

“Performance Analysis of PAPR and BER Using Hybrid Method in 5G Communications”

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Abstract: In the era of wireless communication, internet devices such as smart phones, hotspots, and Wi-Fi zone are important player of rapid growth of data usage. Internet connection devices are building new challenges for internet service providers such as higher bandwidth and indomitable increasing users day to day. The focus of 5G technology is to accomplish high data rate (10-12 Gbps). For this a huge bandwidth is needed. Since limited frequency resources are available, the frequency spectrum should be efficiently utilized to obtain high data rate. OFDM is used in 4G communication but it has the drawback of low spectral efficiency and high out of band radiation, which makes it a poor choice for 5G communication. In this thesis error correcting code trellis code is used for 5G communication. High PAPR is always a problem in multicarrier communication system. 5G is also a multicarrier communication system, so it also suffers from high PAPR problem. To reduce the PAPR several PAPR reduction techniques have been proposed over the last few decades. Clipping techniques give good result and it is used for reduction of PAPR in system. In this paper a combined scheme of error correcting code and clipping technique using compressive sensing are used, which gives significant performance improvement compared than other techniques. Simulation is performed to analyse the PAPR and BER performance of proposed system. All the simulations are performed in MATLAB.

Keywords: Trellis code, turbo code, error correcting code, PAPR, BER, OFDM

I. INTRODUCTION

Due to the ever-growing number of mobile devices, increased trend in the usage of applications, and more

data hungry applications, there is a constant need for increased data rates. To meet the required data rates, improving the currently used technologies to make them more efficient will just not be enough as the currently employed 4G has almost reached the theoretical limit on data rate [3]. New technologies need to be employed to meet the demands of the future and hence researchers have started investigating new 5G techniques. The 5G network ought to achieve 1000 times the system capacity, 10 times the spectral efficiency, energy efficiency and data rate, 25 times the average cell throughput, 10 to 100 times higher number of connected devices, and 5 times reduced end-to-end latency [3,4]. The goal is to connect anyone/anything and achieve seamless communication anywhere, at any time. The focus of our paper is on the new techniques of 5G that reuse the available microwave spectrum.

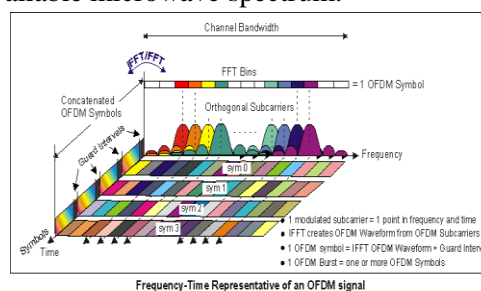


Figure 1 Frequency time representation of an ofdm signal

5G is based on Orthogonal Frequency Division Multiplexing (OFDM). Orthogonal frequency-division multiplexing (OFDM) is initially developed for use in cable television systems. OFDM is similar to the broadcasting technique known as frequency division multiplexing (also known as FDM), which uses a multitude of transmitters and receivers to send information on different frequencies over a single

wire, such as an electrical power cable. The objective of this paper is to focused on ofdm and error correcting coding in 5G communication systems, Study and analyze different PAPR reduction techniques which can be applied in 5G and Impelemented hybrid method to achieve good PAPR reduction techniques to improve PAPR performance of the system and better BER

II. OFDM (Orthogonal Frequency Division Multiplexing):

An OFDM signal consists of N sub carriers spaced by the frequency distance. thus,the total system bandwidthB is divided into Nequidistant sub channels. On each sub carrier, the symbol duration Ts = 1/ f is N times as large as in the case of a single carrier transmission system covering the same bandwidth.

Additionally, each sub carrier signal is extended by a guard interval–called cyclicprefix – with the length Tg.All subcarriers are mutually orthogonal within the symbol duration Ts.

$$\int_{-\infty}^{\infty} x_1(t)x_2(t)dt = 0 \dots\dots\dots(1)$$

For each sub carrier a rectangular pulse shapingisapplied. Theguardinterval orcyclic extensionisaddedtothe sub carriersignalinordertoavoidInter-Symbol Interference (ISI), which occurs in multipath channels. At each receiver the cyclic prefix is removed and only the time interval [0, Ts] is evaluated. The total OFDM block duration isT=Ts+Tg.Each subcarrier can be modulated independently.

