International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-2, July 2019

Cooperative Qos Control Scheme Based on Power Allocation and Scheduling of WDM-OWC Network

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Abstract: ***In the past two decades, transfer of data can be possible with the combination of radio frequency and optical wireless communication (OWC) system. An alternative to radio frequency and fiber optic communication system is an OWC. Optical wireless Communication network have high data rate, license free spectrum, high immune to electromagnetic interference, low power and cost of optical components used. In this paper we have designed a WDM-OWC system for a range of 800 Km. Different simulation module like power allocation and scheduling have been performed on WDM-OWC. With Power allocation in which Q-factor and output power increases, whereas BER decreases other module is scheduling of OWC and it is found that 100 GHz of frequency spacing at a wavelength of 1550 nm is the best efficient in terms of Q-factor and BER.***

Keywords: WDM (Wavelength division multiplexing), OWC (Optical wireless communication), BER (Bit error rate), QoS (Quality of Service), APD (Avalanche Photodiode), LPF (Low Pass Filter).

I. INTRODUCTION

Due to the increasing demand of high data rate, wireless optical communication have been regenerated as a promising solution for future communication systems. Because of higher carrier frequency and less availability of spectrum in RF frequency ranges, there is an explosive increase is in the field of (OWC) technologies. Upcoming application and services that needs data without errors and delay, requires optical wireless communication (OWC) technologies [1]. Optical radiation have been transmitted in free space by using optical wireless communication. As we know there is a huge impact of internet on modern society, the demand of OWC have increased tremendously. OWC have huge advantages as it is a secured, safe, low cost and high bandwidth mode of communication.OWC may be used for indoor as well as outdoor applications [2]. Fig.1. Shows the basic blocks of OWC used as transmitter and receiver.

Revised Manuscript Received on 30 July 2019.
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Below Our study shows the comparison between radio and optical wireless communication [3-6].

1. For long and broadband data transmissions, optical wireless networks have high data rate, whereas in radio transmission commercial transceiver are used for Gbps data rate services.
2. Since optical wireless spectrum is license free, permission is not required for optical channels, where in wireless radio services which are on licensing band will not be able to save the money required for the same.
3. Electromagnetic interference will not effect on optical beams.
4. Optical components are cheap and less power required for transmission of optical signal as not in the case of RF power.

The rest of the paper is organized as follows design of Optical Wireless communication followed by a system parameter. The results are presented in Section 3. Finally, conclusion is discussed in Section 4.

II. DESIGN OF OPTICAL WIRELESS COMMUNICATION

A. *Optical Wireless Communication (OWC)*

OWC system is designed for higher bit rates, as millimeter waves (10 to 1 mm) were previously used whose range is limited [13]. Penetration of signal through walls is not possible in millimeter wave and more attenuation is present at a 60 GHz frequency of wave for long distances when transmit in air. For overcoming these problems a Radio over Fiber (RoF) [14-16] technology is introduced which reduces coverage problem but it is an expensive solution because RoF uses Optical Fiber cable, high speed modulators and photodiodes. As seen after implementation that RoF technology is degraded by chromatic Dispersion. A digitized radio over fiber is introduced which improves losses of chromatic dispersion but due to licensing of spectrum it is very expensive. For overall advantage as in Licensing, ease of implementation, less immune to electromagnetic interference, reduction in power consumption an OWC is introduced. The designing of a typical OWC consist of transmitter, OWC channel and a receiver. The design of OWC channel is shown under Fig. 1.The transmitters consist of data or information bearing signal which is in electrical form and converted from electrical to Optical conversion and fed to a WDM transmitter with multiplexer having a wavelength of 1550 nm i.e 193.1

THz frequency and a modulation of NRZ type. The WDM multiplexer which is used is of 8:1 type having frequency spacing of 100 GHz. The OWC link has a range upto 800 km and having a wavelength of 1550 nm followed by an Optical Amplifier of 20 dB gain and 4dB noise figure. The receiver consist of a APD photo detector, Bessels LPF and a BER tester. WDM demux is also used for converting link data into 1:8 users. The design of OWC is shown above in Fig. 2

B. **System Performance:** System can be performed in many ways like BER, Q-Factor and Power received at the output.

c. **Bit error rate (BER):** Quality of the transmitted signal can be accessed by telecommunication system which by calculating the received signal designed with the help of input. Bit error rate gives the quality of signal for any communication system. BER is the ratio of uncorrected bits received at the receiver to that of the bits transmitted. Errored bits are caused due to the presence of noise i.e an incorrect decision is made by the receiver [7].

$$\boldsymbol{BER} = \frac{1}{2}\boldsymbol{erfc}\left(\frac{\boldsymbol{Q}}{\sqrt{2}}\right)$$

$$= \frac{1}{\sqrt{2\pi Q}}\boldsymbol{exp}\left(-\frac{Q^2}{2}\right) \quad [7] \quad (1)$$

From the eq.1 it has been found that bit error rate is inversely proportional to Q-factor, as the bit error increases, Quality of the signal decreases.

