International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 02 | Feb 2019 www.irjet.net p-ISSN: 2395-0072

Comparative Analysis of OOK, BPSK, DPSK and PPM Modulation Techniques for Intersatellite Free-Space Optical Communication

R. PRADEEP[1], B. VINOTHKUMAR[2], M. UDHAYAKUMAR[3], S. DHANALAKSMI[4]

[1,2,3,4]*Assistant professor, KSR INSTITUTE FOR ENGINEERING AND TECHNOLOGY*

---***---

ABSTRACT - The system of transmission of data through a wireless medium is called as Free Space Optical (FSO) communication, which uses modulated carrier wave as a laser beam. Free-space optical communication is the latest technology that has a lot of popularity as an alternative to radio frequency (RF) communication over the last two decades. Optical communication has lots of advantage over baseband or RF transmission systems which has high aggregate bit rates and/ or very long transmission distances. This paper intends to give an overview of optical modulation techniques such as On-Off Keying (OOK), Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying (DPSK) and Pulse Position Modulation (PPM) which compares their characteristics Bit Error Rate(BER), Signal-to-Noise Ratio (SNR) and the receiver sensitivity.

Keywords - *Free Space Optics (FSO), On-Off Keying (OOK), Pulse Position Modulation (PPM), Binary Phase-Shift Keying (BPSK), Differential Phase-Shift Keying (DPSK)*

1. INTRODUCTION

The key element of the optical communication system is the optical source, which can easily be modulated. In this narrow wavelength band, the energy is concentrated and is capable of being modulated at very high data rates. The semiconductor laser is one of the primary sources of light in modern an optical system which is used as a carrier [1]. At the receiver, they are converted to electronic signals by photodetectors. There are many types of photodetectors, but the photodiodes are used almost in optical communication applications because of their size, suitable material, high sensitivity, and fast response time [2]. The two most commonly used photodiodes are the pin photodiode and the Avalanche Photodiode (APD) because they have good quantum efficiency. It is necessary to understand the characteristics of these photodiodes and the noise associated with optical signal detection for the design of receiver system.

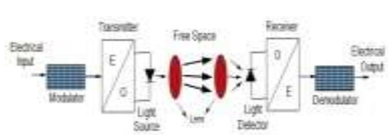


Figure 1 Block Diagram of FSO

1.1 PIN Photodiode

The pin photodiode consists of p region and n regions separated by a lightly n-doped intrinsic I region. When an incident photon has energy, the photon can give up its energy and excite an electron. This generates free electron-hole pairs called photocarriers. The pin photodetector is designed, where most of the incident light is absorbed [1]. The performance of a pin photodiode is often characterized by its responsivity which is given by:

$$R = I/P \qquad (1)$$

Where **I** am the average photocurrent

P optical power incident on the photodiode.

1.2 Avalanche Photodiode

The primary signal photocurrent is multiplied internally by an avalanche photodiode. This increases the receiver sensitivity [1]. The pin photodetector and electronic amplifier have an advantage over APD because of its low cost [1]. For Free Space Optical (FSO) communication systems the required power under various modulation schemes can be derived from the Bit Error Rate (BER) expression for all modulation schemes and can be expressed as follows *P*

$$P = \frac{1}{R}\sqrt{\sigma 2SNR} \qquad (2)$$

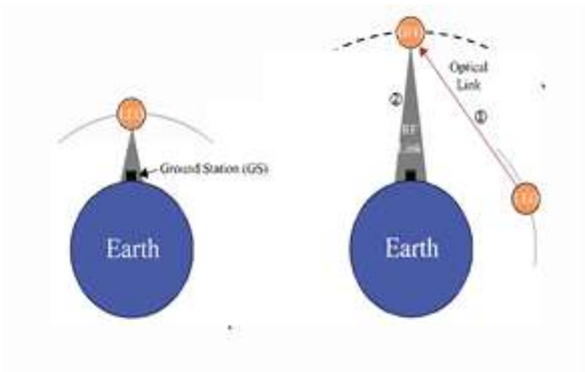
Where **R** is the responsivity of the photodiode.

σ Is the total noise power in the detector current.

SNR is the signal-to-noise ratio.

