PAPR reduction in OFDM signals using clipping and companding technique

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***Abstract*--Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique that divides the available spectrum into many carriers each one being modulated by a low data rate scheme. OFDM is similar to Frequency Division Multiple Access (FDMA) in that the multiple user access is achieved by sub-dividing the available bandwidth into multiple channels, which are then allocated to users.In OFDM, using guard band is cyclically extended in order to avoid inter-carrier interference (ICI). The major drawback of OFDM signals is high peak to average power ratio(PAPR). High PAPR signals would require a large range of dynamic linearity from the analog circuits which usually results in expensive devices and high power consumption with lower efficiency.**

Keywords-OFDM,PAPR,Inter Symbol Interference,Inter Carrier Interference,Companding

I.INTRODUCTION

High PAPR will introduce disadvantages like an increased complexity of the A/D and D/A converters and reduced efficiency of radio frequency (RF) power amplifier.

The number of independent modulated subcarriers in the OFDM signal leads to the problem for increasing PAPR. The high PAPR has nonlinear nature in the transmitter and it degrades the power efficiency of the system. This forces the power amplifier to have a large input backoff and operate inefficiently in its linear region to avoid intermodulation products. It is impossible to send high peak amplitude signals to the transmitter without reducing peaks. So it is necessary to reduce high peak amplitude of the OFDM signals before transmitting it over the channel.

Various no of techniques have been proposed to reduce the PAPR.

In the Block Coding Technique, the basic idea is that from the all probable message symbols, which is having low peak power will be chosen as a valid code for transmission. If there have N subcarriers, they are represented by 2^N bits using QPSK modulation and thus 2^N messages.

In the Selective Level Mapping (SLM) technique a whole set of transmitted signals is generated which is representing the same information, and then the signal which is having less PAPR is chosen and transmitted.

In the Partial Transmit Sequence(PTS), the data block subdivided into non-overlapping sub blocks and each sub-block is rotated with a statistically independent rotation factor. The rotation factor, which generates the time domain data with the lowest peak amplitude,also transmitted to the receiver as side information.

In the Tone Reservation technique a small set of subcarriers (tones) are reserved for peak signal cancellation.

In the Peak Windowing technique the highest signal peak of the OFDM signal is multiplied with a window such as Gaussian shaped, Cosine, Kaiser and Hamming window.The OFDM signal is multiplied with any one of thesewindows, the final spectrum is a convolution of the original OFDM spectrum with the spectrum of multiplied window.

In the Envelope Scaling method the input envelope for some subcarriers are scaled before they are sent to IFFT.

The OFDM signals are used in many wireless applications like WLAN standards(e.g. HIPERLAN-2, IEEE802.11a), Wireless Metropolitan Area Networks (WMAN), Digital Video Broadcasting application (DVB), Asymmetric Digital Subscriber Line (ADSL) and Power Line Communications.

II.OFDM SYSTEM

In an OFDM system, an input data symbol vector $X=[X_0, X_1, \ldots, X_{N-1}]$ in the frequency domain is modulated by N orthogonal subcarriers to generate a discrete time OFDM signal x(t). It is obtained by performing IFFT on X as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X_n e^{j2\pi kt/N}, 0 \le t \le N-1 \qquad (1)$$

Where N is the number of subcarriers and t is the discrete time index.

The PAPR of an OFDM signal is defined as the ratio between the maximum power and the average power. The PAPR of the OFDM signal X(t) is given by,

$$PAPR = \frac{P_{peak}}{P_{avg}} = \frac{\max[x(t)x^*(t)]}{E[x(t)x^*(t)]} \qquad (2)$$

Where $P_{peak}$is the peak power,$P_{avg}$is the average power of an OFDM signal, $x^*()$ indicates to the conjugate operator.

The OFDM signal data are modulated using a QPSK modulation technique.QPSK is a digital modulation technique, in which two bits are modulated at a same time ,selecting any one of four possible carrier phase shifts $(0, \frac{\pi}{2}, \pi, \frac{3\pi}{2})$.

