A Humble Method Based On Trimming and Differential Topping to Reduce the PAPR in OFDM Systems

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ABSTRACT:
The main objective of this project is to reduce Peak to Average Power Ratio (PAPR) in wireless communication systems. PAPR plays a vital role in communication systems for determining the transmitted signals efficiency at the receiver side. For reducing PAPR; Clipping, up scaling, down scaling, up-down scaling and Selected Mapping Algorithm techniques are introduced. The amplitude of complex OFDM signal is clipped and then scaled in such a way so that the PAPR is reduced without causing much degradation in bit error rate (BER). Total OFDM system is designed with QPSK modulation, frequency domain to time domain conversion (IFFT), corresponding reverse operation at receiver side. Synchronous OFDM with low PAPR and low bit error rate is introduced to achieve high data rate and accurate signal transmissions.

KEYWORDS: Peak to Average Power Ratio (PAPR), Bit Error Rate (BER), Orthogonal Frequency Division Multiplexing (OFDM), Fast Fourier Transform (FFT), Inverse Fast Fourier Transform (IFFT), Digital Subscriber Line (DSL), Selected Mapping Algorithm

INTRODUCTION:
OFDM is a multimode modulation and multiple access technique used in a number of commercial wired and wireless applications. In the wired side, it is used for a variant of digital subscriber line (DSL). For wireless, OFDM is the basis for several television and radio broadcast applications, including the European digital broadcast television standard, as well as digital radio in North America. Recently, new frequency bands, modes, and services to wireless communications are increased significantly, mainly due to the increasing popularity of internet and wireless use and the associated increased demand data bandwidth stuffed into handsets in a single packaging.

Principle of OFDM:
The principle of OFDM is to divide the available spectrum or communication channel into a number of equally spaced tones or sub-carriers. Each equally spaced subcarrier carries a portion of user’s information.

![Figure 1 Three sub-carriers within OFDM symbol](image)

The special property of OFDM is that each sub-carrier is orthogonal with every other sub-carrier. Moreover, the spectrum of each sub-carrier can be allowed to overlap. Since the orthogonality is maintained, the sub-carriers do not interfere with each other. The orthogonal property of sub – carrier is given by,

\[ \int \cos(2\pi n f_0 t) + \cos(2\pi m f_0 t) \, dt = 0 \]

Where (n! = m), t – Time, f_0 – frequency of transmission n, m – constants
Figure 1 shows the OFDM spectrum with three sub-carriers. The orthogonality can be completely maintained, even though the signal passes through a time dispersive channel, by introducing a cyclic path. A cyclic prefix is a copy of the last part of the OFDM symbol which is pretended to the transmitted symbol. This makes the transmitted signal periodic so that it avoids Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI).

Benefits of OFDM:

OFDM enables the creation of a very flexible system architecture, which can be used efficiently for a wide range of services, including both voice and data. OFDM segments the available spectrum according to frequency rather than TDMA which segments the available spectrum according to time and CDMA according to spreading codes. OFDM can also be considered as multiple access technique such that individual carriers can be assigned to different users. OFDM can be combined with frequency hopping to create a spread spectrum system, realizing the benefits of frequency diversity and interference averaging of CDMA technique. The cyclic prefix called as a guard time makes the channel to behave as the transmitted waveforms were from time minus infinite which prevents one sub-carrier from interfering with another called Inter Carrier Interference (ICI).

DESIGNING OF OFDM SYSTEM:

QPSK MODULATION:

QPSK (Quadrature Phase Shift Keying) is type of phase shift keying. Unlike BPSK which is a DSBCS modulation scheme with digital information for the message, QPSK is also a DSBCS modulation scheme but it sends two bits of digital information a time (without the use of another carrier frequency). The amount of radio frequency spectrum required to transmit QPSK reliably is half that required for BPSK signals, which in turn makes room for more users on the channel. At the input of the modulator, the digital data’s even bits (i.e., bits 0,2,4 and so on) are stripped from the data stream by a “bit-splitter” and are multiplied with a carrier to generate a BPSK signal (called PSK). At the same time, the data’s odd bits (i.e., bits 1,3,5 and so on) are stripped from the data stream and are multiplied with the same carrier to generate a second BPSK signal (called PSK). However, the PSK signal’s carrier is phase shifted by 90° before being modulated.

FFT and IFFT

As shown in Figs 4 and 8, the IFFT and FFT are the most time consuming part of the base-band OFDM processing for transmitter and receiver, respectively. Note that the IFFT operation can be performed using the FFT operation depicted in Fig. 9. By swapping the real and imaginary parts of the input sequence and swapping the real and
imaginary parts of the output sequence, the FFT function is employed for the IFFT computation. Hence, if the OFDM transceiver is operated in time division multiplexing (TDM) mode, there is no additional hardware or software required for using the OFDM transmitter and receiver separately. In other words, one DSP should be able to handle both IFFT and FFT operations if its throughput is fast enough. Due to the simplicity, the radix-2, decimation-in-time FFT algorithm is chosen, implemented, and used for both IFFT and FFT operation at the transmitter and receiver, respectively. The “butterfly” is the smallest computational unit and implemented by assembly code.

Scale Up: In this method, we scale up the lower amplitudes of the signal by a factor of $\beta$. This leads to increase the average value without affecting the peak values. Therefore, the resulting PAPR reduces. The PAPR reduction function can be defined as

$$h(x) = \begin{cases} \alpha x, & \text{if } x > \alpha x \\ \beta x, & \text{if } x < A \\ x, & \text{if } A \leq x \leq \alpha x \end{cases}$$

where $x_p$ is the amplitude peak value occurring in an OFDM symbol block, $\alpha$ is the factor deciding the clipping threshold in terms of percentage of the peak value and $\beta$ is the scaling factor for the range $[0,A)$ whose value is greater than $s$. The values of the parameters used are mentioned at the end of this section.

