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Investigation of Enhanced Double Weight Code in Point to Point Access Networks

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Abstract. In this paper, an investigation and evaluation to enhanced double weight (EDW) code is performed, a new technique for code structuring and building using modified arithmetical model has been given for the code in place of employing previous technique based on Trial Inspections. Innovative design has been employed for the code into P2P networks using diverse weighted EDW code to be fitting into optical CDMA relevance applications. A new developed relation for EDW code is presented, the relation is based on studying and experimenting the effect of input transmission power with code weight, and the relation developed using numerical analysis method. This relation makes the estimation for the system input power needed more efficient. The results of the code has been explained by eye diagram and parametric illustrations from the simulated results. The result shows a magnificent performance of the code during high number of users and weight. On the other hand, the relation developed for power measurement helps to prevent power loss and consumption.

Keywords— OCDMA; Optical Communication; P2P; EDW; OCDMA; Enhanced double weight; (EDW); Double weight; (DW);

1. Introduction

The last segment of telecom system stands for the right to use that manages the service supplier to the business or home. Optical Network Unit (ONU), Central Office (CO), and Remote Node (RN) are the main elements of broadband access network. Realizing point-to-multipoint (P2MP) and point-to-point (P2P) structural designs, with steadfast fiber from CO to every terminal user stands for a reasonable method to employ the optical fiber in the LAN networks [1].
In previous periods in about two decades ago, numerous codes were established for optical CDMA system [2] because of its outstanding properties [3] in terms of asynchronous [4] access to the network in addition to reliable process [5]. Optical spectrum code division multiple access (OSCDMA) stands for[2] a multiplexing method modified from the efficacious operation in wireless setups[6]. Various popular codes were initiated for OCDMA system as in Hadamard code [7, 8], (MFH) code, and Double Weight (DW) code [9].

Several detection techniques have been studied[10] for OCDMA code detection. However, there are some detection techniques easier to use and to implement (such as direct detection) in addition to the reduction of cost[11, 12].

This paper examines Enhanced Double Weight (EDW) [4, 13, 14] code renovation using theoretical investigation to restructure the code based on arithmetical model for the code in place of previous method reliant on inspection. The simulation results for higher weighted code were presented with parametric investigations, while the core code structure is remained as the same. Additionally, in any optical system, the input power is affecting the system performance and efficiency, finding a relation between the input power and code weight or number of users is important to estimate the power needed for the system to run. In this paper a new developed relation between code weight and input power will be presented. The code used is EDW-OCDMA. A numerical analysis method used to determine the relation.

2. EDW Formation

EDW codes are the augmentation form DW code where the weight number is possibly greater than unity. They can likewise be characterized by K x N matrix[15].
The elementary EDW code matrix has K x N dimensions reliant on code weight. The overall arrangement for this EDW code matrix with weight (W) has presented in Figure 1, where [A1], [A2]… and [Aw] constituent matrices are entirely on W. The elementary matrix has the smallest amount of K and N for explicit code weight amount. Higher K number is feasibly realized by using mapping technique from the basic matrix.

$$[HW]=\begin{bmatrix} & \vdots & & \vdots & & \vdots & \\ & \vdots & & \vdots & & \vdots & \\ A1 & \vdots & A2 & \vdots & \cdots & \vdots & Aw \\ & \vdots & & \vdots & & \vdots & \\ & \vdots & & \vdots & & \vdots & \end{bmatrix}$$

Figure 1: All-purpose EDW Code Matrix Arrangement.

The components in Figure 1 in every sector are described by matrix number [A] that relies on W. Namely, if W=7, A is 5 and so on. In addition, matrix size [A] is of Ka x Na based on the following equations:

$$Ka = W \tag{1}$$

$$\mathrm{Na} = \frac{\sum_{j=1}^{w} j}{w} \tag{2}$$

Every matrix involves grouping series of 2, 2… 1 of columns. These grouping series are reliant on W as well as number of 2 repetition that specified by:

$$\text{Times of } 2 = \frac{W-1}{2} \tag{3}$$

Namely, if W is 5, the grouping series is 2, 2, 1.

