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Modulation Techniques of Free Space Optics using Various Link Ranges

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Abstract: ***Free space optics is the present trend, which enables the communication to achieve the expected data rates for the increasing user demands. The utility of FSO in free space medium enables higher data rates than the conventional microwave links for efficient communication. Several researchers have performed the analysis of free space optics by use of different modulation techniques and optimization of the link budget in free space optical links. In this work, CW laser transmitting source ranging to 10dB of output level, link ranges of 500, 1000 and 1500 mts with attenuation values of 0.2, 0.7 and 0.9 dB/Km respectively are considered. The analysis of free space optics is carried out by using various modulation techniques such as ASK, PSK, FSK, MZ, EA, Dual Drive MZ and it is observed that Dual Drive MZ modulation performs well when compared with the other modulation techniques.***

Keywords: Free Space Optics, Attenuation, Link ranges, Optical Communication, Quality factor.

I. INTRODUCTION

Free space optics is a revolutionary thing happened to tele communication because of its high-speed internet, higher Bandwidth and high efficiency of quality factor only in short ranges/distance (200-2000 meters). This is a technique that modulates light through free space, air/medium which is fiber free no need to bury the fiber in ground for the installation purpose like in fiber optics technology but FSO cannot helps for long distances. This may be biggest drawback in technology FSO. Security is also increased as the beam is narrow and also has the immunity to electromagnetic interference. Generally, FSO follows the LOS (line of sight) principle from transmitter to receiver is point to point transmission of systems has data rate moderately like 1 GB/s the transmitter and receiver will be mounted on the higher places like building rooftops. Hence no obstacles are going to interfere between the light source and receiver. An advantage of FSO is high-speed communication system as transmission involves optical beam and Installation/deployment of FSO is an easy to perform as installing it at normal local area takes less than an hour. Also, it is easily to maintain, upgradeable and license-Free long-range operation in contrast with normal radio communication

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Other merits of FSO system include low power usage per transmitted bit, low bit error rates and no need to connect the transmitter and receiver through a waveguide as the transmission is free space.

Table 1:

FEATURES	*FSO*	*FIBER*
Deployment time	Days to week	4-12 months
Provision time	Immediate	Complex
Investment	Low	High
Distance limitation	200-2000m	200km
Bandwidth/speed	1.25gbps	10gbps

II. FREE SPACE OPTICS

Apparatuses in detailing with every module definition

Low Pass Bessel Filter: The Bessel filter is very similar to the Gaussian filter. The name Bessel is given in honor to great mathematician Friedrich Bessel. Bessel filter is a analog linear filter with maximum phase delay (linear phase response), which store the wave shape of filtered one in pass band. In FSO a low pass filter stores/receives the original data. Which helps to increase the link distance by 22.7% than other filters. Generally, a low pass band filter is a filter that passes the frequency that lowers than the cut-off frequency, attenuates with the higher cut off frequency. The properties of the Bessel beam make it more useful for the optics as the narrow beam is more tightly focused while maintaining its required property. The Bessel channel has better molding variable, compliment stage delay, and compliment bunch delay than a Gaussian of a comparative solicitation, anyway the Gaussian has cut down time deferral

BER: BER stands for Bit Error rate. In digital transmission the number of bits that received by the communication channel/receiver have been changed due to noise, interference and distortion is the Bit errors. The number of bit errors per unit time is called Bit Error Rate. This can also define as no of bit errors divided per total number of bits transferred during a particular interval of time. This is unit less and used to measure the performance of the received signal for the validation process of taking the best modulation technique

APD: APD stands for Avalanche Photodiode. Generally, a photodiode is used to convert light into electric current. This happens when photons are absorbed by the photodiode and Works on the principle photoelectric effect. Where in FSO to detect light a very high level of sensitivity device is needed.

That's why avalanche photodiode is taken generally APD requires the high voltage to perform the reverse bias condition. In order to have the high gain in the avalanche diode high voltages are used**.** This enables to increase in the number of hole and electrons which a greater number of hole-electron pairs are created and increases the gain with more sensitivity

FSO Channel: It is a subsystem of two telescopes and the free space station/medium between them. FSO will turn out to be most secure and fast mode of information transmission from transmitter to receiver and also immune to electromagnetic interface due to its very narrow beam from the laser which is also a reason for the high security

CW Laser: Continuous-wave (cw) operation of a laser means that the laser is continuously pumped and continuously emits light. The emission can occur in a single resonator mode (→ single-frequency operation) or on multiple modes. The first continuous-wave laser was a helium–neon laser operating at 1153 nm which helps to transmit the data from one point to another point through the air as the medium without causing any harm to the living thing that's why a very sensible ray pass through the CW laser

III. MODULATION TECHNIQUES

Analog Modulation is less immune to noise. Therefore, we are making use and advancements in Digital Modulation.

