Analysis of Walsh & FCC codes with EDFA & Raman Amplifiers in Optisystem

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***Abstract*— Due to the increased usage of optical communication, it has become the major topic for the research work among the research community. The optical communication has various sub domains under it. A large number of researches have been done in this domain and some of them are still under process. This study also contributes in this list of researches by working on optical amplifiers in optical communication. At initial stage, first of all the traditional work that has been done in respective domain has been analyzed and it is evaluated that it lacks at various factors such as the amplifiers were not utilized and implemented in an effective way and along with this the NRZ modulation scheme was implemented that has its own drawbacks. After finding the loopholes in traditional work, the proposed work develops a novel mechanism by using the RAMAN and EDFA amplifiers. Along with this, the code schemes like PN codes, FCC codes and Walsh codes are also implemented. The proposed communication system is modeled in two different ways with unique configuration i.e. single stage model with PN code, FCC code, Walsh code and three stage model with PN code, FCC code and Walsh code respectively. In proposed models, the DRZ modulation scheme has been used. After analyzing the simulated results, the proposed models have been found to be quite effective and impressive with lower BER and high Q factor.**

Keywords—Optical Amplifiers, Raman amplifier, EDFA, Hybrid amplifier, Amplifier Gain.

I. INTRODUCTION

Due to the advancements in wireless communication media it seems as the global internet protocol traffic reached at a massive level and it is also predicted that it can cross the threshold of zeta byte till the end of the 2016. This growing requirement of higher data rates is fulfilled by optical communication system. This communication system transmits the data from transmitter to receiver in the form of light wave through optical fiber. This electromagnetic wave is modulated and carries the information potentially. The concept of optical communication was initially introduced in 1970s and from that period to till the date this becomes as an evolution or milestone in the field of telecommunication. To enhance the performance of the proposed work the advanced coding techniques as well as FCC codes and Walsh codes are used that are illustrated below as:

1.1 Walsh Code

By attaining high auto correlation and low cross correlation properties the Walsh codes are mutually orthogonal error correcting codes as well as fixed length codes. The n bit messages are encrypted into 2^n bit orthogonal code words by the linear code that is Walsh code. At the time when even one fourth of the bits have been corrupted the real message can be retrieved. In communication mechanisms these codes have crucial applications. Because of the simplicity of the execution the popularity of the Walsh codes exists. Every Walsh Code is orthogonal to every another Walsh code, that means it is feasible to recognize and thus extort a specific Walsh Code from a combination of other Walsh codes. If the result of xoring a couple of similar length binary strings has the same number of 0s as 1s afterward they together are supposed to be orthogonal. From Hadamard matrices of orders that are a power of 2, the one of the mechanisms of Walsh codes generation is occurred. The Walsh Codes are contained in the rows of 2N order matrix that encrypts N bit sequences [3]. Initiating from H1 = [0] and ∀n > 1 the Hadamard matrices are constructed recursively.

$$H_{2n} = \begin{bmatrix} H_n & H_n \\ H_n & \overline{H_n} \end{bmatrix}$$

Here $\overline{H_n}$ is the complimentary of H_n. Through locating the matrix H_n in the first three quadrants as well as locating the complimentary of H_n in the fourth quadrant the Matrix H_{2n} is created.

1.2 Flexible Cross Correlation (FCC) Codes

A set of K is considered in this, weight *w* and reliable in-phase cross correlation codes of length N for K users. The K rows of the K×N matrix represent the set of codes. The elements of A_K^w are a_{ij} that are illustrated below as:

$$A_K^w = \{a_{ij} = '0' \ or \ '1', i = 1,2, \dots K, j = 1,2, \dots N\} \quad (1)$$

Here

A_K^w = Code Matrix

The K rows of A_K^w are used to represent the K codes that are independent as well as unique. The Code Matrix must have K rank because of that

$$N \geq K \quad (2)$$

The K rows of the K×N A_K^w are used to present the set of code matrix the elements of which are represented in equation (1). An optical code is presented by every row of the K×N matrix i.e. A_K^w. The *w* is presumed to the weight of every K code. Here the equation number 3 shows the matrix of A_K^w as well as the K code words are represented by the rows that are A_1, A_2, A_K.

$$A_K^w = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1N} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2N} \\ . & . & . & & . \\ . & . & . & & . \\ . & . & . & & . \\ a_{K1} & a_{K2} & a_{K3} & \dots & a_{KN} \end{bmatrix} \quad (3)$$

Here,

$$A_1 = a_{11}, a_{12}, \dots \ a_{1N}$$

$$A_2 = a_{21}, a_{22}, \dots \ a_{2N}$$
$$A_K = a_{K1}, a_{K2}, \dots \ a_{KN}$$

1.3 DRZ

Fig.1 determines the schematic of DRZ transmitter. Owing to their optical modulation bandwidth, DRZ organization is very attractive. It can be compressed to the data bit rate B that is half- bandwidth of NRZ arrangement 2B [40]. Similarly, the working of MDRZ is shown in figure 1.6.