Dual elementary constituents in the elementary EDW code matrix that are:-
Basic length of this code can be calculated using,

$$NB = \sum_{j=1}^{W} j \tag{4}$$

Additionally, Basic subscribers number,

$$KB = W \tag{5}$$

NB is elementary code's column size while KB stands for the elementary size of the code's rows. EDW code matrix, consequently, is characterized in KB x NB matrix form.
Original EDW code employs trial initiation technique for code forecasting to form code matrix[14]. Since advanced weighted code is too hard to scrutinize physically, for instance, through attempting to create the code in the case of W=5, 5 rows and 15 columns are to be forecasted. It is hugely tricky to prepare this physically, the advanced weights code generation is practically intolerable, as in the case of W=11 that results in 11 rows and 66 columns.
New procedure has been developed to produce the code by an arithmetical formula and sequential steps as follows:

a) Outlining the base code matrix.
b) Shifting is employed via dual rows for W=3 and increased by one for advanced weights
c) Shifting the base matrix makes subsequent matrix and its parts dependent on preceding matrix.
d) Building EDW code based on previous steps.
e) Afterward, by using previous steps, code can be produced, and so on for upper code weights.

2.1. Base Matrix Generating

For instance in the case of W is 3, the base matrix is as follows:

Step 1:
Create 0's Bm Matrix and matrix size as outlined by:

$$\text{Rows} = W \tag{6}$$

$$\text{Columns} = \text{grouping sequential number} = Na = \frac{\sum_{j=1}^{w} j}{w} \tag{7}$$

0	0
0	0
0	0

Step 2:
Apply Eq 6 ,7 and alter the matrix by single round shift process for every row

$$\sum_{j=1}^{Na} (Bm[j,j] = Bm[j,j] + 1) \tag{8}$$

1	0
0	1
0	0

Step 3:
Concluding row is the summation consequence of entire rows
$Bm_{n\ Final} = Bm1 + Bm2 + \ldots\ldots + Bm_n$
Or Using this equation

$$Bm_{n\ Final} = \sum_{j=1}^{Na} Bm[n,j] = Bm[j,j] \tag{9}$$

1	0
1	1
0	0

Part (A)

From above steps and after Applying Eq 6,7,8,9, the concluding consequence is from the code matrix that taken in to consideration for the base matrix.

2.2. Shift Steps in Single Column

1-Let $X=C_n$
2-Y=X
3- X [1] =Y[W]
Based on Fig 1 and apply on C1

$$C=\sum_{i=1}^{W-1} X(i+1)=Y(i) \qquad (10)$$

C stands for the subsequent shifted matrix for single shift
W is the weight number
For 2nd shift, the steps 2-3 are repeated.

X=C1

1	1	0

1st Shift

0	1	1

2nd Shift

1	0	1

C3 Part B

Applying on C2
The above outcome is via relating dual step Shifts on Base Matrix of Part (A) to create subsequent part of matrix B. Similar procedure can be used for B to get other versions of matrix.

X=C2

0	1	0

1st Shift

0	0	1

2nd Shift

1	0	0

C4 Part B

The shifts number can be controlled by:

$$\text{Number of Shifts} = \frac{W+1}{2} \qquad (11)$$

2.3. Complete Row Shift and Complete Base Matrix Shift
Sequential number is determine by:
S=W-1
X=Bm
X= [ ] (Row, Columns) = (W, S)
On the way to regulate subsequent matrix from the base matrix and produce the code, Presume y=X
For 1st row

a. $$\sum_{i=1}^{s} X(1,i) = y(W,i) \qquad (12)$$

b. For remaining rows

$$c. \sum_{i=1}^{s} \sum_{j=1}^{W-1} X(j+1,i) = y(j,i) \qquad (13)$$

1- Iterating steps (1) (a) and (b) for 2nd shift
Namely,
X=Bm, Y=X
In the case of subsequent shift
X_{next} arises from previous shift operation and thus, $y=X_{next\ shifted}$

To regulate the complete code, these steps are repeated for every part of code subsequent to code sequence (S). The configuration to assess EDW performance in point to point access network is presented in Figure 2.

Figure 2 shows the basic EDW code matrix denoted by the sequence (6, 3, 1).

W=3	A		B		D		
Users	C1	C2	C3	C4	C5	C6	
1	1	0	1	1	0	0	3
2	1	1	0	0	1	0	3
3	0	0	1	0	1	1	3
	2	1	2	1	2	1	

