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Manchester Signaling Scheme for Ground to Satellite DWDM Communication

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Abstract*: For the modulation of various data streams, Wavelength division multiplexing is utilized. Further, Dense Wavelength Division multiplexing is the type of WDM which is capable of spacing the wavelengths more closely due to its greater capacity. This technology is widely used in fiber optics as it utilizes the bandwidth in an appropriate manner. Various researchers have been carried out to make it worth using. Recently, in research, the author had used DWDM in clear weather conditions and turbulence generated in a channel. In this work, the author had utilized the RZ modulation technique which has some drawbacks. Due to this, the performance of the entire model is affected. Thus in this paper, a novel approach is presented to overcome the problems of the existing system. In the novel system, RZ encoding is replaced by Manchester encoding. Manchester encoding has several advantages over RZ encoding. Further, the simulation of the model is performed under the opti-system. Here, the Q-factor of both (proposed and with RZ encoding) models are determined in terms of a single channel, 4 channels, and 16 channels. The results showed the effectiveness of the proposed system as it increases the quality of the signal transmitted from one source to another.

Keywords: OWC, DWDM, RZ modulation, Manchester encoding technique, Q-factor

I. INTRODUCTION

The usage of the Internet has shown a steep rise in multimedia users who demand high data rates. Radiofrequency (RF) is getting a noteworthy strain due to this demand. OWC has emerged as a rescue to its problem by providing huge data rates at a high-security level. This technology has opened the doors to make complicated communication easier [1]. For instance: high capacity, high data rate, and least interference links for communication with short-range, inter-building communication, and sensor networks. The biggest challenge in this approach is to preserve the beam quality in the presence of adverse conditions as well as turbulence [2]. Various does are done to utilize the whole bandwidth offered by OWC which not only improves reliability but also avoids severe link failures. One of the promising solutions in this race is Dense Wavelength Division Multiplexing (DWDM).

The utilization of DWDM in the OWC can greatly increase system capacity and transmission distance performance. A network that has to be stable against linear and non-linear effects such as cross-phase and self-phase modulation, polarization modes, etc is needed with a constantly changing environment. OWC networks set standards for low-cost, lower power and long-term transmission applications, although long fiber optic cables are challenging to deploy.

Through the deployment of DWDM, data can even be transmitted over a thousand kilometers range at a high speed (Tbit.S-1) in optical transport networks. The features of DWDM, despite its economic costs, make this technology highly competitive for international telecommunications transmission providers. DWDM systems mainly utilize a bandwidth around 1550 nm as its primary width, and the range from 1525 to 1610 is utilized by the channels [3]. Today, a system with 16, 24, 40, 80 128 and 256 channels are used commercially. Channel range utilized for 40 and 80 channel systems is 100 GHz and 50 GHz respectively. The width of the spectral wavelength for each channel is determined by this separation, i.e. as the channels are close together [4].

In this technique (DWDM) optical signal multiplexing is done at different frequencies and frequency separations which take advantage of the OWC range. A de-multiplexer is used at the receiver side to split the multiplexed signal transmitted via the OWC Channel (OWCC). The laser beam meets different factors when passing through OWCC such as dispersion, atmospheric loss, sparks, etc. These factors are responsible for deteriorating the quality of the signal.

Optical amplification is a primary technique to increase the transmission efficiency in a network of optical fibers [5]. Transmission studies with various optical and hybrid optical amplifiers (HOAs) have been published in recent years, using the capacity of terabit power per second, in the DWDM transmission. To improve the system's ability and decrease the performance degradation caused by transmission loss, the designing and optimization of the system would be required. The spectrum efficiency, transmission quality and dispersive system tolerance would be determined by the optical system's optical code pattern. The signal format for the fiber-optic system is therefore needed to be optimized. In literature, the researchers have reported on various formats of modulation for high-speed DWDM systems [5].

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II. LITERATURE REVIEW

In order to increase system capacity and decrease the performance degradation of the DWDM system, various authors have proposed different approaches that are discussed in this section. In the article [6], the author introduced a 40 GB/s 8 channels' DWDM that depends on FSO communication system. In this, the RZ modulation was used and at the distance of 4000 m, at divergent channels that are 1, 4 and 8, the bit error rate for RZ modulation format was 2.32e-17, 1.70e-16 and 9.51e-15 respectively.

In paper [7], the author introduced a 43 GB/s DWDM system based on NRZ Format and Electro-absorption Modulation. It consisted of 900 km single-mode fiber with 100 km spans.

The author analyzed optical modulation formats for the DWDM approach in paper [8]. The analyzed outcome depicted that the highest data rate for NRZ-OOK modulation format and RZ-OOK modulation format was 100 GB/s and 50 GB/s respectively.

In order to achieve a higher rate of data for future inter-satellite communication, OWC or optical wireless communication system can be utilized. In the article [9], the author introduced Lp-Is OWC (Low power Inter satellite Optical wireless Communication) system based DWDM having higher capacity.

