

Companding and clipped filtering based Hybrid Technique for PAPR reduction of FBMC-OQAM

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Abstract— For transmitting QAM signals, a sensor subcarrier - quadrature amplitude modulated (FBMC-QAM) system using two sample filters is presented. Filtration for even post symbols and odd-numbered sub-carrier symbols is done separately in the proposed transmitter. Multicarrier transmission, which sends data over the channel in several frequency subcarriers at a lower data rate, has become popular in this situation.

A potential waveform for 5G is the filter bank multicarrier system, which is an efficient multicarrier system. FBMC has a high Highest point Power Ratio (PAPR), similar to OFDM and other multicarrier systems, which necessitates the use of high-power amplification with a wide dynamic range. Precoding methods are employed to reduce PAPR at the cost of BER performance loss. A unique application of A-law and Mu-law companding methods for PAPR reduction of the FBMC-OQAM method is proposed in this work. Utilizing A-law and Mu-law companding algorithms, the paper also analyses the tradeoff between Parameter estimation and FBMC-OQAM Bit error efficiency. The PAPR of the system has decreased significantly as a result of the simulated results, but the BER has increased. Both companding strategies yielded mixed results, with Mu-law companding marginally outperforming A-law companding in terms of PAPR reduction. However, A-law companding has a higher BER than Mu-law companding.

Index Terms—High Power Amplifier (HPA), Filter Bank Multicarrier (FBMC), Bit Error Rate (BER), Peak to Average Power Ratio (PAPR)

I. INTRODUCTION

Despite the fact that wireless transmission and related technologies are thought to be nearing the end of their life cycles, the need for new technologies and better throughputs continues to grow. They are now extensively linked to the majority of infrastructural facilities and are inextricably linked to daily operations. Many interdisciplinary applications and cross-functionalities have been added to services and operations. Despite the fact that the last enormous boom has passed, experts and programmers are still searching for new technologies to better the present systems that have evolved through generations.

Mobile phones are no longer just devices for private contact. They've evolved into portable intelligent computers that can run multimedia apps and perform functions that can be controlled remotely. Communication capability is one of its features, albeit it is a required infrastructural resource.

Thru the network connection, several stationary and mobile devices are connected to systems in concurrently. These will be even more efficient, user-friendly, complex, and intelligent than they are now. They will be able to meet these demands by acquiring and/or utilising remote resources with the help of wireless communication. These resources are in high demand, and may include cloud-based computing and intelligence, as well as storing. In remote centralised or distributed systems, certain jobs can be processed much more quickly and intelligently.

Orthogonal Frequency Division Multiplexing (OFDM) [2] is a prominent multicarrier system that is utilised in Digital Audio Broadcast (DAB), Digital Video Broadcast (DVB), and other applications. OFDM is a spectrally efficient method that reduces ISI by using a cyclic prefix (CP). At the same hand, based on its height, this CP reduces spectral efficiency. Filter bank trade marks, a new multicarrier system, successfully overcomes this flaw (FBMC). The system can have strong stopband attenuate in an FBMC system cos of subcarrier filters, which limit frequency leaking between the subchannels and allow the prototype filtering ordering to be large. Sub channel filters can simplify equalisation at the receiver and eliminate the need for CP [3].

Because OFDM struggles from either a high peak to average power ratio (PAPR) due to the non of actual HPAs used to magnify the message data, FBMC suffers from the same problem, hence lowering the PAPR is the major requirement for achieving large data rates. Because of the high PAPR, high dynamic range amplifiers and ADC/DACs are used [1]. High PAPR is the primary issue in all multicarrier systems because it distorts the signal, resulting in poor BER efficiency

PTS [4], coding methods selection projection (SLM) [4], phase optimization, tone injection (TI), companding [5], tone reserve (TR), clipping and filtering, and active constellations elongation are some of the PAPR reduction strategies utilised in OFDM (ACE).

