Impact of Various Parameters on the Performance of SAC-OCDMA FSO System Employing Random Diagonal Codes

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Abstract— Performance evaluation of Random Diagonal code with free space optics is presented. Analysis is presented at different weather conditions, power levels, data rate and wavelength. By comparing the theoretical and simulation results taken from the commercial optical systems simulator "Optisystem 7.0" it was verified that performance of proposed system improves at 1550 nm, at lower data rates (2.5 Gb/s) and with higher transmit power levels.

Keywords: Free space optics, Random Diagonal Code, attenuation.

I.   INTRODUCTION

Free space optics has been a famous wireless communication technology because of the fact that the spectra is unlicensed with the frequencies of the order of Terahertz and moreover it utilizes One-Off Keying modulation format which allows FSO to be developed as bandwidth and protocol-transparent physical layer connections[1-3]. It is also known as fibreless optics as signal is transmitted through air which leads to absence of radiation hazards [4]. The Optical Code Multiple Access (OCDMA) is one of the wireless communication systems and modulated with RF to offer high bandwidth, increase users, asynchronous access and decrease multi access interference (MAI) with high security [5]. However, the SAC-OCDMA system with FSO combines two schemes in such a way that the resulting hybrid system is robust against the Multi Access Interference (MAI) and provides high data rate [5]. Consequently, the hybrid system based on the Random-Diagonal (RD) code suppresses the PIIN noise [6].The RF over Free Space Optical (FSO) link uses light source such as laser (continuous wave) to propagate through the atmosphere. However, the advantages of FSO are unlimited bandwidth, free license compared with the deployment of microwave link, and immunity to electromagnet interference. Moreover, FSO links can be deployed quickly at lower cost compared with any other technology.

In this section, we provide background on free-space optics and Random Diagonal Code and argue why this technology is appropriate for our goals:
(1) Low Interference and Bit-Error Rates: FSO uses very narrow laser beam widths, diverging with an angle of 0.25 mrad.This reduces the probability of interference. Minimal interference and narrowness of the beams also results in very low bit-error rate. Random Diagonal Code with zero cross correlation result in minimal PIIN noise and MAI.
(2) High Bandwidth over Long Ranges and Security: Optical communications inherently provide significantly higher bandwidth of the order of THz. FSO links are able to offer higher data rates at long distances (several kms) even with optimal transmit power (-10dbm,0dbm) whereas Random Diagonal Code with zero cross correlation provides enhanced security [6].

II.   SYSTEM DESCRIPTION

Figure.1 shows the proposed SAC-OCDMA network which is based on RD code. In the transmitter side, a RD segment is attached which consist of LED which generates code segment and Laser operating at different wavelength for different users generates data segment. The signal is collected by the combiner and passed onto the FSO link having divergence angle of 0.25 mrad and transmitter aperture of 10 cm, Receiver aperture of 20 cm.While at the receiver side, an optical Splitter is used to separate the different modulated code sequences. The RD code sequences are filtered by using Fiber Bragg Grating (FBG) filters and then, transferred to photo-detector (PD) at the receiver which converts optical signal to electrical one. A band pass filter (BPF) is used to filter and reject unwanted signals [7]. Visualizer can be used at any point of the design to visualize the spectrum and can conclude changes occurred in signal during transmission in optical and electrical domain.
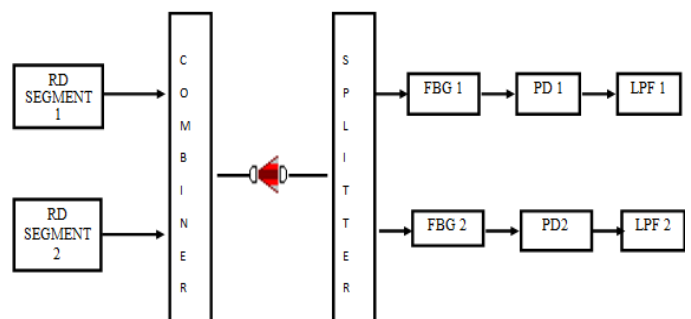

Fig.1: Simulation setup of SAC-OCDMA FSO System operating at 10Gbps

III.   RESULTS AND DISCUSSION

Simulation software Optisystem 7.0 is used in order to evaluate the performance of the SAC-OCDMA FSO system based on RD code. The proposed system was evaluated in different weather conditions like clear, hazy, heavy rain, moderate fog weather. This simulation was carried out at input power of 0 dBm (ideal condition), data rate of 10Gbps.0dBm indicates that there exists no impairment due to channel between transmitter and receiver [8]. Optical power launched from the transmitter side is similar to the optical power received at the receiver side.Figure.2 depicts that with increase in distance the BER increases due to larger dispersion and attenuation effects. It also indicates that proposed system performs better in clear weather because the rain drops, snow, hail, cloud droplets and heavy fogs will geometrically scatter laser bit's signals and there is no dependence of the attenuation coefficient on laser wavelength. Through simulation it was verified that transmission distance of 3.6 km, 2.3 km, 1.26 km, 0.61km was covered in clear, hazy, heavy rain, foggy weather respectively.All the parameters value used during simulation is arranged in Table.1presented below.

Table.1 List of Parameters used during Simulation

Parameters	Value
Operating wavelength region	1550nm
Signal data	128-bit PN sequence
Signal Bit Rate	10Gbps
Transmitter aperture	10 cm
Receiver Aperture	20 cm
Beam Divergence	0.25 mrad
Attenuation	According to weather conditions

Fig.3: BER of proposed system at different power levels in heavy rain.

