INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume3, Issue4)
Available online at www.ijariit.com

Simulink Model Design for FSO Communication System for Analysing Of Different Parameters

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Abstract**: In our dissertation work, an approach has been made to analyze the effect of free space transfer function by considering various parameters like path loss factor, atmospheric turbulence, pointing errors on the performance of free space optical (FSO) communication system. The performance of the proposed free space optical communication system is studied by developing a MATLAB simulator. In our research work, two cases are considered for two different probabilities when binary codes are generated by Bernoulli generator with 0.5 and 0.4. Finally, we evaluated the Bit Error Rate (BER) and signal to noise ratio (SNR) performance of the proposed system varying with different system parameters. The BER is highly degraded on severe atmospheric turbulence condition ever for a short distance of free space channel. The effect of path loss factor due to dense fog is also severe on the BER even though the turbulence effect and free space distance are short. After Bernoulli generator spectrum analyser used to see the result in the frequency domain and later on both signal are convoluted with Hadmard code to achieve orthogonality criterion and the passed through AWGN channel and 10db SNR also added the both signal are processed with FSO circuit with different parameters condition and finally BER is received on display. FSO communication is latest trend technology and during this lot of problem have to face and one important parameter is that range. Signal cannot be transmitted to long distance if we transmit then BER also increased and due to which communication is not reliable so we required to work on distance and power utilized and atmospheric condition so that data can be transmitted successfully for a long distance

Keywords: Bit Error Rate, FSO, Path Loss Factor, quantization, Intensity, Turbulence, Modulation

I. INTRODUCTION

Free Space Optics refers to the transmission of modulated visible or infrared (IR) beams through the atmosphere to obtain broadband communications. FSO systems can function over distances of several kilometers. FSO is proposed as a complementary technology to the RF technology. It offers an unregulated bandwidth in excess of terahertz technology (THz) and very high speeds, which makes this an extremely attractive means of meeting the ever-increasing demand for broadband traffic, mostly driven by the last-mile access network and high definition television broadcasting services [1-2]. FSO systems based on the WDM technology can reach up to 1 Terabit/s capacity or even beyond. Further advantages include smaller and more compact transceivers, reduced installation and development costs and immunity to electromagnetic interference. Free-space optical communication (FSO) systems have developed in response to a growing need for high-speed and tap-proof communication systems. The block diagram of a typical terrestrial FSO network is shown in figure 1. FSO system, like any other communication technology, is essentially composed of three main systems namely the transmitter, the communication channel and the receiver. The transmitter has the primary task of modulating the source message onto the optical carrier for propagation through the atmosphere to the receiver end of the communication channel [4-6]. The transmitter is made up of the modulator, driver circuit, optical source and the transmitter telescope. The modulator is responsible for modulating the source message onto the optical carrier. On-Off-Keying (OOK) modulation scheme is the most common used in FSO communications. On-Off-Keying modulation is very sensitive to distortions in signal amplitude. Atmospheric conditions such as clouds and fog can significantly affect its performance by attenuating the received signal. The exact wavelength and the phase of the optical carrier are however irrelevant for the demodulation of the received signal.

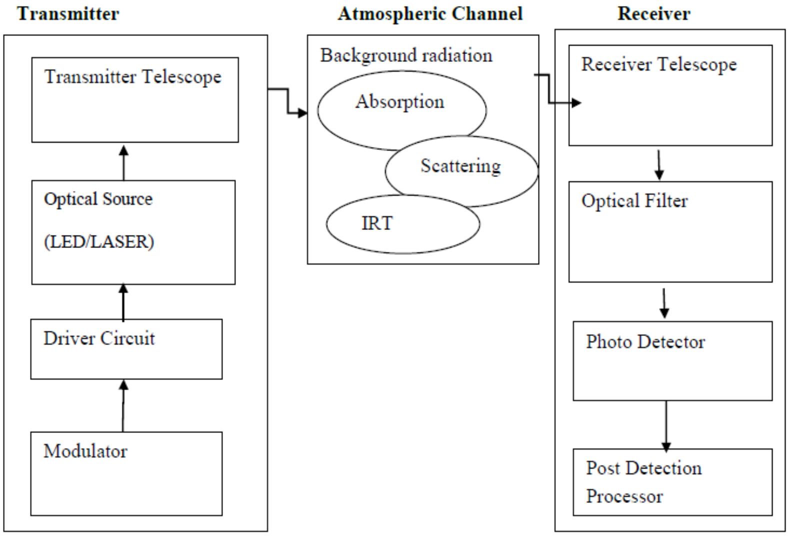

Figure 1 Block Diagram of FSO

A typical implementation of FSO is a point-to-point communication with two similar transceivers at each end of the link as shown in figure 2. This arrangement allows data to be transmitted simultaneously between the two transceivers.