The author of the paper [10] introduced a 64 channel DWDM model having a data rate of 20 Gbps and channel spacing 1.28 Tbps. Except this, analysis of EDFA and transmission capacity of hybrid configuration was carried out on the factors like bit error rate and quality factor.

In the article [11], the author introduced a 10x16 GB/s DWDM system consisting of 50 GHz frequency space in clean atmospheric conditions and irregular atmospheric conditions with 15000 km distance. The analysis depicted that Q factor directly depends on the optical power transmission and vice versa with turbulence impacts in RZ and NRZ modulation format.

In order to investigate cross-phase modulation or XPM, the author in [12] implemented a DWDM system having 4 channels. After investigated XPM, it was suppressed from the optical fiber with the selection of transmit power levels operated at 193,025 THz to 193,175 THz.

In order to transmit the data at long distances, the author in paper [13] analyzed the performance of the Inter Satellite OWC system link by using the DWDM approach. Except for this, the author analyzed return to zero or RZ and non-return to zero or NRZ modulation formats with divergent power levels.

In the article [14], the 5×16 Gbps DWDM system was proposed with 16 users sending 5 Gbps each with channel spacing 100 GHz to the satellite. RZ formatting was done in this and 16 channels are multiplexed at the transmitter side.

This proposed work is considered an efficient system. However, in this work, the RZ modulation is used which consists of various drawbacks.

III. PRESENT WORK

As mentioned above, in conventional work [14], the RZ modulation is used which consist of various drawbacks:

- There is the presence of the DC level.
- The continuous part is non-zero at 0 Hz which causes "Signal Droop".
- Does not have any error correction capability
- It is not transparent.

Due to these pitfalls, it degrades the performance of the system.

Therefore, in order to overcome the issues caused by RZ modulation, the Manchester encoding is used in the proposed work instead of RZ modulation.

The Manchester coding is used in the proposed work because it consists of various advantages that overcome all the previous issues and helps to enhance system performance. These advantages are:

- There is no dc component because each bit has a positive and negative voltage contribution.
- Does not suffer from signal droop (suitable for transmission over AC coupled lines)
- It has an error detection capability.
- It provides a transition for every bit in the middle of the bit cell i.e. synchronization on mid bit transition.
- Easy to synchronize with.

Thus, due to all the aforementioned advantages, the Manchester encoding overcome all the previous issues of RZ modulation and thus can help to achieve efficient results.

Also, in the previous work, the modulation is done for 16 channels only. However, the user demand is increasing day-by-day, for which 16 channels cannot be sufficient enough. Therefore, in the proposed work, 32 channels are considered for the modulation.

Thus, with the help of the proposed approach, all the previous issues can be overcome and thus the efficient system can be achieved.

IV. RESULTS AND DISCUSSIONS

This section explains the simulation results carried out to analyze the performance of the proposed system. A comparison is carried out for existing (RZ-OWC) and proposed work (Manchester-OWC) with respect to different numbers of channels and power in the network.

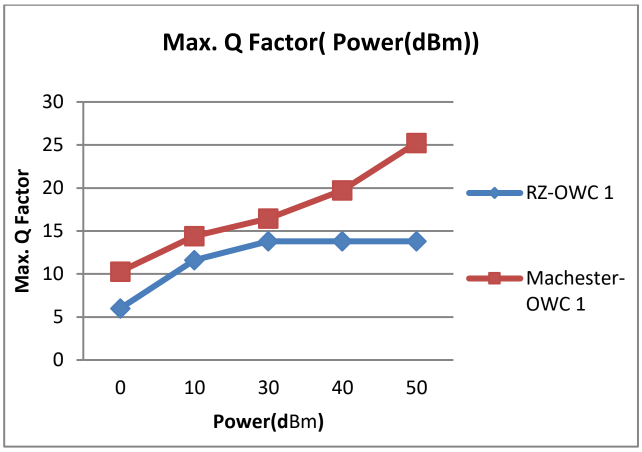

Fig. 1. Max Q-factor for single-channel

Fig. 1 exemplifies the comparative view of the max Q-factor with respect to power. The graph represents the q-factor on the y-axis and power on the x-axis. The range of power lies between 0 dBm to 50 dBm and for Max. Q-factor, it is from 0 to 30. The graph clearly shows that the max Q-factor for the proposed work is higher than that of the existing approach. When the power is high, Q-factor is also high. The Q-factor obtained in the proposed model is just below twice the Q-factor for the existing system which shows the efficiency of the Manchester-based OWC. The corresponding values of Q factors are given in Table I.

