International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 07 | July -2017 www.irjet.net p-ISSN: 2395-0072

Analysis of Free-space Optical system under DifferentAtmospheric Channel

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Abstract *- Over the last few decades Free Space Optical (FSO) communication is mostly preferred over the radio frequency communication and microwave communication Systems because of its license-free long-range operations. Also it is having various advantages like small size, high bandwidth, low cost and lease of deployment. Free Space Optical communication has very few limitations also like beam dispersion, scintillation etc. We know that limitation of FSO is the effect of weather conditions on it. In paper we designed to operate at 2.4 Giga bits per second. FSO communication system and presented analysis of 2.4 Gbps FSO system uses different Atmospheric weather condition by distance of 10 km. From the result it seems that as we move clear weather to heavy fog Quality factor as well as transmission range will effectively decrease.*

Keywords—Attenuation, Free Space Optics, Bit Error Rate (BER), Mach Zender Modulator (MZM) and Q(Quality)-factor

I. INTRODUCTION

Free Space Optics(FSO) is a wireless communications technology which utilizes light for the transmission of data through the air in the similar manner as the fiber optics uses a fiber cable.FSO is an optical communication technology in which using data is transmitted by propagation of light in free space allowing fiber optical connectivity. There is no requirement of the optical fiber cable. Free Space Optics(FSO) is having the same capabilities as that of fiber optics, but at a lower cost and H highly fast deployment speed [1]. It has very high speed, low cost, high bandwidth, quick and easy installation, high security and also having license-free long-range spectrum. Free Space Optics (FSO) works on the principal of laser source driven technology which uses light sources and detectors at receiver to transmit and received information, through the atmosphere same as Fiber Optics Communication (FOC) link, which uses light sources and detectors to transmitting and receiving information but through a only fiber optic cable.

Free space optics (FSO) communication links having over some distinct advantages over conventional microwave and optical fiber communication system by virtue of their very high carrier frequencies that permit large capacity, enhanced high security, high data rate and so on respectively. In telecommunications, FSO(Free Space Optics) is an optical communication technology that uses light propagating in free space medium to transmit data between two end points. FSO systems are being considered for military systems application, because of their inherent benefits as normally most of the systems are rated for greater than 1 km in three or more lasers operating in sequence parallel to mitigate distance related issues.

II SYSTEM DESIGN

Consider a FSO link, the transmitter modulate data onto the instantaneous intensity for optical beam communication. The laser beam propagates through gamma-gamma turbulence channel and the receive integrates the photocurrent signal.

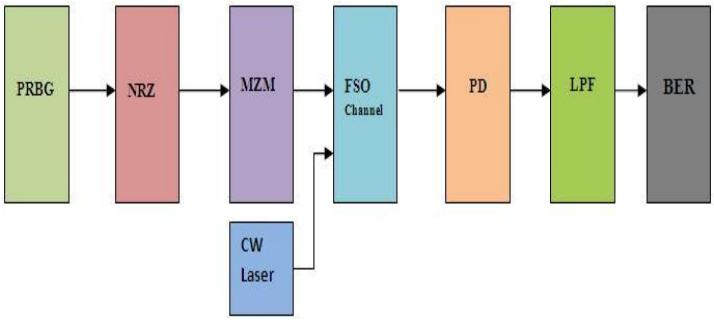


Figure 1: FSO System Designing

Figure 1 shows the basic concept and device that have been using in designing. There are many Pseudo-Random Bit Generator, NRZ(Not Return to zero) Pulse Generator, CW Laser, Mach-Zender Modulator(MZM) at transmitting part; while, PIN photo detector diode and Low Pass Bessel Filter(LPF) at the receiver part. However, some of Parameter measurement tools such as BER Analyzer, Electrical Power Meter are used as well. Pseudo random bit generator which generates the logic signals i.e. in the form of 1110 etc. and transmits to the NRZ(Not return Zero) pulse Generator. A Mach-Zehnder effectively uses modulator for controlling the amplitude of an optical wave. The input waveguide is split up into two different waveguide interferometer arms. If a voltage is applied across one of the arms, a

phase shift is induced for the wave passing through another arm.

A, Atmospheric attenuation:-

Atmospheric Attenuation present in the atmosphere of the system can large affect its performance. Atmospheric attenuation and geometric losses constitute all different type attenuation. It is the effect of particles present in the air such as e.g. haze, rain, fog, snow etc. Atmospheric absorption losses consist of an atmospheric absorption as well as a strongly weather-dependent auxiliary atmospheric absorption by fog and rain. The electromagnetic waves are weakened when penetrating through air and water vapor layers.

B. Atmospheric Turbulence

There has been going very significant research after finding accurate and efficient model for atmospheric turbulence in channel. Generally for weak turbulence log-normal is widely accepted model while for medium to strong atmospheric turbulence Gamma-Gamma is a optionally perfect distribution for analysis.