2. OPTICAL INTERSATELLITE LINK

Optical (inter-)satellite communication describes data transmission between satellites using laser sources in the near- infrared spectrum instead of the conventional radio frequency (RF). Fig. 1 illustrates a typical OISL scenario. As part of an earth observation process a satellite in a low-earth orbit (LEO) accumulates a high amount of data. This data should be transmitted to a ground station (GS) on earth in real time, e.g. in case of a fast tsunami forecast system. However, the transmission time window of a LEO satellite is too short (several minutes per day) and the RF link data rate is too low (~Mb/s) in order to send all data to GS during one flyover



3. AN OVERVIEW OF OPTICAL WAVEFORMS

3.1 OOK Modulation

OOK modulation technique is the direct detection technique which is widely used in the optical communication [1]. It transmits bit 0's and 1's. when bit 0 is transmitted it remains in off state ad when bit 1 is transmitted it remains in on a state. This modulation can be done by using RZ and NRZ waveforms. The probability of error from the optical photodiode can be found from the following equations.

$$BER - NRZOOK = \frac{1}{2} erfc\left(\frac{1}{2\sqrt{2}}\sqrt{SNR}\right) \quad (3)$$

$$BER - RZ\ OOK = 0.5 erfc\left(0.5\sqrt{SNR}\right) \quad (4)$$

3.2 Differential Phase-Shift Keying (DPSK).

The DPSK modulation technique is the direct detection technique which is used for short distance communication [4]. The signal High 1 or Low 0 decided the phase of the previous bits transmitted. If the data bit is low ie 0 the bit does not reverse it continued there is no phase change when the data is high ie 1 the bit get reversed there is a phase change. The probability of error for the DPSK modulation from the optical photodiode can be given by the following equation,

$$BER = 0.5 erfc(\frac{\sqrt{SNR}}{\sqrt{2}}) \quad (5)$$

3.3 Pulse-Position Modulation (PPM)

PPM is especially suited for direct detection of an optical signal transmitted through free-space. A logical '0' and '1' could be represented by a pulse present in the 'first' slot and the 'second' slot, respectively [1]. 4PPM encodes two bits of information into each four-slot symbol whose duration is two-bit periods. M-ary PPM extends the number of bits represented by each of M distinct symbols to log2M which lowers the band-utilization efficiency.

BER equation for 2-PPM can be expressed as

$$BER\ 2 - PPM = \frac{1}{2} erfc(\frac{\sqrt{SNR}}{2}) \quad (6)$$

BER equation for 4-PPM can be expressed as

$$BER\ 4 - PPM = \frac{1}{2} erfc(\frac{\sqrt{SNR}}{\sqrt{2}}) \quad (7)$$

BER equation for 8-PPM can be expressed as

$$BER\ 8 - PPM = \frac{1}{2} erfc(\frac{\sqrt{3\sqrt{SNR}}}{\sqrt{2}}) \quad (8)$$

BER equation for 16-PPM can be expressed as

$$BER\ 16 - PPM = \frac{1}{2} erfc(2\sqrt{SNR}) \quad (9)$$

3.4 Binary Phase Shift Keying (BPSK)

The BPSK modulation technique is the coherent detection technique. In optical communication, the carrier is always taken as the laser [7]. The demodulation can be done by two methods homodyne and heterodyne detection. The phase shift occurs in BPSK modulation is 0 degree and 180 degrees. The BER of this technique is given by the equation

$$BER = 1/2 erfc(\sqrt{SNR} \quad (10)$$

TABLE I COMPARISON OF DIFFERENT MODULATION TECHNIQUE

Modulation Techniques	Features
OOK-NRZ	Direct detection, Moderate SNR, Low Cost, requires the adaptive threshold
OOK-RZ	Direct-detection, High sensitivity
PPM	Direct-detection, Superior power efficiency than any other baseband modulation
DPSK	Direct detection used for short

	distance communication
BPSK	Coherent detection, long-haul communication, power efficiency

4. RECEIVER SENSITIVITY

4.1 Analysis

The lowest power level at which the receiver can detect the optical signal and demodulate it data is known as optical receiver sensitivity [2].