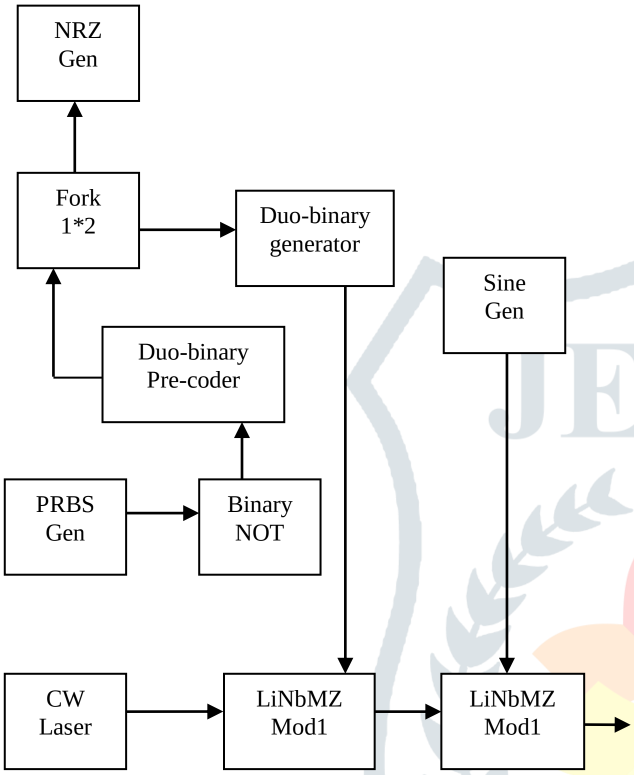


Figure 1 DRZ Modulation Scheme

II. PROBLEM FORMULATION

With the increase in the technology of networks and the internet, the need of the users also increases. The requirement of high bandwidth, high data transmission rate, etc increases. To fulfill this need the concept of WDM and fiber optic was developed. WDM is a wavelength division multiplexing. In which the multiple input signals are combined together and transfers as a single input. It uses the concept of multiplexing and de-multiplexing. In the existing work 8 signals with different wavelengths are transmitted at 10 Gbps with reduced channel spacing of 50 GHz. Each signal is modulated by NRZ format. The use of NRZ have some disadvantages like no error correction will be done using it, signal may drop due to presence of low frequency components, absence of clock, loss of synchronization is there in it. To remove this we will use another advance modulation scheme that will help in overcoming the drawback of using NRZ. This part is done at receiver side. At the receiver side, all the channels are demultiplex and pass to individual's receiver. Another issue that was faced in earlier developed systems was that no advanced coding scheme is utilized to improve the performance of the system. Hence there is a requirement to develop such a system which will improve the overall BER of the system as well as enhance the performance of the system.

III. PROPOSED WORK

The previous section gives a brief revelation to the existing inventions that has been done in the field of optical networks to make it advantageous to the users. But after getting more engaged into the inventions various inabilities were brought up to the existence which was related to the Quality factor and BER reduction. Hence it is adjudicate to flourish such a mechanism which can overcome the previous limitations. The proposed work is decided to implement a hybridization of two amplifiers such as Raman-EDFA and replacing the existing NRZ modulation scheme with improved DRZ scheme that is the advanced coding scheme is utilized in the proposed work in order to enhance the performance of the projected mechanism. Additionally, the PN diode is used in this work in order to overcome the NRZ issues. The BER of the system is improved by testing it using different filters. So, the existing system will be tested using different filters and compared it in terms of BER.

