ENGINEERING IN ADVANCED RESEARCH SCIENCE AND TECHNOLOGY

ISSN 2352-8648
Vol.02, Issue.11
December -2020
Pages: -289-302

USING PTS COMPANDING TECHNIQUE FOR THE PAPR REDUCTION OF FBMC-OQAM ALONG WITH A-LAW AND MU-LAW COMPANDING

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ABSTRACT: The recent trend in wireless communication is based on LTE (Long Term Evolution) which includes OFDM (Orthogonal Frequency Division Multiplexing). OFDM is one of the main technique used for 4Th Generation(4G) data transmission technique. FBMC (Filter Bank Multicarrier) is similar to OFDM and it is multicarrier based 5th generation technique. There are some considerable drawbacks for FBMC which degrades its performance for high data transmission. One of the major drawback of FBMC-OQAM is PAPR (Peak to Average Power Ratio). To overcome this drawback of PAPR, we used PTS-A-law and PTS-mu-law companding. Also, this proposed work is used to investigate improved trade-off between PAPR and BER for OFDM-OQAM technique using A-law and mu-Law companding. PTS (partial transmit sequence) is signal scrambling technique and companding is signal distortion technique which we integrated in this proposed work. Proposed technique is designed using MATLAB and communication toolboxes in MATLAB.

KEYWORDS: *Peak to Average Power Ratio (PAPR), Filter Bank Multicarrier (FBMC),Long Term Evolution (LTE), Offset Quadrature Amplitude Modulation (OFQAM).*

I. INTRODUCTION: OFDM (Orthogonal Frequency Division Multiplexing) is the most widely used MCM scheme in wireless networks. It uses CP (Cyclic Prefix) to minimize the ISI (Inter Symbol Interference), which reduces the spectral efficiency of the system. As low spectral efficiency is one of the major problems being faced today, OFDM will not be a suitable choice for future wireless networks [1-3]. In FBMC/O-QAM system a filter is applied on each subcarrier which significantly reduces the OOB (Out Of Band) emission. Because of low OOB emission, FBMC/O-QAM system does not require CP, hence provides high spectral efficiency. It also resolves other problems of OFDM system such as frequency sensitivity, high side lobes etc. [4-5]. FBMC/O-QAM is a MCM scheme and has high PAPR. Usually a HPA (High Power Amplifier) is used at the transmitter of the communication system. When a signal with high PAPR passes through the HPA, it gets distorted and because of this, power efficiency of the system gets reduced. Therefore, PAPR is a big issue and it needs to be resolved. To overcome this issue, many research works have been proposed to reduce PAPR. In [6], PPTS (Pretreated Partial Transmit Sequence) scheme is proposed. Iterative clipping method is used in [7]. In [8], SLM (selective mapping) technique is being proposed, DSLM (Dispersive Selective Mapping) is presented in [9]. In this research study, some PAPR reduction methods such as companding and clipping are studied and implemented on FBMC/O-QAM system, and it is found that clipping technique provides better result among the considered schemes.Filter bank multi-carrier (FBMC) is one of the most promising transmission techniques for 5G mobile communication system. Orthogonal frequency division multiplexing (OFDM) is the latest modulation technique used in existed communication system. Insertion of cyclic prefix (CP) in OFDM results in wastage of bandwidth and also results in out band radiation. To estimate the disadvantage of OFDM system FBMC has drawn the attention of many academic researchers. As a promising modulation technique for next generation mobile communication it uses the pulse shaping property of bank of filter and alternate Offset-QAM (OQAM) data, intrinsic signal double the information rate of FBMC, are weighted on the carrier of FBMC. Therefore, FBMC utilizes the bandwidth in an efficient manner. Moreover FBMC donor uses CP results in higher speed as compared to OFDM [1]. Peak average power ratio (PAPR) is one of the biggest problems in a multi carrier system. It normally takes place when an amplifier swings from linear region to nonlinear region due to high power peak. It drastically reduced efficiency of the FBMC system. High PAPR is one of the common problems for OFDM and FBMC system.Several PAPR reduction techniques for OFDM system have been studied and suggested [2–4]. PAPR reduction techniques cannot be utilized in FBMC system due to its overlapping structure. Several PAPR reduction techniques have been suggested for FBMC system [5–7]. Overlapping structure problem of FBMC has been held into the consideration of implementing a PAPR reduction technique based on SLM (selective mapping). The authors in [9] suggested an SLM and AS (alternate signal) PAPR reduction technique for FBMC system. Even so, it necessitates the additional bandwidth to achieve the peak reduction signals. In [10], the authors suggested a sliding window tone reservation PAPR reduction schemes. The proposed technique uses peak reduction signal of many continuous symbols to do away with the amplitude power of the FBMC system.

III. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING:

The OFDM is the most broadly spread modulation among all the multicarrier modulations. In general, the idea of MCM is to divide the transmitted bit stream into different substreamsand send them, after mapping, over different orthogonal sub channels centered at different subcarrier frequencies f_k, with k = 0; 1,....,N - 1. The number N of sub streams is chosen sufficiently large to insure that each subchannel has a bandwidth less than the coherence bandwidth of the channel. Fig. 2.1 illustrates a multicarrier transmitter. The transmitter and receiver of the classical OFDM systems are constituted of

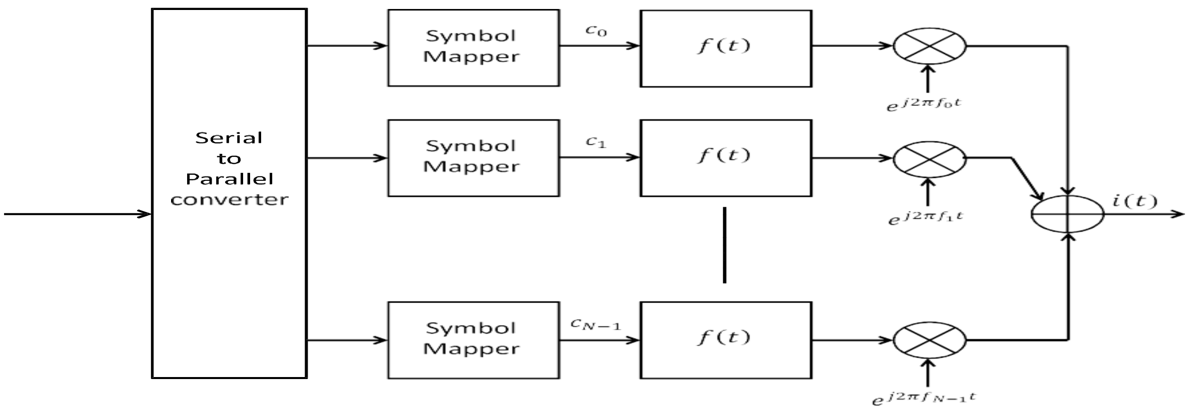

FIGURE 1: Multicarrier transmitter.

inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT) respectively. Therefore, OFDM is based on overlapping sine function type subcarrier spectra, where the adjacent subcarriers are at the nulls of the sine function. The constellation symbols are mapped with N sub-carriers and the modulated signal can be represented in time domain as,

$$i(t) = \sum_{m=-\infty}^{+\infty} \sum_{n=0}^{N-1} c_{m,n} f(t-mT) e^{j\frac{2\pi}{T}n(t-mT)}$$

- The PSD of a single sub-carrier OFDM signal is given below,

$$\Phi_{OFDM}(f) = T\left(\frac{sin(\pi f T)}{\pi f T}\right)^2$$

Most of the advantages of OFDM arise from the use of the IFFT block, easing the signal generation, receiver signal separation, channel equalization and ability to cope with severe channel conditions, by adding a cyclic prefix (CP). If Δ is the duration of CP, then the CP-OFDM data symbols are transmitted every $T_{ofdm} = T + \Delta$. These symbols are uniformly spread along the frequency axis at the spacing F = 1/T. The symbol density of a CP-OFDM system is

$$\frac{1}{T_{ofdm}F} = \frac{T}{T+\Delta} \leq 1$$

Since, we always need a cyclic prefix to avoid the interference in the presence of a frequencyselective propagation channel, the CP-OFDM can only achieve a symbol density lower than one. Nevertheless, OFDM suffers from spectral efficiency loss (due to CP), sensitivity to Doppler shift and frequency synchronization problems, and susceptibility to power amplifier characteristics.