Quality Factor (Q- Factor): Q-factor is a dimensionless quantity which signifies whether the system is underdamped or overdamped [8].Q-factor is estimated with the help of Optoelectrical sampling method which is used in eye diagrams.

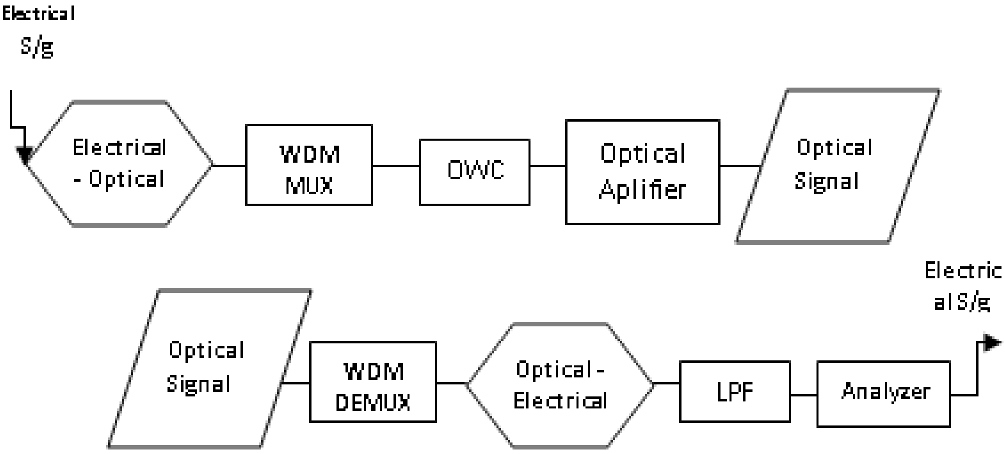

Fig. 1: A brief review of a WDM-OWC Transceiver

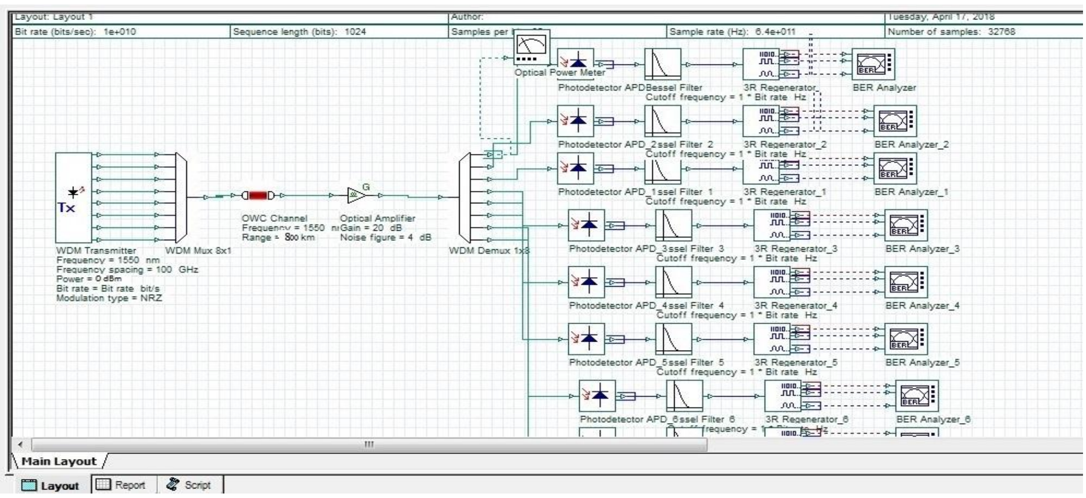

Figure 2: Design of WDM- Optical Wireless Communication

The basic block Diagram and estimation of Q-factor capturing with the help of asynchronous Optoelectical Sampling is explained by shake [17].

Q-factor is defined by

$$Q = \frac{\bar{I}_1 - \bar{I}_0}{\sigma_{1+\sigma_0}} \text{ [8]} \qquad (2)$$

Here $\bar{I}_0$ and $\bar{I}_1$ are the electrical current at the output of photo diode followed by a low pass filter and marks, respectively, and $\sigma_1$and σ_0 are the corresponding standard deviations.

