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ANALYSIS OF FSO LINKS USING VARIOUS MODULATION FORMATS AND ESTIMATING THE LINK PERFORMANCE FOR COMMERCIAL AND MEDICAL APPLICATIONS.

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ABSTRACT

Free Space Optics (FSO) Links are deployed for high bandwidth requirements and for achieving high- er data rates and by reducing the complexity of the system design. As the links operate in the unlicensed Tera Hz spectrum bands it offers improvement in the signal bandwidth. A point to point link can be established for two outdoor buildings with a data rate of 1Gbps per link and can also be in- creased to 100 Gbps using Wavelength division multiplexing (WDM). As the medium is free space the major drawback is various weather conditions, such as rain, fog as the light interacting with free space leads to signal fluctuation and increases the attenuation and which consequently reduces the efficiency of the system. In this paper, system models are designed for same wavelength working at different power levels with different modulation formats to have a secured transmission which can work for long distance communications and the model is designed and valuated for different atmospheric conditions. The quality factor and bit error rate is calculated and tabulated for analysis.

Keywords: Return to Zero (RZ); Non-Return to Zero (NRZ); MSK (Minimum Shift Keying) BER (Bit error rate); FSO (Free space optics); WDM (Wavelength division multiplexing), Quality Factor.

1. INTRODUCTION

Data can be transmitted between the modules by using any transmitting media like copper cables. twisted pair cables, optical fibers and microwave and satellite links. An optical fiber can be used to transmit the information for longer distances with THz frequency and to achieve higher data rates. But due to its wired nature and cable laying it be- comes tough to install. In order to overcome the difficulties technology have been ramped up to look at wireless models to transmit the data for commercial space and medical applications. The solution is visible in the form of Free Space Optical links where data is transmitted in free space without the help of any channels. But the difficulty that raises is as the medium is free space atmospheric conditions plays a vital role in reducing the efficiency of the system .As the medium is free space the FSO link will undergo many atmospheric turbulences in the form of rain, haze, fog, snow .Because of this atmospheric conditions the quality factor and Bit error rate of the system will simultaneously and significantly re- duce the overall transmitting efficiency of the system.[1][2]

An FSO link propagates in free space with the speed of light so it can cover longer distances with very high speed and the required higher data rates can be easily achieved but due to the atmospheric conditions we cannot use for longer distances and the link needs to be limited to shorter distances up to 50kms in range. A free space op- tical link can be deployed using optics but in this model a simulation technique is carried for better understanding for limited medical and commercial applications [3][4]. As the weather is very tropical in a country like India it becomes very difficult for signal transmission so many mitigation techniques are needed to be followed to re- duce the losses in the system. The link can carry any form of data such as audio, video, voice files without the need of license agreement.

1.1.1 Merits of FSO:

No License: As no license is required any person can be able to transmit the information which makes the job easy for the service providers.

Data Rate: In the absence of atmospheric turbulence higher data rates are easily achieved using FSO Link.

Easy to Design: The circuitry required for installation is very minimum as it don't require to lay down any cables.

2. SYSTEM MODEL OF AN FSO LINK

A Free space optical link is designed with the help of Opti system. In the design a pseudo random sequence generator is considered which will generate the random sequences and will represent the digital link of the system. A light wave is required which is generated with the help of continuous wave laser. Either a LED or CW Laser with serve the purpose to transmit the light but LED cannot be used for longer distance communication a CW Laser is utilized[5].

The message signal and the carried need to be modulated only then they can be transmitted. This purpose is served with the help of Modulator it can be RZ or NRZ, Manchester OOK Schemes. When the signal gets modulat- ed it is easily transmitted through the FSO channel and amplification is done with the help of Gaussian filter.

