Design and Performance Study of Next Generation OOFDM

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ABSTRACT

OFDM technology is being promoted as one of significant ingredient in the development of the 4G communication technology that will be commercialized in forthcoming decade. This paper presents proposed topology to perform performance study of optical OFDM system with different modulations. Simulated results report that performance of optical OFDM transmission is dependent upon a number parameters selected as baud rate of transmission, cyclic prefix , QAM size and FFT size is selected by analyzing the transmission channel by the use of OFDM training symbols. Further OOFDM transmission performance under AWGN channel the MSK scheme and under Rayleigh channel environment BPSK scheme employing OOFDM has depicted good optical transmission performance. It has been perceived that better transmission performance is dependent upon best fit selection of number of optical OFDM transmission parameters

KEYWORDS

Mach Zehender Modulator (MZM), coplanar waveguide (CPW), Code Division Multiple Acess(CDMA).

1.INTRODUCTION

The communication techniques have observed a lot of changes since ancient times till now a lot of schemes in different wireless communication generations along with their respective pros and cons have been employed. Wireless communication systems presently employed are in the transition phase and swiftly moving towards next generation techniques such as fourth generation and further proposed higher order wireless generation realizations in the near future. As well as with development of advanced techniques it would incorporate swiftly increasing different types and different sizes of communication networks in an apparent and smarter way. Significant challenges towards deployment of 4G will be the classification of a flexible re-configurable network architecture which enables simultaneous optimization of bandwidth as well as quality of service management. A noteworthy advancement has been made right through the last decades of twentieth century to individually optimize each unit in modern communication systems, even though outstanding results have been already obtained. Highly challenging task for twenty first century system designers are concentrating towards a more integrated strategy. Further orthogonal frequency division multiplexing (OFDM) is one of alternative wireless modulation technology to CDMA. The orthogonal frequency division multiplexing is having with its proven higher potential to surpass the CDMA systems capacity and hence it offers wireless access method for fourth generation (4G) systems. The fourth generation (4G) systems have been also projected to accomplish the requirements of next generation [1]. The shortcomings of third generation are expected to be resolved by advanced fourth generation communication systems and hence it is on the side which is capable of exploiting the telecommunication commercial market. This advanced technique is highly focussed to join altogether all of the previously existing technologies as a consequence an active subscriber may easily roam from one service provider region to another region. Advantages of this advances scheme is that it provides small cost per bit transmission as well as it carry higher data rate communication services. Therefore it increases the roaming capability and expected high mobility data rate, obviously achieving this high data rate needs careful selection of multi-carrier modulation scheme [2].OFDM is also considered as one of the most compromising candidates of physical layer standard for future generation communication, because OFDM is robust against multipath fading and could be efficiently implemented. Due to several reasons a communication system based on OFDM is the most capable candidate for future generation communication systems. Hence these systems were being intensively considered for the next generation standard by 4G committees [3].

The very basic notion with OFDM is the partition of a larger bit rate data flow into numerous small bit rate flows and which were at the same time modulated onto the subcarriers which are orthogonal. In general the subcarriers were generated in the digital domain, so these systems consisting of typically of many subcarriers (typically more than 50). The channel estimation was realized by periodically inserting training symbols in such type of systems [4]. The Orthogonal-frequency-division multiplexing when employed with optical fiber medium is referred as optical orthogonal frequency-division multiplexing (OOFDM) in which subcarriers are generated in the optical domain. It has got remarkable respect in the present era by both the academicians and with industrial community [5].Under this widespread technical plans were studied for both the optical and electrical domain transmission [6, 7] have been projected. Due to its numerous benefits such as its strong inherent tolerance to fiber chromatic dispersion (CD) and polarization mode dispersion (PMD), significant system flexibility, relatively high signal transmission capacity, as well as potentially low system cost [8-12].The two main categories of OOFDM are coherent OOFDM [8] and incoherent OOFDM such as Intensity Modulation and Direct Detection (IMDD) OOFDM [9-12].

The direct detection OpticalOFDM is extensively employed for wide range of applications due to lower cost it is also very much striking scheme. With this scheme the OFDM signal amplitude were transformed into the optical intensity and optical carrier is also transmitted so that the detection at the receiver side can be realized along with employed external modulator (MZM).Further signal on the receiving side were detected with photodiode [13].Therefore resulting in a simplified construction for the receiver and this is the advantage of direct detection OOFDM in relation to CO-OFDM. Consequently the CO-OFDM was projected to combat fiber nonlinearities such as chromatic dispersion [14].Thus it illustrates improved transmission performance than IM/DD based OFDM systems in terms of the bandwidth efficiency and robustness against polarization dispersion as well as receiver sensitivity however it needs higher complexity in the transmitter and receiver(transceiver) design in contrast to direct detection systems [15].As a consequence a lot of scholars with great eager and related commercial interests were studying OFDM applied to optical communications that is COOFDM [16].Therefore it has created a remarkable development through theoretical analysis and experiments but specifically in terms of large-capacity and distance. Since OFDM's superior tolerance to various fiber nonlinearities such as fiber dispersion and polarization mode dispersion (PMD) [17-18].Consequently OOFDM exhibited enormous potential in the field of fiber optic communication.