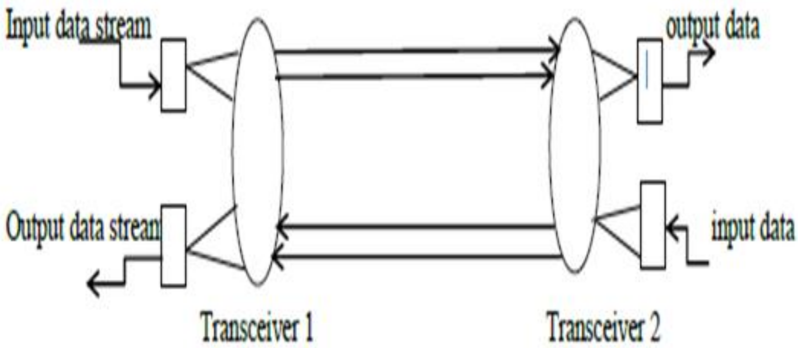

Figure 2 Typical FSO point to point Setup

II. LITERATURE SURVEY

Over the last two decades, free-space optical communication (FSO) has become more and more interesting as an adjunct or alternative to radio frequency communication. This article gives an overview of the challenges a system designer has to consider while implementing an FSO system [8-10]. Typical gains and losses along the path from the transmitter through the medium to the receiver are introduced in this article. Detailed discussions of these topics can be found in this special issue of the Radio engineering Journal. Today's demand is a communication link with maximum performance and minimum errors. Free Space Optics is a medium with high bandwidth having maximum data rates and security issues favouring its promotion for the present era. Turbulent atmosphere affects the performance of the link [3]. Humidity, water vapour, signals absorption, beam scintillation, spreading and wandering are some of the factors which cause laser beam degradation. Maintaining a free space optical link between two junctions is a tough challenge and needs enhancement in its features. The optical fiber was first developed in 1970 by Corning Glass Works. At the same time, GaAs semiconductor lasers were also developed for transmitting light through the fiber optic cables. The first generation fiber optic system was developed in 1975, it used GaAs semiconductor lasers, operated at a wavelength of 0.8 µm, and bit rate of 45Megabits/second with 10Km repeater spacing [13].

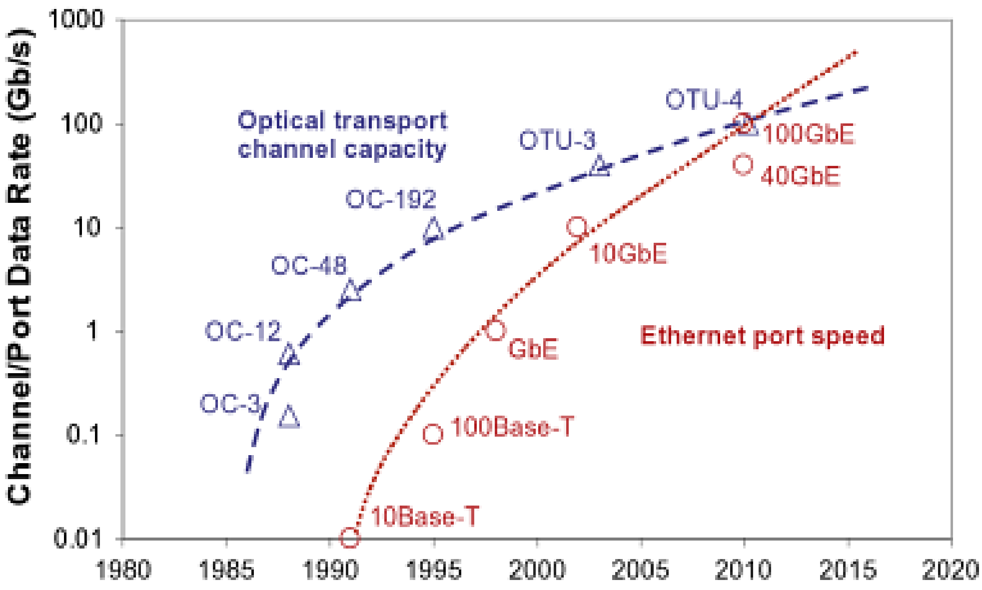

Figure 3 Optical fiber data rate (Gb/s) with time

III.PLANNING OF WORK/METHODOLOGY

In proposed technique base paper model is upgraded into Matlab 2015a so that improved simulation result could be gained. These models include a model for the transmission of optical signals through the atmosphere and model for the study of the effects of scintillation [15-16]. The lognormal statistical model is used to study the effects of scintillation. The transmission of optical signals through the atmosphere can be modelled by the Beer-Lamberts law. The Beer Lamberts law can be stated as:

$$\tau(\lambda, L) = \frac{Pt(\lambda, 0)}{\Pr(\lambda, L)} = \exp(-\gamma(\lambda) L)$$

where $\tau(\lambda, L)$: the transmittance of the atmosphere

$Pt(\lambda, 0)$: the emitted power from the transmitter

$\Pr(\lambda, L)$: the received power after a distance of propag

$\gamma(\lambda)$: the atmospheric attenuation coefficient (km^{-1})

The value of the atmospheric attenuation coefficient is dependent on the optical wavelength, is composed of both atmospheric absorption and scattering terms and can be expressed as:

$$\gamma(\lambda) = \alpha_m(\lambda) + \alpha_a(\lambda) + \beta_m(\lambda) + \beta_a(\lambda)$$

