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2*20 GBIT/S MDM-OFDM-IAOWC LINK WITH ENHANCED DETECTION

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ABSTRACT. This article presents the performance investigation of 2*20 Gbit/s orthogonal frequency division multiplexing based inter-aircraft optical wireless communication link using mode division multiplexing of two spiral phased Hermite-Gaussian modes (HG01 and HG03) under the impact of increasing link range. Further the improvement of the proposed link is being reported using a Square root module technique.

1. INTRODUCTION

Free space optics (FSO) also known as optical wireless communication (OWC) is an information relaying technique which uses optically modulated signals as the carrier signal and for transmission free space as the intermediate by a necessary condition of establishing a clear line of sight configuration among the transmitting and the receiv-ing parts for realistic communication, [1]. It has many advantages in contrast to con-ventional radio frequency (RF) based information transmission systems such as fast and inexpensive installation process, easy deploy ability, high speed links, large mod-ulation bandwidth, high channel capacity, and no requirement of spectrum licensing, [2]. Owing to its many advantages, FSO links find applications in many areas such as terrestrial links, ground to high altitude platform links, inter-satellite links, and military applications, [3]. The traditional ground to aircraft and inter-aircraft links are based on

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microwave communication technology, but in the future will be based on FSO technology. Although FSO links are gaining popularity due to its numerous merits, they also suffer from certain limitations such as received signal degradation and thus an overall decrease in the system performance due to absorption, scintillation, scattering, beam divergence losses, pointing and tracking error losses, cloud obstruc-tion etc. One of the most determining parameter which reduces the performance of links is atmospheric attenuation. Researchers have developed different techniques to enhance the data carrying capacity of FSO links and also mitigate the degrading effects of atmospheric attenuation. The application of spatial diversity links in order to maximize the link dependability in FSO communication systems has been explored in [4]. Result shows that as the number of beams carrying information is increased, the performance of the system also improves. Here [5], reported the using of wavelength division multiplexing system (WDM) in FSO links to raise the capabil-ity of the link. The use of an optical pre-amplifier to mitigate the degrading effects of atmospheric turbulence has been reported in [6, 7]. Orthogonal frequency division multiplexing (OFDM) is another technique which can be used to increase the FSO link performance. In OFDM, the data is communicated using various orthogonal sub-carriers with overlapping frequency bands spaced apart at a certain frequency. The Fast Fourier Transform (FFT) operation at the transmitter provides orthogonality to the sub-carriers which prevent the demodulation units to see other frequencies trans-mitted. The implementation of OFDM with FSO technology can be used to achieve high bit rates without any interference thus optimizing the link performance. To im-prove the data carrying capacity of the link, mode division multiplexing (MDM) can be considered as a cost effective and reliable technique in which multiple independent information carrying signals are transmitted using various modes of a spatial laser produced with optical signal processing, spatial light modulator, single mode fiber and photonic crystal fiber, [8]. This work emphases on designing investigation of hybrid MDM-OFDM based inter-aircraft optical wireless communication (IaOWC) link. The paper is structured as follows. The system design and simulation parameters are described in Section 2. In section 3 results and discussion is calculated, and in section 4 conclusion is presented.

2. SYSTEM MODELING

Figure 1 shows the planned OFDM based IaOWC link incorporating MDM. Two inde-pendent 4-level quadrature amplitude modulation (QAM) OFDM signals having data rate 20 Gb/s are modulated over two spiral phased HG modes (HG01 and HG03) over an OWC link. A 4-QAM generator is placed at each

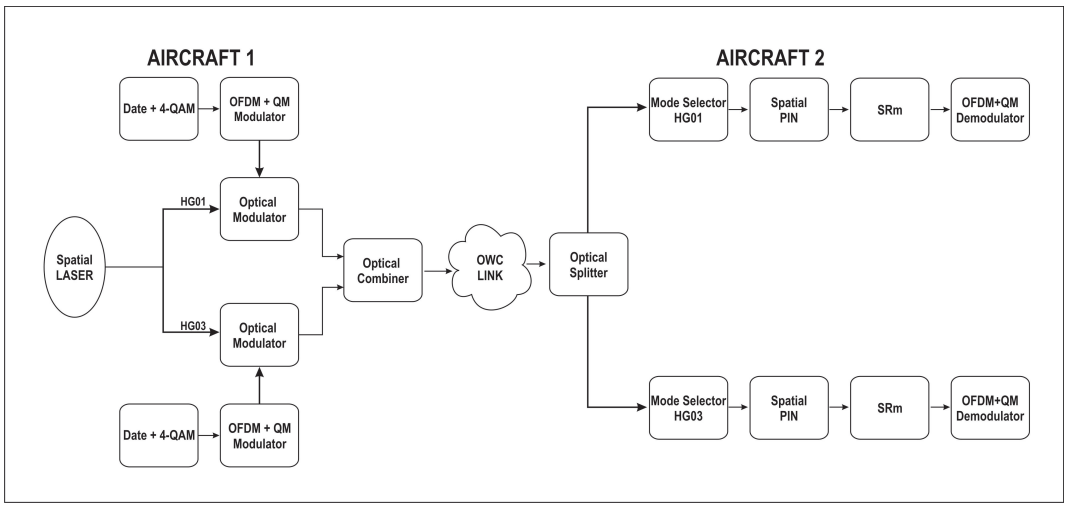

FIGURE 1. Block diagram of the proposed hybrid MDM-OFDM based IaOWC link

channel to produce 20 Gbit/s signals which is then modulated with OFDM modulator taking 1024 FFT points, 512 subcarriers and 32 prefix points and modulated again using a QAM mod-ulator. The modulated signal is amplified and transmitted into the space by various HG modes. Various parameters in this planned study includes transmitter/receiver aperture di-ameter as 10 cm, 0.25 mrad value of beam divergence angle, additional loss of 1 dB, 0.1 urad is transmitter pointing error loss and atmospheric attenuation is 0.4 dB/km.

3. RESULTS AND DISCUSSIONS

Figure 2 shows the signal to noise ratio and Figure 3 shows the power of the signal for various channels with increasing distance in the proposed link. Different values of SNR from Figure 2 and Figure 3 for HG01 mode come out to be 73.33, 42.63 and 8.21 dB and for HG03 mode these are 68.95, 37.94 and 4.25 dB. Values of total power for HG01 and HG03 mode are calculated as

40.96, -22.65 and -70.74 dBm and-34.50, -29.11 and -76.47 dBm at a distance 10 km, 50 km, and 100 km respectively.

