Analysis and Improvement of KPI Parameters in 5G Communication Networks

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Abstract

For a greener tomorrow, an important step today will be the energy efficient designs in any aspect. The 5G networks which is used for future communication should have better data rates of 10 Gbps or more. In order to achieve this frequency spectrum should be utilized efficiently to obtain high data rate. 4G communication uses OFDM but it has the drawback of low spectral efficiency and high out of band radiation, which makes it a poor choice for 5G communication. So for 5G communication new waveform is required. FBMC, UFMC, GFDM are some of the waveform candidates for 5G communication. FBMC is a potential candidate for 5G communication and it is used in many 5G projects around the world. The goal of this paper is to analyze KPI parameters and to improve them so that performance of 5G communication networks can be improved. 5G communication technology is beyond 4G and LTE technology and is expected to be employed around 2021. Research is going on for standardization of 5G technology. High PAPR is always a problem in multicarrier communication system. Out of the various parameters our focus will be on some QOS parameter such as PAPR and BER which will be analyzed for 5G communication. In our work we will analyze some parameters on different waveform contenders and systems and on the basis of the analysis will propose improvement measures.

Keywords: - *5G, PAPR, QOS, BER, FBMC.*

I. INTRODUCTION

With increasing demand of high data rate in coming years the present technology like 3G, 4G are not able to handle the networks. So a requirement of new technology i.e. 5G communication is needed. To achieve high data rates there is a need of new waveform contender for 5G communication. The main aim of the research work is a comprehensive study about the challenges in 5G and analyzing various waveform contenders for 5G communication. Further focusing on the performance parameters like better signal coverage, low latency, high data speed greater than 1Gbps, etc. In multicarrier communication system high value of PAPR is always a problem. Out of the various parameters our focus will be on some QOS parameter such as PAPR and BER which will be analyzed for 5G communication. The vision of 5G can be achieved by combining various radio access technologies like LTE, HSPA with 5G. The rest of the paper is organized as follows. Section II presents Literature Review about the topic. Section III tells us about problem formulation. Section IV gives us simulation results and finally Section V gives concluding remarks which are then followed by the bibliography.

II. LITERATURE REVIEW

- The motive of 5G is to provide very high data rate, better QOS (quality of service) compared to existing 4G LTE networks. The users expected to download data in terabytes annually. The major requirements for initiating 5G are as: this increases the data rate 1 to 10 times than the 4G LTE, it needed to provide connectivity between thousand of devices with higher bandwidth, to provide the connectivity among thousands of devices in IOT 5G networks are required, 5G need to provide the coverage at anywhere, anytime. Small radio wave lengths demand for small size antenna. This can make possible to use large number of small antennas. Directional radiation patterns of antenna provide better protection by using adaptive beam forming schemes, and as a result it gives the reference of Spatial Division Multiple Access (SDMA) or beam forming. In this, the researcher **Mamta Agiwal et. al** [34] discussed the future of 5G.

- In the paper of **Arman Farhang et al**. [35] discussed that Generalized Frequency Division Multiplexing is taken into consideration when we talk about the new candidate waveforms of fifth generation (5G) communication systems. This decision is taken on the basis of several facts that prove GFDM can replace the previous OFDM communication systems. Cyclic prefix is one the reason for GFDM in place of OFDM. GFDM is using only one cyclic prefix to the aggregation of the symbols whereas in case of OFDM the CP is added to every subcarrier. GFDM is more bandwidth efficient because of this approach. There is a transceiver proposed which uses the FFT at the transmitter side and IFFT at the receiver side. With the help of DFT and IDFT matrices we can reduce the computational complexity.

- The high peak-to-average power ratio (PARP) is the major issue in all multicarrier communication systems introduced by **Hanwang et.al** [33]. In past time the methods used to reduce the PARP in OFDM were as: clipping and filtering scheme, SLM (selective mapping scheme), PTS (partial transmit sequence) scheme, and TR (tone reservation) scheme, but due to the different structure of FBMC these schemes were not useful for FBMC. A hybrid scheme for FBMC/OQAM signals to reduce the PARP (peak-to-average ratio) and this is depends upon the multi data block PTS (partial transmit sequence) and TR (tone reservation) approaches. Hybrid PTS scheme the data blocks are divided into segment and this is used to optimize every data block signal for which the optimalphase rotation is needed to choose. To achieve this iterative clipping filtering is used to generate peak canceling signal for each segment of signal. This operation is very useful to cancel peak of signals.
- **Stefan H. Muller et al.** [4] proposed a flexible and distortion free technique for OFDM that is eradicating redundancy that was present in it. This technique may enhance the complexity of the OFDM. It is brought to our notice that the results of PAR reduction obtained from the performed histogram are not good as compared to those which are theoretically found. When the 4-DPSK is

implemented in alliance with PTS-OFDM along with the subcarriers, it is found that redundancy is Rap=2(V-1) which was independently of W. V is depicting the number of sub blocks used in PTS and W is depicting the admitted angles for bμv which must not be quite high.

