PERFORMANCE ANALYSIS OF FREE SPACE OPTICAL COMMUNICATION USING DIFFERENT MODULATION TECHNIQUES

A.Anand[1], S.Haripriya[2], S.Nagamai[3], M.S Pranava[4],

[1]Assistant Professor, Department of ECE, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore

[2,3,4]UG Students, Department of ECE, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore

ABSTRACT:

FSO communication is the emerging technology and its contribution is big in all the fields. Because of Technological transformation in the prior two decades, we could obtain the potential growth in digital modulation techniques. The modulation techniques help mobile communication in terms of quality, capacity, BER, and speed. With the worldwide demand for larger bandwidth & greater mobility, there is a rapid advancement in the area of broadband wireless communications. Fiber optic technique has high channel capacity and low loss of signal. It helps the growth of WAN's and LAN's. While comparing to the current trending technologies Free-space communications offer high information rate and it supports the mobile wireless communication infrastructure. FSO has potential strength to send more amounts of data with high security at a moderate cost. It is also a good technique in broadband communication. This system is also destroyed by many turbulence conditions like snow, rain, fog… In this survey paper, different modulation techniques are studied and explained under various weather conditions.

1. INTRODUCTION

FSO cannot able to transmit the signal if any object present between the sender and the observer. The need for channel capacity is increased in a day to day life. RF communication can be replaced by FSO technique in many applications. Though RF can provide information rate in the range of several Mbps, it is also affected by the spectrum congestion and interference. FSO is better for larger bandwidth. Ground to the satellite link alternative is provided by the FSO. FSO systems are affected by atmospheric turbulence conditions which create the error and make the system to behave improperly for some period of time. Fiber optic technology is affected by many ways which attenuate the transmitted signal .so we need alternative technology called FSO technology. Different techniques are used to decrease the turbulence present in the signal.

2. LITERATURE SURVEY

In [1], FSO offers many advantages over existing techniques which can be either optical or radio or microwave. Less cost and time to setup are the main attraction of FSO system. Optical equipment can be used in FSO system with some modification.As mentioned in [2], RZ modulation format is best for long distance, but is complex and costly. Where NRZ is used for short distance and it is less complex, cheaper in comparison to RZ.Proposed by [3], the received average signal is measured and used to characterize the strength of turbulence. The experimental result show that the performance of the BPSK is far better than the ASK-NRZ and ASK-RZ in case of bandwidth and power efficiency.In [4], BER for FSO communication systems employing OOK and subcarrier BPSK modulation format through turbulence channels are analyzed from the overall analyzed. Performance of communication systems by significantly reducing the BER of systems and the performance is better under subcarrier BPSK modulation than of OOK for all range at turbulence variance.In [5], The BER is measured using Nakagami-m channel and Richian channel with different SNR values. The QPSK provides high data rates and high bandwidth efficiency. The QPSK modulation provides better performance in the BPSK modulation in terms of higher data rates.In [6], Performance of average BER and average channel capacity for FSO system based on modulation techniques such as OOK (NRZ), BPSK (RZ), DPSK with effect of atmosphere turbulence were investigated.In [7], Bit rate of BPSK modulation based on Single input single output and multiple input multiple output free space optical communication system in strong turbulence condition was analyzed. it is observed that MIMO system provides better BER performance compared to SISO system.

3. EXISTING MODEL

3.1 AMPLITUDE SHIFT KEYING

Today communication is very important and the signal has to be transmitted properly without any loss of data. Many technologies are developed to transmit the signal efficiently without any loss of data. One of the growing technologies is Free Space Optical communication (FSO) and it has received much attention in recent years because of speed, channel capacity, and bandwidth. Many researchers were tried to improve the quality of the signal and reduce the BER (bit error rate). Existing models are investigating the performance of average BER and average channel capacity and (signal to noise ratio) SNR for FSO system based on different modulation schemes such as On-Off keying (OOK), Binary Phase Shift Keying (BPSK), and Differential Phase Shift Keying (DPSK) etc. with the effect of atmospheric turbulence conditions. In FSO channel transmitted signals are affected by weather conditions. Existing model discuss the performance of transmitted signal under Amplitude shift keying condition.

3.1.1 BLOCK DIAGRAM

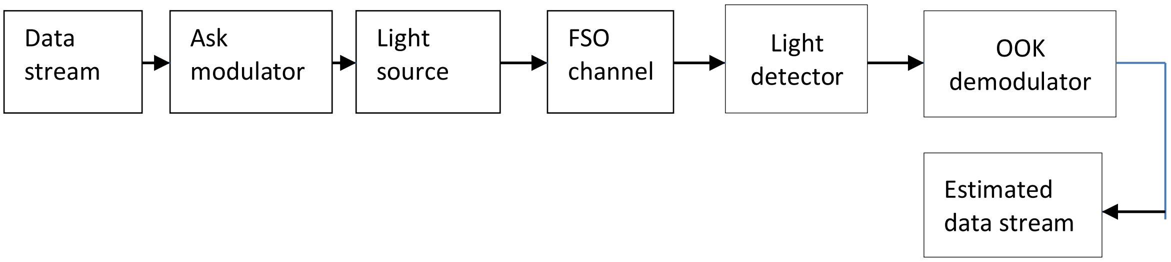

Fig 1: Block diagram of ASK Modulation in FSO channel

In Fig 1 the transmitter modulates data onto the instantaneous intensity of an optical beam. First, we consider intensity-modulated direct detection channels using OOK modulation, which is widely employed in practical systems. The received signal y suffers from a fluctuation in signal intensity due to atmospheric turbulence and misalignment, as well as additive noise. It offers lower power efficiency. ASK modulation is very susceptible to noise interference. This is due to the fact that noise affects the amplitude. Hence another alternative modulation technique such as BPSK which is less susceptible to error than ASK is used.