The optical modulator used in the link converts the information into the desired signal and controlling the amplitude of an optical wave signal. Laser driver used to provides the power for the laser for its proper functioning and helps to prevent quick aging and other environmental effects of laser.Atmosphere turbulence also changes with time and results to intensity fluctuations so that are temporally correlated. Modeling the movement of atmospheric eddies is extremely difficult.

III.Different Atmospheric Conditions

3.1 Clear Weather Condition: For clear weather; as we all know there less attenuation or its amount is negligible [4]. The amount of Atmospheric attenuation in the clear weather is from 0 to 2 dB/km.

3.2 Rainy Condition: Rain has a long distance-Degrading impact on FSO, although its impact is significantly less than that of other Atmospheric weather conditions. Due to Because the radius of raindrops (150–2000 μ m) is significantly larger than the transmitting wavelength of typical FSO(Fiber Space Optics) light sources [5]. Rain attenuation values are moderate in nature. For example, for a rainfall of 3 cm/hour, a signal attenuation rate of 6 dB/km is observed. There are two Different conditions of Rain i.e. light rain & heavy rain.

3.3 Snow Condition: Snowflakes are ice crystal which comes in a variety of shapes and sizes. In general, snow tends to be marginally larger than rain. White out conditions might be attenuated the travelling beam, but scattering of light doesn't tend to be a big problem for FSO systems because the size of snowflakes is larger when compared to the operating wavelength of transmitting information

[6]. The large impact of light snow to blizzard and whiteout conditions falls approximately in between light rain and moderate fog, with link attenuation potentials of approximately 2.5 dB/km to 29 dB/km. [7].

3.4 Atmospheric Fog Condition: Fog is the most detrimental weather phenomenon for FSO Communication because it is mainly composed of small water droplets having radii about the size of nearly infrared wavelengths. The particle size distribution varies from different degrees of fog condition. Weather conditions are mostly referred to as fog when visibilities range between 0– 2KM. Because of foggy conditions are somewhere difficult to describe by physical means and descriptive words such as "densed fog" or "thin fog" are sometimes used to characterize for appearance of fog .

Condition	Attenuation
Clear Weather	0.2 to 3 *dB/km*
Rain	4 to 17 *dB/km*
Snow	20 to 30 *dB/km*
Light Fog	40 to 70 *dB/km*
Heavy fog	80 to 200 *dB/km*

Table 1 shows the different weather conditions with their attenuations.

IV. RESULTS AND DISCUSSION

Analysis of Quality factor in Different Atmospheric Condition over range in Kilometer. There are Different type of graph Shown in Different Image Which varies from Different Graph. The comparison is gives result the improvement in the output when more than one receivers are inserted in the link. It shows that curve of Q factor has become sharp after using

array of receivers at different values of attenuation. Figures in the table have proved that received signal power decreases as increasing attenuation presence of bad weather condition.

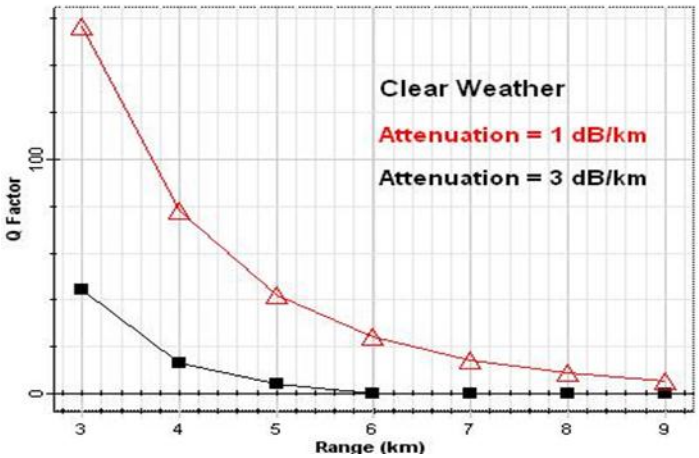


Figure 2: Evaluation of Quality factor Vs Transmission range at clear weather condition

Figure 2 shows the measurement of Quality factor Vs transmission range in KM with different attenuation in FSO(Fiber Space Optics) system. It has been seen that Q factor reduce from 170 to 5 in the transmission range 2 to 9 km rate of attenuation 1 dB/km.

