A Fuzzy Logic Based Three Dimensional OCDMA Direct Detection Single per Plane Pulse Codes

[1]Simarpreet kaur, [2]Ashu Verma, [3]Neeraj Julka

[1]Research Scholar, [2]Research Assistant, [3]Assistant professor
[1]Electronics and communication,
[1]Guru kashi university, Talwandi Sabo, Punjab, India

Abstract : In this paper, the performance of cost efficient direct detection OCDMA code is evaluated in terms of overall reach and received Quality of information. This work focuses on the suppression of environmental temperature variation effects that occur in the transmission links that impact the expected magnitude of the autocorrelation peak in the users' code. The FLC system, whose input variables are the propagation distances and the estimated temperature changes, is installed in the network receivers. This system sets the threshold detection level according to the variations of the environmental temperature provided by external sensors.Evaluation has been carried out by changing wavelength and time dimensions by keeping third dimension constant. Moreover, different distances are taken into account to measure the reach within the acceptable limits of bit error rate (BER). Requirement of star coupler is eliminated by designing 3-D code division reliant on only time delays thus to make system cost efficient. Simulation results revealed that with the increase of wavelength/ time dimensions, more interference is observed and system works for 125 Km for W/T=3 and 110 Km for W/T=4. Also, a comparative analysis has been done between Wavelength/Time/Space and Wavelength/Time/Polarization 3-D OCDMA.

***IndexTerms* - OCDMA, Auto correlation, Cross correlation, bit error rate, Q-factor, Fuzzy logic, single pulse per plane**

I. INTRODUCTION

An OCDMA system shares a common strategy of distinguishing data channels not by the wavelength or the time slot, but by distinctive spectral or temporal code impressed on to the data bits for each channel [1]. Each user is assigned one signature sequence called codeword. Each bit of information data is encoded by the codeword consisting of number of shorter bits called chips [2]. When this code is sent, it represents that a user with that unique code has sent information bit '1'. If the information bit is '0', it simply means that the corresponding length of zeros is sent i.e. no light pulse during that interval. The three dimensional codes either spread in wavelength/time and space or polarization domain. Several types of such codes are available for the coding process. MUI is major source of noise in OCDMA system [3][4]. The key to an effective OCDMA system is the choice of efficient address codes with good or almost zero correlation properties for encoding the source. The nature of codes is another important factor in OCDMA system which means that whether the codes are unipolar or bipolar [5].In bipolar (+1,-1) codes, both the positive and negative logic levels are used to encode the data bits, but in unipolar (0,1) codes, positive level is used to encode the data bit '1' and zero logic level is used to encode the data bit '0'. In OCDMA systems, the unipolar codes are used because optical power is used to transmit the information and optical power cannot be negative [6]. The constraint of the 1-D codes is that due to multiple pulses in plane that out of phase correlation cannot be zero. Moreover the as the supported users increase, code length also increases rapidly [7]. The 2-D codes are also suffers from the problem of the timing skew . Due to the dispersion in the optical fiber, the impact of timing becomes more prominent. To overcome the context of these constraints, 3 dimensional codes are proposed.So far, the three dimensional SPP codes were realized using differential detection, In this differential detection each user is assigned two codes: one for the transmission of bit '1' and other for the transmission of bit '0' for antipodal signaling but at the present in this manuscript we are implementing SPP 3D codes by means of direct detection instead of differential detection. The direct detection, which we use in this paper is ON-OFF keying which means that each user assigned a single code and that code is used for the trans-mission of bit '1' and this system said to be in 'ON' state, and for the transmission of the bit '0' there is no such code is assigned and this system is said to be in 'OFF' state. In this detection technique only wanted chip in the optical domain is filtered. This detection scheme does not need subtraction detection technique at electric side. Therefore, MAI will not exist in this detection scheme. How-ever this scheme is only applicable to codes, where the time chips are not overlapped with other time chips of other channels. In this manuscript, we presented a control fuzzy system for OCDMA receivers that dynamically adjusts the detection threshold level due to environmental temperature variations that occur in the transmission links between the OLT and ONU devices.A family of 3-D code for OCDMA systems with NRZ and RZ data format, which gives more flexibility in the selection of the code weight and time. A number of different wavelength / time in OCDMA code are used to improve performance. The goal of the proposed control fuzzy system is to estimate the decrease of the autocorrelation peak value so as to dynamically adjust the detection threshold at the receiver end. This paper is organized as follows: after this introductory part, the construction of the SPPDD OCDMA codes is described. After that, the simulation set up of these codes is presented. The results are discussed in last section.

