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Performance Improvement of FSO Communication System using MIMO Technique

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Abstract*: In proposed simulation model, the effect of different MIMO system has been analyzed on performance of free space optical (FSO) system concealed by various climatic conditions like clear, haze and fog. FSO is a free space communication system where space acts as medium between transceivers which provides a strong and efficient method for transmission and reception of information. The effect of different weather conditions has been investigated for range of 1 and 2 km at frequency 193.1 GHz. The proposed MIMO-FSO simulation system has been analyzed for different parameters like Q factor, height of eye, power received and bit error rate. The designed 4X4 MIMO-FSO system provides better results as compared to the 2X2MIMO and SISO-FSO system.

Index Terms: Radio Over Fiber, Differential Phase Shift Keying, Radio Frequency.

I. INTRODUCTION

Wireless communication loom as one of the most significant innovation in the history of communication technology. Communication system has turn into an essential part of our routine life. It means transmitting data from one end to another end using space as a medium turn into an alternate method which provides the mobility and easy access to the discrete services such as data, text messages, voice and videos etc. [1]. Presently, there is huge demand of such services which requires a huge data rate and large capacity system. Achieving extremely big data rate and huge bandwidth is very much challenging task in the wireless communication but optical communication is being used as good alternate [2-4]. Optical Fiber communication is a technology used to transmit signals like data, text, video or voice which uses intensity modulation technique that serves as carrier wave to send information along the glass fiber over a long distance with very small attenuation or loss[5]. The today's communication systems uses microwave, radio or the coaxial cables etc. as communication media that has its own restrictions about the bandwidth and faces high amount of loss during the transmission that make these conventional systems outdated for meeting the existing and future demands of the bandwidths. On the other hand Optical fiber has the provision of large bandwidth and has fewer losses for the transmission that make the optical fiber suitable for the future services. This is the reason optical fiber is considered as a reliable media for the recent telecommunication engineering [6]. FSO communication system is an emerging technology in field of optical communication that purpose line of sight (LOS) path for transmission of signal between source and destination in free space. This technology can be used for telecommunications or computer networking as an alternate to optical fiber when a physical connection is not a viable solution due to high costs or other considerations [7]. Laser beam propagation through space such as atmosphere or underwater has been studied extensively for many years. FSO technology provides several advantages over traditional radio frequency (RF) or microwave communication owing to its increased low mass, power efficiency, and space requirement, higher directivity (i.e., larger antenna gain), and license-free extremely high bandwidth channel [8].

In this paper, we analyze MIMO-FSO and SISO- FSO communication system with Non Return to Zero (NRZ) and Avalanche Photodiode (APD) on the receiver side which is connected to the BER generator to analyze the BER performance for different atmospheric turbulences. The objective is to design and simulate MIMO and SISO FSO link and study its parameters. On increasing the number of transmitters and receivers in the MIMO system, the efficiency can be increased, which lowers the BER value.

II. SIMULATION MODEL

The proposed FSO system comprises of transmitter section, FSO channel and receiver section. The transmitter section includes: CW laser source (1550nm), Pseudo Random Bit Sequence (PBRS) generator, NRZ pulse generator, and MZM (Mach-Zehnder Modulator). At receiver side, APD photodetector is used to detect the light signal. The proposed simulation model make use of two visualizers component, first one component is optical power meter used to measure the power received (in dB), and BER analyzer used to measure the BER value, Q-factor and display the eye diagram.

1. Single input Single output (SISO) FSO systems

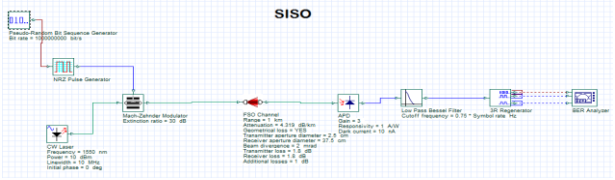

Fig. 1 SISO-FSO System

2. 2X2 Multiple input Multiple output (MIMO) FSO systems

The proposed FSO system uses optimal designing can be done by two different MIMO systems.

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By using two transmitters and two receivers MIMO FSO system used to increase the efficiency of communication. Use of multiple transmitters and receivers increases the efficiency of communication. Fig. 3 and Fig. 4 depict the type of MIMO systems depending on the number of transmitters and receivers. If the number of transceivers is 2 then it is known as 2x2 MIMO [5].

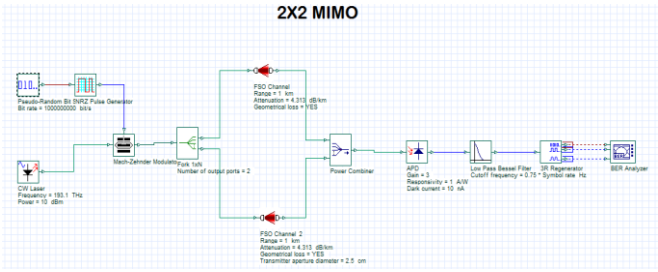

Fig. 2 2×2 MIMO-FSO System

3. 4X4Multiple input Multiple output (MIMO) FSO systems

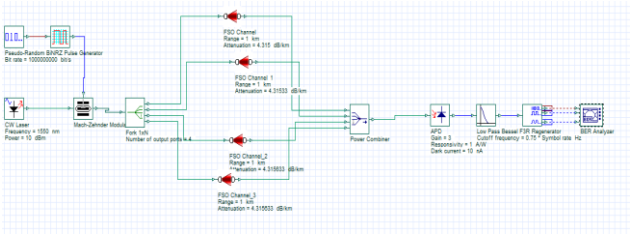

Fig. 3 4×4 MIMO-FSO Systems

III. RESULTS AND DISCUSSION

Based on the above FSO model, analysis is done or different types of models that is on increasing the no. of transmitters and receivers. Performance simulation of the communication link at propagation distance "L" of 1km with NRZ line code and 1550 nm wavelength and APD receiver for various atmospheric conditions is done. Optical spectrum analyzer, BER analyzer and optical power meter are included in the model to determine the system BER& Q-factor and the received and transmitted signal power levels. The parameters here are taken such that the maximum range can be achieved for a constant bit rate of 1 Gbps and the maximum bit rate can be achieved for a constant range of 1 km. The changes were then implemented and compared to check their efficiency [6]. Based on the results, a system was chosen that provided the maximum bit rate and the maximum range

TABLE I: PARAMETER SELECTION

PARAMETER	VALUE
Data Rate	1 Gbps
Wavelength	1550 nm
Sequence length	128
Sample per bit	64
Number of samples	8192
Extinction Ratio	30 dB
Transmitter Aperture	2.5 cm
Transmitter Loss	1.8 dB
Receiver Aperture	37.5 cm
Receiver Loss	1.8 dB
Additional Loss	1 dB
Geometric Loss	YES
Beam Divergence	2 mrad
Cut-off Frequency	0.75 X Data Rate
APD Gain	3 dB
APD Responsivity	1 A/W
APD Dark Current	10 nA

Table-I represents the values of the parameters which will be used in simulation of FSO link with the help of Optisystem [7].

TABLE II: ATTENUATION FOR DIFFERENT WEATHER CONDITIONS

Weather Conditions	Attenuation (dB/km)
Clear air	0.304
Haze	4.319
Fog	15.56

TABLE III: Q-factor & BER values for 1Km range for SISO,2X2 MIMO, 4X4 MIMO systems

SYSTEM	WEATHER CONDITION	Range=1 Km	
		Q-Factor	BER
SISO	AIR	8.38386	1.96182×10^{-17}
	HAZE	7.5467	1.56353×10^{-14}
	FOG	4.27373	6.78209×10^{-6}
2X2 MIMO	AIR	7.30603	1.29045×10^{-13}
	HAZE	7.32321	1.13497×10^{-13}
	FOG	5.30029	4.25859×10^{-8}
4X4 MIMO	AIR	457.519	0
	HAZE	245.989	0
	FOG	31.1792	1.01638×10^{-213}

TABLE III: Q-factor & BER values for 2Km range for SISO,2X2 MIMO, 4X4 MIMO systems

SYSTEM	WEATHER CONDITION	Range=1 Km	
		Q-Factor	BER
SISO	AIR	6.04164	5.3738×10^{-10}
	HAZE	4.99503	2.06187×10^{-7}
	FOG	0	1
2X2 MIMO	AIR	7.18702	3.04325×10^{-13}
	HAZE	4.41543	2.80845×10^{-6}
	FOG	0	1
4X4 MIMO	AIR	182.866	0
	HAZE	37.094	1.73318×10^{-30}
	FOG	0	1

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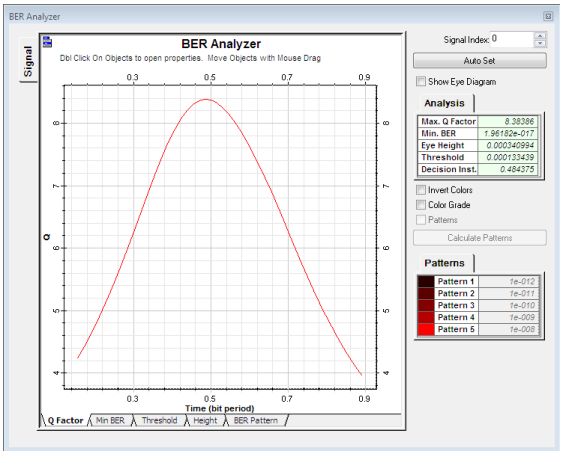

Fig. 4 SISO-FSO BER Analyzer for clear air at 1Km range

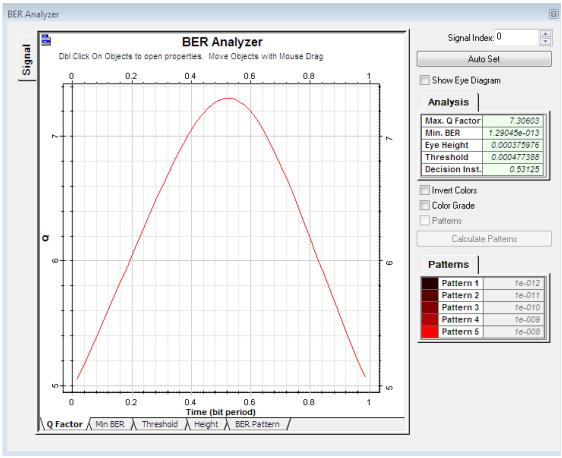

Fig. 5 2x2 MIMO-FSO BER Analyzer for clear air at 1Km range

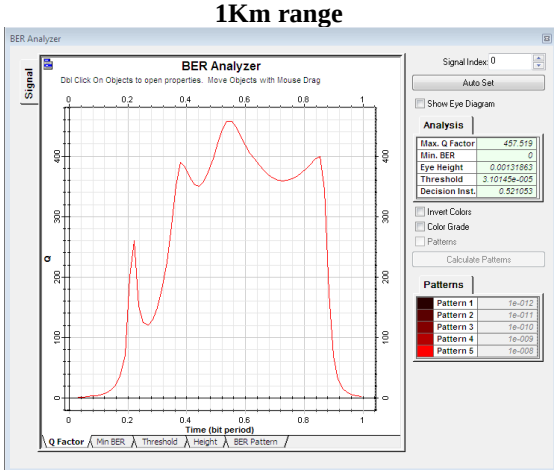

Fig. 6 4x4 MIMO-FSO BER Analyzer for clear air at 1Km range

IV. CONCLUSION

The proposed MIMO-FSO model gives better results as compared to SISO FSO system in terms of different parameters like BER, Q-factor and Eye diagram. At a frequency of 193.1 THz, a minimum value of BER i.e. 5.85 for SISO-FSO system and high quality factor i.e. 239.647 for 4X4 MIMO-FSO system is achieved for range of 1Km. Due to high quality factor the noise in the system is reduced which provides more efficient system.

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Arjun Dubey is a student of ME, Electronics and Communication Engineering, Chandigarh University, Gharuan, Punjab, India. He has carried out his research work in Optical Fiber Communication. His research interest includes study of optical fiber losses, optical amplifier, FSO and Radio over fiber etc..

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