In the design of communication systems, the choice of digital modulation methods is very important and worthy of exploration. Proper selection of digital modulation schemes must be taken into account along with a number of key factors, such as: bandwidth efficiency, BER, signal to noise ratio (SNR) and the employed equipment implementation complexity. That is why it has to have in accordance with particular states of use to decide on the appropriate modulation scheme, in contrast to wireless communication system [19-21] and fiber dispersion is one of the most noteworthy features of the CO-OFDM system. It also forms the basis of comprehensively considering other design parameters that could be appropriately selected mainly from the transmission distance, transmission capacity, spectral efficiency [22], BER and the balance among them. In view of this paper proposes a novel designed OOFDM system and analyzes its performance study for various significant transmission parameters.

2.THE DESIGN PRESENTMENT

The proposed design topology is bifurcated into two levels as upper and lower one. The upper one corresponds to the transmitter section and the receiver section which ultimately split terminations to compare the effects of different options in the model, is corresponding to lower one. In the designed scheme is employed with pseudo-random bit sequence (PRBS) which generates random signals and this is further converted into a number of smaller rate bit sequences controlled by the symbol QAM_bit_number. Actually the multiplicity of the serial-to-parallel conversion corresponds to the number of bits used by the model MQAMIQ to encode one QAM symbol. By performing an appropriate IFFT operation, the QAM signal is made to directly modulate the subcarriers of the OFDM signal. Using a multipoint IFFT ensures that each of the used subcarriers were orthogonal over one OFDM symbol. That is equivalent to saying that each of the subcarriers was orthogonal over one IFFT operation. The number of subcarriers used may be adjusted to tailor the bandwidth of the signal, after that cyclic prefix (CP) is inserted to the start of each of the OFDM symbol. That means appending a tiny portion, taken from the end of each OFDM symbol to the start of the symbol. It helps to combat inter symbol interference. Further with prefixing the end of a symbol to the beginning, the linear convolution of the channel has been made to emerge as a circular convolution. It is same as multiplication in the frequency domain and therefore it facilitates single tap frequency domain equalization at the receiver. Hence this resulting in a complex OFDM signal. Further the signal has been converted from parallel to serial it is then separated into its real and imaginary parts and mixed up to a given radio frequency (RF). The quadrature and in-phase components were modulated onto the RF carrier and then recombined before transmission. Single OFDM symbol is designated as training sequence and training sequence occupies one entire OFDM symbol, meaning that contained in the training sequence is one element from each subcarrier. The time data is still in the digital domain. At this stage the stream is converted to an analog signal for transmission or modulation of a carrier. Afterward the received QAM symbols on the receiving end were transformed into small-data rate parallel bit flows at MQADEMIQ and further converted into a single high-rate bit sequence along with a parallel-to-serial conversion process. Subsequently FFTOFDM model extracts the transmitted QAM symbols from the OFDM signal at baseband with an FFT operation. The OFDM modulation is very sensitive to the sampling instant at the receiver also the OFDM modulation are very much sensitive to the sampling instant at the receiver end. For the amplitude modulation an optical interferometer is not used. Optical interferometer (MZI) is used for phase modulation which converts phase deviation in amplitude deviation placed along with photo detector. Employed MZI modulator is generally a waveguide (dual) device, in which an electromagnetic signal interacts with an optical signal in one of the waveguides over a predetermined length that is also referred as the interaction distance and radio frequency signal propagates in a coplanar waveguide (CPW) mode. From the construction point of view Mach-Zehnder optical modulator are designed such that the phase difference in between the two optical waveguides which propagate the split beams is 0 when voltage is not applied. For ultra-high-rate optical communication systems the MZI optical modulators are mostly employed as external modulator due to its excellent modulation characteristics and its offered good signal to noise(S/N) ratio due to cancelling out in-phase noise components as well as its higher stability against disturbance. Further a number of multiplexing schemes were co simulated with fiber environment, as illustrated in figure(1, 2 and 3) below modelled as one of the simplest block diagrams employed for the simulation purpose.