Scale Down: In this method, we scale down the higher amplitudes of the signal by a factor of $\gamma$. This leads to decrease the peak value. Although the average value would also fall down, the resulting PAPR reduces. Because the reduction in peak power is greater than the reduction in the average power. The PAPR reduction function can be defined as

$$h(x) = \begin{cases} \alpha x, & \text{if } x > \alpha x \\ \gamma x, & \text{if } B \leq x \leq \alpha x \\ \beta x, & \text{if } x < A \\ x, & \text{if } A \leq x < B \end{cases}$$

where $x_p$ is the amplitude peak value occurring in an OFDM symbol block, $\alpha$ is the factor deciding the clipping threshold in terms of percentage of the peak value and $\gamma$ is the scaling factor for the range $[B,\alpha x]$ whose value is less than one.

Scale Up and Down: In this method, we combine both the above-mentioned approaches i.e. up-scaling and down-scaling. This method exploits the advantages of both the methods. Hence, a PAPR can be reduced considerably. The PAPR reduction function can be defined as

$$h(x) = \begin{cases} \alpha x, & \text{if } x > \alpha x \\ \gamma x, & \text{if } B \leq x \leq \alpha x \\ \beta x, & \text{if } x < A \\ x, & \text{if } A \leq x < B \end{cases}$$

where $x_p$ is the amplitude peak value occurring in an OFDM symbol block, $\alpha$ is the factor deciding the clipping threshold in terms of percentage of the peak value. $\beta$ is the scaling factor for the range $[0,A)$ and $\gamma$ is the scaling factor for the range $[B,\alpha x]$. 

QAM/PSK Demapping | P/S | FFT | S/P and Inverse PAPR Reduction Algorithm | A/D
In the SLM technique [5] the transmitter generates a set of sufficiently different candidate data blocks, all representing the same information as the original data block, and selects the most favourable for transmission. A block of the SLM technique is shown in Fig. 1. Each data block is multiplied by U different phase sequences, each of length N, \( B(u) = [bu,0 = 1, 2, \ldots, U, \) resulting in U modified data blocks. To include the unmodified data block in the set of modified data blocks, we set \( B(1) \) as the all-one vector of length N. Let us denote the modified data block for the \( u \) th phase sequence \( X(u) = [X0bu,0 T XN–1bu] \), \( u = 1, 2, \ldots, U \). After applying SLM to \( X \), the \( N–1 \) multicarrier signal becomes \( bu,1, \ldots, bu,N–1T] \), \( X1bu,1, \ldots, X(u) \),

\[
X^{(u)}(t) = \frac{1}{n} \sum Xn bu,n.e^{j2\pi ft}
\]

Among the modified data blocks \( X(u), \ u = 1, 2, \ldots, U \), the one with the lowest PAPR is selected for transmission. Information about the selected phase sequence should be transmitted to the receiver as side information. At the receiver the reverse operation is performed to recover the original data block. The SLM technique implementation needs U IDFT operations, and the number of required side information bits is \( \log_2U \) for each data block. This approach is applicable for all types of modulation with any number of subcarriers. The amount of PAPR reduction for SLM depends on the number of phase sequences U and the design of the phase sequences.

**AWGN channel characteristics:**
Additive white Gaussian noise (AWGN) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. In this channel model, an additive noise is included with modulator and demodulator as parts of the channel except that the demodulator output is left unquantized. Such a model is called a Discrete-Input Continuous-Output channel. Indeed, the discrete-time input symbols X take their values in a finite alphabet while channel output symbols Y can take any values along the real line. Such a channel is characterized by the conditional probability density function relating the real output value to all possible inputs.

**RESULTS:**
Comparison Table:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EXISTING METHOD</th>
<th>PROPOSED METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNR</td>
<td>12.125</td>
<td>31.953</td>
</tr>
<tr>
<td>PAPR</td>
<td>4.572</td>
<td>4.504</td>
</tr>
</tbody>
</table>

ADVANTAGES:

- Using adequate channel coding and interleaving one can recover symbols lost due to the frequency selectivity of the channel.
- Channel equalization becomes simpler than by using adaptive equalization techniques with single carrier systems.
- OFDM is computationally efficient by using FFT techniques to implement the modulation and demodulation functions.

APPLICATIONS:

The wireless LAN (WLAN) radio interfaces IEEE 802.11a, g, n and HIPERLAN/2. The digital radio systems DAB/EUREKA 147, DAB+, Digital Radio Mondiale, HD Radio, T-DMB and ISDB-TSB. The wireless personal area network (PAN) ultrawideband (UWB) IEEE 802.15.3a implementation suggested by WiMedia Alliance. The OFDM based multiple access technology OFDMA is also used in several 4G and pre-4G cellular networks and mobile broadband standards.

CONCLUSION: Finally, This project established an efficient and huge tremendous channel accessing communication in OFDM with less PAPR and reduced Bit Error Rate Probability. Using simulations, we obtained the values of threshold for clipping and parameters for scaling with a view to reduce PAPR without degradation in BER. We have presented the PAPR and BER performance for all the techniques considered. The proposed up-down scaling technique is able to achieve PAPR reduction of the order of 8.5 dB from 12 dB PAPR initially.

REFERENCES:

