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Performance Evaluation of Different Phase Rotation on OFDM Signal

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Abstract- OFDM signal is a multicarrier modulation technique, one of the attractive techniques for 4th Generation Wireless communication System. One of the major disadvantages of OFDM is that in time domain, its leads to high peak to average power ratio (PAPR).Selective Mapping Phase Rotation is used in this paper for reducing the PAPR in time domain of OFDM signal. In this paper 32 sinusoids subcarriers are taken and find the value of phase rotation at which there is least PAPR obtain.

Index Terms*-* OFDM, PAPR, selected mapping, Phase Rotation, QPSK, IFFT, Sinusoidal Subcarriers

I. Introduction

A promising modulation technique that is increasingly being considered for adoption by 4G community is OFDM [1]. Orthogonal frequency division multiplexing (OFDM) is a promising solution for high data rate transmission in frequency-selective fading channels. Existing 3G systems uses single carrier modulation technique whereas OFDM which is otherwise known as Multicarrier Modulation (MCM) / Discrete Multitone Technique (DMT) sends a high speed data stream by splitting it up to multiple lower speed stream and transmitting it over a lower bandwidth subcarriers in parallel. OFDM has several favorable properties like high spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, and capacity to handle very strong echoes and less non-linear distortion, immunity to inter-symbol interference. However, a major drawback of OFDM is the high peak to- average power ratio (PAPR) of the transmitted signal. As the result of large peak power, the D/A converter may become highly complex and the power amplifiers such as ClassA, Class B, Class C and Class D may have a non-linear range, which leads to an inefficiency of the amplifier. Therefore, it's useful to reduce the PAPR of OFDM system. There are number of techniques to deal with the problem of PAPR. Some of them are amplitude clipping, filtering, coding, partial transmit sequence and selected mapping (SLM) [2], [3]. The selected mapping method (SLM) provides good performance for PAPR reduction [8], and this requirement usually results in high computational complexity. Several techniques have been proposed based on low-complexity selected mapping schemes for Peak-to-Average Power Ratio reduction in OFDM Systems [4], [5].

In recent years OFDM is employed in Digital Television Broadcasting (such as the digital ATV Terrestrial Broadcasting) [6], European Digital Audio Broadcasting (DAB) and Digital Video Broadcasting Terrestrial (DVB-T) [7], and numerous Wireless Local Area Networks (e.g. IEEE 802.11a operating at 5 GHz) and European Telecommunications Standard Institute (ETSI) Broadband Radio Access Networks (BRAN)'s High Performance Radio Local Area Network (HIPERLAN) Type-2 standard [11].

II. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is a technique in which we use both modulation and multiplexing. Multiplexing generally refers to independent signals those produced by different sources and modulation may be defined as a process by which some characteristic of a signal known as carrier is varied according to the instantaneous value of another signal known as modulating signal. In OFDM the signal itself is first split into independent channels, modulated by data and then re-multiplexed to create the OFDM carrier. OFDM is a special case of Frequency Division Multiplex (FDM) [12]. As an analogy, a FDM channel is like a shipment via a truck we have two options, one hire a big truck or a bunch of smaller

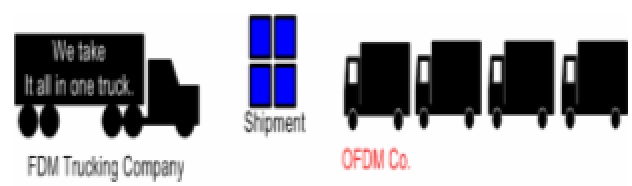

Figure 1: All cargo on one truck vs. splitting the shipment into more than one.

Ones. Both methods carry the exact same amount of data. But in case of an accident, only 1/4 of data on the OFDM trucking will suffer. These four smaller trucks when seen as signals are called the sub-carriers in an OFDM system and they must be orthogonal.The independent sub-channels can be multiplexed by frequency division multiplexing (FDM), called multi-carrier transmission or it can be based on a code division multiplex (CDM), in this case it is called multi-code transmission.

The paper is organized as follows section II gives Orthogonal Frequency Division Multiplexing(OFDM).The importance of being orthogonality is given in sectionIII.The PAPR of OFDM Signal in section IV and Algorithm for least PAPR is in section V.Simulation Result shown in section VI,Finally conclusion are in Section VII.