Block Diagram illustrating the process of FSO is depicted as follows:

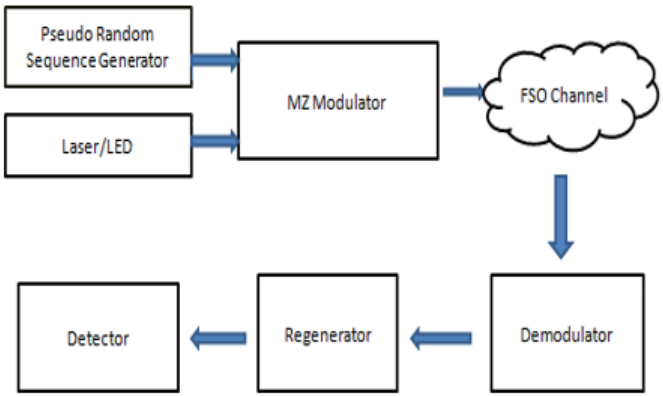

Fig 1: Block Diagram Representing the FSO System

When the Link undergoes the atmospheric turbu- lence the resulted signal is demodulated with the help of Photo detector which will convert the op- tical signal to electrical signal.

For transmitting to long distances a regenerator and a repeater are used which will amplify the signals without any distortions and attenuations. Quality factor and Bit error rate are computed using the BER Analyzer and Spectrum Analyzer. The attenuation can be computed based on the visibility (Km) and the empirical relationship can be computed using the Kim Model, depending upon the size of the particle k. The specific attenuation can also be calculated for fog using Kruse model.

The bit error rate can also be computed for evaluating the performance of the system which is given the empirical relationship as follows:

BER=No of bits in error/Total no of bits in transmission.

BER and quality factor determines the efficiency of any system where if the no of bits in error are more, it reduces the quality factor and vice versa.

$BER=1/2\text{erfc}(Q/\sqrt{2})$[6]

3. Mathematical and Design Analysis.

Using Opti system the system link is designed with attenuations and distance taking into consideration, and the receiver loss is negligible with no additional losses taking into consideration. The link distance is carried up to 50kms and the attenuation of 0-5 dB/Km is taken for evaluation and simulation.[7]

Table 1: Design Parameters of FSO System

S NO	NAME	VALUE
1	Attenuation	0-5 (dB/Km)
2	Range	1-50 Km
3	Any Additional losses	Nil
4	Geometrical losses	0 dB
5	Transmitter aperture diameter	5cm
6	Receiver aperture diameter	25cm
7	Receiver loss	0dB

3.1.1 System Design for NRZ Links.:

The system has been designed with 1550nm wavelength initially with 0 dB/Km and as the distance increases attenuation also increases so simultaneously the aperture size of the transmitter and the receiver are changed for better performance of the system. [8]

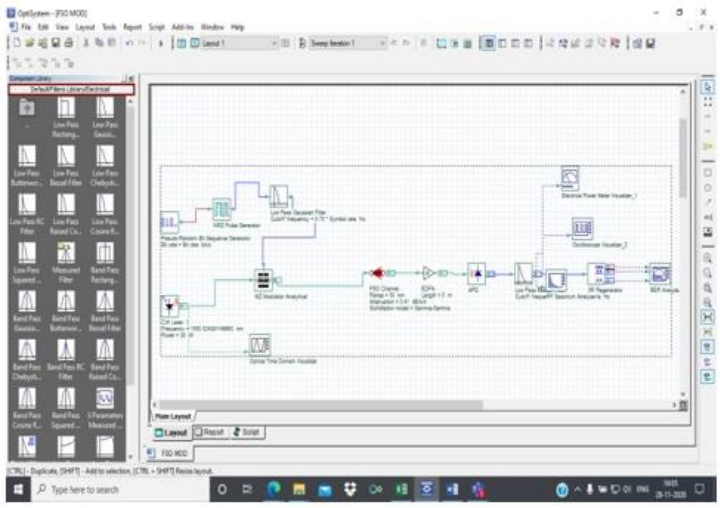

Fig 2: Layout for System Design at 1550 nm

The Eye pattern can be visualized for NRZ For- mat at 0 dB/Km and for distance of 5 km. In the below figure a clear eye pattern is visualized without any deviations.

