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Performance Analysis of High Speed Spectrum Sliced FSO System

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***Abstract*: In this work, spectrum sliced free space optical communication system employing semiconductor optical amplifier is demonstrated to provide cost effective solution to high cost wavelength division multiplexing based FSO systems. Atmosphere has great impact on free space optical communication channels and therefore we have analyzed different weather instabilities. Self-phase modulation in SOA is employed for narrowband laser signal broadening which can serve high bit rates. A data rate of 5 Gbps is catered over each channel (4 channels) and total capacity of 20 Gbps over 10 km when weather is clear. SOA generates high power spectrums slices and ultra-dense spacing is achieved of 50 GHz. Proposed system is less complex, economical, and performance enhanced.**

***Keywords*: FSO, WDM, atmospheric conditions, Q factor, BER**

1. Introduction

The rapid growth in computers and laptops for the uses in offices, warehouses, industries, factories, shopping has put the peer pressure on indoor communications. Numerous computers are operated in the single indoor room to accomplish the tasks of companies. Cluster of several computers needs a centralized communication which can cater the nodes and offer a reliable interconnection.

In order to meet the needs of the users, diverse approaches have been applied to boost the efficiency of the systems such as encryption, high capacity systems (multichannel systems), optimal amplifications, and modulations [1]. However, it is perceived and reported that widely and most prominently use of wired connection has been done to cater the users. Basically, end users can be connected at high bit rates with wired mediums but they are realized at the high cost of physical wires. Moreover, there exists some issues in the employment of cables such as problem in expansion of network, acquire more room, require time for installation, man power for trenching. Besides many cons in the deployment of wired cables, there are some pros such as wired medium can offer security and seamless connectivity [2]. With the deployments of wireless mediums, cost of trenching and time of installation reduces to high extent. Wireless is emerged as the ultimate candidate to overcome the issues of wired transmission. It is defined as the technology which is used to transmit signals without using wires and only air is the medium in the terrestrial link. Radio frequency (RF) is prominent alternative which is used in RF communication. However, RF communication has many limitations such as low bandwidth, less data rates, electromagnetic interference and high losses [3].

Transmission of data from one end to another wirelessly based on optical light signals in the telecommunication is termed as Free space optical communication. In free space optical communication, free space can be empty space with or without air. FSO is widely used in the areas where trenching and fiber deployment is tedious and this is ultimate solution to lower the cost of the system. FSO is merged as the promising technology for indoor and outdoor communications and will be extensively used in next generation services based on broadband [4]. FSO provides optical spectrum license free communication or in short it does not require any license to accomplish the transmission

Access networks reliant on WDM support many users and are based on spectrum slices of available spectrum. Bidirectional transmission and multiplication of capacity represent the WDM (wavelength division multiplexing) as adaptive and reliable that can give wide coverage over atmospheric instabilities in FSO. Spectrum slicing is the important candidate that provides assurance for distribution of multi wavelength intensity source in numerous end users [5]. But so far reported systems support low data speed and number of channels, but FSO can support high speed and provide large bandwidth. An optimal method of spectrum sliced FSO is needed.

In this work, a 5 Gbps ultra-dense spectrum sliced free space optical communication system employing semiconductor optical amplifier is demonstrated to provide cost effective solution to high cost wavelength division multiplexing based FSO systems.

2. System Setup

For the completion of demonstrated work, software optisystem is incorporated and investigation is also performed in the simulation tool. Wavelength division multiplexing (WDM) is capacity boosting technique which is able to pack number of channels. WDM is used in free space optical communication for different applications. In WDM, number of lasers are required to cater different channels due to this cost of WDM is high. Spectrum slicing is technique which is used to generate different channels from single laser source. It is cost effective technique and used in free space optical communication systems. In this article, SOA is used to generate spectrum broadened slices of spectrum with self-phase modulation. High power signal of 30 dBm is fed to SOA at 193.1 THz frequency as shown in Fig. 1. Broadened spectrum which spread over multiple frequencies sliced into 4 slices such as 193 THz, 193.050 THz, 193.1 THz and 193.150 THz. Frequency spacing is set to ultra-dense mode such as 50 GHz. After spectrum slicing, signals are fed to modulation (non return to zero) and modulated at the rate of 5 Gbps through mach-zehnder modulator. All four signals then transmitted over FSO after multiplexing through 4 x 1 MUX. Beam divergence of FSO channel is set to 1 mrad and transmitter antenna sizes of transmitter and receiver are 5 cm and 20 cm respectively. Different atmosphere instabilities are investigated and haze, snow, rain etc are the weather conditions. Attenuation and weather conditions are given as Clear weather (0.11 dB/km), Haze (4dBm), Mild Rain (6.27 dBm), Medium Rain (9.64 dBm) and Fog (22 dBm).

