$3.136e^{-006}$	7.31	$1.320e^{-013}$	8.06	$3.633e^{-016}$

The table 2 above shows the output of Q-Factor and BER for the various modulation formats like RZ, NRZ, Triangular and Sine along with the MZ modulator in the tabular form. It is analyzed that in this research work different types of optical wavelengths have been used i.e.1510 nm, 1550 nm, 1600 nm and 1635 nm to transmit the bit rate of 6 Gbps. The different values of the Q-Factor are obtained by using the various parameters in design set up. The best value of Q-Factor is obtained in RZ format at the optical wavelength of 1635 nm. The 1550 nm wavelength in RZ format also gives the good value of Q-factor as shown in table above. The best value of Q-Factor for NRZ format is obtained at optical wavelength of 1510 nm. Similarly the optical wavelength of 1550 nm is the best suitable wavelength for the triangular format and at last the wavelength of 1510 nm is best suitable for the sine format. The graphical representation between the different optical wavelengths and Q-Factor is shown below in figure 7. In this graph the different colours show the various formats like Sine, Triangular, RZ and NRZ. The x-axis represents the Q-Factor and the y-axis represents the different optical wavelengths.It is indicated that the RZ format is the best modulation format in data transmission for FSO transmission system.

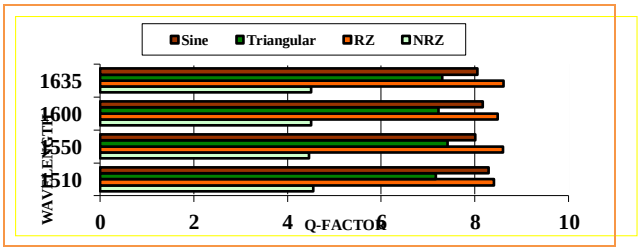

Figure 7. Graphical representation between wavelength and Q-Factor

Conclusion

The FSO transmission system is designed to transfer data in form of bits per seconds from transmitter to receiver through various formats along with MZ modulator. The medium used for transferring of data is FSO channel. The different modulation formats like RZ, NRZ, Triangular and Sine are used along with the MZ modulator for the same parameters. In this paper it is concluded that the maximum of Q-Factor i.e. 8.62 is obtained in case of RZ format for FSO transmission system. The other values of Q-Factor with RZ format are also good on comparing with other formats in FSO transmission system. The NRZ format along with MZ modulator performs with lower values of Q-Factor in FSO transmission system.

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