Thesis Abstract

Free space optical (FSO) communication systems continue to take up a pivotal position in the continuing evolution of cutting-edge global telecommunications and networking systems. The prime advantages of this growing technology are its licence free spectrum and higher spectral efficiency–virtually unlimited bandwidth. FSO communications have excellent features like utilization of unregulated spectrum, lower cost implementation, lesser power consumption, faster deployment capability, etc., due to which it has drawn significant attention in both research and industrial domains. For the past few decades, FSO communication has grown its appeal to a broader extent in the scientific research communities. This contemporary technology provides numerous benefits over typical radio frequency networks. Having acknowledged its popularity for its manifold technical benefits, the broadcast nature of FSO communication can expose the system to various privacy and information security related risks. Thereby, the intervention of illegitimate sources such as jammers in the FSO network has become a raising concern in the present day–which needs closer attention.

The work presented in this dissertation unfolds the detailed investigation of jamming effect over different FSO set-ups and how this denial-of-service (DoS) attack can be a serious threat for this promising high-speed wireless network. The analysis starts with a single-input single-output (SISO) FSO system in the presence of jammer, and closed-form expressions of different performance metrics such as average bit error rate (ABER), outage probability (OP), diversity order, and coding loss are obtained for the Gamma-Gamma and negative exponential fading channels. To get more insights on the error performances, the effects of pointing errors for both the jamming and legitimate sources are also studied. Further, the performance of a multiple-input single-output (MISO) FSO system is analysed and significant improvement in the error and outage performances is obtained in the presence of jammer. The BER and OP of the MISO FSO system are mathematically derived and are compared with the SISO FSO system performances in the presence of jamming effects.

After a detailed study of SISO and MISO FSO systems in the presence of FSO jammer, a double relay-assisted FSO system is studied under the jamming attack. A novel mathematical framework is developed to obtain the mathematical expression of BER of decode-and-forward (DF) protocol-based cooperative FSO system in presence of random relay jamming effects. Subsequently, the analysis is performed for a general relay-assisted FSO system with an arbitrary number of relays in the presence of multiple random jammers.

In order to study the effect of jamming over an aperture averaged FSO receiver, an exponentiated Weibull (EW) distributed FSO fading channel is considered due to its excellent fit for all aperture sizes over the ranges of atmospheric turbulence conditions. A framework to obtain the mathematical expressions of BER and OP of the considered FSO system under aperture averaging scheme is provided. Additionally, the asynchronous jamming effect over the error performances is described.

This dissertation also explores how the efficacy of FSO communication channel can be affected in the presence of random jamming attacks. In the presence of jammer, the theoretical expression of discrete-input continuous-output memoryless channel (DCMC) capacity of a SISO FSO communication system is derived analytically. The study reveals that

the FSO channel capacity is very sensitive to the degree of jamming and the ergodic channel capacity alters crucially even for small change in jamming activity. The presence of a rational jammer is addressed by modelling the interaction between the FSO transmitter and the jammer as a non-cooperative game. Closed-form expressions of the equilibrium of the proposed game are derived.

In short, this dissertation presents the fundamental analytical framework to investigate the jamming effects and its mitigation approaches in different FSO set-ups.