Where $\alpha_m(\lambda)$: molecular absorption coefficient

$\alpha_a(\lambda)$: aerosol absorption coefficient

$\beta_m(\lambda)$: molecular scattering coefficient

$\beta_a(\lambda)$: aerosol scattering coefficient

Simulation block diagram of FSO Model

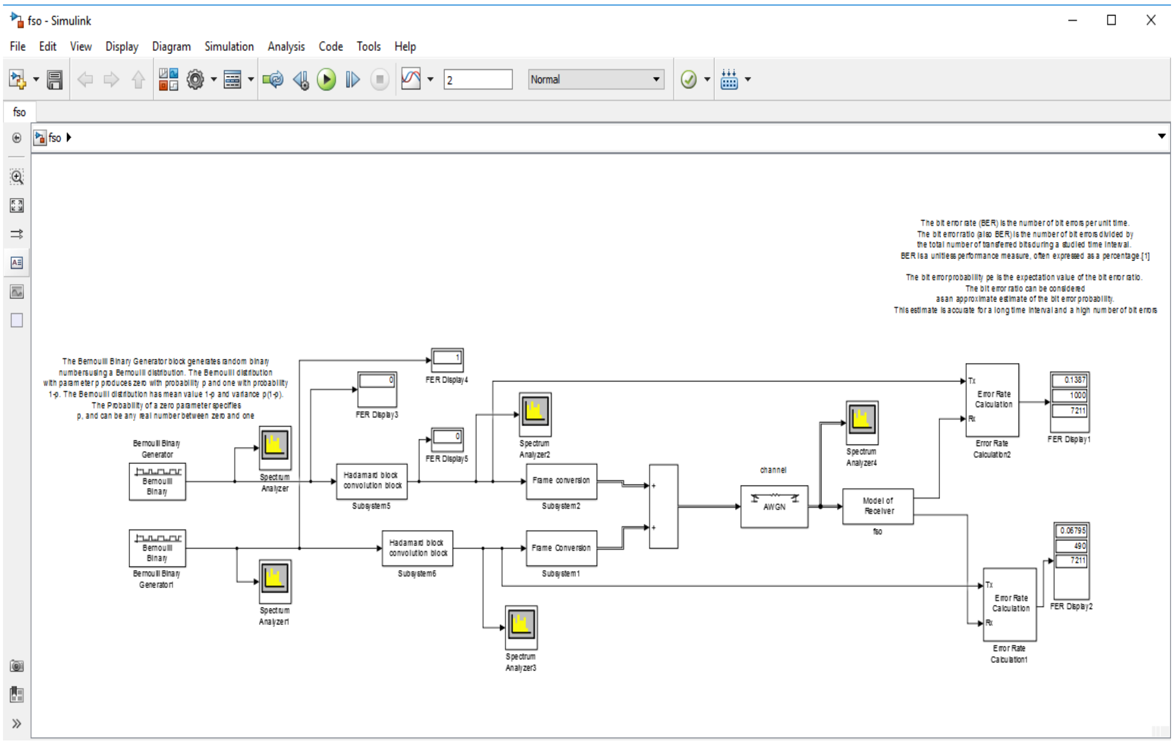

Figure 4 Block diagram of FSO system

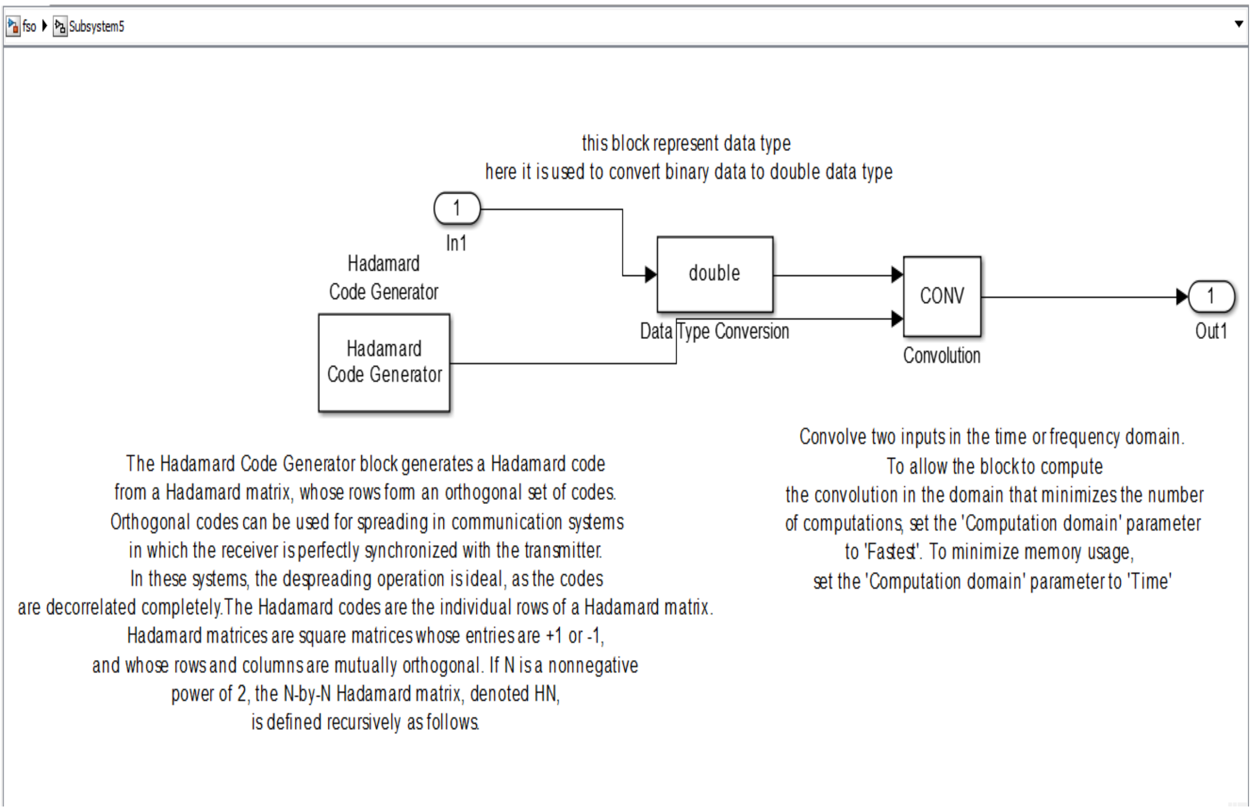

Figure 5 Block diagram Hadmard Code Generator which is part of FSO system

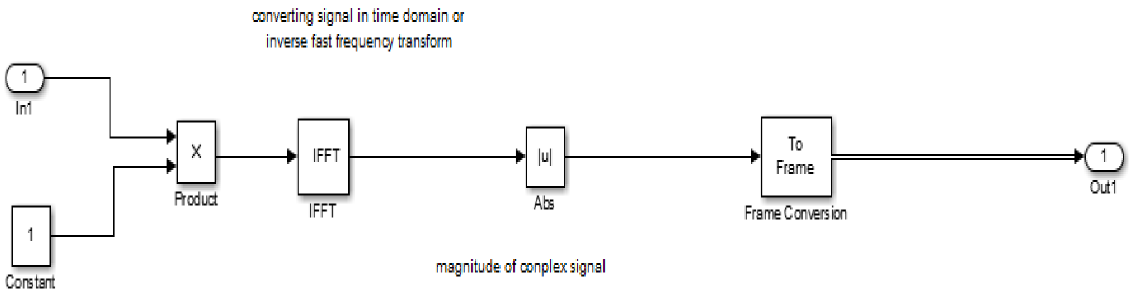

Figure 6 Conversion of signal in time domain from frequency domain

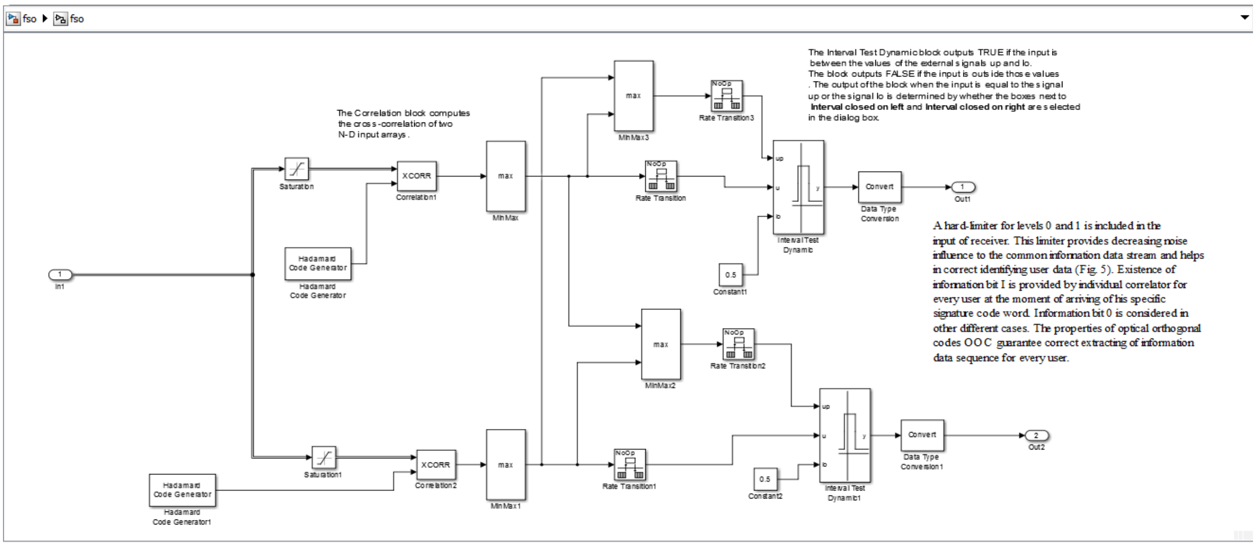

Figure 7 Internal Circuit of FSO

BER performances of an FSO link and visibility range are adversely affected by the weather conditions which causes attenuation and outage in the FSO link [17]. The wavelength of signal and aperture area of optical detector affects quality factor of the receiver. The received SNR plays a very important role in the performance of any communication systems. SNR is the signal power to noise power ratio. The noise in FSO system includes the thermal noise, shot noise, background noise etc. that contribute to the total noise at the FSO receiver system [9]. The performance of FSO link can be calculated by the system BER which depends on SNR value and on the modulation format used as well as on SNR [11-12]. Considering Gaussian distribution of noise, in the absence of atmospheric turbulence, the SNR at the output of the photo detector is given by,

