Int. J. Advanced Networking and Applications
Volume: 10 Issue: 06 Pages: 4065-4069 (2019) ISSN: 0975-0290

Noise Reduction in Optical Communication System

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ABSTRACT

The aim of this paper to find best suited filter for given photo detector i.e APD and PIN for the suppression of noise in the proposed optical system. This paper also analysis the effect of SOA for noise reduction in the optical communication system. It is concluded that APD photodiode gives a better Performance in given optical system in comparison with PIN photodiode. Low pass Bessel filter shows the best performance among the other filters at 1310 nm wavelength. Bessel filter provides constant group delay. Eye opening height is more in Bessel filter. It gives minimum Bit error rate in received signal. Semiconductor optical amplifier reduces the noise in optical system. It improves the quality of received signal. It provides lower bit error rate upto 20 km optical fiber.

Keywords - **BER, Eye-diagram, Filter, Optical source, Photo diodes.**

Date of Submission: May 06, 2019 Date of Acceptance: May 21, 2019

1. INTRODUCTION

When the optical source emits light due to long distance transmission of light there is occurrence of noise. At the receiving section this noise effects the performance of received signal like BER, Q factor etc. This proposed system design to reduce noise in the received signal. First we try to check which filter well situated for better performance of given system and which photo detector work smoothly for better operation of system with lower bit error rate and high quality factor[1-4].

In the last section of this paper it is also discussed about the semiconductor optical amplifier responsible for noise reduction for the improvement of system functionality [5-7].

1.1 Optical Source

In this system Continuous-wave laser is used. It is continuously pumped and emits light. The operating frequency is 1550 nm and 1310 nm respectively. It operates at 10mW power.

1.2 Mach-Zehnder Modulator

Mach Zehnder works on the principle of electro- electro-optic effect. By applying a external voltage optical path length is changed.

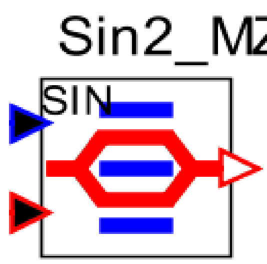

Fig. 1. Mach-Zehnder modulator

A Mach-Zehnder modulator controls the amplitude of an optical wave. The input waveguide split into two waveguide arms. Voltage is applied across one arm, it gives rise to phase shift when light wave passes through that arm. These two arms recombined the phase difference between two arms waves responsible for the amplitude modulation.

Delaying signal of one arm with respect to another arm. This delay is achieved by changing refractive index of one arm. This refractive index change is proportional to external applied voltage across one arm. The output is a result of interference between two signal combinations. When phase of light is in phase there is constructive interference. If phase in each arm differ by π destructive interference occurs. Hence this modulator modulated the intensity of light.

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1.3 Optical fiber

In this proposed system single mode fiber is used. It provides high data rate and efficient long c transmission of signal. It is not suffered from modal dispersion. In this set up I am uing 10 km single mode fiber.

1.4 Photo Detectors

Photo detectors converts optical energy into electrical energy. Photo detector performance depends upon the responsivity of that detector. The responsivity decides generated amount of photocurrent for the amount of optical power incident on the photo detector.

1.4.1 APD Photo Diode

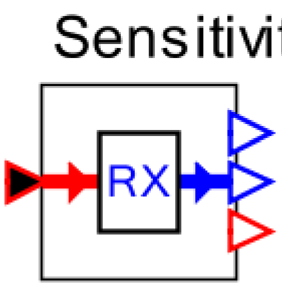

Fig. 2. APD Photo Diode

Avalanche photodiodes (APDs) are specially designed for reverse breakdown region. This diode has High level of sensitivity. It provides higher gain due to multiplication effect.

1.4.2 PIN Photo Diode

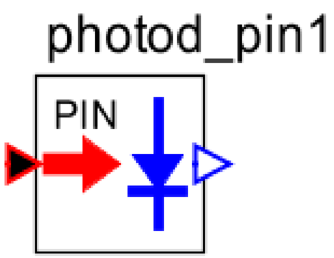

Fig. 3. PIN Photo Diode

A Pin diode contains intrinsic semiconductor layer between the p-type semiconductor and n-type semiconductor layer. Intrinsic layer is made by pure semiconductor material. The p-type and n-type layer is heavily doped.