I. QoS Parameters for WDM-OWC

A QoS variant of the WDM-OWC is basically a network capability to provide better service over various parameters like min. BER, Output Power and Q-Factor. As shown in fig. 3. below graph between various QoS parameter and Distance. Parameters used for Simulation of WDM-OWC is listed in Table 1 below

Table 1: Simulation Parameters for WDM-OWC

S.No	Description	Values
1.	Bit Rate	2.5 Gbps
2.	Sequence length	1024 bits
3.	Number of Samples	32768
4.	Wavelength	1550 nm
5.	Range	800 Km
6.	Amplifier Gain	20 dB
7.	WDM Frequency Spacings	100 GHz
8.	Modulation Type	NRZ
9.	Power	0 dBm

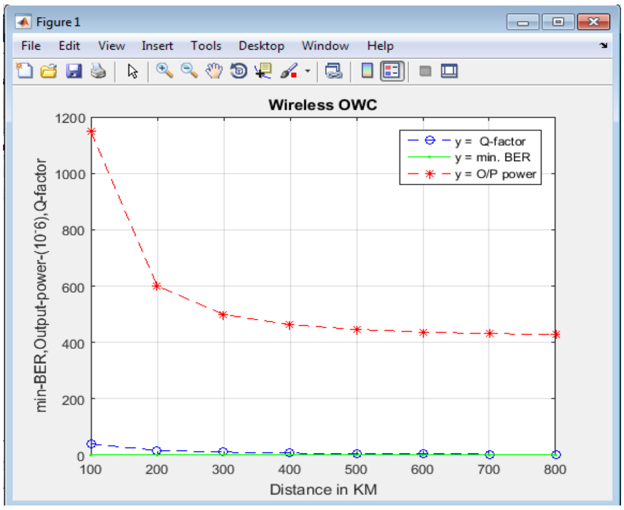

Fig. 3: QoS parameters for WDM-OWC

D. Power Allocation of WDM-OWC

For better system performance, we adopted a wavelength of 1550 nm i.e a frequency of 193.1 THz and adjusted allocated power. For improvement of QoS parameters like Q-factor and Output Power, the value of Input Power changes and as explained in equation 3 and 4, the value of received power depends on Input Power, they are directly proportional to each other, the results reflects the same. When Input power changes from 0 dBm to 50 dBm, Output power also get raised indicated by P-simulation. In Power allocation, the wavelength for the best channel condition is 1550 nm among the N number of users, we will allocate M number of Powers in dB that have maximum Output power and Q-factor.

E. Scheduling of WDM-OWC

Consider scheduling of the channel based on Wavelength division multiplexing in which an user accesses the channel with a frequency fi and then increment its frequency by fm for further improvement in QoS parameters and to access the channel for frequency having best QoS. Data of Different users are feed onto a scheduling entity (SE) which routes the data further from OWC channel and the receiver to get QoS parameters like Output Power and Minimum BER. Fig. 7 shows the steps involved in scheduling of WDM-OWC. To meet this growing demand for bandwidth, the channels were now spaced at an interval of about 400 GHz in the 1550-nm window, but it is found that by proper choice of the frequency spacings, more number of wavelengths could be added and the capacity could be increased [12] as shown in fig. 5.

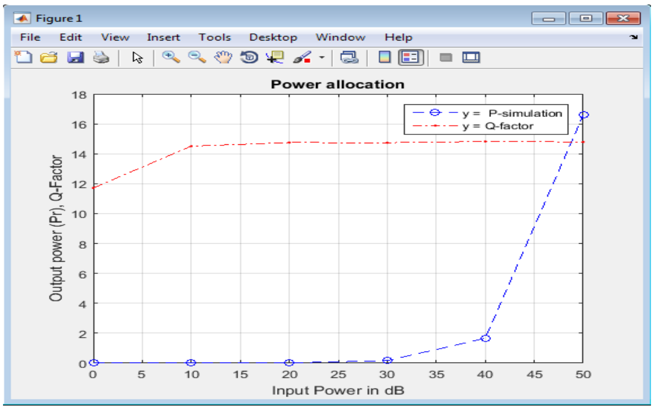

Fig.4: QoS parameters in terms of Power allocation for OWC

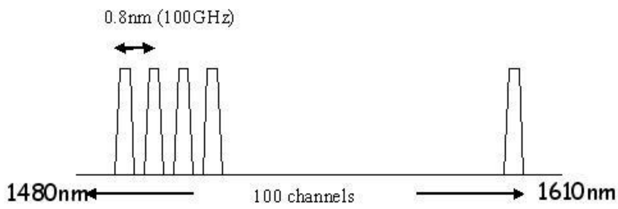

Fig.5 Wavelength spacing in WDM [12]

For Scheduling of WDM-OWC Multiplexer is divided into M number of frequency i.e having a frequency spacing of fs GHz and the range of OWC is 800 km also the wavelength for transmission is 1550nm.For getting better QoS parameters, frequency spacings of WDM-MUX have been changed. For getting this we have allocated a frequency fi to the user and check the design and compute the QoS parameters. Increment the spacing by fm where fi>fm i.e now frequency is (fi+fm) and check the design if there is a maximum increase in QoS parameter, this frequency is taken as a reference frequency for the further analysis. Fig. 6 below is the graph between various QoS parameter and Frequency.