IV. SOFTWARE USED AND SIMULATION RESULT

Software: MATLAB Version R2015a: It is powerful software that provides an environment for numerical computation as well as a graphical display of outputs. In Matlab, the data input is in the ASCII format as well as binary format. It is a high-performance language for technical computing integrates computation, visualization, and programming in a simple way where problems and solutions are expressed in familiar mathematical notation. The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter p produces zero with probability p and one with probability 1-p. The Bernoulli distribution has mean value 1-p and variance p(1-p). The Probability of a zero parameter specifies p and can be any real number between zero and one. In our FSO dissertation, we took two cases in which we generated two sequences of codes using Bernoulli Binary Generator. Figure 8 represents First Input from Bernoulli Binary Generator with probability 0.5

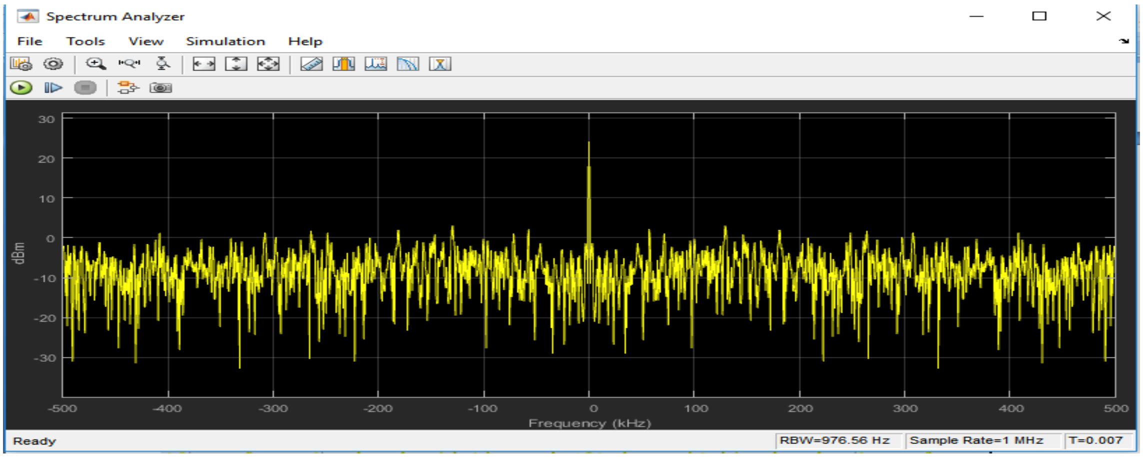

Figure 8 First Input from Bernoulli Binary Generator with probability 0.5

In our FSO dissertation, we took two cases in which we generated two sequences of codes using Bernoulli Binary Generator. Figure 9 represents First Input from Bernoulli Binary Generator with probability 0.4

