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Performance Optimization of Diagonal Identity Matrix and Enhanced Double Weight Codes in Terms of Security for Short Haul Communication

Simarpreet Kaur, Simranjit Singh

Abstract ***Optical code division multiplexing is getting attention because it is an imminent multiple access technology which can cater ever increasing data traffic as well as multiple user access in optical networks. In this work, a zero cross correlation based diagonal identity matrix code is presented and it is compared with the enhanced double weight code to check the superior code in OCDMA system at data speed of 30 Gbps. Effect of some parameters of OCDMA system which prominently affects the security of the system and these are input power, linewidth and modulator extinction ratio. Optimization using single parameter optimization and multiple parameter optimizations has been done. In order to accomplish the work, optiwave optisystem software is used and extensive literature survey is done, issues encountered are carefully checked and to address the issues, proposed system is presented. Results are evaluated in terms of Q factor, bit error rate (BER) and signal to noise ratio. Novelty of proposed work is the search of optimal parameters of both the codes in terms of enhanced security such that eavesdropping at these optimal parameters will become tedious for unauthorized user.***

Keywords ***Diagonal Identity Matrix (DIM), Enhanced Doubleweight code (EDW), Optical Code Division Multiple Access system (OCDMA), Zero Cross-Correlation (ZCC), Multiple Access Interference (MAI), Optimization, Security***

I. INTRODUCTION

Potential of optical fiber communication to cater high speed internet services is gaining much attention of the researchers from last two decades and emerges as a medium that can serve applications at trillions of bits per second data speed [1]. In order to cope up with bandwidth hungry applications such as peer-to-peer downloading, video-on-demand, social networking, and Mobile backhaul traffic etc, new techniques are developing. Service providers are accentuating on the high speed OCDMA due to their ability to provide wide bandwidth to optical network units or end users [2].

OCDMA can cater number of users at the same time with coded signature codes. It can provide enhanced spectral efficiency with more security than wavelength and time division multiplexing systems [3-5].

Till now, maximum work is reported in the literature on the capacity and data rate enhancement in OCDMAs, however, data confidentially of public data is also an important work to be addressed. Security breaching of systems can be accomplished through two ways such as Active attacks and Passive. Passive threats are prominent such as eavesdropping in which no system state change takes place as changes in Active threats.Eavesdropper can access the information of authorized user from line, on the other hand, active threats can be performed in various forms such as masquerading as an authorized entity and denial of service. Several detections of attacks on the all optical communication systems are elaborated in [6], and also categorized the attacks such as (1) Eavesdropping (2) Service denial (3) Traffic analysis (4) Spoofing (5) Data delay (6) Quality degradation. Out of aforementioned attacks, eavesdropping severely affects the performance of the system and gives away the confidential information of authorized user. Advantages of security enhancement of physical layer are to provide robust network. Physical layer security enhancement allows integration of traditional data coding or encryption methods with other upper layers. In [7], diverse spectral amplitude codes are investigated such as Diagonal Doubleweight code,Enhanced Doubleweight code, and Modified Doubleweight code etc. These codes are suffered from cross correlation and therefore MAI limit the system performance. Further, security of the codes with long code lengths and optimal parameters brings better confidentiality to the OCDMA systems and ZCC code increase Quality of the reception.

Effect of some parameters of OCDMA system which prominently affects the security of the system and these are input power, linewidth and modulator extinction ratio. More power cause more probability of correct information detection at eavesdropper and same is true for high ER.Therefore, in this work, optimization of DIM and EDW codes have been accomplished for different laser powers, linewidths and extinction ratio of Mach Zehnders in terms of Q factor, BER and signal to noise ratio. Novelty of proposed work is the search of optimal parameters of both the codes in terms of enhanced security such that eavesdropping at these optimal parameters will become tedious for unauthorized user.

II. SYSTEM SETUP

In proposed work, two different OCDMA codes are simulated at 30 Gbps such as enhanced double weight code and diagonal identity matrix code in optisystem software.

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Code construction of EDW codes for seven users is given in [7] and similarly, DIM code construction is presented in [8]. Figure 1 depicts the block diagram of proposed system by incorporating two different SAC codes.

For implementation of codes, code matrix for each code is considered. Array of lasers depending on the code length is taken and then data modulation is performed through binary bit generator (pseudo random bit sequence generator), pulse shaper (non return to zero),

intensity modulator (MZM) with the continuous drive of lasers. Multiplexed signals then coupled to the single mode fiber for the transmission and SMF-28 model is employed with 0.2 dB/km amplitude degradation and 17 ps/nm/km pulse broadening.