The simplest way to use is clipping and filtering [5]. Peaks that surpass the threshold value are clipped and then filtered to keep the peak value low. PTS and SLM are probabilistic algorithms that weight signal subcarriers with phase factors before transmitting signals with low PAPR [6][12]. Both of these strategies require the transmission of side information in addition to the signal, lowering the spectral efficiency. Because of their simplicity and flexibility, companding methods are commonly utilised for PAPR reduction [7].

In this paper, we look at how FBMC-OQAM (Offset Quadrature Amplitude Modulation) performs in terms of PAPR and BER, and then use A-law and Mu-law companding approaches to reduce PAPR.

It is worth noting that the researchers of [1] have also given a PAPR reduction analysis using the same approaches, but there is no detailed comparison based on the number of subcarriers and compressing parameter values. In this paper, we show and discuss a complete Papr and BER analysis for various numbers of sub - carriers (16, 32, 64, and 128) and varied compressing parameter values for both pressure approaches. The choice of compression parameter results in a trade-off between PAPR reduction and BER efficiency as demonstrated.

II. LITERATURE REVIEW

In the mid-1960s, FBMC communications mechanisms were initially established. Chang [10] described the criteria for signalling a parallel set of PAM symbol patterns across a bank of overlaps filters with a minimum bandwidth using a bank of overlaying filters. Chang suggested vestigial sideband (VSB) signalling for subcarrier sequencing to send PAM symbols in a broadband fashion. Saltzberg [14] developed the concept and demonstrated how Chang's approach could be adjusted to transmit QAM symbols in a DSB-modulated manner. Saltzberg suggested that the in-phase and quadrature components of each QAM symbol be time staggered by half a symbol interval to retain the bandwidth efficiency of this method identical to Chang's signalling. Bellanger and Daguët [11] originally proposed an efficient digital version of Saltzberg's multicarrier system using polyphase structures, which was later examined by Hirosaki [13]. Another important advance was reported in [15], which stated that Chang's approach Saltzberg's could be used to match channel variations in doubly dispersed networks and thereby eliminate inter symbol and inter carrier interfering (ICI). Saltzberg's method has gotten a lot of attention in the research, and it's been given various titles. To highlight the fact that the in-phase and quadrature components are broadcast with a time offsets with regard to each other, most writers have adopted the designation offset QAM (OQAM). The suffix OFDM has also been added to underline the method's multicarrier functionality, leading to the term OQAM-OFDM. Others have coined the term staggered QAM (SQAM), or SQAM-OFDM. [18] was the first time we used the term staggered multitone (SMT). On the other hand, Chang's method [2] has gotten very little attention. For example, those who have cited [8] have just recognised its presence without providing any information. Hirosaki, who has thoroughly examined and developed digital constructions for the execution of Saltzberg's method [9], has presented a short allusion to Chang's method, noting that it is more complicated to enforce than Saltzberg's method because it uses VSB attenuation and thus necessitates a Hilbert transformation. This assertion, is incorrect because, as we proved in [9], Chang's and Saltzberg's methodologies are comparable, and thus an integration for one can be applied to the other with percent of global gdp modification.

The most often used multicarrier technology is OFDM. It is used in a wide range of communication goods. Alternative approaches for OFDM systems are FBMC. Guard period is used in OFDM systems to mitigate channel distortion. FBMC, on either hand, uses filters techniques to reduce the problem of channel distortion. When using appropriate Filter design, only adjacent subcarriers overlap, resulting in nearly little interference from diagonal subchannels. As a consequence, FBMC approaches are more suited for systems with high mobility and large doppler effect, when subcarrier orthogonality may be lost and ICI causes significant distortion in OFDM signals. Large elements of OFDM subcarriers cause interference and, as a corollary, significant degradation in asynchronous multiplexing transmissions in multiuser systems and cognitive radio networking. To minimize the coefficients, bandwidth efficiency will be reduced by up to 50% [9]. It's also worth noting that academics that have examined Filter banks have created a new class of Filterbanks known as altered DFT (MDFT) Filterbanks [14]. A close examination of MDFT reveals that it is, in reality, a discrete-time version of Saltzberg's Filterbank with a focus on compression and coding. The literature on MDFT starts with Fliege's original paper [7], and has since been expanded by others, such as [8] and [9]. SMT, CMT, and FMT filter bank communication mechanisms are discussed in this article. We concentrate our efforts on SMT and CMT, which have the highest transmission rate. SMT and CMT poly - phase solution is discussed.

