Abstract

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Free Space Optical Ground-to-Train Link: Design and Characterization

This thesis investigates experimentally a free space optical (FSO) continuous ground-to-train communication link under static conditions. A preliminary experiment is implemented to study the performance of an FSO link. A simple low speed transmitter and a receiver are designed and implemented, and then a small scaled link between ground and train is constructed. The aim of this experiment is to set the geometrical boundaries including the track length and the tilting angles of transceivers for continuous transmission. After setting the boundary limits of this experiment, a geometrical model for an FSO rail-track is suggested. A 90 cm track length experiment is conducted using a 3 ? and a 13 ? field of view (FOV) 50 mW light emitting diodes (LEDs). The received signal voltage is measured and bit error rate (BER) is calculated along the track. A corresponding model for the train is then simulated in order to verify the obtained results. The experimental setup is constrained by the simulation results. An investigation for different noise effects is conducted in the simulation of the transmission link based on the Lambertian ray trace model of the light source. The received power is compared with the power sensitivity at BER of 10-9 at different data rates. The preliminary experiment results in a reliable link at data rates ranging from 512 kb/s up to 5 Mb/s according to the available data source and can be extended to higher data rates. A clear wide eye pattern is obtained with theoretical BER ? 10-9. Error-free transmission with Q-factor > 6 is achieved along the train track at 5 Mb/s for both the 3 ? and 13 ?-LEDs. As for the train track experiment, full train track coverage (90 cm) is obtained using the 13?-LED, unlike the 3?-LED, which has shown limited track coverage (15 cm). Later, a modification to the conditions of the 3?-LED experiment is forced to modify the train track coverage to 85 cm The system is modified in terms of the geometrical dimensions. A simulation is used to check the maximum bit rate that the transmitter and the receiver can communicate at, which is obtained to be nearly 336 Mb/s. The maximum distance between transmitters on the train side ranges between 1 m and 9 m starting from 500 kb/s and reaching 336 Mb/s. As for the 3?-LED, the range of coverage distance is between 5 m and 38 m for the same data rate range.