In Figure 2 the simulation model of single stage for PN, FCC and Walsh code is shown. In this model initially, DRZ transmitter is used to transmit its duo binary return to zero signal to EDFA amplifier through optical fiber as well as to the optical spectrum analyzer. The Erbium Doped Fiber amplifier is used to enhance the intensity of the signal that is optical signal received from the optical fiber and transmit this signal to the Raman amplifier that is used to amplify the optical signals over long haul fiber optic communication. The other signal to the Raman amplifier is comes from Pump laser. The output of the Raman amplifier is transmitted to the rectangle optical filter that is used to filter the received optical signal. This filtered signal is received by the Photo detector in order to detect the light signal and transmit this signal to the Low pass Squared Cosine Roll off Filter, the outcome of which is given to the 3R regenerator that is used to regenerate the signal and the final BER output is attained by the BER analyzer in which Max. Q-factor is 0 as well as Min. BER is also 0.

The simulation model for three stage is shown in Figure 3

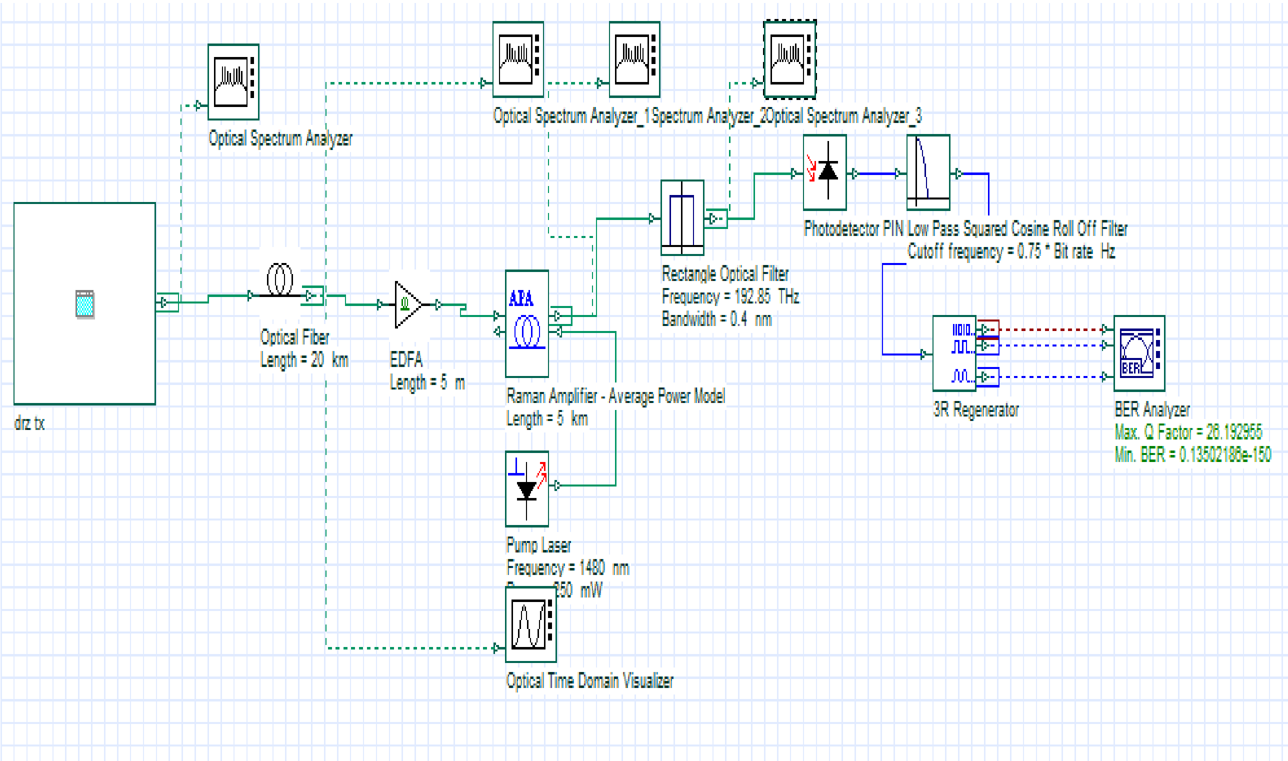


Figure 2 Proposed optisystem simulation Model for Single Stage

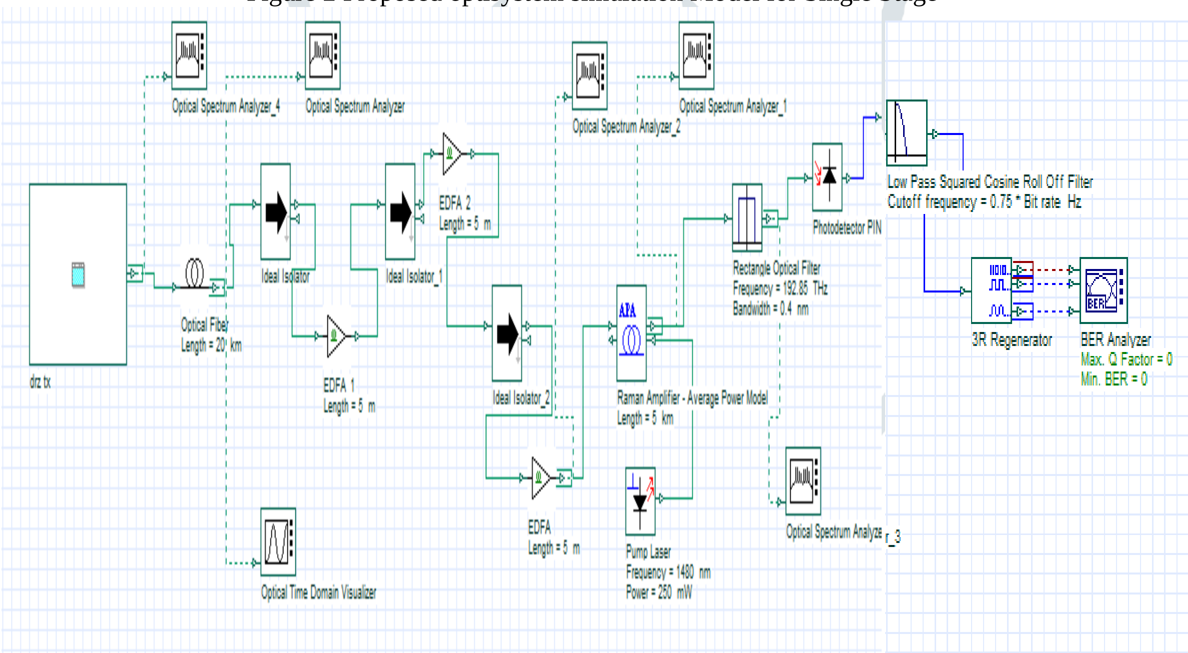


Figure 3 Proposed optisystem simulation Model for Three Stage