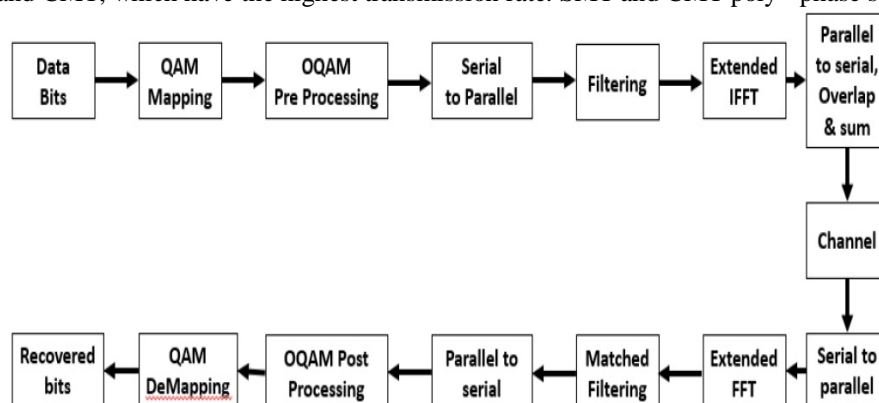


Figure 1: FBMC-OQAM System

For potential remote correspondence frames, channels bank multi-transporter (FBMC) rules, notably FBMC-Offset quadrature amplitude modulation (OQAM), are considered as an attractive alternative to OFDM. The waveforms' moment assessment is broadened and can be traded off, resulting in better utilisation of physical assets and possibly improved strength to time-variation channel qualities as well as bearer recurrence balancing. FBMC-OQAM, like OFDM, breaks down the communication channel into a series of lower-transmission-capacity sub channels that can be compensated at low variance with a single-tap equaliser. Unlike OFDM, FBMC-OQAM does not require a cyclic prefix to be expanded, and the created sub

channels are approximately level and perpendicular. When the channel repetition selectivity increases, the FBMC-OQAM framework encounters both sub channels blockage and picture impedance on each sub channel, necessitating the use of advanced equalisation structures.

III. ORTHOGONAL RECURRENCE DIVISION MULTIPLEXING (OFDM)

A. OFDM

Bits are translated to cluster signals in an OFDM system, and modulating and decoding are ensured by the inverted fast Fourier transform (IFFT) and the fast Laplace transform, respectively (FFT). The wavelet transform of an OFDM symbol calculated using N IFFT points is calculated as follows:

$$i(t) = \sum_{n=-\infty}^{+\infty} \sum_{m=0}^{N-1} c_{m,n} f(t-nT) e^{j2\pi/Tmt} \quad (1)$$

Where,

- N denotes the total number of subcarriers.
- T is the period of the OFDM symbol,
- $C_{m,n}$ is a complex-valued symbol sent across the mth subcarrier at the time nT, and
- A rectangular time window is given by f(t).

$$f(t) = \begin{cases} 1/\sqrt{T} & t \in [0, T] \\ 0 & \text{Elsewhere} \end{cases} \quad (2)$$

