Comparative Investigation of Different Receiver Filter in the Satellite optical Wireless communication systems

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Abstract

Optical communications that links between satellites promise to become an important element of future space infrastructure and are the subject of considerable development. A comparative performance investigation of influence of many filters in wireless communication transceivers is presented in this paper. The three filters of channel 1 have low pass Bessel filter, channel 2 has low pass Butterworth filter and channel 3 has low pass Gaussian filter are used in this research with non-return-to-zero transmission. Changeable distance from 100, 200, 300, 400 km for the different channels performed with the different values of aperture diameters varies from 10 cm to 40cm. The system , modelled and simulated by using optisystem software, in optical wireless communication Channel (OWC), is evaluated with mainly presentation signal power, delay, Q-factor and BER. It has been concluded that Low pass Bessel filter gives the best results compared with the rest of the filters.

Keywords : **Comparative investigation , Wireless Communication, satellite optical.**

لتحقيق مقارنة للمرشحات المختلفه في مستلمه نظم الاتصالات الضوئية اللاسلكية للأقمار الصناعية

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المستخلص

تعد الاتصالات الضوئية بين الأقمار الاصطناعية عنصراً مهماً ، كما تشكل موضوعاً متطوراً وكبيرا في المستقبل. تم في هذا البحث المقارنة في دراسة تأثير الأداء من المرشحات المختلفة على نظام الاتصالات الضوئية اللاسلكية،وتتضمن القناة الاولى مرشح مرور منخفض (Bessel filter) والقناة الثانية مرشح مرور منخفض (Butterworth filter) و القناة الثالثة مرشح مرور منخفض (Gaussian filter) . جميع القنوات تعمل في نفس المصدر الضوئي التي تنتقل مع عدم العودة إلى الصفر (NRZ) وتمت دراسة الأداء لمسافات متغيرة تتراوح من 100، 200، 300،الى 400 كم لقنوات مختلفة، وقيمة الفتحة بأقطار تتراوح من 10 سم إلى 40.سم تحليل وظائف النظام ومحاكاة باستخدام برنامج optisystem ، في القناة البصرية والاتصالات اللاسلكية (OWC) هو دراسة أكثر قوة إشارة الأداء، والحد الأقصى لعامل الجودة Q-factor معدل نسبة الخطا Bit Error Rate (BER). وتبين من هذه الدراسة تشير بقوة إلى أن (low pass Bessel filter) يعطي أفضل النتائج مقارنة مع بقية المرشحات

1.Introduction

The Optical communications transceiver could be developed in terms of lengthy fibers in wireless systems in order to provide the principle of optical wireless communication system in space communication . The use of optical wireless communication systems in free space to increase the bandwidth and decrease the consumption power [1],[2],as a result of the increasing demand to meet the large-scale traffic, driven mostly by the arrival of the Internet access and HDTV broadcasting services at high speed between two locations which offers by optical communication.Space-based optical communications using many techniques used can be used in all applications successfully like space communication for example between Satellite and space as well as the deep and terrestrial communications(e.g. enterprise connectivity and last-mile access network)[3].

To connect one satellite to another IsOWC can be used ,whether the satellite in different orbits or in the same orbits. The orbits for satellites commonly used to revolve around Earth such as GEO, LEO and MEOhave important uses and will require an extremely correct tracking system to occupy the beacon signal of one side and a quadrant detector in tracking a system at other satellite. The other satellites could well relate and will be in correct line of sight. To meet this requirement, the Ephemeris data onto first rough pointing satellites will give good pointing to the other satellite [4]. Many satellites like European Space Agency and Japan satellites are designed in the idea of inter satellite link presented by [5],[6].For transmission of data onto high rates proves to be a better alternative to use IsOWC but various parameters need to be taken into account which degrades the system performance [7],[8].

This paper studies the performance analysis of a minimum of bit error rates, signal power, signal delay and maximum Quality factor (Q-factor) for optical wireless communication system. A circuit design consists of three channel branches of a receiver, first branch low pass Bessel filter, second a branch low pass Butterworth filter and third branch low pass Gaussian filter. The optical wireless communication system transmits the data of range of 100 - 400kms with the aperture diameters varies of 10 cm to 40cms. The spectrum start and shaped by eye diagram Analyzer to perform the system simulation and investigation using optisystem programs.

