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Comparative Analysis Study of Optical Intersatellite links for Different Both Transmission Bit Rates and Operating Wavelengths

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Abstract— *This paper has presented the complete analysis comparison study of optical intersatellite links for different both transmission bit rates and operating wavelengths. Quality factor and bit error rates are the major interesting performance parameters in our comparison. We have modified in all circuit components and compared our simulation results with another and show a good enhancement values. All simulation results are done with using optiwave simulation version 7.*

Index Terms— Optical Wireless Communication; Inter Satellite Link; Intersatellite optical wireless communication; Bit Error Rate (BER).

I. INTRODUCTION:

A satellite is an object rotate around another object in the space [1]. Satellite connectivity has the power to drive communication advances across aboard range of industries and geographies [2-4]. Communication satellite is used in optical wireless communications (OWC) to transmit and receive optical signals from an orbiting satellite to another or between orbits of satellite [5]. Optical wireless communications (OWC) have several advantages such as it operate at high bit rate, high bandwidth, small size of antenna, high power efficiency and low loss [6]. In this paper, the medium surrounding the satellites is considered to be vacuum. The satellites have line of site [7]. In this paper we study the effect of types of bit sequence generator on performance of the system. We study the effect of wavelength, bit rate on the performance of the system. The performance of the system is measured in terms of quality factor and bit error rate [8-9].

II. THE ISOWC BASIC SYSTEM MODEL

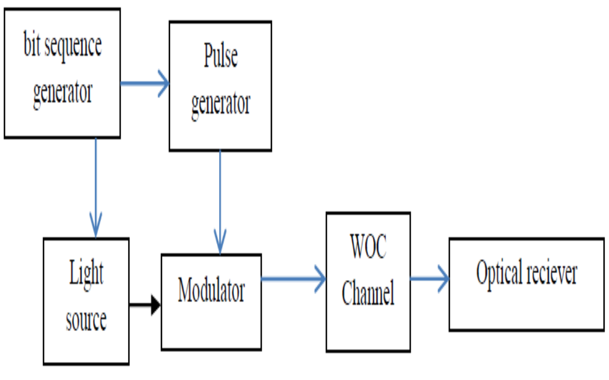

Fig. 1.Intersatellite optical wireless communication system model.

The intersatellite optical wireless communication system consists of transmitter and receiver communicating with optical wireless communication (OWC) channel. The block diagram of a simplex IsOWC model is shown in Fig. 1. The Optical transmitter consists of user defined bit sequence generator which represents the data that wants to be transmitted. Then the data generated from user defined bit sequence generator is modulated by NRZ generator. Then the Mach-Zender modulator modulates the electrical signal by the continuous wave (CW) laser as a carrier producing optical signal which transmitted through the channel. The receiver receives the optical signal and converted it to electrical signal by avalanche photodiode. Then low pass raised cosine filter is used to filter out undesired higher frequency signals. The third operation of regenerator uses to regenerate electrical signal of the original bit sequence, and the modulated electrical signal as in the transmitter to be used for bit error rate analyzer.

III. SIMULATION RESULTS AND PERFORMANCE ANALYSIS

III.1 THE SYSTEM PERFORMANCE FOR THE RELATION BETWEEN QUALITY FACTOR WITH THE BIT RATES

The link performance analysis is obtained using optiwave simulation version 7 as shown in Figs (2-7). The propagation distance is taken from 1000 Km to 3000 Km, the operating signal wavelength is taken from 550 nm to 1550 nm and transmission bit rates is taken from 2.5 Gb/s to 10 Gb/s for both propagation distance of 1000 Km and 3000 Km [1-3].

The system model in Fig. 1 uses user defined bit sequence generator in transmitter and low bass cosine roll of filter in receiver to obtain high quality factor and low BER. If the user defined bit sequence generator is replaced by pseudo random bit sequence generator and low bass cosine roll of filter is replaced by low bass Bessel filter as in previous model [1], the system performance decrease as quality factor decrease. Figs. (2-7) show the difference between two cases (present model and previous model [1]) at different wavelengths and distance 1000 km and show that with increasing bit rate this leads to the quality factor is decreased. In this research, the bit rate is chosen to be 2.5 Gb/s and 10 Gb/s. If we use bit rate equal to 40 Gb/s, the quality factor will be approximately tends to zero. It is observed that from Figs.(2, 3), with increasing optical signal wavelength, this result in decreasing the quality factor as shown in Figs.(8, 9).