Figure. 2. Basic EDW Code Matrix

3. Simulation Model and results

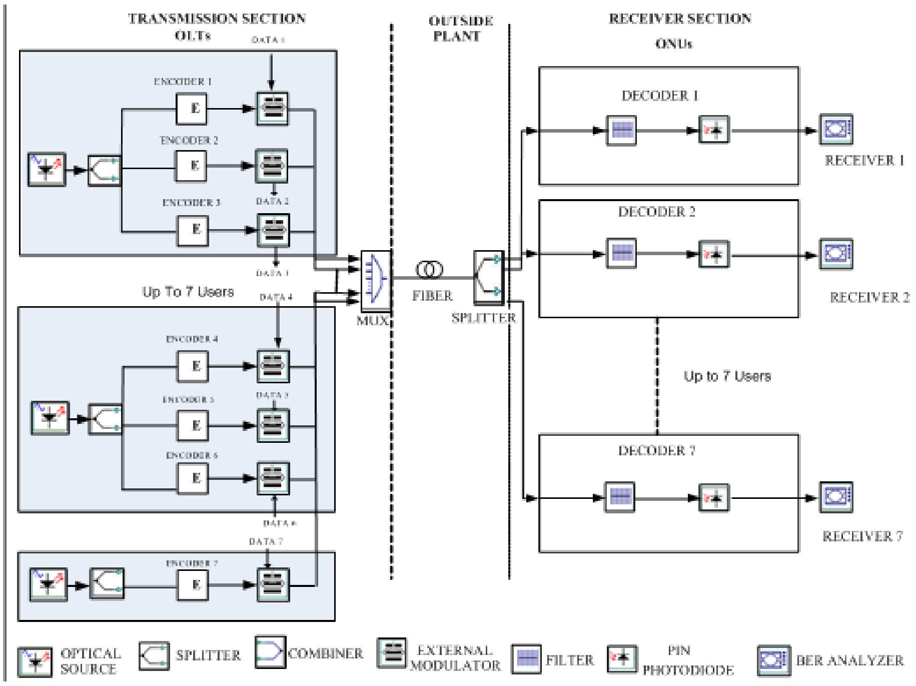

Figure 3. Simulation model to evaluate the performance of EDW in point to point access network

3.1. Consequence of Distance in P2P Network

Figure 4, 5, and 6 show the bit-error rate (BER) as opposed to the diffusion distance. It obviously displays that BER rises with weight number and transmission distance in addition to weight number are in an effectual behavior.

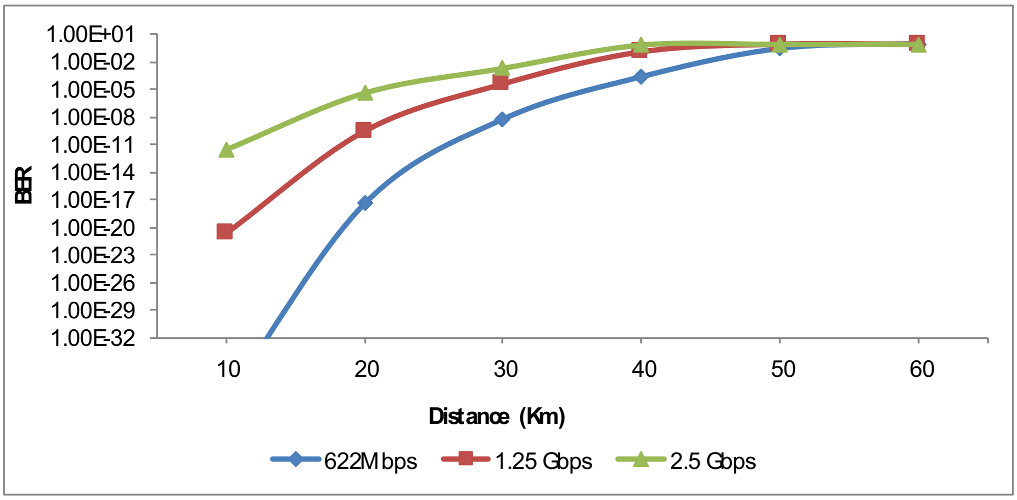

Figure 4. BER vs. distance at various bit rates (W=3)