II. THEORETICAL DISCUSSION

In order to realize the 3-D codes, the extension of 2- D codes is taken into consideration. These three dimensional codes are taken into account 2-D codes by the addition of one extra dimension, due to the fact that optical pulse spread in the all three directions. A range of three dimensional codes are existing, several of them are Space wavelength time codes and Time wavelength polarization codes. The mainly used 3D code is space/wavelength/time for the reason that the time/wavelength/polarization codes needs polarization maintaining fiber for the fiber links, the polarization sensitive components are used throughout the link starting from encoder to decoder. This complex polarization control at all stages in the network, making it very complicated and a costly affair. This space/wavelength/time codes are classified as SPP codes and MPP codes. SPP codes are defined as the single pulse in one plane and on the contrary MPP has multiple pulses in one plane. SPP codes are more flexible then MPP codes due to less interference of pulses in the plains.

III. SYSTEM SETUP

For the evaluation and realization of 3-D OCDMA code, simulation tool Optisystem and MATLAB are chosen as these tools are efficient and provides close to practical scenario outcomes. First and foremost, in order to realize three dimension codes, star coupler is needed and this coupler makes system complex and costly. To solve this constraint, 2-D codes with optical filters and time delays is considered which act as the array waveguide grading and eliminate the necessary of associated star coupler requirement. Due to this reason code can be printed as (W × S) × T, where the number of wavelengths is (W × S). Construction of W2T code is only possible if the number of wavelengths is more than the space channels and by choosing this we get fewer errors on reception. System setup is depicted in figure.1. This represents the three dimensional single pulse codes by not using star coupler. In this work, the demonstration has been done by varying the wavelength and time whole not altering the space value i.e. 2. System operates on 8 Gb/s and values altered of W=3,4,5,6 and T=3,4,5,6 (S=2) .At this time the whole number of the accessible wavelengths is specified by the product (W × S). At this moment, now in this case the entire number of wavelengths becomes 6,8,10 and 12 respectively for W=3, 4, 5, 6. Because the space channels are 2 and each space channel is having same number of wavelengths as in first space. Different wavelengths of one space channel are multiplexed to form broadband source, the next wavelengths of the second channel is delayed by some value this delay works as a function of AWG. Consequently, now light intensity fed to modulator and one arm is occupied by data sequence which using NRZ line coding. For second space channel, the same data sequence is applied however delayed by some time and this delay is identical that provided to the light signal. After the modulator, encoder is located to encode the data this encoder encoded the data in time and wavelength domain, encoding in space domain is already done at transmitter. Two EDFA amplifiers are used to amplify the two space signals and then fed to optical fiber having 0.2dB/km attenuation in C-band. Here power combiners are place in order to accumulate power and signals from different space channels. At the receiver, decoder is implemented by inverting the encoder and where negative delay is given to the wavelengths at decoder. Followed by the photo detector PIN that converts optical signal into electrical domain and Bessel remove the distortions in the signal. Finally received signal is evaluated in terms of bit error rate and Q-factor. Optical spectrum analyzer, power meter and OTDV are placed to see the signal strength and availability after some components. A Fuzzy logic detector prior to demodulation is placed after optical fiber for estimation as shown in figure 1(a).