The structure as well as working of three stage models is similar to the single stage model despite the fact that there is only one EDFA amplifier is used in the single stage model but three stages of EDFA amplifier and ideal isolators are used in three stage simulation models. No ideal isolator is used in single stage amplifier.

IV. EXPERIMENTAL ANALYSIS

In this section performance of parameters like maximum Q-factor, BER, Eye Height, and threshold is evaluated as the resultant outputs are obtained in Optisystem software. In order to enhance the performance of the system as well as improve the Bit Error Rate a new mechanism that is hybrid of Raman-EDFA is proposed and the outcomes are illustrated in this section. The proposed work is implemented by using various codes i.e. PN codes, FCC codes and Walsh Codes. The performance of the proposed system is analyzed with respect to the different stages and coding systems i.e. single stage system with considered code scheme and three stage system with respective code scheme.

A. Single Stage:

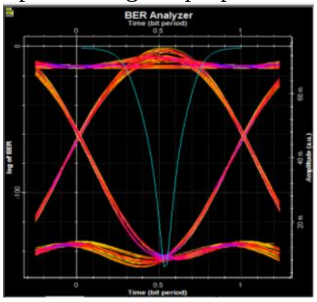
The single stage system is designed by using EDFA and RAMAN amplifier without any ideal isolator. The amplifiers are used once only in this model.

B. Three Stage:

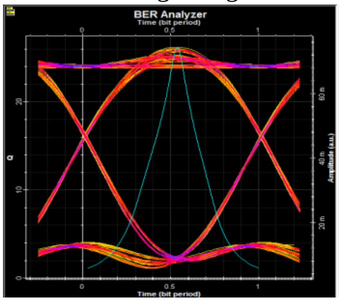
As in single stage model, the amplifiers are used at single state without using any ideal isolator but in three stage model, the EDFA-RAMAN amplifier is used twice and along with this, the three stage ideal isolator is also applied.