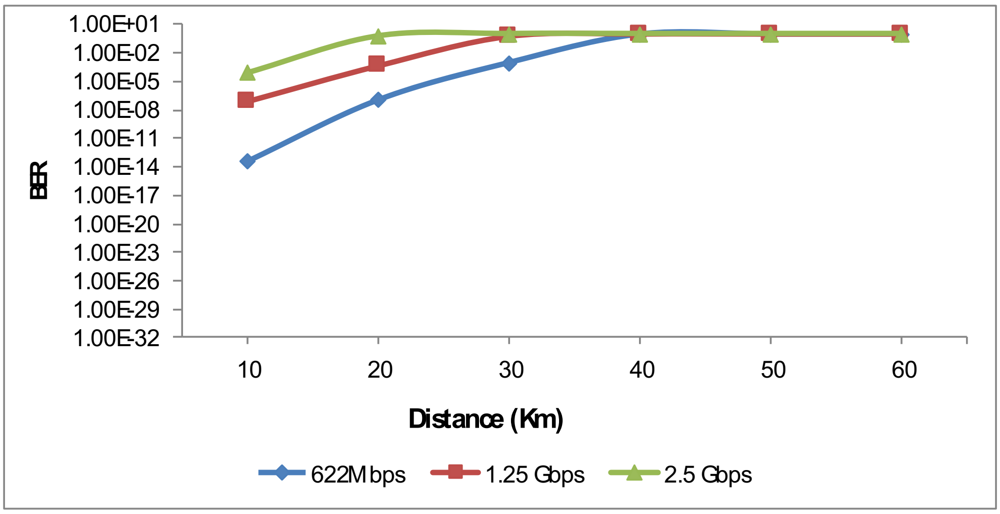

Figure 5. BER vs. distance at various bit rates (W=5)

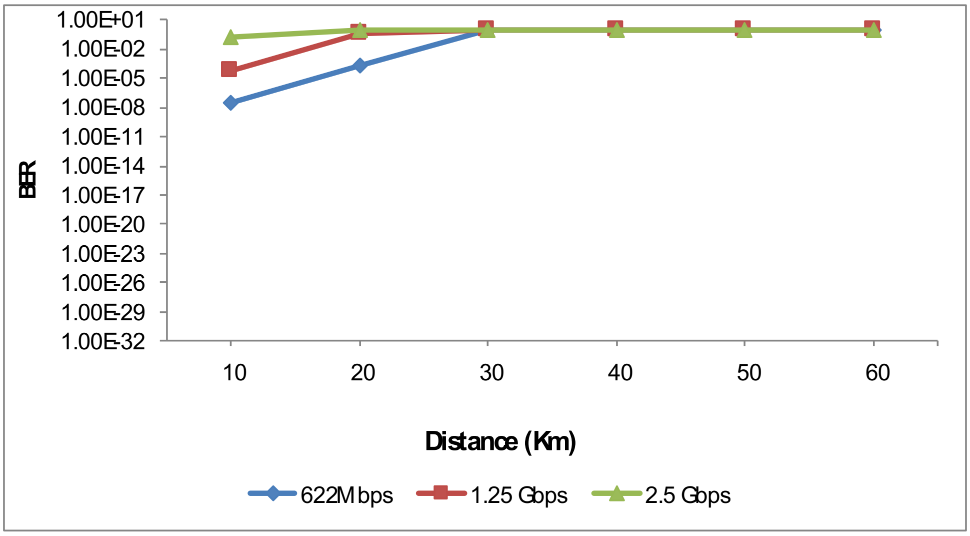

Figure 6. BER vs. distance at different bit rates (W=7)

Figures 4, 5, and 6 explains that the BER increases exponentially with diffusion distance. Lengthier fiber has bigger attenuation besides dispersion, consequently, aggregating BER. The OCDMA system based on EDW code can implement adequately in the case of lesser weights at the smallest input transmit power. For instance, EDW code at 622 Mbps and 1.25 Gbps, if the weight W is 3, the fiber length will be 37 and 33 km, respectively devoid of any amplifying to get BER of 10^{-9}. Whereas in W=5 for BER of 10^{-9}, the distances are 20 and 9 Km respectively. Meanwhile, for 2.5 Gbps, the fiber length is 17km, at the same BER. The results in evidently explain that OCDMA structure based on EDW code is appropriate for P2P optical network background. Besides, the minimum weight is the improved performance of the system attributable to increased chips number in higher weighted system. Consequently, the upper weighted system require additional power.

3.2. Consequence of Distance on Noise in addition to Output Power in P2P Network

Figures 7, 8, and 9 depict the resultant noise power in competition with transmission distance. It noticeably demonstrates that noise power drops as distance and weight raises accordingly.