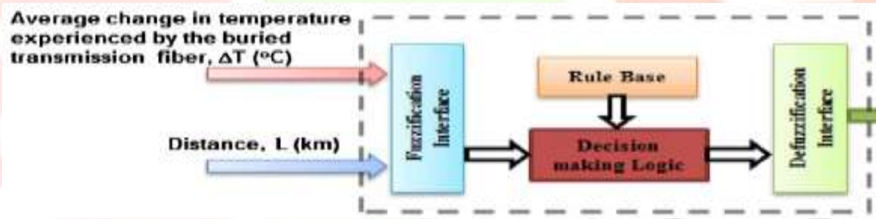


Figure 1(a) Fuzzy Controller

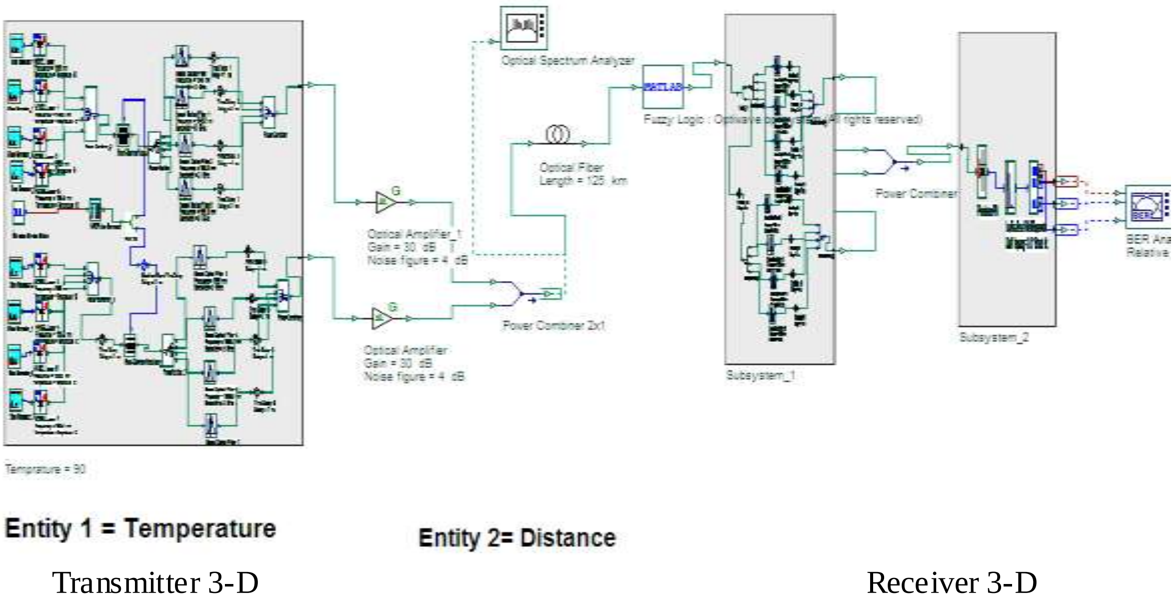
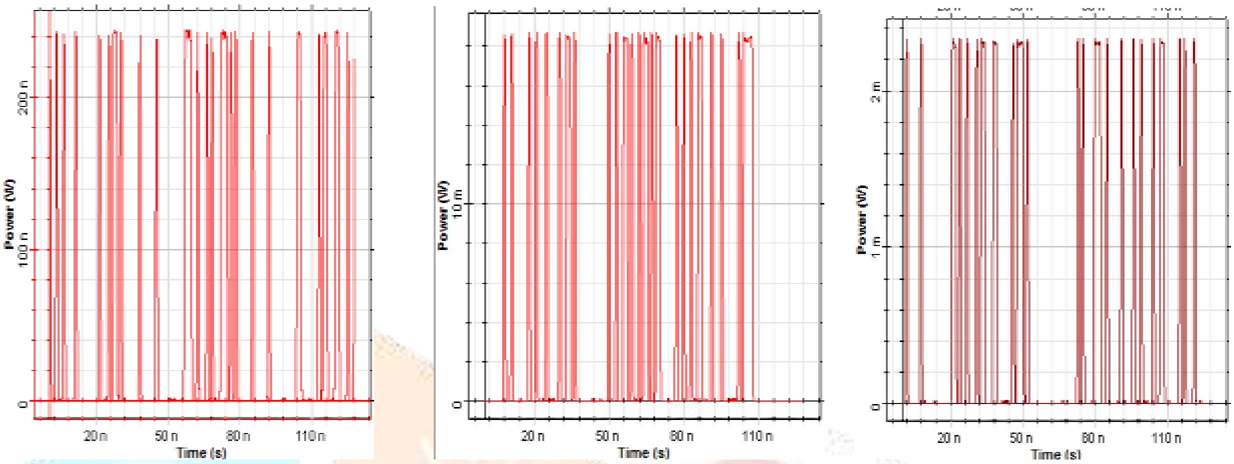


