A NOVEL APPROACH FOR TIME-VARYING CFO ESTIMATION IN UNDERWATER ACOUSTIC COMMUNICATION SYSTEM USING DIFFERENTIAL ALGORITHM

MR. R S Pratap Singh[1], B .Sri Keerthi[2], N.Haritha[3], M .Rupa Sri[4], B .Venkata Kiran[5],K.Sasi Kiran[6]

[1]Associate Professor ,Dept of ECE, PBR VITS ,Kavali, Andhra Pradesh-524201

[2,3,4,5,6]UG students ,Dept of ECE, PBR VITS ,Kavali,Andhra Pradesh-524201 India.

I.Abstract - Orthogonal frequency division multiplexing (OFDM) is the preferred scheme for high-speed communication in the field of underwater acoustic communication. This study used a time-varying CFO estimation method aided by the differential evolution (DE) algorithm to accurately estimate the CFO of an OFDM system. This method was based on the principle that the received OFDM signal with inter-carrier interference could be considered by a Multi Carrier-code division multiple access (MC-CDMA) system on the receiver side .The spreading code of the MC-CDMA was obtained based on the estimated CFO values, which were elements in the DE solutions. The simulation results showed that the proposed method had a high estimation accuracy. Specifically, under the condition of a high signal-to-noise ratio, the improvement of estimation accuracy reaches 36.13%, and the Bit Error Rate of demodulation is thus reduced by 75%, compared with the reference algorithms. The proposed method also has good applicability to modulation methods. For PSK and QAM in particular, the proposed method not only achieved high-precision time-varying CFO estimation values, but also reduced the demodulation deterioration caused by noise.

Index Terms - OFDM ,TV - CFO , MC -CDMA , DE Algorithm.

II. INTRODUCTION:

From oceanography studies to offshore oil exploration, underwater study and exploitation have significantly increased in the last decade. As a result, there is a growing need for reliable and high data-rate underwater wireless communication (UWC) systems. Traditionally, acoustic waves have been used to establish underwater communication. However, the bandwidth of underwater acoustic channel is limited to hundreds of kHz because of strong frequency dependent attenuation of sound in seawater. The slow propagation of sound waves also causes large time delay in acoustic communication systems. In addition, radio frequency (RF) communication is severely limited due to the conductivity of seawater at radio frequencies . Seawater has an electrical conductivity of around 4.3 Siemens/m , which is 2 to 3 orders of magnitude higher than that of natural fresh waters. By exploiting the low absorption of seawater in blue-green (400-550 nm) region of the visible light window (390-700 nm) of electromagnetic spectrum, the UWOC system.

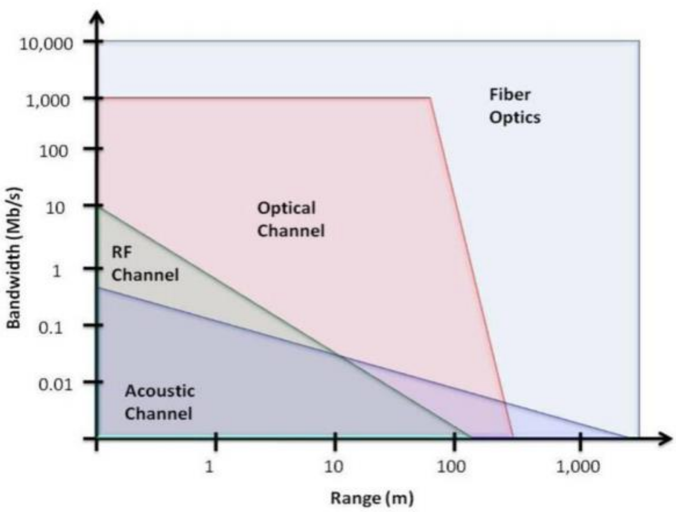


FIG : Comparative performance of different underwater communication channels.