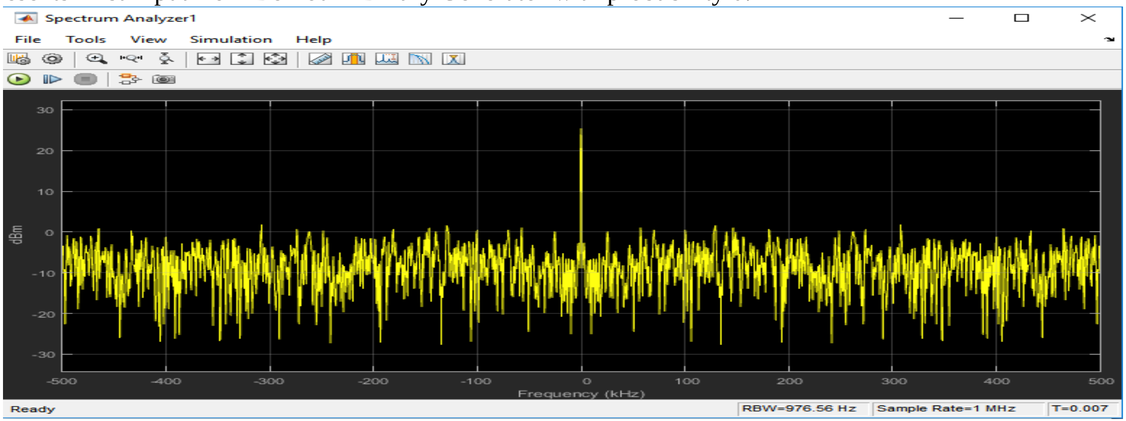

Figure 9 Second Input from Bernoulli Binary Generator with probability 0.4

In telecommunication, a convolutional code is a type of error-correcting code that generates parity symbols via the sliding application of a Boolean polynomial function to a data stream. Convolve two inputs in the time or frequency domain. To allow the block to compute the convolution in the domain that minimizes the number of computations, set the 'Computation domain' parameter to 'Fastest'. To minimize memory usage, set the 'Computation domain' parameter to 'Time'