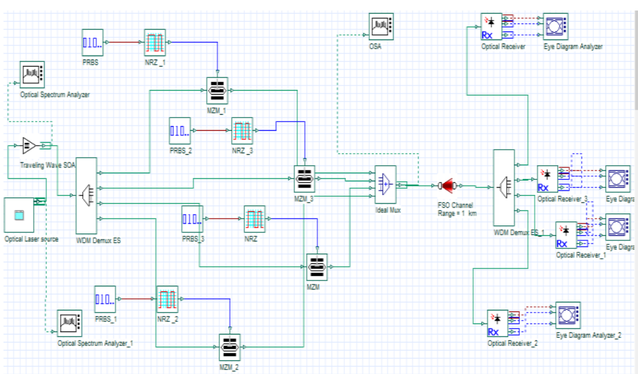
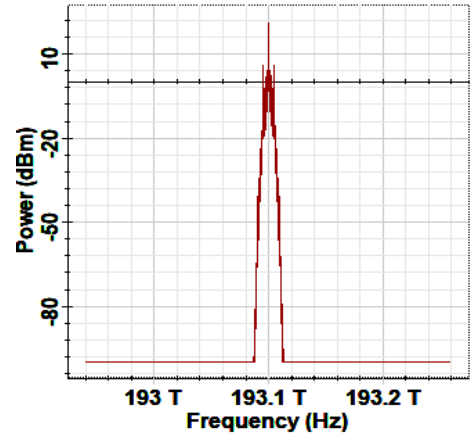


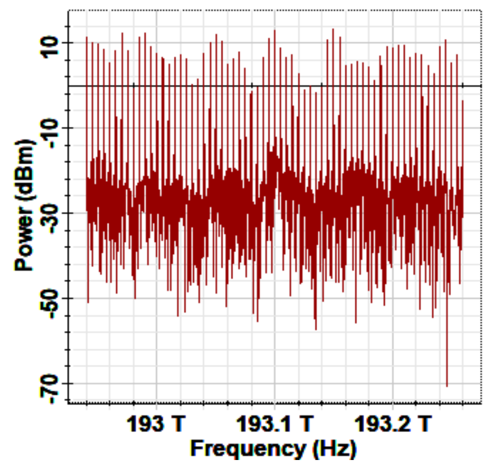
Fig. 1. Proposed spectrum sliced FSO system using SOA

3. Results and discussion

Performance of the analysis system based on spectrum slicing over free space optical communication by employing SOA has been analyzed in this work. In order to study the system, SS-FSO deployed in the system for supporting 5 Gbps bit rate. Analyzers present in the optisystem software library are beneficial to check signals time to time and let us know about signal availability and faults. Therefore, first and foremost, output of optical spectrum analyzer for spectrum slicing is depicted in Figure 2. Figure 2 (a) depicts the optical spectrum of signal prior to the SOA when no SPM has taken place (b) represents the output of OSA after SOA. Basically it provides the information about the power on each carrier and also their center frequencies. Further Figure 3 represents the multiplexed signals of the total 4 users. It is perceived that stating frequency of the spectrum is 193 THz and it lasts till the frequency of 193.150 THz with the input power level of 30 dBm. However, the output power which shown in the Figure is less than 10 dBm due to the different insertion loses of diverse components in the analysis system.