1.5 Filters

1.5.1 Butterworth Filter

This filter has flat frequency response in the pass band.

1.5.2 Chebyshev Filter

This filter will allow ripples in the pass band amplitude response. It has steeper roll-off near cut off frequency compared with the butterworth filter. This filter has Poorer group delay.

1.5.3 Bessel Filter

The Bessel filter provides constant group delay.

2. SIMULATION OF FILTERS AT DIFFERENT OPTICAL SOURCE WAVELENTHS AND PHOTODIODES

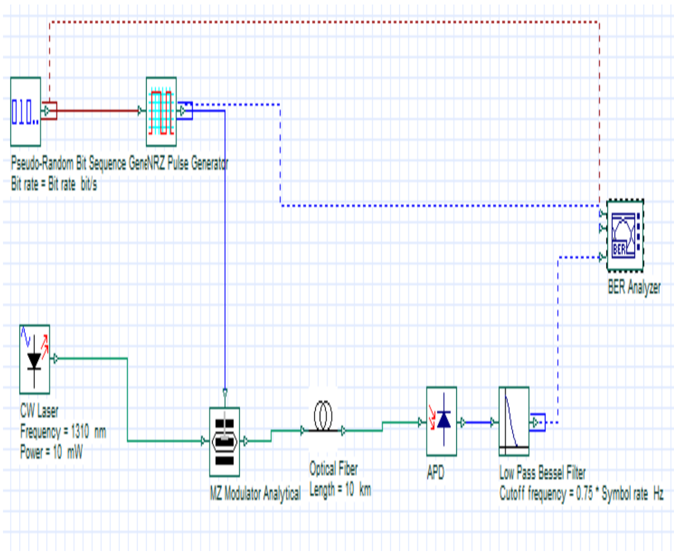

Fig. 4. Experimental Set up of Proposed Optical Communication System

2. 1 Optical System Design

Optical system has been designed for the improvement in the noise and for simulation Optisystem 16.0. The proposed optical system given in fig.4. In the proposed system, first is optical transmitter, then a optical fiber link and at the last optical detector. In transmitter first section continuous wave (CW) laser of wavelength 1310 nm or 1550 nm is used as an optical source at 10mw power. The Pseudo random bit sequence which generates the sequence of ones and zeros in random fashion. The PRBS output is fed to NRZ pulse generator. Signal coded by NRZ scheme is generated by NRZ pulse generator. One terminal of MZ modulator connected with NRZ generator output and another terminal Mach-Zehnder modulator connected with output of CW laser source.

After modulation through MZ modulator signal is transmitted through a channel made by optical fiber of length 10km. The optical detector may be an APD or PIN photodiodes which detects the signal.

The photo detector converts the light signal into electrical signal. At the receiver end there is a low pass filter. This signal after filtration fed to BER analyzer. This analyzer is used to analysis the Q factor , BER and eye diagram of received signal.

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3. SIMULATION AND ANALYSIS OF EFFECT OF SOA ON THE PERFORMANCE OF PROPOSED SYSTEM