3.2 BINARY SHIFT KEYING

As told in the previous modulation technique ASK has low efficiency and it is heavily affected by atmospheric turbulence condition. In order to overcome the problems in ASK modulation and to improve the performance BPSK modulation technique is used. **Binary Phase Shift Keying (BPSK)** is a two phase modulation scheme, where the 0's and 1's in a binary message are represented by two different phase states in the carrier signal: θ=0∘θ=0∘ for binary 1 and θ=180∘θ=180∘ for binary 0.Exsisting model of BPSK modulation technique under different turbulence condition is shown in below figure.

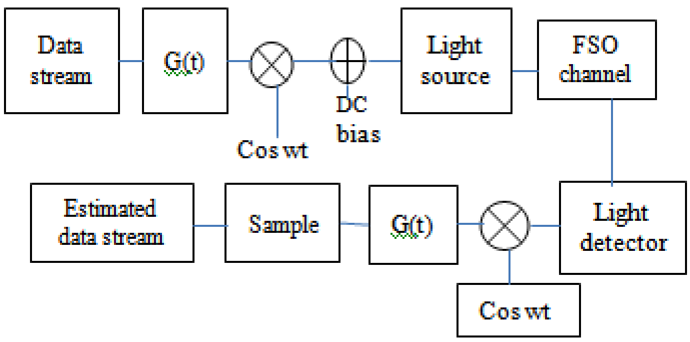

Fig 2: Block diagram of BPSK modulation in FSO channel

Above Fig 2 represents the block diagram of subcarrier BPSK system. The laser beam-widths are narrow but sufficiently wide to illuminate the entire PD array. However, to exploit all potentials of FSO communication systems, the designers have to overcome some of the major challenges related to the optical wave propagation through the atmosphere. Namely, an optical wave propagating through the air experiences fluctuations in amplitude and phase due to atmospheric turbulence. Again in Fig 2 an optical communication system employing subcarrier BPSK intensity modulation, the data sequence is first modulated with BPSK, which can be implemented with existing microchips at very low cost. Secondly, the BPSK signal is up converted to an intermediate frequency (IF). Then, the modulated electrical signal is utilized to control the irradiance of the optical beam in the transmitter. In the receiver, the optical signal is first converted to an electrical signal. Then, the receiver demodulates the electrical signal by using RF devices like selective filters and stable oscillators. The data rate of BPSK is in bits per second is the same as symbol rate. This is half in comparison to the QPSK modulation technique any many timeless compared to other higher modulation techniques such as 16QAM, 64QAM etc...Due to this reason, BPSK is not bandwidth efficient modulation technique compare to other modulation techniques.

3.3 QUADRATURE SHIFT KEYING

The QPSK can be used to double the data rate compared with a BPSK system while it maintains the same bandwidth of the signal. The QPSK can also work in a manner, in which it maintains the data-rate of BPSK but make the bandwidth requirement half as compared to BPSK. So QPSK is bandwidth efficient when compared to BPSK. Quadrature Phase Shift Keying (QPSK) is a form of Phase Shift Keying in which two bits are modulated at once, selecting one of four possible carrier phase shifts (0, 90, 180, or 270 degrees).

3.3.1 BLOCK DIAGRAM

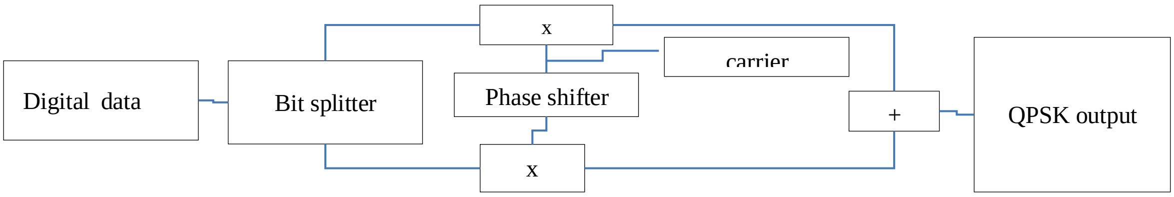

Fig 3: Block diagram of QPSK modulation in FSO channel.

The working of QPSK in the free space optical communication is shown in the above block diagram. The M-ARY pulse generator is used for QPSK modulation. The block diagram of QPSK modulator is shown below. At the input of the modulator, the digital data‘s even bits (i.e., bits 0, 2, 4 and so on) are stripped from the data stream by a ―bit-splitter and are multiplied with a carrier to generate a BPSK signal. At the same time, the data‘s odd bits (i.e., bits 1, 3, 5 and so on) are stripped from the data stream and are multiplied with the same carrier to generate a second BPSK signal. However, the second signal‘s carrier is phase shifted by 90 degree before being modulated. The two BPSK signals are then simply added together for transmission and, as they have the same carrier frequency, they occupy the same portion of the radio frequency spectrum. In QPSK modulation technique, one complex symbol represents two binary bits. Due to this, QPSK receiver is more complex due to four states needed to recover binary data information. QPSK requires eight times bandwidth to transmit same power. Due to above reason, QPSK is not power efficient modulation technique compare to other modulation types as more power is required to transmit two bits. Also QPSK is more sensitive to phase variation.

4. PROPOSED MODEL

4.1 AMPLITUDE SHIFT KEYING

In order to overcome the problems present in the existing model we are moving to proposed model. In this model signal quality is analyzed under different atmospheric conditions (rain, fog, snow) and quality factor, BER and eye diagram of the signal is analyzed.