III. PROBLEM FORMULATION

3.1 INTRODUCTION TO PEAK TO AVERAGE POWER RATIO (PAPR)

High PAPR is an important issue in FBMC system which reduces the efficiency of power amplifier used in the circuit. PAPR problem in any 5G system arises because of the fact that the output symbol of the system is the summation of symbols modulated on different subcarriers and there is a probability that all the symbols have same phase which leads to a very high peak compared to the average value of the symbol. PAPR of an FBMC system is defined as the ratio of peak power to the average power[7]. In general, PAPR of a complex envelope u[n] with length N can be written as

$$\text{PAPR} = \left\{\frac{max\left(u(n)^2\right)}{E\left(u(n)^2\right.}\right\} \qquad (1)$$

Where $|u(n)|$ is amplitude of u[n] and E denotes the expectation of the signal. PAPR in dB can be written as:

$$\text{PAPR(dB)} = 10\log10(\text{PAPR}) \qquad (2)$$

3.2 EFFECT OF HIGH PAPR

The linear power amplifiers are used in the transmitter side of any communication system. For linear power amplifier the operating point should be in the linear region of operation. Because of the high PAPR the operating point moves to the saturation region hence, the clipping of signal peaks occurs which generates in-band and out-of-band distortion. So we should increase the dynamic range of the power amplifier to keep the operating point in the linear region which reduces efficiency and enhances the cost of the power amplifier. Hence, a trade-off exists between nonlinearity and efficiency. so we should reduce PAPR value to improve the efficiency of the power amplifier of 5G communication system.

3.3 PAPR REDUCTION TECHNIQUES

Higher PAPR creates many problems in system like increase the complexity of the analog to digital converters and mitigate the efficiency of the RF power amplifier. To overcome the PAPR problem various techniques has been introduced as distortion technique which remove the amplitude of the signal, coding technique and scrambling technique.

3.4 INTRODUCTION TO FBMC

Filter Bank Based Multi-Carrier (FBMC) is a derivative of OFDM. Cyclic Prefix Orthogonal Frequency Division Multiplexing (CPOFDM) have some drawbacks so that we use the (FBMC), which provides the improved spectral and bandwidth efficiency. FBMC is the extension of the OFDM. As we know that the wireless devices connecting to internet are increasing day by day with very fast rate. and will continue to increase in future, so to handle this situation new modulation techniques are needed. One of them is FBMC which provide the higher data rate than OFDM. This is the modulation technique which transmits the data by splitting it into various sub-channels and sends each sub-carrier over separate carrier signals.

3.5 FBMC SYSTEM MODEL

The FBMC consists of an identical filter banks at the transmission side and the receipt side, but this is not mandatory that the transmitter and receiver should use the identical filters. The FBMC transmitter consists of blocks as: OQAM (Offset Quadrature Amplitude Multiplexing), serial to parallel and parallel to serial data conversion block, frequency spreading and extended IFFT. Firstly we are giving the data bits to the mapping unit of FBMC as shown in Fig. 4.1

3.5.1 FBMC Transmitter

The FBMC transmitter consists of following blocks as:

1. Offset Quadrature Amplitude Multiplexing (OQAM)
2. Serial To Parallel And Parallel To Serial Data Conversion Block
3. Frequency Spreading and Extended IFFT.

Firstly we are giving the data bits to the mapping unit of FBMC. The functioning of each block of FBMC transmitter is given below as shown in Fig.4.1

