PAPR OPTIMIZATION OF SC-FDMA SIGNAL USING M-ARY SIGNALING

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Abstract:- The major advantage of using Single Carrier Frequency Division Multiple Access (SC-FDMA) instead of Orthogonal Frequency Division Multiplexing (OFDM) in uplink of Long Term Evolution (LTE) is the low Peak to Average Power Ratio (PAPR) of SC-FDMA signal which benefits the mobile station (MS) which has limited power. it provides while retaining the performance and not more complex than OFDM. This paper aims at proposing a new technique, of employing M-ary Pulse shaping in SC-FDMA. We compare Complementary Cumulative Distribution Function (CCDF) using different M-ary signaling and found that with increasing M the order of M-ary signaling, the PAPR is reduced. The M-ary signal can be achieved by converting the signal of message from Binary to Non-binary by inserting a block, meant for the purpose, before Baseband Modulation of the signal, Comparison of 8-Differential Pulse Shift Keying (8-Dpsk), 8-Quadrature Amplitude Modulation (8-Qam), 8-Pulse Amplitude Modulation (8-Pam) and 8-Pulse Shift keying (8-Psk) shows that 8-Psk Baseband modulation schemes delivers good performance in terms of PAPR Localized subcarrier mapping is considered throughout this paper.

Keywords-PAPR, SC-FDMA, M-ary, 3GPP

I. INTRODUCTION

Broadband wireless communication is order of the day. As wireless applications became more ubiquitous, leading to the necessity of algorithms which can utilize high data rates and transmit error-free. The best response to the said problem was use of Orthogonal frequency division multiplexing (OFDM) and Orthogonal frequency division multiple access (OFDMA). [4]"OFDM is a multicarrier modulation technique which uses orthogonal subcarriers to convey information"[2]while OFDMA is the scheme for OFDM, enabling multiple users to access it simultaneously. OFDMA was accepted as the most preferred solution because it provide robustness against frequency selective channels, common in broad band communications.[1] Despite this advantage it has a drawback, most important from user standpoint, the Peak to Average Power Ratio (PAPR)

To solve this dilemma Single carrier frequency division multiple access (SC-FDMA) was proposed in Uplink of Long Term Evolution (LTE). SC-FDMA can be regarded as Discrete Fourier Transform (DFT) spread OFDM [2] and is an access scheme utilizing signal carrier modulation and frequency domain equalization. Due to its intrinsic signal carrier structure of smoothly varying pulses and avoiding abrupt changes, it has low PAPR.

The variations in signal or phase-shift of the signal correspond to the amount of power used. The higher the phase-shift, the higher the power consumed. The binary signal has variations of order of 180 degrees using BPSK as the modulation scheme. While it avoids such extravagant use of power by using BPSK, the variations to the degree of 180 still are here. The use of non-binary or M-ary signaling reduces this shift by many order of degrees. [7] This smooth transition from one symbol to another reduce the required amount of power. And the power amplifier operates with higher efficiency. The higher number of M reduces the variations further, So with the use of higher M-ary signaling the PAPR is reduced.

The reminder of this paper is organized as; Section II deals with the logic of using and numerical analysis of M-ary signaling in the conventional SC-FDMA system. Section III goes through the changes required in conventional SC-FDMA system to obtain the desired performance. Section IV deals with simulation results by illustrating the CCDF of PAPR while using different M-ary signaling. As mainly the variations in a signal can be of three types. Change in amplitude, change in frequency and change in phase, through out this paper by variations we mean change in phase only.

