ABSTRACT

Beyond fifth generation (B5G) cellular operators around the globe are considering free space optical (FSO) systems, owing to their high capacity feature, as an alternative to the fixed backhaul radio-frequency (RF) links. One of the major challenges for FSO is the line-of-sight (LOS) requirement, stemming from the fact that light signals are focused, and their propagation is highly directional. Even a minuscule drift of transmitter or receiver causes misalignment; resulting in a situation that is commonly known as *pointing error*. The other major challenge is the turbulence induced by random fluctuations of the medium. The scintillation changes the irradiance in a random fashion leading to *atmospheric turbulence*. The similarity of the turbulence effects with RF multipath fading inspired the FSO link designers to explore the already established fading mitigation techniques; the most popular of them is undoubtedly the receiver and /or transmitter diversity scheme. Utilizing either *transmitter diversity*, or *receiver diversity*, or *both* leads to different FSO communication system architectures: multiple-input-single-output (MISO) FSO, single-input-multiple-output (SIMO) FSO and multiple-input-multiple-output (MIMO) FSO.

The following stages have been accomplished in the proposed research work. At first, we have incorporated the transmitter diversity technique, namely the Alamouti *space-time-block-coding* (STBC) scheme, into a primary single-input-single-output (SISO) FSO link to construct a MISO FSO system. Next, a SIMO FSO link has been modeled by incorporating a *switch-and-examine-combining* (SEC) receiver diversity scheme into the SISO FSO link. Finally, we have integrated both transmitter and receiver diversity schemes in the single FSO link to build up an STBC-SEC MIMO FSO communication system and compare all measuring metrics with the rest of the other FSO communication systems. Besides, another MIMO FSO communication system has been designed using *space shift keying* (SSK) transmitter diversity scheme along with selection combining (SC) receiver diversity scheme and compared the resultant outcome with previously mentioned MIMO FSO systems. Generalized Málaga and gamma-gamma statistical distributions have been considered to analyze the turbulent channel, and the effect of pointing errors in the FSO communication system has also been considered during analytical derivations. In this thesis, we have provided the system outcome based on standard performance metrics of the communication system, such as *outage probability* (OP), *average bit error rate* (ABER), and *average capacity*. The analysis leads to a better understanding of how diversity can help in mitigating the two fundamental challenges, atmospheric turbulence and pointing error. The degree of improvement varies across topologies, and although, in general, a topology of higher complexity (i.e. higher number of transmitter or receiver chains) offers larger improvement, there exists no clear single winner. Rather, the degree of improvement has an uncorrelated nature across the metrics. Thus, before employing such diversity techniques, a detailed study of environmental and design factors are necessary to attain optimal results.