International Journal of Scientific Research & Engineering Trends
Volume 5, Issue5, Sep-Oct-2019, ISSN (Online): 2395-566X

Simulation Result of BER and OSNR Performance for Quasi-Constant Envelope OFDM

M. Tech. Scholar Rishabh Shukla
Department of Electronics and
Communication Engineering, University
Institute of Technology RGPV Bhopal

Hod. Dr.Vineeta Saxena Nigam
Department of Electronics and
Communication Engineering, University
Institute of Technology RGPV Bhopal

Abstract - **Quasi-Constant Envelope OFDM transmits dual-stream simultaneously to improve the spectral efficiency of Constant Envelope OFDM. It can provide high data rate links and maintain a low PAPR to reduce the distortion caused by the nonlinear power amplifier. Thus, the quasi-constant envelope OFDM is suitable for satellite communication system. However, the carrier frequency offset (CFO) in satellite communication must be estimated and compensated before the demodulation. In this paper a CFO estimation scheme is proposed for quasi-constant envelope OFDM satellite system under additive white Gaussian noise (AWGN) channel. Since the null subcarrier at the transmitter can be considered as the prior information at the receiver, this null subcarrier can be used to estimate the CFO through phase demodulator and inverse discrete Fourier transform (IDFT) module at the receiver. Mathematical analysis reveals that the ideal estimation range of normalized CFO is nearly half of the size of IDFT under AWGN channel. Simulation results show that the proposed scheme performs well at moderate and high signal-to-noise ratio (SNR) conditions.**

Keywords: **Quasi-Constant Envelope OFDM, carrier frequency offset, null subcarrier, satellite communication.**

1. INTRODUCTION

Due to the advantages of large coverage area and flexible deployment ability, satellite communication has been widely used for many fields, such as emergency communication and remote sensing. However, the power amplifier (PA) used in satellite system is always nonlinear amplifier, such as Traveling-Wave Tube Amplifier (TWTA) and Solid-State Power Amplifier (SSPA). This requires a low peak-to-average power ratio (PAPR) transmitted signal to minimize the signal distortion caused by the nonlinear PA. Several low PAPR single carrier modulation techniques have been proposed. The Gaussian Minimum Shift Keying (GMSK) has been proposed in [1]. It has a constant envelope and can achieve a 0dB PAPR signal. The Feher Quadrature Phase Shift Keying (FQPSK) has been proposed in [2]. The PAPR of FQPSK is less than 3dB. In general, such techniques which PAPR is less than 3dB can be considered as quasi-constant envelope techniques. However, with the development of communication services, the proportion of high speed services is increasing rapidly, such as multimedia services and internet services. The data transmission rate of single carrier modulation techniques is limited and it is difficult to meet the growing user demands. Thus, the multi-carrier modulation techniques have been got attention by research institutions and companies.

As the data rate increases, the delay spread can increase and extend over tens or hundreds of data symbols, increasing significantly the complexity of the time domain equalizer. Single-input multiple-output (SIMO) orthogonal frequency division multiplexing (OFDM) (SIMO-OFDM)has been proposed to address this problem [6]. In this thesis, in addition to using OFDM for high bandwidth efficiency, unequal error protection (UEP) techniques are proposed to improve the peak signal-to-noise ratio of reconstructed received images. This UEP technique is proposed based on the operation of source coded as well as feature of channel characteristics. Humans have always found ways to communicate, over space and over time. From the messenger pigeon to the Pony Express, from the message in a bottle to cave drawings, smoke signals and beacons, people have used inventive techniques, techniques derived from their natural environment, to share information. A particularly good natural resource for communication is electricity for its speed and ability to be controlled with devices like capacitors, microprocessors, electronic memory storage and batteries. Communication was profoundly enhanced with Morse's telegraph (1837), Bell's telephone (1876), Edison's phonograph (1887), and Marconi's radio (1896). From these early inventions, communications technology has advanced with global telephone networks, satellite communications, and magnetic storage systems; and with the rise of the internet and digital computers, digital communications—the transfer of bits (1's and 0's) from one point to another—has become important.