Figure 1(b) System setup depiction

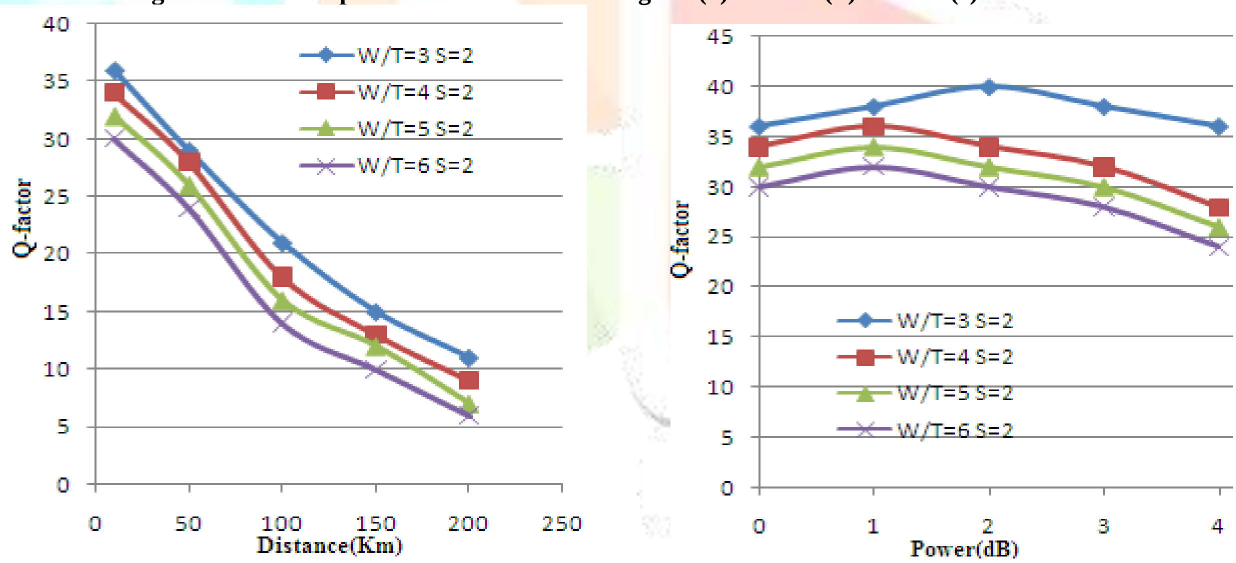
IV. RESULTS AND DISCUSSION

Here results are analyzed for non identical values of wavelength along with time and not disturbing the space channels. Space channels S=2 operate in entire single pulse plane OCDMA code. First and foremost the code has been obtained from Goloumb ruler properties such as distance between two values is not identical. This ruler can be extended to any number according to users supportability. Final fixed numbers decides the value of delays and wavelength set according to it. Major idea here is to evaluate the effects of increasing W/T as these increase the supported users. The assessment amid different setups for W/T = 3, 4, 5 and 6 is completed by means of altering the distance end to end of fiber, by altering the number of users and by means of altering the input power against bit error rate, and as well can be completed by observing, output signal and at receiver. After that the channels which performs better is used for maximum range coverage.



(a) (b) (c)

Figure 2 OTDV representation after encoding for (a) W/T=4 (b) W/T=5 (c) W/T=6

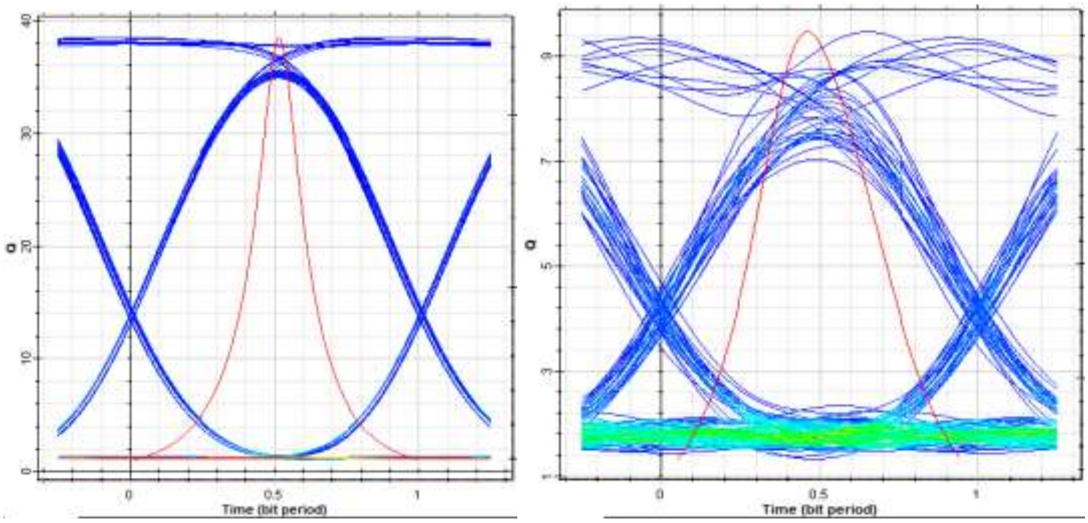


(a) (b)