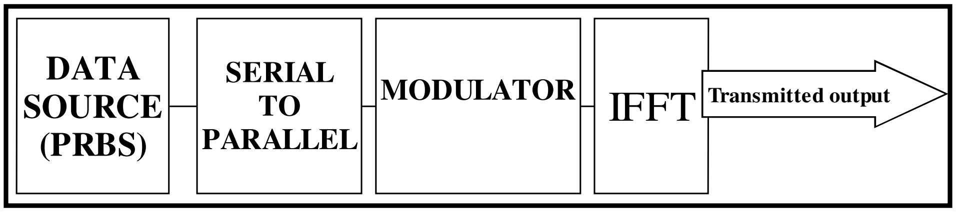

Figure1: Transmitter model used

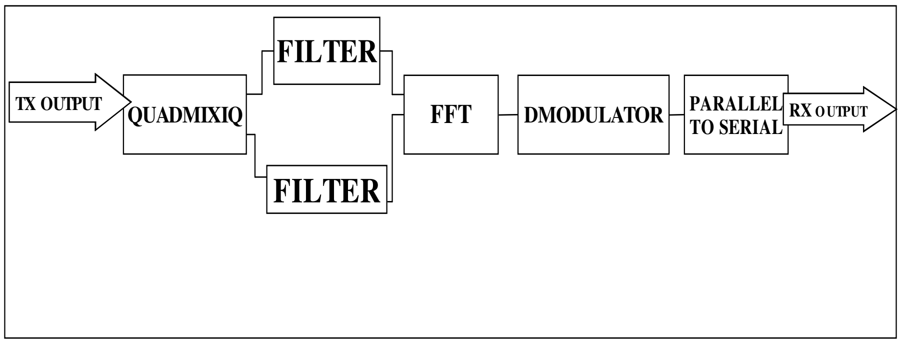

Figure2: Receiver model used

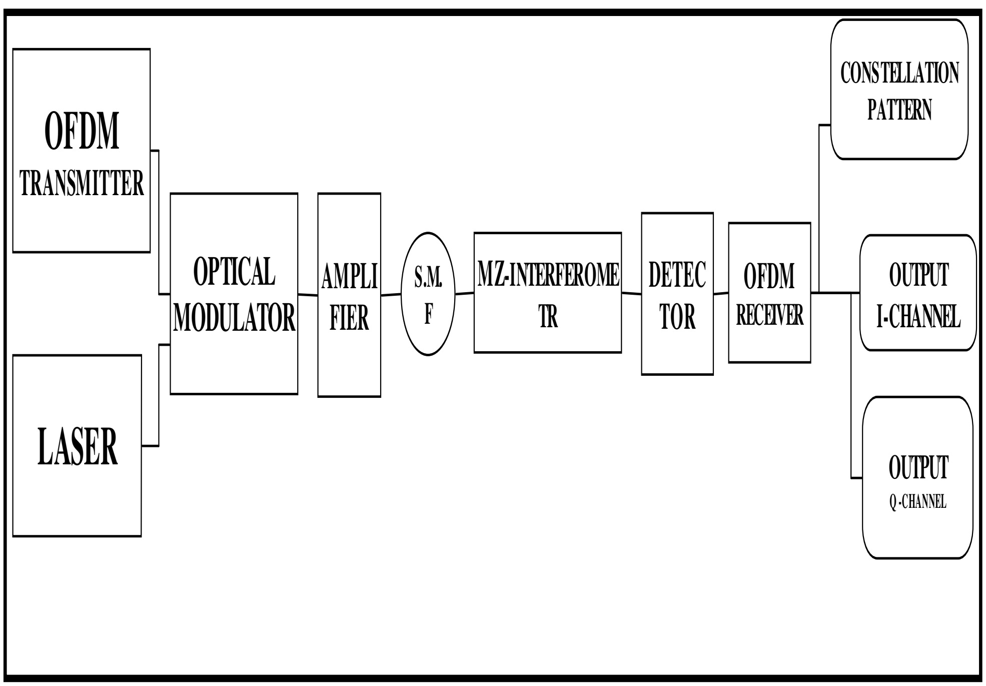

Figure3: Block diagram used for Optical OFDM

3. RESULTS AND DISCUSSION

Numerous investigated results have been shown in fig (4) to fig (18) for the designed topology. Transmission performance were investigated with number of modulation schemes such as with amplitude modulated OOFDM and phase modulated OOFDM is analyzed and the generated

OFDM signal converted into optical signal by employing MZIM modulator. The simulations were tested for constellation pattern, BER, Q factor and parametric variations like varying number of subcarriers, cyclic prefix, different bit rates and baud rates.

Figure4: Q vs. Length (50KM) simulated OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier8, CP0.99)

Figure 4 reveals transmission plot for quality factor(Q) vs. transmission length for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(8), cyclic prefix-CP(0.99).It show that with increase in transmission length Q factor for both quadrature and in phase channel decreases slowly but it still it is satisfactory(>10).

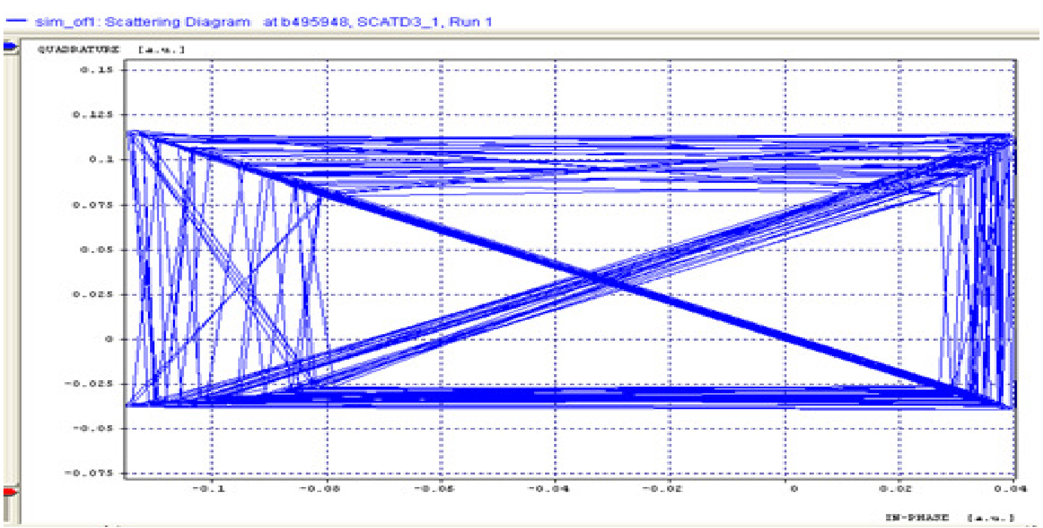

Figure5: Constellation pattern of MQAM-OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier8, CP0.99)

Figure 5 exhibit constellation plot OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(8), cyclic prefix-CP(0.99).It show better constellation pattern means satisfactory transmission performance.

