F3: Point to point propagation effects

Statistics of Fade Slope on a Free-Space Optical Communication System at 0.83μm Operating over Densely Urbanised Terrain

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Abstract

A free space optical communication system at 0.83μm operated across central London for 4 years. The 4.1 km link connected the 11th floor of the Engineering building at University College London to the 12th floor of the Imperial College of Science and Medicine. The beam passed over a variety of urban elements such as buildings of different heights, "canyons" formed by flat terrain such as squares and even a small lake at Hyde park (the Serpentine). The system was used to test the viability of a free-space optical communication system over a densely urbanised environment. The study consisted of the analysis of long term measurements of received power scintillations, angle of arrival, attenuation of the received signal and the effects of rain and urban climatology. In this paper, the statistics of fade slope, defined as the rate of change of attenuation, are presented and discussed. Among the results obtained are the distributions of fade slope for the negative and positive values and for the entire data bank. The relationship between the average fade slope and fade depth is also analised.

Several authors who had explored this subject for lower frequencies (mainly for satellite links operating at Ku and Ka bands) found that the distribution of fade slope values follows a gaussian shape, which means that the distributions for negative and positive slopes are mirror images of each other. On the other hand, no general agreement has been reached as to the relationship between the level of attenuation and the average level of fade slope.

With the results from this study of this dynamic aspect of attenuation, designers will be able to build an array of tools for building intelligent fading countermeasures, which may increase the overall quality of the service provided by the link.

The distributions of fade slope values were found in general to be leptokurtic, departing from the expected gaussian bell-shaped curves towards a more pronounced mode on the obtained densities. There seems to be a straight line relationship between fade depth and the average value of fade slope. The descriptive statistics of fade slope values also seem to have well defined relationships with fade depth.

As for the contributions of this work to "new knowledge", this is the first paper (as far as the authors are aware) to explore the characteristics of fade slope at optical frequencies and with a system operating in such an free space optical propagation-hostile (yet realistic for any commercial Free Space Optical Communication System) environment as central London.

This work is part of a series of related studies in the propagation characteristics of a free space optical communication system operating in urban environements, as well as the effects of the urban microclimatology in the reliability of such systems. Several papers, dealing with other aspects of optical propagation such as the effects of scintillations and angle of arrival variations have been produced over the course of the study and are published in journals and conference proceedings.