Figure 3 Graphical representation of (a) Distance Vs Q factor (b) Power Vs Q-factor

Optical time domain visualizes the data and power meter used to measure the total power. Figure 3 represents that as the distance end to end of the fiber varied, Q factor is also varied and the BER increases with increase in the length of the fiber. By altering the span of the fiber for all the design W/T = 3,4,5,6 in that order quality is calculated and compares the varied span of the fiber versus Q-factor. By observing this graph, we find out that the W/T=3 gives better results for 180 Km. Also with the increase of time values results are deteriorated as MAI increase.

Results shows BER against the number of users, as the numbers of users vary correspondingly BER is vary and BER increases with increase in number of users. Also as the input power increases, output increase to some extent and after that decreases. This is due to the nonlinear effects at high powers such as four wave mixing etc. Also BER versus input peak power, in this case as the peak power increases, the BER rate of the system decreases. Varying the peak power for all system correspondingly varied BER is measured and compare the peak power versus BER curves of all the channels and find out that which W/T value performs better. By observing this, we find out that W/T=3 perform better.



(a) (b)

Figure 4 Eye diagram for W=T=4 S=2 after (a) 50 Km (b) 110 Km

Further, a comparison has been made of the system for fuzzy detection and conventional detection. It is observed that for W/T=4 S=2 system, fuzzy detection exhibit superior performance than conventional detection by adjusting threshold.

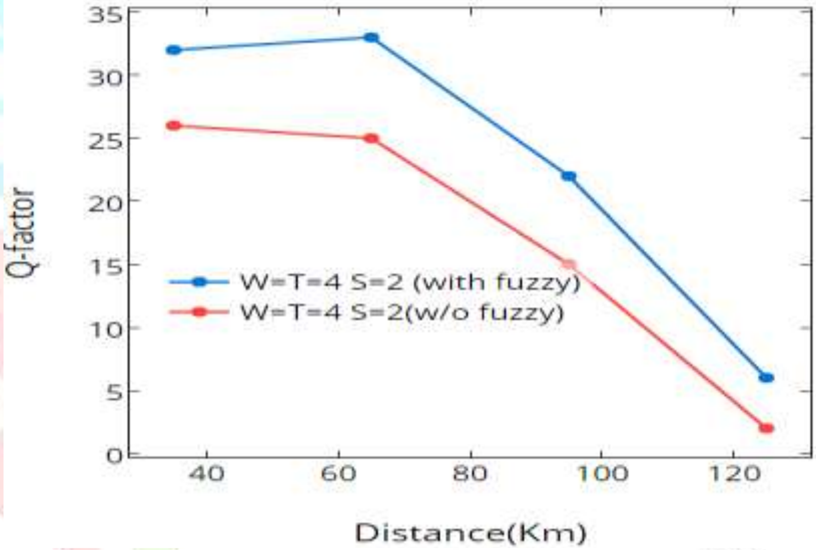


Figure 5 With Fuzzy and W/O Fuzzy logic detection

V. Comparative Analysis of Wavelength/Time/Space and Wavelength/Time/Polarization 3-D OCDMA

In this section, main emphasis is on the comparison of three dimensional data coding W/T/S and W/T/P for Space/Polarization=2. Using simulation setup for both the schemes differently, find out the BER against variation in length, input power and also determine the output signal at receiver, input data signal and eye diagram. It is reported that as the length of the fiber varies, correspondingly BER is varies and BER increases with increase in length of the fiber.

Firstly, BER is obtained for Wavelength/Time/Space and then for Wavelength/Time/Polarization. Figure 7 depicts the performance of the different setup at different link length. By observing the graph, we observed that W/T/P provides better BER as compared to W/T/S.

In OCDMA, encoding and decoding is performed in temporal domain and wavelength domain. This temporal OCDMA performs the coding in time domain, by using very short optical pulses, using optical delay lines to compose the coded optical signal. In wavelength OCDMA the intensity of the spectrum of broadband optical signal is spread by using wavelength division masks. The 2-D encoding scheme based on SPPDD codes is presented in the figure 8.

