A Novel Approach to Overcome the Electromagnetic Wave Propagation using Linear Time Invariant System (LTI)

Aanchal Mathur
Deptt. of Electronics & Communication
Krishna Engineering College
Ghaziabad,Uttar Pradesh
India

Mrs. Poonam Goyal
Deptt. of Electronics &Communication
Krishna Engineering College
Ghaziabad,Uttar Pradesh
India

Abstract **- In FSO technology the propagation channel is earth's atmosphere which during the propagation of signal through it introduces many problems like attenuation,additive noise,dispersion and inter symbol interference(ISI). These problems further increases the power requirements of the system,bit error ratio and subsequently high signal-to-noise ratio.These problems happen because thechannel i.e. earth atmosphere has various atmospheric conditions like Fog, Rainsnow and clouds which results in multiple scattering effects. Therefore in this paper, in order to mitigate the problem of electromagnetic wave propagationthrough the atmospheric channel we have introduced a model that is mathematically stable and traceable,that is we consider Linear time invariant (LTI)system which have properties like:- linearity,causality,memory,time-invariance,stability and BIBO so that its impulse response function can be easily calculated with the help of Fourier transform.**

Keywords : FSO, Inter Symbol Interference, Liner Time Invariant, BER

1. INTRODUCTION

Free space optical communication, also known as Optical wireless communications (OWC), is an innovative technology that has been around for the last three decades and is gaining more and more attention as the demand for bandwidth continues to increase. FSO offers high bandwidth as optical fibre, but reducing the cost and maintenance problem of fibre. In optical fibre channel property is fixed, but in FSO line media property is randomly varied. Moreover, accurate pointing is necessary to have desired performance. The main challenges in atmospheric channel are turbulence, pointing jitter, scattering, absorption and attenuation due to rain, fog, cloud and snow etc. These phenomena can cause power loss in received signal. Performance improvement in terms of bandwidth and power is done by different modulation scheme due to safety regulation of transmitted power and its cost effectiveness. Unlike the conventional RF communication, Free-space optical (FSO) communication uses light instead of radio wave to carry information transmitted through free space. FSO communication can provide us with high data rates, high-level of security in data transmission and license-free deployment. However, since the optical signal in FSO systems is propagated through the atmosphere, it will be strongly influenced by atmospheric factors such as turbulence and adverse weather conditions. Atmospheric turbulence is introduced by the refractive index fluctuations. It causes intensity fluctuation, beam spreading, beam wander and loss of spatial coherence which are detrimental to FSO communication.

Because of its simplicity, intensity modulation with direct detection (IM/DD) is commonly used in FSO communication systems. However, effective communication techniques are required to mitigate the turbulence-induced performance degradations. Both detectors with maximum-likelihood symbol-by-symbol detection and maximum-likelihood sequence detection are investigated.Multi-hop relaying is employed to improve the performance of long-range FSO links. The performance of direct detection with spatial receiver diversity is investigated and it is concluded that diversity is an effective method to mitigate the turbulence-induced log-amplitude fluctuations. The diversity and multiplexing gain have been investigated for multi-beam FSO systems in near-field regime.

Besides direct detection, coherent detection can be employed in less reliable links to increase the sensitivity of the receiver and improve the robustness of FSO systems against impairments caused by turbulence, the performance improvement of coherent detection is compared to direct detection and the advantages of using spatial diversity are investigated. A phase compensation technique is applied to mitigate the degradation caused by phase fluctuations in the performance of coherent receivers. The capacity improvement of coherent FSO links using this technique is demonstrated.

2. LITERATURE REVIEW

Md. Hasan Yeaseen et al [2015] stated that an analysis has been carried out to evaluate the Signal to Noise Ratio (SNR) and average bit error rate (BER) in presence of pointing error and atmospheric turbulence. The probability density function (pdf) of atmospheric turbulence and pointing error has been combined to find out the joint effect on the BER performance on Free-Space Optical (FSO) system.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Mahesh Kumar et al [2015] described that the communication links at high speed requires bit synchroniser for countering bit phase misalignment at the receive end. This paper describes the design of IC based digital bit synchroniser for high speed optical communication links. It supports data rate from 10 Mbps to1 Gbps. The design shows the excellent jitter and eye performance with an eye opening of 95.5% at data rate of 1Gbps.

E.Samain et al [2015] A first free space optical communication campaign was established during June-October 2015 between the NICT SOTA.The main objectives of this experiment are the study of the laser beam propagation through the atmosphere and the design of all the sub-systems constituting the OGS. This experiment has been developed in the framework of an agreement signed between the Japan's National Institute of Information and Communications Technology (NICT) and the French space agency (CNES). The development of the OGS and the measurement campaign were conducted in collaboration with NICT, CNES, ONERA and OCA.