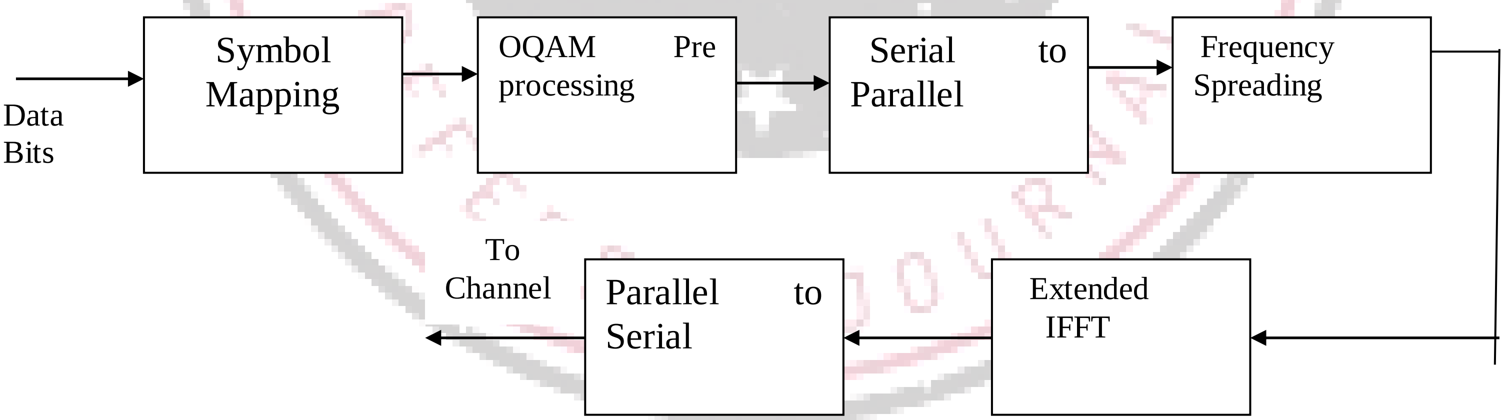

Fig.1. FBMC Transmitter

3.5.2 FBMC Receiver

Filter Bank Multicarrier receiver work on the opposite basis from transmitter to obtain the actual information back. It contains the FFT, symbol de – mapper and frequency de-spreading etc blocks

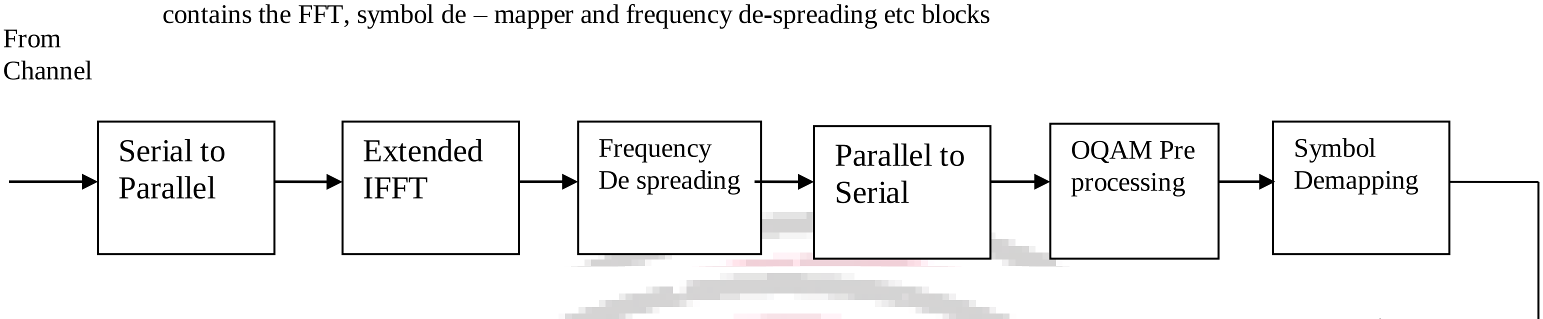

Fig.2. FBMC Receiver

For the better performance of the receiver the transmitter should align in time domain properly with transmitter. Now the channel has multipath propagation, which is due to the impulse response of the channel. So that the multicarrier overlap with each other, and it is not possible to demodulate the symbol with FFT at the receiver. Because inter-symbol interference has been developed and due to that the orthogonality has been lost. So we have two options for this, one is to increase the symbol time and guard time, called OFDM. Another option is the add some processing to FFT and keep time and guard interval as they are previously. This is called FBMC, because the additional processing and FFT combined together which construct the filter bank.

3.6 FORMULATION OF THE PROBLEM

On the basis of the above analysis it is found that PAPR and SER plays an important role in improving the network performance of 5G communication system So the main objective of this thesis are

1. To analyze and modify PAPR techniques to improve PAPR performance of the 5G systems.

2. Designing network system and analyzing Bit Error rate and Signal to Noise ratio for 5G communication systems.

IV.SIMULATION RESULTS

4.1 Simulation Results Obtained of the 5G Systems

Simulation is performed using SCILAB TOOL for FBMC-FMT system with 4-QAM and 16-QAM modulated input signals. Number of sub-channels are N=64 and overlapping factor taken as K=4. Tone injection, µ-law companding and combined scheme of these two techniques are used as a PAPR reduction technique. Clipping level A is chosen to be 3 dB above average power. For simulation 104 randomly generated complex input symbols are taken. Fig. 5.2 represents the CCDF plot for original FBMC-FMT signal, companding and tone injection with 3 iterations for 4-QAM input signal. Figure represents CCDF plot for original FBMC-FMT signal and combined scheme of tone injection and companding for 3 iterations for 4-QAM input signal. Comparing the plots we can conclude that by combining TI and companding techniques