Table- I: Maximum Q-factor for a single channel with respect to power

Power(dBm)	Single-Traditional	Single-Proposed
0	6	10.29
10	11.6	14.42
30	13.8	16.44
40	13.8	19.74
50	13.8	25.24

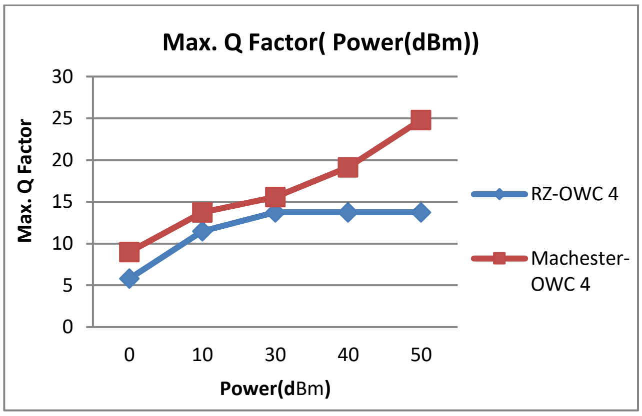

Fig. 2. Max Q-factor for 4 channels

Similarly, for 4 channels based model, the results are compared and presented in a graphical manner. The results are demonstrated in fig. 2. In 4 channels based communication, the Q-factor for both the approaches increases with an increase in power.

At low power, the Q-factor for proposed and traditional model accounts to 8.99 and 5.8 respectively. However, when the power is increased, the difference between the values obtained for Q-factor is also increased. The maximum q-factor at 50 dBm is 24.82 for Manchester-OWC and 13.75 for traditional RZ-OWC which ensures the efficacy of the projected system.

A table (Table II) is presented in which the values of the Q-factor obtained at different power values are recorded.

Table- II: Maximum Q-factor for 4 channels with respect to power

Power(dBm)	4-Traditional	4-Proposed
0	5.8	8.99
10	11.5	13.74
30	13.75	15.59
40	13.75	19.13
50	13.75	24.82

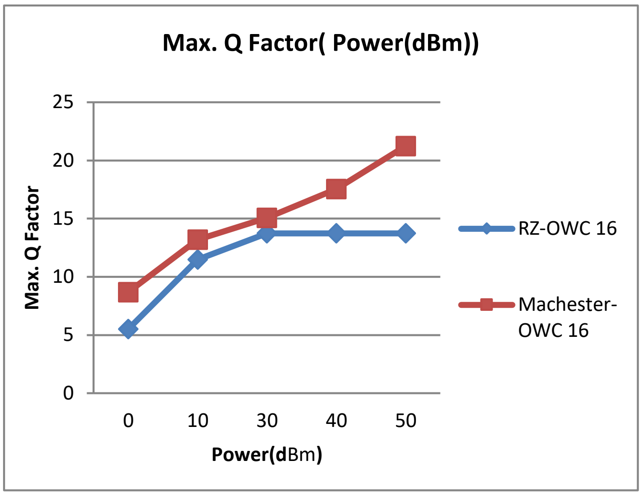

Fig. 3. Max Q-factor for 16 channels

The comparison performed for 16 channels based on OWC is presented in fig. 3. The graphical view presents that proposed Manchester OWC has a high Q-factor than traditional RZ-OWC. The maximum Q-factor obtained for proposed work at the highest power is 21.24 which is higher than that of the existing approach. The respective values of the Q-factor are recorded in Table III.

Table- III: Maximum Q-factor for 16 channels with respect to power

Power(dBm)	16-Traditional	16-Proposed
0	5.5	8.68
10	11.48	13.19
30	13.73	15.06
40	13.73	17.54
50	13.73	21.24

From the above discussion, it is clear the proposed work is better than the existing approach as it generates high-Quality factor, therefore, signal distortion is very less in the model.

V. CONCLUSION

DWDM is a technology used for proper utilization of the bandwidth in optical communication. This technology is one of the most used technologies in optical fiber. In previous work, it has been used with RZ modulation which is countered to be effective but RZ modulation lacks in some aspects which affect the performance of the system. The problem affecting the efficiency of the existing model is overcome by implementing a novel modulation technique, i.e., Manchester Encoding technique. It is implemented due to its advantageous features.

It enables the model to easily synchronize and reduce complexity. The signal distortion is also reduced. The simulation of the proposed Manchester- OWC is performed in Optisystem environment. This process is carried out in three different channels: single channel, 4 channels, 16 channels. The results are obtained for each channel. A comparison with the existing system is performed in order to validate its efficiency for single, 4, and 16 channels only. The quality factor is the main parameter on the basis of which the entire performance is determined. It is observed that the quality factor for the Manchester encoding based approach is higher than the existing mechanism. There is a great difference which can be seen for Q-factor obtained for proposed work. For the proposed technique, the values obtained for single-channel, 4 channels and 16 channels are 25.24, 24.82 and 21.24 respectively at 50 dBm which is higher than that of an existing system. Thus it ensures the effectiveness of the proposed model.

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