Figure6: Q vs. Length (50km) OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier16, CP0.99)

The results as shown in the figure 6 illustrates designed systems transmission plot for quality factor(Q) vs. transmission length for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier (16), cyclic prefix-CP (0.99).It showed that with increase in transmission length Q factor for both quadrature and in phase channel decreases slowly but still it is satisfactory (>12) that is with increase in number of subcarriers Q factor have been increased and hence an improved transmission performance.

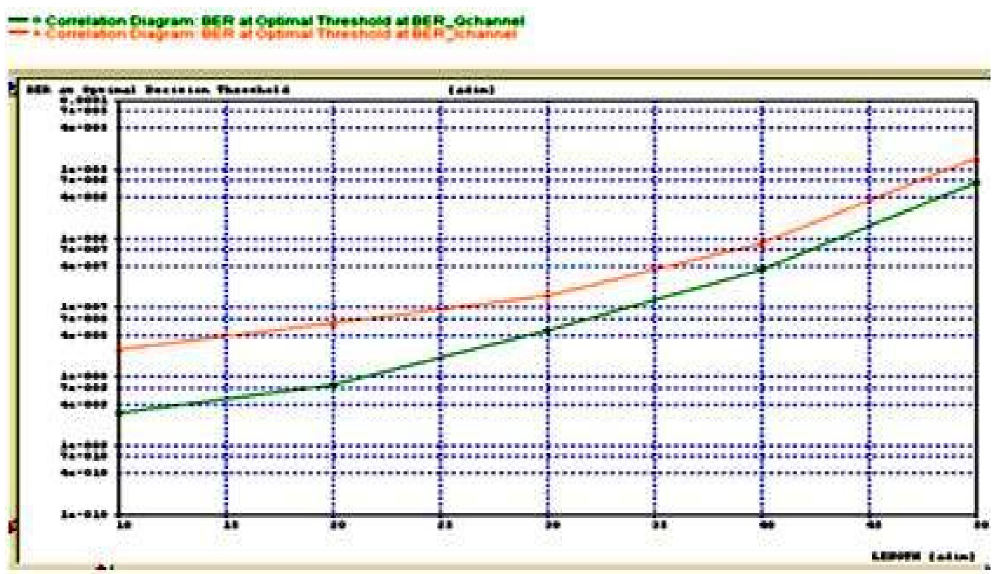

Figure7: BER vs. Length OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier16, CP0.99)

Results in the figure 7 illustrates its transmission plot for BER vs. transmission length of fifty kilometres with OOFDM system employing selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier (16), cyclic prefix-CP (0.99).It reveals that with increase transmission length BER increases.

Figure8: Q vs. Length OOFDM (bit rate 10Gbps, baud rate2.5, subcarrier32, CP0.99)

Results in figure 8 reveals transmission plot for Q vs. transmission length for OOFDM system with selected parameters bit rate (10Gbps), baud rate (2.5), subcarrier (32), and cyclic prefix-CP (0.99) .It show that with increase in bit rate, transmission length Q factor decreases slowly.

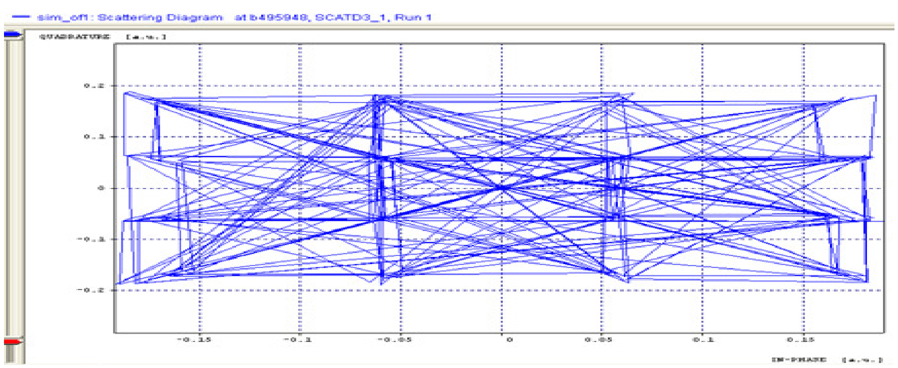

Figure9: Constellation pattern of MQAM-OOFDM (baud rate2.5, subcarrier32, CP0.99)

Results in figure 9 exhibits constellation plot for OOFDM system with selected parameters bit rate (10Gbps), baud rate (2.5), subcarrier (32), and cyclic prefix-CP (0.99). It shows that with increase in bit rate, transmission length constellation pattern becomes denser.

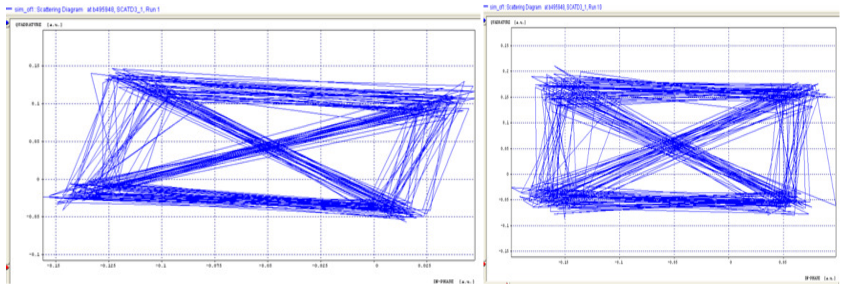

Figure10: Constellation pattern Phase modulated MQAM-OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier32, CP0.99)

Results in the Figure 10 illustrates constellation plot for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(32), cyclic prefix-CP(0.99).It show good constellation pattern that means good optical transmission performance. Further from the above simulated results it is observed that transmission performance is better at low bit rate and higher number of subcarriers.