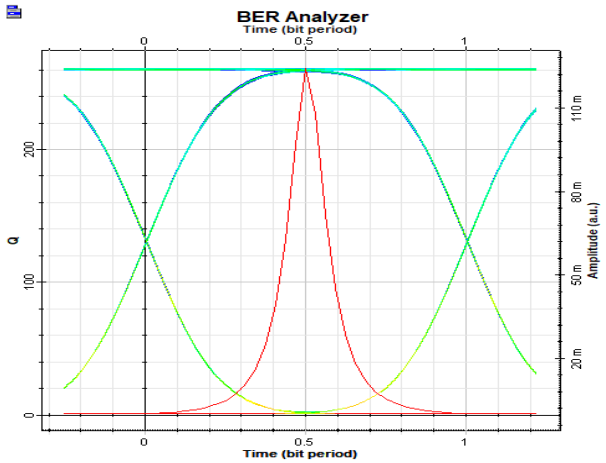

Fig 3:Eye pattern for NRZ at 1550nm for 5Km transmission.

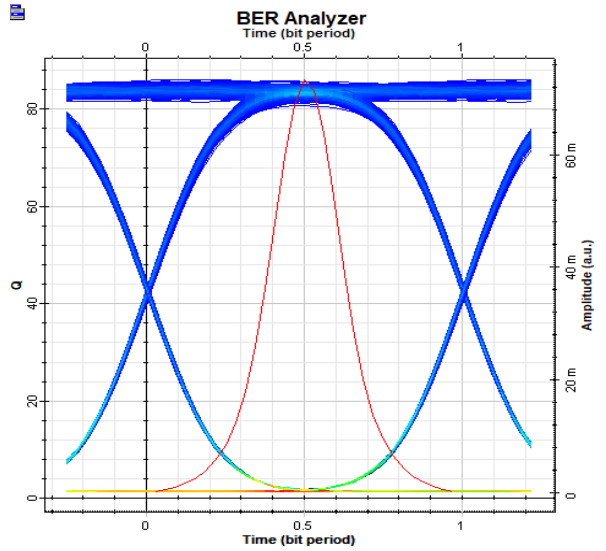

Fig 4:Eye Pattern for NRZ at 1550 for 20 Km transmission

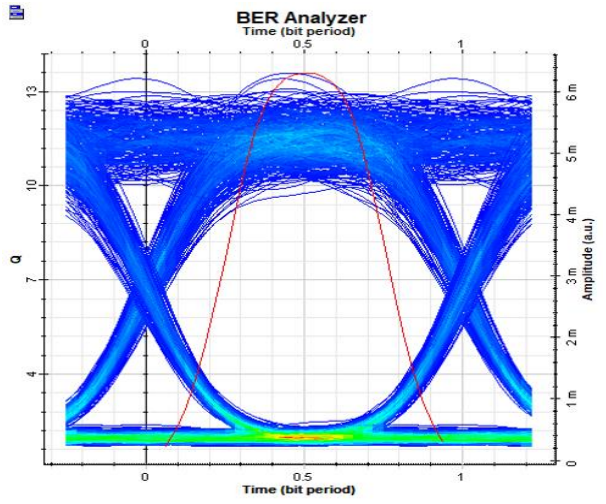

Fig 5: Eye Pattern for NRZ at 1550 for 50 Km transmission

From the above three Figures 3,4,5 it is cleared observed that as the distance of transmission is increasing the quality factor of the system reduces and the signal gets attenuated.