FBMC-OQAM system

Usage of a filter-bank is a computationally efficient way to implement a large number of filters that are well localized in time and frequency, in order to separate the sub-channels. According to polyphase decomposition theory, a filter-bank can be implemented through the fillters' poly-phase decomposition associated with the FFT. A FBMC MCM system can be described by a synthesis-analysis _filter bank i.e. a trans-multiplexer. The synthesis filter-bank (SFB) is composed of all the parallel transmit filters known as poly-phase network (PPN), which is the set of the so-called prototype filters, with the IFFT to divide the bandwidth in N sub-channels for transmission. The inverse operation in reversed order is realized in the receiver by the analysis filter-bank (AFB) consisting of all the matched receive filters, to recover the transmitted data. So, SFB and AFB implement the systems' modulator and the demodulator, respectively.Albeit, the usage of these efficient filters to separate the sub-channels, instead of the rectangular window, imposes the use of a real modulation to maintain the orthogonality between sub-carriers, since the trans-multiplexer impulse response is non-unitary due to interference from the neighbouring sub-channels and time instants. Thus, the FBMC system has to transmit a real symbol every half OFDM symbol duration, yielding to the so-called FBMC-OQAM system.

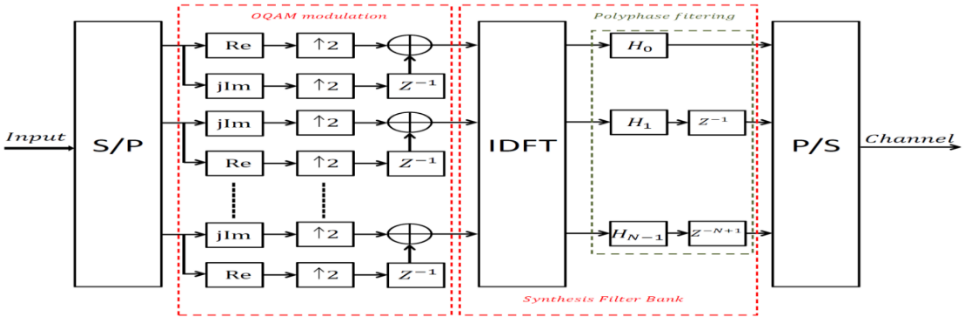

FIGURE 2: FBMC-OQAM transmitter

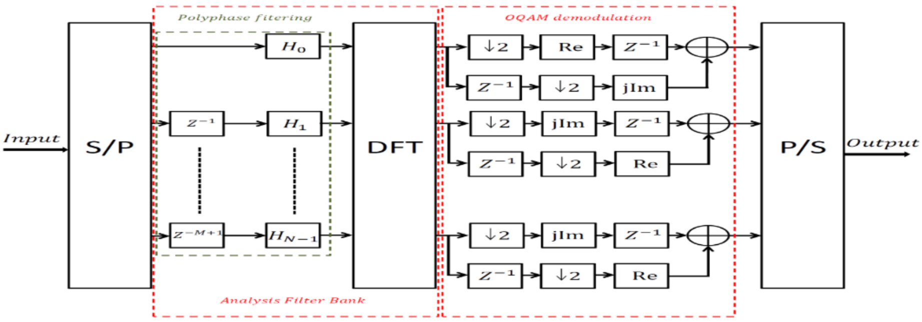

FIGURE 3: FBMC-OQAM receiver

IV. PEAKTOAVERAGE POWER RATIO:

The peakto average power ratio (PAPR)is the major drawback of OFDM system which decrease the performance of the transmitted signal. The large peak to average power ratio(PAPR) push the power amplifier to work in nonlinear area which result in bandand out of band distortion. When subcarriers with large number are out of phase, a significant PAPR can cause the transmitter's power amplifier to run with in a non-linear operating region. This cause significant signal distortion at the output of the poweramplifier. In addition, the high PAPR can cause saturation at the digital to analog converter, leading to saturation of the power amplifier. PAPR also causes inter-modulation distortion between the sub-carriers and distorts the transmit signal constellation. Therefore, the power amplifier must operate with a large power back-off, approximate to that of PAPR which lead to insufficient operation. Therefore it isnecessaryto overcome thePAPR of thetransmitsignal in MIMO-OFDM systems.