***Amplitude Shift Keying*:** In Amplitude Shift Keying message signal is digital signal and the carrier signal is analog signal. In this digital signal is converts into analog signal. In this technique amplitude of the carrier signal is varies with respect to the message signal. In this high frequency carrier is used

***Frequency Shift Keying*:** In Frequency Shift Keying, message signal is digital signal and the carrier signal is analog signal. In this digital signal is converts into analog signal. High frequency is used in carrier signal. In this technique frequency of the carrier signal is varies with respect to the message signal.

Phase Shift Keying: In phase shift keying, message signal is digital signal and the carrier signal is analog signal. In this digital signal is converts into analog signal. In this technique phase of the carrier signal is varies with respect to the message signal. High frequency is used in the carrier signal

MZ Modulation: In MZ (Mach Zehnder) modulation technique a wave guide is split up into two arms in which voltage is applied to one arm and also phase shift is induced to the wave passing through that arm. When the two arms recombined phase difference between the two arms is going to be the converted into amplitude modulation by using this, we are going to control the amplitude of the wave

EA Modulation: An electro-absorption modulator (EAM) is a semiconductor device which can be used for modulating the intensity of a light beam by an electric voltage. Its principle is based on the Franz-Keldysh EAM works with the lower voltage impact, generally EAM are made with electrodes and electric field is applied perpendicular to light beam which is modulated

