Section A-Research paper

PERFORMANCE ANALYSIS OF FSO FOR VARIOUS MODULATION SCHEME IN ATMOSPHERIC TURBULANCE

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ABSTRACT– In the area of wireless communication, free space optics (FSO) has become well-known for its extremely large bandwidth, unlicensed spectrum, and low power secure transmission. Despite the benefits, atmospheric turbulence and fog weather conditions have a significant negative impact. In this study, various modulation techniques are examined when air turbulence and fog are present. Modeling the turbulence as a gamma gamma distributed channel yields the appropriate expression of bit error rate (BER), and for this channel condition, 16- PPM has outperformed other techniques. For the evaluation of channel performance, BER is taken into account. This study can assist in selecting a modulation method that is appropriate for the channel situation. Turbulence or a misalignment between the transmitter and receiver are the causes of pointing inaccuracy. Range pointing inaccuracy and attenuation can cause increased BER and link failure in long FSO links. High power losses can be brought on even even a slight pointing error shift.

Keywords— FSO, atmospheric turbulence, modulation techniques, lazers, los (line-of-sight), optical wireless, scintillation, Bit Error Rate (BER), OOK, BPSK, DPSK, Pointing error.

INTRODUCTION

Information and communication technology have grown tremendously in response to the rise in demand for high-speed internet, live streaming, video conferencing, etc. The Radio Frequency (RF) spectrum has been congested as a result of the rising demand for data. Hence, switching from an RF carrier to an optical carrier is necessary. With a much larger bandwidth than RF carriers and no licencing requirements, optical carriers are a much more appealing field to research and develop.The method known as wireless optical communication (WOC) uses an optical carrier to transmit data via an unguided medium, such as open space or the air. It represents the nascent field of high-speed communication. Free Room For telecommunication and computer networking, optical communication is a WOC that sends information using light that is present in the free space.

The transmitter, receiver, and separate optical aperture acting as a tracking telescope make up the FSO system..The FSO system can display reflective, refractive, diffusional, or combinational circuit properties [3]. It can display a different arrangement of a straightforward optic carrying out a combined function, conserving money, weight, and space. Lens assembly, often Plano convex lenses, make up the transmission telescope. The size and quality of the optical system are factors that are taken into account in the transmitter section. The minimum divergence determines quality. In contrast, background radiation, signal distortion, and noise interference are present in the receiver section. Depending on the f-number and aperture size, the signal is optically collected and detected under these circumstances [4]. The aperture size determines how much light is captured on the receiver, and the F-number indicates the detectors' field of vision.

MODULATION SCHEME

There are several stages that the optical transmission system takes. It involves modulating the optical information, sending it through the medium, detecting it, and finally, demodulating it. In FSO communication systems, modulation refers to changing an optical source's intensity to send signals over a channel. Amplitude, frequency, phase, and polarisation are some of the different signal parameters that can be modulated in an optical transmission. BER, optical power, SNR, and other parameters can be used to evaluate different modulation schemes that are appropriate for FSO systems.[24] Intensity modulation with direct detection has been the most frequently used modulation method up to this point. The modulation schemes are selected based on their power and bandwidth effectiveness, ease of design, cheap implementation costs, and immunity to background radiation interference.

The easiest and most effective intensity modulation (IM) method is on-off keying (OOK). The transmitter in a binary OOK system sends a light pulse into a channel to symbolise a "1" and no light at all for a "0." There are two methods errors can happen when signal plus noise are present at the receiver input. When a "1" was communicated, the receiver thought a "0" had been sent. Additionally, the recipient might mistakenly believe a "1" was sent when a "0" was actually sent. It has the ability to code using both NRZ (Non Return to Zero) and RZ (Return to Zero) methods. Compared to NRZ, RZ exhibits greater reactivity [25] coherent apart from above schemeModulation scheme such as Binary Phase ShiftKeying (BPSK) and differential phase shift keying(DPSK) can also be used [26]. Under all turbulenceConditions, BER performance of subcarrier BPSK Always better than OOK. pulse position Modulation scheme (PPM) is quadrature modulation technology. PPM has slots and Symbol sync where information is present However, it is encoded in the position of the light pulse Provides greater resistance to turbulence than amplitude Because soft demodulation is available Algorithm[27][28]