III.BLOCKDIAGRAM

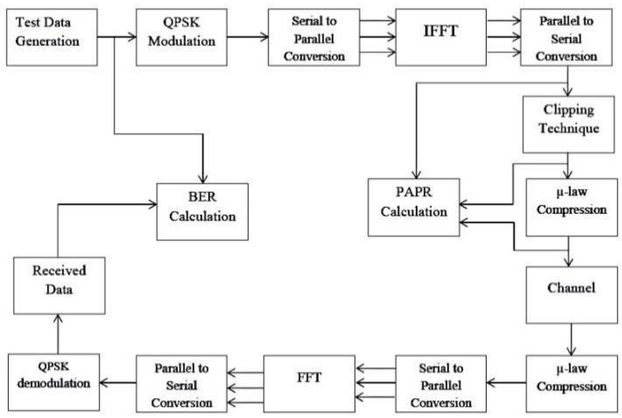

Fig.1 Block Diagram of OFDM System with Clipped Companding

The proposed scheme uses both the Clipping and Companding technique to reduce the high peaks of the OFDM signals.

Clipping is a simple PAPR reduction technique in which a threshold value is set to limit the peak envelope of the input signal. Signals having amplitudes higher than this threshold value are clipped and the rest are allowed to pass through .The input OFDM data points are modulated using the QPSK modulation and then IFFT transform is applied to obtain the OFDM signals.

The IFFT transform will convert the time domain signals into frequency domain signals. This will produce the OFDM signals. After the OFDM signal generation the clipping technique is applied. At this stage certain threshold level is fixed. Signals having amplitude values above this threshold level will be clipped and rest remain undisturbed.

Companding is a common technique for reducing the data rate of signals by making the quantization levels unequal. The use of companding allows signal with a large dynamic range to be transmitted over facilities that have a smaller dynamic range capability. The dynamic range of a signal is compressed before transmission and is expanded to the original value at the receiver. By applying the companding scheme at the transmitter side the higher peaks are compressed to an equal level. Now the power amplifier can transmit the OFDM signals with efficiency in the system. Since the amplitude of the OFDM signals are almost equal in the compressed signal the energy obtained by the power amplifier to transmit those signal will be less in nature.

The Companding Equation is given by

$$F(x) = \frac{sgn(x) \cdot \ln(1+\mu|x|)}{\ln(1+\mu)} \qquad 0 \le |x| \le 1 \qquad (3)$$

where µ is the compression parameter (µ=255 in U.S. and Japan) and x is the normalized integer to be compressed.

At the receiver end the inverse of $F(x)$ is used in the expanding operation. It is given by

$$F^{-1}(y) = \frac{sgn(y)(\frac{1}{\mu})}{((1+\mu)^{|y|-1})}, \qquad -1 \le y \le 1 \qquad (4)$$

IV.SIMULATION PARAMETERS

Sl.No	Description	Specification
1.	Modulation Scheme	QPSK/M=4
2.	No of sub-carriers	256
3.	µ value	255
4.	Channel	AWGN
5.	No of bits per symbol	1

Table.1 Simulation Parameters

V.RESULTS

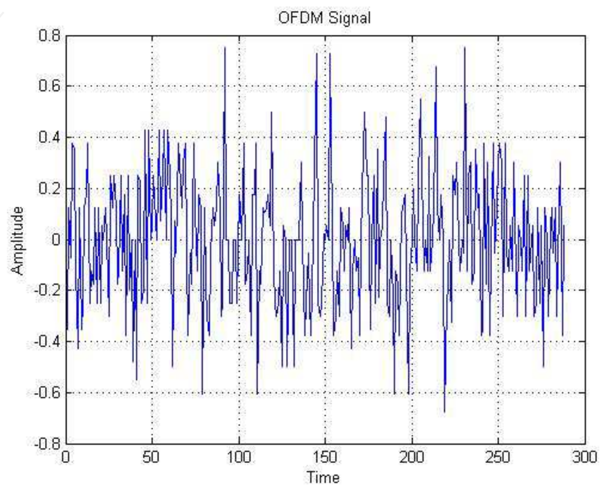

Fig.2 OFDM Signal Plot of 256 data points

OBSERVATIONS

PAPR Reduction technique	PAPR value (in db)
Original signal	16.1060
Clipping technique	10.6896
Clipping and Companding technique	4.9198