2. System Model

The Inter-satellite Optical Wireless Communications systems(IsOWC), that is also free-space optics, are used for large distances where the atmospheric attenuation is not the major source of penalties, but the pointing angle. Figure 1 shows the satellite communications designed and presented by [9],[10]. The presented design model has been done by using simplex systems for one path information transmission. The inter-satellite optical wireless communication system includes transmitter, channel and receiver in optical mode. In this case, the transmitter and receiver is in different satellites. In the transmitter, the electrical signal is converted into optical signals by using a laser and launch the resulting optical signal into free space. The optical signal is transmitted through optical wireless channels to optical receiver and then the optical receivers converted the distorted and attenuated weak optical signals to electrical signal, thus the transfer process is completed. The apprenticeship performance of IsOWC system is affected by the distance between the satellite, bit a rate, transmitter power, optical channel distance and aperture diameter of transverse antenna add for IsOWC system[3] .

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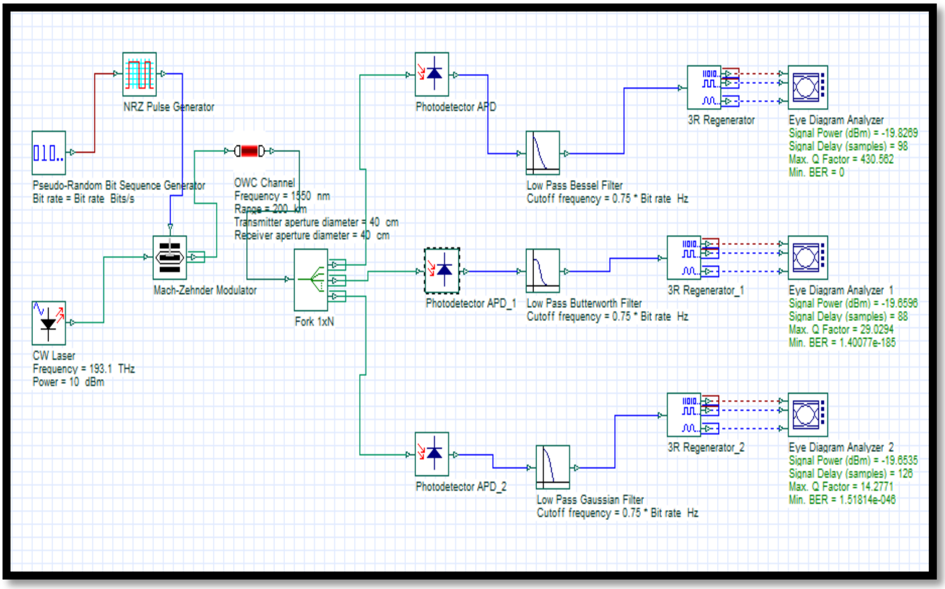


Figure1. IsOWC simplex design model

2.1. IsOWC Transmitter

The optical transmitter consists of bit sequence generators, electrical pulse generator, optical source and optical modulator. The information is typically fed to the satellite's TT&C system. The continuous wave laser is important components in optical systems, power is set at input power of 10dBm an whose line width is 10 MHz. The suitable frequency of the light is selected wavelength to be 1550nm for extended distance free space communication due to its monochromatic, coherent and high radiance. The function of Pseudo-random bit sequence generator (generating 10 Gbps) is to generate a sequence random of bits (0 or 1) [11]. NRZ-pulse generator produces the electrical data signal for modulation process [12]. The NRZ pulse generator grows and drop time is chosen to be .05 bit. The Mach Zehnder has an extinction ratio of 30db. The output signal from Mach Zehnder is transmitted in transmission media.

2.2. OWC Channel.

This system performs much influence of the broadcast space and the OWC channel is the gap between first and second satellites has been considered for light transmission. In the OptiSystem programs, the transmitter and receiver is separated from OWC channel and the aperture diameters diverge from 10 cms to 40cm of each antenna and the gains are selected to be 0 dbm with efficiency of 1. Additionally, an optical wireless channel has been modelled mathematically. The received power of LOS system is cumulated by satellite receivers.