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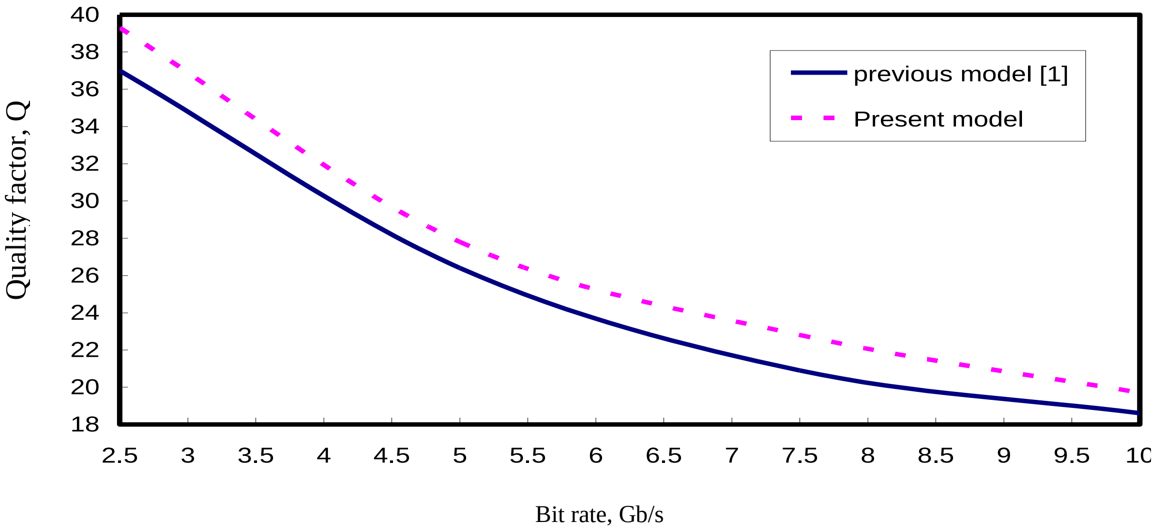

Fig.2 . Relation between quality factor and bit rate of the model using pseudo random bit sequence generator and present model which used user defined bit sequence generator at wavelength, λ=550 nm.

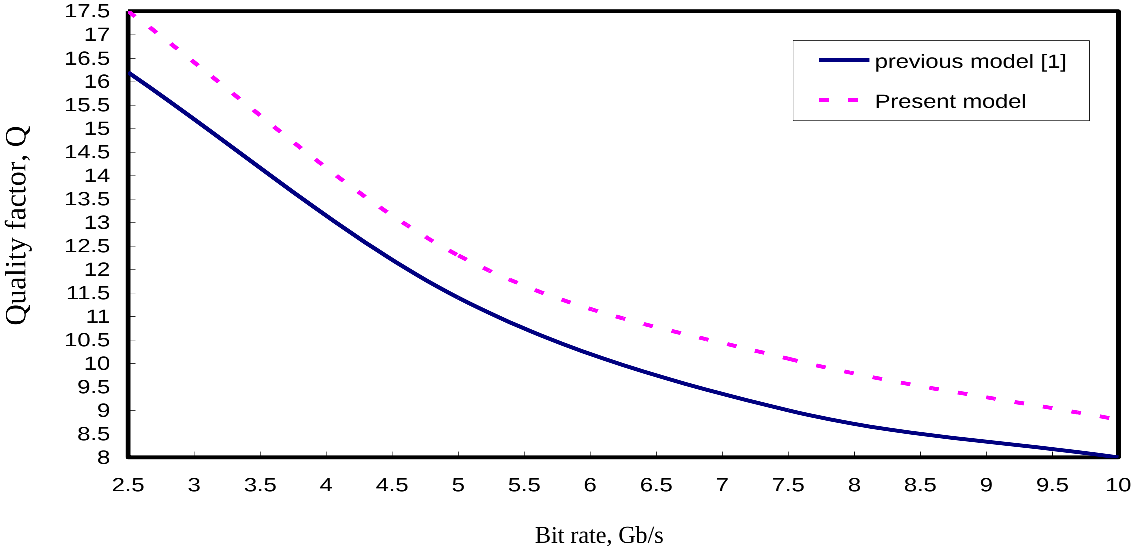

Fig. 3. Relation between quality factor& bit rate at wavelength, λ=860nm.

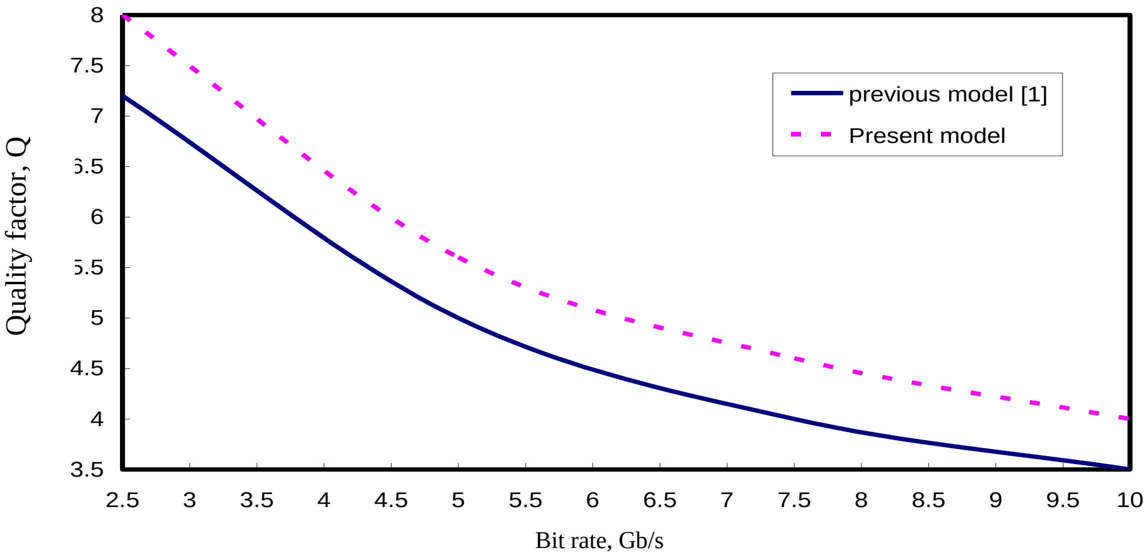

Fig. 4. Relation between quality factor& bit rate at wavelength, λ=1300 nm.

