

Reliability and Availability of FSO for different Weather Conditions

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Abstract—Today Free-Space Optical communication (FSO) has overcome the radio frequency communication. This paper gives an overview of the availability of an FSO system and its different weather conditions. It describes problems that the designer faces while implementing an FSO system and to overcome that problems. Performance analysis of a system for different weather conditions is carried out. Calculation of attenuation due to fog by using KIM and KRUIZE Model and other parameters such as received power, BER and Q factor are analyzed. FSO provides data rate upto 1 gbps. A laser diode at the transmitter side of 850nm and the PIN diode as a photodetector at the receiver side is used. It is possible to calculate visibility from the measured data which is the main factor for estimation the availability and reliability of FSO link. The system link is established using simulation software optisystem and system characteristics is studied.

Keywords: Free Space Optics (FSO) link, Bit error rate (BER), Automatic Power Controller (APC), Kruze's Model, Kim's Model mach zehnder modulator, (MZM)

I. INTRODUCTION

Today is the world of high data rate communication with recent needs of high speed and bandwidth devices has gone through wired and wireless RF communication but these communication systems has limited bandwidth so to enhance the bandwidth a wireless technology is used by employing optical beam from one point to another in free space. It is efficient in places where line of sight is possible without turbulence such as indoor or obstacle less places but in environmental conditions such as fog, rain, and haze such as outdoor places limits the fso link. it provides data rate upto sveral gbps, immune to RF interferences, no licencing is required, provides a highly secured link communication due to digging as in case of optical fiber. these links are suitable for few GB/s for a distance of 1- km. Most detrimental effect of fso is fog among all the other effects. The performance of FSO can be analyzed by calculating the attenuation factor in terms of visibility by using KIM and KRUIZE model. In our proposed design fso

has three subsystem; Transmitter, Fso channel, Receiver. Transmitter has data source, nrz driver, CW laser, mach zehnder modulator. The first subsystem is pseudo random binary sequence (PRBS) generator. Output of PRBS is given to NRZ driver. NRZ is an encoding technique and output of NRZ is given mach-zehnder modulation has one electrical input and other is optical input port. A CW laser is connected to the optical input port of MZM. The optical receiver consists of PIN photo diode followed by a low pass filter (LPF) A Bessel LPF is a type of linear filter with a maximally flat group delay with a cut-off frequency of 0.75*bit rate of signal. FSO laser transmissions are optical and travel along a line of sight path which cannot be intercepted easily. Its main requirement is matching a FSO transceiver carefully aligned to complete the transmission path. Typical attenuation values of three conditions clear, haze and fog are 0.43 dB/Km, 4.3 dB/Km and 43 dB/Km respectively. Initially, the attenuation value is set as 0.43 dB/Km (clear). Fork is used for duplicating the input beam to all the channels

II. FSO CHALLENGES

Optical wireless networks based on FSO technology must be designed to combat changes in the atmosphere, which affects FSO system capacity. FSO is a line-of-sight technology; the interconnecting points must be able to “see” each other despite the physical obstructions. Potential disturbances can be addressed through appropriate network design and planning. The primary challenge to FSO-based communications is dense fog. Rain and snow have very little effect on FSO technology. Fog is vapor composed of water droplets, which are only a few hundred microns in diameter but can modify light characteristics or completely hinder the passage of light through a combination of absorption, scattering, and reflection. Absorption takes place when suspended water molecules in the terrestrial atmosphere extinguish photons. absorption causes a decrease in the power density (attenuation) of the FSO system and directly affects the availability of a system. therefore, the use of appropriate power, based on atmospheric conditions, and use of multiple beams within an FSO-based unit helps maintain the required level of network availability. Scattering is caused when the wavelength collides with the scatter. The physical size of the scatterer determines the type of scattering. rayleigh scattering is When the scatterer is smaller than the wavelength. Mie scattering is When the scatterer is of comparable size to the wavelength. Non-Selective Scattering is when the scatterer is much larger than the wavelength. In scattering there is no loss of energy, only a directional redistribution of energy that may have significant reduction in beam intensity for longer distances

III. SYSTEM MODELING

A new model for FSO communication using Mach Zehnder modulator is designed in Optisystem software. Optisystem is a simulation engine that can be embedded into application software. It provides user-friendly software to customers to implement their own simulation using distributions created and managed by Optisystem. It also provides tools to examine the outputs of the simulation and feedback for efficient simulations:

- a) **A Typical FSO System:** A typical FSO system consists of FSO transmitter, a FSO channel and the FSO receiver. The frequency of the TX is set to be 850 nm in wavelength and the power is 8.dBm. The actual transmit power for a single TX of the experimental FSO system installed