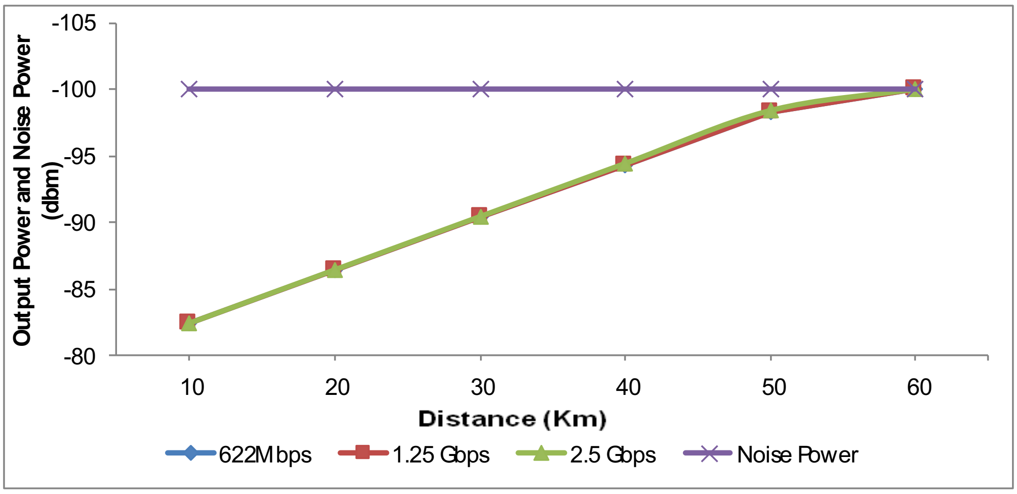

Figure 7. Noise and output power vs. distance in the case of W is 3

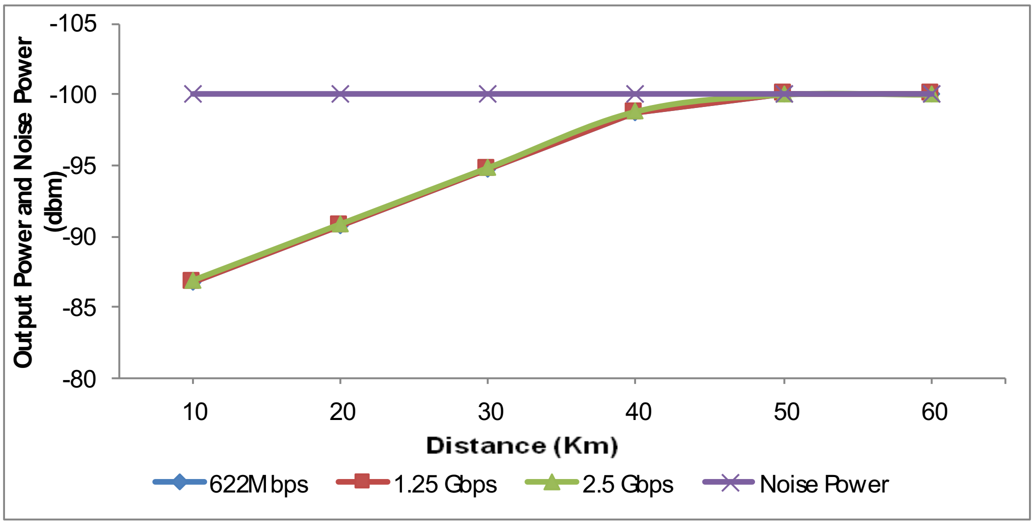

Figure 8. Noise and output power vs. distance in the case of W is 5

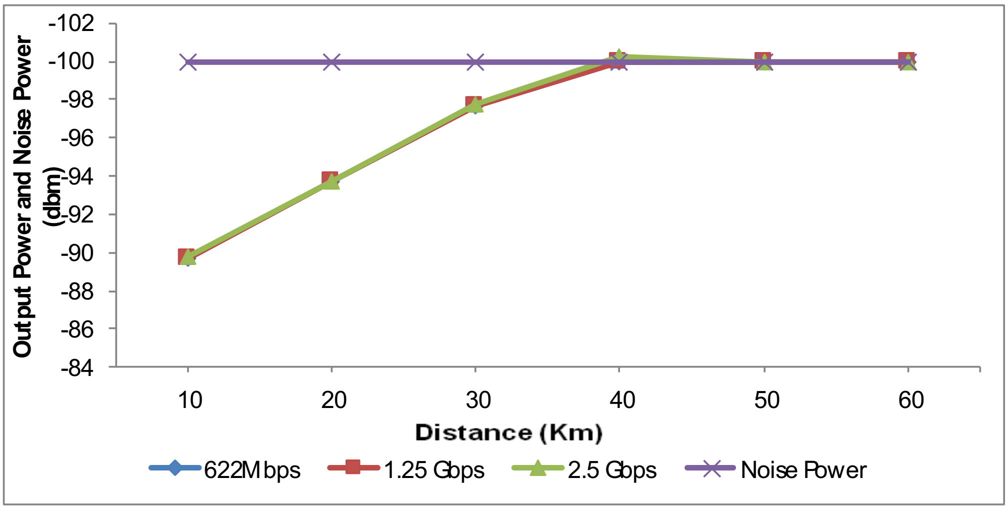

Figure 9. Noise and output power vs. distance in the case of W is 7

The results above illustrate the distance consequence on output noise power for EDW code at dissimilar weights and bit rates. Although the system is activated at diverse bit rates, the distance consequence on resultant power is identical. E.g., at distance of 18 km and W=5, the resultant power for 1.25 Gbps and 2.5 Gbps systems were both -86.6 dBm. Nevertheless, the resultant power values for 1.25 Gbps and 2.5 Gpbs systems at W=3 are -81.2 dBm. Optical signal to noise ratio (OSNR) for OCDMA scheme with 1.25 and 2.5 Gbps at W=3 has been upper than OCDMA scheme with W=5. Consequently, W=3 system can reach to lengthier distance as compared with W=5 and 7 cases at identical power as a result of that greater weight causes greater channel number and upper insertion loss.