III. LITERATURE SURVEY :

[1] : H. Gao and H. Zhao: In this article, we develop an efficient forward solver for steady-state or frequency-domain radiative transfer equation on 2D and 3D structured and unstructured meshes with vacuum boundary condition or reflection boundary condition. Although we emphasize applications in optical imaging, our method may be applied to more general radiative transfer equations, for example, other types of scattering function. Efficiency and accuracy of our algorithm is demonstrated by comparison with both analytical solutions and Monte Carlo solutions and with various numerical tests in optical imaging.

[2] L. Johnson, R. Green, and Mark Leeson:This paper describes and assesses underwater channel models for optical wireless communication. Models considered are: inherent optical properties; vector radiative transfer theory with the small-angle analytical solution and numerical solutions of the vector radiative transfer equation (Monte Carlo, discrete ordinates and invariant imbedding). Variable composition and refractive index, in addition to background light, are highlighted as aspects of the channel which advanced models must represent effectively. Models are assessed against these aspects in terms of their ability to predict transmitted power and spatial and temporal distributions of light a specified distance from a transmitter. Monte Carlo numerical methods are found to be the most versatile but are compromised by long computational time and greater errors than other methods.

[3] Z. Zeng, S. Fu, H. Zhang, Y. Dong, and J. Cheng:

Underwater wireless communications refer to data transmission in unguided water environment through wireless carriers, i.e., radio-frequency (RF) wave, acoustic wave, and optical wave. In comparison to RF and acoustic counterparts, underwater optical wireless communication (UOWC) can provide a much higher transmission bandwidth and much higher data rate. Therefore, we focus, in this paper, on the UOWC that employs optical wave as the transmission carrier. In recent years, many potential applications of UOWC systems have been proposed for environmental monitoring, offshore exploration, disaster precaution, and military operations. However, UOWC systems also suffer from severe absorption and scattering introduced by underwater channels. In order to overcome these technical barriers, several new system design approaches, which are different from the conventional terrestrial free-space optical communication, have been explored in recent years. We provide a comprehensive and exhaustive survey of the state-of-the-art UOWC research in three aspects: 1) channel characterization; 2) modulation; and 3) coding techniques, together with the practical implementations of UOWC.

[4] E.M. Sozer, M. Stojanovic, and J. G. Proakis: With the advances in acoustic modem technology that enabled high-rate reliable communications, current research focuses on communication between various remote instruments within a network environment. Underwater acoustic (UWA) networks are generally formed by acoustically connected ocean-bottom sensors, autonomous underwater vehicles, and a surface station, which provides a link to an on-shore control center. While many applications require long-term monitoring of the deployment area, the battery-powered network nodes limit the lifetime of UWA networks. In addition, shallow-water acoustic channel characteristics, such as low available bandwidth, highly varying multipath, and large propagation delays, restrict the efficiency of UWA networks. Within such an environment, designing an UWA network that maximizes throughput and reliability while minimizing the power consumption becomes a very difficult task. The goal of this paper is to survey the existing network technology and its applicability to underwater acoustic channels. In addition, we present a shallow-water acoustic network example and outline some future research directions.

[5] E. Illi, F. El Bouanani, and F. Ayoub: In this paper, a unified performance analysis of underwater wireless communication system is presented. The radio link between the source (S) and the destination (D) is subject to κ-μ shadowed fading channel. We present an analytical closed-form expression for the cumulative distribution function (CDF) and the probability density function (PDF) of the total end-to-end SNR in terms of the Kummer's Hypergeometric function. Based on these results, we present exact closed-form expressions of communication system performance criteria, such as outage probability (OP) and average bit/symbol error rate (ABER/ASER) with their respective asymptotic expansion, at both low and high SNR regimes, expressed in terms of basic elementary functions. All the derived analytical expressions are validated through computer-based simulation. Index Terms—Wireless communication systems, Radio-Frequency (RF), Underwater communication, κ-μ shadowed fading ,outage probability, average bit/symbol error rate, asymptotic expansion.