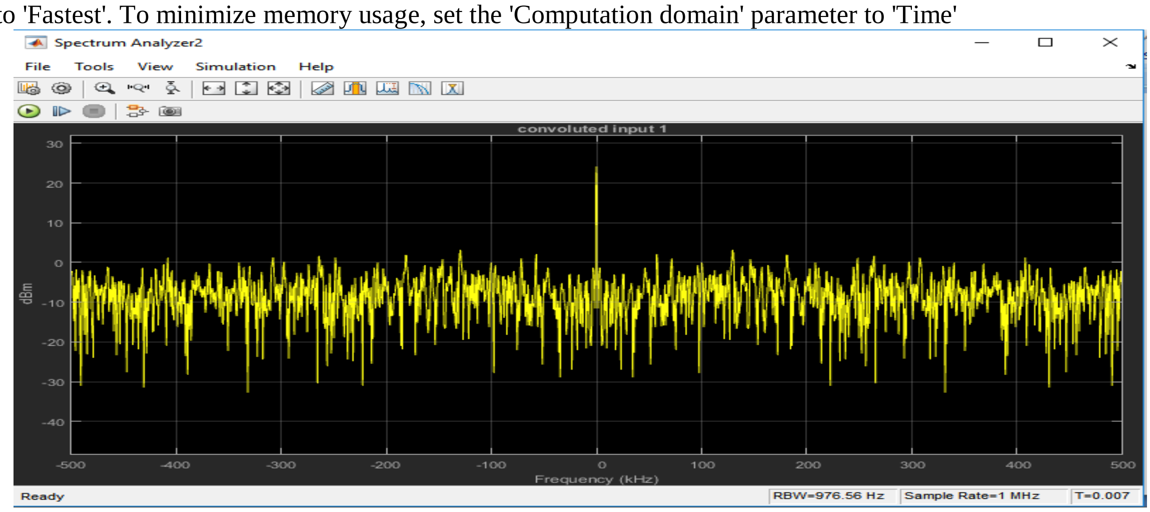

Figure 10 Convoluted input 1 for orthogonal code

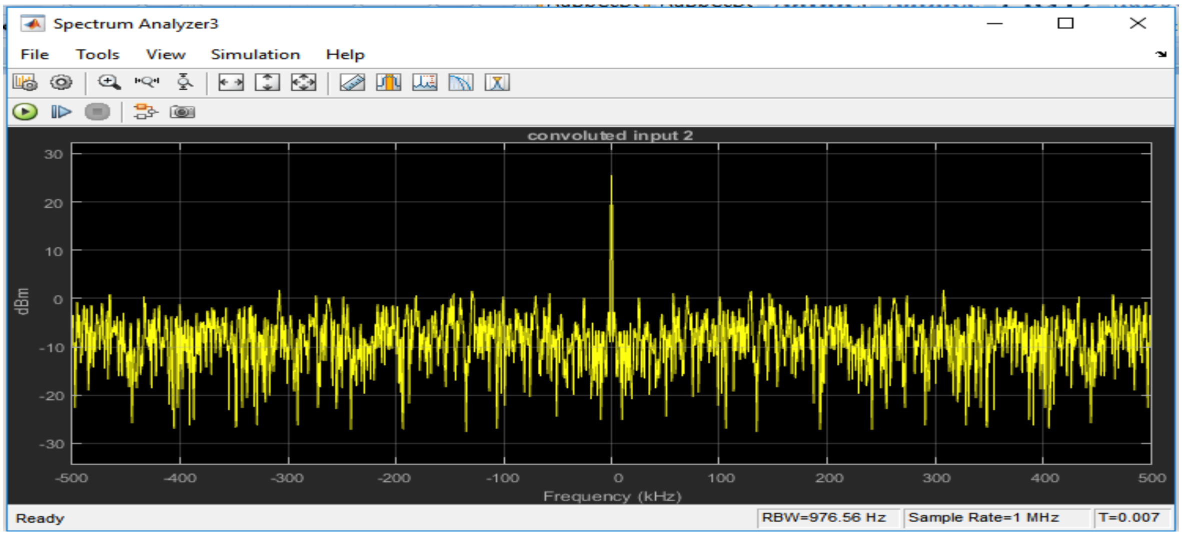

Figure 11 Convoluted input 2 for orthogonal code

After convolution process, we transfer our data through free space and during this process various noise came into existence and our original data is lost so to recover it we have to use devices at the receiver side to restore information. Normally AWGN channel is used for transmission data.

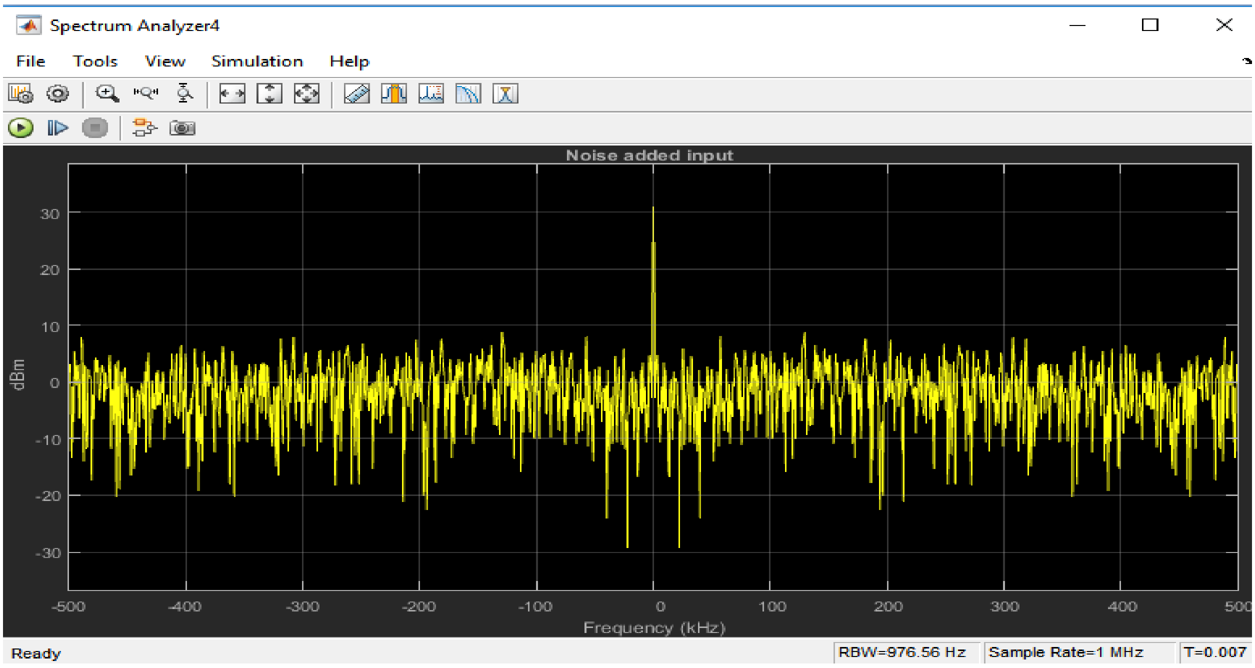

Figure 12 Output after signal passed through AWGN channel with SNR =10 db

Figure 13 represents power signal for the different scheme in the time domain as well as in frequency domain. As we know in the frequency domain it is very effective to analyze the signal in an efficient way so that we can further process it very well and crucial information can be extracted.

