Asian Journal of Computer Science and Technology
ISSN: 2249-0701 (P) Vol.5 No.1, 2016, pp.25-29
© The Research Publication, www.trp.org.in
DOI: https://doi.org/10.51983/ajcst-2016.5.1.1760

Simulation and Analysis of Filters Using Different Photodiode and Wavelength in Free Space Optics

Priyanka Sharma[1] and Himali Sarangal[2]
[1]Student, [2]Assistant Professor, Guru Nanak Dev University, Amritsar, Punjab, India
E-mail: [1]s.priyanka1191@gmail.com, [2]himali.sarangal@gmail.com

(Received 3 March 2016; Revised 23 March 2016; Accepted 12 April 2016; Available online 19 April 2016)

Abstract - Free space optics is a technology which uses beam of light to provide optical connection for transmitting and receiving purposes. **F**or the **increasing demand for high bandwidth in different network topology**, **FSO links has been a solution to the connectivity bottleneck problem. Transmitter consist**s **of NRZ modulating** CW laser **with the link range** 1 km **in the wavelength 1310 nm or 1550 nm. W**hen the signal is transmitted in the channel, the performance could be severely degrated due to atmospheric **attenuation and earth inequalities**. **T**he purpose of this paper is to find a suitable filter for any of the two receivers i.e APD and PIN for the reduction of noise. **Filters used are low pass Bessel filter, low pass butterworth filter, low pass Chebyshev filter.**

Keywords: FSO**,**NRZ**,**SNR**,**Timing Error**,*Q Factor*,** ***BIT Error Rate***

I. INTRODUCTION

Earlier, Free Space Optics has achieved attentions due to its outstanding bandwidth, high data rate and capacity. Compared to RF communications, the advantages of FSO communication includes more com pact equipment, lower power consumption, better protection against interference and greater security against eavesdropping. However, random change of refractive index occurs in FSO links caused by the variation of air pressure and temperature[5]. FSO is the technology where data from electrical signal is transformed into optical waveform at the transmitter and at the receiving side data is transferred back into electrical waveform. PRBS data is converted into electrical format through NRZ technique[3]. The performance of FSO link is affected by atmospheric turbulence and fog but is less vulnerable to snow and rain. There are many modulation schemes such as CSRZ, NRZ, RZ, PPM, DQPSK and BPSK[1]. We have number of light sources like LED, APD, VSCEL, and PIN laser diodes. After choosing the suitable optical light source and modulation method various wavelength can be evaluated.

A. PIN Photodiode

The PIN diode is used in a number of areas. Its intrinsic region property makes it unique and applicable for a number of applications. Its performance can be characterized by its responsivity. Its characteristics are High breakdown voltage, Carrier storage and Low capacitance. It consists of p and n regions separated by a lightly n-doped intrinsic region. A sufficient reverse bias voltage is applied across the device in normal operation so that the intrinsic region is fully depleted. When the energy of an incident photon is greater than the band gap energy of the material, it gives up its energy and excites a negatively charged electron from the valence band up to the conduction band and generates free electron-hole pairs called photo carriers[11]. The most of the incident light is absorbed in the depletion region; therefore photo carriers are generated in this region.

B. APD Photodiode

In the APD photodiode, the electrons are multiplied by the avalanche effect in the intrinsic zone in order to obtain an important SNR, the idea of multiplication phenomenon is applied so that the incident photon can generate several photoelectrons; is used to increase the incident optical power[11]. Modification of a PIN photodiode from a physical ionization by impact process made an APD diode. One of the drawbacks is the response time of APD photodiode which becomes longer due to the ionization phenomenon. For a high bit rate communications, APD is chosen over the PIN diode because of its better sensitivity and internal gain. APD has many drawbacks such as the high cost, the temperature sensitivity, the complex circuit and the need of high voltage power[11]. Improvements in materials and structures will overcome the drawbacks and set the stage for future systems[3].

II. FILTERS

low pass filters completely eliminate signals above cutoff frequencyand perfectly pass above cutoff frequency. trade off is done to get optimum performance for a given system.