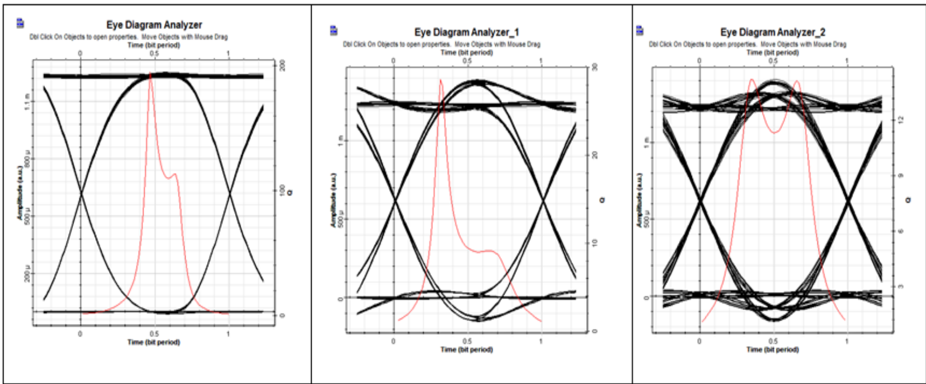
2.3. IsOWC Receiver

In this receiver type, the receiving path is consisting of three subsystems. The APD photodiode and LPF Bessel a window in the first stage with eye diagram scope. The second subsystem consists of APD photodiode, a LPF Butterworth window filter and eye diagram scope. The third subsystem consists of APD photodiode, LPF Gaussian window filter and eye diagram scope. The purpose of photodiode is to detecting the received light signals converting it into electrical signal in long distance transmission. The cut off frequency of LPF is chosen to be 0.75*bit rates.

3. Simulation Results andDiscussion

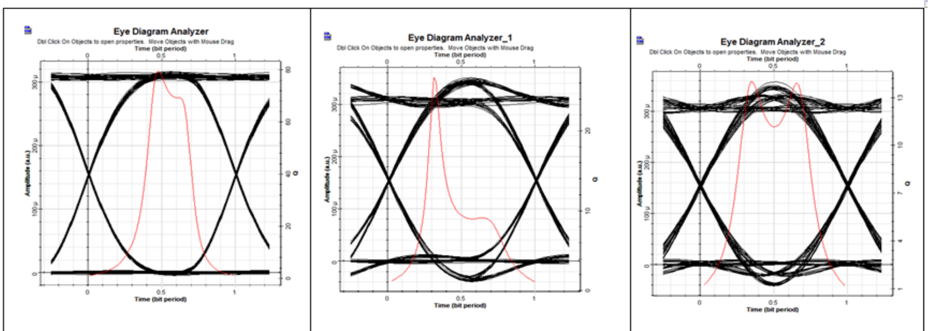
Study performance of the inter satellite optical wireless communication is done by OptiSystem simulation software.

The digital information signal in the receiver path is displayed by eye diagram
scope to evaluate the digital transmission of using time domains and overlap the traces for some symbols which represent the visual data. Figure 2,3,4 and Figure 5 highlight the output power BER and maximum Q-factor in the receiver path with different length of optical fiber. The aperture diameter is chosen to be 20cm. Figure 6,7,8 and Figure 9 shows the eye diagram with three different filters at different aperture diameters from 10cm to 40 cm.



a	b	c

Figure2:Optical wireless communication of length 100km at aperture diameter 20cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.



a	b	c

Figure3:Optical wireless communication of length 200km at aperture diameter 20cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

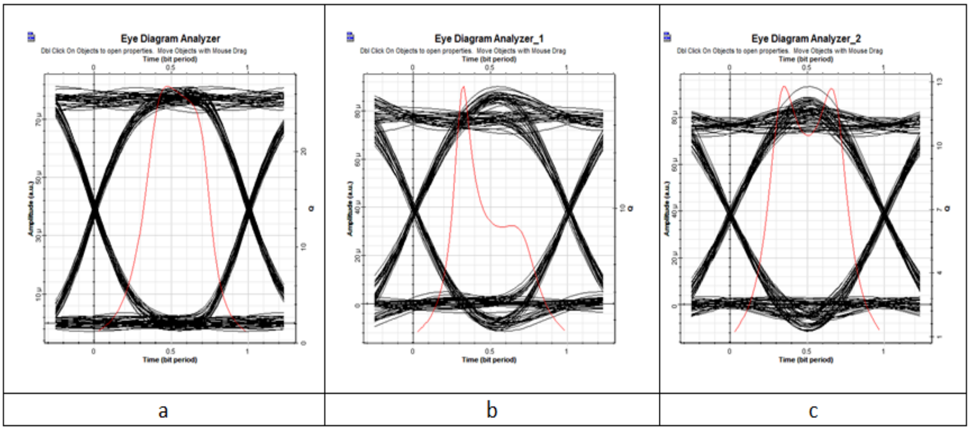


Figure 4: Optical wireless communication of length 300km at aperture diameter 20cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