IV. EXISTING SYSTEM:

The performances of the DE algorithm, GA, and SAMGA when estimating the TVCFO in the form of a polynomial function with the same computing resources. The data in the figure are the averages obtained from 50 independent runs under different SNRs, as are the data in the following figures. The measurements show the Root-Mean-Square Error (RMSE) of the CFO values on the OFDM blocks which can be defined is as follows :

$$\mathrm{RMSE}(\hat{\varepsilon}) = \sqrt{\frac{1}{K}\sum_{i=1}^{K}(\hat{\varepsilon}_i - \varepsilon_i)^2}.$$

The black, blue, and red curves represent the results obtained by the SAMGA, GA, and DE estimators for the improved model, respectively. The RMSE values improved as the SNR increased. However, the SAMGA did not improve the performance of the genetic algorithm in this case. It was inferred that this lack of improvement was a result of the limited computing resources, which made the large population size unsuitable. Moreover, the SAMGA increased the diversity to prevent premature, which also wasted computing resources. Generally, the available time resources are seriously constrained in underwater acoustic communication. Therefore, the advantages of the SAMGA could not be fully utilized. The GA had a remarkable performance compared to that of the SAMGA; However, the performance of the DE algorithm was slightly better than that of the GA. The average RMSE value with the DE algorithm was approximately 9.68% smaller than that of the GA when the SNR was less than 12 dB. When the SNR exceeded 12 dB, the average RMSE of the DE estimator increased, becoming 30.02% smaller than that of the GA estimator, and finally reaching a peak that was 43.71% lower at 20 dB. This significant improvement was due, not only to the adaptive parameters of the DE algorithm used in this study, but also to its advantage when solving problems with dependencies between adjacent variables. The GA could not compete with the DE algorithm in terms of the dependencies between adjacent variables which is the pivotal characteristic of TVCFO estimation. The above analysis was confirmed by the gap between the two curves becoming progressively obvious as the SNR increased. Because the amplitude of the noise followed a normal distribution and had significant randomness, the dependencies between adjacent variables were diluted. However, as the SNR increased, the influence of the noise decreased, and the connections between adjacent TVCFO values could be more easily mined by the DE algorithm.

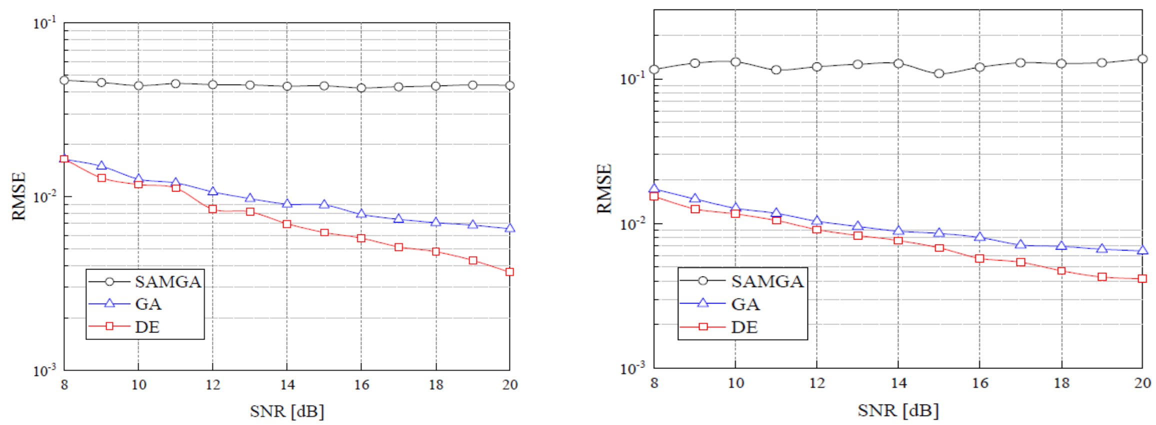


Fig : (a) RMSE Performances of three estimators on the improved model with CFO values varying in polynomial function

(b) RMSE Performances of three estimators on the improved model with CFO values varying as a sinusoidal function.