$$P_{rec}(R_1) = (Q\sigma_T + Q^2 q B_e / R(1 - r_1{}^2 Q^2) \quad (11)$$

Where,

$$Q = (I_1 - I_0 / \sigma_{1-} \sigma_0)$$

The receiver sensitivity for the OOK modulation technique is given by,

$$P_{b=} 1/2 erfc(\frac{\sqrt{n_P}}{2}) \quad (12)$$

Where,

$n_{P=}$ No of photons per bit

The receiver sensitivity for the BPSK modulation technique is given by,

$$P_b = \frac{1}{2}\ erfc(\sqrt{n_p}) \quad (13)$$

$n_{P=}$ No of photons per bit

The receiver sensitivity for the DPSK modulation technique is given by,

$$P_b = \frac{1}{2}\ erfc\left(\frac{\sqrt{n_p}}{\sqrt{2}}\right) \quad (14)$$

$n_{P=}$ No of photons per bit

The receiver sensitivity for the PPM modulation technique is given by,

$$P_b = \frac{1}{2} erfc(\sqrt{n_p}/2) \quad (15)$$

TABLE II COMPARISON OF DIFFERENT MODULATION TECHNIQUE RECEIVER SENSITIVITY

BER	Modulation	Receiver Sensitivity
10-9	OOK	70 PPB
10-9	BPSK	9 PPB for Homodyne 18 PPB for Heterodyne
10-9	DPSK	18.4 PPB for NRZ and 18.1 PPB for RZ
10-9	M-PPM	5 PPB