3.1.2 System Design for RZ Link

A system link is designed at 1550nm for Return to Zero and the BER and the Quality Factor is Analyzed [9]

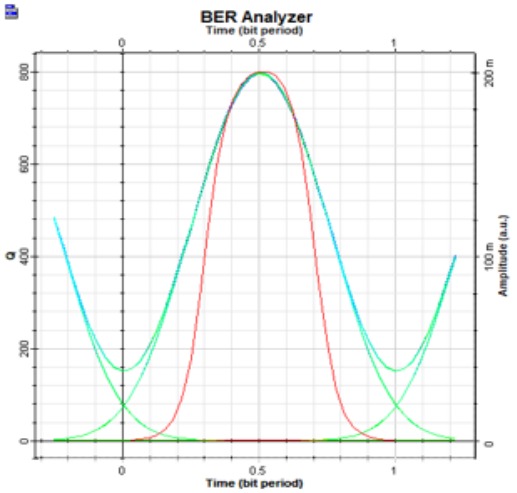

Fig 6: A RZ Format is deployed for 5km.

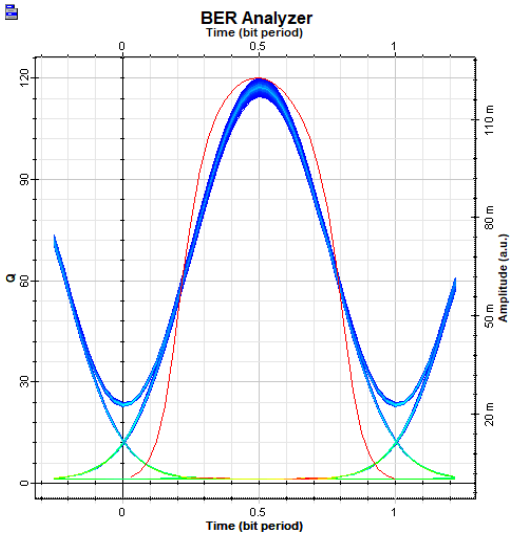

Fig 7: Eye Pattern for RZ at 20km.

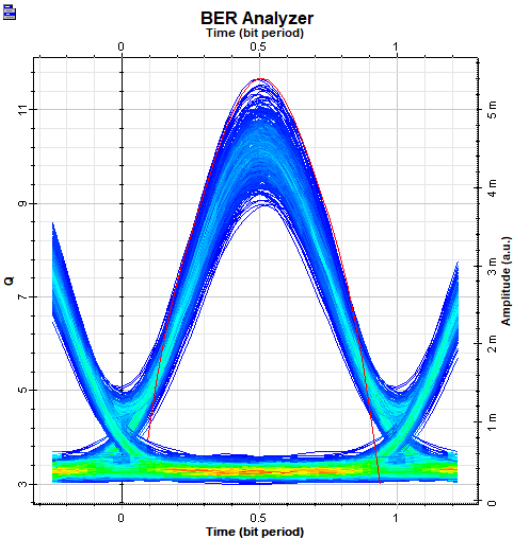

Fig 9: Eye Pattern for RZ at 50km

3.1.3 System Design for MSK

A system link is designed at 1550 nm for Minium shift keying for two different distances and the bit error and quality factor are analysed. [10]