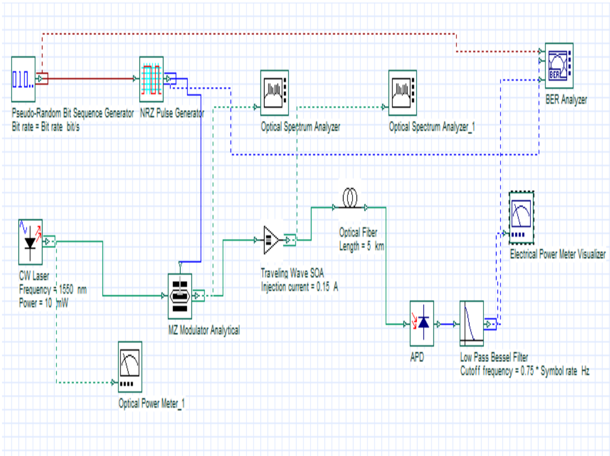
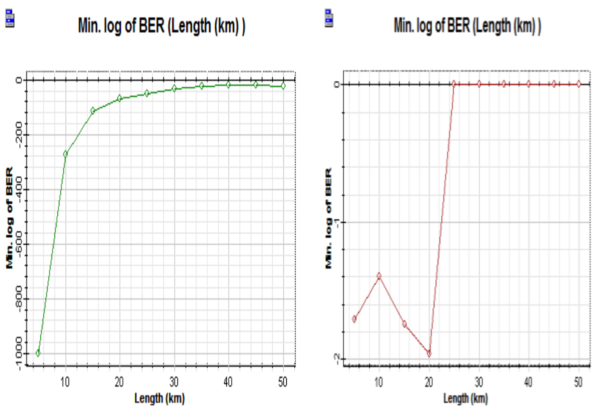


Fig. 5. Experimental set of upgraded optical system with SOA.

In this set up we insert semiconductor optical amplifier for the better performance of optical system. Input power of optical source is varied to test the operation of SOA. At different input power it provides different values of signal and noise power. Some bits changed due to noise in optical communication channel bit error rate gives us idea bits in error in the received signal data. SOA gives low BER hence it suppressed the noise. It provides high signal to noise ratio.



(a) Without SOA (b) With SOA

Fig. 6. BER varies according to length of optical fiber

4. RESULTS AND DISCUSSION

In this proposed system, the performance of optical system having 10 km optical fiber has been analyzed on the basis of operation of various filters with combination of various types of photo detectors and at different wavelengths. The simulation is done on optisystem 16.0. After simulation I get the comparative result of the performance of photodiodes such as avalanche photodiodes (APD) and PIN photodiodes on the basis of their quality factor at two different wave lengths 1550 nm and 1310 nm respectively.

Table 1: Quality Factor Obtained by using Filters and different Wavelengths

Photo Detector Type	λ (nm)	Low Pass Chebyshev Filter	Low Pass Butterworth Filter	Low Pass Bessel filter
PIN	1550	20.46	23.01	36.40
PIN	1310	37	28	59.38
APD	1550	20.50	23.38	36.64
APD	1310	37.24	28.10	59.94

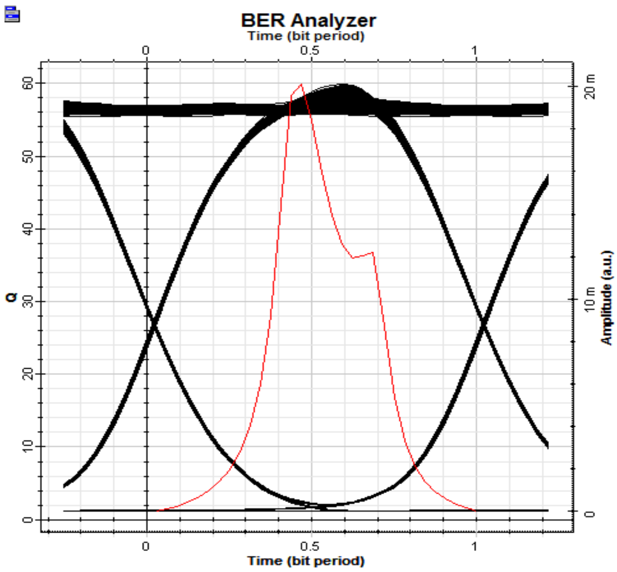


Fig. 7. Q Factor of Low pass Bessel filter

Fig. 7. shows the eye diagram of a optical system having wavelength 1310 nm. The modulation coding is NRZ with photo detector APD is used. In this eye diagram we get result that the Q factor in this system is highest for low pass bessel filter is 59.94.

