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A new Model of Free Space Optical Communication using Mach Zehnder Modulator

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Abstract: Free Space Optics (FSO) refers to line of sight technology which used visible or infrared (IR) beam through the atmosphere to obtain broadband communication. FSO attracted a lot of attention due to its number of applications in communication field. FSO has advantages of unlicensed spectrum, high speed, broader and unlimited bandwidth, low cost solution and easy toinstall are soul of the device to deploy FSO. Numbers of model are used for FSO. In this paper we describe a communication model for FSO using the Mach-Zehnder modulator and we observed that using Mach-Zehnder modulator system performance is increased in terms of Q-factor and BER. Recent transmission experiments used Mach-Zehnder modulators which is well suited to high bit rate and long distance communication systems.

Keywords: Free Space Optical Communication, Mach-Zehnder optical modulator, Bit error rate, power, Q-factor, Bit rate.

I. INTRODUCTION

Free Space Optics (FSO) is line of sight communication involves the transfer of information between one points to another point using optical radiation as the carrier signal through unguided channels. For transmitting purpose Laser beam are used mostly, although many times non-lasing source like light emitting diodes or IR emitting diodes (IREDs) will serve the purpose. FSO communication is same as the communication used by fibre optic transmission. The only difference is in FSO thelight beam is transmitted through free space from source to the destination, and in case of optical fibre communicationoptical fibre is used as guidedmedium [1].An FSO link is essentially based on line of sight (LOS), for a successful exchange of information between both the transmitter and receiver it is essential for FSO system to see directly one another without any obstruction in their path. FSO system can function over a long distance of several kilometres. Although FSO systems can be a good solution for some broad band networking needs, but there aresome limitations. Atmospheric turbulence is the main parameter that can block the transmission path [2]-[5]. Due to rain, dust, snow, fog or smog absorption, scattering and scintillation take place in signal.The scattering is defined as Mie scattering (particles are of same size as compared to wavelength) and Rayleigh scattering (particles are small as compared to wavelength).And the coefficient βn in clear weather can be expressed according to visibility and wavelength by the following expression [6]:

$$\beta_n = \frac{3.91}{Z}\left(\frac{\lambda}{550nm}\right)^{-Q} \qquad (1)$$

Where Z is the visibility in km and λis the wavelength (in nm), Q is a factor which depends on the scattering particle size distribution.

In FSO, data is to be transmitted via an external modulator such as Mach-Zehnder modulator. The Mach-Zehndermodulator consists of combiner work as an output port, aninput splitter;and two arms which are phase modulated with independent drive electrodes. A Mach-Zehndermodulator is shown in Fig. 1 has two blocks (PM and interference). In this path is simulated only when the modulator is symmetricthe interference block automaticallywith opposite phase difference [7].

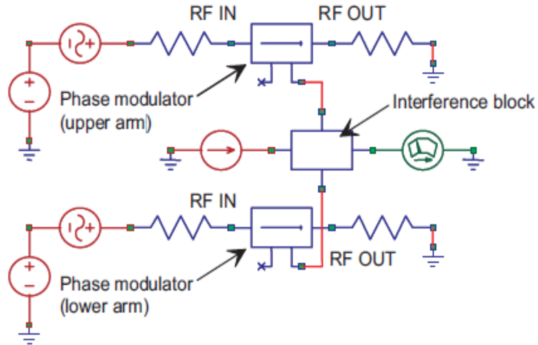

Fig. 1: Mach-Zehnder modulator with two phase modulating path showing the phase modulation and interference blocks.

An optical signal is applied at input port it gets split into two arms of the modulator. ON state is achieved When the signal recombines at the output port and there is no differential phase shift between the two signals, and in the OFF state differential there is [7]-[8].

II. SYSTEM MODELING

InOptisystem (a simulation engine) software a new model for FSO communication using Mach Zehnder modulator is designed from source to destination communication. Optisystemis user-friendly software to customers to implement their own simulation using