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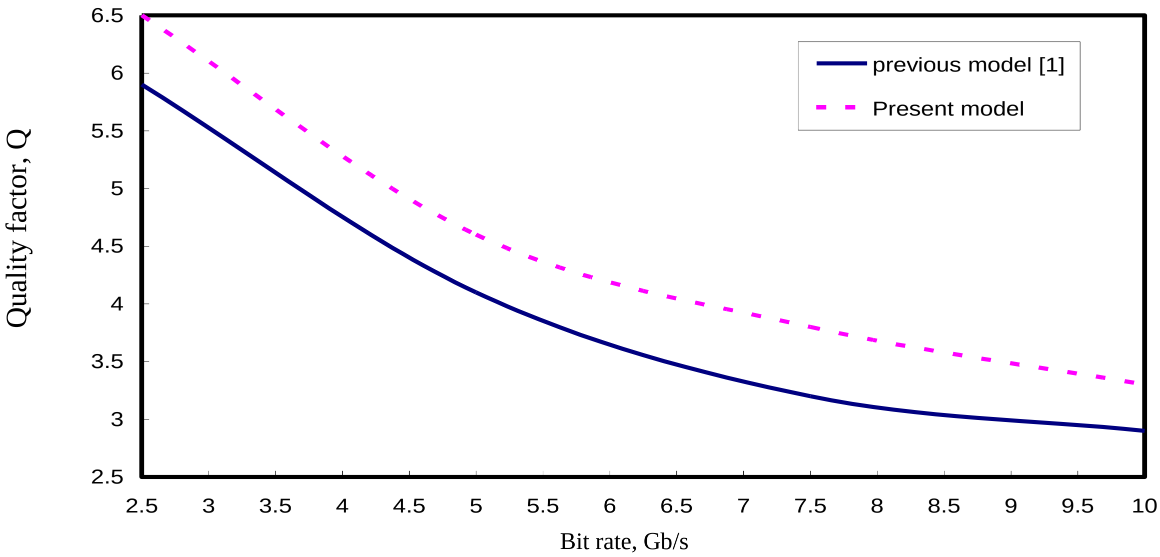

Fig. 5. Relation between quality factor& bit rate at wavelength, λ=1440 nm.

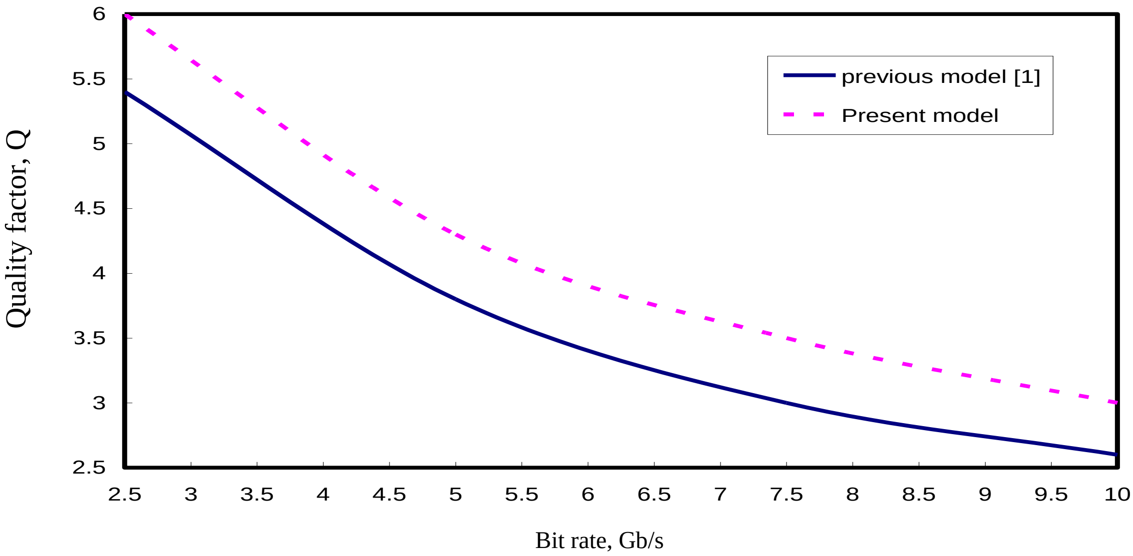

Fig. 6.Relation between quality factor& bit rate at wavelength, λ=1500 nm.