Orthogonal frequency-division multiplexing (OFDM) technique is a typical multi-carrier modulation technique and it has been studied for decades [3]. The main advantage of OFDM is the ability to provide high data rate link against harsh propagation environment. However, the main drawback of OFDM is that its PAPR is much higher than that of single carrier modulation techniques [4]. Thus, OFDM needs either sufficient input power backoff (IBO) or PAPR reduction schemes to reduce the signal distortion. As the energy of satellite is collected by solar panels, the energy is limited. A large IBO will seriously reduce the energy efficiency and increase the energy consumption of whole system. The overview of PAPR reduction schemes has been given in [5]. However, the disadvantages of these schemes include increased complexity, reduced spectral efficiency, and performance degradation. Therefore, a multi-carrier modulation technique which has a low PAPR will be more suitable for satellite communication. Constant Envelope OFDM can obtain a 0dB PAPR signal by modulating the OFDM signal to the phase of a constant envelope signal [6]. Thus, IBO is needless and the energy efficiency is high. It has been proved that CE-OFDM compares favorably to OFDM considering the impact of nonlinear PA. Due to this advantage, the applications of CEOFDM in satellite communication have been researched. A CE single-carrier FDMA (CE-SCFDMA) scheme has been proposed in [7] and the bit error rate (BER) performance has been evaluated with nonlinear satellite channel in the Q/V and W band satellite communication system. The comparison between Constant Envelope multicarrier waveforms (CEOFDM and CE-SCFDMA) and single carrier impulse-based waveforms for EHF broadband satellite communication has been presented in [8]. However, it has been proved that the spectral efficiency of CE-OFDM is less than half of OFDM [6]. In order to improve the spectral efficiency, a dual-stream transceiver structure has been proposed in [9]. The Taylor series expansion demodulation scheme in [10] is extended to dual-stream signals. It has been proved that the PAPR of the dual-stream transceiver is lower than 3dB and the BER performance of the transceiver compares favorably to CEOFDM. Therefore, the dual-stream transceiver can be considered as a quasi-constant envelope OFDM technology which is able to support high data rate communication services. Since the carrier frequency offset (CFO) is large in satellite communication, the frequency synchronization is necessary in quasi-constant envelope OFDM satellite system.

II. METHODOLOGY

In proposed system we use quasi constant envelope OFDM and other OFDM schemes for comparison with quasi CE-OFDM and 16 QAM subcarriers are used. This scheme can improve spectrum efficiency effectively and maintain the advantages of low PAPR and high resistance to fiber nonlinearity. Such a high spectrum efficiency and large nonlinearity tolerance scheme is attractive despite the increased complexity of the introduced system. In this in-phase and quadrature modulator is used through which a laser pulse is passed and gets an optical output. The optical output is loaded with coherent detection to get the real and imaginary values. No scheme based on I/Q modulator, to the best of our knowledge, has been proposed for CE-OFDM. We report simulation results of Quasi-CE-OFDM system using 16-QAM subcarrier modulation. The results reveal an effective spectrum efficiency improvement when compared to existing constant envelope system and substantial increase of fiber nonlinearity tolerance when compared to the Con-CO-OFDM system. In baseband OFDM demodulation the certain functions are performed and we can recover data. The BER and OSNR performance is done with the quasi CE-OFDM recovered data.