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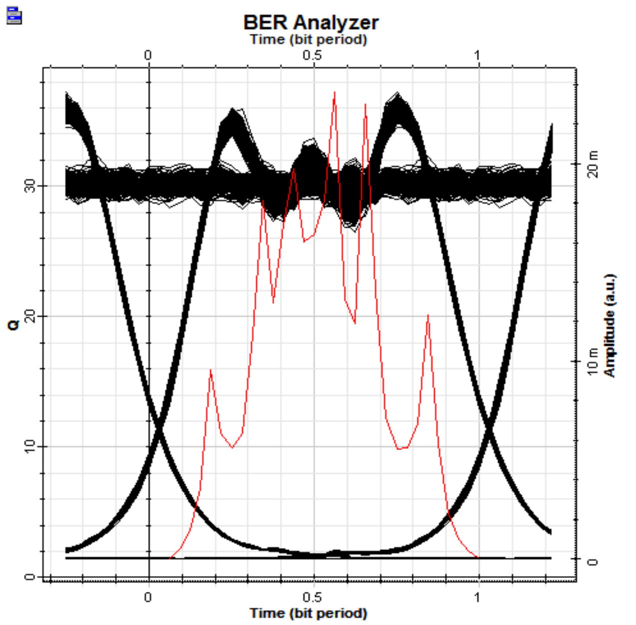

Fig. 8. Q Factor of Low Pass Chebyshev Filter

In this fig.8. eye diagram taken at 1310nm frequency of optical source at 10mW input power low pass chebyshev filter value of Q factor is 37.24 came after simulation in optisystem software.

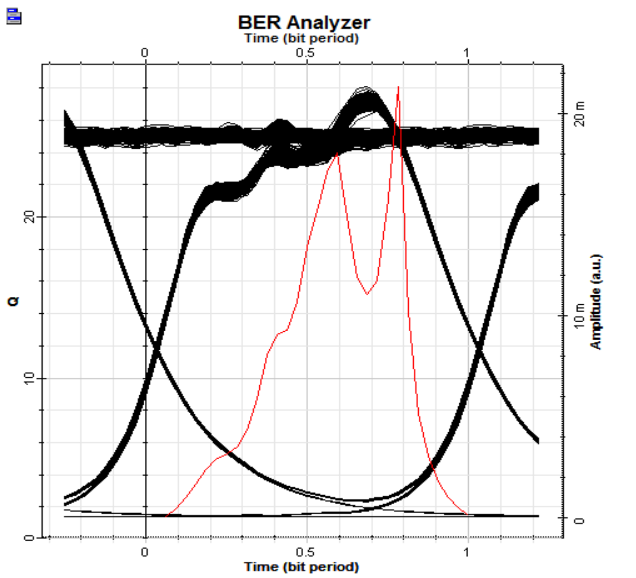

Fig. 9. Q Factor of Low Pass Butterworth Filter

In this eye diagram taken at 1310nm frequeny of optical source at 10mW input power Q factor for low pass butterwoth filter came 28.10.

4. 1 BIT ERROR RATE SIMULATION

BER rate response taken on 1550nm frequency of optical source at 10mW power. Bessel filter provides constant group delay due to this eye opening height is more. Bit error rate of Bessel filter is minimum.

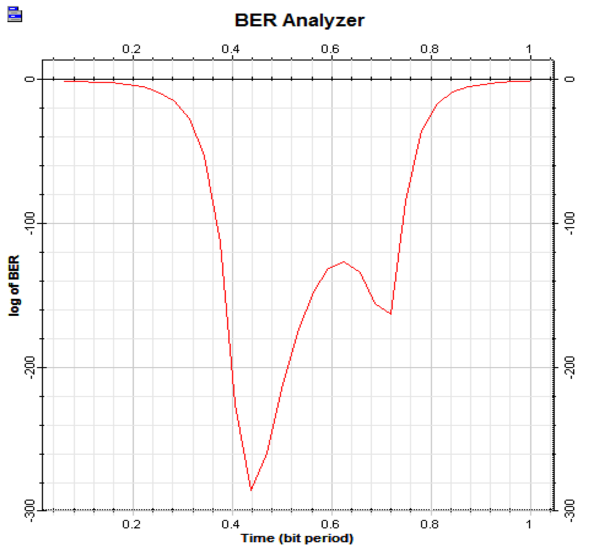

Fig. 10. BER curve of Bessel Filter Min. BER=3.303716e-286

In Fig. 10. shows that Bessel filter has minimum bit error rate at 1550nm frequency at 10mW power.