II. OVERVIEW OF PAPR AND ITS REDUCTION TECHNIQUE

A. Overview of PAPR

[6] The ratio between maximum instantaneous power and its average power is known as continuous time Peak to Average Power ratio (PAPR). This term is very important in multicarrier or single carrier communication systems. [1] In LTE 3GPP, SC-FDMA is adopted as uplink modulation scheme and OFDM is adopted as downlink modulation scheme. [2] SC-FDMA signal has lower PAPR as compare to OFDM due to the discrete fast Fourier transform (DFT) block before the sub-carrier mapping. As there is very limited power available in the user equipment (UE) and high PAPR means that the battery in the UE will discharge quickly. There is a power amplifier at the transmitting side if the efficiency of the amplifier is high the battery will take large time to discharge

and low amplifier efficiency means the battery will discharge quickly [5] If the variations in the Incoming input signal is high the amplifier will have lower efficiency and low variations means the amplifier has high efficiency

B. PAPR Reduction techniques

There are nine techniques used for the reduction of PAPR [6]. Some of the techniques are most used than others like clipping and filtering. [3]Clipping and filtering is the most widely used technique for PAPR reduction, part of the signal outside the allowed region is clipped, [3] clipping is performed at the transmitter side, so the receiver needs to have estimate of the clipping performed. So as the signal is clipped and filtered the peak power of the signal reduces and so the PAPR of the OFDM or SC-FDMA signal reduces, Another technique used is called coding scheme, signals with same phases when added produce peak power, its amplitude increases almost by twice but before occurrence of such scenario with the help of coding the phases of the signals are changed. So after addition of the signals peak power reduces as compare to conventional form of addition.

C. Methodology

Suppose we have some binary data 100110110101 the BPSK modulation for this digital signal will be 1 -1 -1 1 1 -1 1 1 -1 1 -1 1 the waveform for the said data is shown in the fig 1 there is a 180 degree phase shift in between 1 and -1 the fig 1: clearly shows how much variations are in there as compare to fig 2 which is also phase modulated. the waveform in fig 2 carries the same information as the fig 1. In the fig 2, 8-ary signaling is used or we can say that each of the three message bits generates a waveform these waveforms differ from each other by phase, frequency or amplitude based on the designer choice which scheme to use. The information carried by the waveform in fig 2 is the same as the information carried by the waveform of fig 1 the technique used in fig 2 is three times faster than the technique of fig 1 because each waveform of fig 2 carries information of three bits while each waveform in fig 1 carries 1 bit data.

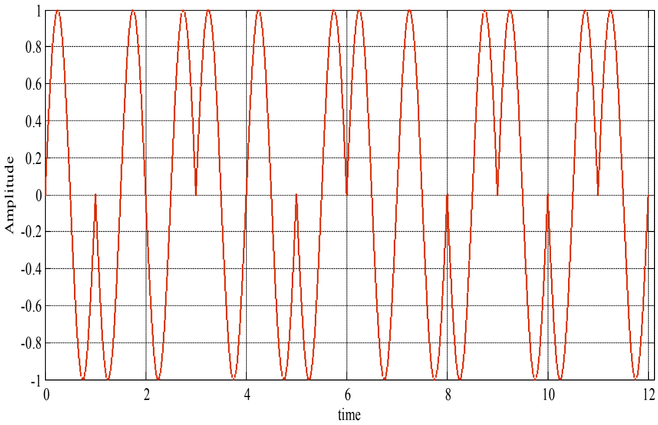

Fig 1. BPSK Modulated Signal

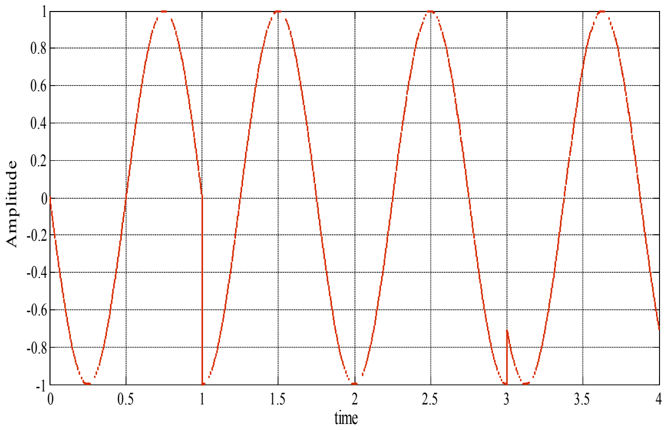

Fig 2. 8-PSK or Non-Binary Octal

By converting the binary message to octal or to some M-ary the variations in the input to amplifier reduces means that the PAPR of the signal reduces and the efficiency of the amplifier efficiency increases.