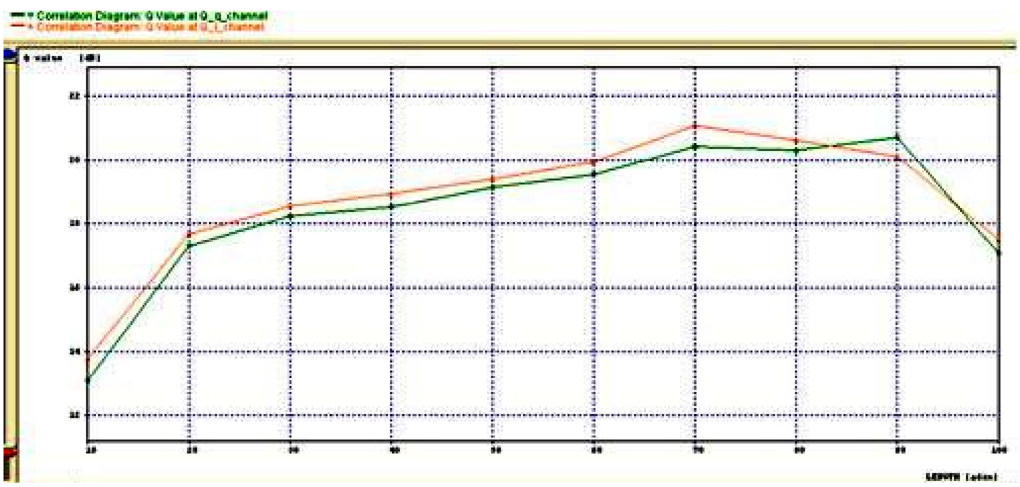

Figure11: Q vs. Length Phase modulated OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier8, CP0.99)

Results in the figure 11 exhibit Q vs. transmission length plot for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(8), cyclic prefix-CP(0.99).It shows good optical transmission performance(Q>10).

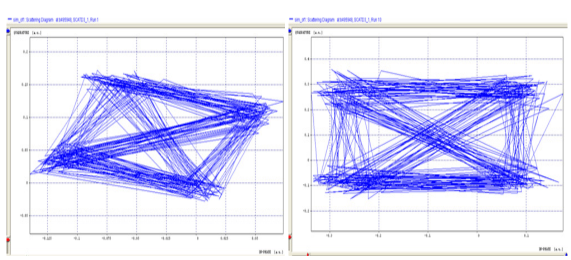

Figure12: Constellation pattern of Phase modulated MQAM-OOFDM (bit rate 5Gbps, baud rate2.5, subcarrier4, CP0.99)

Results in the figure 12 exhibit constellation pattern plot for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(4), cyclic prefix-CP(0.99).It is noticed that constellation pattern show overlapping with decrease in number of subcarriers.

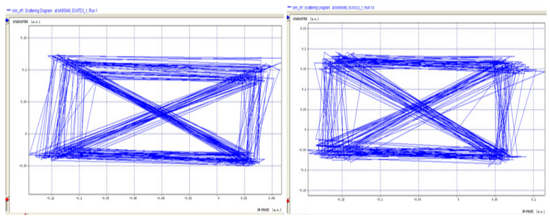

Figure13: Constellation pattern of Phase modulated MQAM-OOFDM (bit rate5Gbps, baud rate2.5, subcarrier16, CP0.99)

Results in the figure 13 exhibit constellation pattern plot for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(16), cyclic prefix-CP(0.99).It shows good constellation pattern thus with increase in number of subcarrier constellation pattern is improved that is good transmission performance.

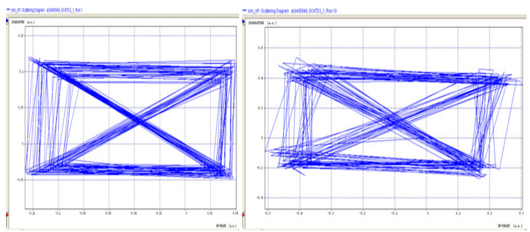

Figure14: Constellation pattern of Phase modulated MQAM-OOFDM (bit rate5Gbps, baud rate2.5, subcarrier32, CP0.99)

Results in the figure 14 reveals constellation pattern plot for OOFDM system with selected parameters bit rate (5Gbps), baud rate (2.5), subcarrier(32), cyclic prefix-CP(0.99).It shows good constellation pattern so with increase in number of subcarrier constellation pattern is further improved that is good transmission performance.