(a)



(b)

Fig. 2. A continuous wave laser spectrum (a) without (b) with self-phase modulation in SOA

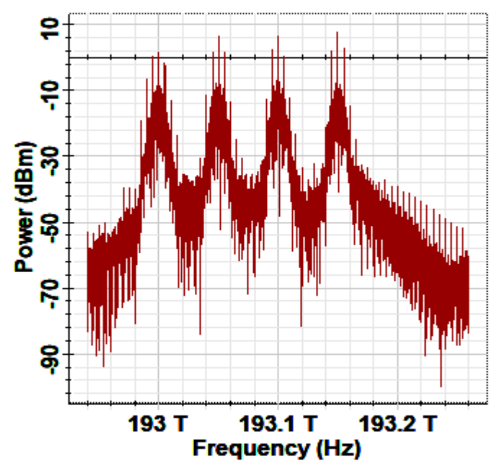


Fig. 3. Representation of four multiplexed spectrums slices channels at OSA

For the investigation of proposed system, distance of FSO link is varied from 1 km to 5 km with the difference of 1 km and Q factor has been checked for different weather instabilities. Maximum attained distance is under the condition

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of clear weather and Q factor is 35.3-27.54 for 1 km and 5 km respectively. Figure 4 depicts the performance of proposed system under different weather conditions. Q factor for mild rain is 33.84-0, medium rain 32.59-0, haze 34.21-0, and fog 9.47-0. Highest link length achieved is 14 km under clear weather, haze (3.5km), fog (1.2 km), mild rain (2.8 km) and 1.7 km for medium rain.

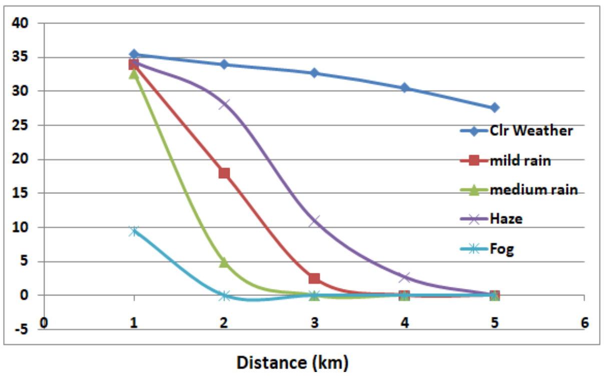


Fig. 4. Distance variation and Q factor analysis of spectrum sliced FSO

Fig. 5 for the investigation of proposed system, distance of FSO link is varied from 1 km to 5 km with the difference of 1 km and log BER has been checked for different weather instabilities. It is perceived that BER is at 1 km for clear weather is minimum and at Fog log BER maximum. Due to scattering, attenuation and pulse broadening, errors increase abruptly.

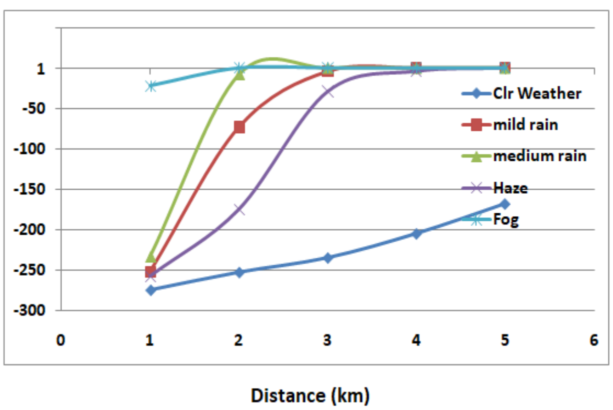
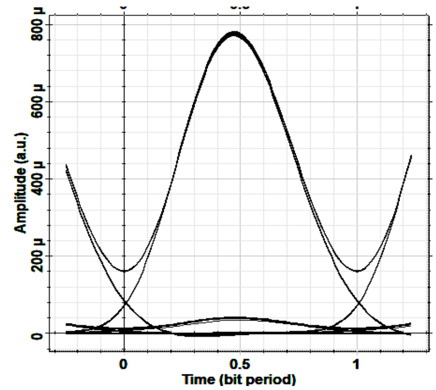


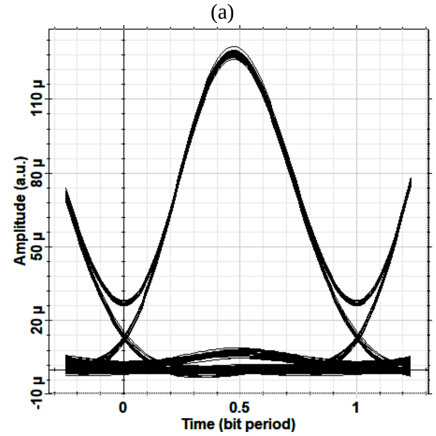
Fig. 5. Distance variation and log BER analysis of spectrum sliced FSO

Signal propagation after FSO transmission is separated by de-multiplexer and each receiver has photodetector, low pass filter and BER analyzer.