Randall J. et al [2015] Radio Frequency (RF) signals have been relied on exclusively and successfully to communicate with spacecraft since satellite communications began nearly 60 years ago. However, missions now demand higher data rates to meet their data collection requirements. For example, NASA's Lunar Laser Communications Demonstration (LLCD) successfully demonstrated high data rate communications links to and from the LADEE satellite orbiting the moon during the Fall of 2013. As a next step, the Laser Communication Relay Demonstration (LCRD) will build upon the experience gained from LLCD and perform multi-year testing of Free-Space Optical Communications (FSOC) from geosynchronous orbit. Planning for these missions has included quantifying the impacts of the atmosphere on the data links, and developing operational concepts for mitigating transmission losses due to clouds, turbulence, and aerosols. This paper discusses the atmospherics over the Hawaiian Islands as they already include astronomical observing and therefore may be quite favourable.

3. PROBLEM FORMULATION

Free space optical communications is a promising technology for very high speed ,secure, rapidly deployable communications links for short and moderate-range terrestrial line-of-sight networks. FSO systems offer smaller size and weight of components ,such as antennas and therefore there is an increase in the available modulation bandwidth. One of the main challenges in practical deployment of FSO systems is adverse weather conditions like hail, snow, temperature variations and most importantly fog which results in signal degradation by atmospheric scattering and ther estimate the atmospheric channel transfer function and impulse responseto design receiver equalisers which correct the signal distortion.

6. METHODOLOGY

The project begins with the understanding of the problems that occurs in the practical deployment of Free Space Optical communication technology. This

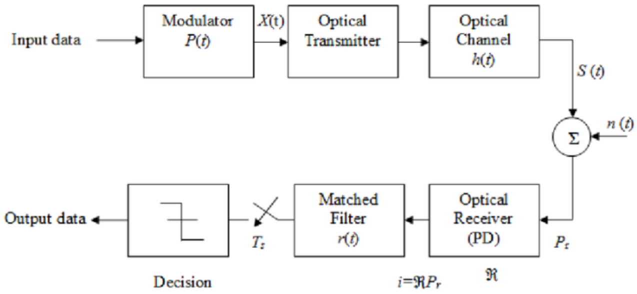

Fig 1. Block diagram of FSO

includes the study of Radiative transfer theory that is a useful solution for electromagnetic wave scattering problems in channels arising due to adverse weather conditions. The information is used to estimate the channel frequency response based on modified pulse vector radiative transfer equation.. The software used for numerical simulation is Matlab software.