Bessel filters have excellent transient response and linear phase response to a pulse input. They are optimized for maximally-flat time delay (or constant-group delay). This comes at the expense of flatness in the pass-band and rate of rolloff. The –3-dB point is a point where cutoff frequency is defined. second-order low-pass Bessel filter is made by a circuit with the transfer function[10]:

$$H_{LP}(f) = \frac{K}{-\left(\frac{f}{fc}\right)2+2.206\frac{jf}{fc}+1.622} \quad (1)$$

Butterworth Filters are optimized for gain flatness in passband. these filters are also termed maximally-flat-magnitude-response filters. The transient response of a Butterworth filter to a pulse input shows moderate overshoot and ringing. attenuation at cutoff frequency is -3db and above cutoff frequency it is –20 dB/decade/order[10]. second-order low-pass Butterworth filter is made by a circuit with the following transfer function:

$$H_{LP}(f) = \frac{K}{-\left(\frac{f}{fc}\right)2 + 1.414\frac{jf}{fc} + 1} \qquad (2)$$

Chebyshev filters have steeper roll off after the cutoff frequency and ripple in the pass-band. Frequency at which the response falls below the ripple band is defined as the Cutoff frequency. In any given filter order steeper cutoff can be achieved by allowing more ripple in the pass band[10]. The transient response of a Chebyshev filter to a pulse input shows more overshoot and ringing than a Butterworth filter. Chebyshev filter with 3-dB of ripple is accomplished with a circuit having a transfer function of the form:

$$H_{LP}(f) = \frac{K}{-\left(\frac{f}{fc}\right)2 + 0.6448\frac{jf}{fc} + 0.7080} \qquad (3)$$

TABLE I COMPARISON BETWEEN FILERS

FILTER TYPE	ADVANTAGE(s)	DISADVANTAGE(s)
Bessel	Constant group delay	Above fc Slow rate of attenuation and no overshoot with pulse input
Butterworth	Maximum pass-band flatness	Moderate rate of attenuation above fc and Slight overshoot in response to pulse input
–3-dB Chebyshev	Fast rate of attenuation above fc	Ringing in response to pulse input and Large overshoot

III. SYSTEM DESIGN

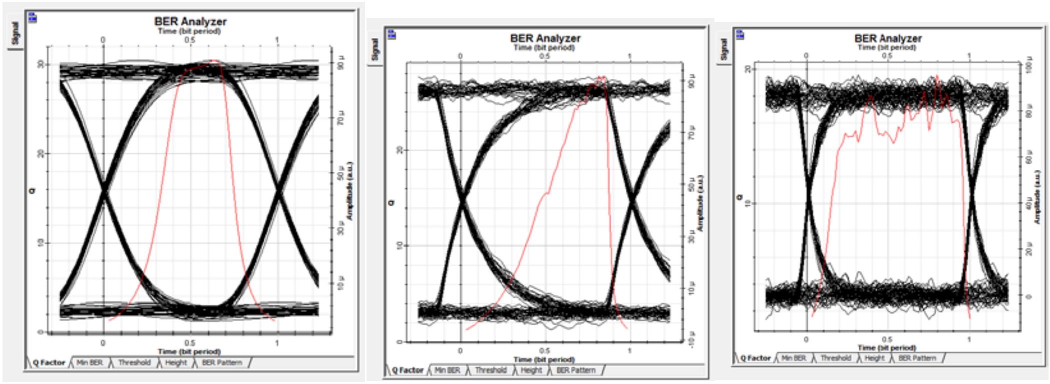
FSO has been designed for the performance development and for simulation Optisystem 14.0. In the proposed design, first is optical transmitter, then a FSO channel and at the last optical receiver. In transmitter first block is the PRBS generator which randomly generates the sequence of ones and zeros. In transmitter section, NRZ and RZ pulse generator are next blocks. The PRBS output is fed to the NRZ pulse generator. Non return to zero coded signals is generated by this block. In the third block, directly modulated lasers are measured[4]. This laser allows us to specify different parameters such as line width, side mode, chirp, relative intensity noise and suppression[3]. Then this signal is transmitted in the free space called channel which is distance between transmitter and receiver telescope. The parameters which affect the FSO link in the channel are link distance, geometric losses, attenuation, transmitter loss, receiver loss, additional losses, beam divergence etc[6]. The optical receiver consists of an APD and PIN photodiodes which is used to regenerate electrical signal. Receiver at the optical side consists of a low pass filter, a 3R regenerator and photodiode. The regenerated signal at the output is fed to BER analyzer. This analyzer is used to calculate the BER and analyses the Q factor and eye diagrams of the signal.