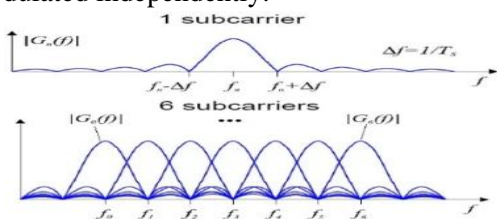
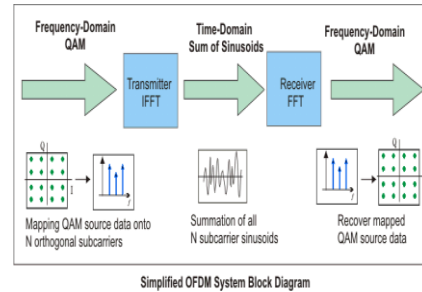


Figure2 OFDM subcarriers

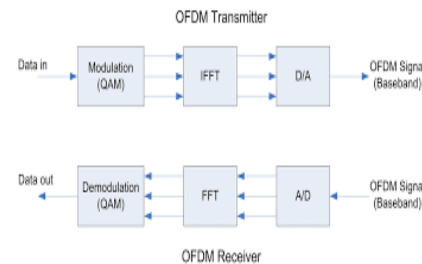
The spectra of the subcarriers overlap, but the subcarrier signals are mutually orthogonal, and the modulation symbol can be recovered by a simple correlation.In above figure we shown that spectrum with 1 subcarrier frequency and 6 sub carrier frequency

BASICS OF OFDM:The fundamental theory of OFDM is to split the available frequency band into

multiple subcarriers, each carrying a low data rate signal. The subcarriers are spaced at equal distances, and each subcarrier is orthogonal to the others. The orthogonality between the subcarriers ensures that they do not interfere with each other and allows for



Simplified OFDM System Block Diagram



OFDM Transmitter

OFDM Receiver

Figure 3 ofdm block diagram

Figure 4

OFDM Transmitter and receiver

efficient use of the available bandwidth. The data to be transmitted is modulated onto the subcarriers using a technique called inverse fast Fourier transform (IFFT). The IFFT transforms the data from the time domain to the frequency domain and maps it onto the subcarriers.At the receiver end, the subcarriers are demodulated using a fast Fourier transform (FFT). The FFT converts the received signal from the frequency domain to the time domain, where the data can be recovered.

III. CODING TECHNIQUES

Hamming Codes, Convolutional Encoding, and turbo code Trellis Coding are all error correction coding techniques that can be used in conjunction with OFDM (Orthogonal Frequency Division Multiplexing) to improve the reliability and performance of the communication system.

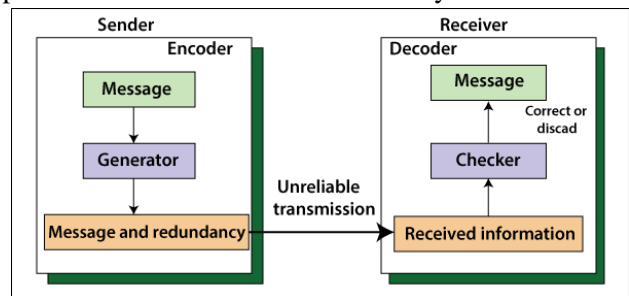


Figure 5 Error correction process

Turbo codes: Turbo codes were invented by C. Berrou, et al., in 1993. It has excited the coding community with the promise of performing near channel capacity by using an iterative decoding technique that relies just on simple constituent code. Because the interleaver, the code appears to be long and random, thus emulate the good performance of the random codes. Conventional turbo codes are parallel concatenated recursive systematic convolutional codes. Two convolutional encoders are connected by a large enough random-like interleaver, which is shown in figure 6 Turbo codes are error-correcting codes with performance close to the Shannon theoretical limit [SHA].