Table.2 Observed values

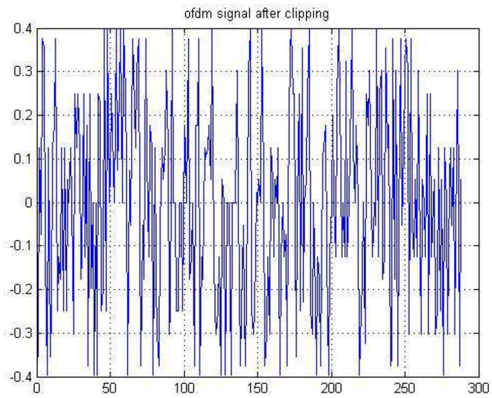

Fig.3

OFDM signal after Clipping

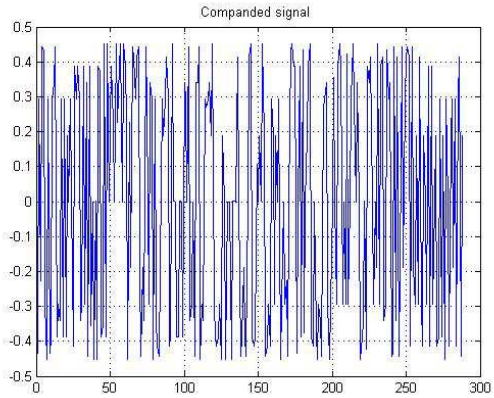

Fig.4

Companded OFDM signal

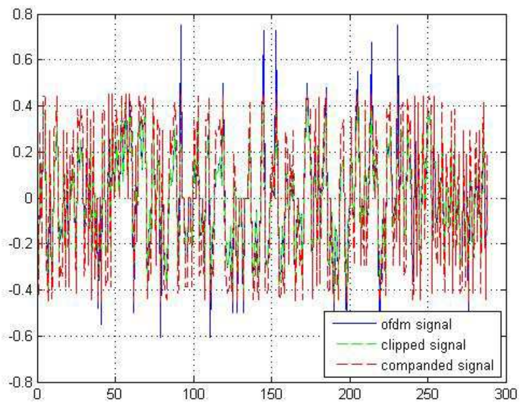

Fig.5 OFDM signal, Clipped signal andCompanded signal

VI.CONCLUSION

The OFDM signal was generated by using the QPSK modulation technique. Then the higher peaks of the OFDM signals which is above the threshold value were clipped.

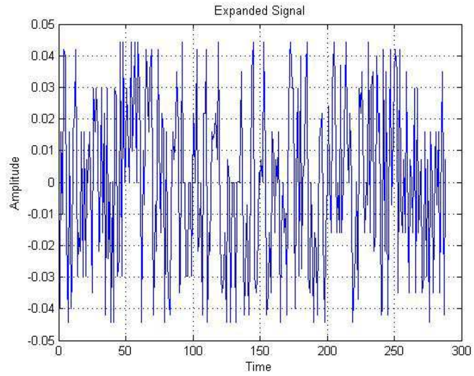

Fig.6 Expanded OFDM Signal at the Receiver Side

And then the clipped signals are companded to further minimize the PAPR. The original PAPR is calculated 16.1060 db and it is minimized to 4.9198 db by applying Clipping and Companding techniques. From this it is inferred that this is a better technique to implement for reducing PAPR for performance improvement

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