4.1.1 BLOCK DIAGRAM

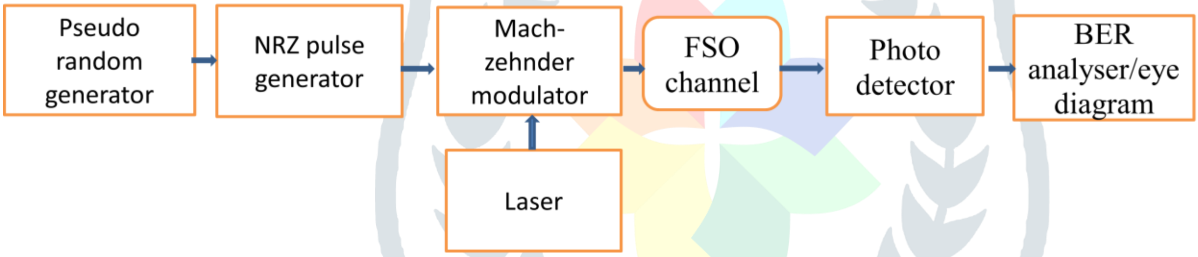

Fig 4: Block diagram of ASK modulation in FSO

4.1.2 EYE DIAGRAM ANALYSIS

The eye diagram of received signal in ASK modulation is shown in fig 4.The eye width for ASK is very reasonably wide open, so it is a time synchronized and less effect of jitter distortions. Eye height is small, which indicates that it is less immune to additive noise and inter modulation distortions.

Table4.1-ASK Modulation

Distance(m)	Quality Factor (rain)	Quality Factor (fog)	Quality Factor (snow)
40	3.99851	3.99945	4.01024
60	4.00593	4.00896	4.04983
80	4.01614	4.02302	4.08364
100	4.02875	4.04112	3.74283
120	4.04301	4.06131	2.4161

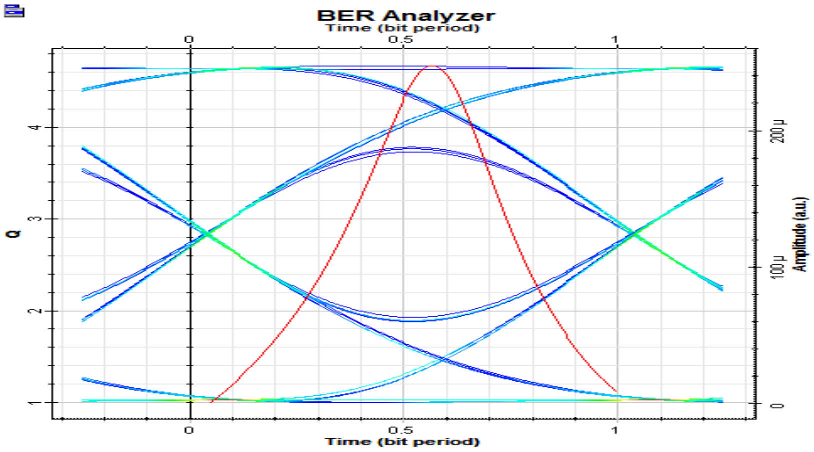

Fig 5: Eye diagram analysis of ASK Modulation

4.1.3 BER ANALYSIS

The BER analysis in ASK modulation is shown. The BER is very minimum nearly zero for a distance up to 90 m. The BER is slightly increased after 100m. For a distance above 100m there is a steep linear increase in BER. So it leads to the conclusion that as the distance increases the BER is very high, which is not encouraged. ASK is most suitable for of digital modulation for distance between 0 to 100m. In the quality diagram analysis it is inferred that whenever distance increases quality factor decreases and under rain atmospheric condition quality of the signal is good compare to fog and snow weather conditions.

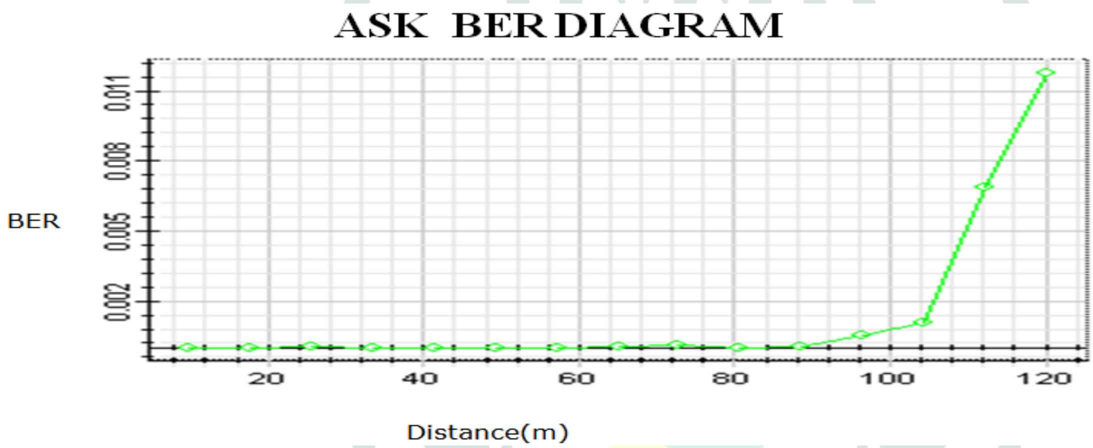

Fig 6: BER versus transmission length.

4.1.4 QUALITY FACTOR ANALYSIS

From above quality diagram analysis it is inferred that whenever distance increases quality factor decreases and under rain atmospheric condition quality of the signal is good compare to fog and snow weather conditions.