The IFFT block turns a set of isolated complicated random variables into a set of complex Gaussian random elements using large incomes of N and the central limit theory. The transmitted signal in a distortion-free noiseless channel is provided by the coconut

$$y_{m0,n0} = C_{m,n} = i(t), f(t-n_0T) e^{j2\pi/Tm_0t} = \int_{-\infty}^{+\infty} i(t) f(t-n_0T) e^{-j2\pi/Tm_0t} dt \quad (3)$$

$$\sum_{n=-\infty}^{+\infty} \sum_{m=0}^{N-1} \int_{-\infty}^{+\infty} c_{m,n} f(t-nT) f(t-n_0T) e^{j2\pi/T(m-m_0)t} dt \quad (4)$$

Where, C_{mn} is the received symbol,

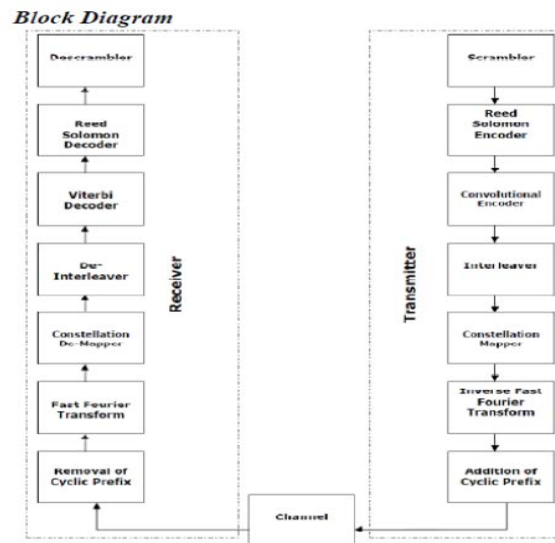


Figure 2 complete OFDM systems

B. ORTHOGONALITY

Maintaining orthogonality of the carriers is crucial in OFDM. When the integral of the sum of two impulses is zero for a certain time period, the signals are said to be orthogonal. This requirement can be satisfied by two sinusoids with values that are integers multiple copies of a common frequency. As a result, orthogonality is defined as follows:

$$\int_0^T \cos(2\pi n f_0 t) \cos(2\pi m f_0 t) dt = 0 \quad (n \neq m) \quad (5)$$

where n and m are two unequal numbers, f_0 is the basic frequencies and T is the time of integration. T is one symbol period in OFDM, and f_0 is set to $1/T$ for maximum efficiency.

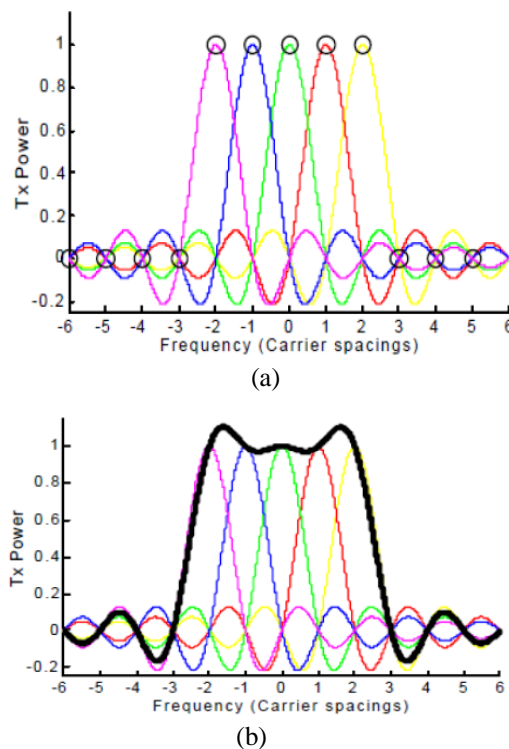


Figure 3 (a) depicts each carrier's spectrum; (b) depicts the overlapping combination response.

C. SCRAMBLER/DESCRAMBLE

The transmitter receives information bits as outputs. These bits are scrambled, which makes the bit arrangement random. This is done with the express objective of scattering the information arrangement so that the reliance of the energy variety of information signals on the authentic sent information can be eliminated. Descrambling is the final step on the collector's end. Descrambler only recovers unique bits of information from the jumbled bits.

