Comparative Analysis of PAPR Reduction Techniques in FBMC System

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Abstract— Upcoming wireless systems can look large variety of users. This needs an efficient allocation of the on the market time-frequency resources, this is often advanced in ancient OFDM system. Hence, improvement of OFDM, by filtering, become mandatory .So, we have a tendency to apply numerous modulation approach, like FBMC. The prime disadvantage of FBMC systems is high PAPR. Once a symbol is passed by a high PAPR system, it gains high distortion because of non-linear power amplifier. To overcome this drawback of PAPR is significant within the realization of FBMC systems. There are numerous techniques used for the reduction of PAPR in OFDM systems. During this article, we applied some techniques in OFDM are enforced on FBMC systems .The simulation results of the varied approaches are displayed with comparison.

Keywords: Multicarrier Modulation, OFDM, FBMC, OQAM, CMT, SMT, Cognitive Radio

I. INTRODUCTION

The evolution of web and the growing demand of high data rate users have given Dynamic spectrum access networks a widespread attention within the recent years.Within the DSA networks, multiple nodes contend to use a shared frequency spectrum. The OFDM technique with cyclic prefix (CP-OFDM) that uses an orthogonal set of subcarriers is by far the foremost widespread case of multicarrier systems that have been anticipated for the aim of sharing the various sub- sets of those subcarriers amid nodes [1] [2] put in for DSA. But, the tight temporal arrangement and synchronization demand in OFDM is problematic to achieve in observe once the nodes belong to varied body units. Hence, mutual interference amid the signals of varied users is resulted just in case of an absence of synchronization. moreover, the CP utilized is virtuously redundant in terms of data and considerably diminishes the information measure efficiency. The disadvantages of OFDM technique were overcome by a multicarrier communication sys- tem known as as FBMC 1st projected by Saltzberg [3] that delivers an improved spectral shaping of subcarriers than OFDM systems. this can be then achieved by the careful planning of the prototype filter, that abridges equalization within the lack of CP and also guarantees a further effectual spectral utilization by decreasing interference across subcarriers [4].By participating Offset construction AM (OQAM), the total capability of the transmission information measure are often earned in FBMC systems. Hence, the most aim of this analysis paper is to com- pare the multicarrier techniques OFDM and FBMC techniques for 5G wireless systems .By exploitation MATLAB all the simulations are performed for examination the two multicarrier techniques in terms of the facility Spectral Densities, machine complexness and prototype filter comparisons of FBMC and OFDM [5].This analysis paper is organized into the subsequent sections—Section 1 provides the introduction of OFDM techniques, Section 2 provides the introduction of the FBMC. Section 3 provides the main differences between the OFDM and FBMC. Section 4 is regarding the Companding technique for PAPR reduction. Section 5 is regarding the OQAM Pre/Post process Section 6 is regarding the simulations performed on MATLAB for examination the FBMC and OFDM techniques in terms of Power spectral densities, machine complexities of the techniques in terms of magnitude response and also the magnitude responses of the epitome filters for each techniques, finally Section 6 provides the conclusion of the analysis paper. Section 7 is followed by Acknowledgements, word utilized in the paper and also the references.

II. OFDM

In OFDM multicarrier system, the frequency spectrum of the subcarriers is overlapped with the least frequency spacing and also the orthogonality is attained amid the various subcarriers.The input stream is divided into parallel information streams by means that of the serial to parallel (S/P) convertor, that are then passed into an inverse quick Fourier transformation (IFFT) block to supply time sequence of the streams. Consequently, by totaling a cyclic prefix (CP), the OFDM symbol time sequences are extended. The CP may be a copy of the latter portion of the symbol that's further within the begin of the sequence and may be larger than the network deferral unfold so as to diminish the entomb image interference (ISI) made by the flow of assorted OFDM symbols with distinct de- lay. The resultant digital signal is remodeled into analog type and transmitted over the channel [5].At the receiver finish, the signal is reconstructed into digital type and also the so much Fourier transform (FFT) is achieved within the received streams when eradicating the CP [5]. Finally, the parallel streams are collected into one stream because the original transmitted one. a number of the disadvantages of OFDM are enumerated below:

1) Decreased spectral efficiency as a result of the CP employed;
2) High spectral leakage as a result of the rectangular windowing.