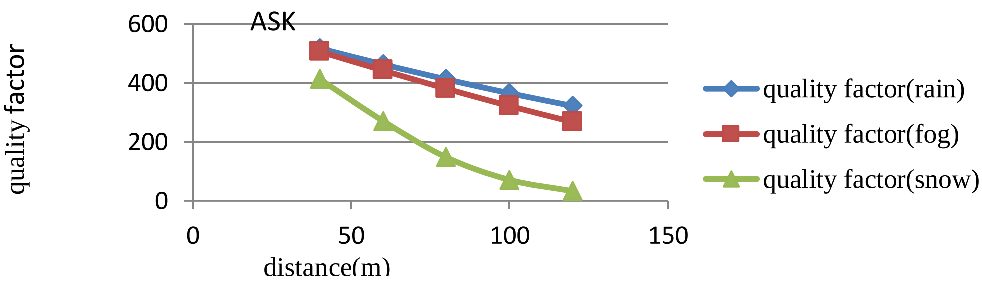

Fig 7: Q factor versus transmission length at different turbulence condition

4.2 BINARY PHASE SHIFT KEYING

BPSK is a binary modulation technique, whereas the zeros and ones are the two bits that represent two various phases in the message signal 0 degrees for binary 1 and 180 degrees for binary 0.The main aim of this model is to investigate the performance of transmitted signal under three atmospheric conditions (rain, fog, snow) and finding which weather condition gives better performance using simulation software called Optisystem 7.0.

4.2.1 BLOCK DIAGRAM

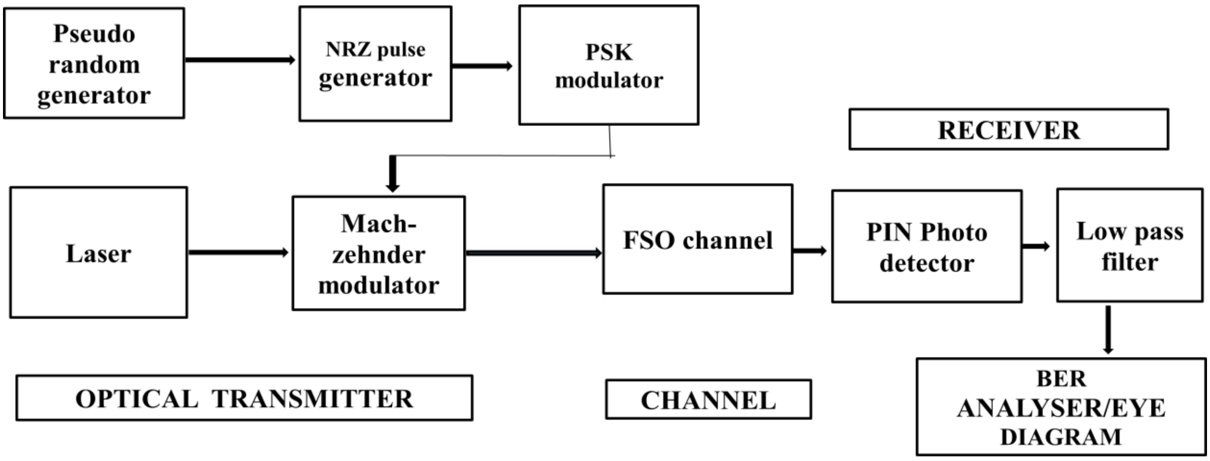

Fig 8: Block diagram of BPSK modulation in FSO channel

4.2.2 EYE DIAGRAM ANALYSIS

From the fig 8 it is inferred that eye amplitude is good but eye width is less. it is because of the signal is affected by noise and also less immune to the noise.

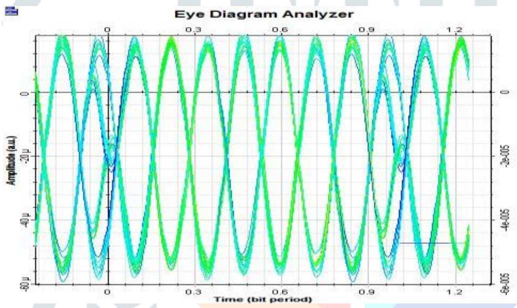

Fig 9: Eye diagram analysis in BPSK modulation

Table 4.2-BPSK Modulation

Distance(m)	Quality Factor(rain)	Quality Factor(fog)	Quality Factor(snow)
40	517.236	505.609	412.196
60	463.107	441.798	269.98
80	412.485	380.142	146.522
100	365.462	321.593	69.7384
120	322.063	267.436	31.3877

4.2.3 BER ANALYSIS

Bit error rate is used to analyze the signal quality that up to which range the signal is error free signal. From below Fig 9 it is inferred that whenever distance increases BER increases.

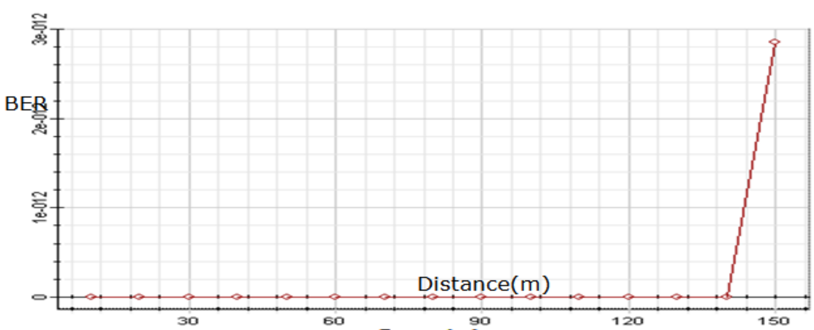

Fig 10: BER versus transmission length in BPSK modulation

From 10 to 130 m BER is almost zero above 130 m BER is gradually increasing. From this we infer that after 130 m signal is affected by noise.

4.2.4 QUALITY FACTOR ANALYSIS

The quality factor is measured at different turbulence condition at a varying transmission length.