D. ENCODER/DECODER

After that, the mixed bits are directed to the Reed Solomon Encoder, which would be a component of Forward Error Correction (FEC). Reed Solomon coding is a revision coding system based on mistake. Over-inspection of data is performed, and equality images are created, which are subsequently associated with unique data. Long these lines, repeating bits are appended to the authentic message, providing resistance to severe channel capacity. The structure RS (n, k) is used to speak to a Reed Solomon code.

$$n = 2^m - 1 \quad (6)$$

$$k = 2^m - 1 - 2t \quad (7)$$

The number of items per signal is m, the number of incoming data symbols (to be encoded) is k, the overall amount of symbols in the RS codeword (data + parity) is n, and the greatest amount of available signals that can be rectified is t. Reed Solo encoded symbols are decoded at the receiver by eliminating parity symbols.

E. CONVOLUTION ENCODER/DECODER

Convolutional encoder additionally codes mistake bits. This programmer also inserts in extra bits. Each m bit symbol is converted into a n bit symbol in this type of coding scheme; the block length is m/n. Because the conversion of a m bit signal into a n bit symbol is dependent on the last k data symbols, k is referred to as the Clustering algorithm code's time complexity.

F. INTERLEAVER / DE-INTERLEAVER

Interleaving is used to protect data from burst errors during transmission. The in-coming piece stream is re-managed in such a way that neighbouring bits are no longer adjacent to each other. The data is broken down into smaller chunks, and the bits inside each chunk are improved. When it comes to OFDM, the bits inside an image are adjusted in such a way that neighbouring bits are set on non-nearby subcarriers. When it comes to De-Interleaving, it restructures the bits into a unique structure during the gathering process.

G. CONSTELLATION MAPPER/DEMAPPER

The Constellation Mapper assigns distinct sub-carriers to the receiving (interleaved) bits. Distinct modulating algorithms (such as QPSK, BPSK, and QAM) can be used for different sub-carriers. At the recipient, the De-Mapper merely separates bits from modulated signals.

H. INVERSE FFT/FFT

In the OFDM communication system, it is the most significant block. The orthogonality of OFDM is largely due to IFFT. The IFFT converts a spectra into a time domain by converting the amplitude and phase of each component. It translates a large number of complicated data points into an equal number of time domain points. FFT, on the other hand, does the opposite work at the receiver, converting from transmitter to the receiver.

I. ADDITION/REMOVAL OF CYCLIC PREFIX

Interleaving is used to protect data from burst errors during transmission. The in-coming piece stream is re-managed in such a way that neighbouring bits are no longer adjacent to each other. The data is broken down into smaller chunks, and the bits inside each chunk are improved. In terms of OFDM, the bits within an OFDM picture are adjusted in such a way that adjacent bits are put on non-nearby subcarriers. When it comes to De-Interleaving, it restructures the bits into a unique structure during the gathering process.

IV. FILTER BANK MULTICARRIER (FBMC)

For potential remote correspondence frames, channels bank multi-transporter (FBMC) rules, notably FBMC-Offset quadrature amplitude modulation (OQAM), are considered as an attractive alternative to OFDM. The waveforms' moment assessment is broadened and can be traded off, resulting in better utilisation of physical assets and possibly improved strength to time-variation channel qualities as well as bearer recurrence balances. FBMC-OQAM, like OFDM, breaks down the communication channel into a series of lower-transmission-capacity sub channels that can be compensated at low variance with a single-tap equaliser. Unlike OFDM, FBMC-OQAM does not require a cyclic prefix to be expanded, and the created subchannels are roughly level and perpendicular. When the channel recurrence selectivity increases, the FBMC-OQAM architecture encounters both subchannel obstruction and picture impedance on each subchannel, necessitating the use of advanced equalisation structures. Furthermore, the combination of FBMC-OQAM and SIMO approaches causes an uncontrollable impedance term to appear between the reception apparatus streams on surrounding subchannels, obstructing the framework testing outline. The setting of SIMO FBMC-OQAM frameworks has recently sparked a lot of interest.