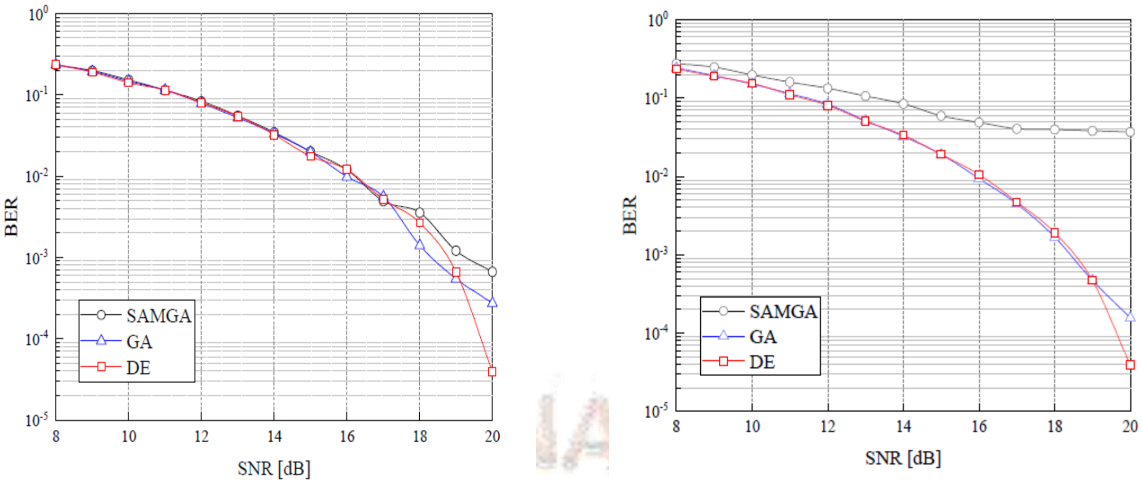


Figure (a) Bit error rate statistics of three estimators on the improved model with CFO values varying as a polynomial function.
(b) Bit error rate statistics of three estimators on the improved model with CFO values varying as a sinusoidal function.

V. PROPOSED METHOD :

Orthogonal frequency division multiplexing (OFDM) was developed from multi-carrier modulation technology and has the characteristic of anti-narrowband interference.The spectral efficiency of the communication process was improved by the adoption of overlapping sub-carrier modulation technology, which reduces the communication bandwidth. As its name suggests, orthogonality between subcarriers can maximize the spectral efficiency and reduce inter-carrier interference (ICI).The presence of carrier frequency offset (CFO) in a communication system can destroy the orthogonality, which reduces the signal-to-noise ratio (SNR) and intensifies the ICI, significantly increasing the bit error rate (BER) of the received OFDM signal.Because of factors such as the sea surface fluctuation effect, turbulence, and internal wave motion, the transmitter and receiver terminals used in underwater communication usually have relative velocities, which leads to the Doppler effect.Presently, the methods used for CFO estimation can be mainly divided into two categories : data-aided estimation and non-data-aided estimation .The data-aided estimation is performed in the time domain, it utilizes a training sequence, whereas if it is performed in the frequency domain, it uses pilot symbols.The non-data-aided estimation methods are also commonly referred to as blind estimation.Moreover, the ICI matrix in OFDM is an orthogonal matrix. An $N \times N$ ICI matrix acts as a spreading code matrix; thus N data symbols in the OFDM are spread over all N subcarriers in the MC-CDMA system.

Simulation results showed that the proposed scheme achieved a promising performance, which was comparable to that of OFDM in the absence of ICI.This TVCFO is very difficult to deal with because its tracking and equalization usually require high computational complexity. Simultaneously, the first-order statistics of the cyclic prefix are also estimated to reduce the ICI. The DE algorithm has a feature that distinguishes it from other intelligent optimization algorithms: it is especially suitable for solving problems where there are dependencies between the adjacent variables to be optimized. Simultaneously, the crossover characteristic of the DE algorithm was used to track the TVCFO and obtain the best estimation values based on its strong optimization ability.The optimal estimation of the TVCFO was achieved by the iterative use of the genetic operators of the DE.