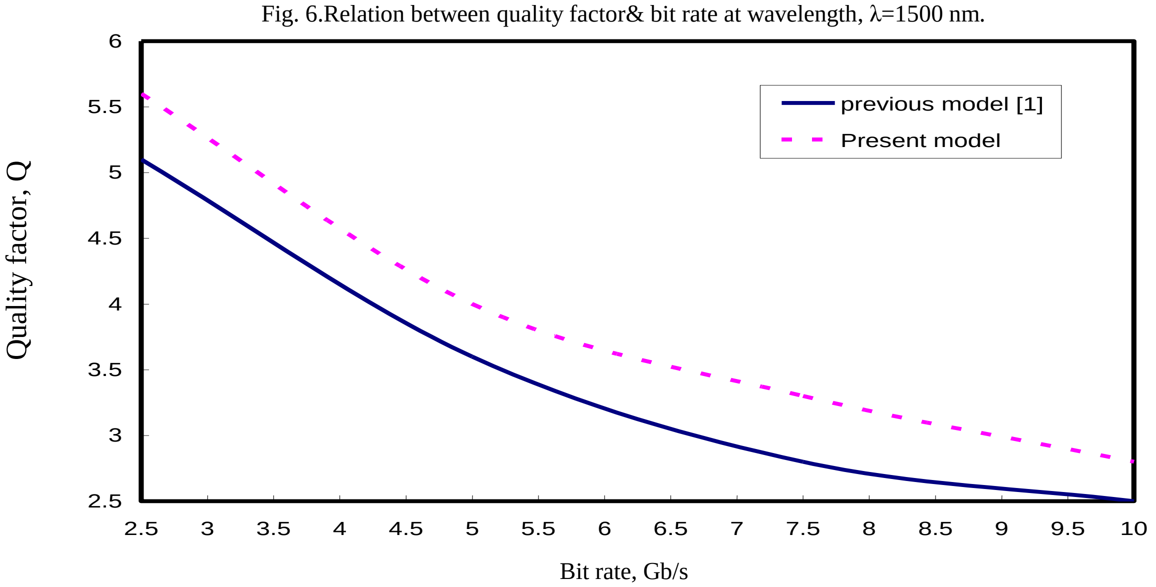

Fig. 7. Relation between quality factor& bit rate at wavelength, λ=1550 nm.

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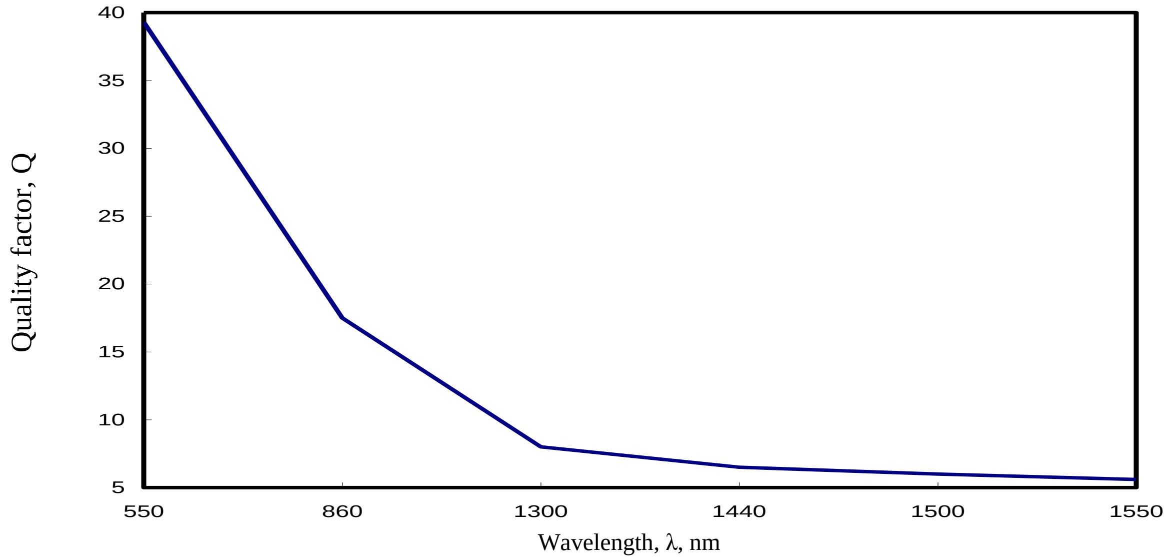

Fig. 8. Relation between quality factor & wavelength at bit rate= 2.5 Gb/s.