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dissemination created and managed by Optisystem. A block diagram for FSO system is shown in Fig. 2).In our proposed design, FSO has three subsystems: transmitter, FSO channel and receiver.For transmitting signal four subsystemsa data source, NRZ driver, CW laser, and Mach-Zehnder modulator are used. The first subsystem is pseudo-random binary sequence (PRBS) generator [6]. It will generate a random sequence of bits. These bits area string consists of a sequence of '1' (ON) and '0' (OFF) represents the binary pulses of a consistent pattern. The output of a PRBS is provided at the input of second subsystem is that NRZ driver. NRZ driver encodes the data in which '1' is represented by a significant bitand '0' is represented by another significant bit. NRZ has high dispersion tolerance as compared to RZ. The output of a NRZ driver is passed through a subsystem Mach-Zehnder modulator. In Mach-Zehnder modulatorhas two input ports, one is electrical input connected to NRZ driver and another is optical input port connected to a CW Laser.Mach–Zehnder interferometers are used in electro-optic modulators, electronic devices used in various fibre-optic communications applications.Mach-Zehnder modulators are integrated in monolithic integrated circuits and offer well-behaved, high-bandwidth electro-optic amplitude and phase responses over a multiple GHz frequency range.A CW laser is connected to optical input port of Mach-Zehnder modulator.A accumulate beam is split by a half-silvered mirror. The two resulting beams (the "sample beam" and the "reference beam") are each reflected by a mirror. The two beams then pass to a second half-silvered mirror and enter two detectors. The fully silvered and half-silvered surfaces of all mirrors, except the last, face the inpouring beam, and that the half-silvered surface of the last mirror faces the departing beam exiting in the same direction as the original accumulate beam. That is, if the original beam is horizontal, the half-silvered surface of the last mirror should face the horizontally departing beam. CW laser is operated at wavelength of 1550 nm. The 1550 nm band is attractive due to its affinity with the third window and eye safety. Output of Mach-Zehnder modulator is given to optical amplifier which increases the gain and traverse through FSO channel which is propagation medium and received at the receiver side. The beam divergence angle is set to 2 mrad. The optical receiver consists of avalanche photo diode (APD) followed by a low pass filter (LPF).An avalanche photodiode (APD) is a highly sensitivesemiconductor electronic device that accomplishment the photoelectric effect to convert light to electricity. APDs can be thought of as photodetectors that provides a built-in first stage of gain through avalanche multiplication. APD has its own internal gain.A Bessel LPF isa type of linear filter with a flat group delayused with a cut-off frequency of 0.75*bit rate of signal. The Bessel filter has better buildfactor, flatter phase delay, and group delay than a Gaussian of the same order, though the Gaussian has lower time delay.A LPF is used to remove the unwanted high frequency signal. Receiver is used to regenerate an electrical signal of the original bit sequence and bit error pattern is analysed by using a BER tester. Bit Error Rate Testers deliver remarkableresilience and performance to help compress your product advancement cycles and reduce verification testing costs. Perform broad bit error rate analysis on your device under test.

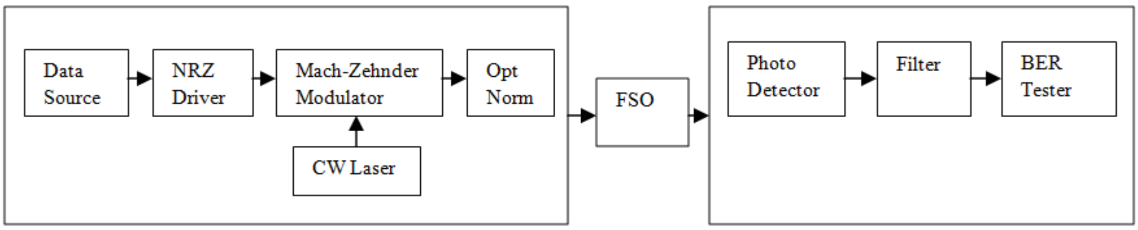

Fig.2: System model of FSO using Mach Zehnder modulator

The parameters and their specifications taken during the simulation are shown in Table 1.

Parameters	Values
Modulator Type	Mach-Zehnder
Extinction ratio	30 dB
Transmitted Power	8dBm
Divergence	2 mrad
Noise Figure	4 dB
Bit Rate	1.5 Gbps
Attenuation	25dB/km

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Transmitter aperture diameter	10 cm
Receiver aperture diameter	20 cm
Ionization ratio	0.9
Dark current	10 nA

Table 1: Parameters and their specifications taken during the simulation.