TABLE II PARAMETERS CHOSEN

PARAMETER	SYMBOL	VALUE
Transmission Rate	Bit Rate	1.25 Gbps
Link Distance	Z	1 Km
Power	P	10 dBm
Low Pass Filter Cutoff Frequency (at receiver)	Bit rate	0.75*
Transmitter and Receiver Apertures	DT , DR	10 cm
Transmitter and Receiver Optics Efficiency	ȠT ,ȠR	0.75-0.8
APD and PIN(Responsivity)	R	0.8-52 A/w, 0.55-0.85 A/w

IV. RESULTS AND DISCUSSION

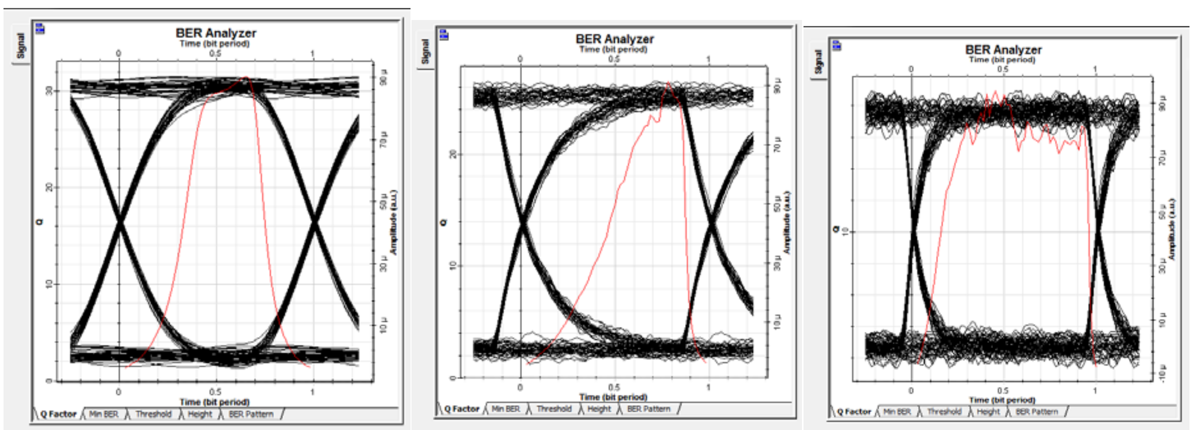
In this proposed system, the performance of free space optical link has been evaluated on the basis of different filters, different types of photodiodes and different wavelengths. The simulation link on optisystem 14.0 has been made for NRZ modulation formats. A comparison has been performed between two photodiodes such as avalanche photodiodes (APD) and PIN photodiodes and between two wavelengths 1550 nm and 1310 nm .



Low pass Bessel filter low pass Butterworth filter low pass Chebyshev filter

Fig.1Quality Factor of PIN 1550

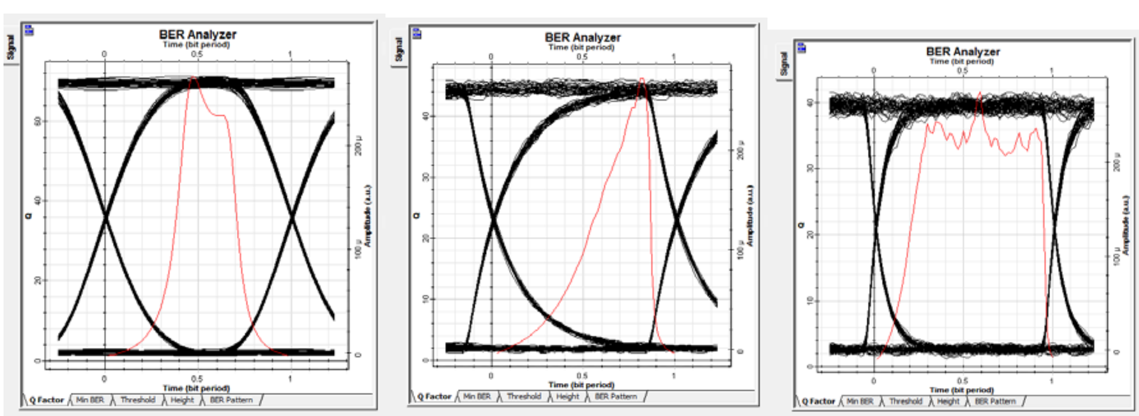
Fig. 1 shows the eye diagram of a system having wavelength 1550 nm. The modulation formats NRZ with photodiode PIN is used to detect the optical signal. It is clear From the eye diagram that the Q factor in this design is highest for low pass bessel filter is 31.82. Q factor for low pass butterwoth filter is 24.67 and for chebyshev filter is 18.27.