Table 1: parameters choosen

PARAMETER	SYM-BOL	VALUE
modulator type	MZM	mach zehnder
Transmission data rate	Bit rate	1 gbps
Link distance	Z	2 km
Transmitted power	Pt	8.66 dbm
Wavelength	f	850nm
Transmitter aperture	Dt	2.5cm
Receiver aperture	Dr	10cm
Extinction ratio	Re	10 db
Beam divergence	theta	2 mrad
Equipment loss	Leqip	3.6 db
Line width	W	10 Mhz

practically is 7.80dBm; usage of additional 0.90dBm is due to the power penalty caused by the TX’s extinction ratio value. The output of the TX is connected to the fork which is a component used to duplicate the number of output ports so that each of the signals coming out from the fork’s output has the same value with the output signal from the previous component connected to it. The first fork connected to the TX will produce a multiple laser beams from one source. Then, each of the output signals will be connected to another set of forks to produce another set of multiple laser beams. The multiple laser beams produced are then combined together with a power combiner before it is sent to the FSO channel. The output signals coming from the power combiners are sent to the FSO channel which is the free space channel. It is a subsystem of two telescopes with the FSO channel between them. The apertures of the TX and RX are set to 2.5 cm and 8 cm. The beam divergence is 2mrad and the distance of the channel is set to 2km .The bit rate used here is 1gbps. In system losses due to the equipment inefficiency cannot be ignored. Since they are two FSO terminals involved, each terminal has a loss of 1.8 dB according to Fso installed. Hence, the equipment loss is set to be 3.6DB for two FSO systems. Here the receiver used is the PIN receiver. All the multiple signers coming from the FSO channels are then again combined using the power combiner before received by the RX.

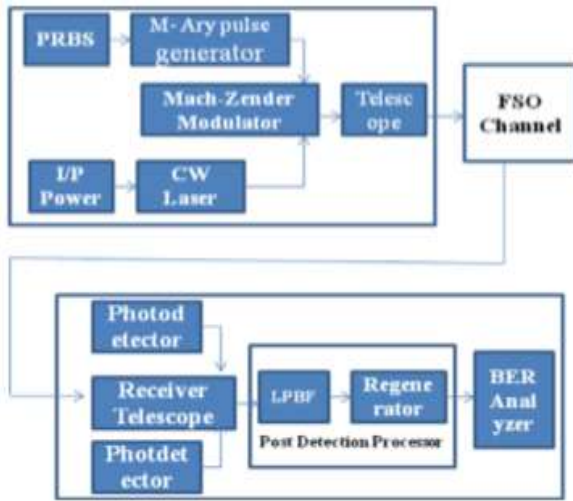


Fig1 : Block diagram of typical FSO system

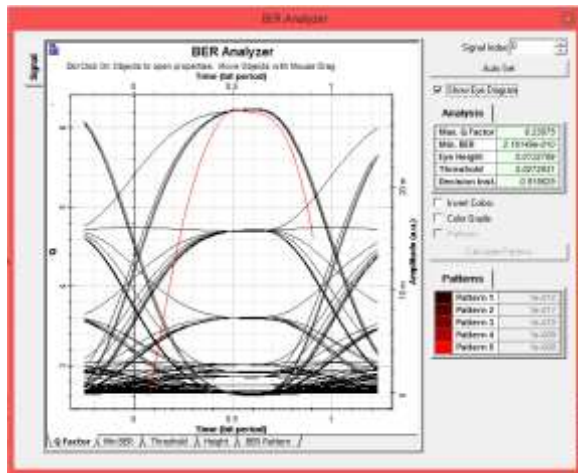


Fig 2: BER Analyzer

The two visualize BER used in the simulation is the optical power meter and the BER analyzer. The first power meter is used to measure the transmit power signal coming out from the TX output port and the second power meter is used to calculate and display the average received power at the RX. As for

frequency (nm)	visibility(km)	particle distribution	size	attenuation(db/km)	received power (db/km)
850	55	1.7		0.05	-19.108
850	15	1.4		0.4	-19.54
850	5	1.3		0.38	-19.78
850	1	0.58		3.03	-25.088

Table 2 : Simulated parameters for kruze

frequency (nm)	visibility(km)	particle distribution	size	attenuation (db/km)	received power (db/km)
850	55	1.7		0.05	-19.108
850	5	1.3		0.38	-19.78
850	1	0.5		3.03	-25.307
850	0.5	0.1		.12	-31.98
850	0.1	0		39.12	-98.1

Table 3 : Simulated parameters for kim

the BER analyzer, it will automatically calculate the BER value and display the eye diagram of the designed system. The FSO systems are immune and free from electromagnetic interference

b) Prediction of fog attenuation using visibility data:

According to the fog models visibility is defined as the distance to an object where the image distinction drops to 2% of what it would be if the object were nearby instead. As the fog produces huge signal attenuation, so it is considerable as the most destructive factor. The visibility is measured at 850 nm wavelengths. Visibility is the only one at most parameter which describe fog. It is measured at meteorological stations or airports. The attenuation for both KRUZE and KIM model is given by the following formula.

$$A = (3.912/V) * ((\lambda/550)^{-q})$$

Where, V(km)= visibility

λ (nm)= wavelength

850= visibility reference wavelength

q= particle size distribution

for q to find there are two models followed which are as follows:

KRUZE's model:

$$q = \begin{cases} 1.3 & \text{if } V > 50 \text{ km} \\ 1.6 & \text{if } 6 < V < 50 \text{ km} \\ 0.585 V^{1/3} & \text{if } V < 6 \text{ km} \end{cases}$$

KIM's model:

$$q = \begin{cases} \text{if } V > 50 \text{ km} \\ 1.3 & \text{if } \text{km} < V < 50 \text{ km} \\ 0.1 V + 0.34 & \text{if } 1 \text{ km} < V < 1 \text{ km} \\ V - 0.5 & \text{if } 0.5 \text{ km} < V < 1 \text{ km} \\ 0 & \text{if } V < 0.5 \text{ km} \end{cases}$$

c) **For normal condition:** We have simulated the FSO link using Optisystem with the parameters chosen. We have considered an attenuation of 0.1 dB/km and calculated OSNR (Optical Signal to Noise Ratio) at the transmitter and receiver, noise figure, optical power output and also analyzed the BER (Bit Error Rate). LASER frequency are chosen as 850nm with input power of 8 mW and line width of 10 MHz. During the normal conditions the input optical power is 4.4dBm, the output optical power is -7.35dBm from which the video can be retrieved.

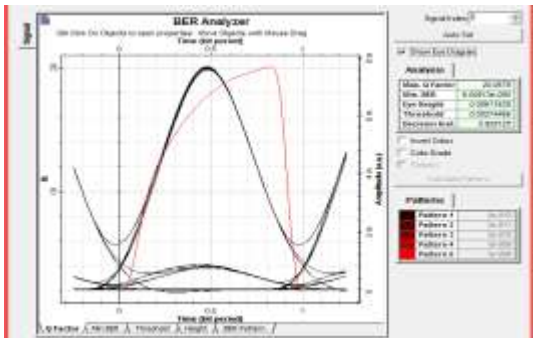


Fig 4 : EYE diagram for Normal condition

d) **For rain condition:** The rain is coded in matlab component and simulated along with optisystem the output optical power is -3.848 dBm. The video signal is not obtained and is distorted. To obtain a clear video the power of the laser has to be increased accordingly to withstand the attenuation due to rain. The power is increased by automatic power control. With automatic power control employed the output power is -1.4 dBm, which is sufficient to produce a clear video. The eye diagram also gives a clear pattern which verifies the result. eye pattern obtained after employing APC with rain.

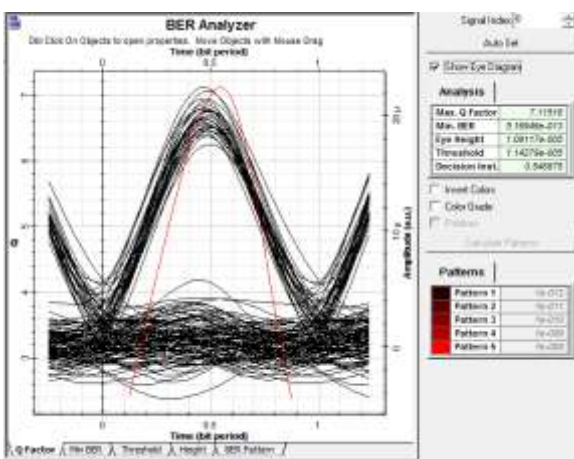


Fig 5 : EYE diagram for Rain condition

IV. CONCLUSION: The aim of this work is to setup and investigate FSO link with different weather conditions at the range of 2 km. As the visibility decreases, the attenuation increases and the received power in turn

decreases. we have achieved quality factor of 13.1 in typical fog conditions and 20.0 for normal condition and 7.11 for rainy condition. Also we have calculated OSNR, Noise figure, Gain, Optical power, analyzed the spectrum and BER using Optisystem 7.0. This analysis describes that the different attenuation conditions lead us to different weather conditions like clear weather, rain, snow, light fog, heavy fog. We have achieved what we set out to do - to implement data multiplexing through FSO and to eliminate the effects of Fog and Rain attenuation on the link. Thus this analysis leads us to the conclusion that the multiple transceiver FSO system can be well operated under different weather conditions. So the multiple transceiver system is beneficial under these weather conditions. With further research and development it is hoped that it can be used for medical, defense, LANs and various other applications over greater distances and during all weather conditions.

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