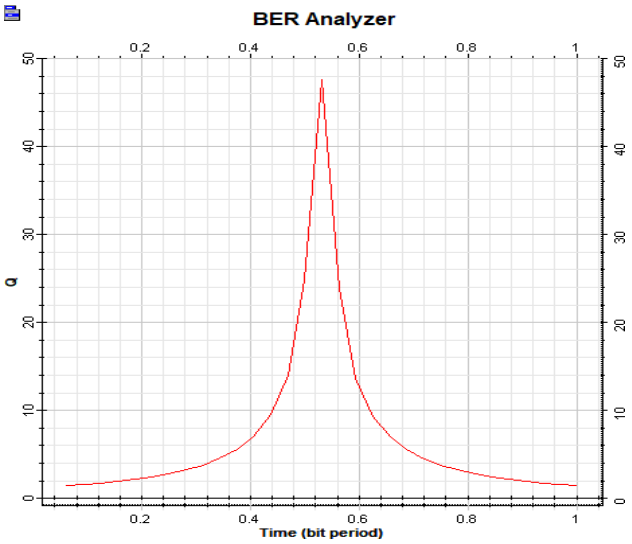

Fig 10: Eye pattern for MSK AT 5Km

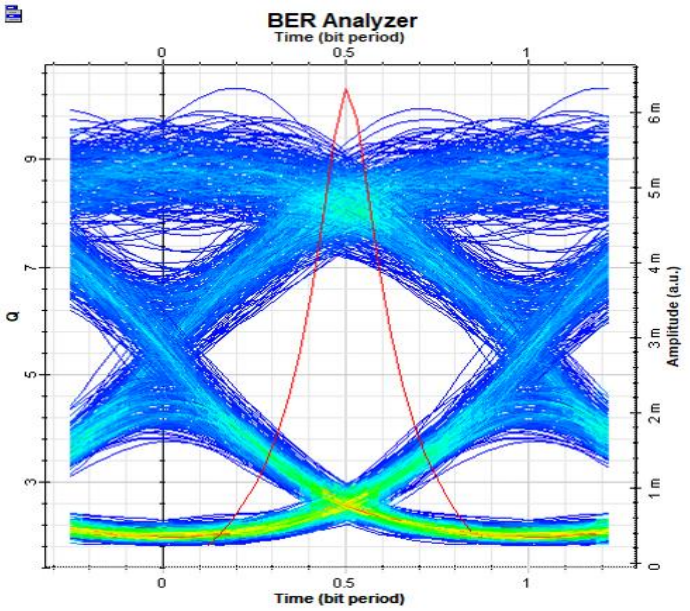

Fig 11: Eye Pattern for MSK at 50 Km

4. RESULTS AND DISCUSSIONS

Systems are designed at 1550 nm wavelength working with various modulation formats such as RZ,NRZ,MSK .The three links are operated from 1Km to 50 Km.

From figures 3,4,5 It is clearly visible for NRZ Format that as the distance is increasing the eye opening is increasing which simultaneously reduces the quality factor and Bit error rate of the system.

From figures 6,7,8 it is evident that for RZ Format as the distance is increasing it too tends to have a declination in the quality factor of the system and bit error rate too increases which is not at all desirable

From figures 10 ,11 the system is designed for modulation scheme reffered as Minimum Shift Keying where it performes better than the other two factor which we have considered for link analysis as RZ and NRZ.

In the MSK Model, transmitting at 1550 nm, we can see a very sharp waveform generated for 5km and the losses are negligible when compared to RZ and NRZ Formats. When the distance increases, MSK Model also tends to have reduction in the quality fac- tor but its very minimal value.

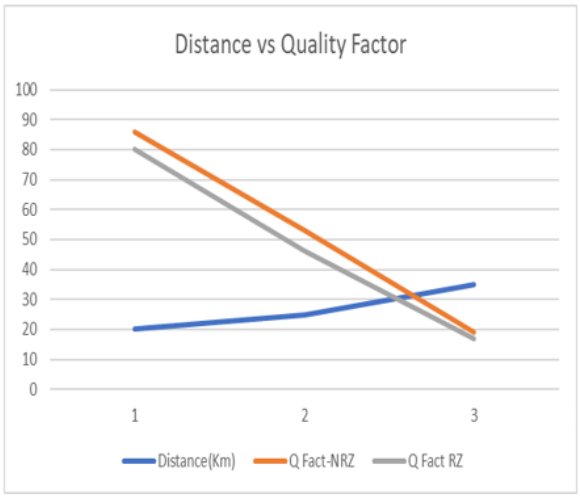

Fig:12 Distance vs Quality Factor for Both formats.