PAPR performance improves significantly. Fig. 3 represents the CCDF plot for original FBMC FMT signal, companding and tone injection with 3 iterations for 16-QAM input signal. It represents CCDF plot for original FBMC-FMT signal and combined scheme of tone injection and companding for 3 iterations for 16-QAM input signal. PAPR performance improvement for 16-QAM modulated signal is same as for 4-QAM modulation. PAPR performance improves as we move from 4-QAM to 16-QAM.

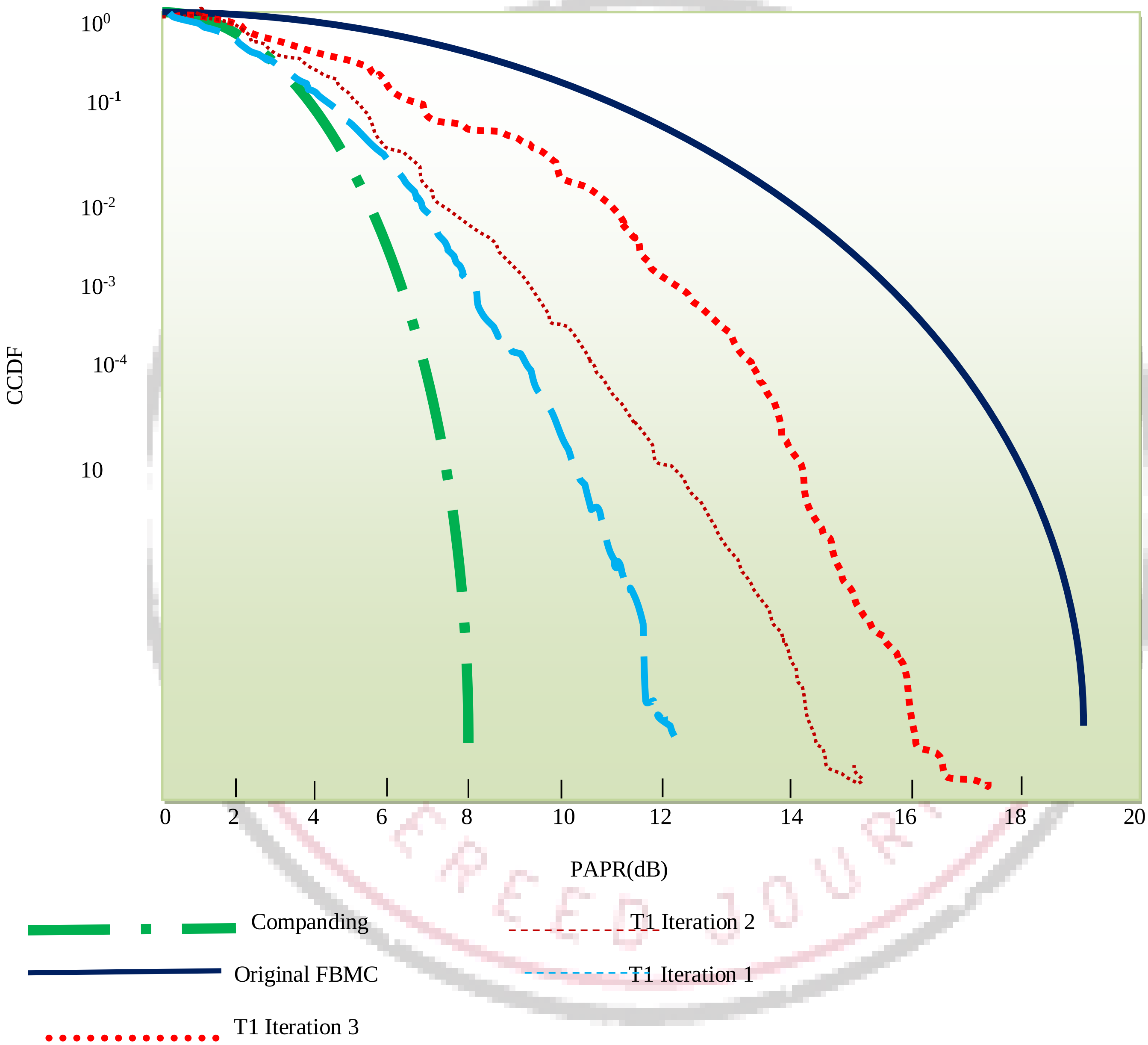

Fig 3 CCDF plot for original FBMC-FMT signal, TI and Companding techniques (4-QAM)