3.3. Effect of Input Power in Point-to-Point Network

Figure 10 displays BER against input power at the bit rate of 1.25 Gbps for 20 km for multiple weights. It obviously envisaged that BER decreases input power increases.

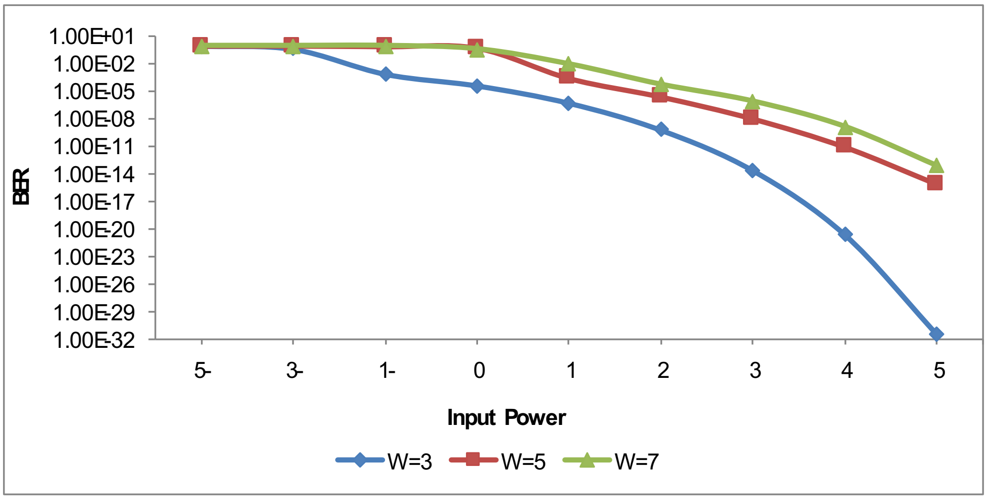

Figure 10. BER vs. input power at bit rate 1.25 Gbps at W=3, 5, 7

In addition, BER is reduced exponentially when the input power increased, and by intensifying rated power from -5 to -1 dBm, there was a trivial enhancement in system functioning, whereas enhancing input power from 0 to 5 dBm improved the performance clearly. As a result, the functioning of the system by means of EDW code can be enhanced by increasing the input power.

3.4. Effect of Bit Rate in Point-to-Point Network

Figure 11 depicts the BER vs. the transmission bit rate. The fiber length is set to 20 km and transmitted power is adjusted to 0 dBm.

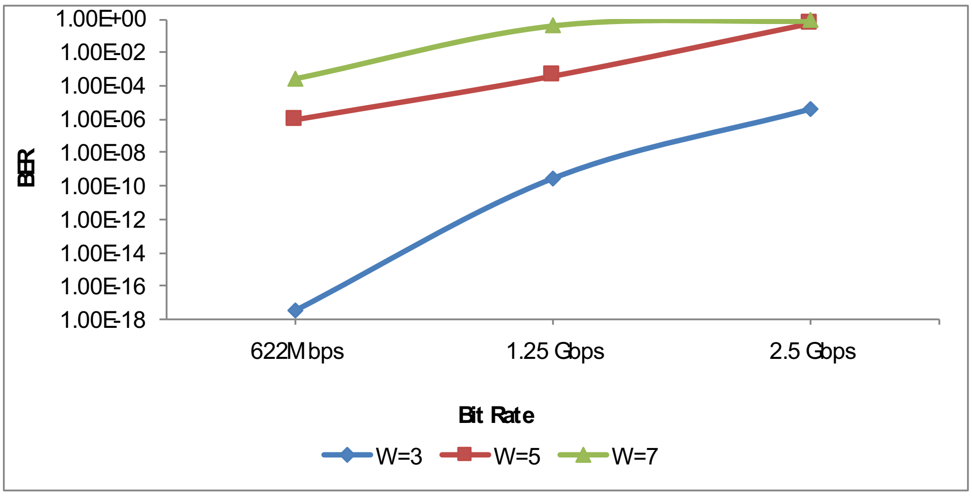

Figure 11. BER vs. bit rate

Figure 10 shows the BER rises exponentially with bit rate. This can be attributed that intensifying bit rate drops pulse width, creating bits further susceptible to dispersion influence. With W=3 is much better than the higher weighted systems at the minimum input transmitting power.