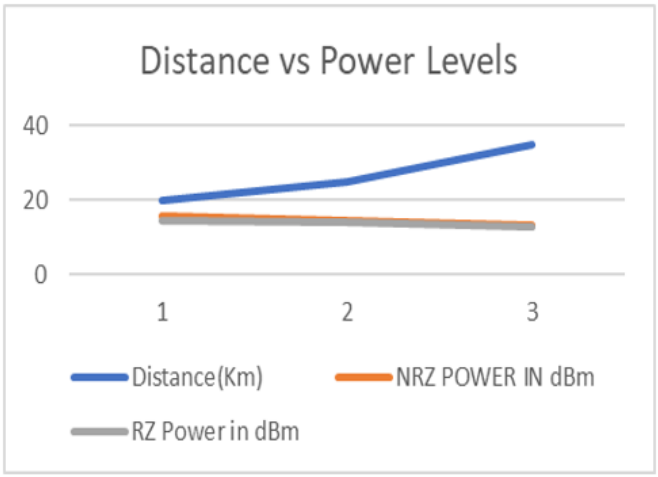

Fig 13: Distance vs Power levels for RZ &NRZ

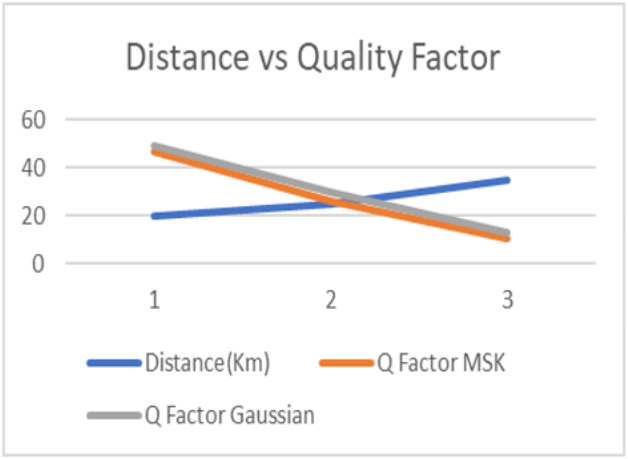

Fig 14: Distance vs Quality Factor for MSK & Gaussian modulation Formats.

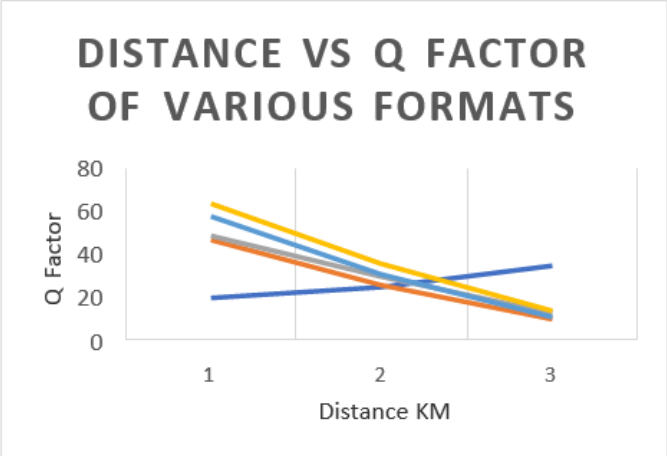

Fig 15: Quality factor for different modulation schemes.

5. CONCLUSION AND FUTURE SCOPE

We can easily build a system link for short distance communications inside the hospitals or any commercial spaces for easy exchange and fast delivery of messages without the help of any li- cense spectrum provided the atmospheric turbulences are overcome by the mitigation techniques such as aperture averaging or coding and decoding of the carrier signals or by the usage of the adaptive optics.

All the results obtained are designed up to 50Km link and further analysis need to be taken for effective implementation for longer distances with very less Bit error Rate and high-Quality Factor.

New coding schemes are yet to be studied which can further improvise the performance of the system by increasing the layer of security incorporated into the system design link.

As hospitals require the real time information it is highly recommended to install the FSO Links for quick and safe transmission of data for providing the X ray reports or MRI or any CT Scans.

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