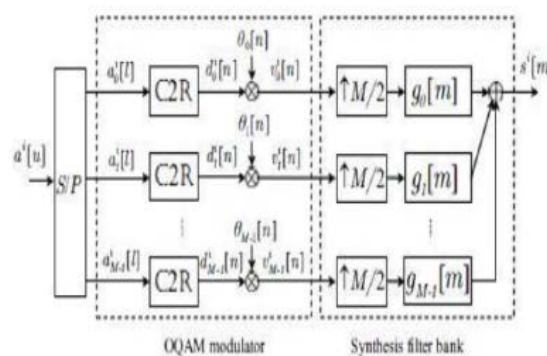


Figure 4: Filter bank for OQAM modulation and synthesis.

A. Mu-law Companding

For the given input x , Mu-law presented in a tabular is as follows:

$$F(x) = \text{sgn}(x) \frac{\ln(1 + \mu|x|)}{\ln(1 + \mu)} \quad (8)$$

The value used here is $\mu = 25$ and $\mu = 255$. Although this technique has a stronger influence on tiny amplitudes, the image quality of the transmitted signal is expanded [1]. The method for de-companding is as follows:

$$F^{-1}(x) = \text{sgn}(x) \frac{1}{\mu} ((1 + \mu)^x - 1) \quad (9)$$

B. A-law Companding

For the given input x , the A-law companding is as follows:

$$F(x) = \text{sgn}(x) \begin{cases} \frac{A|x|}{1 + \log(A)}, & |x| < \frac{1}{A} \\ \frac{1 + \log(A|x|)}{1 + \log(A)}, & \frac{1}{A} \leq |x| \leq 1 \end{cases} \quad (10)$$

Where A is $A=13$ and $A=87.6$ are the compression parameters and values used. This value should be chosen in such a way that it reduces PAPR and improves BER performance. The decompounding formula is as follows:

$$F^{-1}(x) = \begin{cases} \frac{|x|(1 + \ln(A))}{A}, & |x| < \frac{1}{1 + \ln(A)} \\ \frac{\exp(|x|(1 + \ln(A)) - 1)}{A}, & \frac{1}{1 + \ln(A)} \leq |x| < 1 \end{cases} \quad (11)$$

The above expression show as A- Techniques for Reducing PAPR under the law.

V. RESULT AND ANALYSIS

The PAPR performance of FBMC is explored, as well as the BER performance, with or without reduction efforts. The amount of subcarriers is fixed at $N=128$ and randomized input is created and OQAM processed. The upsampling factor is $K=4$ and the channels is additive white Gaussian noise (AWGN).