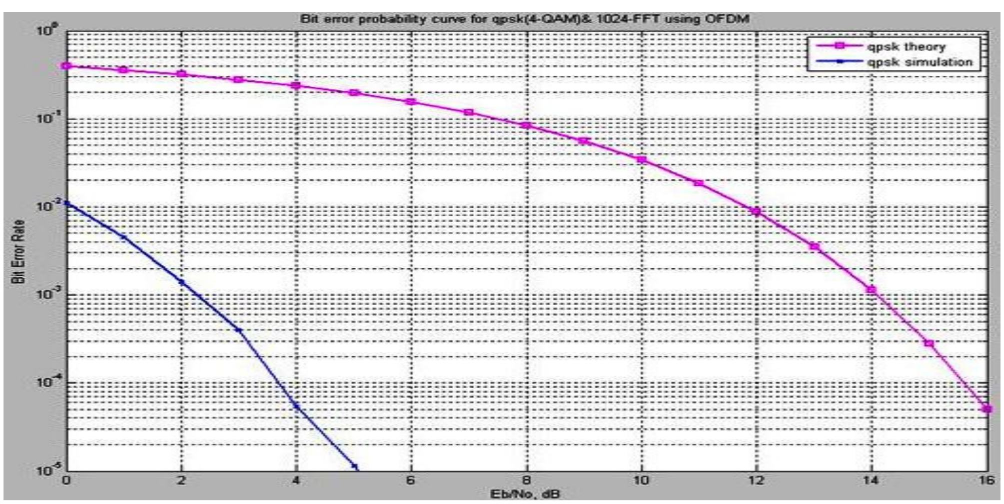

Figure 15: BER vs. E_b/N_0 plot with 1027 FFT and 4QAM

Above show the simulated results with QPSK (4QAM) and selected FFT (1027) as illustrated in the figure15, it is noticed that BER decreases with increase in E_b/N_0 ratio.

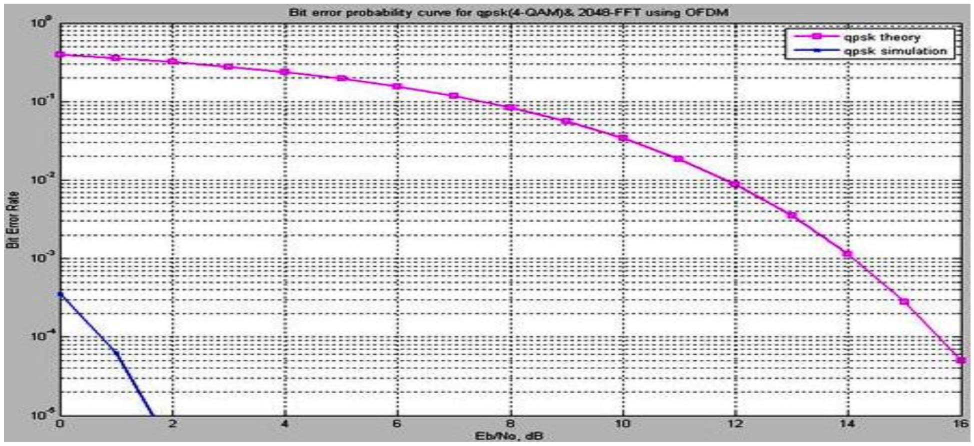

Figure 16: BER vs. E_b/N_0 plot with 2048 FFT and 4QAM

The simulated results with QPSK (4QAM) and selected FFT (2048) have been illustrated in the figure16, it is noticed that BER decreases with increase in FFT and E_b/N_0 ratio.

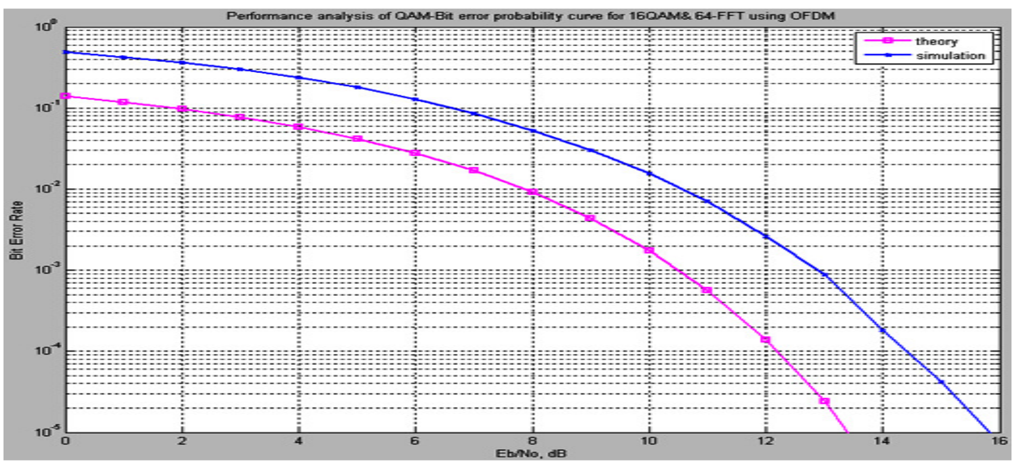

Figure 17: BER vs. E_b/N_0 plot with 64 FFT and 16QAM

The simulated results with 16QAM and selected FFT (64) have been illustrated in the figure17, it is noticed that BER decreases with increase in E_b/N_0 ratio. From the simulated results with 16QAM and selected FFT (1024) which have been illustrated in the figure18, it is noticed that BER reduces with increase in FFT size (1024) and E_b/N_0 ratio.