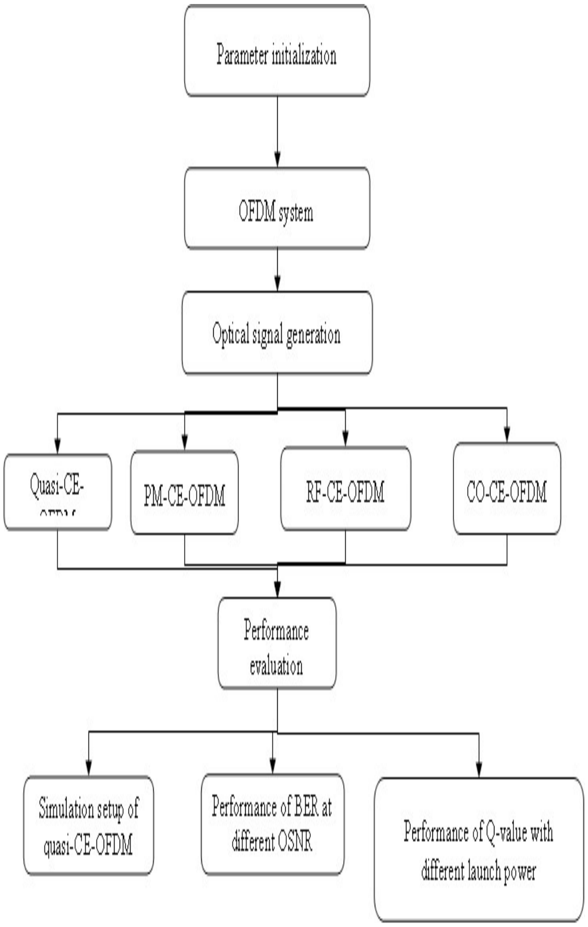

Fig.1. Flow diagram of proposed system.

OFDM is based on the well-known technique of Frequency Division Multiplexing (FDM). In FDM different streams of information are mapped onto separate parallel frequency channels. Each FDM channel is separated from the others by a frequency guard band to reduce interference between adjacent channels.

The OFDM scheme differs from traditional FDM in the following interrelated ways:

1. Multiple carriers (called subcarriers) carry the information stream,
2. The subcarriers are orthogonal to each other, and
3. A guard interval is added to each symbol to minimize the channel delay spread and intersymbol interference.

The following figure illustrates the main concepts of an OFDM signal and the inter-relationship between the frequency and time domains. In the frequency domain, multiple adjacent tones or subcarriers are each independently modulated with complex data. An Inverse FFT transform is performed on the frequency-domain subcarriers to produce the OFDM symbol in the time-domain. Then in the time domain, guard intervals are inserted between each of the symbols to prevent inter-symbol interference at the receiver caused by multi-path delay spread in the radio channel. Multiple symbols can be concatenated to create the final OFDM burst signal. At the receiver an FFT is performed on the OFDM symbols to recover the original data bits.

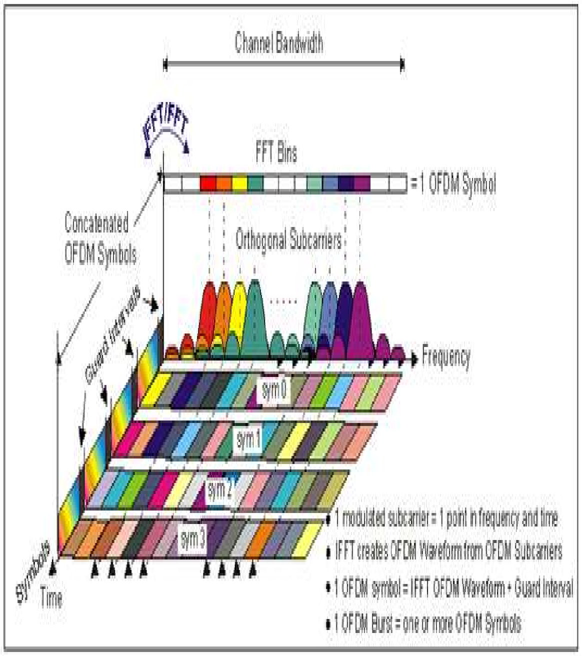

Fig.2. frequency time representative of an OFDM Signal.