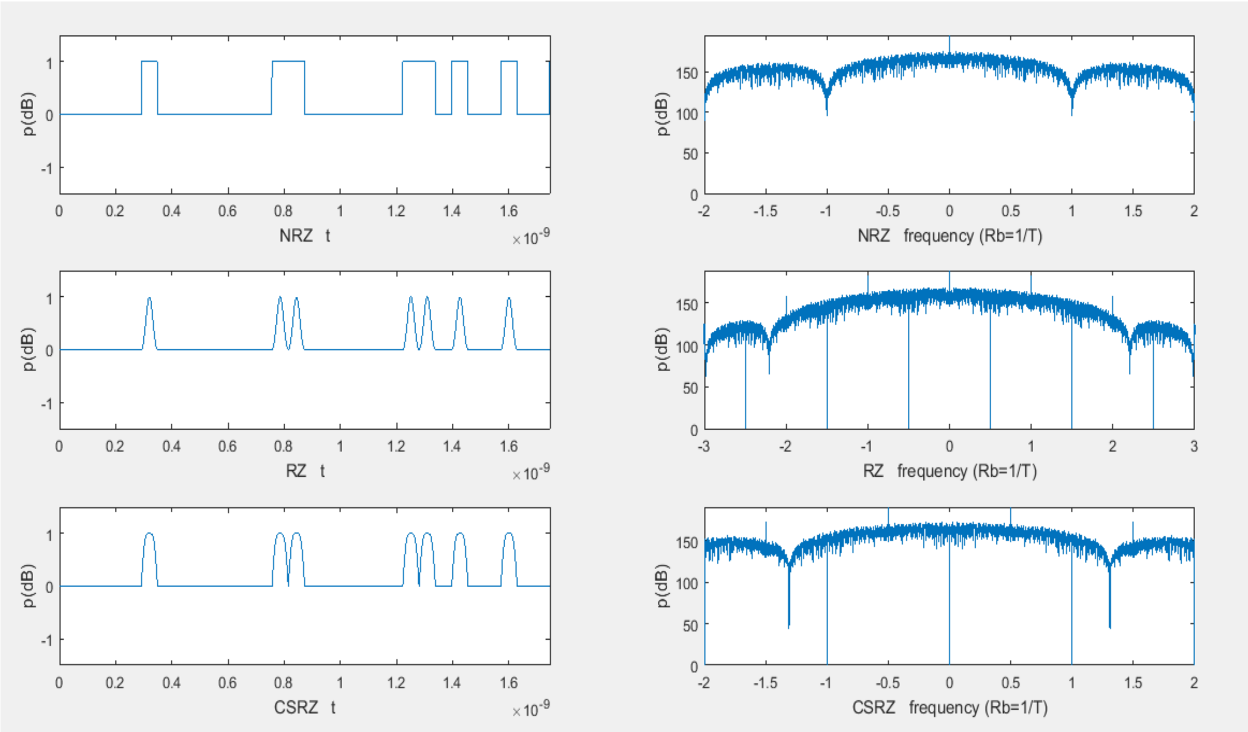

Figure 13 Power signal for NRZ RZ and CRZ in FSO on frequency domain as well in time domain analysis

In FSO transmission we used OOK or also known as On OFF Keying. Figure 14 represent distorted signal after passing through AWGN channel.

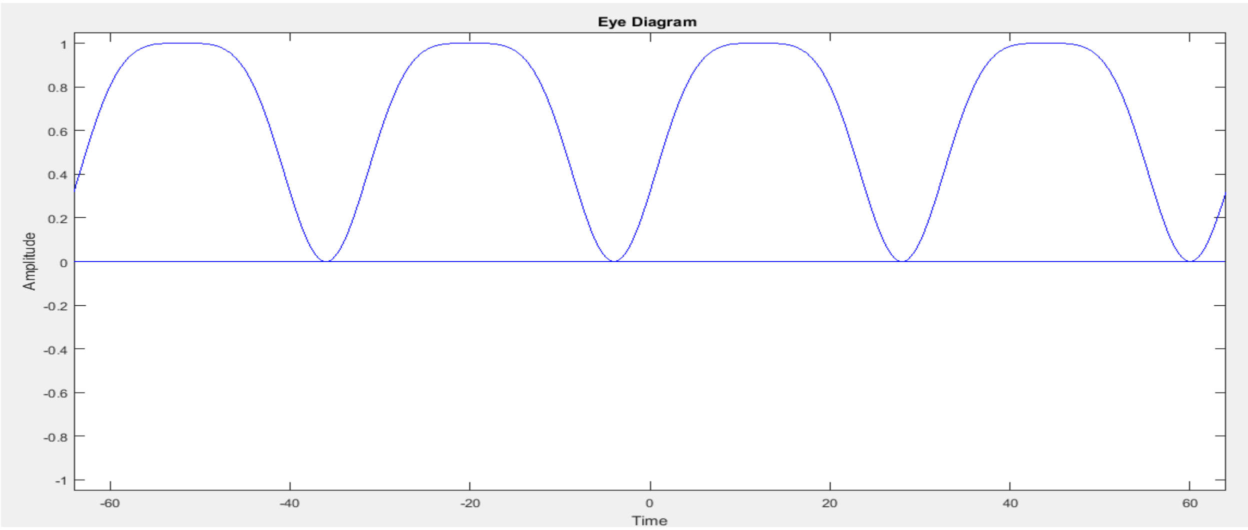

Figure 14 Eye diagram for modulation technique OOK with distortion

Figure 15 represents signal in original condition means before transmission via AWGN channel as we know as the signal transmitted with the channel it suffers various distortion and signal will be fade.