III. FILTER BANK MULTI CARRIER

The FBMC technique overcomes the constraints of OFDM by adding generalized pulse shaping filters that delivers a well localized sub channel in each time and frequency domain.

Consequently, FBMC systems have a lot of spectral containment signals and provide more practical use of the radio resources wherever no CP is needed. In Figure 2 it are often seen that the filter banks on the transmitter side and also the receiver side contains an array of N filters that processes N input signals to allow N outputs. If the inputs of those N filters ar associated along, the system in analogous manner are often measured as an instrument to the signaling supported every filter characteristics. In Figure 1 the filter bank used at the transmitter side is termed synthesis filter bank and also the filter bank utilized in receiver side is termed analysis filter bank. As represented in Figure 1 the signaling is initial born-again from serial to parallel type and so more responsible synthesis filter bank and so it's regenerate back to serial type when initiating of synthesis bank. when this it are often seen in Figure 1 that within the receiver aspect when the signal passes through the channel it's regenerate to parallel type by serial to parallel device and more responsible analysis filter bank. The core of the FBMC system is that the TMUX configuration conferred the most process blocks during this direct type depiction are OQAM pre-processing, synthesis filter bank, the analysis filter bank, and also the OQAM post-processing. The channel is classically misplaced once analyzing and designing TMUX systems because the channel equalization drawback is controlled clearly. The synthesis and analysis filter banks are naturally the key parts. As already mentioned, the sector of filter banks is incredibly broad and even modulated filter banks are often divided into sorts differing types |differing kinds depending on the selection of the proto- type filters, modulation functions, and desired properties.

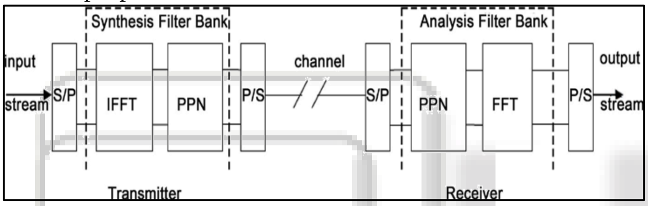

Fig. 1: Block diagram of FBMC[5] [6].

IV. DIFFERENCES BETWEEN OFDM AND FBMC MULTI CARRIER TECHNIQUES

Property	OFDM	FBMC
CP Extension	CP extension required and therefore reduces Bandwidth (BW) effeciency	Not required and hence conserves BW
Sidelobes	Large sidelobes	Low sidelobes
Synchronization	For correct detection, multiple access interference cancellation should be performed at the receiver	MAI is suppressed due to the excellent frequency localization of the subcarriers
Doppler effect	Highly sensitive to the carrier frequency offset	Less sensitive and hence performs significantly with the increase of the user mobility
MIMO Systems	High flexibility while adopting MIMO techniques.	Limited flexibility
Spectrum sensing	Degraded spectrum sensing performance due to the spectral leakage in OFDM signals	High spectrum sensing resolution
Computational Complexity	Less complex	More complex

Table 1: Major differences between OFDM and FBMC [5].

V. COMPANDING TECHNIQUES FOR PAPR REDUCTION

A. *Mu-law Companding*

Mu-law companding for the given input x is stated as:

$$F(x) = \mathrm{sgn}(x)\,\frac{\ln(1+\mu\,|x|)}{\ln(1+\mu)}$$

The value used here is μ=25 and μ=255.This technique does has greater effect on small amplitudes but dynamic ranges is increased of the
Transmitted signal[10].
The de-companding formula is given as –

B. *A-Law companding*

A law companding for given input x is given as –

$$F(x)=\mathrm{sgn}(x)\begin{cases}\frac{A|x|}{1+\log(A)}, & |x| < \frac{1}{A}\\ \frac{1+\log(A|x|)}{1+\log(A)}, & \frac{1}{A}\le|x|\le1\end{cases}$$