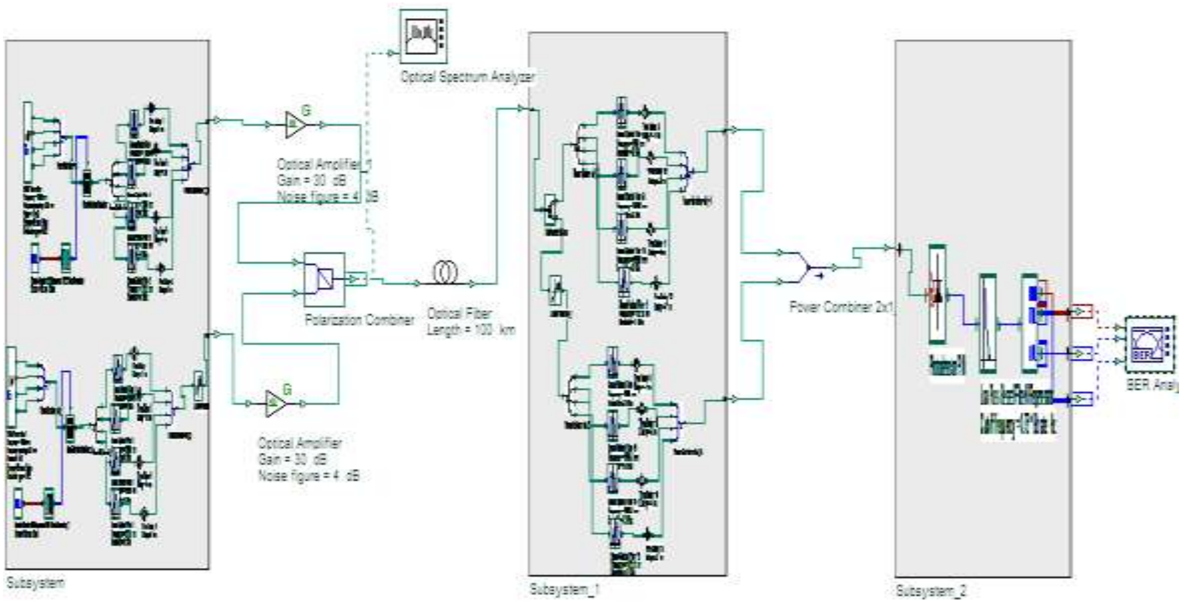


Figure 6 System Setup for Wavelength/Time/Polarization 3-D OCDMA

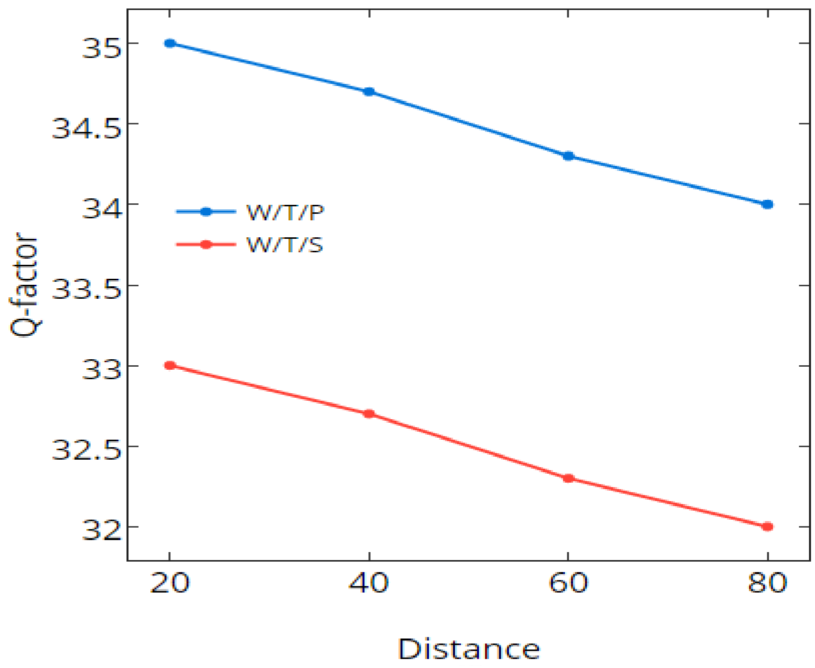


Figure 7 Graphical representation of Distance versus Q-factor for Wavelength/Time/Space and Wavelength/Time/Polarization