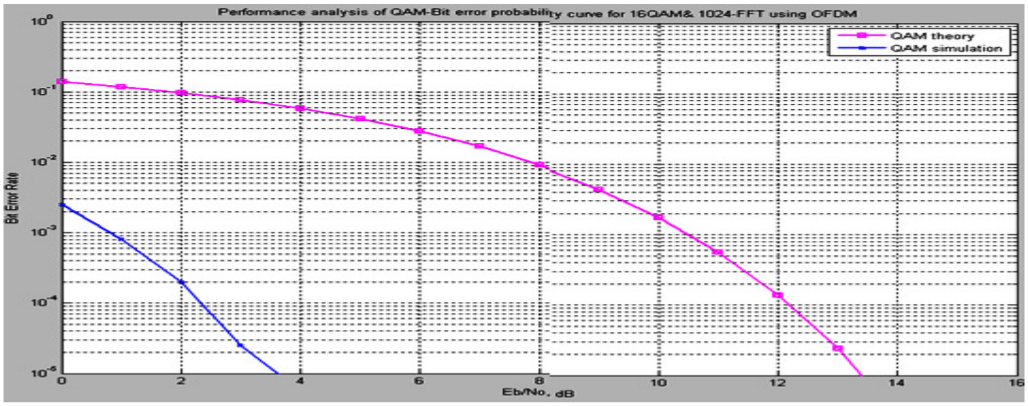

Figure 18: BER vs. E_b/N_0 plot with FFT (1024) and 16QAM

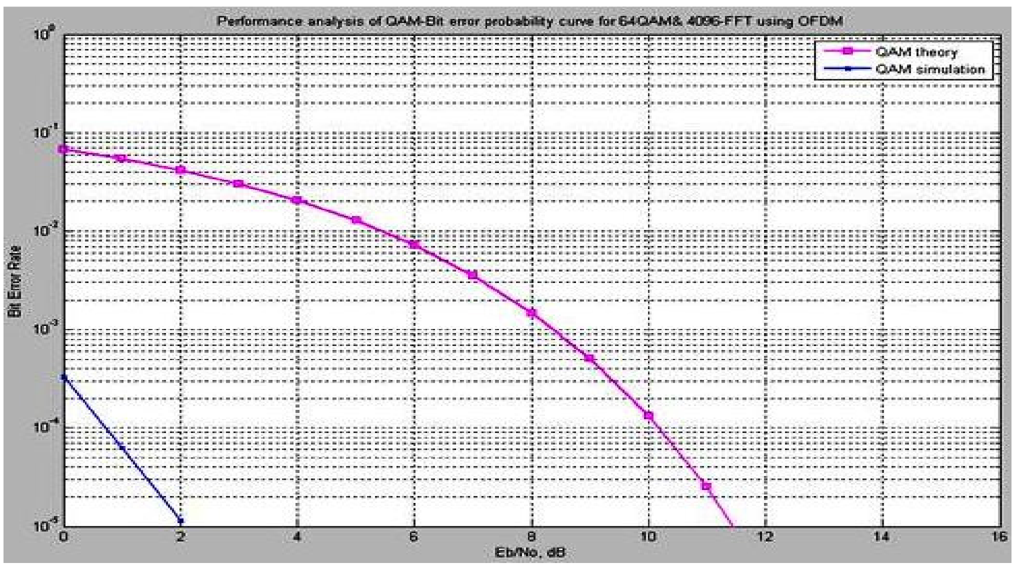

Figure 19: BER vs. E_b/N_0 plot with FFT (4096) and 64QAM

From the simulated results with 64QAM and selected FFT (4096) have been illustrated in the figure19, it is noticed that BER reduces with increase in FFT size (1024) and E_b/N_0 ratio.

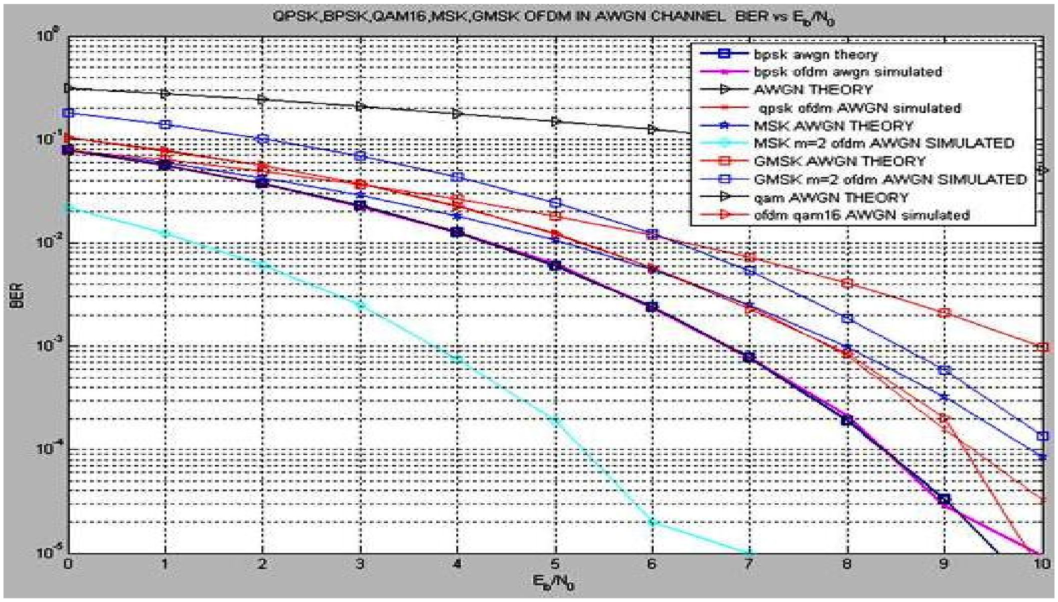

Fig20:BER vs Eb/N0 ratio plot for different modulation scheme with AWGN channel

The simulated results as illustrated in the figure20 for bit error rate vs signal to noise ratio(E_b/N_0) for different modulation schemes considering gaussian channel.