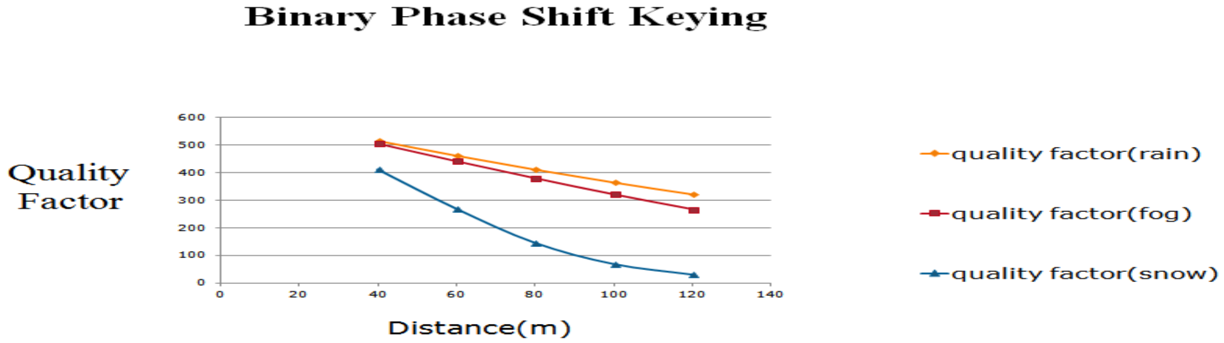

Fig 11: Q factor versus transmission length at different turbulence condition.

From above quality diagram analysis it is inferred that whenever distance increases quality factor decreases and under rain atmospheric condition quality of the signal is good compare to fog and snow weather conditions.

4.3 QUADRATURE PHASE SHIFT KEYING

QPSK (Quadrature Phase Shift Keying) is type of phase shift keying. Unlike BPSK which is a DSBCS modulation scheme with digital information for the message, QPSK is also a DSBCS modulation scheme but it sends two bits of digital information a time (without the use of another carrier frequency).The amount of radio frequency spectrum required to transmit QPSK reliably is half that required for BPSK signals, which in turn makes room for more users on the channel.

4.3.1 BLOCK DIAGRAM

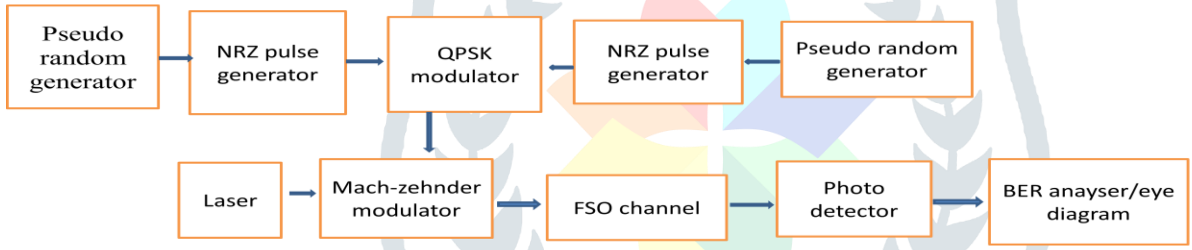

Fig 12 : Block diagram of QPSK modulation in FSO channel

4.3.2 EYE DIAGRAM ANALYSIS

From fig6.3.1 it is inferred eye height is small, which indicates that it is less immune to additive noise and inter modulation distortions.

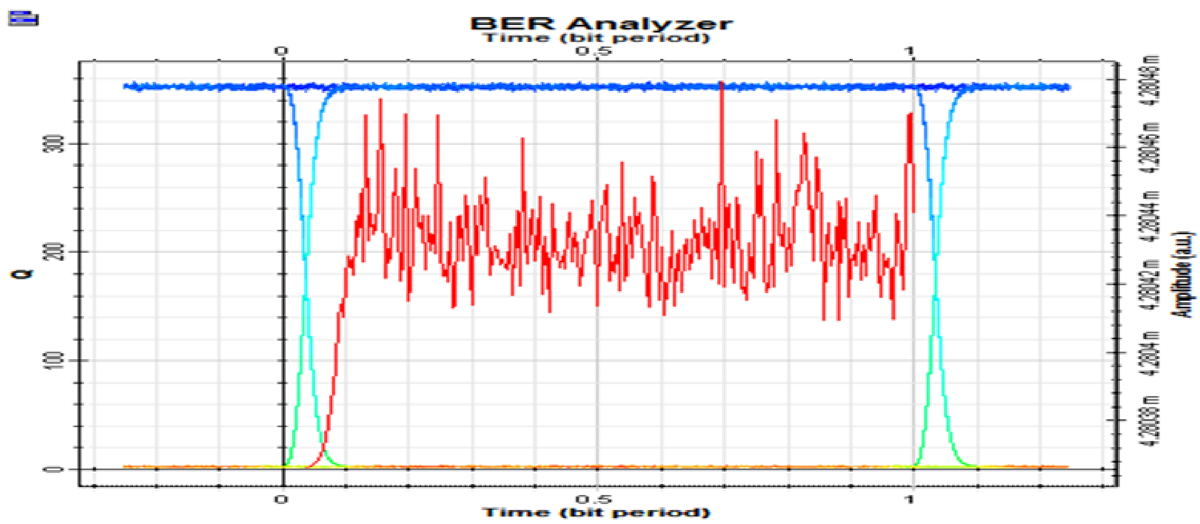

Fig 13 : Eye diagram analysis in QPSK modulation

4.3.3 BER ANALYSIS DIAGRAM

Bit error rate is used to analyze the signal quality that up to which range the signal is error free signal.