Low pass Bessel filter low pass Butterworth filter low pass Chebyshev filter

Fig. 2 Quality Factor of PIN 1310

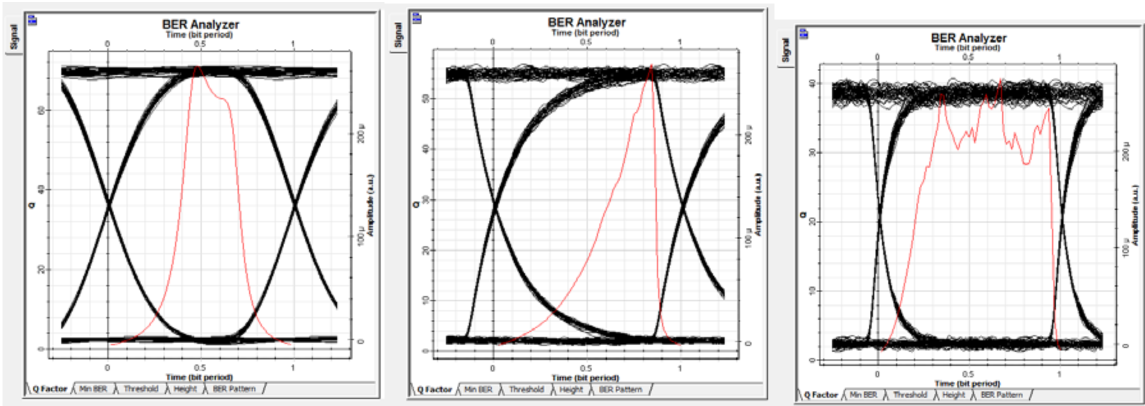
Fig. 2 shows the eye diagram of a system having wavelength 1310 nm. The modulation formats NRZ with photodiode PIN is used to detect the optical signal. It is clear From the eye diagram that the Q factor in this design is highest for low pass bessel filter is 33.60. Q factor for low pass butterwoth filter is 29.25 and for chebyshev filter is 18.21.



Low pass Bessel filter low pass Butterworth filter low pass Chebyshev filter

Fig.3 Quality Factor of APD 1310

Fig. 3 shows the eye diagram of a system having wavelength 1310 nm. The modulation formats NRZ with photodiode APD is used to detect the optical signal. It is clear From the eye diagram that the Q factor in this design is highest for low pass bessel filter is 59.40 . Q factor for low pass butterwoth filter is 37.52 and for chebyshev filter is 38.51 .



Low pass Bessel filter   low pass Butterworth filter   low pass Chebyshev filter

Fig.4 Quality Factor of APD 1550

Fig. 4 shows the eye diagram of a system having wavelength 1550 nm. The modulation formats NRZ with photodiode APD is used to detect the optical signal. It is clear From the eye diagram that the Q factor in this design is highest for low pass bessel filter is 63.85 . Q factor for low pass butterwoth filter is 47.15 and for chebyshev filter is 38.05 .

TABLE III QUALITY FACTOR OBTAINED BY USING FILTERS

Receiver type	Wavelength	Low pass Bessel filter	Low pass butterworth filter	Low pass Chebyshev filter
PIN	1550	31.82	24.67	18.27
PIN	1310	33.60	29.25	18.21
APD	1310	59.40	37.52	38.51
APD	1550	63.85	47.16	38.05