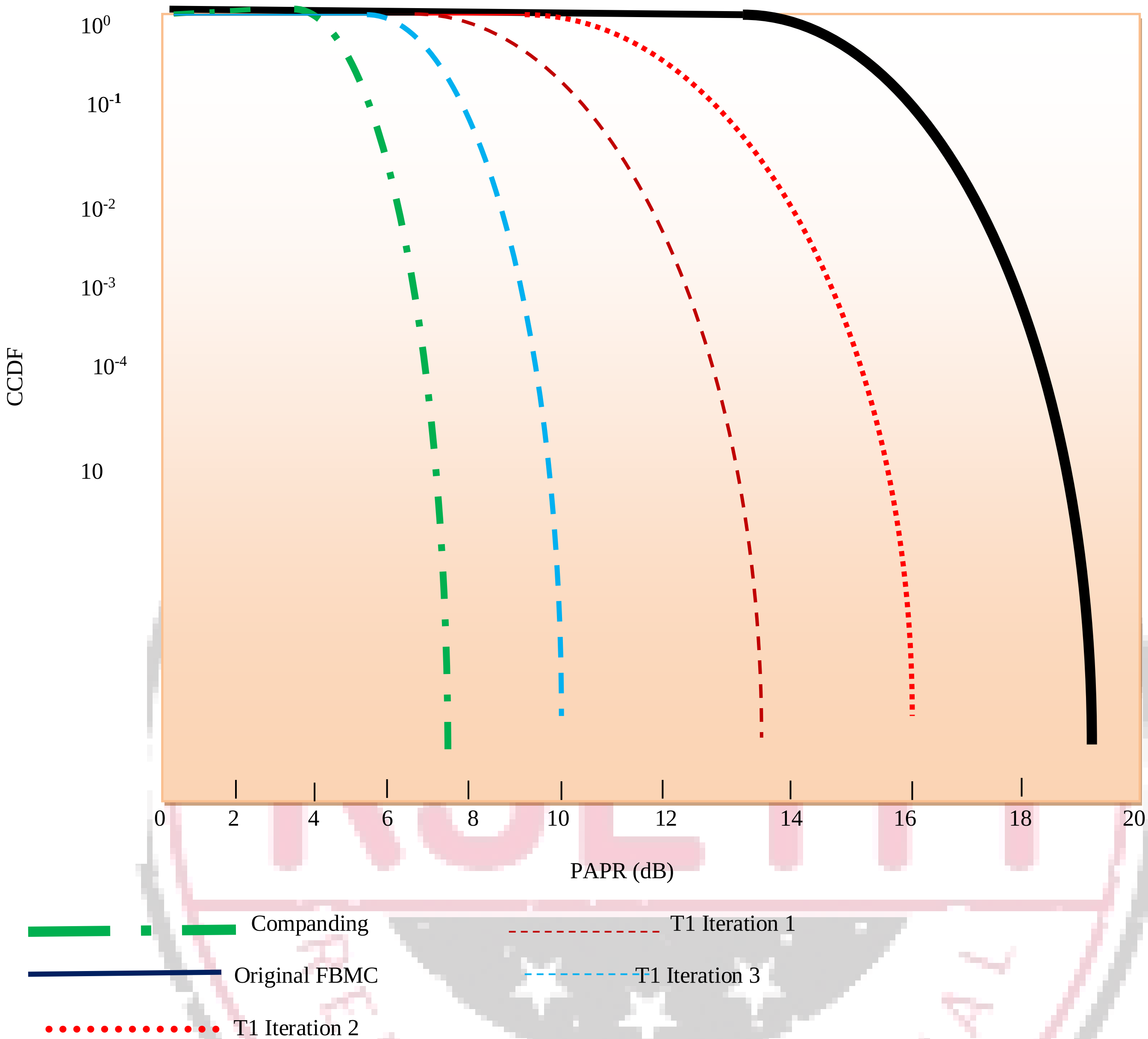

Fig 4 CCDF plot for original FBMC-FMT signal, TI and Companding techniques (16-QAM)

4.2 Simulation Results of PAPR Reduction for FBMC -SMT Systems

Simulation is performed for FBMC-SMT system with 4-QAM and 16-QAM modulated input signals. Number of sub-channels are N=64 and overlapping factor is taken as K=4. Tone injection, µ-law companding and combined scheme of these two techniques are used as a PAPR reduction technique. Clipping level A is chosen to be 3 dB above average power. For simulations randomly generated complex input symbols are taken. Fig.5 represents the CCDF plot for original FBMC-SMT signal, companding and tone injection for 4-QAM input signal. Fig.6 represents the CCDF plot for original FBMCSMT signal, companding and tone injection for 16-QAM input signal .Comparing these two plots we can conclude that by combining TI and companding techniques PAPR performance improves significantly. PAPR performance improves as we move from 4-QAM to 16-QAM. Fig 5.7 represents the SER plot for original FBMC-SMT signal, tone injection, companding technique and combined scheme of tone injection and companding for 4-QAM input signal. It shows that the SER -performance of the combined scheme is better as compared to companding and tone injection techniques but some degradation in performance occurs compared to original FBMC-SMT signal.