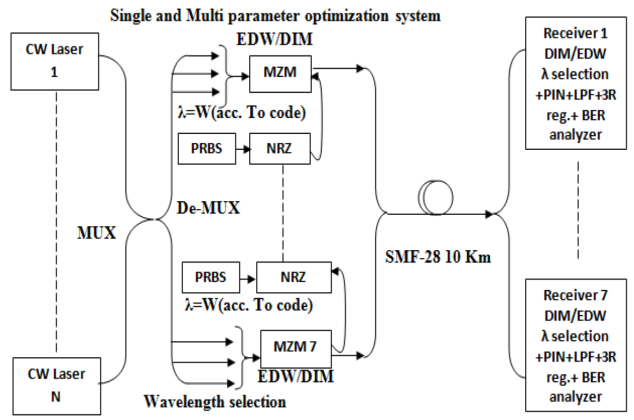

Figure 1 Proposed EDW and DIM based OCDMA system

Transmission signal exit at the receiver which has de-multiplexer with specific wavelengths according to the transmitted code. One filter for each user is employed at the output because lasers and direct detection is incorporated in this system. Further, photo detector (PIN), Bessel filters (LPF), 3-R regenerator (re-time, re-shape, re-amplification) and BER analyzer is placed for the detection and evaluation of the signal. Parameters of the proposed works are given in Table 1.

Table-1 Parameters for EDW and DIM codes for SPO and MPO based system

Input Parameters	Values
Data rate	30 Gbps
OCDMA codes	EDW, DIM
Users	7
Optimization	Single and Multi parameter optimization
Distance	10 km
Laser power	-10 dBm to 10 dBm
Linewidth	0 MHz to 200 MHz
Extinction ratio	0 to 200
Optical Fiber	SMF-28
Detection	Direct

III. RESULTS AND DISCUSSION

3.1 Selection of optimized parameters

EDW codes are premier OCDMA codes in double weight code family which can provide better performance. However there is cross correlation due to which its performance limits in the multi user network. In our previous work [8], we have proposed zero cross correlation code without mapping to support any number of users and named it as diagonal identity matrix codes.Along with the performance on the OCDMA codes, security is an utmost issue because without high security, an unauthorized user can access sensitive information. In order to increase the security of the system, long length CDMA codes are needed but it comes on the stake of low bandwidth efficiency. Therefore, in this work, single parameter optimization of the proposed codes is performed so that parameters will be selected to increase security. Multiple parameter optimization in EDW and DIM system is carried out and input parameters considered are input power, laser linewidth andMZM extinction ratio. Here, after selecting the input parameter, user needs to give maximum and minimum range of the parameter which user wishes to iterate. Further result parameters are selected as Q factor, min BER and SNR.

Figure 3 represents the performance optimization of EDW and DIM codes with the variation of launched power. Received Q factor is checked on different power levels using SPO algorithm of optisystem. Q factor trends are different in both the codes such that in DIM, due to non linear tolerance of the code and zero cross correlation, performance of DIM increase with the increase in input power. However in case of EDW codes, input power more than 2.36 dBm decrease Q factor. Overall performance of DIM codes is far better than EDW codes. Cross correlation in EDW codes lower the system performance and optimal power of DIM in terms of better Q is 10 dBm and EDW is -10 dBm (but unacceptable range at 30 Gbps). In terms of security, optimal power in DIM is 2.36 dBm because Q of 6.82 is achieved here and at 10 dBm, Q factor only increase to 7.9. For better security, input needs to be less because eavesdropper can steal information easily if high powers are inside fiber. Therefore 2.36 dBm is chosen optimal because margin in Q decrease is very less but security at this point will be comparatively higher than 10 dBm power. Our major emphasis is on security so therefore, Q factor of 6 is sufficient (result within acceptable range).

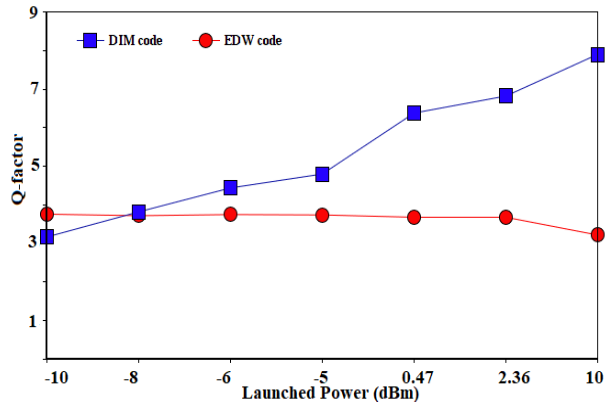

Figure 3Single parameter optimization of input power for the DIM and EDW systems

Figure 4 represents the effects of linewidth increase on the DIM and EDW codes in terms of min. log BER. Linewidth increase, degrade the performance of the system because of information distribution and lowers the bandwidth efficiency.Single parameter optimization of linewidth is done to select optimal linewidth in order to get more security.