- **Simple Digital OFDM system Implementation using FFT transforms**

The concepts used in the simple analog OFDM implementation can be extended to the digital domain by using a combination of Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) digital signal processing. These transforms are important from the OFDM perspective because they can be viewed as mapping digitally modulated input data (data symbols) onto orthogonal subcarriers. In principle, the IFFT takes frequency-domain input data (complex numbers representing the modulated subcarriers) and converts it to the time-domain output data (analog OFDM symbol waveform).

In a digitally implemented OFDM system, the input bits are grouped and mapped to source data symbols that are a complex number representing the modulation constellation point (e.g., the BPSK or QAM symbols that would be present in a single subcarrier system). These complex source symbols are treated by the transmitter as though they are in the frequency-domain and are the inputs to an IFFT block that transforms the data into the time-domain. The IFFT takes in N source symbols at a time where N is the number of subcarriers in the system. Each of these N input symbols has a symbol period of T seconds. Recall that the output of the IFFT is N orthogonal sinusoids. These orthogonal sinusoids each have a different frequency and the lowest frequency is DC.

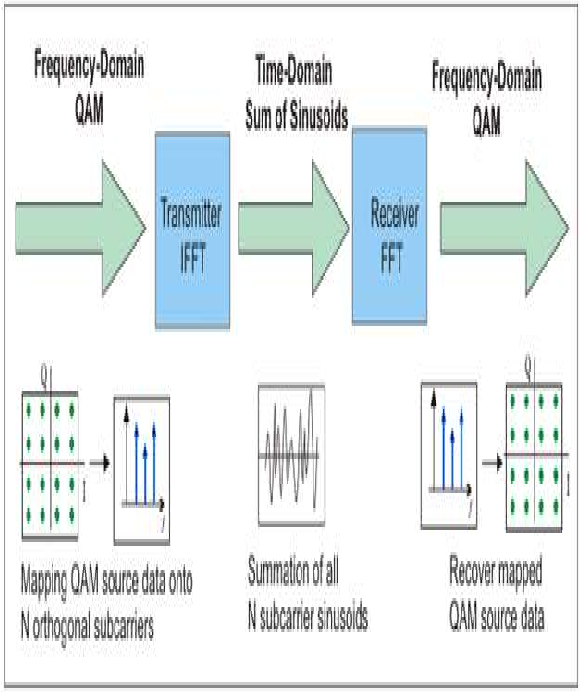

Fig.3. Simplified OFDM System Block diagram.

III. RESULT

MATLAB used for simulation to verify the performance of the proposed Quasi-CE-OFDM System.

The performance of Quasi-CE-OFDM was compared with PM-CE-OFDM, RF-CE-OFDM and Con-CO-OFDM in the presence of nonlinearity. In order to make an unbiased and fair performance comparison, in all OFDM schemes, the number of subcarriers used for data transmission, the duration of an OFDM symbol, the overhead and the net data rate are equal. So the FFT length and sampling rate for PM-CE-OFDM and RF-CE-OFDM are 512 and 20GSa/s, while for Con-CO-OFDM, they are 256 and 10GSa/s, respectively.

In order to evaluate the system more effectively, Q-value is used to evaluate the performance. The definition of Q-value is

$$q=\left(\frac{1}{\sqrt{N\bullet N_{SC}}}\sqrt{\sum_{i=1}^{N}\sum_{k=1}^{N_{SC}}\frac{\left|C'_{ik}-C'_{i,ave}\right|^{2}}{\left|C'_{i,ave}\right|^{2}}}\right)^{-1},$$

$$Q=20\times\lg(q)$$

where Nsc is the number of subcarrier, N is the number of received OFDM symbol, ' Cik is the received i-th data symbol on the k-th subcarrier, and ' Ci,ave , is the average of corresponding received OFDM symbols.