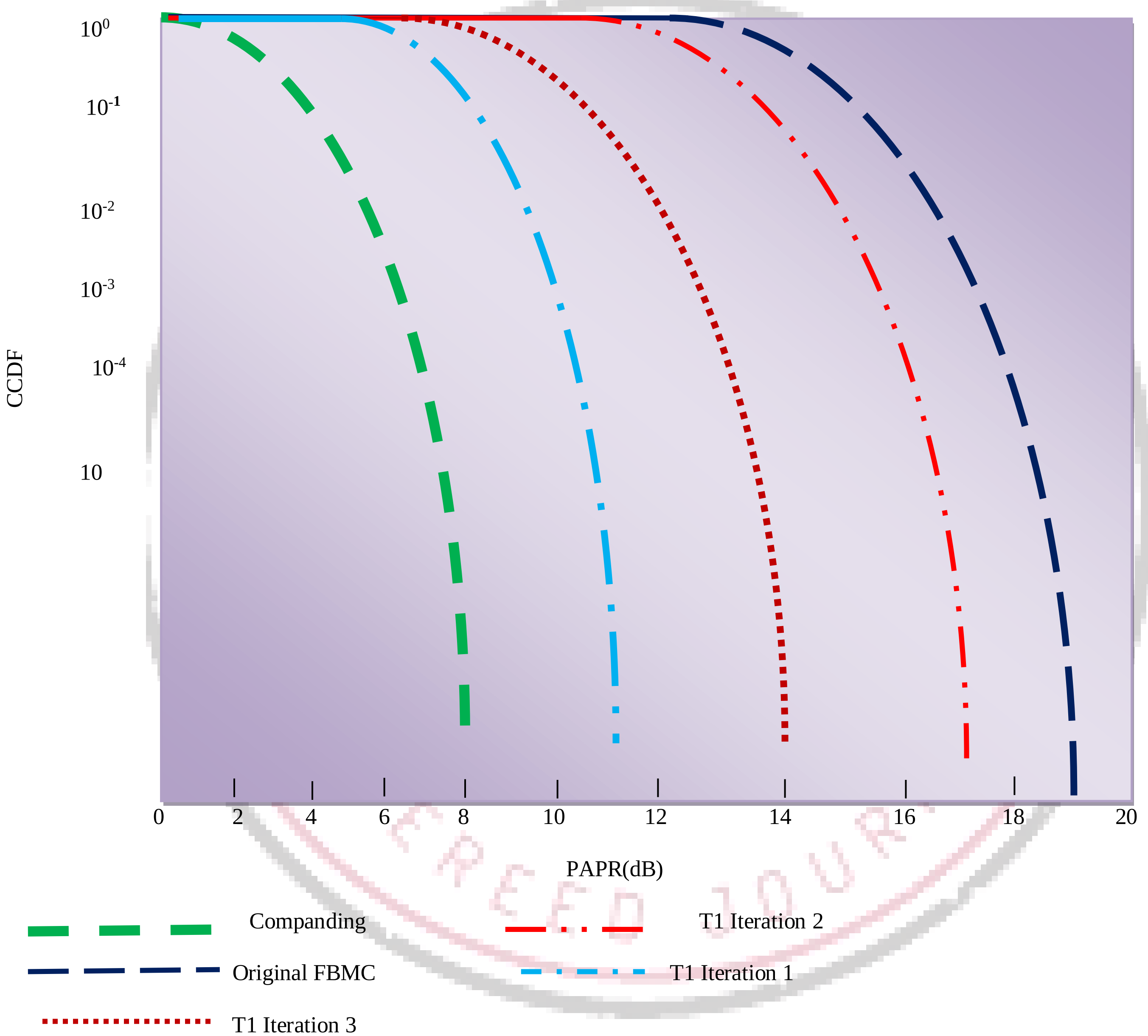

Figure 5 CCDF plot for original FBMC-SMT signal, TI and Companding techniques (4-QAM