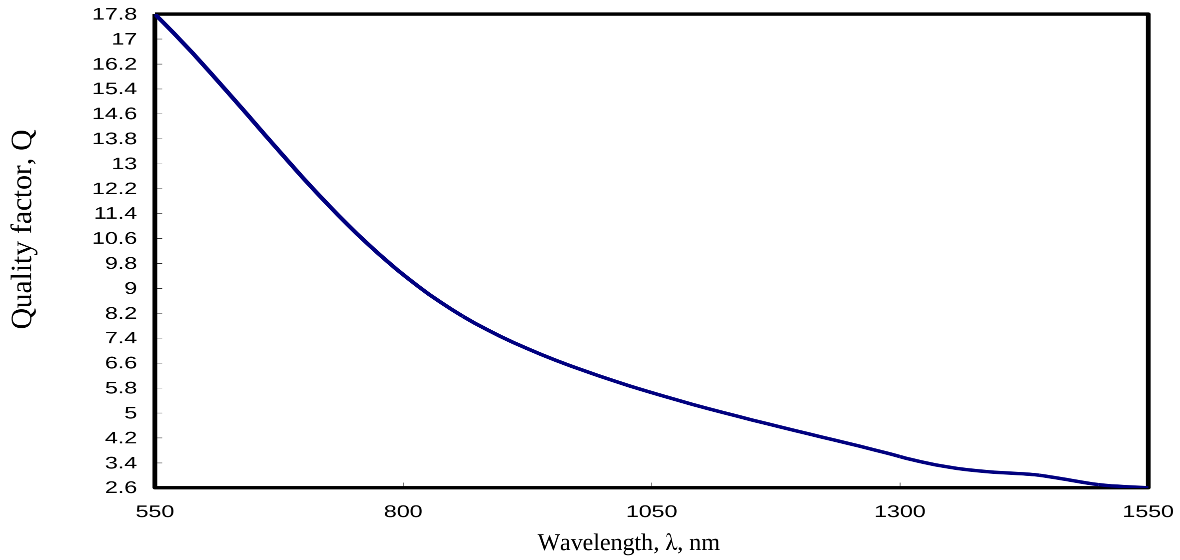

Fig. 9. Relation between quality factor & wavelength at bit rate= 10 Gb/s.

III. 2. BIT ERROR RATE(BER) EYE DIAGRAM AT BIT RATES 2.5 GB/S AND 10 GB/S AT DIFFERENT WAVELENGTHS FOR DISTANCE=1000 KM.

BER is proportional to bit rate, by increasing bit rate , the BER increases at the same wavelength . By increasing wavelength, BER increases at the same bit rate. The following Figs (10-21) show that at the lowest bit rate which equal 2.5 Gb/s and at the lowest wavelength, BER is the best.

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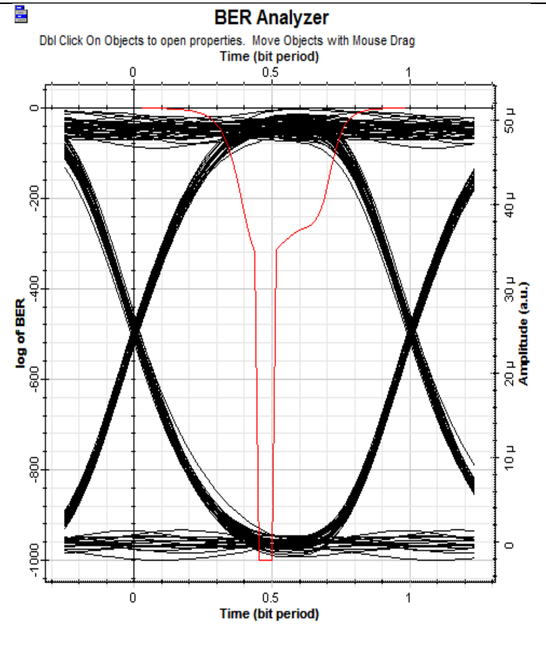

Fig. 10. Eye diagram for BER using wavelength, λ =550 nm at bit rate=2.5 Gb/s

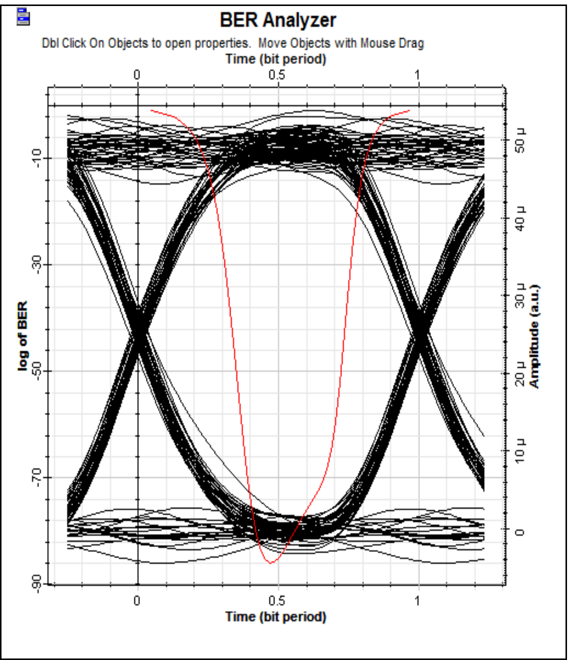

Fig. 11. Eye diagram for BER using wavelength, λ =550 nm at bit rate=10 Gb/s

In Fig.10 the BER is 10^{-290} , it is approximately low at bit rate equal 2.5 Gb/s and wavelength equal 550nm , and at the same wavelength and bit rate equal 10 Gb/s the BER is increased to be equal 10^{-86} as shown in Fig.11.

