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ScienceDirect

Procedia Computer Science 89 (2016) 99 – 106

Procedia Computer Science

Twelfth International Multi-Conference on Information Processing-2016 (IMCIP-2016)

Comparative Analysis of Free Space Optical Communication System for Various Optical Transmission Windows under Adverse Weather Conditions

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Abstract

Free Space Optics (FSO) link offers gigabit per second data rates with less system complexity. However, the availability of link under various atmospheric conditions is a major concern. As these links are highly weather dependent, thus increase in signal attenuation under these conditions reduces the link efficiency. This paper evaluates the effects of bad weather conditions on FSO link having range 500 meters up to attenuation of 70 dB/km. The suitability of three optical transmission windows that are 850 nm, 1310 nm and 1550 nm, with the FSO link is analysed and compared in this work. Simulation parameters such as Quality factor, minimum BER and Eye diagram are taken into consideration. The results of analyzer for various transmission windows are compared to find out the most suitable wavelength of transmitter under adverse weather conditions for reliable communication.

Peer-review under responsibility of organizing committee of the Organizing Committee of IMCIP-2016

Keywords: Attenuation; BER Analyzer; Free Space Optics (FSO); Optical Transmission Windows; Spectrum Analyzer.

1. Introduction

The Free Space Optics (FSO) system has fascinated the attention of large numbers of users as it has proved to be the best solution the last mile problem for communication in urban areas[1,2]. It has come up as a better alternative to Radio Frequency (RF) technology for reliable and feasible deployment of communication networks[3]. Though the deployment of RF wireless networks is rapid having data rates up to several hundred Mps but the increase in traffic of users, range limitations and small available bandwidth has posed several drawbacks in the communication using this technology[4]. FSO technology can easily replace RF technology due to its very high bandwidth up to 2.5 Gbps. In fact, FSO is best suited for multi Gbps data rate communication. License free bands, robustness, high data rate transmissions, high security and negligible signals interference appear promising for high speed wireless communication[5,6].

The only drawback of the FSO link is that its performance is strongly dependent on atmospheric attenuations. Different atmospheric conditions like snow, fog and rain scatter and absorb the transmitted signal, which leads to attenuation of information signal before receiving at receiver end[7]. Maintenance of an apparent Line of Sight (LOS) between transmitter and receiver end is the main confront to set up communication through FSO technology especially

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1877-0509
Peer-review under responsibility of organizing committee of the Organizing Committee of IMCIP-2016
doi:10.1016/j.procs.2016.06.014

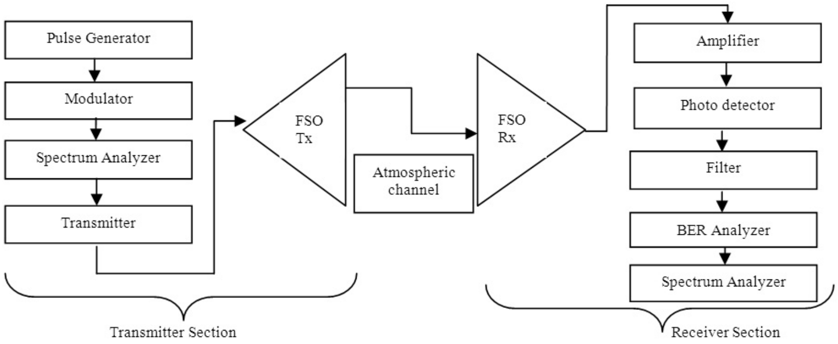

Fig. 1. Block diagram of FSO Link.

in the troposphere. As a result of attenuation caused by atmospheric conditions the range and the capacity of wireless channel are degraded[8]. Thereby restricting the potential of the FSO link by limiting the regions and times[9].

In order to completely exploit the remarkable bandwidth of FSO technology, it is required to properly characterize the influence of various weather conditions and to use the different optical windows of transmission to mitigate the effects of increasing signal attenuation[10]. In this paper, three optical transmission windows are considered that are 850 nm, 1310 nm and 1550 nm each having their own advantages. Equipments operating on 850 nm wavelength are usually cheaper than equipments operating at higher wavelengths. The window at 1310 nm has zero group velocity dispersion. And at 1550 nm the loss of optical fiber is minimum that is 0.2 dB/km[11]. Low loss means the distance between 3R repeater and Optical Amplifier can be large. 1550 nm is also a eye safe wavelength. Erbium Doped Fiber Amplifier (EDFA) can also be used in the FSO if the link is operating at 1550 nm. EDFA provides second largest peak gain at this wavelength[12].

The three wavelengths mentioned above are mainly chosen among large wavelengths in the spectrum due to the transmission properties of existing light sources best match with the transmission qualities of these optical windows. The attenuation of the information signal travelling in free space is much less at these wavelengths[13]. The attenuation of signal that deteriorates the quality of signal is mainly caused by two factors, absorption and scattering. So, these three optical transmission windows are preferred as compared to other wavelengths in infrared spectrum of light[14].

The paper focuses on finding the optical transmission window that is best suited for FSO link under the atmospheric factors chosen. Comparison is made in terms of Q factor, minimum BER, Eye diagram of received signal and power of signal using different windows of optical transmission. The remaining paper is structured as follows. In Section 2, the FSO system is explained. In Section 3, the output of FSO system is analyzed using output of BER analyzer. The analysis of system output in terms of signal power is outlined in Section 4, and the conclusions drawn are provided in Section 5.

2. System Description

The FSO link comprises of transmitter, atmospheric channel and the receiver. As shown in Fig. 1 the transmitter in the FSO link is used to transmit information signal in free space by modulating the electrical information signal into optical signal. The optical signal travels through free space which is captured by the receiver and is converted into an electrical signal. The transmitting module consists of a pulse generator, modulator, spectrum analyser and a transmitter. The pulse generator used in the link generates pulses that carry information in electrical form. Spectrum analyzer is used to display the scale of an input signal versus frequency within the complete frequency range of device. Then the signal is transmitted over free space through the transmitter. In the atmosphere, the signal is scattered, absorbed and attenuated as a result of turbulences and atmospheric variations[14]. Total attenuation of signal travelling through FSO communication link can be calculated as:

$$\alpha = \alpha \mathrm{fog}_{\gamma} + \alpha \mathrm{snow}_{\gamma} + \alpha \mathrm{rain}_{\gamma} + \alpha \mathrm{scattering}_{\gamma}, \ \mathrm{dB/km} \tag{1}$$

where, $\alpha =$ attenuation and $\gamma =$ is operational wavelength in μm.