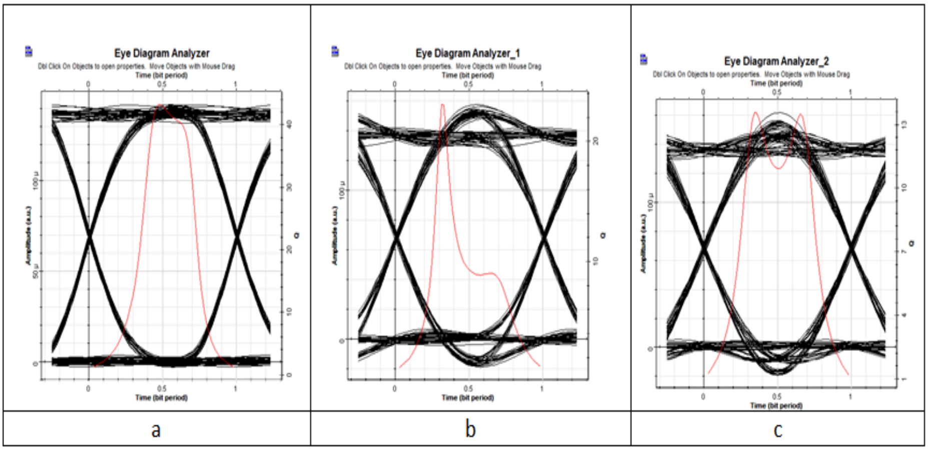


Figure5 : Optical wireless communication of length 400km at aperture diameter 20cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

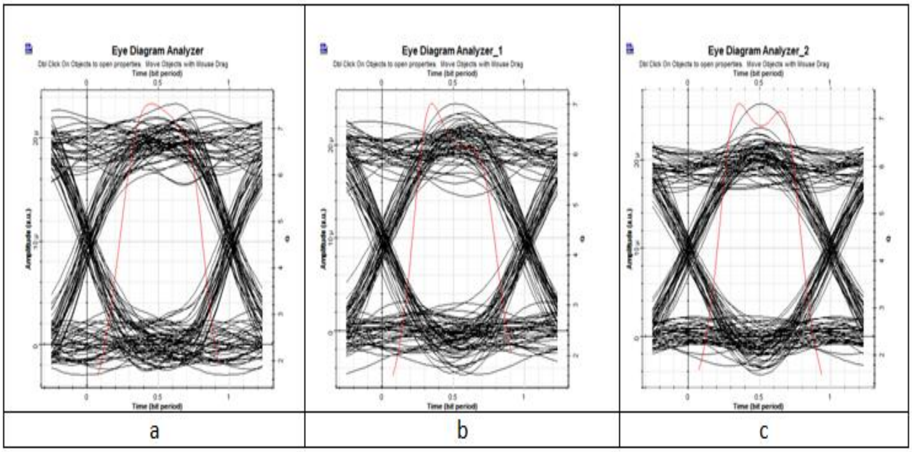


Figure6 : Optical wireless communication of length 200km at aperture diameter 10cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

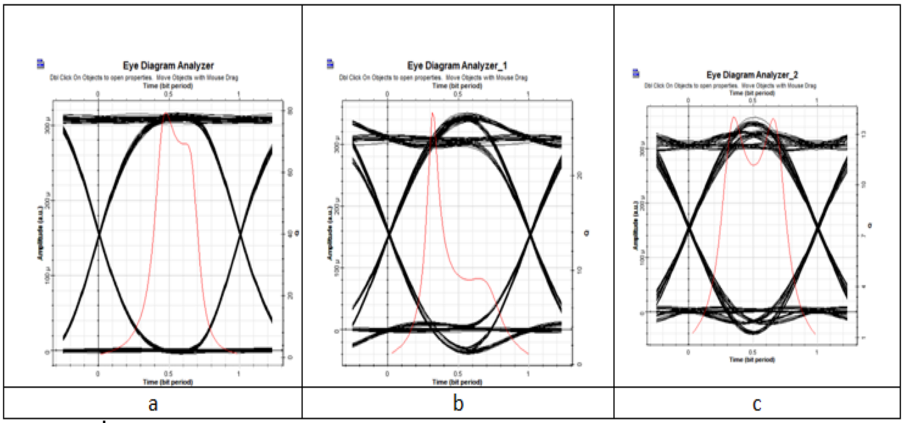


Figure7 : optical wireless communication of length 200km at aperture diameter 20cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