VI. Evaluation of 2-D and 3-D SPPDD Codes

The code employed in the single pulse per plane OCDMA system is a pseudo-random code. The OCDMA system requires a multi- wavelength source. The stream of laser pulses is then modulated with the user's data which is taken drive from non return to zero. After data modulation, signal is sent into a encoder, which applies a particular OCDMA code to the spectrum and also provide time. Each user is assigned one set of N element codes. Once the signal has been encoded, it can be passively combined with other OCDMA signals, each of which have their own unique codes but overlap completely in frequency domain. In order to recover a particular OCDMA use's signal at the receiver end of the system, a inverse time decoder is first employed. Physically, it is nearly identical to the encoder located at the transmitter, but it has conjugate time after the decoding, it is necessary to remove the multi-user interference noise resulting from the undesired OCDMA users. The desired use's data signal can be recovered through data demodulation and detection.

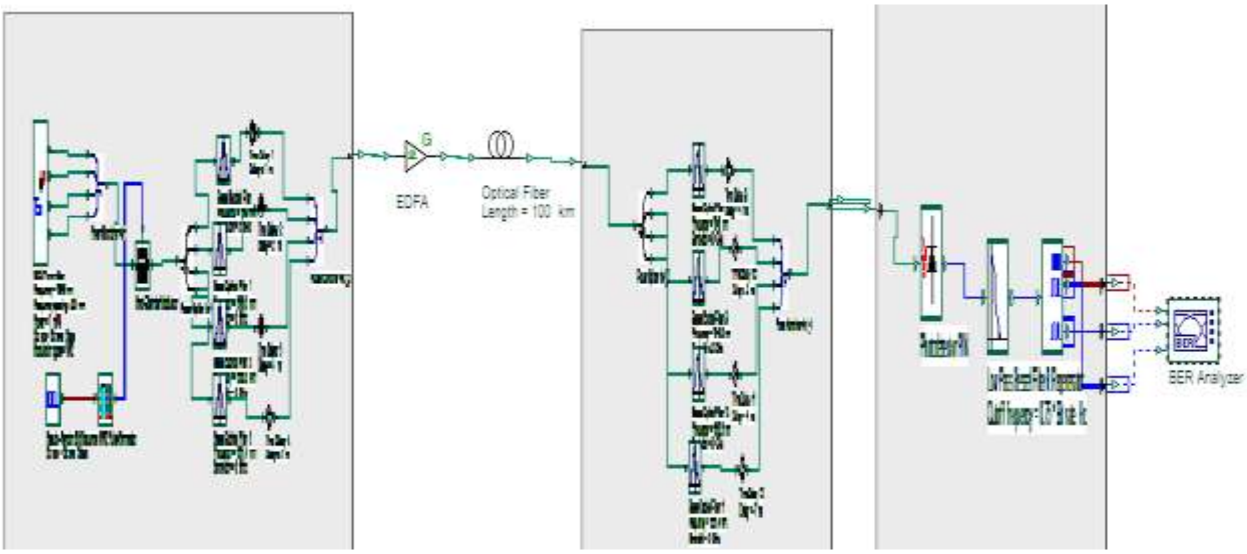
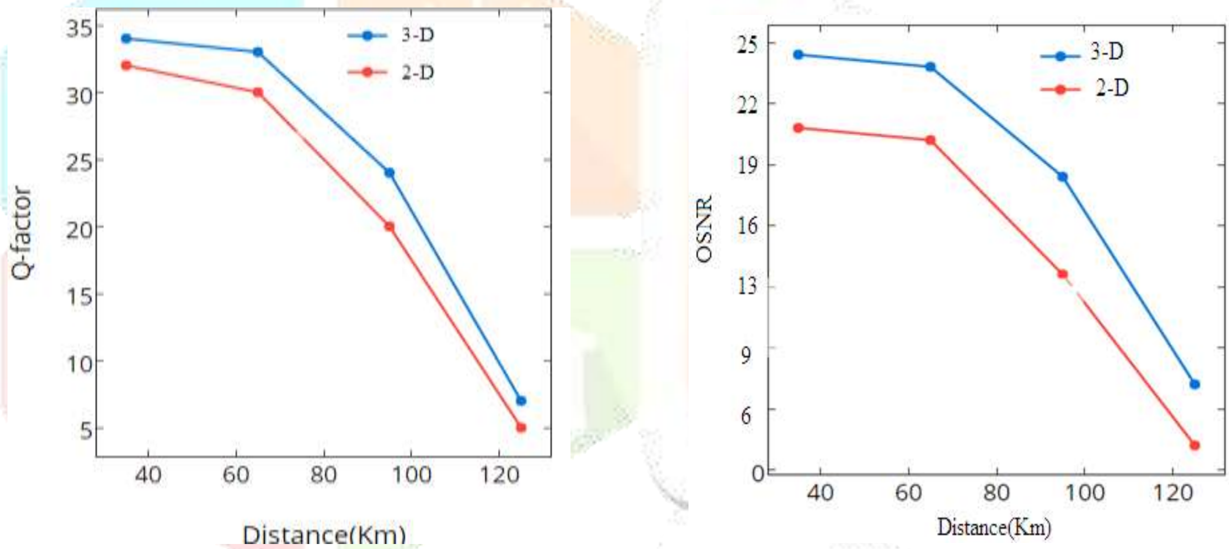


