PERFORMANCE EVALUATION OF GROUND TO SATELLITE OPTICAL LINK AND STRATEGIES FOR PERFORMANCE IMPROVEMENT

by

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Certificate

This is to certify that the thesis entitled "**Performance Evaluation of Ground to Satellite Optical Link and Strategies for Performance Improvement**" being submitted by Ms. Hemani Kaushal (nee Sharma) to the Department of Electrical Engineering, Indian Institute of Technology Delhi is the record of the bonafide research work carried out by her. She has worked under our supervision and guidance during the period July 2007 to May 2012. She has fulfilled all the requirements for submission of the thesis which has reached the requisite standard.

The results contained in the thesis has not been submitted either in part or in full to any other university or institute for the award of any degree or diploma.

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Abstract

The increasing demand for high bandwidth requirements have generated renewed interest in free space optical (FSO) communication links. Also, FSO links are an attractive technology for broadband communications where fiber optic links are not feasible. The transition from conventional radio frequency (RF) band to optical and near infrared band offers the capability to increase the data rate by several orders of magnitude. The other advantages offered by a FSO link are its low mass and less power requirement, immunity to interference and unlicensed spectrum. Most of the advantages are due to the higher frequency of optical signals as compared to RF signals. However, the signal in FSO link suffers due to the adverse effects (viz., absorption, scattering and turbulence) of the atmospheric channel. Out of these three effects, the atmospheric turbulence is a major challenge that may lead to serious degradation in the link performance and make the communication link infeasible.

The work reported in this thesis is concerned with the effect of atmospheric turbulence on the link performance of ground-to-satellite FSO system for coherent (subcarrier BPSK and QPSK) and noncoherent (OOK and $\mathbb{M}$-PPM) schemes. Various strategies to improve the link performance have been investigated. It is seen that link BER performance is affected with change in transmitter beam size, zenith angle and operating wavelength. Therefore, the effect of beam size for coherent and noncoherent modulation schemes has been investigated for various zenith angles and operating wavelengths in weak atmospheric turbulence. To achieve the better propagation of laser beam through turbulent atmosphere, an optimization of transmitter beam size is carried out.

A comparative study of both coherent and noncoherent modulation schemes have been made using two performance metrics i.e., BER and acquisition time. Further, the improvement in the link performance using transmit diversity has been worked out. In the

analysis for transmit diversity, effect of correlation among the transmitting antennae beams has been incorporated. In addition to transmit diversity, error correcting coding techniques i.e., convolutional and LDPC codes are also used to improve the link BER performance. Improvement with these coding schemes in terms of coding gain (in dB) has been evaluated for both the modulation schemes. Finally, for a given requirements, a link power budget has been made for SC-BPSK modulation scheme. The variations of link margin with zenith angle have been studied. It is seen that the link margins decrease continuously with the increase in zenith angles for single transmitter and transmit diversity. However, the decrease in the link margin with zenith angle is relatively less in transmit diversity as compared to single transmitter. Also, transmit diversity provides more gain at higher zenith angles i.e., in adverse conditions. Further, the gain provided by the LDPC code is much more than the gain provided by transmit diversity irrespective of the zenith angle. Usage of LDPC code becomes more advantageous than transmit diversity especially at higher zenith angles and is more effective in improving the link margin for same BER and data rate requirements in weak atmospheric turbulence channel.

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