5. SIMULATION AND RESULTS

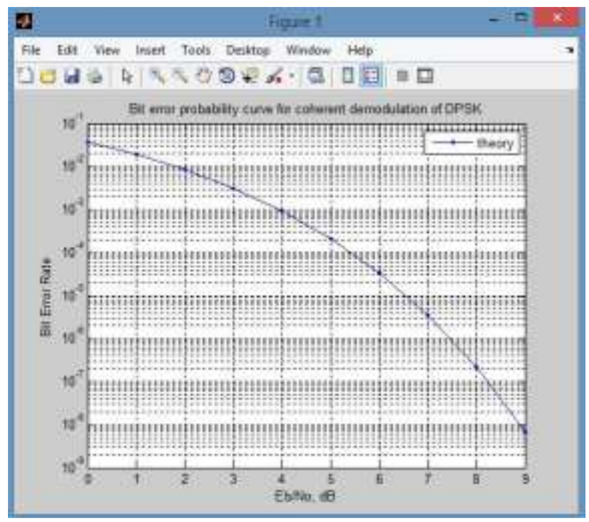


Figure 2 Simulation of BPSK

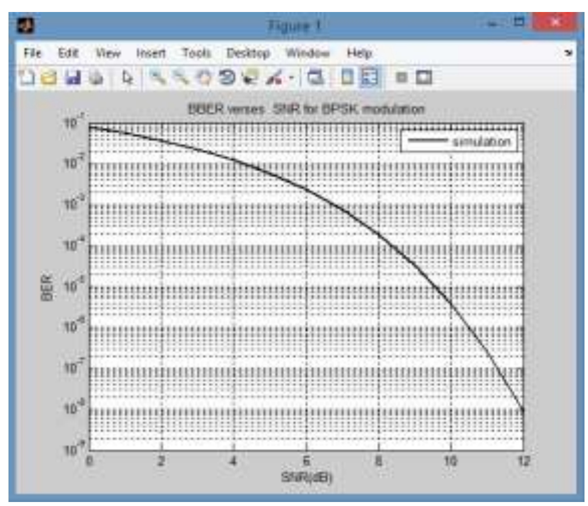


Figure 4 Simulation of DPSK

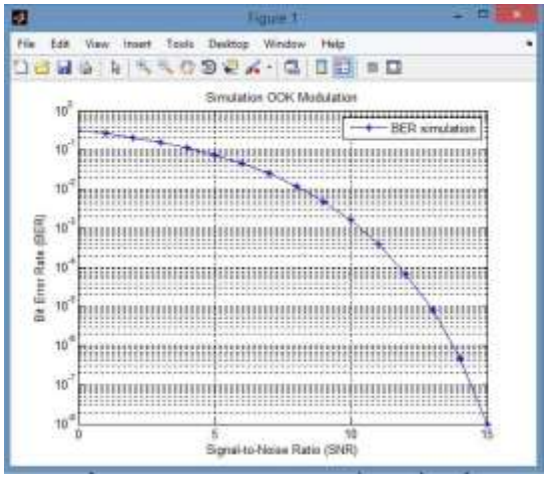


Figure 3 Simulation of OOK

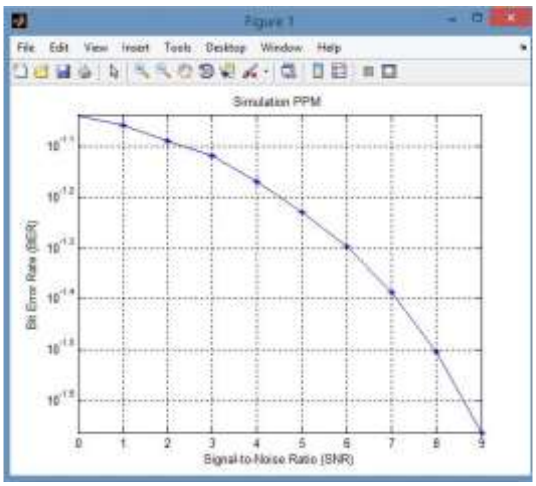


Figure 5 Simulation of PPM

6. CONCLUSION

As it is shown in this paper, the most power-efficient modulation scheme used for FSO communication systems is Pulse Position Modulation Technique .And we simulated the BER performance for different modulation schemes. Thus the simulation results show an excellent agreement with the analytical results. In our simulations, BER for 10-9 is evaluated and the receiver sensitivity theoretical analysis is also done.

FUTUER ENHANCENMENT

Different climatic conditions are the real issues to work on the FSO connection those are Haze, Light fog and Moderate fog conditions. Typical noise sources as well as the cycle slip phenomena which influences the system performance in optical Intersatellite communication systems and the effect of atmospheric turbulence

REFERENCES

1) Gurpreet Kaur, Harmeet Singh, Amandeep Singh Sappal "Free Space Optical Using Different Modulation Techniques – A Review" International Journal of Engineering Trends and Technology (IJETT) – Volume-43 Number-2 -January 2017

2) Hadj Bourdoucen and Amer Alhabsi "Improvement of Bit-Error-Rate in Optical Fiber Receivers" World Academy of Science, Engineering and Technology International Journal of Electrical and Computer Engineering Vol:3, No:4, 2009

3) John M. Senior "Optical Fiber Communications Principles and Practice" Third edition published 2009

4) Md. Mobarok Hossain Rubel "BER Performance Analysis for Optical Communication using DPSK modulation" International Journal of Computer Applications (0975 – 8887) Volume 59– No.9, December 2012

5) Mehdi Rouissat1, "Dual Amplitude-Width PPM for free space optical systems", Information Technology and Computer Science, 2012

6) Minal M. Madankar, Dr. P.S. Ashtankar "Performance analysis of BPSK modulation scheme for different channel conditions" IEEE Students' Conference on Electrical, Electronics and Computer Science, 2016

7) Naresh Chand, Andrew J. Hunton, Bruce M. Eteson "A comparative study of 2.667 Gb/s OOK, DPSK, and PPM modulation formats for FSO applications" Proc. SPIE 7091, Free-Space Laser Communications VIII, 70910G, 19 August 2008

8) Taissir Youssef Elganimi "Performance Comparison between OOK, PPM and PAM Modulation Schemes for Free Space Optical (FSO) Communication Systems: Analytical Study" International Journal of Computer Applications (0975 – 8887) Volume 79 – No 11, October 2013

9) Taissir Y. Elganimi "Studying the BER Performance, Power- and Bandwidth- Efficiency for FSO Communication Systems under Various Modulation Schemes" IEEE Jordan Conference on

Applied Electrical Engineering and Computing Technologies (AEECT), 2013

10) Wansu Lim "BER Analysis of Coherent Free-Space Optical Systems with BPSK over Gamma-Gamma Channels" Journal of the Optical Society of Korea Vol. 19, No. 3, June 2015, pp. 237-240