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BER performance in UDP Layer in a FSO Communication Link

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Abstract—*FSO communication is an alternate to the existing OFC communication system with same the features. This paper presents the Bit-Error-Ratio performance on the User Datagram Protocol (UDP) layer in different weather conditions. The experiment was done with UniPRO MGig 1 LAN analyzer in collaboration with Light Pointe Airlite 100 to analyze the BER variation.*

Keywords: *FSO, UDP, BER, LAN Analyzer*

1. INTRODUCTION

Free Space Optical (FSO) communication system is an advanced and latest technology in the field of Optical Communication. It provides an alternate to the existing Optical Fiber Communication in the last-mile technology barrier. The features and systems of FSO are almost similar to the OFC system, but the FSO uses air as a medium for data transfer whereas OFC uses optical fibers for connectivity, which increases is mobility and decreases the time of deployment by the user.

2. THEORETICAL ANALYSIS

The Free Space Optical (FSO) communication system, unlike the conventional Optical Fiber Communication (OFC) system where optical fiber is used as a transmission medium, uses the free space or air as its transmission medium. Random variations in the air's refractive index profile commonly referred as optical turbulences, responsible for the change in different properties of the transmission and reception of optical signals. The cause of these Optical Turbulences in the atmosphere is due a combination of moisture and temperature gradients caused from the Sun's heating of the Earth's surface. The performances of these optical signals are highly affected by these optical turbulences [1], causes the BER [2] to change from its theoretical set parameters. Also the change in atmospheric temperatures affects the refractive index parameter C_n^2.

There are many models explaining this refractive index parameter C_n^2, and the most popular model is the *Hufnagl-Valley* model [3,4], which is based on the inland sites and daytime viewing conditions as it considers the high-altitude wind speeds and near-ground turbulence effects. The model is given as:

$$C_n^2\,(h) = A \exp(-h/100) + 5.94 \times 10^{-53}\,(v/27)^2\, h^{10} \exp(-h/1000) + 2.7 \times 10^{-16} \exp(-h/1500) \quad (1)$$

Typical values of C_n^2 at within a height of 100 meters is taken as $C_n^2 = 1\mathrm{X}10^{-14}$.

Also a vital effect of on FSO system is the Scintillation effect, directly related to the refractive index parameter C_n^2. The Scintillation index is given as:

$$\sigma_i^2 = \frac{\langle (I - \langle I^2 \rangle) \rangle}{\langle I \rangle^2} = \frac{\langle I^2 \rangle}{\langle I \rangle^2} - 1 \quad (2)$$

The variation of Scintillation effect σ_i^2, with respect to refractive index parameter C_n^2 is given as:

$$\sigma_i^2 = 1.23\, C_n^2\, k^{7/6}\, l^{11/6} \quad (3)$$

The effectiveness of a FSO system can be determined by its bit-error-ratio (BER) performance, which is based on the signal-to-noise ratio (SNR) and the modulation scheme involved in the FSO system [5]. The contributions of noise are from all possible sources like shot noise, dark noise, thermal noise in the photo detector, and the background noise.

In absence of turbulence effect, the SNR at the photo detector is given as:

$$\mathrm{SNR}_0 = \frac{P_S}{\sqrt{\left(\left(\frac{2h\nu B}{\eta}\right)(P_S + P_B) + \left(\frac{h\nu}{\eta e}\right)^2 \left(\frac{4kT_N B}{R}\right)\right)}} \quad (4)$$

Now, in presence of turbulence effect, the SNR becomes a variable term and considering its average value the $\langle SNR \rangle$ is given as [6]:

$$\langle SNR \rangle = \frac{SNR_0}{\sqrt{\left(\frac{P_{S0}}{\langle P_S \rangle} + \sigma_i^2(D) SNR_0^2\right)}} \quad (5)$$

The experiment conducted with Light Pointe [7] equipment uses the on-off keying (OOK) modulation scheme in transferring the data. The BER calculation is done based on the OOK modulation scheme. In OOK scheme, “1” is represented by presence of light pulse where “0” is represented by an absence of light pulse. The error occurs when the receiver detects a “0” when “1” is sent or detects a “1” when “0” is sent, both under the noisy conditions of the atmosphere.

Now, the bit-error-ratio with respect to the signal-to-noise ratio in absence of atmospheric turbulence is given as:

$$\mathrm{BER}_0 = \frac{1}{2}\left(\frac{SNR_0}{2\sqrt{2}}\right) \qquad (6)$$

And in presence of turbulence is given as:

$$\mathrm{BER} = \frac{1}{2}\int_0^{\infty} p_I(s)\; erfc\left(\frac{\langle SNR\rangle s}{2\sqrt{2}\langle i_s\rangle}\right) ds \qquad (7)$$

Legends-

h is the altitude in m

v is the wind speed at high altitude in m/s

A is turbulence strength at the ground level practically (A= 1.7 x 10^{-14} $m^{-2/3}$)