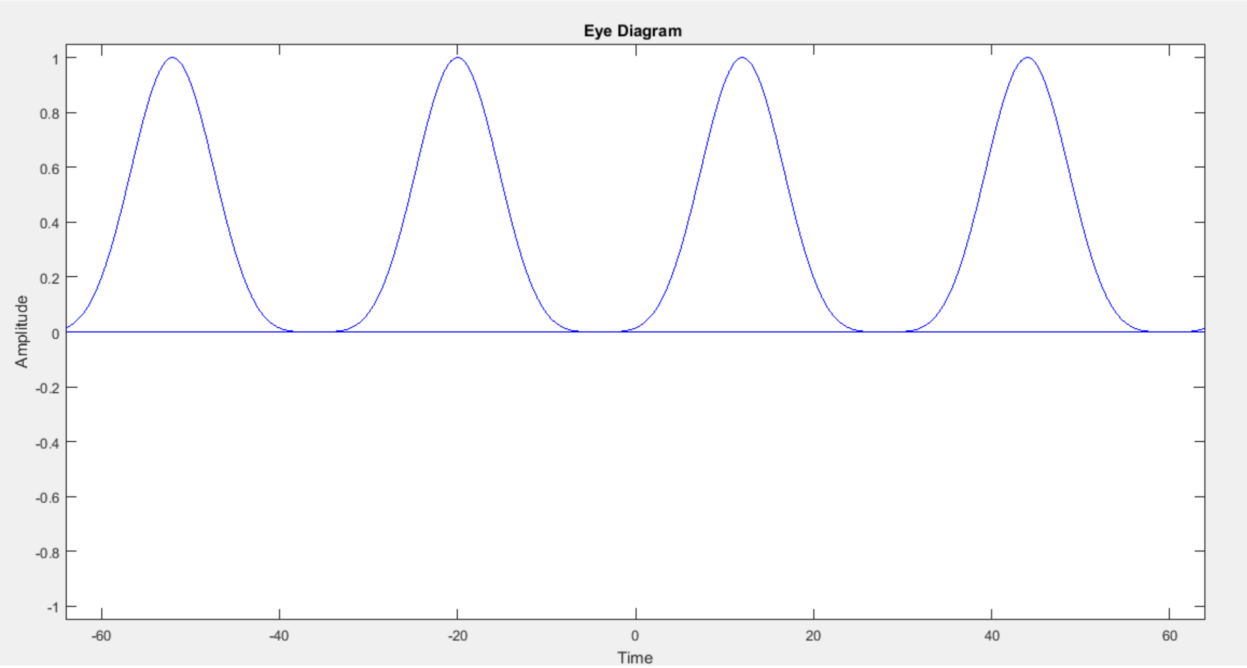

Figure 15 Eye diagram for modulation technique OOK without distortion

The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage. The bit error probability pe is the expectation value of the bit error ratio. The bit error ratio can be considered as an approximate estimate of the bit error probability. This estimate is accurate for a long time interval and a high number of bit errors. Figure 17 represents bit rate analysis versus signal to noise ratio for different distance up to 5 Km. The figure depicts that as SNR in db increases then BER will be low and for distance up to 1000 meter bit error rate will be low wrt 3000 meters and 5000 meters.

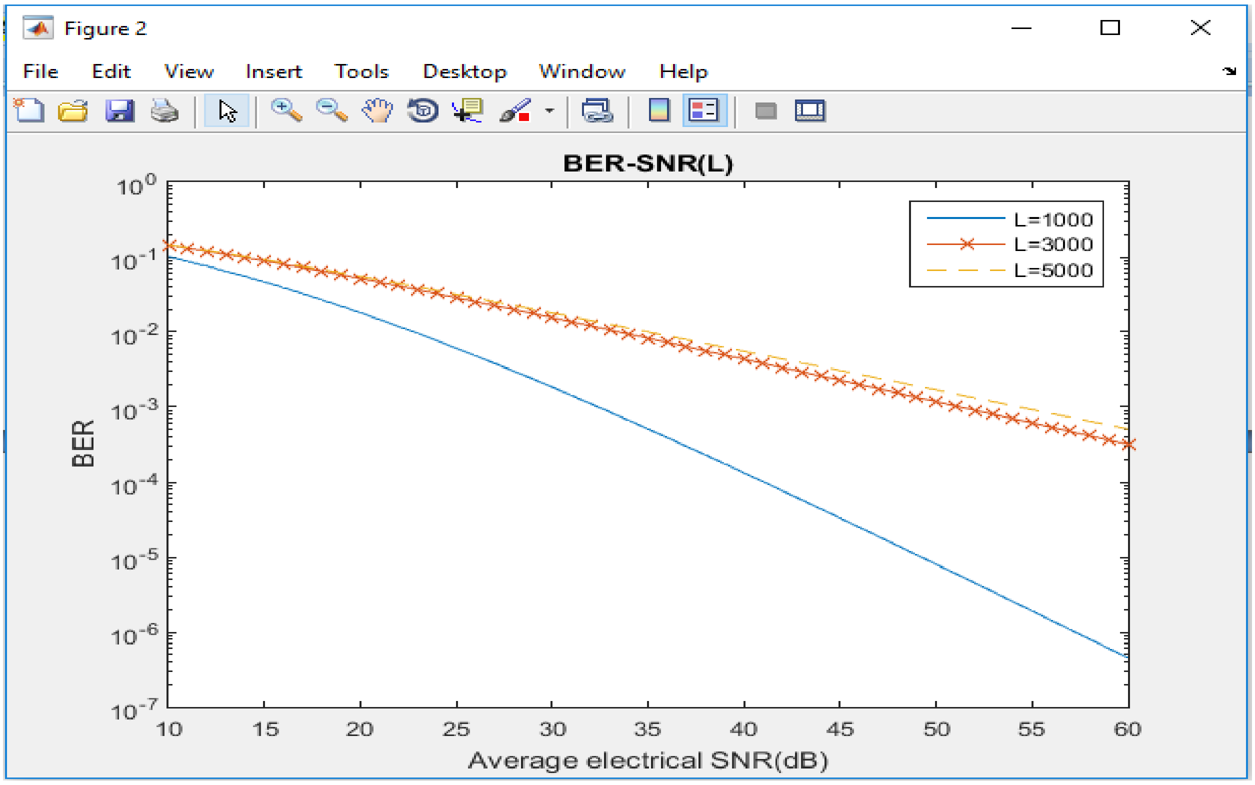

Figure 16 BER and SNR comparison diagram for 1000, 3000 and 5000 meters

CONCLUSION

In our research work FSO communication is set up in Matlab environment and as data transmitted from transmitter to receiver through FSO, various challenges have to face so that data can be transmitted successfully. The impact of atmospheric turbulence, path loss factor and pointing error on the performance of free space optical communication system is analysed. A simulation model of free space communication system is developed in Matlab using Simulink. Bernoulli generator is used for generating random data sequence for every user and the data of the individual user is coded with Hadamard code before transmission through the free space channel. At the receiving end, the direct detection technique is used. Then the BER is evaluated. When the path loss factor is maximum BER is also high. This path loss factor is severe in presence of dense fog. The effect of atmospheric turbulence was also observed at maximum turbulence condition the BER is also very high. In our research work, two cases are considered. First of all, with help of Bernoulli binary code generator binary data is produced with different probability and after that spectrum analyser used to see the result in the frequency domain. After that, both signals is convoluted with Hadmard code to achieve orthogonality criterion and the passed through AWGN channel and 10db SNR also added the both signal are processed with FSO circuit with different parameters condition and finally BER is received on display.

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