III. CHANGES REQUIRED IN CONVENTIONAL SC-FDMA

Fig. 3 shows the changes required in conventional binary SC-FDMA system. The figure shows both the transmitting and receiving sides. In the first block, we encoded our baseband signal. Before going to baseband modulation, we have to convert our baseband signal into its non binary equivalent numbers using binary to non binary converter; in our case we have used non binary octal digits. As each octal digit corresponds to three binary digits as shown in Fig X. , the equivalent octal digit is then assigned to each group. The transmitter first groups the modulation symbols into blocks. each containing N symbols. Next, it performs an N-point DFT to produce a frequency domain representation of the input symbols. It then maps each of the N-DFT outputs to one of the (M > N) orthogonal subcarriers that can be transmitted. If N = M/Q and all terminals transmit N symbols per block, the system can handle Q simultaneous transmissions without co-channel interference. As in SC-FDMA an M-point IDFT transforms the subcarrier amplitudes to a complex time domain signal is then modulated the remaining portion is almost same to the binary case. The receiver transforms the received signal into the frequency domain via DFT, De-maps the subcarriers, and then performs frequency domain equalization. At the receiver side after taking the N-point IDFT, the non binary signal is demodulated, and by the use of non binary to binary converter it is converted back to is binary form. The decoder then decodes the signal in binary

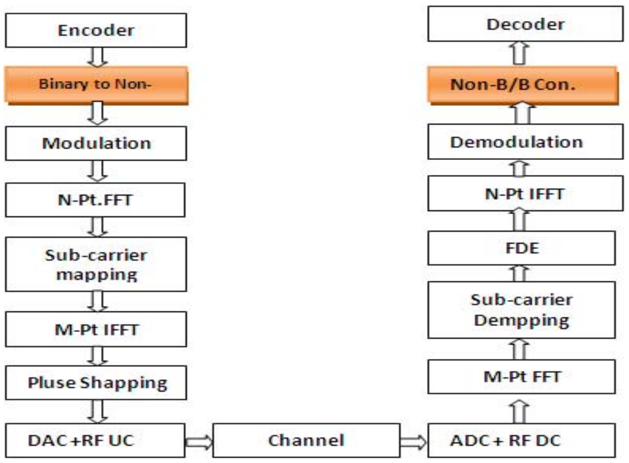

Fig.3 Block Diagram of Non-Binary SC-FDMA

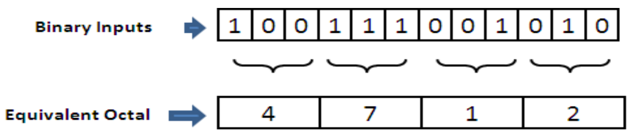

Fig.X Binary of Octal Conversion

IV. EXPERMENTAL RESULTS FOR DIFFERENT

Localized sub-carrier mapping scheme is used in the simulation. We have taken M fft Block size 512 and N=16 the size of the M block is constant but the size of the N block changes according to the signaling used. In 4-ary signaling the N size becomes 8, similarly for 16-ary N block size becomes 4 and for 8 PSK we changed M block size to 15 which is then changed to 5 after Binary to Non-Binary conversion.

We calculated the CCDF (Complementary Cumulative Distribution Function) of PAPR, this is the probability that PAPR is higher than a certain PAPR value PAPRo. The simulation results shows that using higher M-ary signaling the PAPR reduces.