3.5. Effect of Input Power on the System Performance

Figure 12. Shows a test system with 3 users

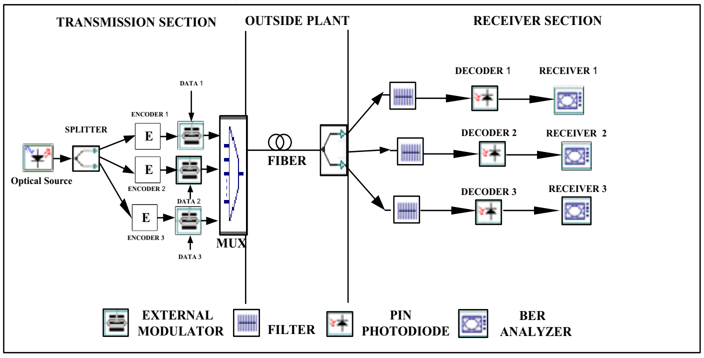

Figure 12. Simulation setup for EDW OCDMA system.

Direct detection used at the receiver side [16]. The EDW code eye pattern is shown in Figures 13.

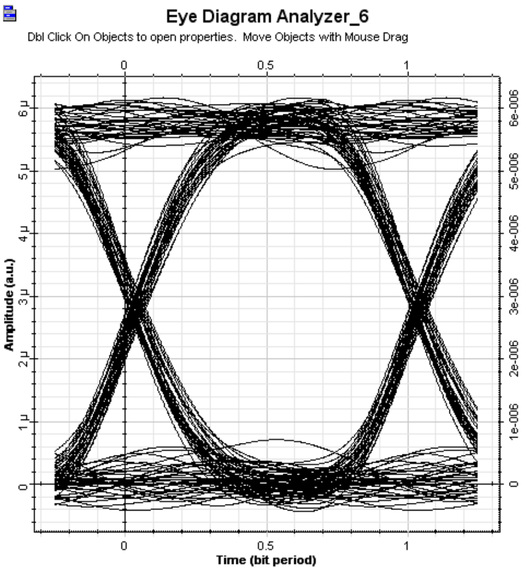

Figure. 13. Eye diagram of (W=3) at transmission speed of 1.25 Gbps after 20 km distance transmission.

In the system tested an optimum channel's number was chosen i.e. (W=3) will contain (three channels) and (W=5) (5 Channels). Therefore, no mapping is used to add extra users's.

Figure 14 shows the BER versus the input power for the two weights. The BER decreases with the increase of the input power.

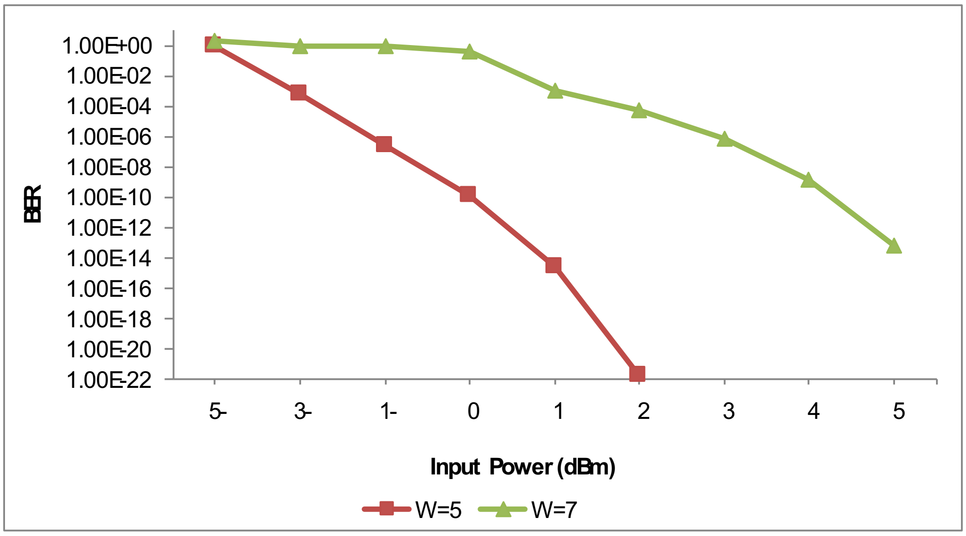

Figure. 14. BER versus input power for the different weights

Figure 14 shows that increasing the input power from -5 dBm to -3 dBm for different weights, there are small improvement in the performance of the system (except for W=3 where the BER is almost zero), while increasing the input power from -3 dBm to 3 dBm, the performance of the system improves significantly. However, the system with higher weights gives small improvement in the performance as clearly shown. This is due to increase of channel number and insertion.