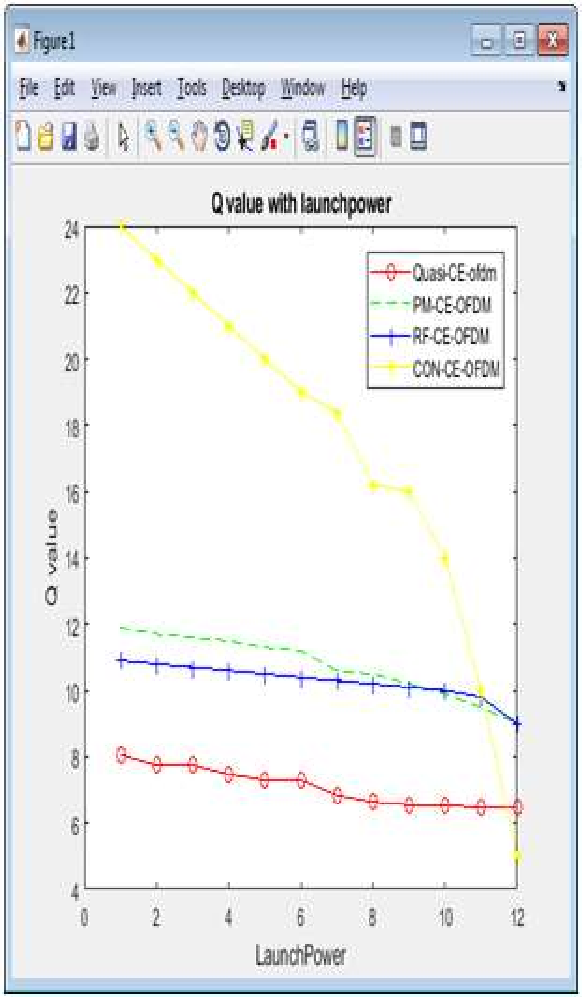

Fig.4. Q value with launch power.

Fig.4 shows compared the nonlinearity tolerance of the proposed scheme and other three different schemes after 100km SSMF transmission by varying the fiber optical input power from -2 to 12 dBm. The red line represents the proposed Quasi-CE-OFDM and blue line represents RF-CE-OFDM. PM-CE-OFDM (green line) and CON-CE-OFDM (yellow line) are also investigated as comparison.

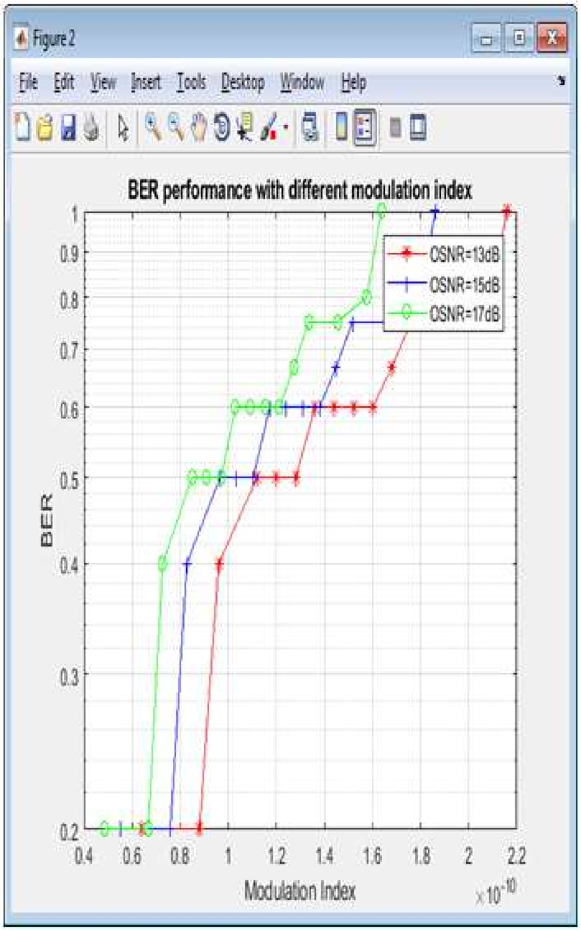

Fig. 5. BER performance with different modulation index.