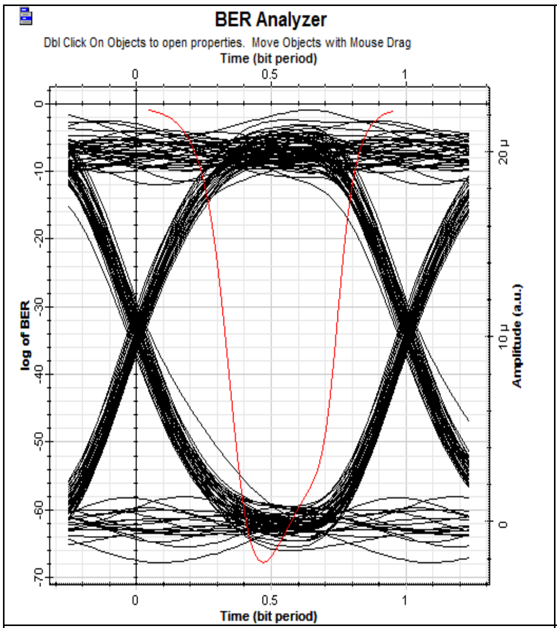

Fig. 12. Eye diagram for BER using wavelength, λ=860 nm at bit rate=2.5 Gb/s

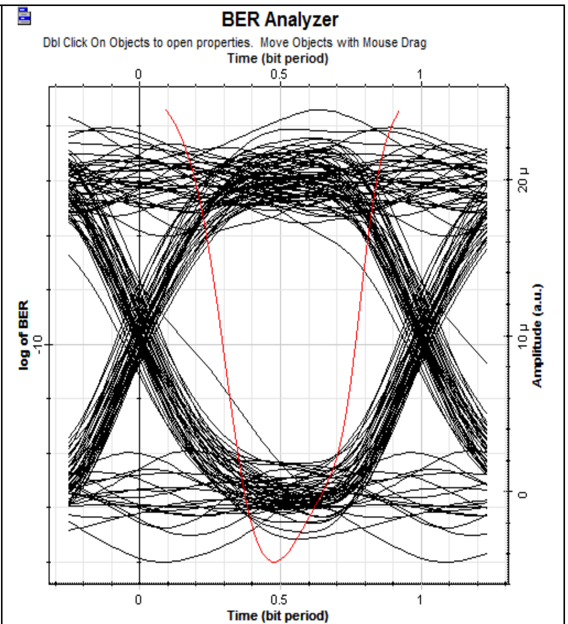

Fig.13.Eye diagram for BER using wavelength, λ =860 nm at bit rate=10 Gb/s

In Fig.12 the BER is 10^{-68} at bit rate equal 2.5 Gb/s and wavelength equal 860nm , and at the same wavelength and bit rate equal 10Gb/s the BER is increased to be equal 10^{-18}. As well as shown in Fig.13, this shows that with increasing bit rate, this result in increasing BER at the same wavelength

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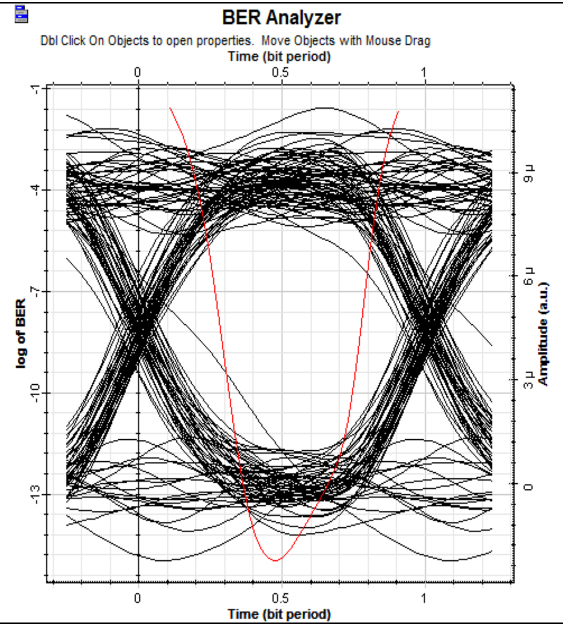

Fig. 14. Eye diagram for BER using Wavelength, λ =1300 nm at bit rate=2.5 Gb/s

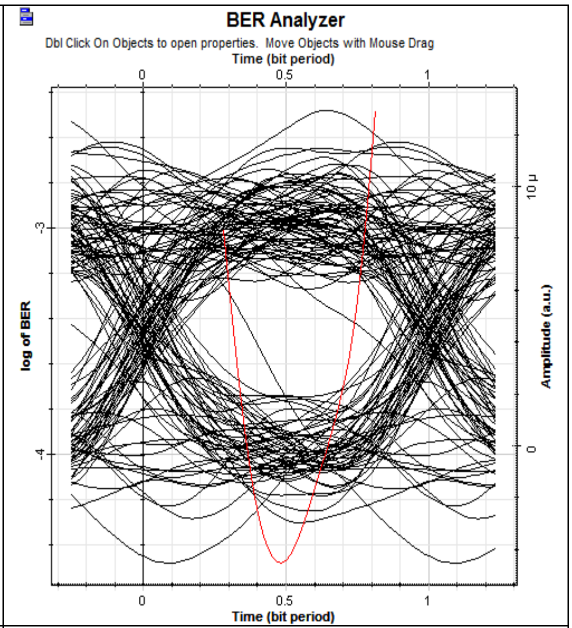

Fig. 15. Eye diagram for BER using Wavelength, λ =1300 nm at bit rate=10 Gb/s

In Fig.14 the BER is 10^{-15} at bit rate equal 2.5 Gb/s and wavelength equal 1300nm , and at the same wavelength and bit rate equal 10Gb/s the BER is increased to be equal 0.0002 as shown in Fig.15.