The main contribution of this paper is to provide a feasible idea for time-varying CFO estimation, and the proposed method not only has the general applicability of modulation methods but also can improve the noise tolerance in demodulation.

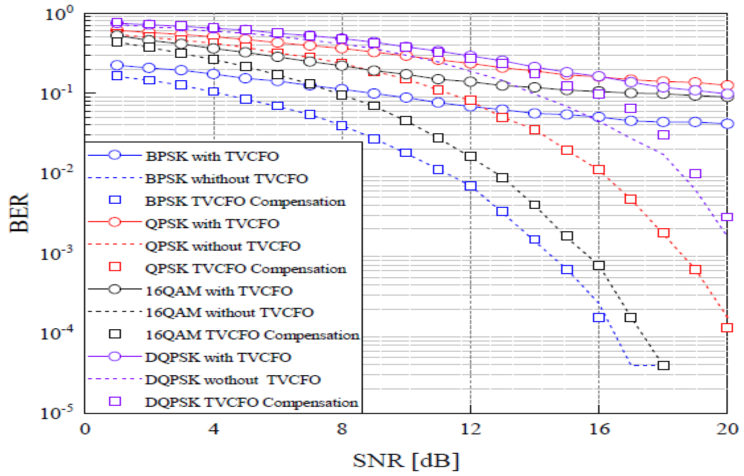
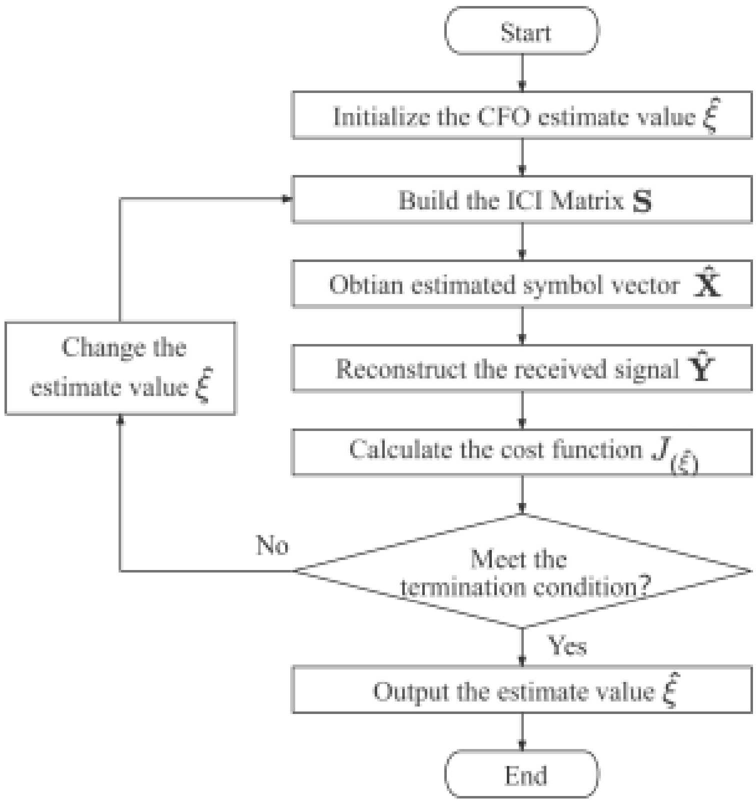


Fig Bit error rate statistics of demodulation results in four cases: BPSK (blue), QPSK (red), DQPSK (purple), and 16QAM (black).

VI. FLOW CHART :



Advantages:

- Highly Accurate.
- Efficiency is very high.
- Can estimate the CFO accurately.
- Requires less hardware
- High Speed Processing

.

