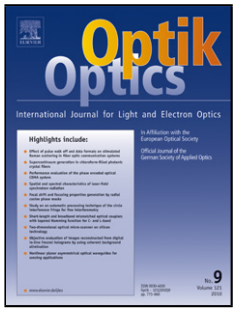

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Effects of fog-haze random media on the short-range Optical Wireless Communications link

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Abstract

A model for short-range optical wireless communication (OWC) link under fog-haze random media is presented based on the consideration of beam pointing error. The performance of OWC is analyzed in terms of received power, link margin, signal to noise ratio (SNR) and bit error rate (BER) with different track length, visibility of atmosphere, strength of the atmospheric turbulence, operating wavelength, emitting beam width, and variance of pointing error. It is found that we can ignore the impact of emitting beam width on the link margin, however, there is a optimizing emitting beam width w_{op} for the SNR performance of the channel. The link margin and SNR decrease as the increasing of the track length and the turbulence strength. The link margin and SNR decrease as the meteorological conditions transform from clear, haze to heavy fog. The longer operating wavelength can increase the link margin and SNR. The pointing error caused by beam wander is the dominant factor and it seriously reduces the link margin and SNR, and increases the BER.

Keywords—ground-to-train link, optical wireless communications, fog-haze random media, signal to noise ratio

1. Introduction

The optical wireless communications is an alternative wireless access technology to the existing radio frequency (RF) wireless systems, which can improve the bandwidth bottleneck of RF. OWC have multiple advantages that can complement the existing RF links such as huge unregulated spectrum, immunity to electromagnetic interference, high security since optical beams do not penetrate opaque objects and frequency reuse resulting in a high capacity per unit volume [1-5]. Owing to the exponential growth of handheld devices such as smart-phones or tablets, there is a growing demand for high-speed internet connections in trains, ships, buses, etc. [1].

A ground-to-train communications (short-range) link using the OWC technology is proposed in [2], where a tracking control algorithm is used to establish a stable communication link between the mobile unit and the ground. However, the ground-to-train OWC channel is an atmosphere channel, so the optical signal must be suffered by the atmosphere turbulence caused by the variation of atmospheric temperature and pressure, and the visual range (attenuation) caused by the fog or haze. The mathematical models of the OWC ground-to-train system using a Lambertian source [3] and Gaussian source [2] for the straight track and curved rail tracks in atmospheric turbulence [4] have been reported. The effects of turbulence on the link margin, signal to noise ratio(SNR) and bit error rate (BER) of the ground-to-train OWC system are discussed. The model of average capacity of ground-to-train wireless optical interconnects of log-normal and Gamma-Gamma turbulence is given in [6,7]. As we know, there are almost no discussion with respect to the effects of the fog-haze random atmosphere on link margin, signal to noise ratio(SNR) and bit error rate (BER) of the ground-to-train OWC system with beam pointing error.

In this letter, we discuss the link margin, signal to noise ratio(SNR) and bit error rate (BER) under the fog-haze random media in Section 2. In Section 3, numerical simulations for the link margin, SNR and BER are presented. We end with conclusions in Section 4.

2. Receiving power, link margin and SNR

Considering a short-range OWC link that is a straight track, a typical ground-to-train OWC link consists of optical transceivers (T/R) positioned on the roof of the train and ground stations positioned

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