Where A is compression parameter and value used is A=12 and A=86.6 .This value is chosen in such a way that it gives a good PAPR reduction and better BER performance.

$$F^{-1}(x)=\begin{cases}\frac{|x|(1+\ln(A))}{A}, & |x| < \frac{1}{1+\ln(A)}\\ \frac{\exp(|x|(1+\ln(A))-1)}{A}, & \frac{1}{1+\ln(A)}\le|x|<1\end{cases}$$

VI. OQAM PRE/POST PROCESSING

The TMUX system transmits OQAM symbols instead of QAM symbols. The pre-processing block, which utilizes the transformation between QAM and OQAM symbols, is shown in Figure 4. As can be seen, the first operation is a simple complex-to-real conversion, where the real and imaginary parts of a complex-valued symbol $c_{k,}j$ are separated to form two new symbols $d_{k,2i}$ and $d_{k,2i+1}$ .So So the order of these original symbols depends upon the sub channel number, *i.e.*, the conversion is distinct for even and odd numbered sub channels. The complex-to-real conversion upsurges the sample rate by a factor of 2. After this the second operation is the multiplication by □$_{k,n}$ sequence [9].

A possible choice is:

$$\Theta_{k,n} = j^{(k+n)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

However, it should be noted that the signs of the $\theta_{k,n}$ sequence can be chosen arbitrarily, but the pattern of real and imaginary samples has to follow the above definition. For example, an alternative sequence

$$\Theta_{k,n} = \begin{cases}1, j, 1, j \cdots \text{ for } k \text{ even}\\ j, 1, j, 1 \cdots \text{ for } k \text{ odd} \ldots\ldots\ldots(2)\end{cases}$$

The input signals are purely real or imaginary-valued after the OQAM pre-processing. The post-processing block is shown in Figure 5 and again there are two slightly different structures depending on the sub channel number. The first operation is multiplied by $\theta^*_{k,n}$ sequence that is followed by the operation of taking the real part.

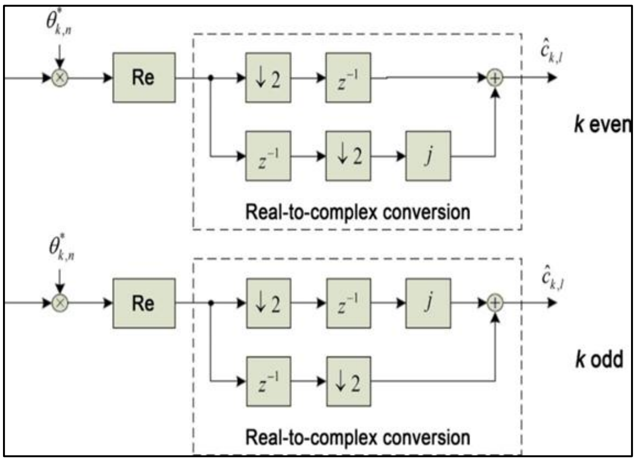

Fig. 2: OQAM preprocessing [9].

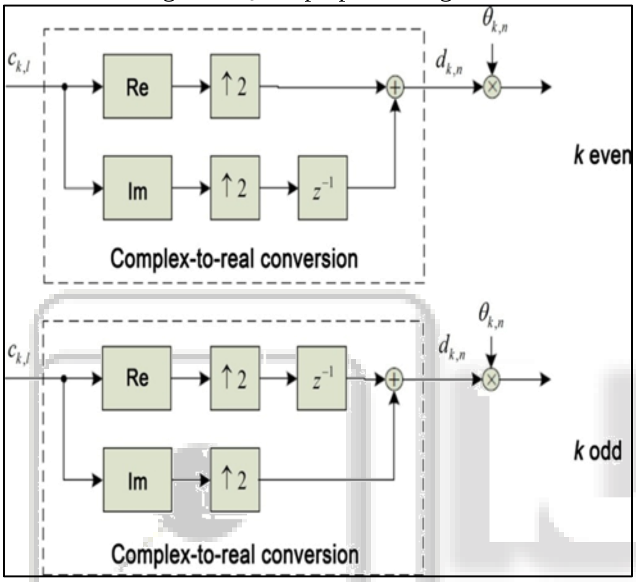

Fig. 3: OQAM post processing [9].

VII. SIMULATION RESULTS

In this analysis we represent results by using Matlab simulations. The PAPR performance of FBMC with and without reduction techniques is implied together with BER performance.

		PAPR in dB at CCDF = 10^{-3}
FBMC without Reduction		17.87
μ-Law Companding	μ = 25	10.62
	μ = 255	7.38
A-Law Companding	A =13	10.91
	A =87.6	7.9

Table 2: PAPR Analysis OF FBMC OQAM

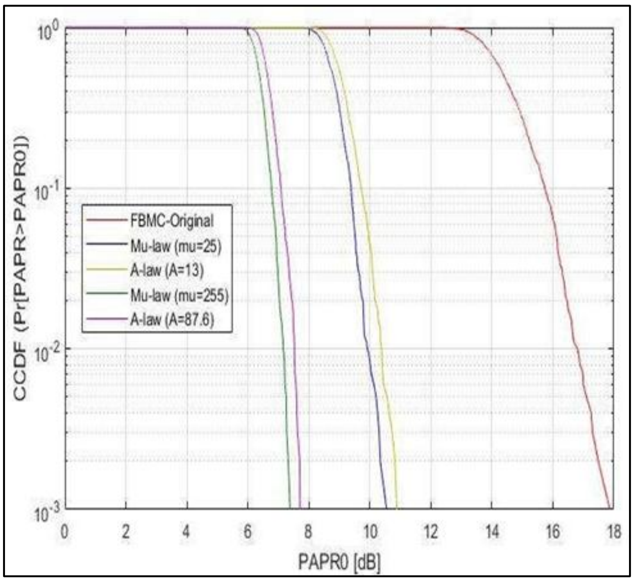

Fig. 4: CCDF of original FBMC-OQAM and companded signals

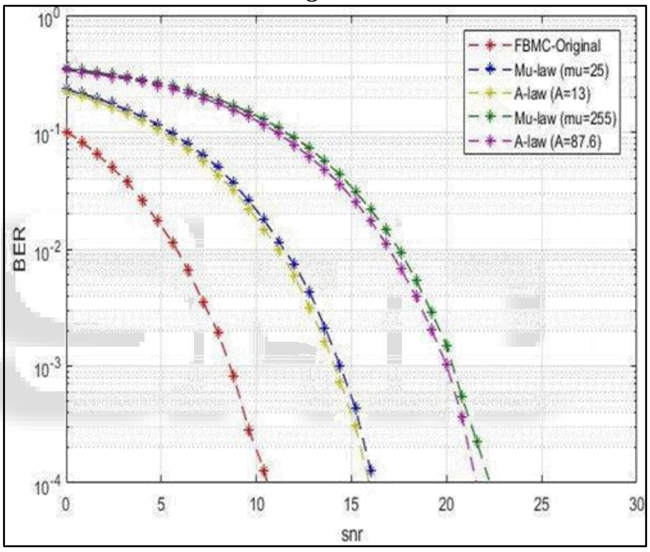

Fig. 5: BER performance of original FBMC-OQAM signal and companded signal over AWGN channel

When μ = 255 and A =87.6 At CCDF=10-3dB there is a difference of 0.32 dB. From the figure 4 it can be seen that Mu-law is giving slightly better result compared to A-law. Figure 5 shows the BER of original FBMC signal and companded signals. There is a very high increase in BER of companded signals. A- law companding is giving slightly better BER than Mu-law companding .It can also be seen in figure 4 and figure 5 that by increasing the values of μ and A a better PAPR reduction can be achieved but BER of the system is also increased.

VIII. CONCLUSION

In this article, we proposed companding techniques such as Mu-law and A-law for the reduction of PAPR in FBMC-OQAM system .These techniques are tremendous for PAPR reduction but the overall system performance is also affected. It is marked from the simulation results that there is a significant decrease in PAPR when companding is applied but at the cost of high BER. More the reduction in PAPR, more the BER of the system enhances.

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