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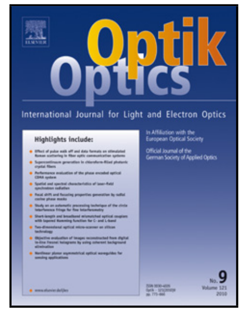

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Multiplexed Free-space Optical System Design using Manchester Coding

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Abstract

Free space optics (FSO) has been considered as the alternative to wireless radio communication system because of the inherent advantages such as huge data rate, license-free operation, easy and quick deploybility. Nevertheless, the performance of the FSO system is greatly influenced by atmospheric temperature, pressure, humidity etc. To overcome these challenges various techniques have been proposed in literature, not only in the physical layer but also in the transport layer. Generally the average bit error rate (BER) and quality factor (Q-factor) are prime parameters to measure the performance of the FSO systems. To improve the average BER and Q-factor different types of modulation schemes have been analyzed for different weather conditions. In this paper, for the first time, to improve the performance of the system, differential phase shift keying (DPSK) modulation technique with Manchester coding is used. Manchester encoding synchronizes the signal itself; hence, it minimizes the error rate and optimizes the reliability of the proposed system. In addition, a 16 channel wavelength division multiplexing (WDM) FSO system is considered for improving the spectral efficiency of the system. For analyzing, the low to high turbulence level of atmosphere Gamma-Gamma type channel model is preferred.

Keywords: FSO, DWDM, DPSK, BER

1. Introduction

Free-space optical communication (FSO) systems (in space and in terrestrial regions) have evolved in counter to a growing need for high-speed and bug free information transmission and reception systems. The FSO correspondence framework is generally implemented for the high speed data transmission in both space and ground terrestrial stations. The last-mile applications like communication involving deep-space link establishment, terrestrial stations links, unmanned aerial vehicles (UAVs), high altitude platforms (HAPs), inter-sattelite communications, airliner, and other nomadic communication systems can be used in integrated systems of military and civilian contexts [1]. Because of its unregulated spectrum range, huge data transmission potential, relative low power prerequisite, low bit error rate (BER) and simplicity of redeployment, high-speed rate (THz) wireless communications have attracted the researchers for the evolution of short distance ultrahigh rate mobile applications [2]. The FSO system can also be used as a prime alternate system to RF (Radio Frequency) wireless system and the wireless application. Applications like native space network, local area network (LAN)-to-LAN communication, disaster recovery, metropolitan area network (MAN), high definition TV, biomedical image and videographic transmission,wireless cellular networks,wireless ondemand videos for police investigation can be explored with FSO system. In spite of various advantages, the performance of the FSO system is influenced by the atmospheric turbulence, which costs distortion of transmitted signal along the path of propagation. Thus it is exposed to beam wandering, intensity fluctuation (scintillation) and beam broadening at the receiver, which is leading to significant decrease of coupling efficiency at the receiving terminal [3-5]. Due to the above atmospheric effects the optical links suffer from random variation in index-of-refraction turbulence (IRT), as a result image bluring effect will occur by the obscuration such as clouds, snow and rain etc [1][6].

There has been innumerous research carried out to achieve the above mentioned challenges in FSO system. The innovative techniques which was incorporated with RF technology are now being implemented in next generation of FSO system, such as orthogonal frequency division multiplexing (OFDM), multiple-input multiple-output (MIMO) communication systems, cooperative diversity and adaptive transmission system [7]. Wang *et al.* [8] showed that the numerical analysis for BER performance of DPSK is better than OOK formats not only in the moderate but also in the strong turbulent channel. They have prefered phase modulation due to its high sensitivity, which uses full phase information i.e. it encodes information on its phase. It can mitigate the severe effect of free space channel scintillation up to an great extent, but traditional intensity modulation/direct detection (IM/DD) is simple to construct [9]. Also DPSK requires least amount of power compare to OOK modulation (both RZ and NRZ signaling). Popoola *et al.* [10] verified the BER performance of DPSK modulated system and they have shown that the DPSK system is better than higher order QAM systems as well as BPSK modulation systems. Vats *et al.* [11] observed the fluctuation of BER versus range for different data rates and proved that for a susceptible vale for BER, the link distance is 1300 m for the laser operated in 1550 nm. When the optical signal travels through a non-homogeneous medium, there arises fluctuation in intensity in the received optical signal, and thus degradation of the optical intensity. To measure the scintillation caused by the atmospheric turbulence, the scintillation index is an important parameter [7]. To distinguish the strength of turbulence level, choice of appropriate channel model is very crucial for system design [7]. In literature various types of stochastic channel models has been proposed such as Log-normal, negative exponential, K-distribution , Rayleigh distribution , I-K distribution and Gamma–Gamma etc. Out of all these models, the Gamma-Gamma model is double stochastic model, which can be implemented for weak turbulence channel to high turbulence channel and is widely accepted in current literature [10]. Another parameter, which can also be playing an important factor for measuring the atmospheric turbulence, is the refraction structure parameter C_n^2 , which is altitude dependent. It has maximum at lower altitude and minimum at higher altitude. Due to the homogeneous turbulence the C_n^2 is considered to be constant over link distance. The typical value of C_n^2 is