The theoretical parameters and real parameters have been co simulated for AWGN environment and the investigated results depict good transmission performance for MSK scheme with OOFDM in contrast to other schemes employed.

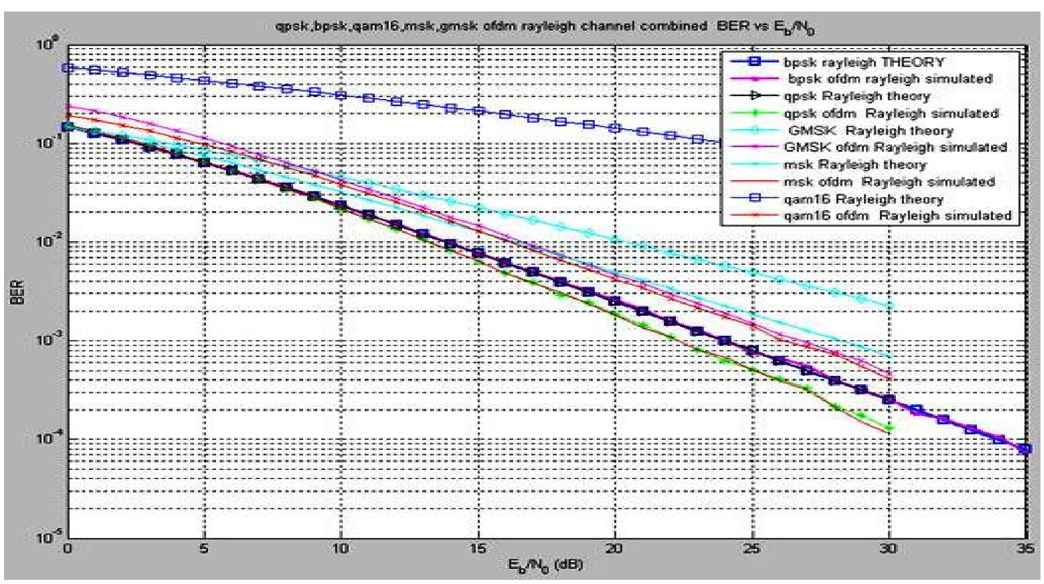

Fig21:BER vs Eb/N0 ratio plot for different modulation scheme with rayleigh channel

The simulated results as illustrated in the figure21 for bit error rate vs signal to noise ratio for different modulation schemes considering rayleigh environment.As well as a comparative study for the theoretically observed parameters and real parameters along with cosimulation under employed single mode fiber assuming rayleigh scheme were investigated. Results depict that

OOFDM with BPSK scheme under rayleigh environment show comparatively good transmission perforamnce in contrast to other schemes employed

Further investigated results reveals that the cyclic prefix samples determine the amount of tolerable multi path delay, or in fiber optic applications dispersion. It increases the reliability of the OFDM transmission however it is at the cost of data throughput. From the number of investigations it is noticed that for large FFT size, low baud rate means error free transmission, large cyclic prefix, sub carrier favours for good constellation pattern, error free optical transmission. Further it is noticed that transmission performance QAM size and QAM size is selected by analyzing the transmission channel by the use of OFDM training symbols and phase modulation OOFDM transmission performance is better means error free transmission as compared amplitude modulation for a chosen cyclic prefix and subcarrier. When noise becomes a problem for the optical transmissions lower QAM constellation could be selected, in order to minimize BER.QAM achieves larger distance between adjacent points in the I-Q plane by distributing the points more evenly and in such a way the points on the constellation are more distinct and data errors were minimized. Numerous investigated results reveal that OOFDM could provide high data rates and high spectral efficiency by applying OFDM to an optical system but with proper combination of selected Optical OFDM system transmission parameters.

4. Conclusion

This article successfully demonstrated design and performance investigation of OOFDM scheme with numerous modulation schemes such as BPSK, QPSK, MSK, GMSK and QAM employing single mode fiber. With employment of phase modulation in optical OFDM transmission link have demonstrated to have the potential of achieving bizarre data rates as compared to amplitude modulated OOFDM for optical transmission at different bit rates. It exhibit transmission performance is dependent upon the suitable selection of cyclic prefix, FFT size, choice of modulation used, baud rate and number of subcarriers must be suitably selected. With larger size FFT, low baud rate, large value cyclic prefix it show better transmission performance and when noise becomes a problem lower QAM constellation could be selected, in order to improve transmission performance (minimum BER).Further good optical transmission performance has been showed by the MSK scheme while considering AWGN and BPSK scheme with Rayleigh environment employing OOFDM have been noticed.

The investigated transmission performance further exhibit that OOFDM may provide high data rates and high spectral efficiency (considering the spectral band) and the application of optical technology in combination with OFDM, i.e., O-OFDM therefore can be an attractive solution for future broadband 4th generation communication systems. Furthermore from the study of designed topology it may be also concluded that OFDM signals are suitable for optical transmission and the optical components of an entire direct detection optical OFDM systems.

This present performance study exhibited an invaluable overview about how an actual world structure could perform as well as it permits an extensive theoretical comparison.

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