Forcontinuoustimesignalx[t]theexpressionforPAPRisgiven below

$$\text{PAPR}(\text{x}[\text{t}]) = \frac{\boldsymbol{max}[\boldsymbol{x}(\boldsymbol{t})]^2}{\boldsymbol{E}[\boldsymbol{x}(\boldsymbol{t})]^2}$$

Fordiscreatetimeversion x[n],theexpression forPAPRis givenbelow.

$$\text{PAPR}(\text{x}[\text{n}]) = \frac{\boldsymbol{max}[\boldsymbol{x}(\boldsymbol{n})]^2}{\boldsymbol{E}[\boldsymbol{x}(\boldsymbol{n})]^2}$$

Where E[.] is the expection operator.

V. PARTIAL TRANSMIT SEQUENCE:

Partial Transmit Sequence (PTS) is one of the techniques used to reduce PAPR in OFDM system which is implemented in this paper.Main idea of PTS is data blocks are divided into non overlapping sub-block with independent rotation factor. This rotation factor generates time domain data with lowest amplitude. The fundamental idea of this technique is sub-dividing the original OFDM symbol data into sub-data which is transmitted through the sub-blocks which are then multiplied by the weighing value which were differed by the phase rotation factor until choosing the optimum value which has low PAPR.

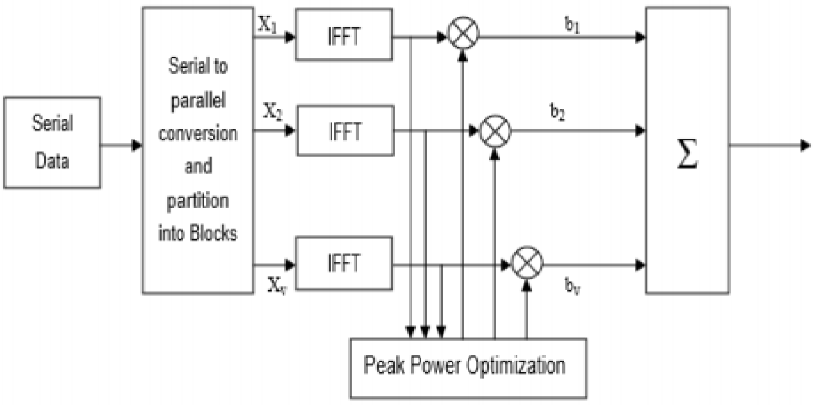

FIGURE 4: Block Diagram of PTS Technique

The block diagram for PTS technique implementation is shown in above figure. The data sequence X in frequency domain is sub-divided into v sub-sequence which were transmitted in sub-blocks without overlapping and having equal size of N which contains N/V non-zero values in each sub-blocks. Thus Peak to average power ratio has been reduced in OFDM using partial transmit sequence. Main drawbacks of this technique are searching complexity increases exponentially with the number of sub blocks.

MATHEMATICAL MODEL FOR PTS TECHNIQUE:

In PTS approach, the frequency domain sequence which are represented by vectors, m= 1,2,3,....., M is partitioned into M disjoint sub block of equal size in X input data block., which can be represented as

$$X = \sum_{m=1}^{M} X_m$$

Where all the subcarrier positions that presented by another block are is set to zero, so that the sum of all the sub-blocks constitutes the original signal. Then, the subblocks X are transformed into time-domain partial transmit sequence by used Inverse Discrete Fourier Transform operation, which can expressed as

$$x_m = \sum_{m=1}^{M} IDFT\{X_m\}$$

Each sub-block x is multiplied by phase factors and combined together to create a set of candidates. The candidate with the lowest PAPR is chosen for transmission. After combination, the time domain signal is given by

$$x = \sum_{m=1}^{M} b_m x_m$$

COMPANDING TECHNIQUES

Companding stands for compressing-expanding mechanism. In this, the stronger signals are compressed and the weaker signals are expanded. Companding action improves the average power of the signal and reduces the peak power of the signal hence PAPR reduces.

- A-Law Companding
- µ-Law Companding

A-Law Companding

An A-law algorithm is a standard companding algorithm, used in European 8-bit PCM digital communications systems to optimize, i.e. modify, the dynamic range of an analog signal for digitizing. It is one of two versions of the G.711 standard from ITU-T, the other version being the similar µ-law, used in North America and Japan.