Analysis of proposed work for PN Singe Stage:

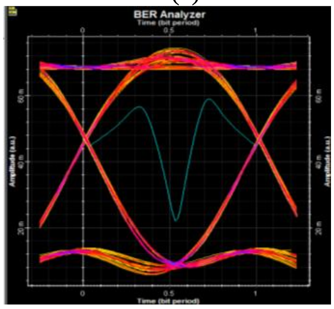
This section defines the results that are obtained after implementing the proposed model for PN single stage.



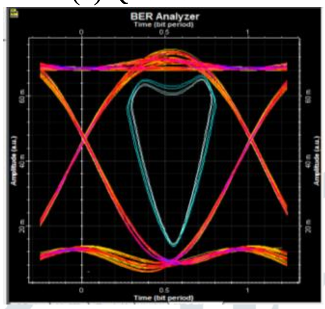
(a) Min BER



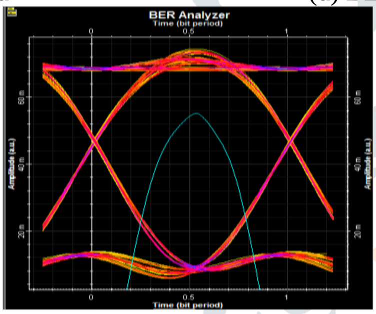
(b) Q-factor



(c) Threshold



(d) BER Pattern



(e) Eye Height

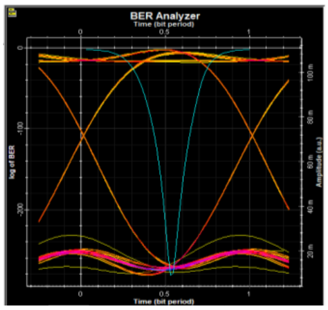
Figure 4 Performance analysis of proposed single stage model with PN codes

The graph of Figure 4 shows the eye diagram of (a) Minimum BER, (b) Q-factor and (c) Threshold (d) BER pattern and (e) Eye height of PN for single stage simulation model. In this graph on the x-axis Time is shown in bit period that ranges from 0 to 1 whereas the log of BER, Q-Factor and Amplitude is shown on the y-axis. The value of Minimum BER is 1.35022e-151, value of Q-Factor is 26.193 and the value of Threshold is 0.022161. The values of parameters for PN single stage are shown in table 1.

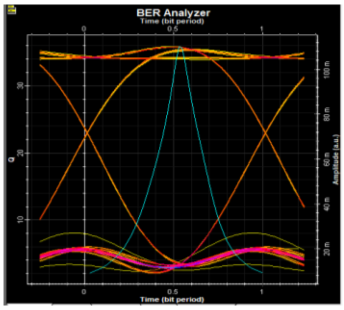
Table 1 Performance parameters with values for proposed single stage model with PN codes

S.No	Parameters	Values
1	Maximum Q-factor	26.193
2	Minimum BER	1.35022e-151
3	Eye Height	0.0552081
4	Threshold	0.022161
5	Decision Inst.	0.53125

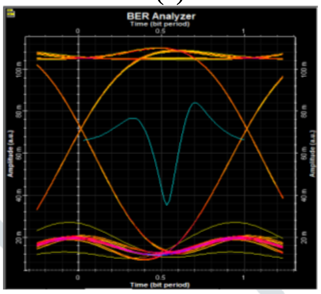
6.2.2 Analysis for FCC Single Stage:



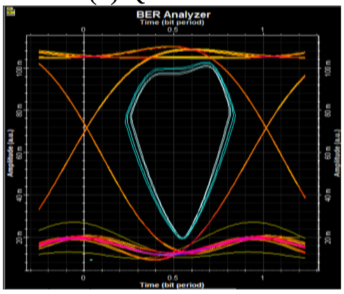
(a) Min BER



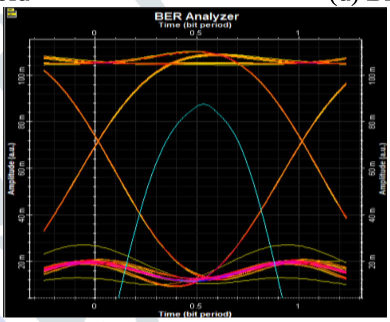
(b) Q-factor



(c) Threshold



(d) BER Pattern



(e) Eye Height

Figure 5 Performance analysis of proposed single stage model with FCC codes

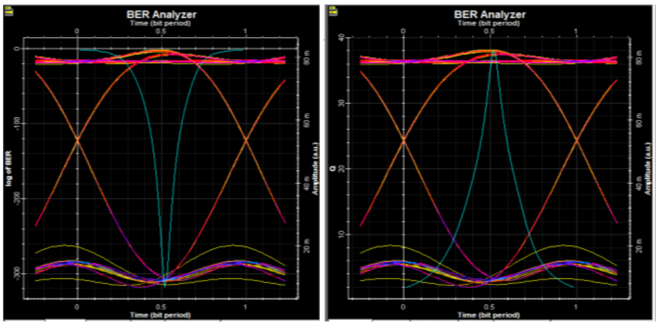
The eye diagram of Figure 5 shows the Min BER, Max. Q-factor, Threshold, BER pattern and eye height of FCC for single stage. The values for maximum Q-factor, Minimum BER, Eye Height, Threshold and Decision Inst are 35.8645, 3.47739e-282, 0.0875391, 0.0352548 and 0.53125 that are shown in table 2.

Table 2 Performance parameters with values for proposed single stage model with FCC codes

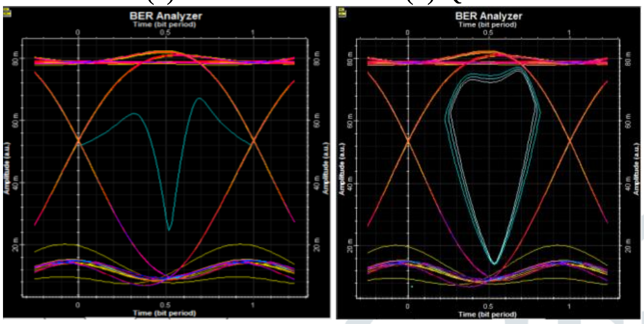
S.No	Parameters	Values
1	Maximum Q-factor	35.8645
2	Minimum BER	3.47739e-282
3	Eye Height	0.0875391
4	Threshold	0.0352548
5	Decision Inst.	0.53125

6.2.3 Analysis for Walsh Single Stage:

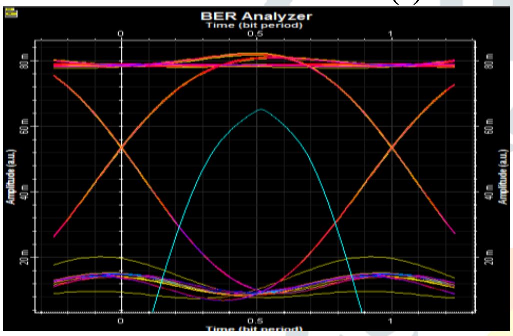
The eye diagram of figure 6 depicts the Min BER, Q-factor, Threshold, BER pattern and eye height of Walsh codes for single stage. The value of Min. BER is shown on y axis that is 5.36491e-319; the value of Q-factor is also shown on y axis that is 38.1593, the value of threshold is 0.0245201 as shown in Table 3.



(a) Min BER (b) Q-factor



(c) Threshold (d) BER Pattern



(e) Eye Height

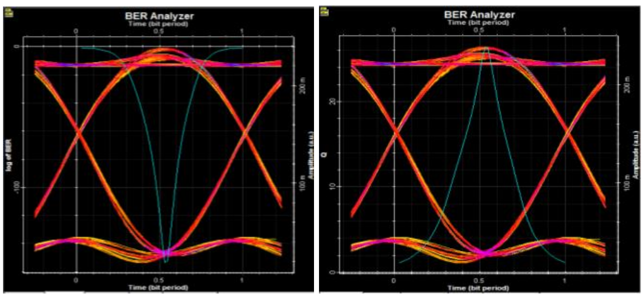
Figure 6 Performance analysis of proposed single stage model with Walsh codes

Table 3 Performance parameters with values for proposed single stage model with Walsh codes

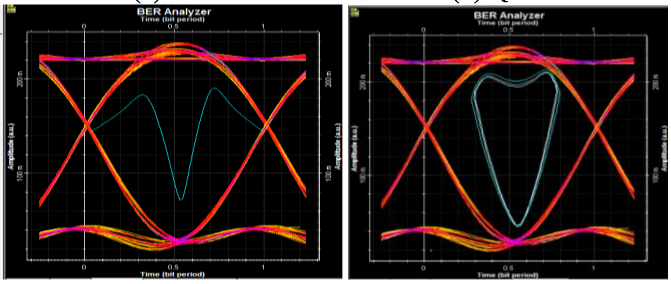
S.No	Parameters	Values
1	Maximum Q-factor	38.1593
2	Minimum BER	5.36491e-319
3	Eye Height	0.0651218
4	Threshold	0.0245201
5	Decision Inst.	0.515625