Therefore linewidth values are iterated from 0 MHz to 200 MHz and results revealed that increase in laser linewidth brings little performance betterment in the OCDMA codes. For security enhancement, higher values of linewidth can bring more security due to the creation of data scrambling for eavesdropper as data bits interfere with each other. Therefore 76 MHz linewidth is optimal in DIM as well as EDW codes because at this value both performance and security of system is better. Min. BER is out of acceptable range for EDW codes.

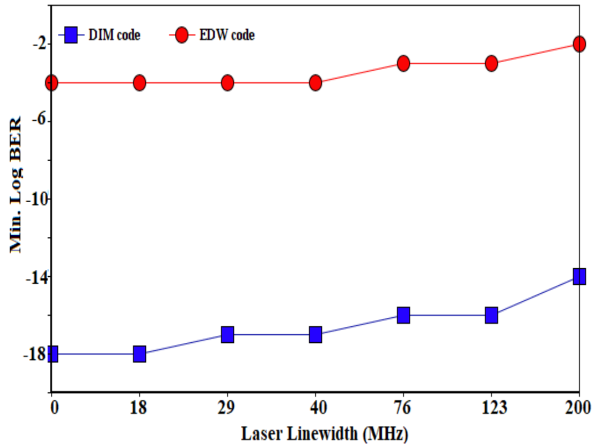

Figure 4 Effect of Laser linewidth on the log BER of the proposed system

Figure 5 shows variation of MZM extinction ratio from 0 to 200 and its effects are checked on the signal to noise ratio of EDW and DIM codes.

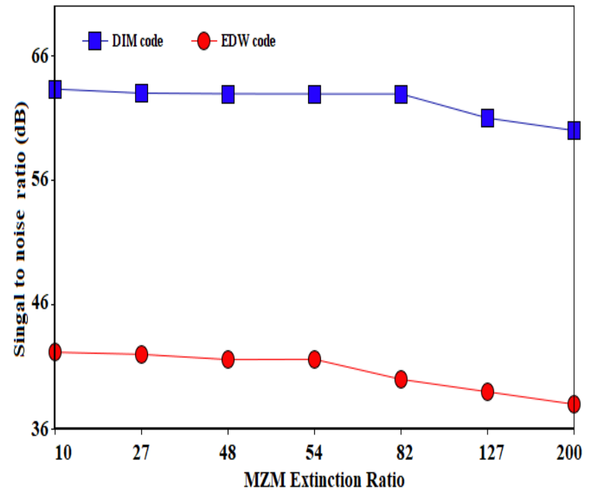

Figure 5 Variation of extinction ratio on SNR of the proposed codes

ER is difference in the levels of one and zeros in the binary sequence. More is the ER, more will be the performance and more are the security threats because high ER will cause eavesdropper to easily decide the levels of one and zeros. Therefore, in terms of SNR, for DIM ad EDW, 54 ER is better and for the security ER of 10 is optimal for both codes. There is tradeoff between performance and security for both the codes.

3.2 Multiple Parameter Optimizations

In order to check the effects of multiple parameters on the system, multiple parameter optimizations are required. Effect of some parameters of OCDMA system which prominently affects the security of the system and these are input power, line width and modulator extinction ratio. More power cause more probability of correct information detection at eavesdropper and same is true for high ER. In aforementioned SPO technique, only single parameter is checked and optimized values of each input parameter is given separately. Here, in MPO, three input parameters such as input power, laser line width and MZM extinction ratio are considered for getting output in terms of optimized Q factor, BER, and SNR. Table 2 represents the results of MPO in proposed system

Table 2 MPO optimization

Input power (dBm)	Linewidth (MHz)	Extinction ratio	Q factor		SNR (dB)		BER	
			DIM	EDW	DIM	EDW	DIM	EDW
-10	0	10	2.56	1.02	23.66	15.4	10-3	10-1
-9.9	0	10	2.56	1.58	23.67	18.32	10-3	10-2
4.95	0.1	10	6.86	3.54	53.22	28.65	10-12	10-5
2.13	0.2	11.30	6.28	4.25	46.93	24.36	10-10	10-6
4.12	0	11.46	6.82	4.12	51.34	21.54	10-12	10-6

It is observed that in order to get optimal performance, input power 4.95 dBm, laser linewidth 0.1 MHz and extinction ration 10 are optimized. Before and after these values, results decreases. But our main concern is security enhancement, therefore, minimum power is required for the operation and minimum ER is needed. So, optimized parameters in MPO for enhanced security are input power 2.13 dBm, linewidth 0.2 MHz, and ER 11.30 because there is little trade off between performance and security at these parameters. But our major concern is security of the system.

A bar graph is shown in Figure 6 represents the comparison when parameters are optimized such as power 2.13 dBm, linewidth 0.2 MHz, and ER 11.30 and when not optimized (default values power 0 dB, 10 MHz linewidth and 30 ER extinction ratio. It is noteworthy that effect on Q factor of optimized parameter is more and more values are observed as compared to Q factor in without optimized system.