III. RESULTS AND DISCUSSION

In this paper WDM-OWC is designed with the help of Optisystem 15.0 having a transmission length of 800 Km, wavelength of 1550 nm, 20 dB gain of Optical Amplifier, 4dB noise figure, APD detector at the receiver side followed by a Bessel filter and BER analyzer. Fig. 2 Design of WDM OWC system at wavelength of 1550 nm Fig. 3 indicates the graph between QoS parameters like (Output Power, Q-factor and min. BER) versus transmission distance in Km. The result reveals that there is a significant decrease in the value of output Power, as the distance is increasing from 100 Km to 800 Km, it is also been observed that Q-factor is also decreasing. As the distance is increasing the error in the received signal increases. To overcome this in our design we have allocated different input powers at the input so that for the same transmission distance the Output Power and Q-factor has been improved, this can be shown in Fig. 4, where there is an improvement in power.

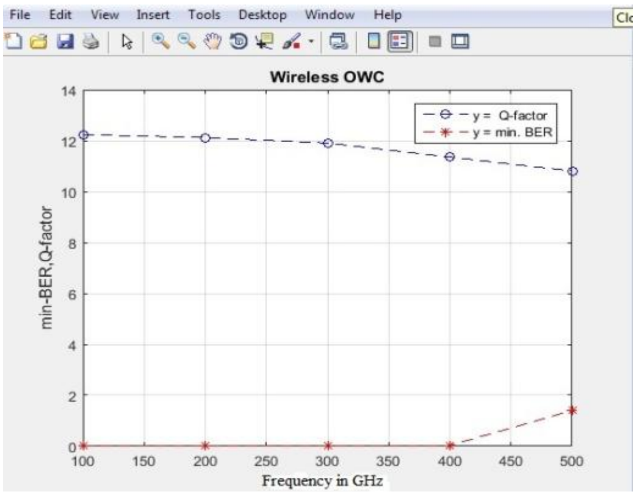

Fig. 6: Scheduling and QoS parameters for WDM-OWC

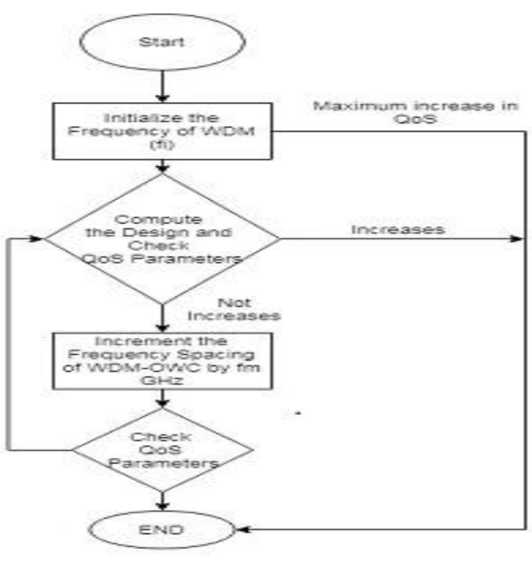

Fig. 7: Structure of scheduling in WDM-OWC

The transmitter and receiver gains are 0dB. The transmitter and receiver antennae are also assumed to be ideal where the optical efficiency is equal to 1 and there are no pointing errors. The operated optical window was set at a wavelength of 1550 nm, as seen from eq. 4, Received power is directly proportional to transmitted power which is indicated in Fig. 4 Fig. 4 indicates the graph between Q-factor and Output Power versus different allocated powers at input. From results it has been observed that Q-factor increases on increasing the input power, also there is a significant increase in Received Output power. Fig. 7 shows table between Q-factor and minimum BER versus different frequency spacings of WDM. From results it has been observed that there is significant decrease in the value of Q factor, which lies within {12 to 10 dBm} for transmission distance of 800 km in case of frequency spacings 100 to 500 GHz respectively. Further, it has been observed that there is significant increase in the value of BER for transmission distance of 800 Km for a wavelength of 1550 nm. As seen from the results the frequency spacing between users must be 100 Ghz, at this frequency overall capacity of the system increases because as the spacing increases, Q-factor decreases and hence BER increases. As the spacing is large, filtering is easy without ISI but overall bandwidth requirement increases.

IV. CONCLUSION

In this work, WDM-OWC system were designed to have a link of 800 Km and simulated over various system parameters were varied to get the analysis of system performance. From the result analysis it is found that by proper selection of frequency spacing of 100 GHz,data can be transmitted with min. BER and overall system quality is good as Q-factor is maximum at 100 GHz. Also observed with the results that by changing the power at the input we can improve the QoS Parameters of WDM-OWC.

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Retrieval Number: B1511078219/19©BEIESP
DOI: 10.35940/ijrte.B1511.078219
Journal Website: www.ijrte.org

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