VII. RESULTS AND DISCUSSION :

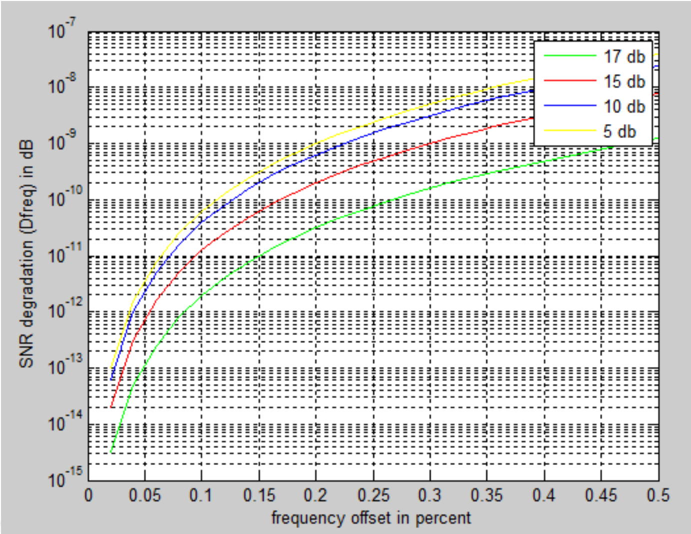


Figure (a) : Signal to Noise Ratio Variation as a function of frequency offset.

In the above figure SNR degradation in DB is high. The frequency offset describes if the signal power is reduced ,the orthogonality will loss.

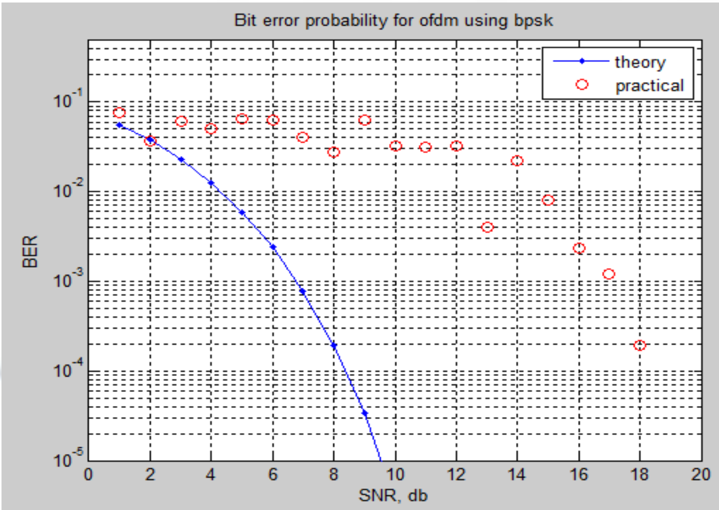


Figure (b) : Bit Error Rate as a function of Signal to Noise Ratio for OFDM using BPSK.

The no of bits errors per unit time (BER) is reduced by using DE algorithm. In proposed case we Esteemed to prove successfully.

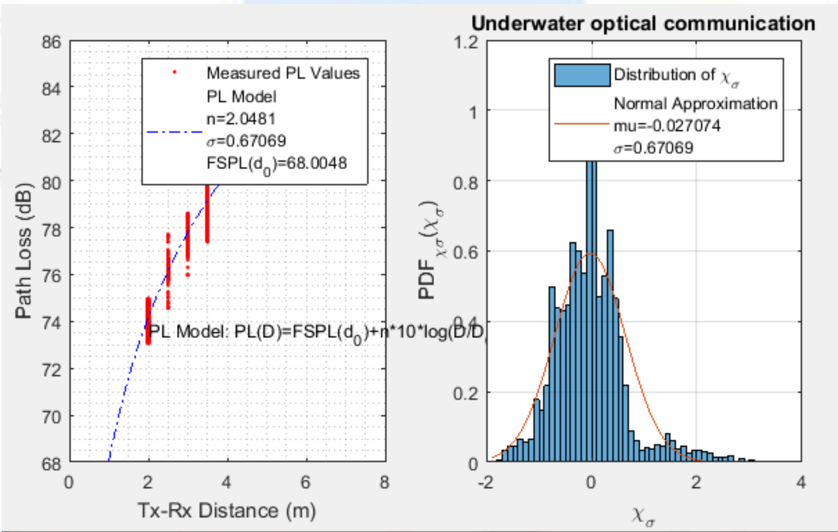


Figure (c) : Overall pathloss analysis of the proposed Underwater Optical Communication system.