7. RESULTS AND DISCUSSIONS

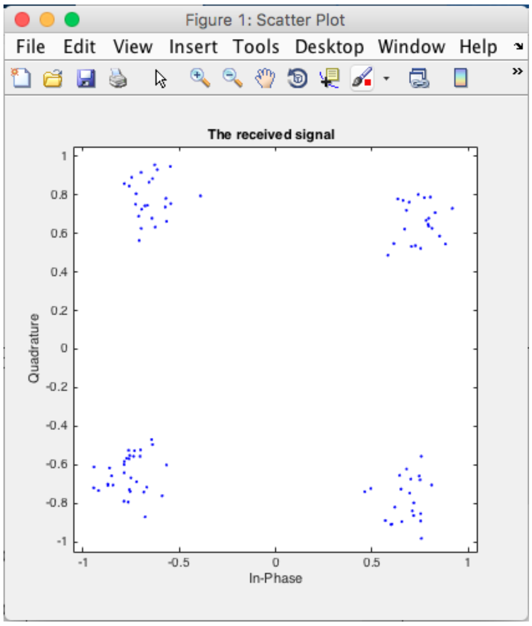

Fig 2. Signal Transmission

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

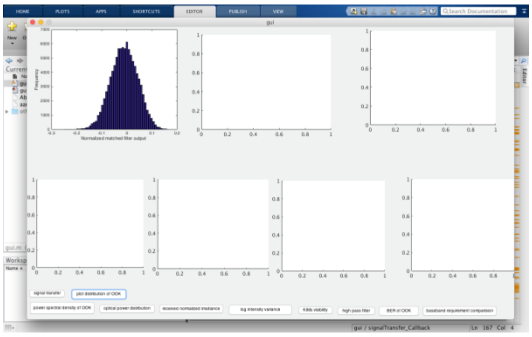

Fig.3 Plot Distribution of OOK

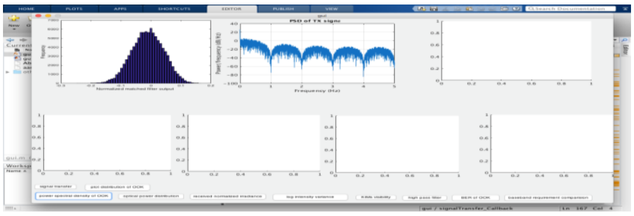

Fig4.Power spectral density of OOK

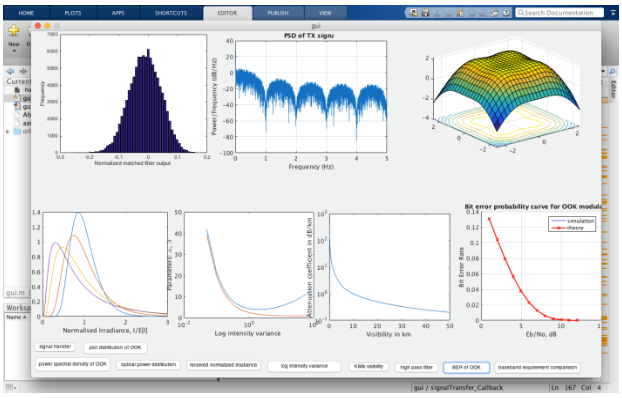

Fig.5 Optical power distribution

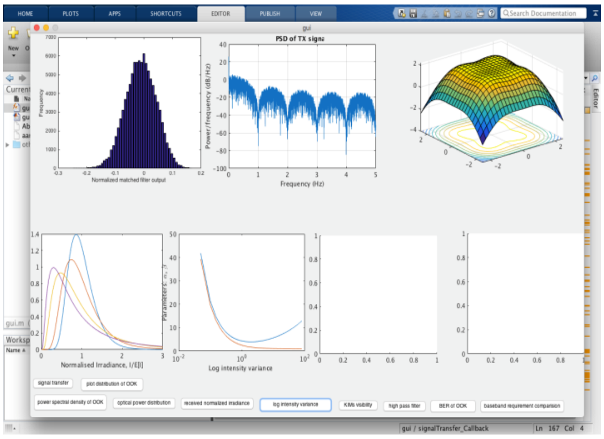

Fig.6 Received normal irradiance

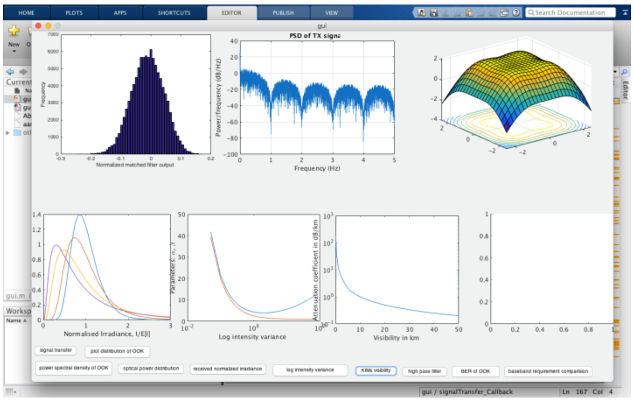

Fig.7 Kim's visibility

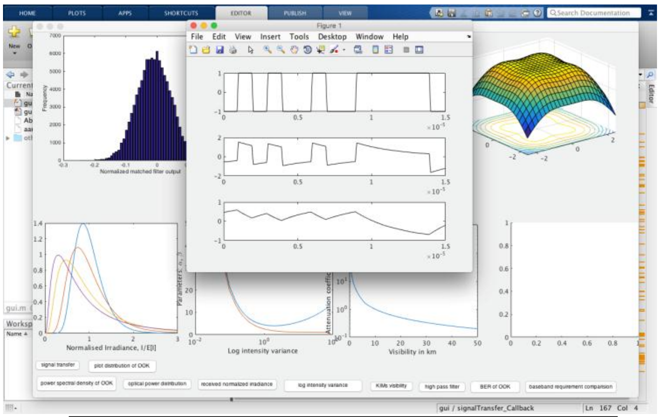

Fig.8 High Pass filter

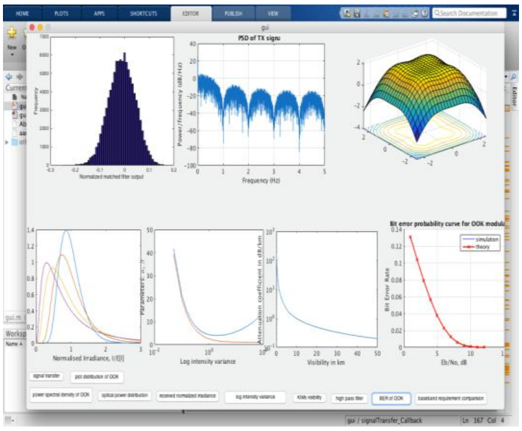

Fig.9 BER OF OOK

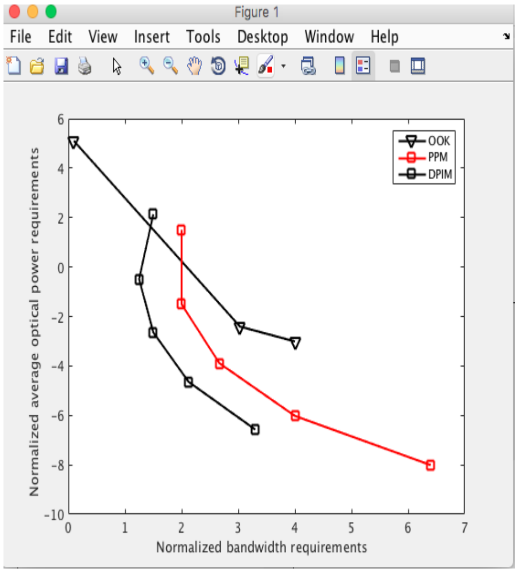

Fig.10 Baseband comparison requirement

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

8. CONCLUSION

In this research, we have proposed a novel method to estimate the atmospheric channel transfer function and impulse responseto design receiver equalisers which correct the signal distortion. The results we achieved are quite positive and will be helpful for the further researches.

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