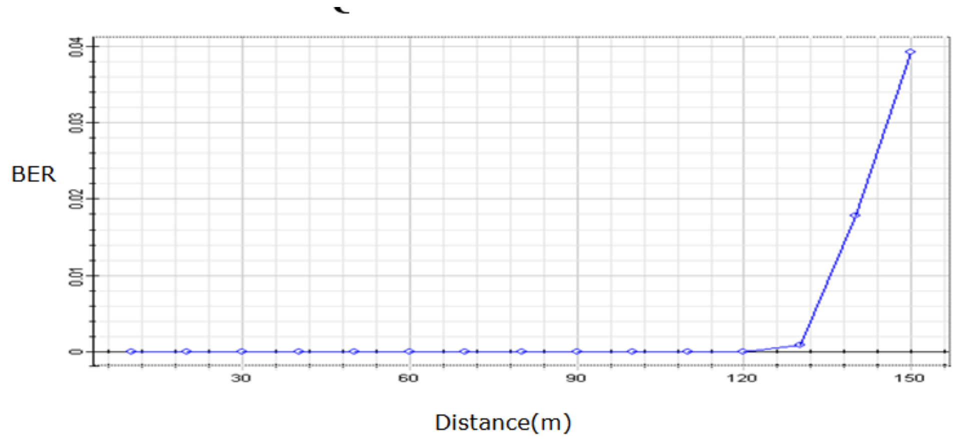

Fig 14 :BER versus transmission length in QPSK modulation

From above Fig it is inferred that whenever distance increases BER increases .form 10 to 130 m BER is almost zero above 130 m BER is gradually increasing. From this we infer that after 130 m signal is affected by noise.

4.3.4 QUALITY FACTOR ANALYSIS

The quality factor is measured at different turbulence condition at a varying transmission length. From quality analysis it is inferred that whenever distance increases quality factor decreases and under rain atmospheric condition quality of the signal is good compare to fog and snow weather conditions.

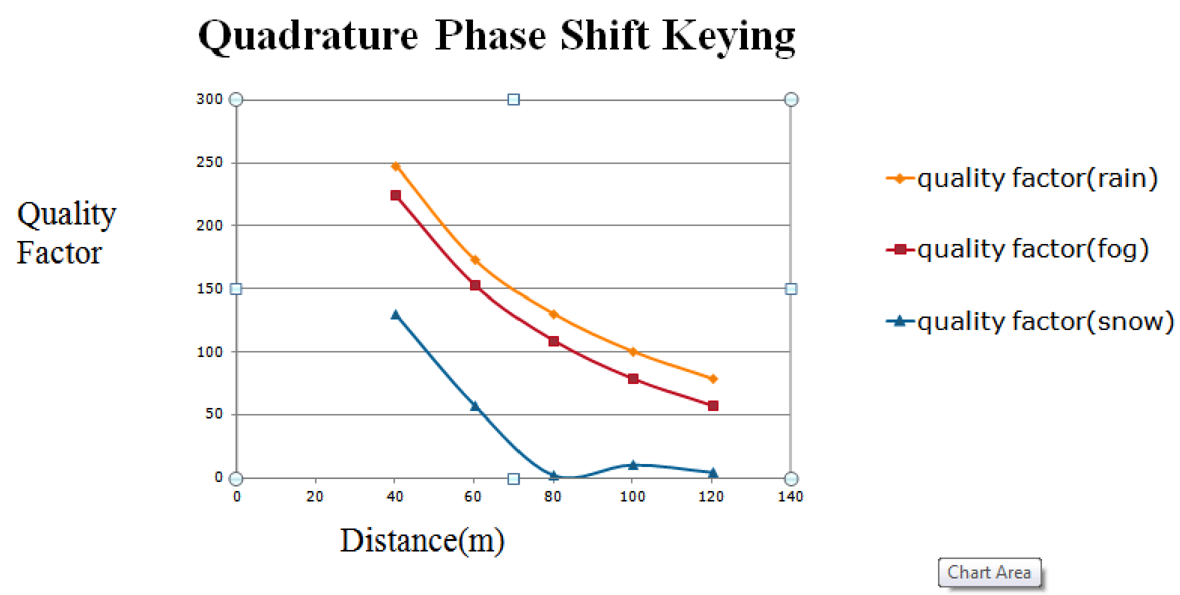

Fig 15:Q-factor versus transmission length in QPSK modulation

4.4 CIRCULARLY POLARIZED SHIFT KEYING:

There are three functional elements contained in a FSO system, transmitter, channel, and receiver. The block diagram of CPSK modulated atmospheric optical communication system is shown in fig 4. The transmitter is used to produce a left-hand (right-hand) polarization light and launch it into the atmospheric channel, including a laser, Polaroid, polarization modulator, code device (Coder) and emission antenna (transmit telescope). Polarization modulator can be an electro-optic crystal, which can change internal birefringence characteristics according to the voltage controlled by signals, and converts linear polarization to circular polarization. In addition, the CPSK modulation can also be achieved by combination of polarization beam splitter (PBS), phase modulator (PM) and polarization beam combiner (PBC). After the +45◦ linear polarized light passing the PBS, it is divided into two orthogonal beams of linear polarized which is along the x axis and the y direction, respectively. Depending on the input data stream, phase modulation is applied to the y-component of the signal. Polarization combiner (PBC) combines x component and phase modulated y component into a bunch of light. After the process above, '0' bits is transmitted via left-hand circular polarized light and '1' bits via right-hand circular polarized light. As a propagation medium, atmosphere occasionally may contain fog, clouds, dust, snow and smoke resulting in substantially signal attenuating, however, the real challenge to the optical wireless links in atmosphere arises in the presence of fog condition as the size of the fog particles is comparable to the optical wavelengths used for transmission and the main phenomena responsible for optical signal loss is Mie scattering. The receiver play a role to extract and detect the circular polarization light, composed of a quarter-wave plate, a polarization beam splitter (PBS), two photo detectors and the differential circuit. According to the theory of polarization optics, no matter what the included angle between the polarization axis of the transmitter and the receiver is, after the quarter-wave plate, the circular polarization (left-hand or right-hand) is converted into linear polarization (+45◦ linear polarized or −45◦ linear polarized), and then detected by the corresponding detector (detector1 or detector2) . So the polarization coordinates of the receiver no longer requires alignment with the transmitter.