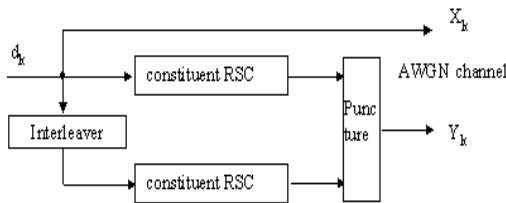


Figure 6 turbo code

Convolutional code: In telecommunication, a convolutional code is a type of error-correcting code that generates parity symbols via the sliding application of a boolean polynomial function to a data stream. Convolutional coding is a widely used coding method which is not based on blocks of bits but rather the output code bits are determined by logic operations on the present bit in a stream and a small number of previous bits. Convolutional codes have been widely used in wireless communications (WiFi, cellular, and satellite) and are constituents of the widely used Turbo coding. Unlike block codes, convolutional codes don't have a finite block length and instead may be considered as linear filters, either IIR or FIR. Another simple example of an FEC code is known as the Hamming code. This code is able to protect a four-bit information signal from a single error on the channel by adding three redundant bits to the signal.

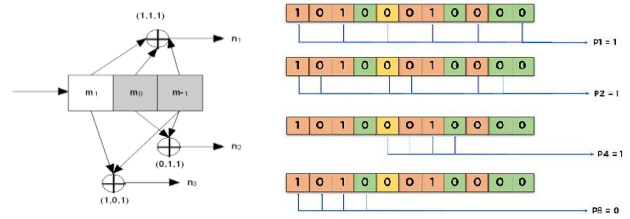


Figure 7 Hamming Code

Trellis Coding: In telecommunication, trellis modulation (also known as trellis coded modulation, or simply TCM) is a modulation scheme that transmits information with high efficiency over band-limited channels. The name trellis derives from the fact that a state diagram of the technique closely resembles a trellis lattice. This scheme is basically a convolutional code of rates $(r, r+1)$. Ungerboeck's unique contribution is to apply the parity check for each symbol, instead of the older technique of applying it to the bit stream then modulating the bits instead of the sequence of bits that is produced by a convolutional encoder, a trellis encoder produces a sequence of modulation symbols. At the transmitter, the channel-encoding process is coupled with the modulation process, producing a system known as trellis-coded modulation. At the receiver, decoding and demodulating are performed jointly in order to optimize the performance of the error-correcting algorithm.[11]

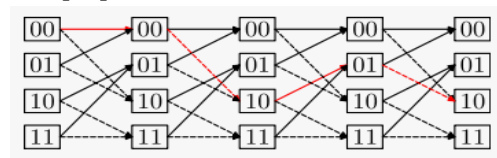


Figure 8 Trellis code

Constellation shaping is an energy efficiency enhancement scheme for digital signal modulation that improves upon the amplitude and phase-shift keying (APSK) and the conventional quadrature amplitude modulation (QAM)) modulation schemes by transmitting low-energy signals more frequently than high-energy ones.

IV. PROPOSED METHODOLOGY

OFDM signal with a large number of subcarriers following the analogue method presented before leads to a extremely complex architecture involving many oscillators and filters at both the transmit and receive ends. In present-day OFDM transmissions, though,

this complexity is reduced by transferring it from the analogue.

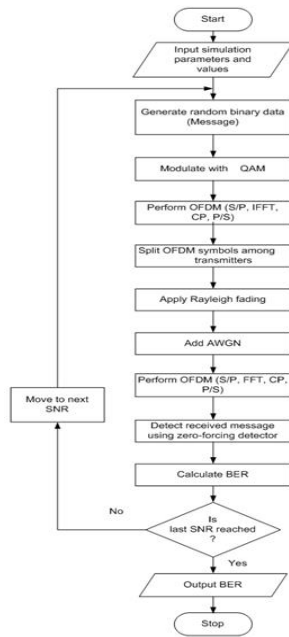


Figure 9 Flow chart of proposed method

to the digital domain. the chances are error is high so we use the error correction method at receiver end to minimize the error. we used error correcting code and amplitude clipping method to improve the performance of parameter papr and ber of system. This method limits the peak envelope of the input signal to a predetermined value or otherwise passes the input signal through a nonlinear subsystem

Effect of High PAPR

The linear power amplifiers are used in the transmitter side of any communication system. For linear power amplifier the operating point should be in the linear region of operation. Because of the high PAPR the operating point moves to the saturation region hence[8], the clipping of signal peaks occurs which generates in-band and out-of-band distortion. So we should increase the dynamic range of the power amplifier to keep the operating point in the linear region which reduces efficiency and enhances the cost of the power amplifier. Hence, a trade-off exists between nonlinearity and efficiency. so we should reduce PAPR value to improve the efficiency of the power amplifier.