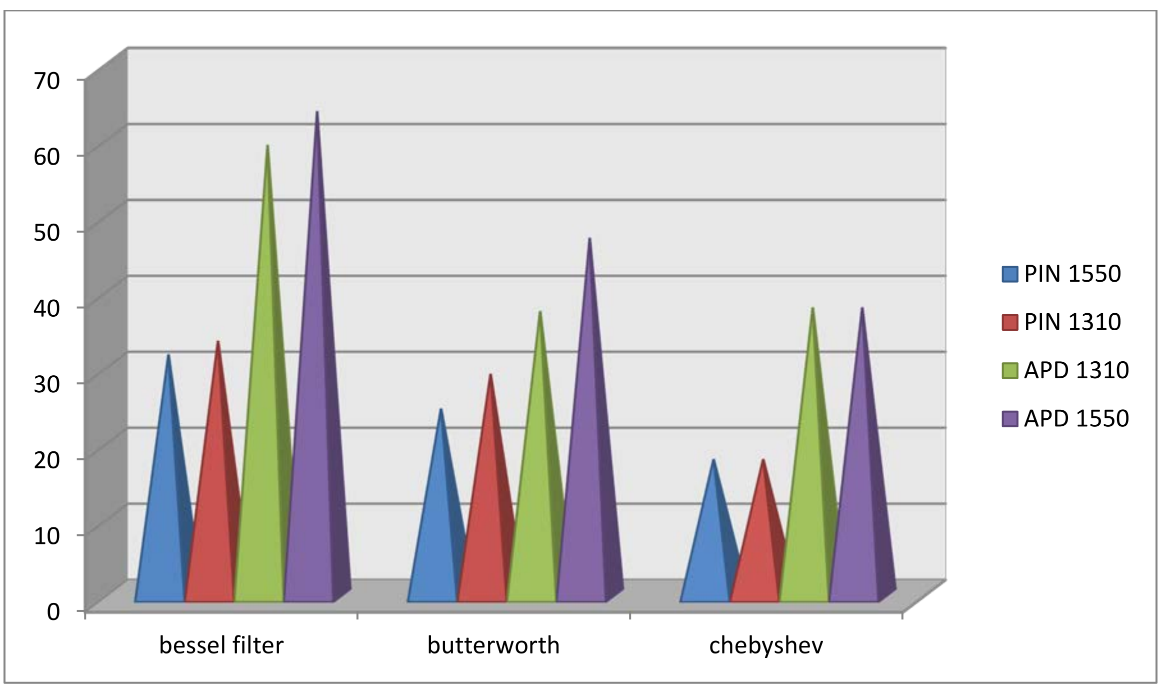


Fig.5 shows the graphical comparison between three different filters using different wavelengths and photodiodes

V. CONCLUSION

It is concluded that APD photodiode gives a better Performance in FSO transmission system as compared to PIN photodiode. After passing through different filters, results show that the signal changes it's parameters i.e. when the optical signal pass through Butterworth and Bessel filter its sensitivity to timing error is high and also its zero crossing distortion is very high but when the signal passes through Chebyshev its sensitivity to timing error as well as zero crossing distortion is reduced but its noise is relatively very high if compared with other filters. Low pass Bessel filter shows the best performance among the other filters.

REFERENCES

[1] Jitendra Singh, Naresh Kumar,"Performance analysis of different modulation format on free space optical communication system"Optik-International journal for light and electron optics. 2013;124(20).

[2] Delower H, Golam SA. Performance evaluation of the free space optical (FSO) communication with the effects of the atmospheric turbulence. A Bachelor Degree Thesis; 2008.

[3] T. Kamalakis I. Neokosmidis A. Tsipouras T. Sphicopoulos S. Pantazis I. Andrikopoulos; "Hybrid Free Space Optical Milimeter Wave Outdoor Links for Broadband Wireless Acess Networks", The 18th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'07) pp 01-05.

[4] Arnon S, Barry J, Karagiannidis G; "Advanced Optical Wireless Communication Systems",Cambridge University, (2012).

[5] N. Haedzerin, M .D. Noor, A. W. Naji and W. Al Khateeb; "Performance analysis of a free space optics link with multiple transmitters/receivers", IIUM Engineering Journal, vol. 13, no. 1 (2012).

[6] Gaurav Soni, Jagjeet Malhotra; "Impact of beam divergence on the performance of free space optics", International Journal of Scientific and Resarch Publications(2012);2(2).

[7] Christopher C, Davis II, Smolyaninov SD. Milner; " Flexible optical wireless links and networks", IEEE Communication Magazine. (2003);51-57.

[8] Priyanka Sharma, Himali Sarangal, "Performance Evaluation of Multiple Transceiver FSO for different Weather Conditions", International Journal of Signal Processing, Image Processing and Pattern Recognition Vol.8, No.12 (2015), pp.149-156.

[9] Achour M; " Simulating atmospheric free- space optical propagation part I, Haze, Fog and Low Clouds, Rainfall Attenuation.Optical Wireless Communications", Proceedings of SPIE; 2002.

[10] Jim Karki; "Active Low-Pass Filter Design", Application Report SLOA049B - September 2002.

[11] Abdelhakim Boudkhi, Belabbes Soudini; "Analysis of Fundamental Photodetection Noises and Evaluation of PIN and APD Photodiodes Performances using an Optical High Debit Transmission Chain Simulated by Optisystem ",International Journal of Computer Applications (0975 – 8887) Volume 115 – No. 18, April 2015.