4.4.1 BLOCK DIAGRAM:

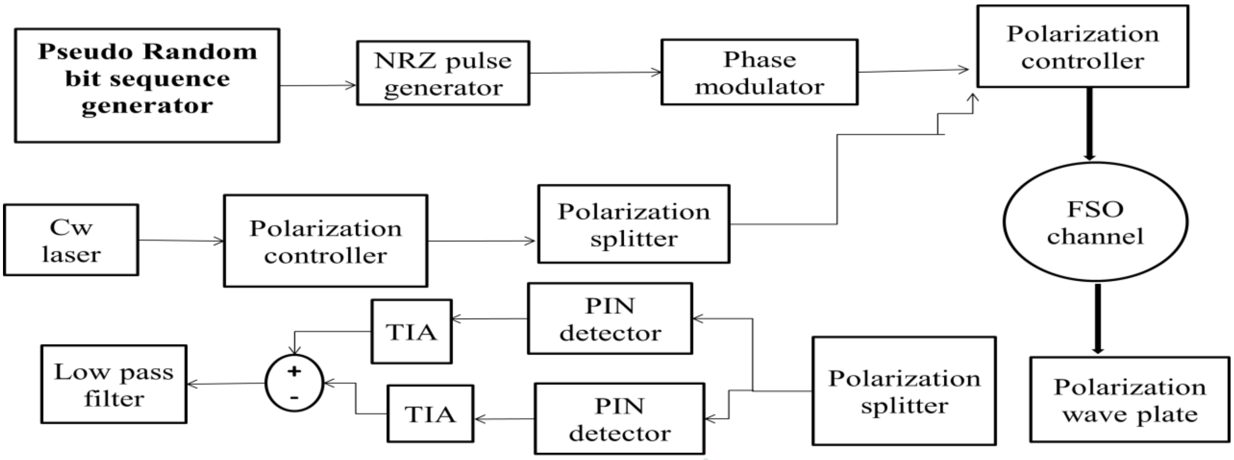

Fig 16: Block diagram of CPSK modulation in FSO channel.

4.4.2 EYE DIAGRAM ANALYSIS

It is inferred eye height is small, which indicates that it is less immune to additive noise and inter modulation distortions

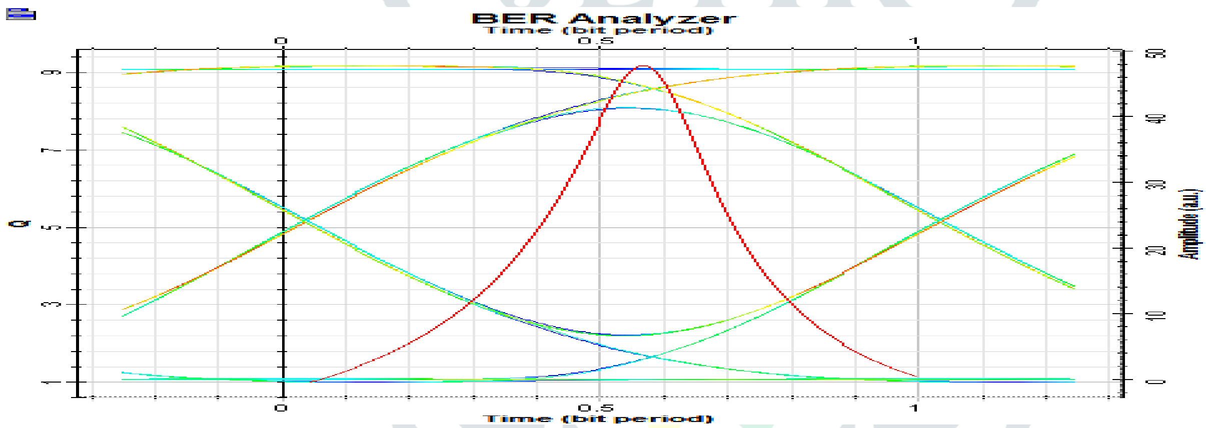

Fig 17: Eye diagram analysis in CPSK modulation

4.4.3 BER ANALYSIS

Bit error rate is used to analyze the signal quality that up to which range the signal is error free signal. From above Fig 6.3.2(a) it is inferred that whenever distance increases BER increases .form 10 to 130 m BER is almost zero above 130 m BER is gradually increasing. From this we infer that after 130 m signal is affected by noise.

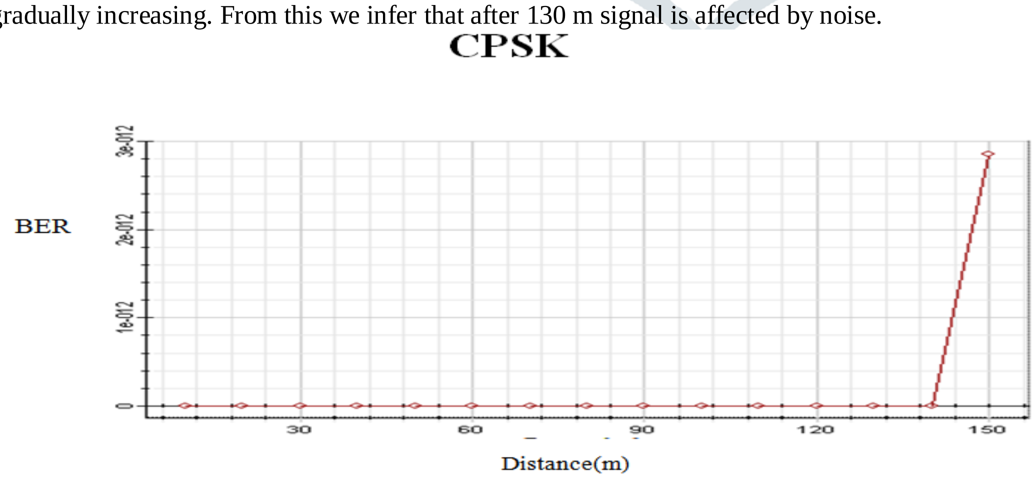

Fig 18: BER versus transmission length in CPSK modulation

4.4.4 QUALITY FACTOR ANALYSIS

From quality analysis it is inferred that whenever distance increases quality factor decreases and under rain atmospheric condition quality of the signal is good compare to fog and snow weather conditions.