V. PAPR REDUCTION TECHNIQUES AND CRITERIA FOR PAPR REDUCTION METHOD SELECTION

The criteria of the PAPR reduction is to find the approach that it can reduce PAPR largely and at the same time it can keep the good performance in terms of the capacity of capability of reducing value of papr without affecting other band frequency, average power value kept lower, to achieve good bandwidth with minimum complexity of circuit. also take care about the value of BER. There are so many techniques presents for the reduction of PAPR.

Clipping using CS and Filtering: We used clipping for PAPR reduction, but after clipping, we send subtraction of original data and clipped data, as extra data, so we prevent loss of BER but we reduce data rate. We use compressive sensing technique to reduce the size of extra data because the extra data are sparse. Compressive sensing is a new technique, where a signal which is sparse in a transform domain, can be approximated with little samples than usually required [1] This is one of the simplest techniques used for PAPR reduction. Clipping is a technique in which the amplitude of the input signal is limited to a predetermined value[9]. Let $x[n]$ represent input signal and $x_c[n]$ denote the clipped version of $x[n]$, which can be expressed as

$$x_c[n] = \begin{cases} -A & x[n] \leq -A \\ x[n] & |x[n]| < A \dots\dots\dots(2) \\ A & x[n] \geq A \end{cases}$$

Where A is the clipping level. However this technique has the following drawbacks:

- Clipping causes signal distortion, which results in degradation of Bit Error Rate performance.
- Out-of-band radiation also occurs in clipping, which is responsible for interference between adjacent channels. Filtering can be used to reduce this out-of-band radiation.
- Filtering of the clipped signal brings the peak regrowth. That means the signal level may exceed the clipping level after filtering operation because of the clipping operation. So we came to know that distortion occurs during the transmission of data in clipping and filtering technique.

Clipping involves simply cutting off the signal above a certain threshold, which reduces the peak power but

can introduce significant distortion. Filtering involves passing the signal through a filter that removes the high-power components, which again reduces PAPR but can cause some distortion in the signal. Partial transmit sequences (PTS) involve splitting the original signal into several sub-signals and then transmitting them with different weights. This technique can significantly reduce PAPR while minimizing distortion.

VI. SIMULATION AND RESULTS DISCUSSION:

MATLAB software’s communication toolbox is used to simulate proposed work. Communications Toolbox™ provides algorithms and apps for the design, end-to-end simulation, analysis, and verification of communications systems. The toolbox includes a graphically-based app that lets you generate custom- or standard-based waveforms. The OFDM technology we changed was designed by 512-QAM mapping for BER reduction and 1024-points FFT/IFFT blocks. At the sender side we generated data string with interleaving bits. [2,3] After this mapping is done and we insert the pilot carrier then convert IFFT transform of that data apply DFT SVD on that data. Similarly after the receiving the data reverse process can take place. For simulation of proposed method some parameter value have to be set. In our work we took carrier frequency 2 GHz with sampling frequency of 8 GHz. FFT 512 & 1024 bandwidth 1.5 GHz, Guard interval of 32 bit and clipping 0.8-1.2 with QAM modulation. In this section, we first present the simulated PAPR results for an OFDM transmitter with 1024 subcarriers using 512 QAM and 1024 QAM for the basic system and the coded system, respectively. For all simulations, a sequence of 50000 OFDM symbols is considered. Also, an oversampling factor of 8 is used. In order to show the effect of the constellation shaping, Estimated the complementary cumulative density function (CCDF) of PAPR given by the following expression: $CCDF(PAPR_0) = Pr(PAPR > PAPR_0)$

In our results it can be seen that as Signal-to-Noise Ratio increases the Bit Error Rate (BER) decreases. PAPR has also been reduced using the proposed DFT based selective mapping method.