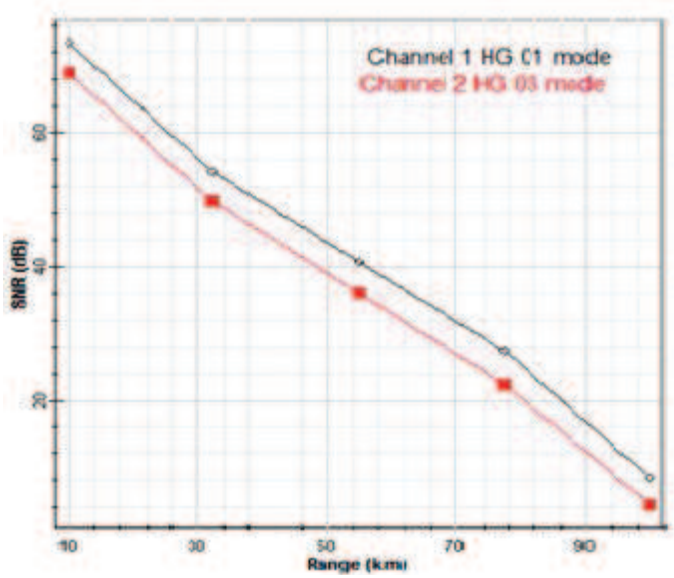

FIGURE 2. Calculation of SNR v/s Link range

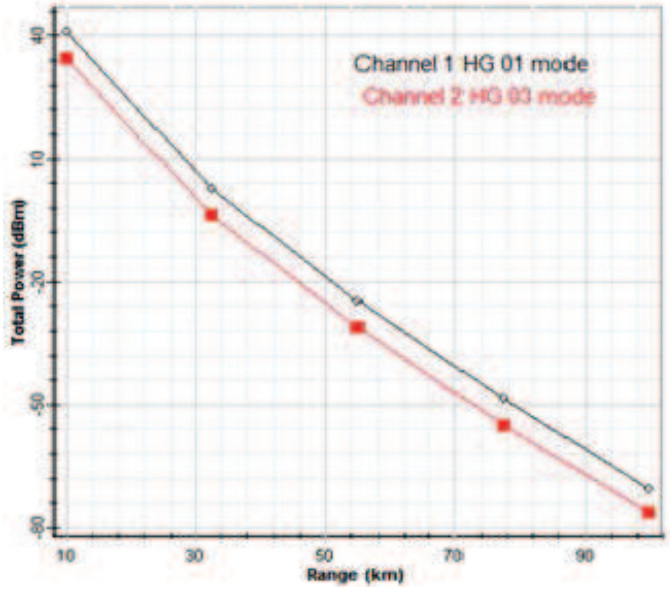

FIGURE 3. Calculation of Received Power v/s Link range

Further, an enhanced performance analysis of the planned hybrid MDM-OFDM based IaOWC link by square root module (SRm) at the receiver terminal is demonstrated which recompenses the non-linear response of the photodiode. Figure 4 and Figure 5 depicts the performance evaluation of the planned link with and without SRm. Figure 4 shows that the signal to noise ratio of the signal decreases from 68.83 dB to 3.80 dB as the distance increases from 10 km to 100 km without using SRm whereas signal to noise ratio of the output signal decreases from 60.45 dB to 52.36 dB as the distance increases from 10 km to 100 km with the use of SRm at the receiver terminal. Alternatively, Figure 5 shows that the power of output signal decreases from 40.96 dBm to -70.50 dBm as the distance increases from 10 km to 100 km without SRm at the receiver terminal while total power decreases from 35.25 dBm to -20.73 dBm as the distance rises from 10 km to 100 km with the use of SRm.

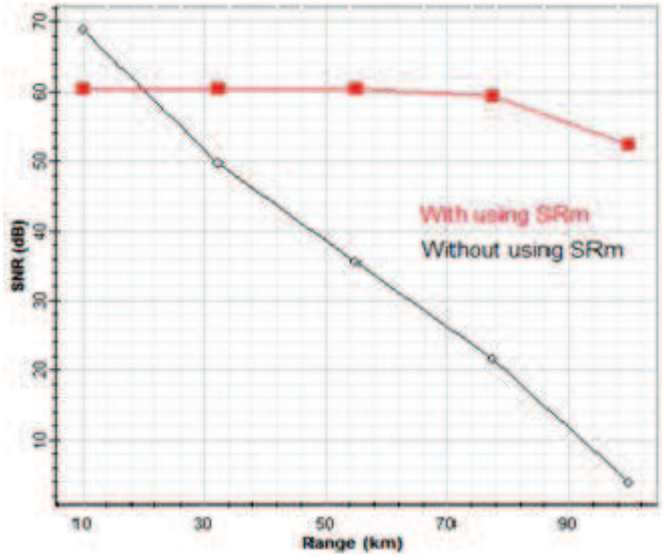

FIGURE 4. Evaluation of SNR v/s Link range with and without using SRm in the proposed link

4. CONCLUSION

The performance analysis and designing of 2*20 Gbit/s OFDM based IaOWC link is reported in this paper using mode division multiplexing of HG01 and HG03 modes under the effect of increasing link range. The outcomes show

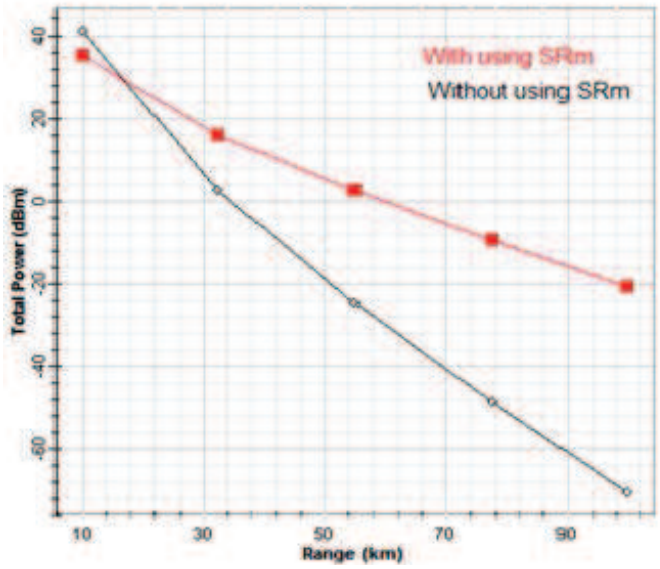

FIGURE 5. Evaluation of Total received power v/s Link range with and without using SRm in the proposed link

that when the link range increases, the system performance degrades. Also, we report an enhanced perfor-mance of the proposed link by a square root module. The results presented show an effective enhancement in the performance of the link in terms of signal to noise ratio and power of the output signal which will further help in increasing the link range of the system

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