RELATIONSHIP BETWEEN SNR AND BER

The performance of the FSO system is Determined by the BER of the system. BER from the system depends on the modulation scheme, Signal-to-noise ratio (SNR). Dark current noise, signal Photo shot noise, Thermal/Johnson noise Detector and background noise all contribute noise in the system. Assume Gaussian noise distribution, SNR at output of the photodetector in the absence of turbulence given by

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$$SNR_0 = \frac{P_S}{\sqrt{\left(\frac{2h\nu B}{\eta}\right)(P_S+P_B)+\left(\frac{h\nu}{\eta e}\right)^2\left(\frac{4kT_N B}{R}\right)}} \qquad (1)$$

where Pt is the signal power of the optical transmitter. PB is the background noise, both expressed in Watts. η is detector quantum efficiency, e is the charge In Coulombs, h is Planck's constant and ν is the optical constant. Frequency in Hertz, k is Boltzmann's constant, B is (Detector) filter bandwidth, TN is effective noise temperature, R is the effective input Resistor to detector amplifier.

Turbulence causes the SNR to fluctuate. Period (instantaneous value) and average(meaning) to take the average SNR will be expressed

(2)

$$\langle SNR\rangle = \frac{SNR_0}{\sqrt{\frac{P_{S0}}{\langle P_S\rangle}+\sigma_1^2(D)SNR_0^2}}$$

where SNR0 is the signal-to-noise ratio in the absence of signal. Turbulent flow as defined before, PS0 is the signal power Lack of atmospheric effects, intermediate inputs signal power (i.e. instantaneous input signal power PS) and σ2I(D) Aperture-averaged scintillation index.

Signal that enters the judgment circuit Fluctuates with various noises mechanism. Therefore, SNR0 will change. Make it variable. [2][29]

REASON BEHIND THE INCREASING IN BIT ERROR RATE

For each detector type bit error probability (that is, the relative error frequency) functionally relevant Possible signal strength (denoted by s) can be defined as the number of signal photons per bit Incident to the detector. The bit error probability is write E(s) for a signal pulse of magnitude s. if Signal strength varies randomly with atmosphere Turbulence, s becomes a random variable in a probability distribution P(s) Hence the bit error Probability is also a random variable. Many Statistics about E The first two moments of the distribution (mean and variance), which can be expressed as

$$\langle E\rangle = \int_0^\infty E(s)P(s)\,ds \qquad (3)$$

$$\text{Var}\quad (E) \quad = \int_0^\infty (E-\langle E\rangle)^2 \qquad (4)$$

where I mean ensemble mean and 'var' Shows dispersion. Expressing E(s) as finite, we have Taylor's formula above, with quadratic error terms we can write

$$\langle E\rangle = E(\langle s\rangle)=$$

$$1/2\int_0^\infty E^{(2)}(\langle s\rangle+\theta(s)(s-\langle s\rangle)(s-\langle s\rangle)^2P(s)ds$$

where E(2) is the second derivative of E(s) and (s) is between 0 and 1 for each value of s, but vice versa totally don't know. It follows from above the equation is always greater than E() if The second derivative of E(s) is positive for all s. Therefore, the condition is sufficient for The disturbance that causes an increase in the bit error rate is than the second derivative of the bit error probability function, E(s) is positive everywhere.[2][30]

CHANNELMODELS

To maintain the required link performance, some models have been proposed. These models are called the channel model. These models study the influence of competitor on FSO link under storm atmosphere. Among these models, the most popular Models were listed viz. gamma-gamma, log normal and negative exponential models.

1) **log normal**
   This model is used for low disturbance and for propagation distances less than 100 m. With this model, the pdf of the optics is obtained field I is given by f (I)[22]

$$f(I)=\frac{1}{2\pi I\sigma^2} \quad \exp\left[\frac{-(\ln(I)-m_i)^{\ \ 2}}{2\sigma_i^2}\right] \qquad (5)$$

Where m_i is mean and is log-irradiance variance

For a given scintillation index, the log-irradiance variance is given by and can be calculated. The scintillation index is between 0 and 0.75 for modest turbulence. The distribution grows more skewed and has longer tails in the direction of infinity as the turbulence strength increases. As the channel's inhomogeneity rises, this shows how much the irradiance fluctuates, which un turn reduces the precision of performance analysis.