Fig.5 shows The results prove that Quasi-CE-OFDM is sensitive to α . This is explained by the fact that the phase waveform of Quasi-CE-OFDM signal with smaller α is more vulnerable to noise, and the signal with larger α is more easily influenced by the phase ambiguity. In addition, the optimum α varies with different OSNR. The optimum α at low OSNR is larger than the one at high OSNR.

IV. CONCLUSION

Coherent optical orthogonal frequency division multiplexing (CO-OFDM) has attracted substantial attention for its high spectrum efficiency (SE) and superb resistance to dispersion, such as chromatic dispersion (CD) and polarization mode dispersion (PMD). This proposed study investigated the performance of the novel

Quasi-CE-OFDM. The simulation results show a relative improvement of spectrum efficiency in comparison with existing CE-OFDM systems without losing the advantage of high nonlinearity tolerance. The proposed Quasi-CE-OFDM scheme maintains large tolerance to fiber nonlinearity and improves spectrum efficiency effectively. It observed simulation results of Quasi-CE-OFDM system using 16-QAM subcarrier modulation. The results reveal an effective spectrum efficiency improvement when compared to existing constant envelope system and substantial increase of fiber nonlinearity tolerance when compared to the Con-CO-OFDM system. In baseband OFDM demodulation the certain functions are performed and we can recover data. The BER and OSNR performance is done with the quasi CE-OFDM recovered data.

REFERENCES

[1.] Li, Y., & Ding, D. (2018). Spectrum efficiency improvement for quasi-constant envelope OFDM. IEEE Photonics Technology Letters, 30(15), 1392-1395.

[2.] Li, Y. (2018, July). Delayed Self-homodyne Direct Detection for Constant Envelope OFDM. In International Conference in Communications, Signal Processing, and Systems (pp. 149-156). Springer, Singapore.

[3.] Pereira, E. D. V., Dias, V. O., Rocha, H. R., Segatto, M. E., & Silva, J. A. (2017). Electrical constant envelope signals for nonlinearity mitigation in coherent-detection orthogonal frequency-division multiplexing systems. Optical Engineering, 56(6), 066101.

[4.] Dias, V. O., Pereira, E. D. V., Rocha, H. R., Segatto, M. E., & Silva, J. A. (2017, August). Impact of the phase modulation index in the performance of CO-OFDM systems based on electrical domain constant-envelope signals. In 2017 SBMO/IEEE MTT-S International Microwave and Optoelectronics Conference (IMOC) (pp. 1-5). IEEE.

[5.] Li, Y., & Ding, D. (2017). Investigation into constant envelope orthogonal frequency division multiplexing for polarization-division multiplexing coherent optical communication. Optical Engineering, 56(9), 096108.

[6.] Giacoumidis, E., Mhatli, S., Nguyen, T., Le, S. T., Aldaya, I., McCarthy, M. E., ... & Eggleton, B. J. (2016). Comparison of DSP-based nonlinear equalizers for intra-channel nonlinearity compensation in coherent optical OFDM. Optics letters, 41(11), 2509-2512.

[7.] Fabrega, J. M., Moreolo, M. S., Chochol, M., & Junyent, G. (2013). Impact of modulator driving on constant envelope optical OFDM based on Hartley transform. IEEE Photonics Technology Letters, 25(6), 598-601.

[8.] Yang, Z., Yu, S., Chen, L., Leng, H., Lan, M., Qiao, Y., & Gu, W. (2012). Constant envelop minimum-shift keying OFDM coherent optical communication system. Journal of Lightwave Technology, 30(23), 3627-3632.

[9.] Silva, J. A., Cartaxo, A. V., & Segatto, M. E. (2012). A PAPR reduction technique based on a constant envelope OFDM approach for fiber nonlinearity mitigation in optical direct-detection systems. Journal of Optical Communications and Networking, 4(4), 296-303.

[10.] Fàbrega, J. M., Moreolo, M. S., & Junyent, G. (2011, June). Constant envelope coherent optical OFDM based on fast Hartley transform. In 2011 13th International Conference on Transparent Optical Networks (pp. 1-4). IEEE.