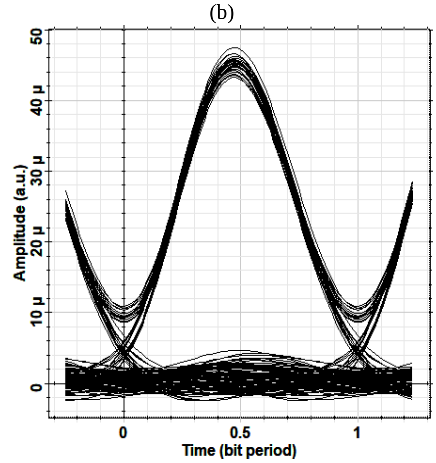
Eye diagram is end component in the communication system which represents the Q factor and BER. Figure 1.6 represents the eye diagrams of different weather conditions such as Clear weather (b) Haze (c) mild Rain (d) medium rain (e) Fog. Results revealed that eye opening in SS- FSO clear weather system is far much better than SS-FSO under Fog due to less power spectrum slicing losses Therefore; the demonstrated system is competent, flexible and promising for low-cost SS-FSO architecture under atmospheric instabilities.



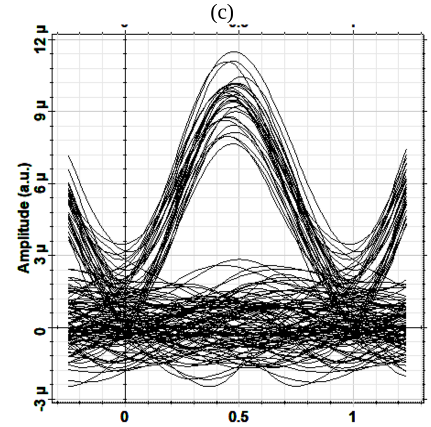
(a)



(b)



(c)



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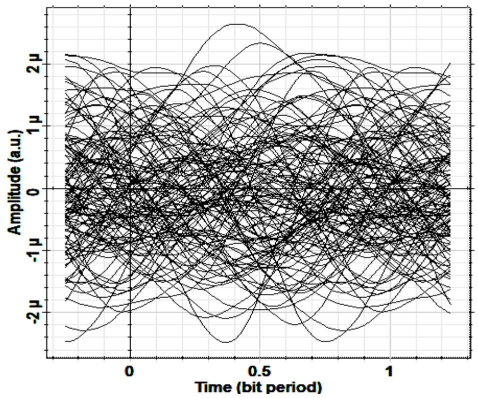

(e)

Fig. 6. Eye diagram for (a) Clear weather (b) Haze (c) mild Rain (d) medium rain (e) Fog

4. Conclusion

A spectrum-sliced FSO is proposed by incorporating wavelength division multiplexing through spectrum broadening in SOA. Self-phase modulation is used to broaden the spectrum of a laser source and it generates high power spectrum slices that support 5 Gbps data speed. Atmosphere has great impact on free space optical communication channels and therefore we have analyzed different weather instabilities. Self-phase modulation in SOA is employed for narrowband laser signal broadening which can serve high bit rates. For the investigation of proposed system, distance of FSO link is varied from 1 km to 5 km with the difference of 1 km and Q factor has been checked for different weather instabilities. Maximum attained distance is under the condition of clear weather and Q factor is 35.3-27.54 for 1 km and 5 km respectively. Q factor for mild rain is 33.84-0, medium rain 32.59-0, haze 34.21-0, and fog 9.47-0. Highest link length achieved is 14 km under clear weather, haze (3.5km), fog (1.2 km), mild rain (2.8 km) and 1.7 km for medium rain. BER for SS-WDM FSO at 5 km is in the case of clear weather calculated as 10-167.

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