For a given input *x*, the equation for A-law encoding is as follows,

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

where *A* is the compression parameter. In

Europe, .

A-law expansion is given by the inverse function,

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

The reason for this encoding is that the wide dynamic range of speech does not lend itself well to efficient linear digital encoding. A-law encoding effectively reduces the dynamic range of the signal, thereby increasing the coding efficiency and resulting in a signal-to-distortion ratio that is superior to that obtained by linear encoding for a given number of bits.

μ-Law companding

μ-law encoding is used because speech has a wide dynamic range. In analog signal transmission, in the presence of relatively constant background noise, the finer detail is lost. Given that the precision of the detail is compromised anyway, and assuming that the signal is to be perceived as audio by a human, one can take advantage of the fact that the perceived acoustic intensity level or loudness is logarithmic by compressing the signal using a logarithmic-response operational amplifier (Weber-Fechner law). In telecommunications circuits, most of the noise is injected on the lines, thus after the compressor, the intended signal is perceived as significantly louder than the static, compared to an un-compressed source. This became a common solution, and thus, prior to common digital usage, the μ-law specification was developed to define an interoperable standard.

VI. RESULT:

To show the performance of PAPR reduction, the FBMC-OQAM is combined with Reduced complexity PTS and companding methods which are imitative of the existing methods with which are simulated by randomly generated data. A CCDF=Prob{PAPR>PAPRo}, was used to present the range of PAPR in term of a probability of occurrence.

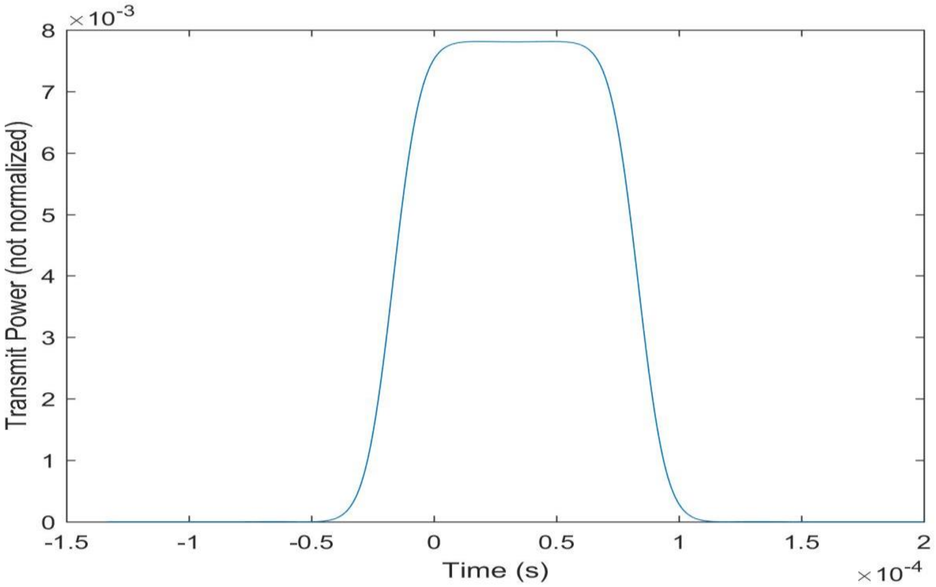

FIGURE 5: Transmit power signal

Here figure 5shows the transmission of the power which is used to in the FBMC-OQAM system and the figure 6 shows the Power spectral Density of a transmitted signal in a FBMC_OQAM system