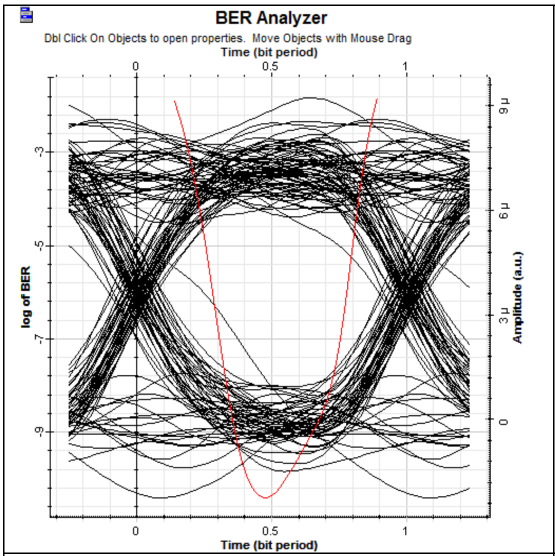

Fig. 16. Eye diagram for BER using Wavelength, λ=1440 nm at bit rate=2.5 Gb/s.

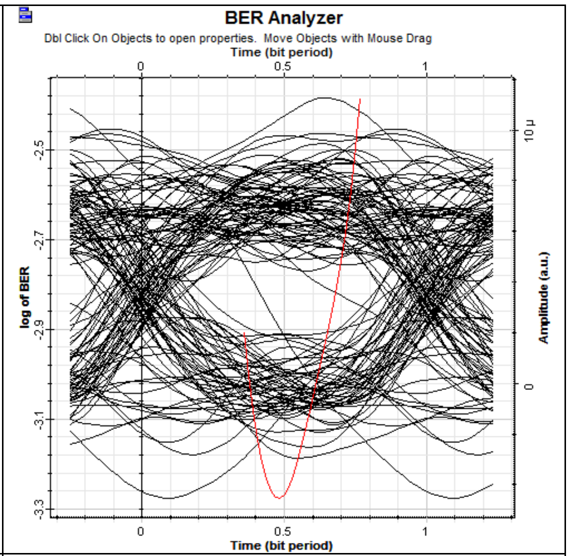

Fig. 17. Eye diagram for BER using Wavelength, λ =1440 nm at bit rate=10 Gb/s

In Fig.16 the BER is 10^{-11} at bit rate equal 2.5 Gb/s and wavelength equal 1440 nm , and at the same wavelength and bit rate equal 10Gb/s the BER is increased to be equal 0.0005 as shown in Fig.17.

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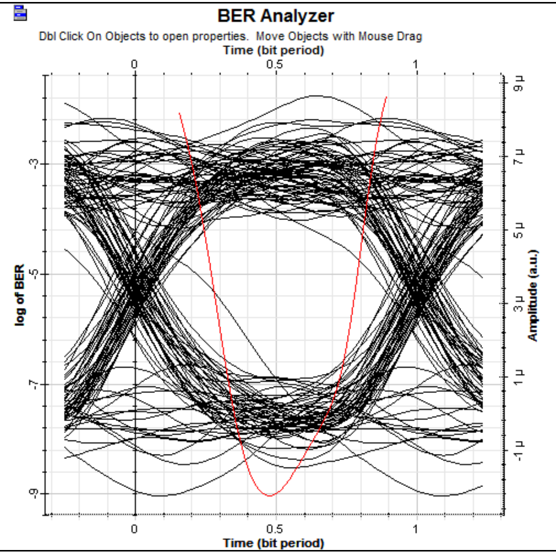

Fig. 18. Eye diagram for BER using Wavelength, λ =1500 nm at bit rate=2.5 Gb/s

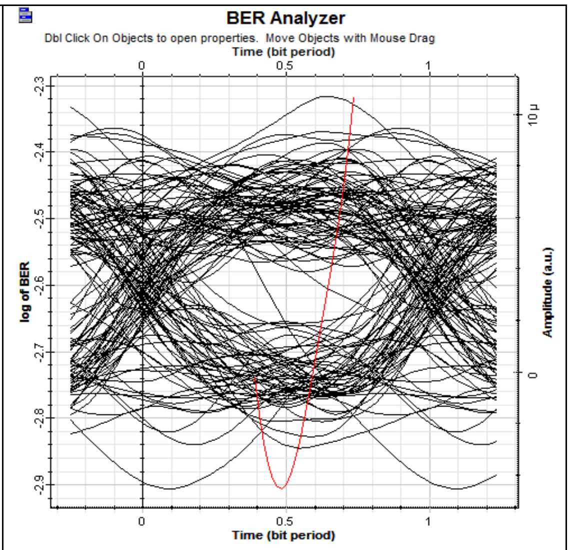

Fig. 19. Eye diagram for BER using Wavelength, λ =1500 nm at bit rate=10 Gb/s

Figure18 shows the BER is 10^{-10} at bit rate equal 2.5 Gb/s and wavelength equal 1500 nm , and at the same wavelength and bit rate equal 10 Gb/s the BER is increased to be equal 0.001 as shown in Fig.19.