Figure.3 depicts BER evaluated with respect to distance at different power levels i.e. at -10 dbm,0 dbm,5 dbm.It was observed that the system performs better when Laser power is increased. More is the transmit power, more the distance covered by the proposed system as the SNR improves with increasing transmit power level and the signal get strengthened to overcome channel impairment. These results can be verified through Eye diagrams taken at different power levels at 8.68db/km (rainy weather) for distance 1.3 km in Figure.4.

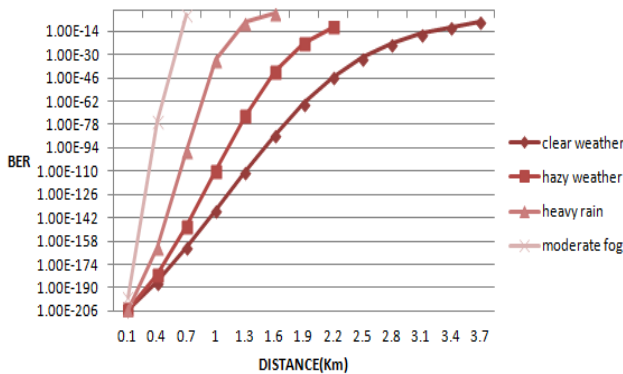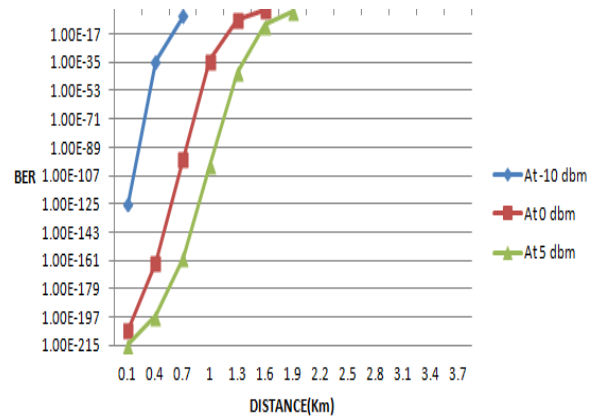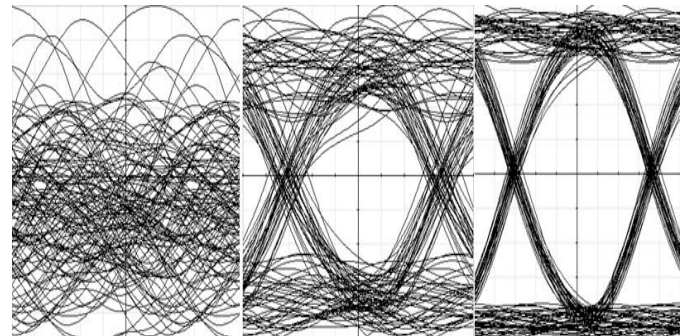Fig.4: Eye Diagram of SAC-OCDMA FSO System operating at 10Gbps in heavy rain at (a) -10 dBm (b) 0dBm (c) 5 dBm

Fig.2: BER of proposed system with different transmission length at 0dBm in different weather.
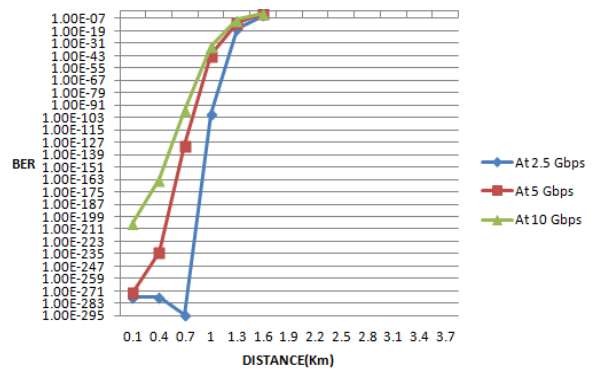

Fig.5: BER of compared system at different data rates in heavy rain.

Figure.5 depicts BER evaluated with respect to distance at different data rates i.e.at 2.5 Gbps, 5Gbps, 10Gbps.It can be concluded from the Figure that with increase in data rate the performance of proposed system degrades because pulse width decreases as data rate increases causing dispersion [9].
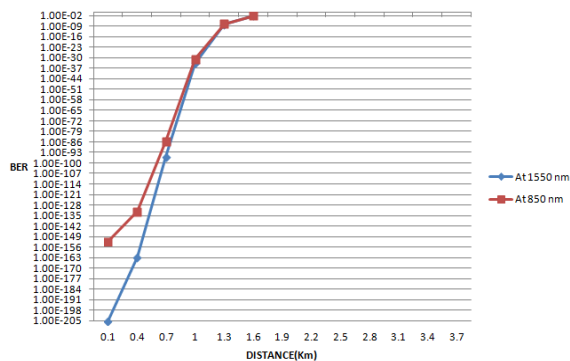

Fig.6: BER of compared system at different wavelength in heavy rain.

Figure.6 depicts BER evaluated with respect to distance at 1550 nm,850 nm.It was made clear from the Figure that 1550 nm is perfect choice with lowest attenuation (in dB/km) for all kind of weathers as there is minimum BER encountered [10].

IV.   Conclusion

In this paper evaluation of SAC-OCDMA FSO system employing Random Diagonal codes was carried out. It has been shown through simulation that BER performance increases with increase in transmit power levels and decrease with increase in data rates at 1550 nm.

V.   Acknowledgment

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