Figure 8 Simulation Diagram of Wavelength/Time 2-D OCDMA

By changing the distance of the fiber for both the design W/T = 4 three dimensional and two dimensional OCDMA, quality is calculated and compared for fiber distance versus Q-factor. From representation, it is concluded that the W/T=4 S=2 gives better results against 2-D codes.



(a) (b)

Figure 9 Performance of 2-D and 3-D SPPDD codes for (a) Distance Vs Quality (b) Distance Vs OSNR

VII. CONCLUSION

Three dimensional codes are generally preferable more than one and two dimensional codes. In current work, Two dimensional functioning of three dimensional codes is completed by means of W^2T scheme, where entire number of wavelengths are (W × S). Evaluation has been carried out by altering wavelength and time dimensions by keeping third dimension constant. Moreover, different distances and temperatures are taken into account to measure the reach within the acceptable limits of bit error rate (BER). We proposed a fuzzy control system for 3D-W/T/S OCDMA receivers to dynamically adjust the detection threshold level at the receiver end due to environmental temperature variations. The adjustment is set by the control fuzzy system via the estimation of the autocorrelation peak value. Simulation results revealed that with the increase of wavelength/ time dimensions, more interference is observed and system works for 125 Km for W/T=3 and 110 Km for W/T=4. It is also observed that polarization as third dimension is better than Space for 3-D SPPPDD codes.

REFERENCES

[1] Bin Ni and James S. Lehnert, "Performance of an incoherent Temporal Spreading OCDMA system with broadband light sources". Journal of lightwave technology, vol 23,no.7, pp-2206-2214, July 2005.

[2] E.Inaty, H.M.H Shalaby, P.Fortier and L.A. Rusch, "Multirate Optical fast frequency hopping CDMA system using power control", "Journal of lightwave technology", vol 20, no.2, pp-166-177,Feburary 2002.

[3] S.A. Aljunid, M.Ismail, A.R. Raml, B.M. Ali and M.K. Abdullah. " A new family of optical code sequence for spectral amplitude coding optical CDMA systems". IEEE photonics technology letters, vol.16, no.10, pp-2383-2385, October 2004.

[4] M. Noshad, K. Jamshidi, Code family for modified spectral-amplitude-coding optical CDMA systems and performance analysis, Journal of Optical communication network, vol- 2, no.8, pp- 344–355, 2010.
[5] S. Kim, K. Yu, N. Park, A new family of space/wavelength/time spread three dimensional optical code for OCDMA network, J. Lightwave Technol. 18 pp. 502–511, April 2000.
[6] R. Randhawa, S. Singh, J.S. Sohal, R.S. Kaler, Wavelength converter using semi-conductor optical amplifier Mach-Zehnder interferometer based on XPM at 40 Gb/s for future transport networks, Fiber and Integrated Optics 28 pp.154–169 , 2009.
[7] R.S. Kaler, T.S. Kamal, A.K. Sharma, Approximate and exact small signal anal-ysis for single-mode fiber near zero dispersion wavelength with higher order dispersion, Fiber and Integrated Optics 21 (5) pp. 391–415 2002.
[8] José V. dos Reis, Jr., Thiago R. Raddo, Anderson L. Sanches, and Ben-Hur V. Borges, Fuzzy Logic Control for the Mitigation of Environmental Temperature Variations in OCDMA Networks, j. opt. communication. network./vol. 7, no. 5 2015