In UAC here transmission of messages between conspecifics via sound waves through water or air. In the above figure the signal degradation loss will occurred, it due to Attenuation,Scattering, Bending , Absorbtion losses will generated. Here we placed a Repeaters for every 100 km(The power of a signal and it retransmits it allowing it to travel further).Repeaters also called as **signal boosters.** Here every repeater placed at an a long and equal distance, the power spectral density is reduces in UOCS. Here we used Beam alignment technique.

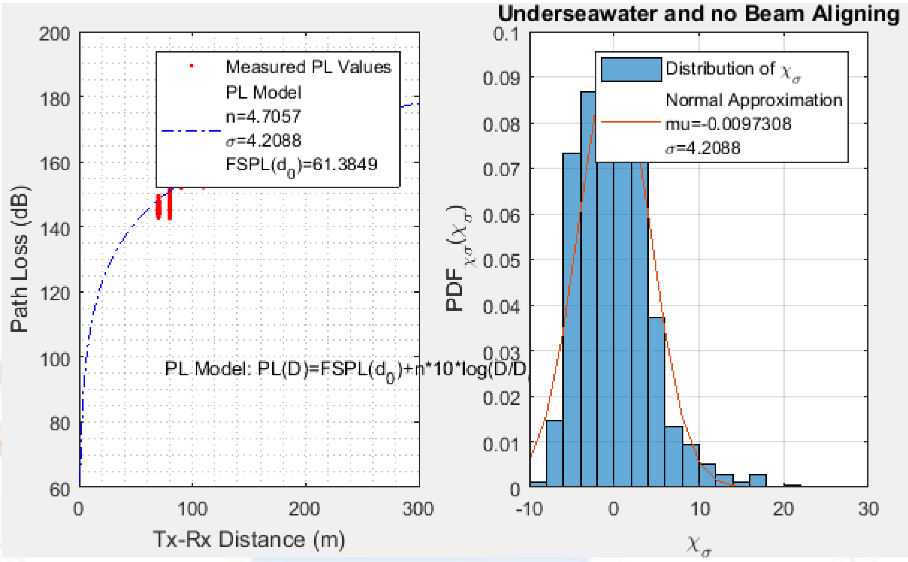


Figure (d) : Overall pathloss analysis of the proposed Underwater Optical Communication system under no beam alignment condition. In above figure describes repeaters placed at a short distance it forms as Angle of incidence is greater than the critical angle the core and cladding is incident and reflected in water and it forms Total Internal Reflection. The Power spectral density is increases in UOCS. Here the technique is no beam alignment. The accuracy is Above 50% it esteemed.

VIII. CONCLUSION :

Previous studies have shown that an OFDM signal with ICI on the receiver side can be regarded as an MC-CDMA system, in which the spreading code matrix is the ICI matrix. This study extended the system model to TV-CFO estimation. The DE algorithm has a unique feature in that its crossover operation is very suitable for solving problems in which there are dependencies between adjacent variables. Considering the change in the relative velocity of the sending and receiving terminals, which produces the TVCFO in the received signal, the velocity changes in different moments are linked by the acceleration. Therefore, the DE algorithm was employed to capture the dependencies between the CFO values on adjacent OFDM blocks. Simulation results showed that the performance of the DE algorithm was better than those of other intelligent optimization algorithms (the SAMGA and GA) in terms of the RMSE of the estimated CFO values and the BER of the demodulation. Furthermore, the proposed scheme not only achieved a demodulation performance with actual TVCFO values, but also reduced the demodulation deterioration caused by noise in both the PSK and QAM modulations. Future research could focus on the effect of noise on the DQPSK modulation with the DE estimator. The DE estimator could also be further utilized to achieve a better balance between the computational complexity and accuracy of TVCFO estimation.