The input power is affecting the system performance. This is very clear at higher weighted system. The more power gives Better system performance. In addition, for any service provider it is important to find

the better power value that the system will perform at the better performance. Using numerical analysis methods, a relation between the systems input power and the code weight is being developed.
The developed relation is:

$$P \approx 0.08W^3 \tag{14}$$

Where P is the input power in (mW) and W is the code weight.
Figure 15 showing the relation on graph draw as is clearly showing with the increment of code weight there is more power needed.

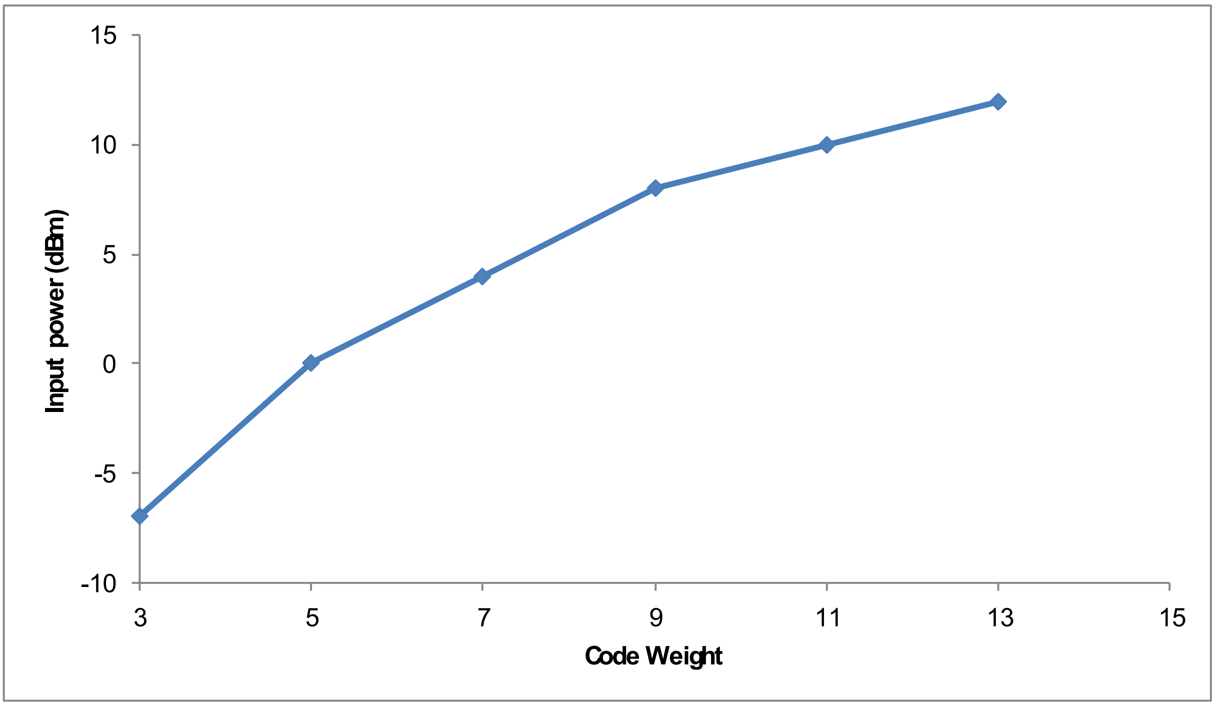

Figure. 15. Input power versus code weight

4. Conclusion

Modified algorithm to produce EDW code is presented in this paper for generating code in logical and straightforward manner. It can be established to accomplish entirely the double weight codes on the way to improve different codes of OCDMA. The different carrying out of EDW-OCDMA for point-to-point access network is advantageous for multiple weights code. Simulated consequences are noticeably viewing good code consequences in the case of diverse weights in terms of bit error rate, bit rate, power and other variables. In addition, these codes upheld interesting results under advanced weights.

Furthermore, the code performance was shown in the result under different weights. The performance of the system was very good under higher weights. In addition, the system test shows that more transmission power is needed for higher code weigh not to mention higher number of users to sustain the code performance stability.

The new relation between input power and code weight have been developed and showed basing on the effect of transmission input power on the code weight. This relation is a solid start-up for further development of full-scale relation to estimate the power needed for the system to run smoothly at best performance. The relation can be developed to carry out all OCDMA codes.

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