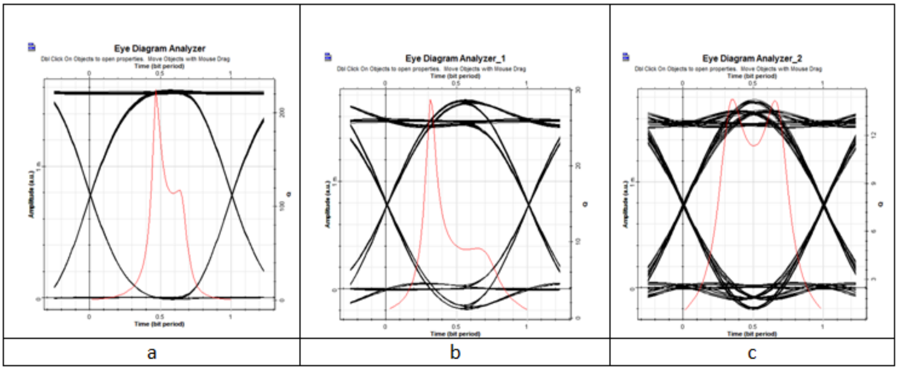


Figure8 : Optical wireless communication of length 200km at aperture diameter 30cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

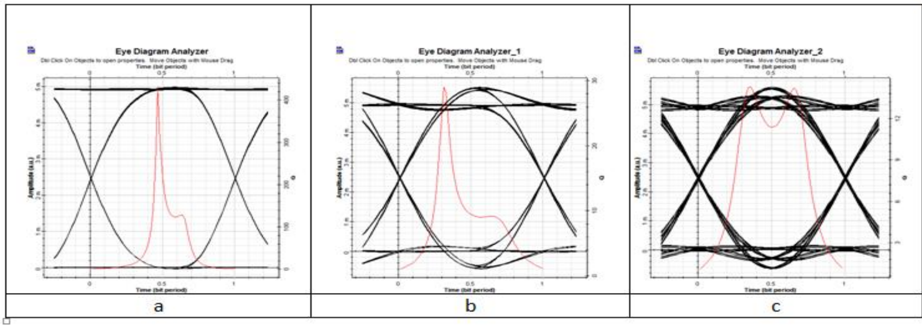


Figure9 : optical wireless communication of length 200km at aperture diameter 40cm (a)Eye diagram of Bessel filter (b) Eye diagram of Butterworth filter.(c) Eye diagram of Gaussian filter.

The relationship between maximum Q-factor and BER with the power is illustrated in figures 10, 11 and Figure 12. This relation is considered with variable distance from 100km to 400 km. The transmitted power is assumed as fixed value of 10dB. The aperture diameter is considered as 20cm for different filter types.