I denotes the irradiance of optical wave and ⟨ ⟩ represents the average irradiance

k is the wave number and given as $k=2\pi/\lambda$ (λ is the wavelength of operation)

l is the distance between the two transreceiver equipments

P_S is the optical power of the transmitted signal in watts

P_B is background noise in watts, η is detector quantum efficiency

e is charge of an electron

h is Planck’s constant

v is operating frequency in Hertz

k is Boltzmann’s constant

B is bandwidth of detector used (APD)

T_N is noise temperature

R is the input resistance of the amplifier

P_{S0} is the optical power in absence of atmospheric effects

$\langle P_S \rangle$ is the mean optical power

$\sigma_i^2(D)$ is the average Scintillation effect of the atmospheric turbulences

3. EXPERIMENTAL OBSERVATIONS

The experiment was executed with the LAN Analyzer [7] in collaboration with Light Pointe Airlite 100 [8], during the month of February-March, 2015. The temperature data [9] along with the BER data was recorded during the experimental days. The equipment runs for 22 hours continuously to measure the BER variations. The UDP (User Datagram Protocol) layer having a frame structure [7] is shown below:

PRE (Preamble)	SFD (Start of Frame Delimiter)	MAC (Media Access Control)	IP (Internet Protocol)	PROT (Protocol Header)	DATA	FCS (Frame Check Sequence)	IFG (Inter Frame Gap)

Fig. 1: UDP (User Datagram Protocol) layer frame structure

Table 1 Below shows the maximum-minimum temperature along with BER data on that day

Table 1: BER values with maximum-minimum temperature

Days of Experiment	**Maximum Temperature in °C**	**Minimum Temperature in °C**	**Measured Bit-Error-Ratio**
1	24	11	5.81465e10^{-8}
2	31	21	4.751166e10^{-8}
3	30	19	8.69302e10^{-8}
4	33	20	1.85397e10^{-8}
5	34	22	5.9041e10^{-8}
6	34	21	1.17969e10^{-7}
7	34	21	5.67371e10^{-8}
8	33	18	4.96748e10^{-8}
9	35	22	3.05231e10^{-8}
10	33	24	6.78855e10^{-7}
11	32	22	1.61353e10^{-7}

4. EXPERIMENTAL RESULTS

The graph shows us the variation of BER with different days of experiment.

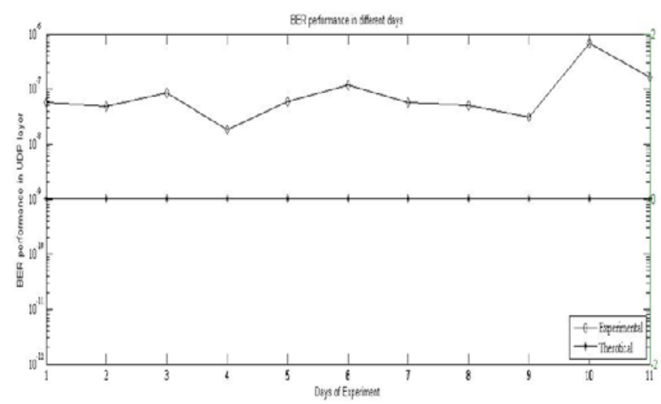

Fig. 2: Graph of BER verses different days of experiment

5. OBSERVATIONS

In this experiment, we try to understand the weather effect on UDP layer of a FSO link. A similar experiment regarding Physical layer [10] has been done earlier. The payload in Physical layer is much greater than the payload in UDP layer, and overhead of UDP layer is much greater than Physical layer. It was observed that the BER was much higher in UDP layer in comparison to that of Physical layer, as expected.

REFERENCES

[1] AltowijKhaleel S., Alkholidi A, Hamam H. Effect of clear atmospheric turbulences on quality of free space optical communications in Yemen. Front. Optoelectron. China DOI 10.1007/s12200-010-0123-8

[2] Cao Ling-Ling, Sheng M, Feng M, XieXiu-Xiu.BER performance of free space optical communication in strong turbulence with pointing errors. IEEE – 2012, 978-1-4673-5829-3/12

[3] Hufnagel R.E. Variations of Atmospheric Turbulences. Optical Society of America, Washington, DC, 1974, p.WA1

[4] Valley G.C. Isoplanatic degradation of tilt correction and short-term imaging systems. Appl. Opt 19(4), 574-577 (1980)

[5] Majumdar A.K, Ricklin J.C. Free- Space Laser Communication. Springer Publication, 2010

[6] Andrews L.C., Bucaille S, Davidson F. M . Performance loss factors for optical communication through clear air turbulence, Proc. SPIE, 5160, 1-12 (2003)

[7] LAN Analyzer. Ideal Industries Network, Buckinghamshire, UK.www.idealnwd.com

[8] LightPointeAirlite 100, Light Pointe Communications, San Diego, California, USA. www.lightpointe.com

[9] Kolkata weather information taken from www.accuweather.com

[10] Sant S., Sen S., Mazumder P. BER performance in Physical Layer of FSO communication system, IJATES Volume No. 3, Special Issue No. 01, March 2015, ISSN: 2348-7550