III. RESULTAND GRAPH ANALYSIS

The system of FSO using Mach Zehnder performance obtained in terms of BER and Q-factor which are depended upon range between the transceiver. As compare to other modulators if we used a Mach Zehnder modulator it gives a good Performance. Eye diagram using BER analyzer is shown below:

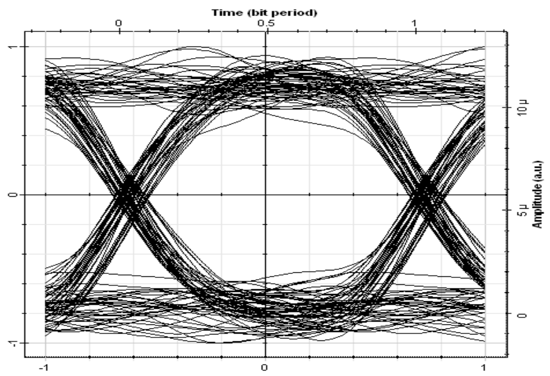

Fig. 3: Eye Diagram

As the range between transmitter and receiver is increased BER is continuously increased and quality factor is decreased [6]. BER, Q-factor and threshold level plot for FSO system using Mach Zehnder modulator is shown in Fig. 4, Fig. 5, Fig. 6.

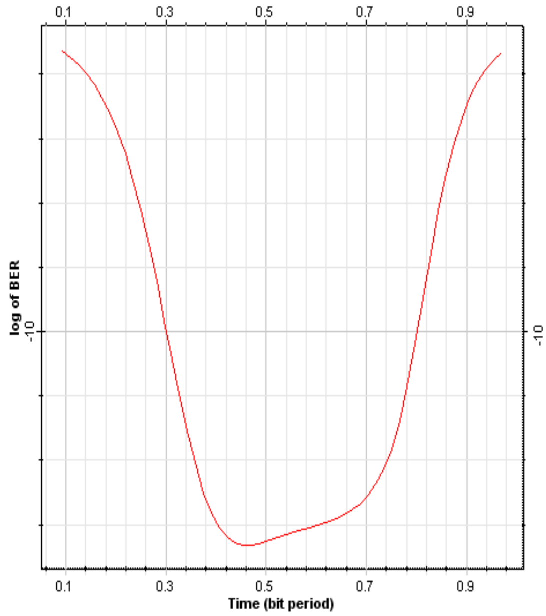

Fig. 4: BER on BER analyser

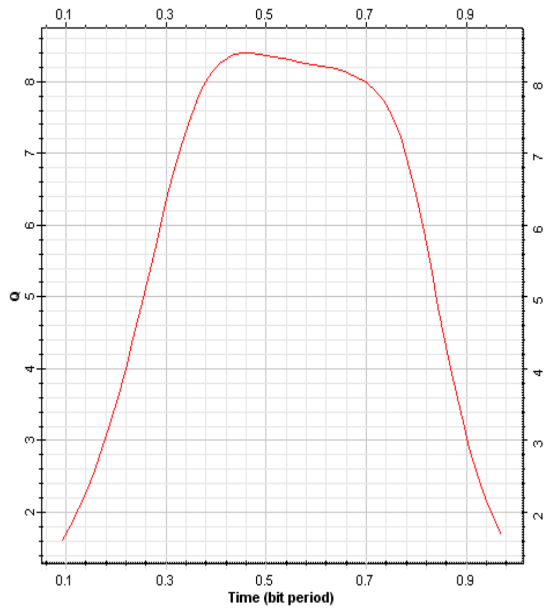

Fig.5: Q-factor on BER analyser

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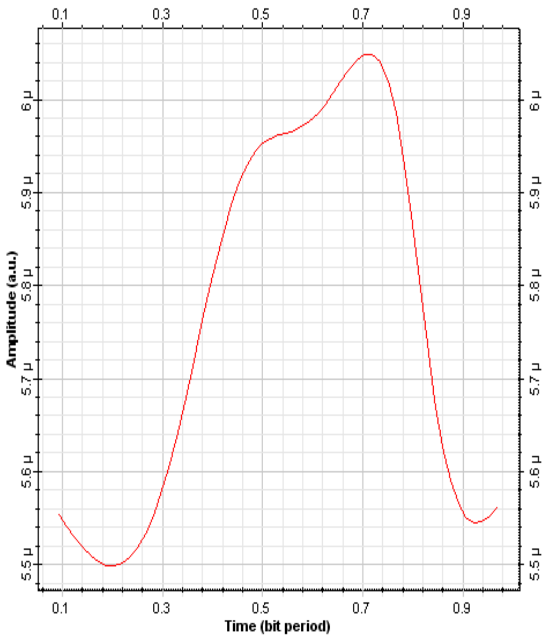

Fig 6 Threshold level on BER analyser

CONCLUSION

This paper represents system performance of FSO link using a Mach-Zehnder optical modulator in terms of BER, Q-factor. It is concluded that BER and quality factor is improved by using Mach-Zehnder optical modulatorand plot has a good curve in BER, quality factor and threshold level. We can transmit data for a long distance by using Mach Zehnder modulator in optical communication for FSO link.

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