6.2.4 Analysis for PN Three Stage:

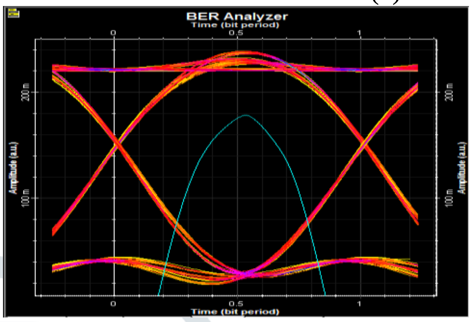
The eye diagram of figure 7 shows the (a) Min BER (b) Q-Factor and (c) Threshold (d) BER pattern and (e) Eye Height PN codes for three stage model. The values of these parameters are shown in table 4 that are Maximum Q-factor = 26.4198, Minimum BER = 3.43337e-154, Threshold = 0.0714967.



(a) Min BER (b) Q-factor



(c) Threshold (d) BER Pattern



(e) Eye Height

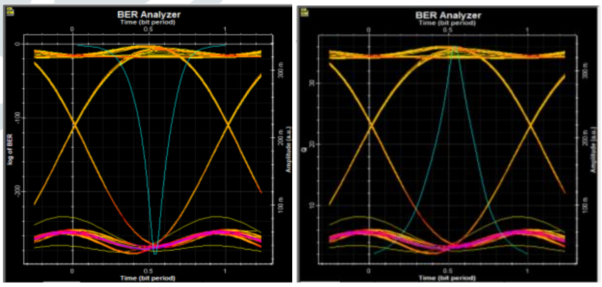
Figure 7 Performance analysis of proposed three stage model with PN codes

Table 4 Performance parameters with values for proposed three stage model with PN codes

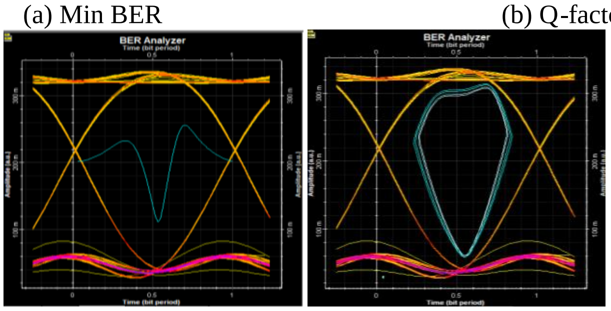
S.No	Parameters	Values
1	Maximum Q-factor	26.4198
2	Minimum BER	3.43337e-154
3	Eye Height	0.178172
4	Threshold	0.0714967
5	Decision Inst.	0.53125

6.2.5 Analysis for FCC Three Stage:

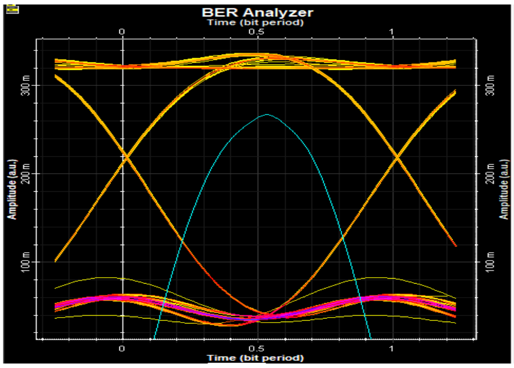
The FCC code implementation for three stage system has been implemented and its outcomes are shown in figure 8. The performance evaluation is done on the basis of defined factors as Bit Error Rate, Threshold, Q factor, Eye height and BER pattern.



(a) Min BER (b) Q-factor



(c) Threshold (d) BER Pattern



(e) Eye Height

Figure 8 Performance analysis of proposed three stage model with FCC codes

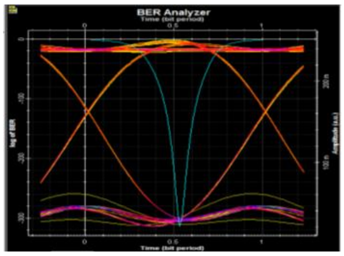
The eye diagram of figure 8 represents that the minimum BER in respective case is 31.64, the highest Q factor is 36.077, the threshold level is 0.111321 and the eye height is 0.266904. Thus, on the basis of these observations, it is concluded that the performance of the system is quite effective in this case as well. The respective facts are calibrated in table below.