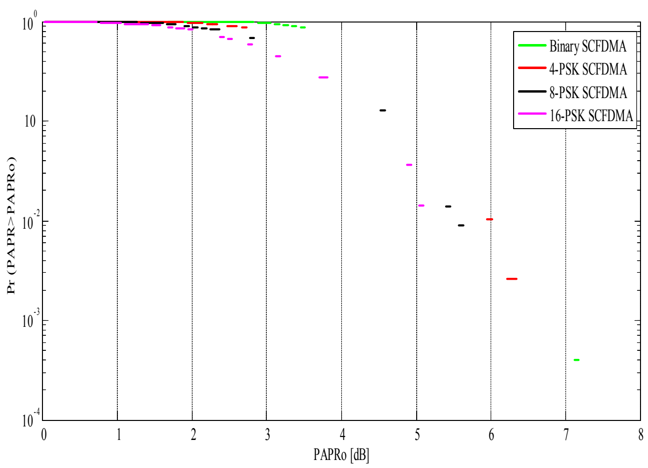

Fig 4. PAPR for Binary and Non-binary signals of SC-FDMA

A. *Effect of some higher M-ary Signalling*

Localized sub-carrier mapping scheme is used here for the simulation. In this simulation we observe the effect of some high order M-ary signaling on the PAPR. The simulation results show that increasing the order of M-ary signaling the overall variations in a block N decreases as the variations decreases the efficiency of the amplifier increases and hence the battery life increases 16-ary, 32ary, 64-ary, 128-ary, 256-ary, 512-ary are shown in Fig.5.

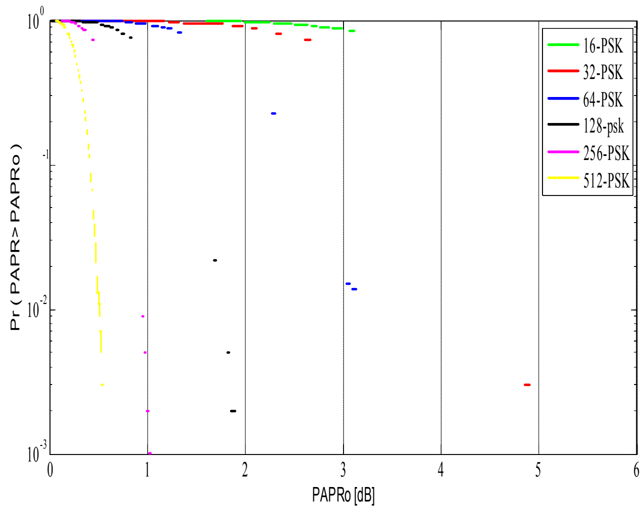

Fig. 5. Effect of M-ary Signaling on PAPR of SC-FDMA

The simulation results show that higher order M-ary signaling has low PAPR then conventional binary signaling.

B. *Choice of BaseBand Modulation Scheme and its effect on PAPR.*

The choice of modulation also effects the PAPR of the SC-FDMA signal but this effect is small as compare to the use of high M-ary signaling. As the PAPR and the efficiency of the amplifier both depends on the variation in the incoming signal. Mainly there can be three type of variations in a signal variation in phase, variation in frequency and variation in the amplitude or there can be combination of any of them. The simulation result show that PSK (Pulse shift keying) has lower value of PAPR as compare to the other modulation schemes. In the PAM (Pulse Amplitude Modulation) the amplitude is changing so this results in high PAPR while in PSK the frequency and the amplitude remains the same only the phase is changed accordingly. Thus the choice of modulation has also effect on the PAPR of the signal.

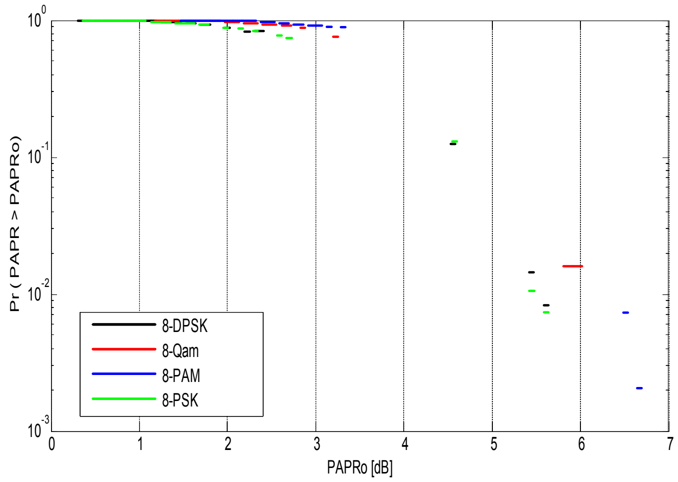

Fig.6 Effect of different modulation schemes on PAPR

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