IX. ACKNOWLEDGMENT :

MR . R S PRATAP SINGH is currently working as an Associate Professor in the Department of Electronics and Communication Engineering at PBR VITS .

X. REFERENCES :

[1] A. Klose and A. H. Hielscher, "Iterative reconstruction scheme fo optical tomography based on the equation of radiative transfer", Medical Physics, vol. 26, no. 8, pp. 1698-1707, August 1999.

[2] H. Gao and H. Zhao, "A Fast-Forward Solver of Radiative Transfer Equation", Transport Theory and Statistical Physics, vol. 38, no. 3, pp.149-192, September 2009.

[3] L. Johnson, R. Green, and Mark Leeson, "A Survey of Channel Models for Underwater Optical Wireless Communication," in the IEEE 2013 2nd International Workshop on Optical Wireless Communication (IWOW) proceedings, Newcastle upon Tyne, UK, 21-21 Oct. 2013.

[4] Z. Zeng, S. Fu, H. Zhang, Y. Dong, and J. Cheng, "A Survey of Underwater Wireless Optical Communication," IEEE Communications Surveys and Tutorials, vol. 19, no. 1, pp. 204 - 238, October 2016.

[5] S. Arnon, J. R. Barry, G. K. Karagiannidis, R. Schober, and M. Uysal, Advanced Optical Wireless Communication Systems. Cambridges: Cambridge Uinversity press, 2012.

[6] E. M. Sozer, M. Stojanovic, and J. G. Proakis, "Underwater Acoustic Networks", IEEE Journal of Oceanic Engineering, vol. 25, no. 1, pp. 72-83, January 2000

[7] S. Arnon, "Underwater optical wireless communication network," Optical Engineering, vol. 49, no. 1, January 2010.

[8] E. Illi, F. El Bouanani, and F. Ayoub, "Asymptotic Analysis of Underwater Communication System subject to κ-μ Shadowed Fading Channel," in 2017 13th International Wireless Communications and Mobile Computing Conference (IWCMC) proceedings, Valencia, Spain,
26-30 June 2017.

[9] Z. Ghassemlooy, W. Popoola, and S. Rajbhandari, Optical Wireless Communications: System and Channel Modelling with MATLAB. BocaRaton: CRC Press, 2013.

[10] M.-A. Khalighi, C. Gabriel, T. Hamza, S. Bourennane, P. Leon, and V. Rigaud, "Underwater wireless optical communication: Recent advances and remaining challenges," in Proc. International Conference on Transparent Optical Networks (ICTON), Center Graz (Grazer Messe), Austria, pp. 1-4, 6-10 July 2014..

[11] C. Mobley, E. Boss, and C. Roesler, "Ocean optics web book," 2010.[Online]. Available: http://www.oceanopticsbook.info/

[12] C. Li, K.-H. Park, and M.-S. Alouini, "On the Use of a Direct RadiativeTransfer Equation Solver for Path Loss Calculation in Underwater Optical Wireless Channels", IEEE Wireless Communications Letters, vol. 4, no. 5, pp. 561 - 564, October 2015.

[13] W. C. Cox, Jr., "Simulation, Modeling, and Design of Underwater Optical Communication Systems". Raleigh, NC, USA: North Carolina State Univ., 2012. [Online]. Available: http://www.github.com/gallamine/photonator

[14] H. Kaushal and G. Kaddoum, "Underwater Optical Wireless Communication," IEEE Access, vol.4, pp. 1518-1547, April 2016.

[15] S. Lloyd, "Least squares quantization in PCM," IEEE Trans. Inf. Theory, vol. 28, no. 2, pp. 129-137, Mar. 1982.