III. THE IMPORTANCE OF BEING ORTHOGONAL

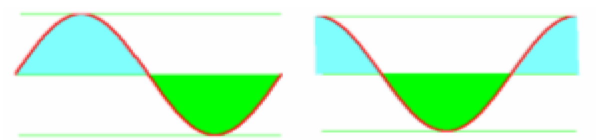

Figure 2: The area under a sine and a cosine wave over one period is always zero.

The main concept in OFDM is orthogonality [12] of the sub-carriers. Since the carriers are all sine/cosine wave, we know that area under one time period of a sine or a cosine wave is zero. This is easily shown in figure3.

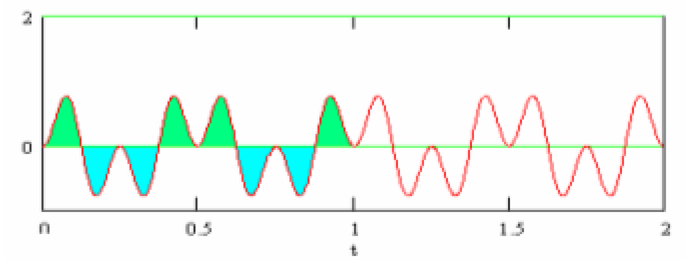

Figure 3: The area under a sine wave multiplied by its own harmonic is always zero.

Let's take a sine wave of frequency m and multiply it by a sinusoid (sine or a cosine) of a frequency n, where both m and n are integers. The integral or the area under this product is given by

$$F(t) = \sin(mwt) * \sin(nwt)$$

By the simple trigonometric relationship, this is equal to a sum of two cosine of frequencies (m-n) and (m+n).

$$= \frac{1}{2}\cos(m-n) - \frac{1}{2}\cos(m+n)$$

$$= \int_0^{2\Pi} \frac{1}{2}\cos(m-n)\,wt - \int_0^{2\Pi} \frac{1}{2}\cos(m+n)\,wt$$

$$= 0 \quad - \quad 0$$

$$= 0$$

These two components are each a sinusoid/cosine, so the integral is equal to zero over one period. We conclude that when we multiply a sinusoid of frequency n by sinusoid of frequency m, the area under the product is zero. In general for the entire integer m and n, sin mx, sinny, cosmx, cosny are all orthogonal to each other [12]. These frequencies are called harmonics. This idea is key to understanding OFDM. The orthogonality allows simultaneous transmission on a lot of sub-carriers in a tight frequency space without interference from each other. In essence this is similar to CDMA, where codes are used to make data sequences independent (also Orthogonal) which allows many independent users to transmit in same space successfully.

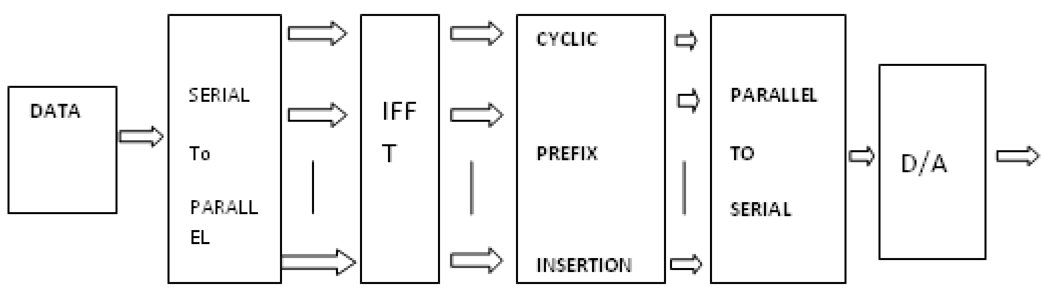

Figure 4: OFDM TRANSMITTER

IV. THE PAPR OF OFDM SYSTEM

The PAPR of OFDM is defined as the ratio between the Maximum power and the average power, The PAPR of the OFDM signal X (t) is defined as

$$PAPR = \frac{P_{peak}}{P_{average}} = \frac{\max_{0 \le t < MT} |x(t)|^2}{\frac{1}{MT}\int_0^{MT} |x(t)|^2} \text{ ----------- (1)}$$