Table 5 Performance parameters with values for proposed three stage model with FCC codes

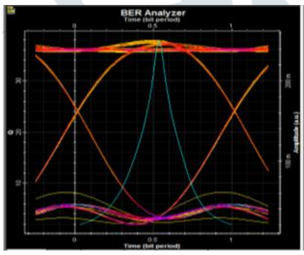
S.No	Parameters	Values
1	Maximum Q-factor	36.0779
2	Minimum BER	31.64316e-285
3	Eye Height	0.266904
4	Threshold	0.111321
5	Decision Inst.	0.53125

*a) **6.2.6 Analysis for Walsh Three Stage:***

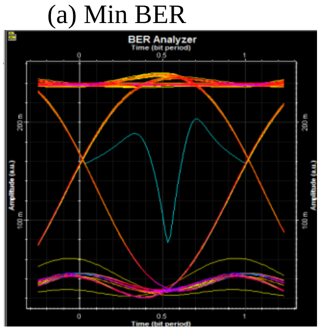
Similarly, this section defines the performance of the proposed work for three stage model by using Walsh code. The performance of this model is analyzed as the BER is 4.766 approximately, Q factor is 37.921, eye height is 0.1977 and the threshold value is 0.774224. The observed facts and figures from eye diagram have been shown in table 8. The observation proves the proficiency of the proposed work in terms of actual obtained statistics.



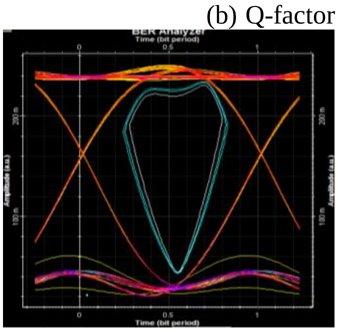
(a) Min BER



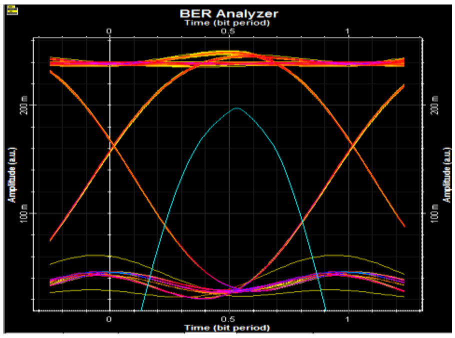
(b) Q-factor



(c) Threshold



(d) BER Pattern



(e) Eye Height

Figure 9 Performance analysis of proposed three stage model with Walsh codes

Table 6.6 Performance parameters with values for proposed three stage model with Walsh codes

S.No	Parameters	Values
1	Maximum Q-factor	37.921
2	Minimum BER	4.76624e-315
3	Eye Height	0.19733
4	Threshold	0.0774224
5	Decision Inst.	0.53125

V. CONCLUSION

In this work, the EDFA and RAMAN amplifier has been used collaboratively to amplify the performance of the optical communication system. The proposed communication system is implemented on two various forms as firstly it is applied for single stage communication model and secondly it is implemented for three stage communication system. Along with the optical amplifiers, the proposed work is also analyzed with various codes such as PN codes, FCC codes and Walsh codes. The performance of the proposed work is evaluated in terms of BER and Q factors.

On the basis of the simulated results, it is evaluated that in case of single stage proposed model, the least BER is 3.43 approximately and it is found when the single stage model is implemented by using PN codes. Similarly, in case of three stage proposed model, again PN codes has the minimum BER i.e. 1.35 approximately. The Q factor that is required to be higher fir an ideal system, in proposed single stage model, the highest Q factor is 38.15 for Walsh code and in three stages it is 37.921 for Walsh code. Whereas, the FCC code scheme is found to be neutral in both cases i.e. single stage and three stage communication system.

Therefore, on the basis of the observations, the proposed work is concluded as quite efficient and effective for single stage and three stage communication system in terms of minimum BER and highest Q factor.

The present communication model is found to be effective with respect to the BER and Q factor. The usage of DRZ instead of traditional NRZ model is leads to the enhancement in the overall performance of the system. In future for the purpose of more amendments, the proposed work could be analyzed with WDM communication system.

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