Table 2: BER ANAYLSIS OF DIFFERENT FILTERS

Filter Type	**Eye Height**	**Min.BER**
Chebyshev	0.016	1.4125e-096
Butterworth	0.0158	5.1976e-124
Bessel	0.0173	3.303716e-286

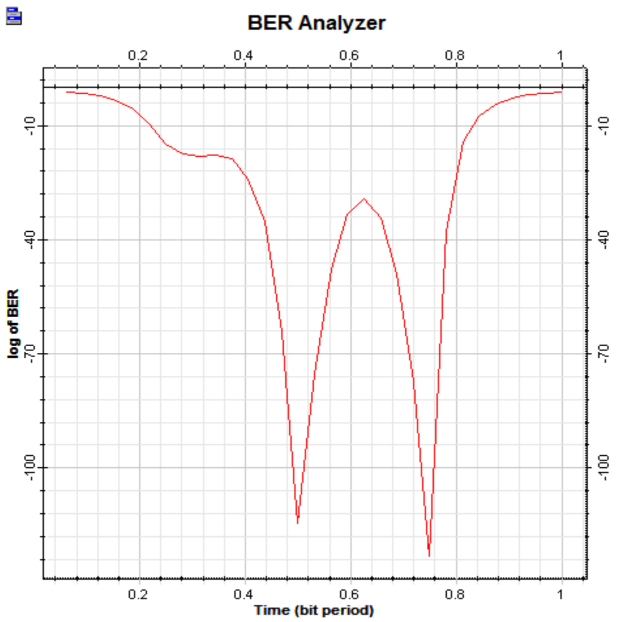

Fig. 11. BER curve of Butterworth filter Min. BER=5.1976e-124

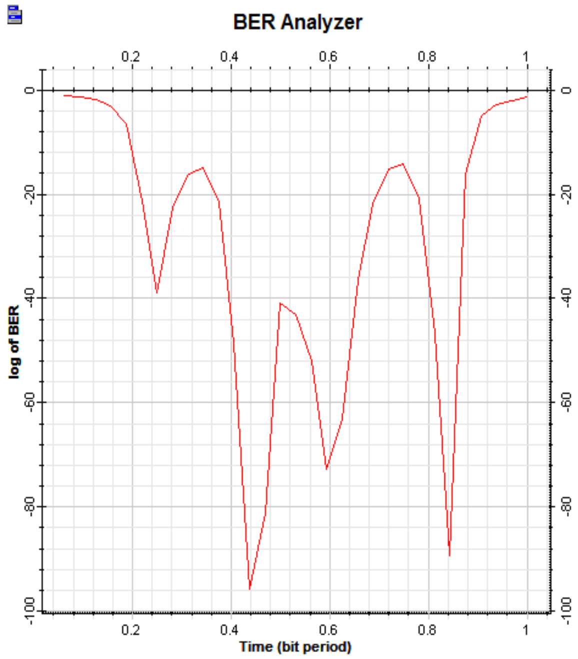

Fig. 12. BER curve of Chebyshev Min. BER=1.4125e-096

At 1310 nm laser power chebyshev filter has BER 6.3453e-304 and butterworth filter bit error rate is 7.94125e-176. But Bessel filter has minimum BER.

5. CONCLUSION

It is concluded that APD photodiode gives a better Performance in given optical system in comparison with PIN photodiode. Low pass Bessel filter shows the best performance among the other filters at 1310 nm wavelength.

Bessel filter provides constant group delay. Eye opening height is more in Bessel filter. It gives minimum Bit error rate in received signal.

Semiconductor optical amplifier reduces the noise in optical system. It improves the quality of received signal. It provides lower bit error rate upto 20 km optical fiber.

6. ACKNOWLEDGMENT

I would like to acknowledge Assistant Professor Chakresh kumar of USICT, Guru Gobind Singh Indraprastha University his encouragement and cooperation during this project.

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