2)Gamma-Gamma model

As a practical mathematical model for air turbulence, Andrews offered the gamma-gamma pdf and introduced the modified Rytov theory. The optical field is a function of disturbances resulting from both large- and small-scale atmospheric influences, according to this modified Rytov theory. The normalised irradiance is denoted by the equation I=Ix*Iy, where Ix and Iy are produced by large- and small-scale turbulent eddies, respectively, and each one follows the gamma distribution. The gamma-gamma pdf is thus given as[23].

$$f(I)=\frac{2(\alpha\beta)^{\frac{\alpha+\beta}{2}}}{\Gamma(\alpha)\Gamma(\beta)} I^{\frac{\alpha+\beta}{2}-1} K_{\alpha-\beta}\left(\sqrt{2\alpha\beta I}\right), I > 0 \qquad (6)$$

Where and are the actual number of small-scale and large-scale eddies in the scattering environment, respectively, and Ka(.) is the modified Bessel function of second type of order a.

3)Negative Exponential model

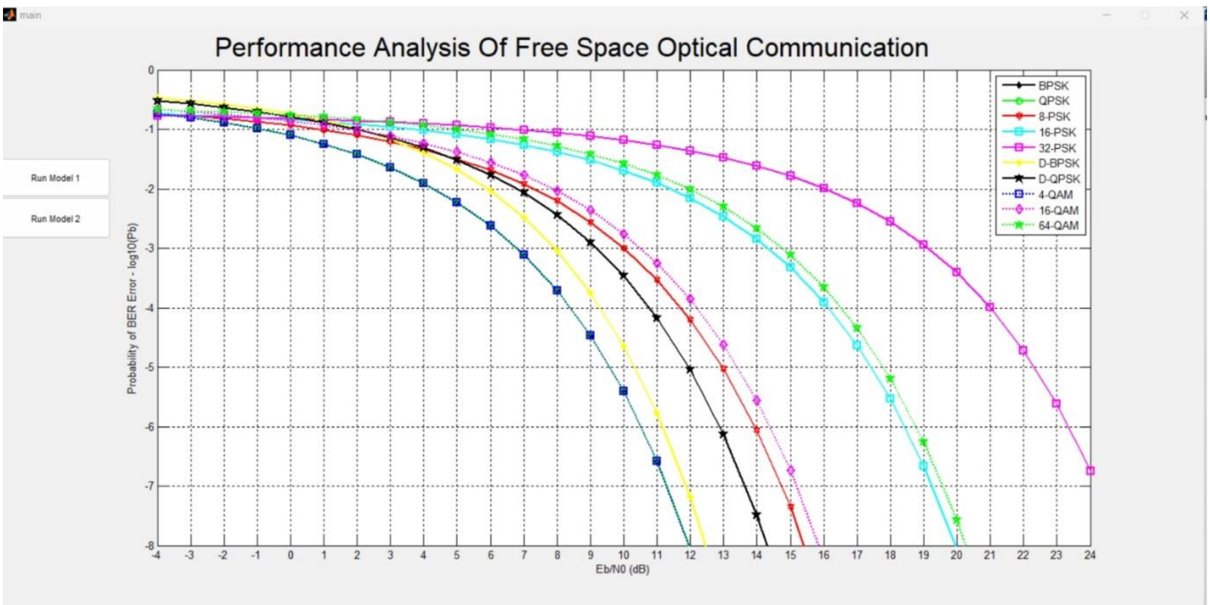
Strong irradiance changes cause a high number of independent scatter when the link length is several kilometres. In that situation, the signal intensity is determined by a negative exponential statistics since the signal amplitude follows a Rayleigh distribution (square of field amplitude). [23] It is provided by

$$P(I)=\frac{1}{I_o}\exp\left(\frac{-I}{I_0}\right),\ I \qquad (7)$$

where Io is the average luminosity (average photon count per slot). Here =1.[24] .[24]

POINTING ERROR

Misalignment between the transmitter and receiver or turbulence are the causes of pointing inaccuracy. Range pointing inaccuracy and attenuation can cause increased BER and link failure in long FSO links. High power losses can be brought on even even a slight pointing error shift. System techniques including auto tracking, focused beams of high power, extremely sensitive receivers, and weather monitoring should be used to solve this issue. In order to attain BER smaller than 10 -9, maximum pointing error is estimated for the proposed FSO link in this paper. With attenuation ranging from 4 dB/km to 56 dB/km, the link is ideal for weak and typical turbulent channels.



CONCLUSION

Also, we looked at several modulation techniques and how they might be used. Eventually, we have come to the conclusion that 32 PSK performs best in turbulence situations. Also, a thorough examination of the FSO system's BER and SNR parameters is conducted in the atmospheric channel.

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