In SLM technique[17], firstly the input information is divided into OFDM data block X, which consists of *M* symbols, by the serial-to parallel (S/P) conversion and then data block X is multiplied carrier wise with each one of the *w* different phase sequences $B^{(w)}$, resulting in a set of *w* different OFDM data block, $X^{(w)} = [X_0^{(w)}, X_1^{(w)} ---- , X_{M-1}^{(w)}]^T$ where $X_m^w = X_m B_m^w$, $m = 0, 1, \cdot\cdot, M - 1$, $w = 1, 2, \cdot\cdot, w$.

$$X_m^w = X_m B_m^w \quad \text{............. 3}$$

$$B^w = [X_0^{(w)}, X_1^{(w)} ---- , X_{M-1}^{(w)}]^T \quad \text{... ... 4}$$

Then all *w* alternative data blocks are transformed into time domain to get transmit OFDM symbol x^w =IFFT $\{X^{(w)}\}$.Finally the transmit sequence $\tilde{x} = x^{(\tilde{w})}$, where $\tilde{w}$ = arg $\{\min_w$ max $|\mathbf{x}(w)|\}$, is selected. The information on the selected phase sequence must be transmitted to the receiver. Where m = 0,1,2,3 ....M-1 .w = 0, 1, 2 …W, to make w phase rotated OFDM data blocks. All w phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block Provided that the phase sequence is known [13]. After applying the SLM technique, the complex envelope of the transmitted OFDM signal becomes

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$$X(t) = \frac{1}{\sqrt{M}} \sum_{m=0}^{M-1} X_m \, e^{j2\pi t f_m}, \; 0 \leq t \leq MT \qquad \text{-------------5}$$

Here, MT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit.

V. ALGORITHM FOR LEAST PAPR

1) Firstly 32 sinusoidal subcarriers are taken. These are available subcarriers (QPSK Modulation) assuming all one positive.

```
x1=sin ((2*180*100*t) +w)
x2=sin ((2*180*200*t) +w)
x3=sin ((2*180*300*t) +w)
.
.
.
.
x32=sin ((2*180*3200*t) +w)
```

These subcarriers are orthogonal [12] to each other because in general for all integers' m and n, sinmx, sinny, cosmx, cosny are orthogonal to each other. These frequencies are called harmonics.

2) Giving these entire subcarriers phase shift (w) from 0 to 30.
3) Now sum all these subcarriers sum=x1+x2+x3+x4+x5+x6+x7+x8+x9+ X10+ ------------------------------+x31+x32.
4) Calculate the PAPR according to formula given in Equation number 1.

VI. SIMULATION RESULT

Simulation is carried in MATLAB 7.8 to evaluate the performance of the different phase rotation on OFDM Signal.

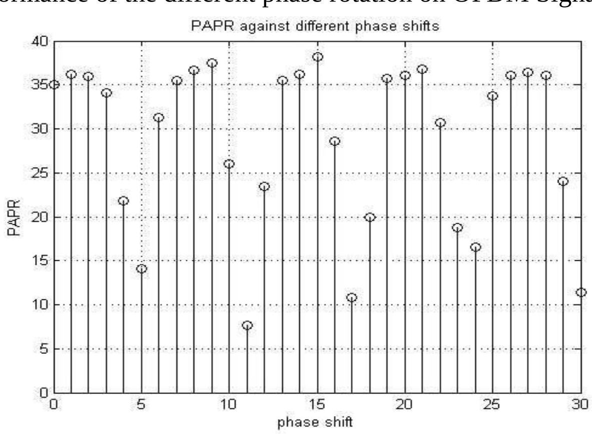

Figure 5: PAPR against different Phase Shift

From the simulation result we see that if we give all these 32 orthogonal subcarriers with phase rotation (w) of 0 to 30 we get the minimum PAPR at phase rotation 11 as shown in figure 5.The PAPR value at 11 degree is found to be 7.6978dB and the resulting OFDM signal is shown in figure 7.After 11 degree Maximum PAPR is obtain at 17 degree (PAPR = 10.8175dB) then 30 degree (PAPR= 11.3961) and the corresponding OFDM signal is shown in figure 8, 9.

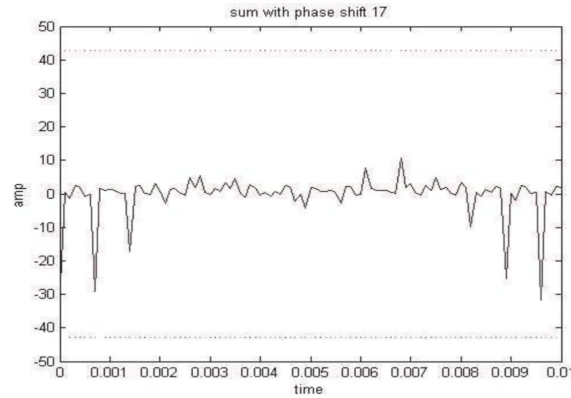

Figure 6: OFDM Signal with Phase shift 17

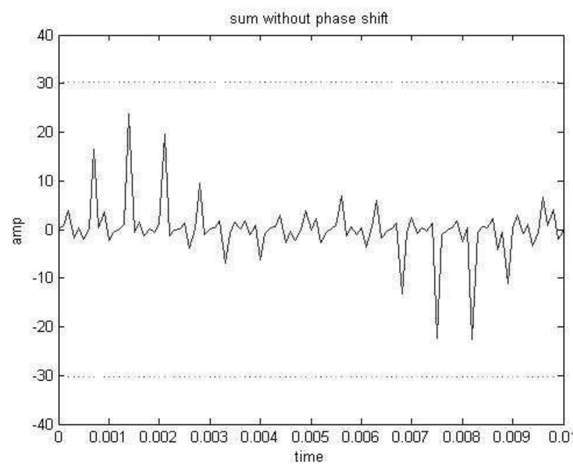

Figure 7: OFDM Signal without Phase shift

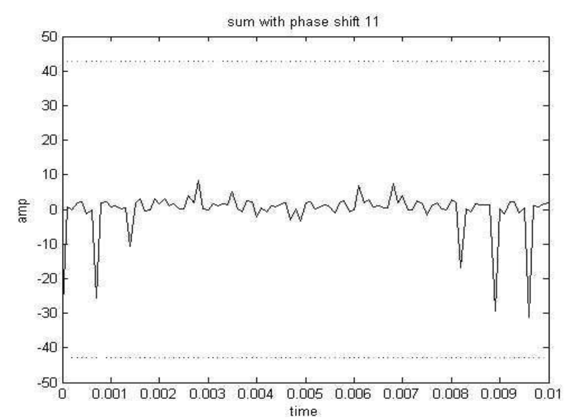

Figure 8: OFDM Signal with Phase shift 11

SYSTEM	Max. PAPR in dB
PAPR Without Phase Shift	35.0303
PAPR with Phase Shift 11	7.6978
PAPR with Phase Shift 17	10.8175

PAPR with Phase Shift 30	11.3961

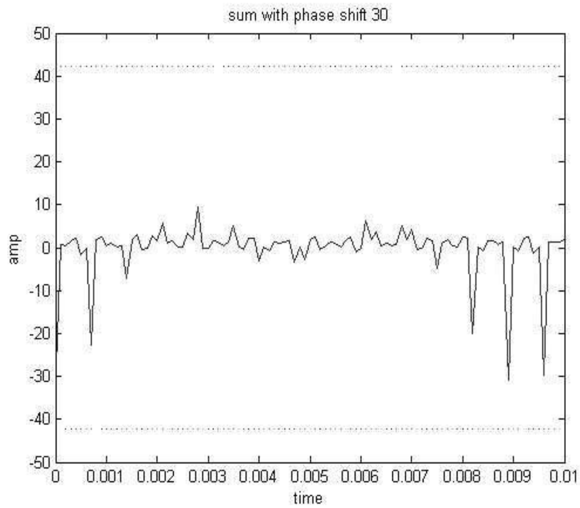

Figure 9: OFDM Signal with Phase shift 30

VII. CONCLUSION

Reducing PAPR value of OFDM signal is very important for improving efficiency of the Equipment (communication system).So, in this paper we obtain a particular phase rotation value at which least PAPR is obtain. With the rising demand for more number of users on limited frequency spectrum in radio Mobile communication, OFDM prove invaluable to fourth generation communication system.

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