A. BASE CODE GRAPHS

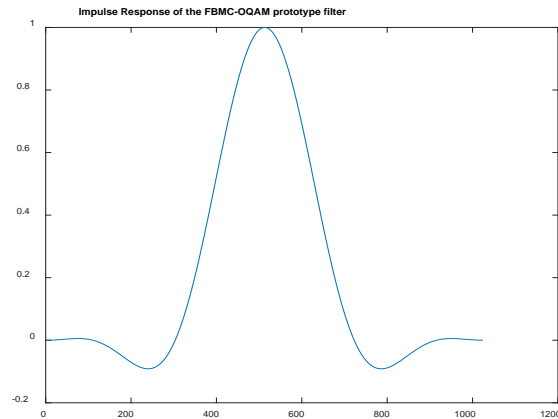


Figure 5: Impulse Response of the FBMC-OQAM Prototype Filter

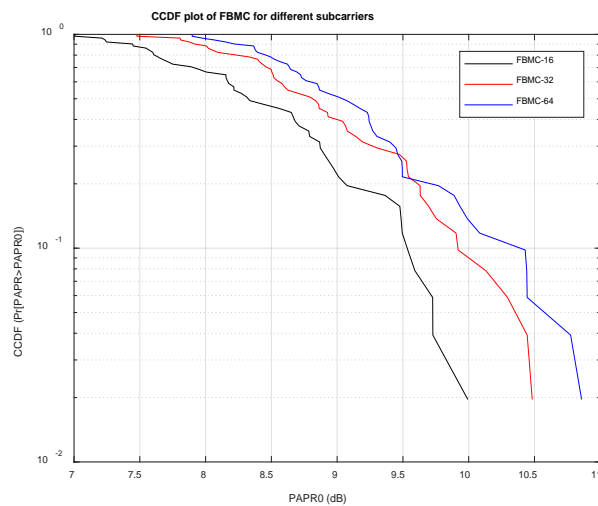


Figure 6: CCDF Plot of FBMC for Different Subcarriers

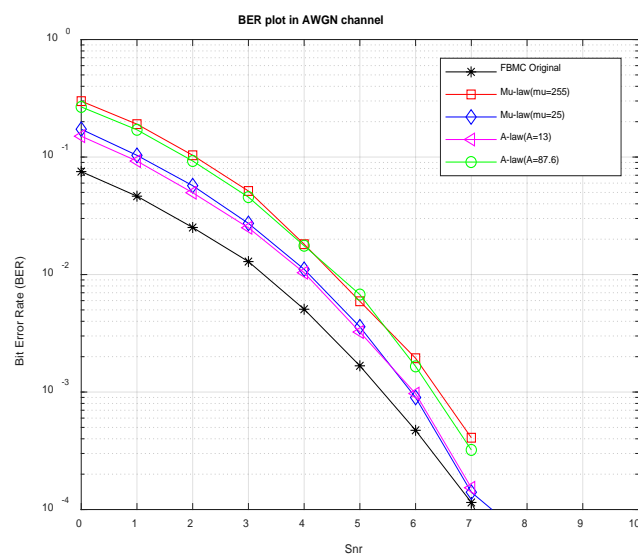


Figure 7: BER Plot in AWGN Channel

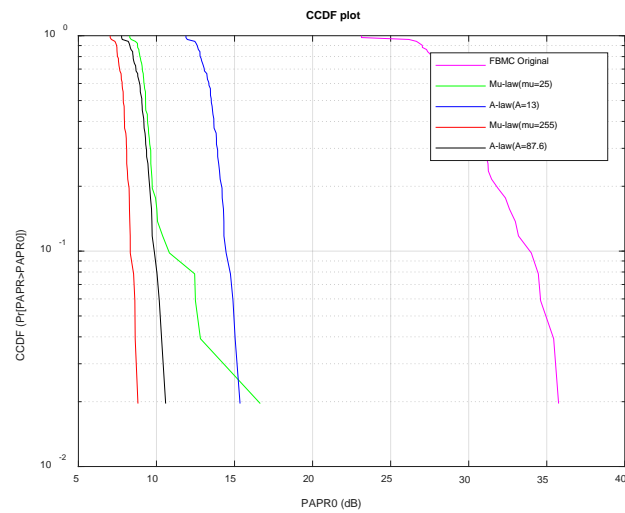


Figure 8: CCDF Plot

Above figure shown as The FBMC-OQAM Prototype Filter's Impulse Response, CCDF Plot of FBMC for Different Subcarriers, BER Plot in AWGN Channel and CCDF Plot

B. PROPOSE CODE GRAPHS:

Propose is based on Hybrid Clipped Filtering and Companding Technique of PAPR Reduction in FBMC-OQAM