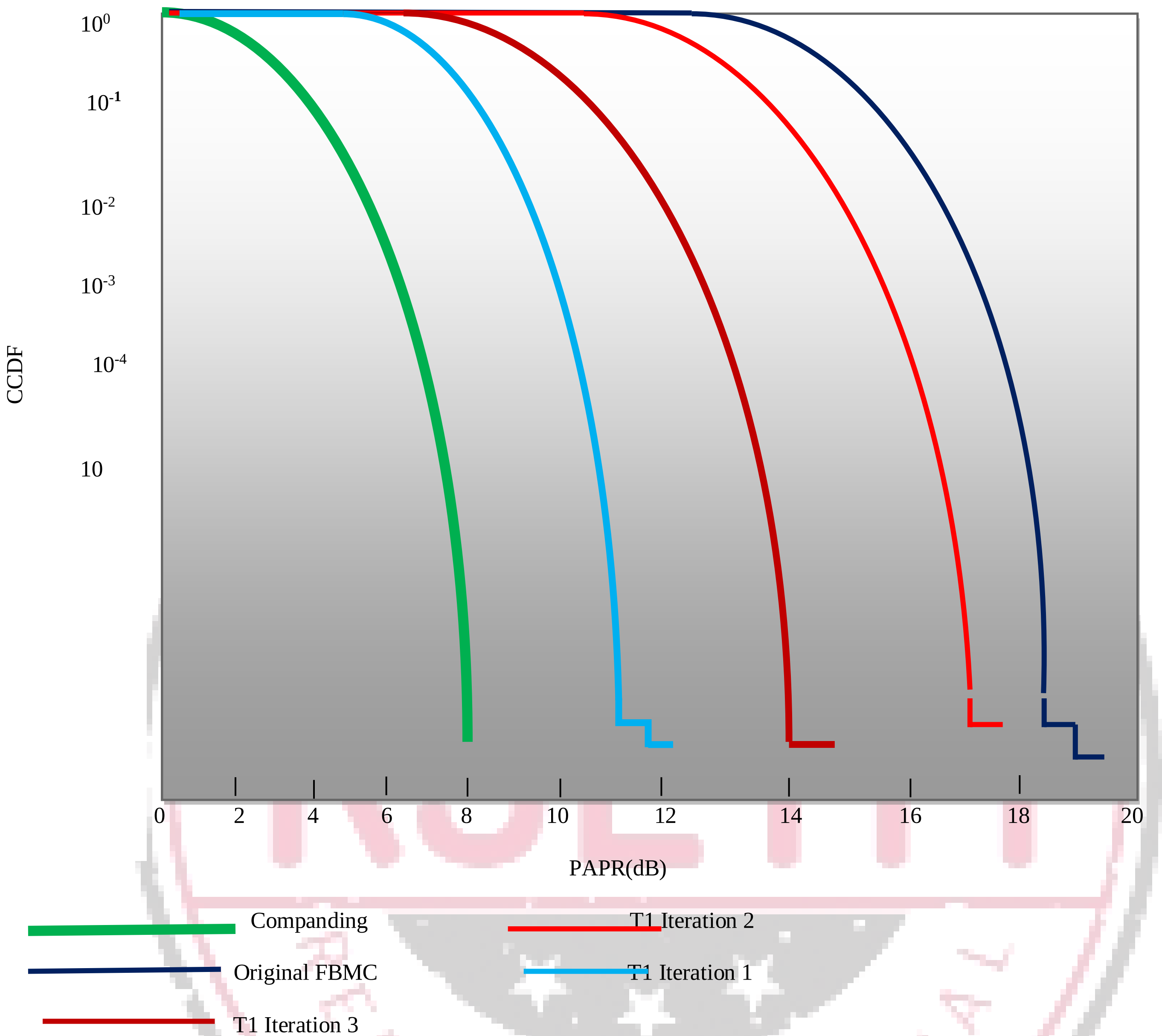

Figure. 6 CCDF plot for original FBMC-SMT signal, TI and Companding techniques (16-QAM)

