ABSTRACT

Due to the rapid increase in the demand of high speed access to voice calls, video calls, and internet, there has been a tremendous growth in wireless communication. The demand for wireless communication has led to the congestion on the network and spectrum scarcity, thereby leading to the need to look for alternative communication technologies. One possible alternate is optical wireless communication (OWC). An OWC system uses a beam of light to transmit data in an unguided medium such as atmosphere, water, and vacuum. Line-of-sight (LOS) is a necessity for efficient communication in OWC. The optical carriers generally lie in the infra-red, ultra-violet, and visible range of the electromagnetic spectrum.

When the unguided medium is atmosphere, OWC systems are called as free space optical (FSO) communication systems. A typical FSO system deals with different kinds of noises such as shot noise, thermal noise, and background noise at the receiver (RX) side, which degrade the RX sensitivity. To overcome this issue, an optical pre-amplifier (OPA) is employed which suppresses the effect of thermal noise and background noise at the RX. However, OPA produces amplified spontaneous emission (ASE) noise, which in turn produces beat noises in the electrical domain of the RX. Generally, in literature, either the effect of ASE noise is not considered at all or is approximated by Gaussian approximation which is not accurate. The received signal conditioned on a given irradiance in the presence of ASE noise is more accurately modelled using the Chi-square statistics. This dissertation provides an exact mathematical framework of a FSO system under the effect of ASE noise, atmospheric turbulence (AT), and pointing error (PE). Closed-form expressions of bit error rate (BER) for different AT models with and without PE and ASE noise are derived in this dissertation. To provide further insights into the system design, asymptotic BER expressions for high signal-to-noise ratio (SNR) values under AT and PEs are provided and diversity analysis is performed.

Owing to the high data rate and high speed of communication, FSO communication systems can be used as backhaul in fifth generation (5G) communication systems. Since 5G communication systems deal with very large number of users which are connected to each other, a backhaul system should be able to manage this data traffic and to connect all users to the core network. Non-orthogonal multiple access (NOMA) is a technique which allows multiple users to transmit in the same time and

frequency band. Using FSO with NOMA makes a competent backhaul technique. This dissertation provides a new beamforming based uplink NOMA technique for a 2×1 multiple-input- single-output (MISO) FSO communication system for negative exponential (NE) AT with error-free feedback under the influence of successive interference cancellation (SIC) error. Closed-form average BER (ABER) expressions are derived for this system. An upper bound on the asymptotic ABER expression is also derived. The performance of this technique is further compared with 4-ary pulse amplitude modulation (PAM) single-input-single-output (SISO) system and an FSO NOMA system without feedback. A comparison of the proposed scheme for 2×1, 3×1, and 4×1 system is also provided in this dissertation.

After studying the performance of OWC systems in atmosphere, this dissertation further studies the performance of OWC systems in underwater scenario. Due to the harsh and turbulent nature of underwater channel, underwater optical wireless communication (UWOC) can work efficiently only in the blue-green region window. Even in this region, optical beam suffers with a huge amount of scattering and absorption. Moreover, the transmitter (TX) and RX in turbulent water are always in a state of motion which further leads to misalignment loss. Beam spread function (BSF) is an equation which models both the effect of attenuation and misalignment loss in a single equation. The existing form of BSF function in literature includes multiple integrals which makes it difficult to use for mathematical analysis. In this dissertation, BSF equation is solved in the form of a simple series based expression. Further, several closed-form approximations of the derived BSF expression are evaluated. Many insights regarding the nature of BSF equation are also provided on the basis of these approximations. Moreover, to further demonstrate the performance of UWOC systems, closed-form expressions of ABER, capacity, and outage probability are also obtained using BSF equation under the effect of oceanic turbulence.