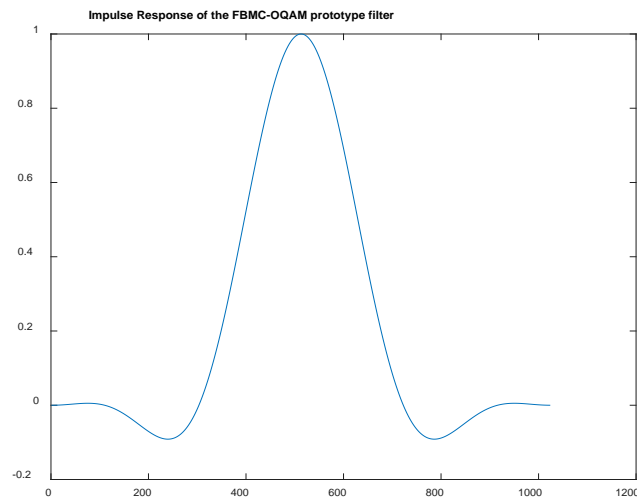


Figure 9: The FBMC-OQAM Prototype Filter's Stimulus Sensitivity

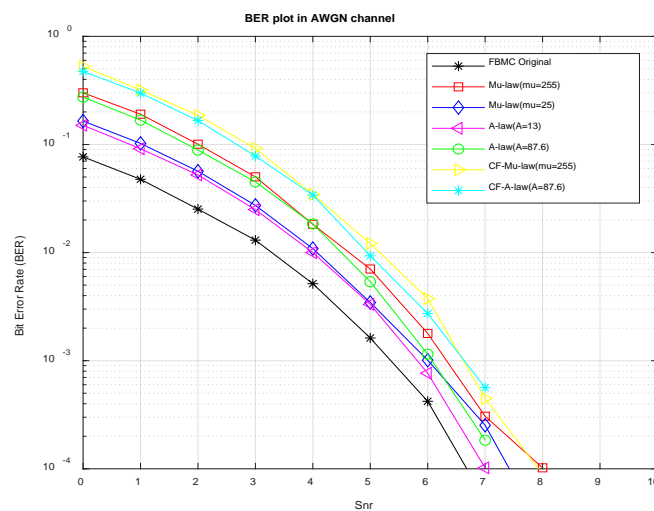


Figure 10: BER Plot in AWGN Channel

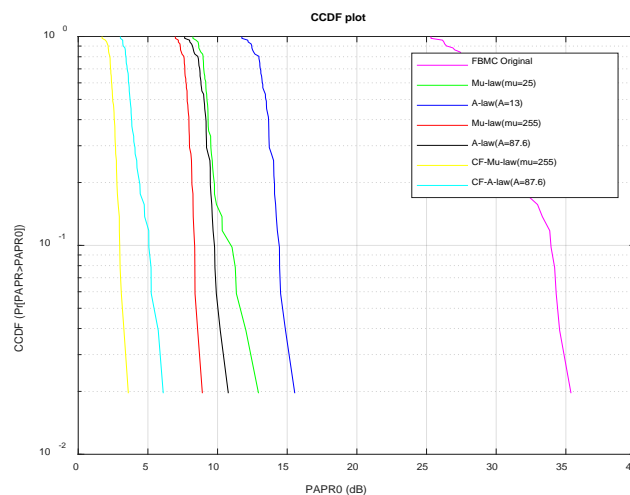


Figure 11: CCDF Plot

Figure 9 shows Figure 10 shows BER Plot in AWGN Channel and Figure 11 shows CCDF Plot for the FBMC-OQAM Prototype Filter. The BER of combined signals has increased dramatically. The BER of A-law companding is slightly higher than Mu-law companding.

VI. CONCLUSION

This work proposes a novel application of Mu-law and A-law companding techniques to reduce PAPR in the FBMC-OQAM system. Companding strategies are effective at lowering PAPR, but they have a negative impact on overall system performance. The simulation findings show that when companding is used, the PAPR decreases significantly, albeit at the cost of a high BER. The lower the PAPR, the higher the system's BER will be.

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