4.3 Designing network system and analyzing Bit Error rate and Signal to Noise ratio for 5G communication Systems.

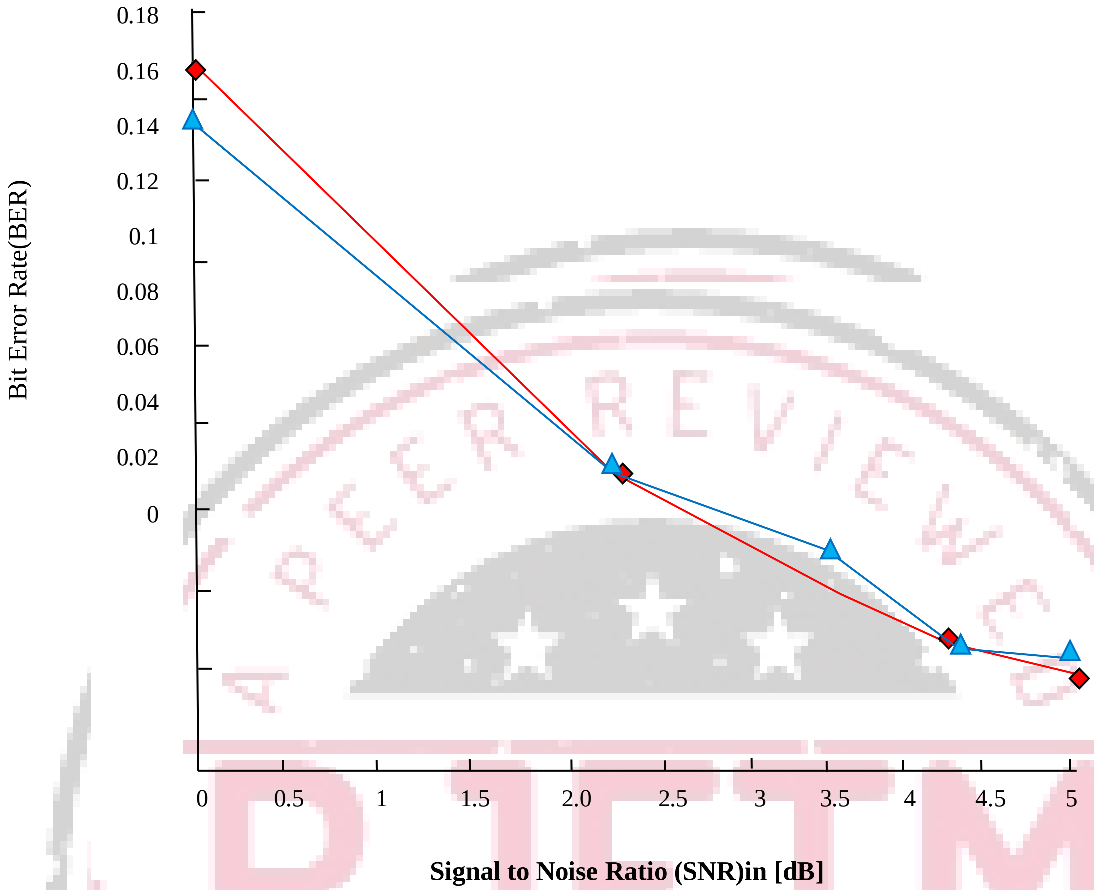

Figure 7 Simulation results showing BER Vs SNR of 5G communication System.

In the above network system considered, filtering is given on per sub carrier basis which gives good sub carrier distinction which proves that FBMC system is having more spectral efficiency than that of OFDM. Thus our system gives good sub carrier distinction because it filters the signal on per sub carrier basis and the filtering scheme is used in signal creation as a result SNR increases with the BER reduction.

V. CONCLUSIONS

In 5G communication in order to get higher data rate performance parameters have to be analyzed. So to get high spectral efficiency and low out of band radiation for 5G communication FBMC is a promising waveform for 5G technology . We have basically concentrated on PAPR reduction techniques and on BER performance of the system. There are several PAPR reduction techniques proposed for 5G system. Tone injection and companding are two techniques for PAPR techniques. Here a combined scheme of these two techniques is proposed which gives a significant PAPR performance improvement . Simulation is performed using SCILAB Tool and results are plotted in the form of CCDF plot. Simulation results show that PAPR performance improves as we combine tone injection and companding techniques. FBMC is generated by using FMT and SMT methods, also 4-QAM and 16-QAM modulated input signals are used for simulation. Comparing the simulation results we can conclude that PAPR performance is almost same for FMT and SMT methods and there is a significant performance improvement as we increase the constellation size with normalization. Further, receiver section is also designed to test the transmitted signal over the channel .AWGN channel is used for modeling and simulation of transmitter and receiver section. Simulation is performed using FBMC(SMT and FMT) generation methods . Simulation is also performed to get SER plot. Results shows that symbol error performance of combined scheme is better than companding technique but some degradation is there in performance as compared to original FBMC signal. So in this way we can improve PAPR performance without degrading SER performance. Further at the FBMC transmitter side we have used the OQAM processing and the synthesis filter bank. In recipient side we have used the polyphase structure and the OQAM post processing. Thus FBMC perform filtering on a per-subcarrier basis to give out of band spectrum characteristics which further improves Bit Error Rate(BER) performance of 5G communication systems.

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