Table 4.3-CPSK Modulation

Distance(m)	Quality factor(rain)	Quality factor(fog)	Quality factor(snow)
40	9.93131	9.91131	9.93132
60	9.93132	9.93132	9.93134
80	9.93132	9.93133	9.93134
100	9.93133	9.93133	9.93129
120	9.93133	9.93134	9.93112

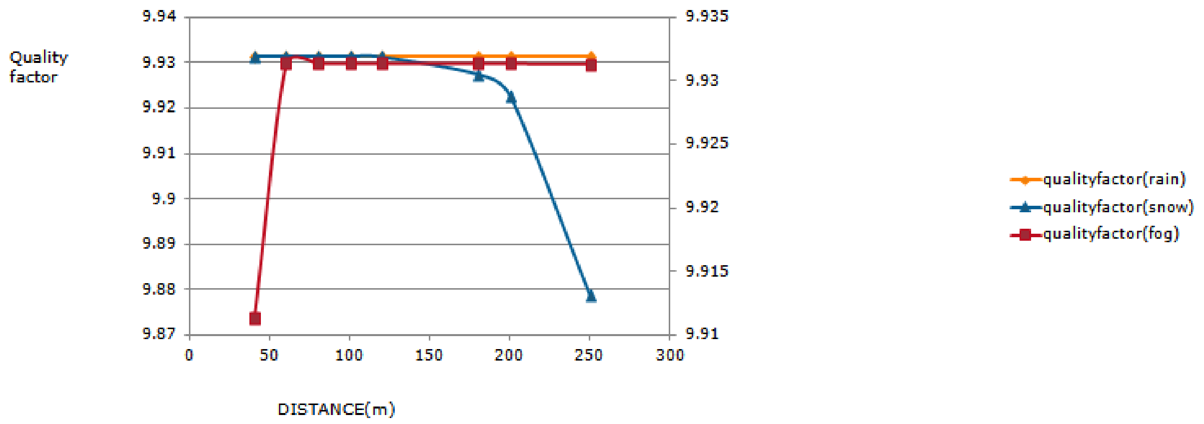

Fig 19: Q-factor versus transmission length in CPSK modulation

5. CONCLUSION

From above all analysis quality factor of the signal under rain condition is good compare to fog and snow. In order to find which modulation scheme provides good quality factor, quality factor of signal under rain condition in all modulation techniques are compared. It is inferred that under BPSK modulation scheme signal quality is comparatively high. Under ASK, QPSK, CPSK modulation technique signal quality is decreases when the distance increases.

REFERENCES

1. Tejbir Singh hanzra and Gurpartap Singh,"Performance of free space optical communication system with BPSK and QPSK modulation", ISRO Journal of electronics and communication engineering, volume 1(May –June 2012).
2. Bobby Barua,"Free-space optical communication with OOK and BPSK modulation under different turbulent condition", IEEE (2013).
3Huiying zhang, Hongzuo li, and Chongzheng hao," Performance analysis for BPSK, DPSK, and OOK based free space communication system in atmospheric turbulence conditions" DOI 10.5013/IJSSST.a.17.36.37.
4.K.Prabu, D.Sirram Kumar, Reza Malekian, "BER analysis of BPSK-SIM-based SISO and MIMO free space systems in strong turbulence with pointing errors", IEEE(2014).
5. Wasiu O.Popoola and Zabih Ghassemlooy, "BPSK Subcarrier intensity modulated free-space optical systems in atmospheric turbulence", Journal of Lightwave Technology, vol.27, no.8.pp.967-973, April 2009.
6. M.S.Modabbes," Performance analysis of shift keying modulation in the presence of noise, IEEE (6 July 2004).
7. Adnan Zafar; S. Zainab Farooq," Implementation and analysis of QPSK & 16QAM modulator & demodulator" 2008 2nd International Conference on Advances in Space Technologies.
8. Dairuo Li and Kai Xu," Analysis of Interference of QPSK and QDPSK Modulation Signals by Mathematical ", Advances in Materials, Machinery, Electronics I AIP Conf. Proc. 1820, 090004-1–090004-9; DOI: 10.1063/1.4977388 Published by AIP Publishing. 978-0-7354-1488-4.
9. Salim Kahveci and M. Edris Rajaby," UWB communication using BPSK modulation", 2017 10th International Conference on Electrical and Electronics Engineering.
10. Alok Kumar Chaudhary, Pranay Pratik, Swastik Gupta, and vipan Kakkar,"Improved digital design of BPSK modulator using look-up table technique", IEEE (2013).
11. Waziha Kabir," Orthogonal Frequency Division Multiplexing (OFDM)," 2008 China-Japan Joint Microwave Conference.
12. S.B.Weinstein," The history of orthogonal frequency multiplexing,"IEEE Communication.Mag.vol.47.no.11.pp.26-35, November 2009
13. Martoyo, H.Schober and F.Jondral, "CDMA versus OFDM, a performance comparison in selective fading channels," in IEEE Symp.on spread-spread Tech.& appl, vol. 1,2002.pp.139-143.
14. H.Yin and S.Alamouti."OFDM: a broadband wireless access technology," in IEEE Sarnoff symposium, March 2004.pp. 1-4