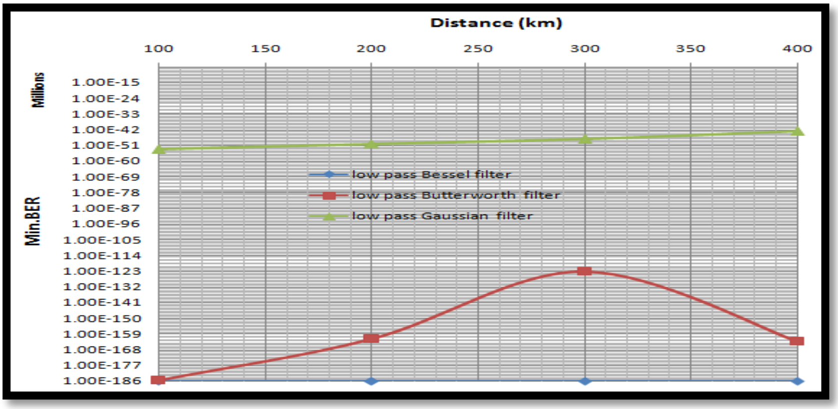


Figure.:10 Max. Q-factor vs. distance for different filters

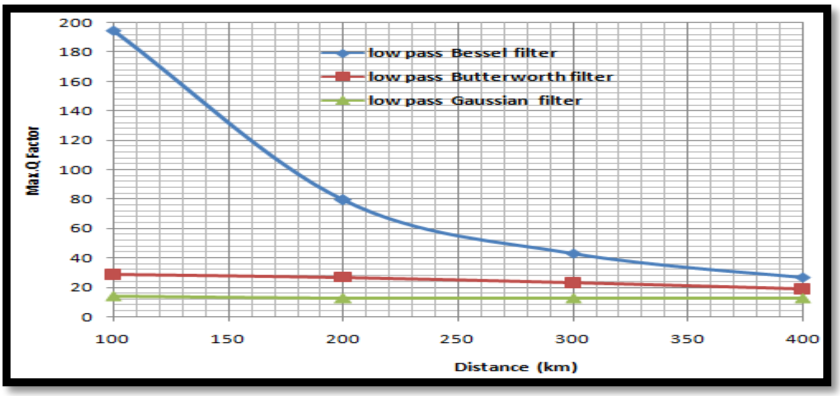


Figure.:11 Min. BER. distance for different filters

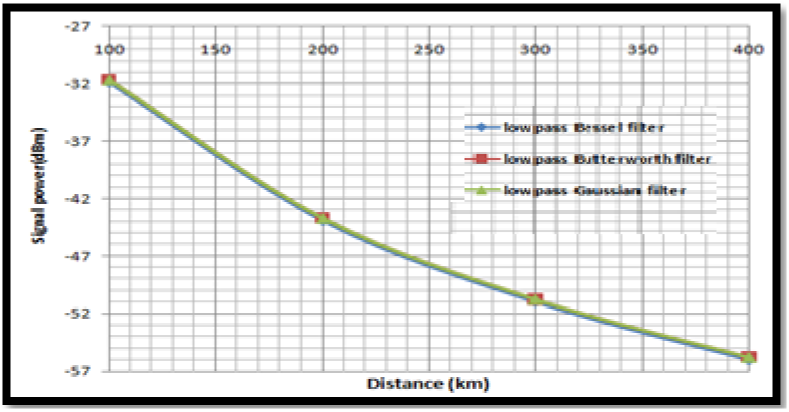


Figure 12: Received signal power vs. distance for different filters

The graphs in Figure 10 until 12 show the relationship between max Q-factor, minmum BER and received signal power for a distance variable from 100 km into 400km and set the transmitter power at a fixed value of 10dBm, for aperture diameters at 20cms, for different filters.

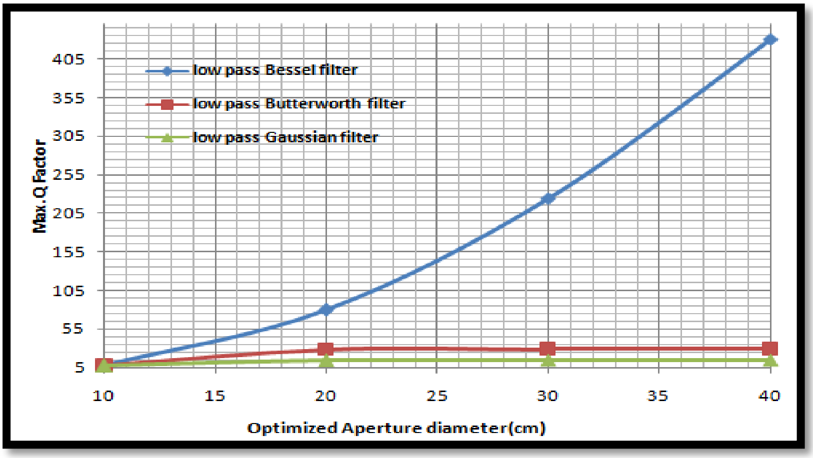


Figure:13 Max. Q-factor vs. diameter for different filters

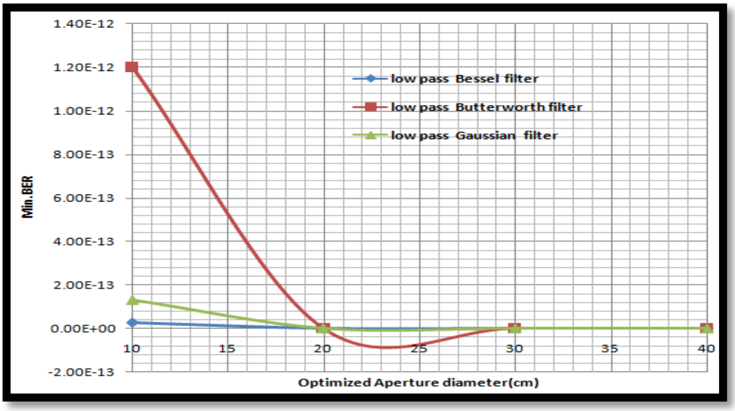


Figure 14 Min. BER. Vs, diameter for different filters

The graphs in Figures 13 until 15 show the relationship between max Q-factor, min. BER and received signal power for aperture diameters of antenna variable from10 cm into 40cm,for a distance constant at 200km.