IV. RESULTS AND DISCUSSIONS

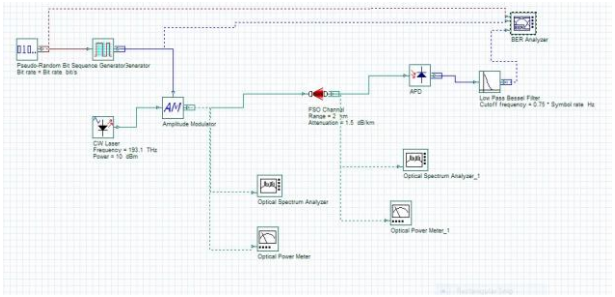

Fig 1: FSO system using ASK modulation technique

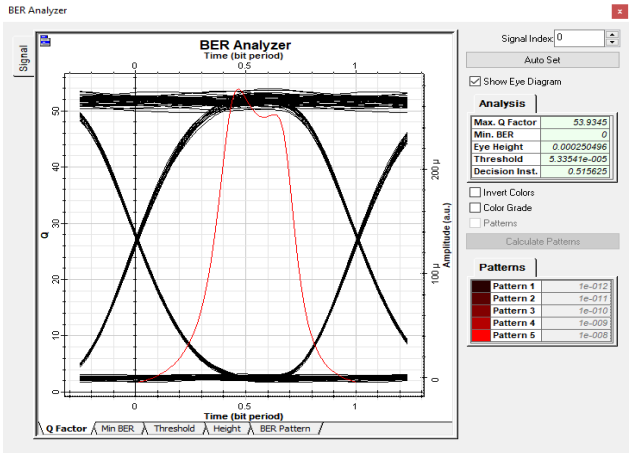

Fig 2: link range 500 m attenuation is 0.2 db./km

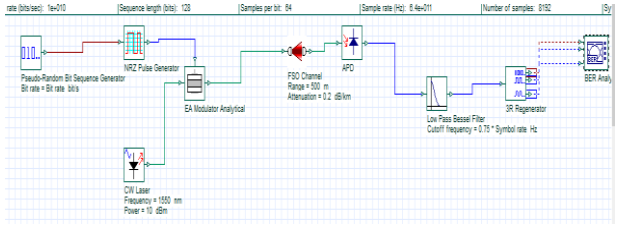

Fig 3: FSO system using EA modulation technique

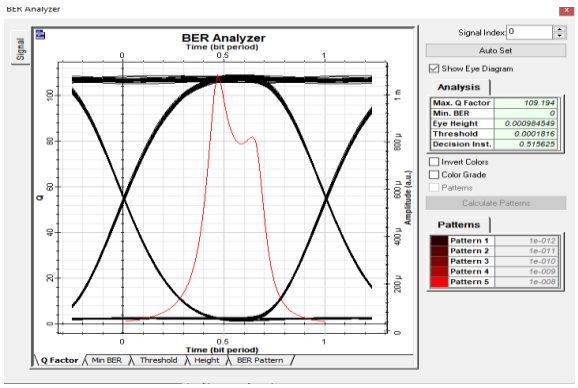

Fig 4: link range 500 m attenuation is 0.2 db/km

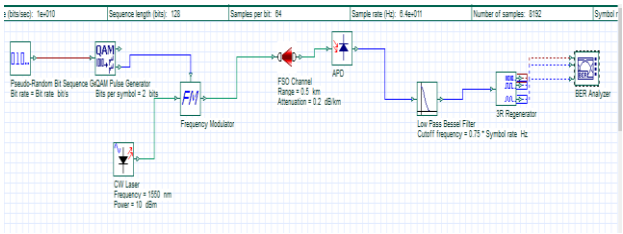

Fig 5: FSO system using FSK modulation technique

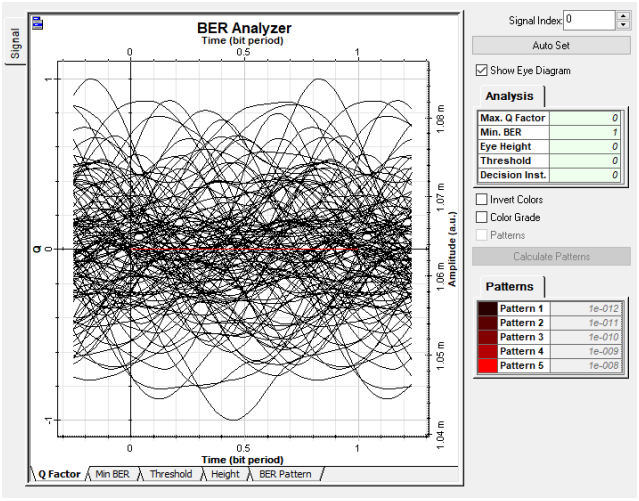

Fig 6: link range 500 m attenuation is 0.2 db./km

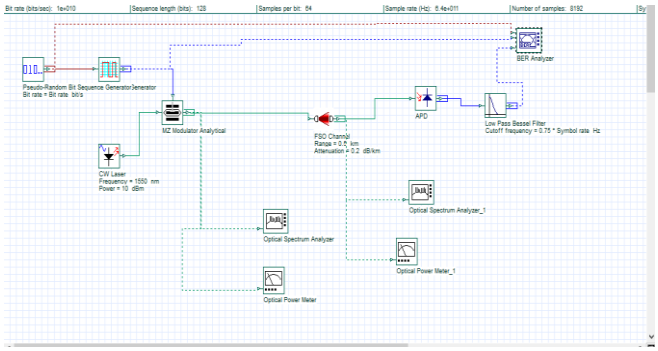

Fig 7: FSO system using MZ modulation technique

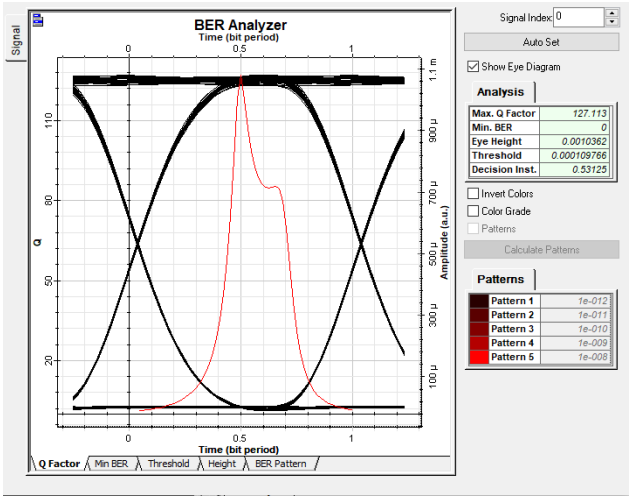

Fig 8: Link range 500 m attenuation is 0.2 db/km

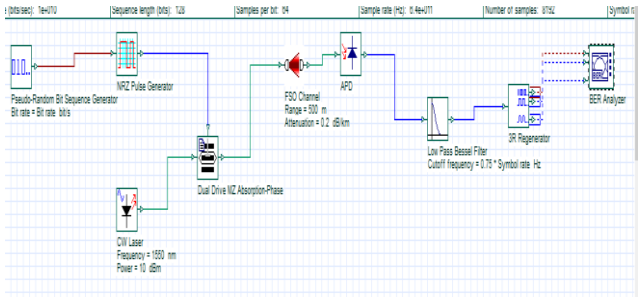

Fig 9: FSO system using MZ Dual modulation technique

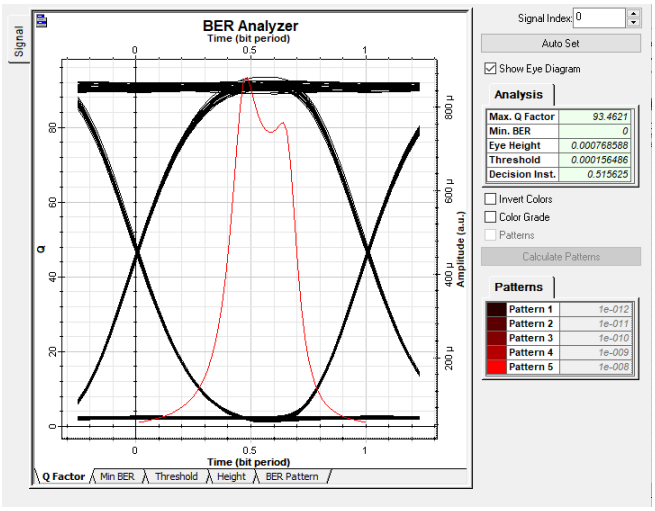

Fig 10: link range 500 m attenuation is 0.2 db./km

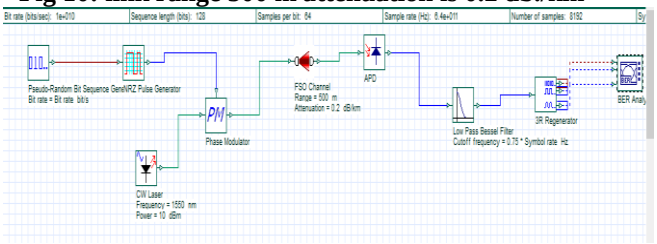

Fig 11: FSO system using PSK modulation technique

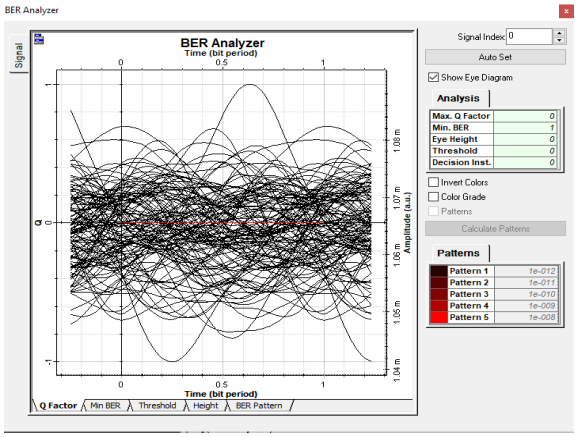

Fig 12: link range 500 m attenuation is 0.2 db./km

Table 2.1: Analysis of various Modulation types

Modulation	Link range (m)	Attenuation (dB/Km)	Q Factor	BER
ASK	500	0.2	110.386	0
	2000	0.9	6.3706	9.07E-11
EA	500	0.2	110.159	0
	2000	0.9	5.92917	1.51E-09
MZ	500	0.2	115.259	0
	2000	0.9	6.48663	4.28E-01

MZ DUAL DRIVE	500	0.2	86.4785	0
	2000	0.9	4.74761	1.03E-06
PSK	500	0.2	0	1
	2000	0.9	0	11
FSK	500	0.2	0	1
	2000	0.9	0	1

As the connection range and weakening quality builds the contortion in eye chart increments. The execution of MZ, EA and ASK is great since the eye charts created are with less twisting and this demonstrates the FSO interface is great to utilize basically. As the connection run builds the quality factor diminishes and the BER increments. The FSK and PSK execution is poor.

V. CONCLUSIONS

FSO offers various focal points over existing techniques which can be either optical or radio or microwave. Less cost and time to setup of FSO system makes it more special than other technologies. Advantages of FSO corresponding to its structure and its application makes it a hot development yet there are a couple of issues rising because of medium and attenuation so we cannot use it for long distance appliance. The execution of MZ, EA and ASK is great since the eye charts created are with less bit error rate and high-quality factor. The FSK and PSK execution is poor. The AM and EA modulators even though they have a better eye opening they have a slight less BER. But in FM and PM the results are not satisfactory. Hence ask modulation is the best when compare with other modulation techniques followed by the MZ EA Dual MZ

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