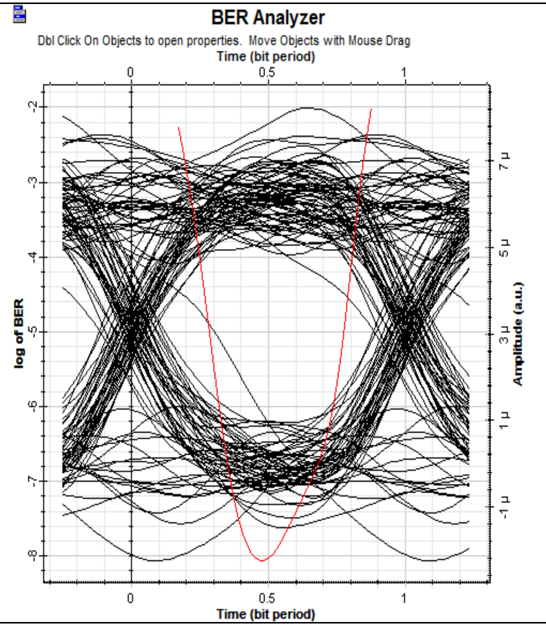

Fig. 20. Eye diagram for BER using Wavelength, λ=1550 nm at bit rate=2.5 Gb/s.

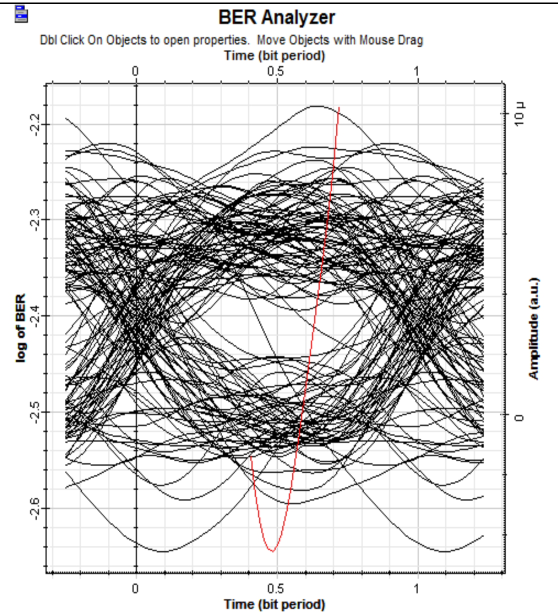

Fig. 21. Eye diagram for BER using Wavelength, λ=1550 nm at bit rate=10 Gb/s

In Fig.20 the BER is 10^{-9} at bit rate equal 2.5 Gb/s and wavelength equal 1550 nm , and at the same wavelength and bit rate equal 10Gb/s the BER is increased to be equal 0.002 as shown in Fig.21.

The previous Figures (from Fig.10 to Fig. 21) show that, with increasing wavelengths, BER increases at fixed transmission bit rate. The best BER is obtained at the least wavelength used which equal to 550 nm. By increasing bit rate, the BER is increased.

IV. Conclusion

In a summary, we have deeply investigated the comparative analysis study of optical intersatellite links for different both transmission bit rates and operating wavelengths. It is observed that by decreasing wavelength, the quality factor increases and BER decreases at the same bit rate, as shown in Tables (1-7). Quality factor is inversely proportional to BER. When bit rate increases, the quality factor decreases as shown in Table. 3. Quality factor is inversely proportional to distance. With increasing the distance , the quality factor decreases and power loss increases as shown in Table. 2. At low wavelengths and small distances, the performance of the system is high because the quality factor is high.

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Table 1.Comparison between quality factor of previous model [1] & modified model at wavelength λ= 550nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	37	39.3
5	26.4	27.8
7.5	20.9	22.8
10	18.6	19.7

Table 2. Comparison between quality factor of previous model [1] & modified model at wavelength λ= 860 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	16.2	17.5
5	11.4	12.3
7.5	9	10.1
10	8	8.8

Table 3. Comparison between quality factor of previous model [1] & modified model at wavelength λ= 1300 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	7.2	8
5	5	5.6
7.5	4	4.6
10	3.5	4

Table 4. Comparison between quality factor of previous model [1] & modified model at wavelength λ= 1440 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	5.9	6.5
5	4.1	4.6
7.5	3.2	3.8
10	2.9	3.3

Table 5. Comparison between quality factor of previous model [1] & modified model at wavelength λ= 1500 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	5.4	6
5	3.8	4.3
7.5	3	3.5
10	2.6	3

Table 6. Comparison between quality factor of previous model [1] & modified model at wavelength λ= 1550 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	5.1	5.6
5	3.6	4
7.5	2.8	3.3
10	2.5	2.8

Table 7. Comparison between quality factor of previous model [1] & modified model at wavelength λ = 1616 nm.

Bit rate (G b/s)	**Q factor**	
	Previous Model	Modified Model
2.5	4.7	5.2
5	3.3	3.7
7.5	2.6	3
10	2.3	2.6

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Author's Profile

Dr. Hamdy A. Sharshar was born in Menoufia State, Egypt country in 24 July, 1956. Received the B.Sc., M.Sc., and Ph.D. scientific degrees in the Electronics and Electrical Communications Engineering Department from Faculty of Electronic Engineering, Menoufia University in 1979, 1987, and 1993 respectively. Currently, his job carrier is Asscoc. Prof. Dr. in Electronics and Electrical Communications Engineering Department, Faculty of Electronic Engineering, Menoufia university, Menouf 32951, Egypt. His scientific master science thesis has focused on Electromagnetic scattering by plane and curved surfaces. As well as his scientific Ph. D. thesis has focused on Helical Antennas. His interesting research mainly focuses on wireless communication, radio over fiber communication systems, and optical network security and management. His areas of interest and experience in wireless optical access networks, analog communication systems, optical filters and Sensors, network management systems, multimedia data base, network security, encryption and optical access computing systems.

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