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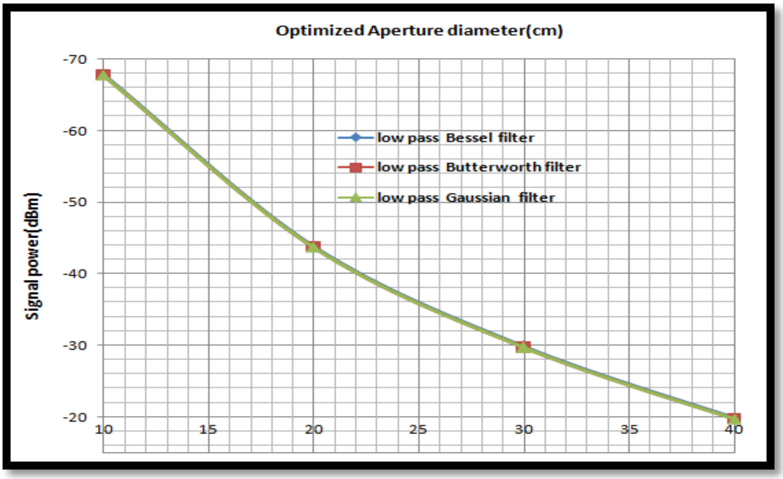

Figure 15: Received signal power vs. diameter for different filters

In this work, study performance of the inter satellite optical wireless communication can be evaluated in many ways such as by analyzing the BER and Q-factor. BER can be said to be the ratio of the number of bit errors detected in the receiver and the number of bits transmitted, a Q-factor is one of the important indicators to measure the optical performance by which the BER is characterized. Figure 2 to Figure 5 explain output eye diagrams of three subsystems, for different transmission distances give a very good eye opening at low pass Bessel filter and low pass Butterworth filter but can very narrow eye diagrams and for low pass Gaussian filter because of the increasing noise and interference by increased distances. Figure 6 to Figure 9 explain output eye diagrams which improvement with increased aperture diameters of antenna at constant distance 200km.

As seen from Figure 10 to Figure 13, comparing the results from using three channels, show four values of different aperture diameters at 10 cm, 20 cm, 30 cm, 40 cm and the link distance was set 200km through used three types of channels, then reading all these parameters at distance 200km and diameter 20cm , the signal power factor with low pass Bessel filter is- 43.9 dBm, max Q-factor79.34 and MIN. BER is zeros. For low pass Butterworth filter the signal power is -43.74 dBm, max Q-factor 28.65 and MIN. BER is 9.9e-157. Anthe endlow pass Gaussian the signal power is -43.73dBm , max Q-factor 13.99 and MIN. BER 8.86e-459.

The graph of Fig13 into Fig.15 show an experiential with increase in aperture diameters, the quality of system increases.ie, the error decreases in the received signal.

4. CONCLUSION

This paper presents three channels of IsOWC system model to provide the maximum efficiency of optical transmission in satellite system. The proposed system gave good results as shown from analyzing the signal path was several parameters of the system characteristics are varied. Consequently, the effect of aperture diameters and link distance on system behaviours is investigated. IsOWC system performance is analyzed in terms of max. Q-factor, signal power and min BER. The value of aperture diameters varies from 10 cm to 40 cm. It is observed that as when the values of aperture diameters, increase the Q-factor increases but the BER is decreases, because the Q-factor is inversely proportional to the BER. But the link distance increased from fixed value of aperture diameters, the value of signal power and Q-factor decreased then the bit error rate is also increased. Hence, the minimum value of signal power is needed for different aperture diameters. The comfort realizing the error at the receiving path increases with increase in inter satellite distance. Additionally, the antenna sensitivity is increased with increasing its aperture and the lower aperture results in low sensitivity can achieve long distance error free transmission.

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