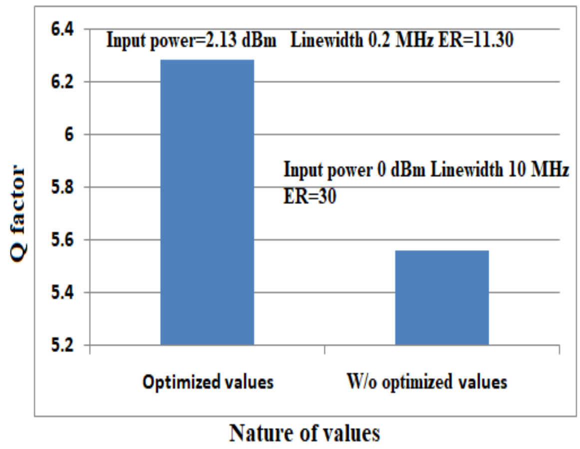

Figure 6 Bar graph of optimized and reference values

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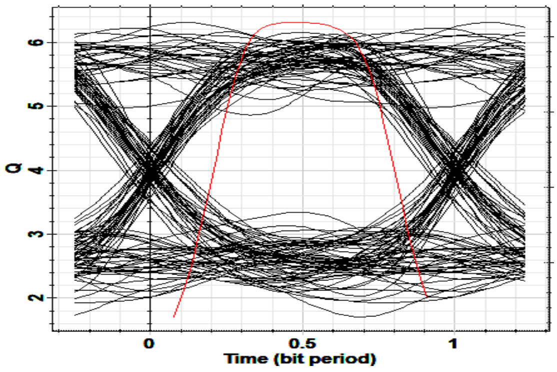
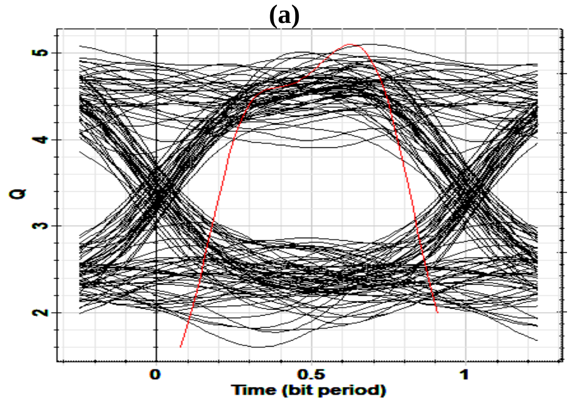
Figure 7 represents the eye diagram of optimized values (a) in the system and without optimization system (b). It is observed that there is more opening in case of optimal parameters.



(a)



(b)

Figure 7 Eye diagrams (a) at optimized values (b) without optimized values

IV. CONCLUSION

Optimization of the enhanced double weight code and diagonal identity matrix codes has been accomplished in this work to check the performance and security of the system at selected values of parameters.Systems are evaluated at 30 Gbps over 10 km using direct detection and lasers for 7 users. Single and Multiple parameter optimization is performed in optisystem software at input parameters of launched power, linewidth and MZM extinction ratio. It is observed that there is tradeoff between performance of the codes and security. Q factor of 6.8 and 7.9are observed at power level of 2.36 dBm and 10 dBm respectively for SPO system. But, in terms of improved security optimization, power of 2.36 dBm is selected because at this power, eavesdropper face problem to detect signal with efficiency. Similarly SPO optimal points for linewidth are 76 MHz and it is observed that higher linewidth brings more security. ER should be lower for the higher security because low SNR cause problems for eavesdropper to detect levels of one and zeros as shown in SPO.In case of MPO, effect of input power, linewidth and ER is checked at the same time to find effect of these parameters on the system. It is observed that in order to get optimal performance, input power 4.95 dBm, laser linewidth 0 MHz and extinction ration 10 are optimized because Q factor 6.86, BER 10^{-12} and 53.22 dB has been achieved. But our main concern is security enhancement, therefore, minimum power is required for the operation and minimum ER is needed. So, optimized parameters in MPO for enhanced security are input power 2.13 dBm, linewidth 0.2 MHz, and ER 11.30 because there is little trade off between performance and security at these parameters. Overall performance of DIM codes is higher than EDW codes at all parameters.

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Simarpreet Kaur has completed B.Tech in Electronics and Communication Engineering from Chandigarh Group of Colleges, Landran, Mohali, Punjab in 2013. She did her M.Tech from Department of Electronics and Communication Engineering, Punjabi University, Patiala in 2015. After that she started her Ph.D. from the Department of Electronics and Communication Engineering, Punjabi University, Patiala in 2015. She is having 5 publications including SCI and Scopus indexed journals both.