Performance Analysis of FSO based Intersatellite Links against Pointing Error

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Abstract - Free space optics (FSO) is a next generation state of the art technology, which can be efficiently used to resolve the last mile connectivity issues. It is a suitable technique for Intersatellite communication links and to meet the demand of increasing capacity and quality of service (QoS). In this paper, performances of FSO based inter satellite links is evaluated under the effects of pointing error. The proposed system is investigated for a pointing error of 2 to 10 micro radian and considering various parameters like bit rate, distance, input power etc. It is reported that system performance degrades with increase in the pointing error. It is evaluated that BER increases from 10^{-16} to 10^{-1} at a pointing error of 10 micro radian when bit rate is increased from 1 to 5 Gbps. Further it is also revealed that MZM yield a healthy BER of 10^{-16} compared with directly modulated Laser which yields BER of 10^{-5} at a pointing error of 4 micro radian & at 3 Gbps bit rate.

Keywords - FSO, MZM, BER, Pointing error.

I. INTRODUCTION

Free space optics (FSO) is a wireless technology, which use free space transmission medium to transmit data signal with high data rates. FSO research was started in 1960s [1]. It works on the principal of laser driven technology in which light source and detector are used to transmit and receive the information via the atmosphere same as fiber optics communication link. FSO is line of sight technology in which data, voice and video communication is attained with maximum data rates up to 10 Gbps using full duplex (bidirectional) connectivity [2]. FSO has various advantage like high data rate i.e. 10 Gbps, requires no licensing, Narrow beam angle, easy to deploy, back-haul for cellular communication, inexpensive and consume less power [3] . There are some drawbacks in the system like atmospheric turbulence and PAT (Pointing Acquisition and Tracking) technology, weather attenuation loss etc. [4].

Radio over Fiber (RoF) is a technology, which is used to control the traffic over the network over the wireless communication network system. It is combination of two technique i.e. wireless and fiber optics network. It is a process in which light is modulated by radio frequency (RF) signal and RF signal is transmitted with the help of optical fiber. The frequency of the radio signal usually in GHz and based on the nature of applications [5]. It is full duplex communication is done by using WDM (Wavelength division multiplexing) and optical Add Drop Multiplexer [9-11]. It accommodates the large no. of user as compared to traditional wireless communication system as it utilized large bandwidth of optical fiber and signal can be transmitted in outdoor range as well as in densely populated area of system are used to increase the cellular coverage inside building [6]. Radio over fiber (RoF) technology is find is many important applications i.e. broadband wireless access network, sensor network, radar and defense system etc [7]. RoF has various advantages like large Bandwidth, low attenuation, low complexity, lower cost and immunity to Radio frequency interference etc [8]. In general various types of modulators can be used like MZM, Optical Phase Modulator (OPM) and Electro absorption Modulator (EAM). Generally external modulation is extensively used compared to direct modulation methods.

II. SIMULATION SETUP

This section provides details of simulative model designed for analyzing the performance of Intersatellite links based on FSO network .OPT SIM simulator is used to investigate the performance of FSO system. Figure1 presents the developed simulative model.

The CW laser is modulated directly & externally using MZM . Bit rate for data transmission is varied from 1 to 5 Gbps over a transmission distance of 700 to 1500 meter. Performance of proposed system is compared in terms of bit error rate (BER).

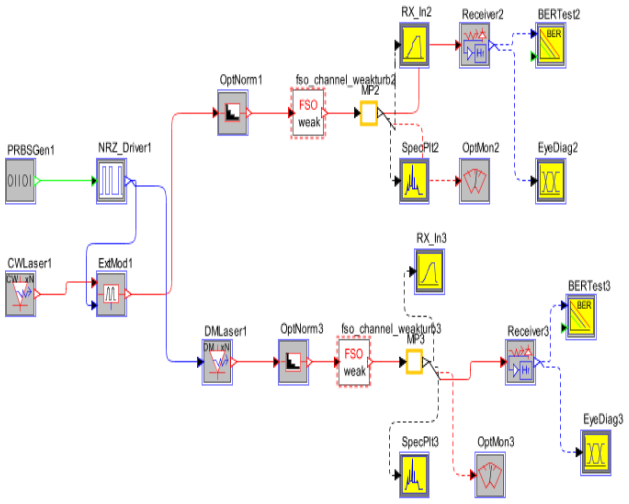

Figure 1: Schematic diagram of developed model

Additional attenuation of FSO block is -4 dB at a wavelength of 1550nm and pointing error is varied from 2 to 10 micro radian. At the end PIN photodetector is deployed to detect the signal. Various measurement devices such as BER meter, power meter, electroscope etc. are used to observe the output.

III. RESULTS & DISCUSSIONS

Figure 2 shows the variation of BER with respect to pointing error for Mach Zehender based modulator. It has been observed that as the pointing error is increased from 2 to 10 micro radian with bit rate of 2 Gbps, BER increases from 10^{138} to 10^{-2} . It is also seen from the diagram that, as bit rate is varied form 1 to 5 Gbps, BER increases significantly degrading the quality of signal transmission.