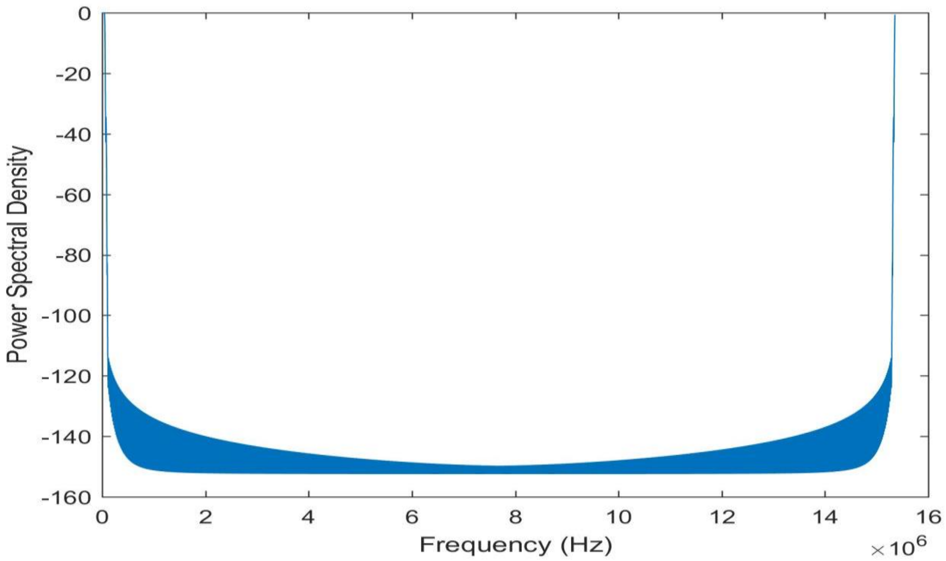

FIGURE 6: PSD of the transmit power

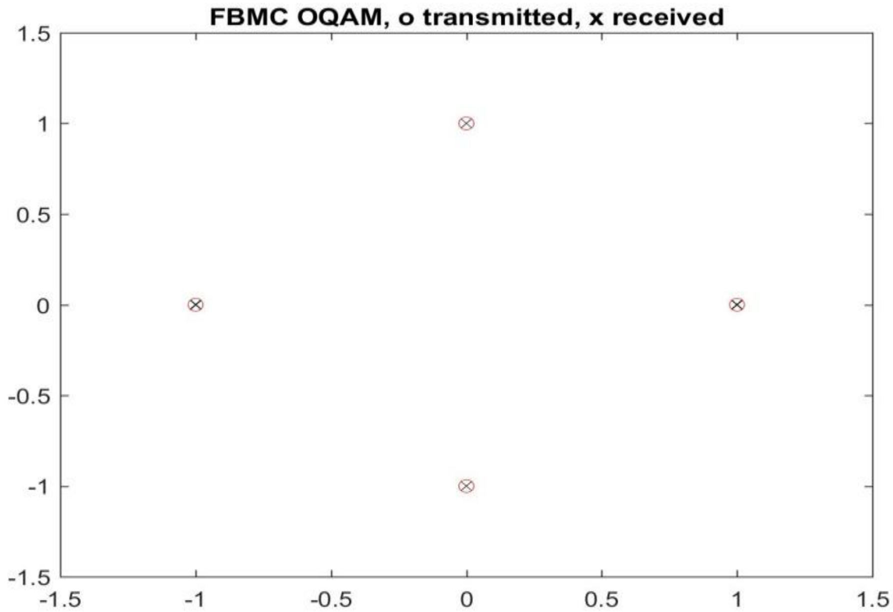

FIGURE 7: FBMC OQAM Transmitted and Received Signal

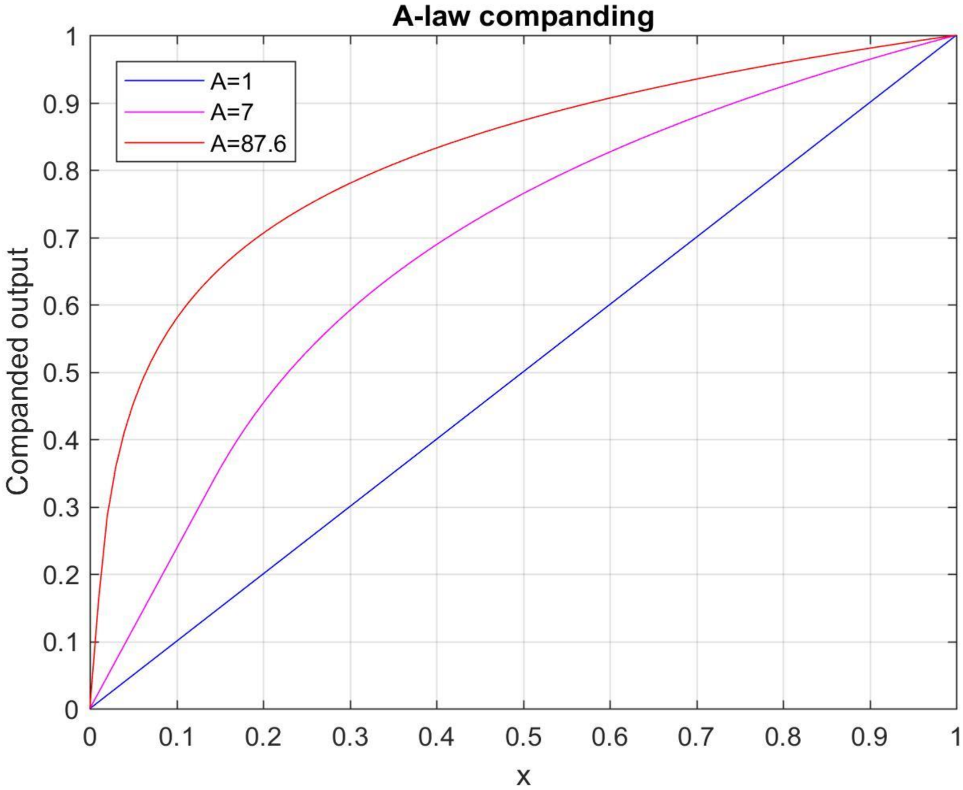

FIGURE 8: A-law companding using different values

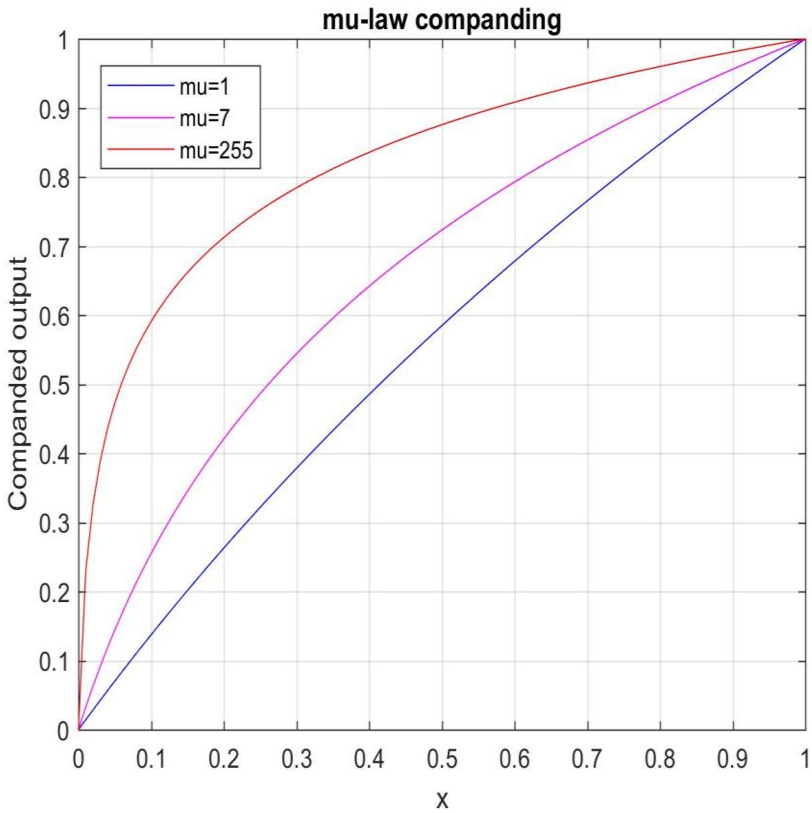

FIGURE 9: Mu-law companding using different values

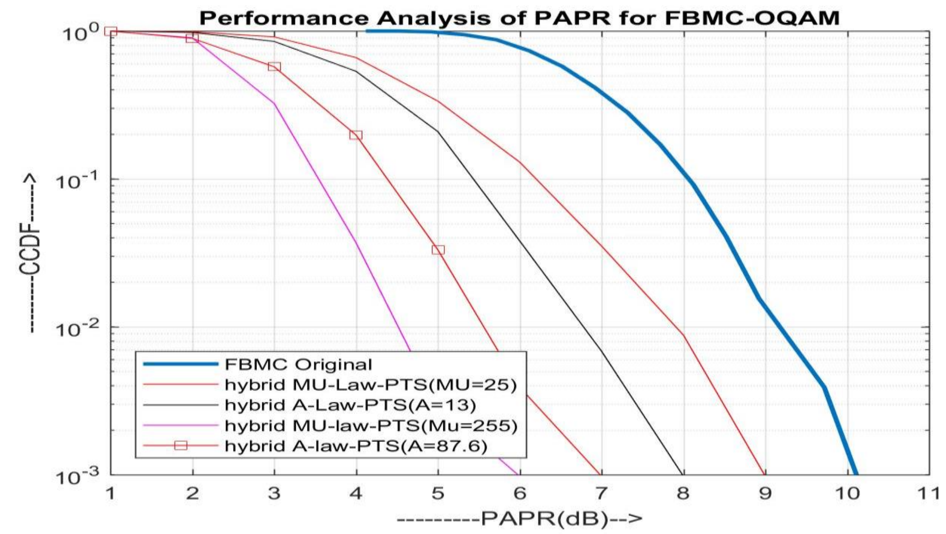

FIGURE 10: BER performance Analysis of PAPR for FBMC-OQAM

Figure 10 shows the CCDF of the original FBMC signal and companded signals. There is a significant decrease in PAPR in both Mu-law and A-law companded signals. At CCDF=10-3Db there is a difference of 0.33 dB when μ= 25 and A =13. When μ= 255 and A =87.6 