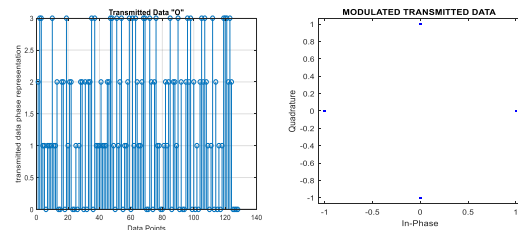


Figure 10(a) Transmitted Data representation and modulated signal

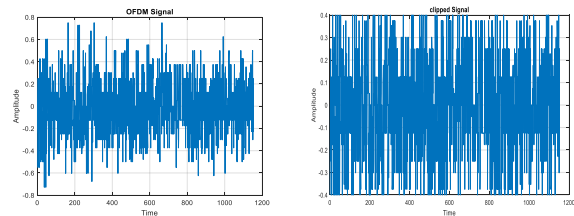


Figure 10(b) OFDM Signal and clipped signal with cs

The curve denoted by the line is drawn for the OFDM signal using the regular 512 QAM constellation without shaping. This curve with line corresponds to the OFDM signal. This is a 1024 QAM signal using the constellation shaping with 6 rings for one transmit antenna. The continuous line corresponds to the OFDM signal using the constellation shaping, which represents a modified 1024 QAM constellation shaping with 36 super-rings for two transmit antennas. The results presented in Figure prove that the 1024 QAM signal using the constellation shaping with six rings provides, for a CCDF less than 10^{-3} , a shaping gain of more than 0.5 dB over the reference 512 QAM signal without constellation shaping. To conclude the discussion about the PAPR simulated results, we can say that the newly proposed constellation shaping algorithm with 36 super-rings performs almost the same as the algorithm for six rings

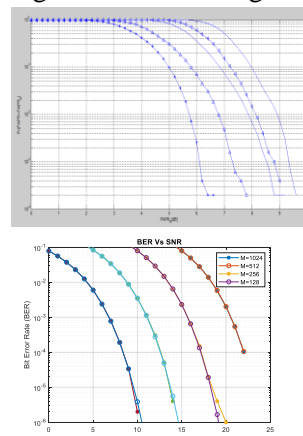


Figure 11(a) PAPR Graph for 512/1024 (b) BER Graph for 256

Figure 11

QAM OFDM Base Vs Proposed
OFDM Base Vs Proposed

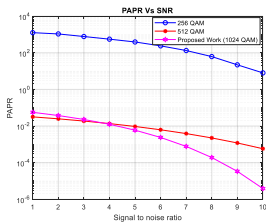


Figure 12 BER Graph for Proposed Work Clipped with cs OFDM for 1024

The OFDM block includes 64 bits. In the 1024 QAM OFDM SVD system with shell mapping, the first 32 bits select the shell using the algorithm that select the 1024 QAM indexes,. Next, the selected sixteen 1024 QAM symbols are transmitted using the space frequency OFDM scheme. The BER performances for the 1024 QAM-OFDM SVD system

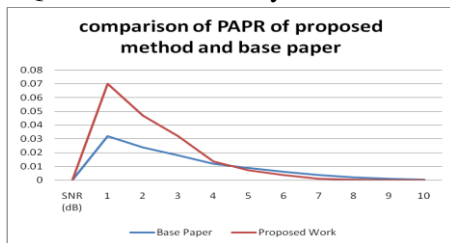


Figure 14 comparison of PAPR (proposed work and previous work)

with shell mapping and its corresponding 512 QAM reference system, both presenting a spectral efficiency of 4 b/s/Hz per subcarrier, As functions of the average SNR. Hence, the 1024 QAM-OFDM trellis-coded system with shell mapping out performs the reference system for high SNR values[4]. The of proposed work is 4-5 dB, BER value of 10⁻⁴, clipping is performed for the sufficiently-oversampled OFDM signals in the discrete-time domain before a low-pass filter (LPF) and the signal passes through a band-pass filter (BPF), the BER performance will be less degraded. Here the PAPR of 0.000038 is obtained for SNR of 10 db for simulated results verifies the proposed technique is better as compared to previous works.

VII. CONCLUSION:

In this paper, we proposed a PAPR reduction technique based on error correcting code and clipping technique with compressive sensing that improves the BER performance of the hard clipping PAPR reduction technique. We see that with using clipping

with CS, obtain better results for PAPR reduction. In future the process can be followed by increasing the OFDM subcarriers. One of the biggest demerits of OFDM PAPR can be Improved. For the future works, it is suggested to develop other modules such as interleaving, or QPSK modulation with 5G mobile communications system.

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