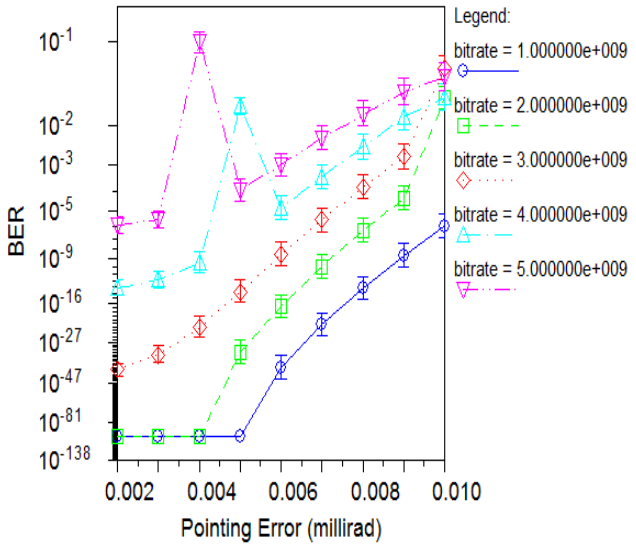

Figure 2: BER vs Pointing error for MZM when Bit rate is varied from 1 to 5 Gbps

Figure 3 shows the variation of BER with respect to pointing error for directly modulated Laser source. It has been observed that as the pointing error is increased from 2 to 10 micro radian with bit rate of 2 Gbps, BER increases from 10^{138} to 10^{-1} . It is also seen from the diagram that, as bit rate is varied form 1 to 5 Gbps, signal quality is further deteriorated as in the case of MZM.

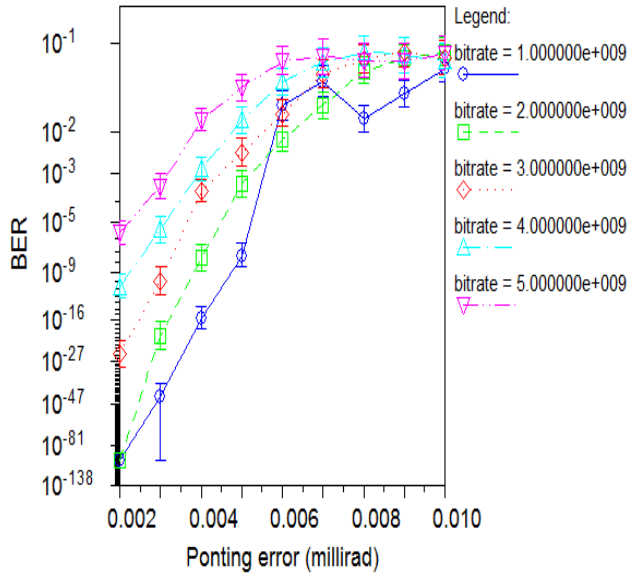

Figure 3: BER vs Pointing error for directly modulated Laser when Bit rate is varied from 1 to 5 Gbps

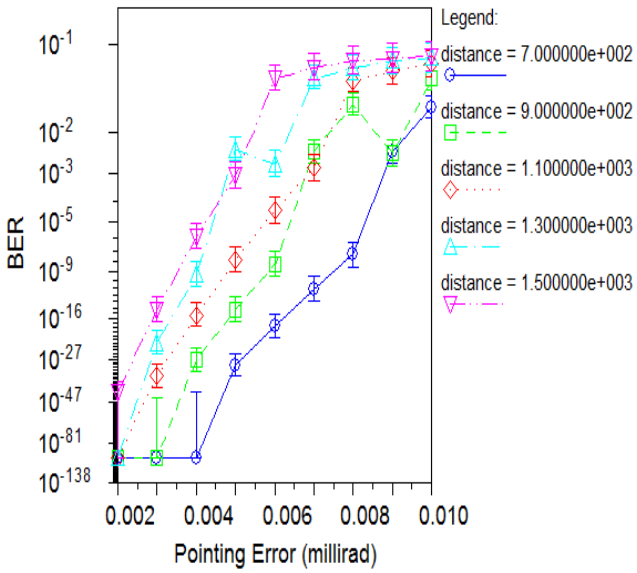

Figure 4: BER vs Pointing error for MZM when distance is varied from 700 to 1500 meter

Figure 4 shows the variation of BER with respect to pointing error for Mach Zehender based modulator against distance as a parameter. It has been observed that as the distance is increased from 700 to 1500 meter, BER increases from 10^{-27} to 10^{-2} at a pointing error of 4 micro radian. It can also be observed that increasing the Intersatellite separation affects the signal quality adversely.

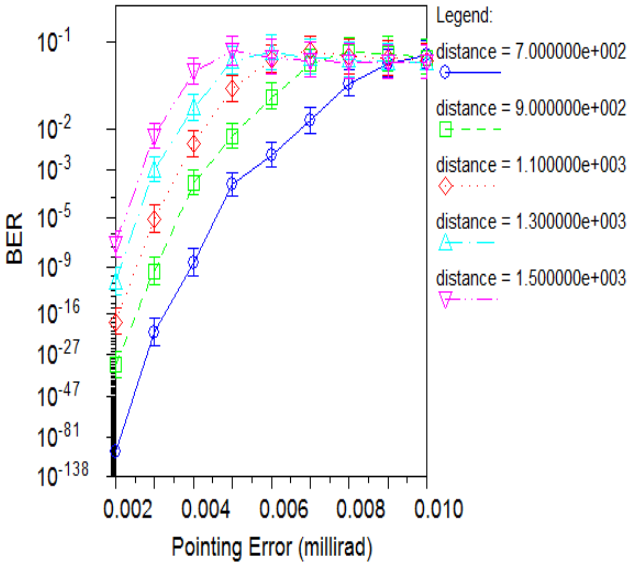

Figure 5: BER vs Pointing error for Directly modulated LASER when distance is varied from 700 to 1500 meter

Figure 5 shows the variation of BER with respect to pointing error for directly modulated Laser against distance as a parameter. It has been observed that as the distance is increased from 700 to 1500 meter, BER increases from 10^{-9} to 10^{-1} at a pointing error of 4 micro radian. It can also be observed that increasing the Intersatellite separation affects the signal quality adversely.

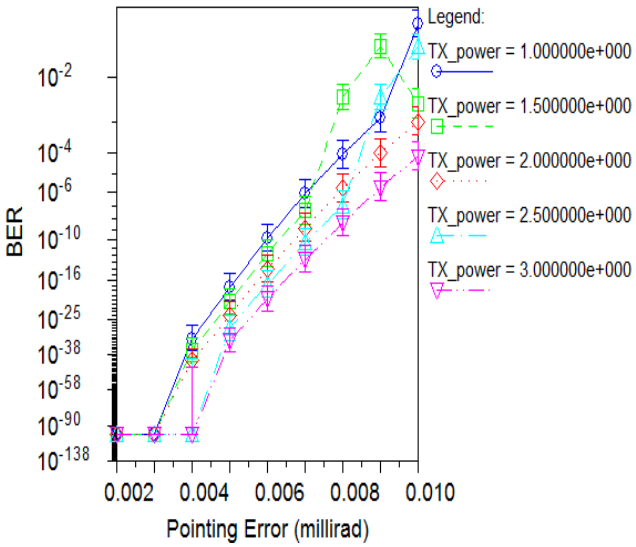

Figure 6: BER vs Pointing error for MZM when input power is varied from 1 to 3 W

Figure 6 shows the variation of BER with respect to pointing error for Mach Zehender based modulator against transmitter input power as a parameter. It has been observed that as the input power is increased from 1 to 3 watt, BER increases from 10^{-38} to 10^{-15} at a pointing error of 4 micro radian. While from figure 7, for directly modulated Laser BER increases from 10^{-10} to 10^{-5} , which implies that MZM based transmitter performs better than directly modulated Laser source.

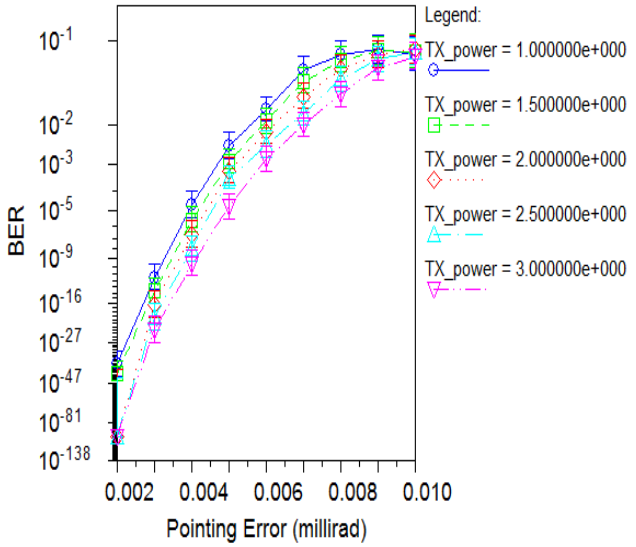

Figure 7: BER vs Pointing error for Directly modulated Laser when input power is varied from 1 to 3 W

IV. CONCLUSION

The presented work projects the analysis of FSO networks for inter satellite links. It is observed that pointing error has a major impact on the signal quality. As the pointing error is increased from 2 to 10 micro radian, the BER increases from 10^{-138} to 10^{-1}. Further increasing the bit rate and intersatellte separation significantly increases the BER. In the given range of pointing error, MZM provides enhanced results compared to directly modulated Laser. Hence it is concluded that to improve the system performance, pointing error should be optimized in the range of 2 to 6 micro radian with bit rate upto 3 Gbps and input power of about 2W with MZM based external modulation.

V. REFERENCES

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