At CCDF=10^-3dB there is a difference of 0.32 dB. From the figure 5 it can be seen that Mu-law is givinglightly better result compared to A-law.

		PAPR in dB at CCDF = 10^{-3}
FBMC without Reduction		10.22
μ-Law Companding with PTS	μ = 25	8.98
	μ = 255	5.98
A-Law Companding with PTS	A=13	7.88
	A=87.6	6.98

TABLE 1: PAPR Analysis OF FBMC OQAM

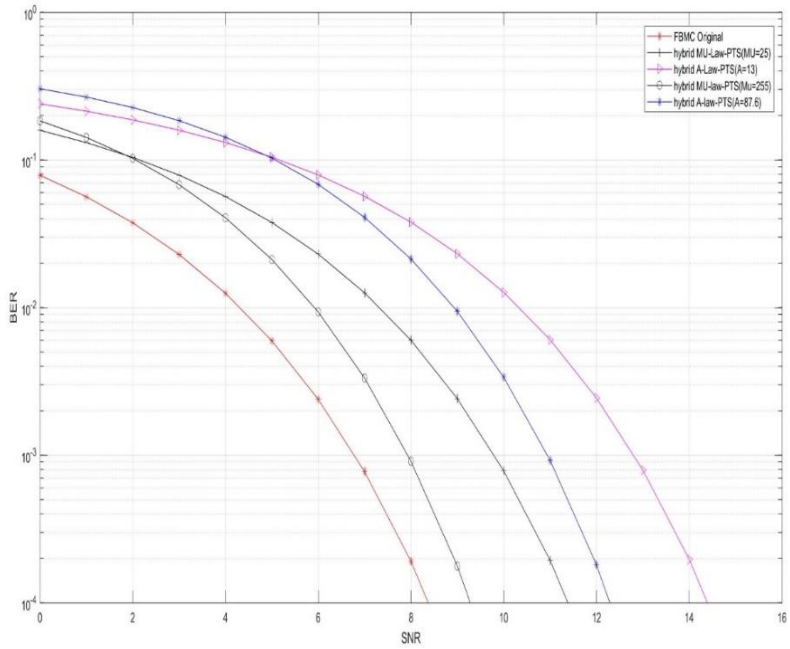

FIGURE 11: BER performance of original FBMC-OQAM signal and companded signal over AWGN channel

Figure 11 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.

VII. CONCLUSION & FUTURE SCOPE:

In this paper a novel usage of the Mu-law and A-law companding techniques for the reduction of PAPR in FBMC-OQAM scheme is proposed, and Companding techniques are good for PAPR reduction but the overall system performance is also affected. It is evident from the simulation results that there is a significant decrease in PAPR when companding is applied but at the cost of high BER, so that the More the reduction in PAPR, more the BER of the system increases. In this we present all the techniques which we can use to overcome the PAPReffect in FBMC-OQAM system as possible for effective transmission of signal. In future wecan go for the combination of two or more techniques to minimize the problems moreeffectively than that of single technique and also improve the performance of thesystem.

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