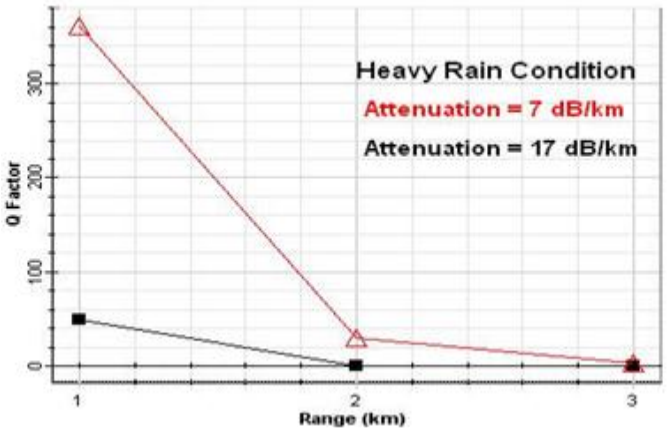


Figure 3: Evaluation of Q factor Vs Transmission range at heavy rain condition

Figure 3 shows that measurement of Quality factor vs range with different type attenuation in FSO system at heavy rainy condition. It seems that Quality factor decreases from 360 to 2 in the transmission range 1 to 3 km at attenuation 7 dB/km. Next to Q value changes in the range of 50 to 0 in the transmission range of 1 to 2 km at rate of attenuation 16 dB/km

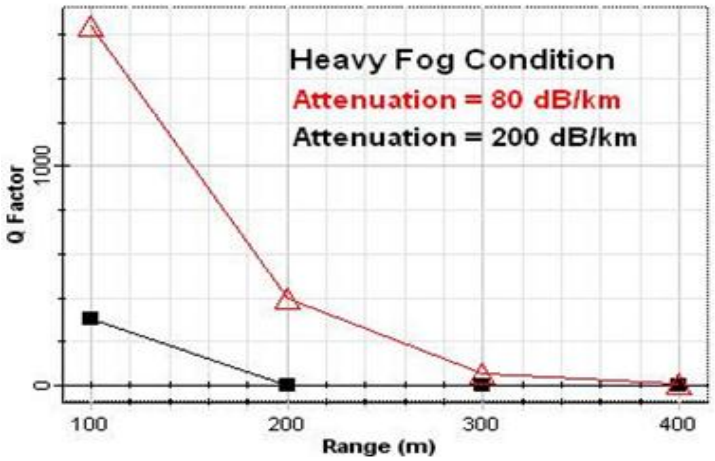
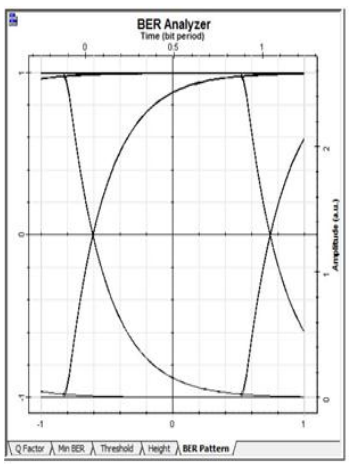
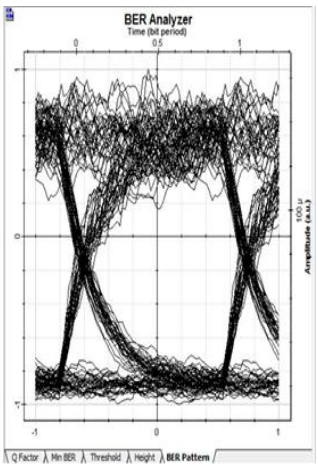


Figure 4: Evaluation of Q factor vs Transmission range at heavy fog

Figure 4 Shows that measurement of Quality factor Vs range with different attenuation in FSO system at heavy fog condition. It has been observed that Q factor reduce from 1600 to 25 in the transmission range 100 to 400 meter at attenuation 80 dB/km.

An eye diagram is a indicator of the quality of signals in high-speed digital transmissions. the eye diagram for digital signals would consist of two parallel lines with instantaneous rise and fall times virtually invisible .An electronic oscilloscope generates graphically an diagram by overlaying sweeping of different type of segments of a long data stream driven by a master clock. The input triggering edge may be positive or negative, it displayed pulse signal that appears after a delay period; Therefore, when such transitions have been overlaid, positive ,negative pulses are superimposed on one another. There are so many bits producing an eye diagram, so called because the resulting image looks like the opening of an eye.





(A) (B)

Fig (A): EYE Diagram in Clear Weather

Fig (B): EYE Diagram in Heavy Fog

V. CONCLUSION

In this paper, the performance of the free space optical (FSO) communication systems under the effects of bad weather conditions especially for heavy rain, fog, dry and wet snow has been analyzed. FSO system with different Atmospheric weather condition by distance of 1 kilometer was done. From the result it seems to move from clear weather to heavy fog Quality factor decreases. We presented an Fiber space optics system whose maximum possible range is 1 km at rate of attenuation 0.5 dB/km Shows in clear weather conditions. But as the weather conditions changes from clear condition to fog condition it effects the transmission data in our FSO systems worst which is clearly showing from the results obtained in this paper. The Quality factor decreases as the Atmospheric Fog conditions occur more immensely that is it changes from light to heavy Fog condition.

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