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PAPR Reduction In DVB Based MIMO OFDM System Using Various Coding Techniques

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Abstract*: The capability of handling very strong echoes, robustness to channel fading, immunity to impulse interference, and lesser nonlinear distortion makes MIMO–OFDM one of the promising technique for the fourth-generation mobile communications. However, one of the main disadvantage associated with MIMO-OFDM is the high peak-to-average power ratio (PAPR) of the transmitter's output signal on different antennas. High Peak to Average Power Ratio (PAPR) for MIMO-OFDM system is still a demanding area and difficult issue. The occurrences of high peaks in the transmitted OFDM signal cases the degradation of the system performance due to various non-linear effects like spectral spreading, intermodulation, and signal constellation that exist inherently in power amplifiers. In this paper, various coding techniques like SQRT, DCT are used to obtain a significant reduction in PAPR. The results obtained are plotted in forms of graphs and are compared with earlier results of transform techniques. Simulations show that better results are obtained in the proposed technique.

I. Introduction

MIMO system basically employs multiple antennas in the transmitter and/or receiver, the correlation between transmit and receive antenna is an important aspect of the MIMO channel. It depends on the angle-of-arrival (AoA) of each multi-path component. Multiple Input Multiple Output (MIMO) one of the several forms of smart antenna technology are the antenna arrays with smart signal processing algorithms are used to identify spatial signal signature such as the direction of arrival (DOA) of the signal, and use it to calculate beam-forming vectors, to track and locate the antenna on the mobile/target. MIMO technology has attracted attention in wireless communication, because it offers significant data throughput and link range without additional bandwidth or increased transmit power. In order to implement MIMO, either the station (mobile device) or the access point (AP) needs to support MIMO. For optimal performance and range, both the station and AP must support MIMO.A MIMO access point (AP) sends multiple spatial streams from its antennas to MIMO station that receives the signals through its multiple antennas. All wireless products with 802.11n support MIMO, which is part of technology that allows 802.11n to reach much higher speeds than products without 802. 11n.MIMO makes antennas work smarter by enabling them to combine data streams arriving from different paths and at different times to effectively increase receiver signal-capturing power. MIMO uses spatial diversity technology, which puts surplus antennas to good use. When there are more antennas than spatial streams, the antennas can add receiver diversity and increase range. By increasing the number of antennas on each side that can transmit or receive a spatial stream, the maximum rate increases. The best scenario is to have three transmit antennas and three receive antennas using 40 MHz channel bonding at 5GHz. With this set-up the maximum theoretical speed is 450 Mbps. OFDM can be used in conjunction with a Multiple-Input Multiple-Output (MIMO) trans-receiver to increase the diversity gain and/or the system capacity by exploiting spatial domain. Because the OFDM system effectively provides numerous parallel narrowband channels, MIMO-OFDM is considered a key technology in emerging high-data rate systems such as 4G, IEEE 802.16, and IEEE 802.11n. In MIMO-OFDM system, a number of antennas are placed at the transmitting and receiving ends and the distances are placed far enough. The idea is to use spatial multiplexing and data pipes by developing space dimensions which are created by multi transmitting and receiving antennas. The transmitted signal bandwidth is so narrow that its frequency response can be assumed as being flat The main advantage of using MIMO-OFDM system include high power spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, capability of handling very strong echoes, lesser nonlinear distortion and use of small guard intervals. It increases system spectral efficiency by adopting the frequency reuse concept. This paper investigates one of the bottleneck.

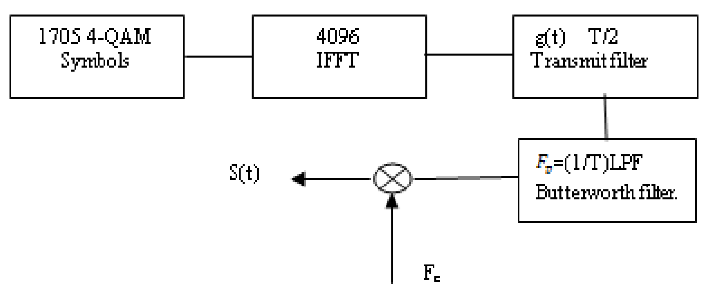

Figure 1. OFDM Transmission

problems that exist in OFDM wireless communication system i.e. High Peak-Average Power Ratio (PAPR of OFDM signal), and a new technique have been proposed to reduce it. In this paper OFDM signal is generated using DVB parameters, then PAPR of that signal is calculated using probability distribution function CCDF and then various coding techniques (SQRT, DCT, Combination of SQRT and DCT) in combination with OSTBC Encoder to obtain a significant PAPR reduction.

II. Proposed block diagram for OFDM Transmission

The first task to consider is that the OFDM spectrum is centered on f_c, subcarrier is 7.612 MHz to the left of the carrier and subcarrier 1,705 is 7.612 MHz to the right. One simple way to achieve the centering is to use a 2N-IFFT and T/2 as the elementary period. As we can see in parameters of simulation, the OFDM symbol duration, TU, is specified considering a 2,048-IFFT (N=2,048), therefore, we shall use a 4,096-IFFT. A block diagram of the generation of one OFDM symbol is shown in Figure 1 where we have indicated the variables used in the Matlab code. The next task to consider is the appropriate simulation period. T is defined as the elementary period for a baseband signal, but since we are simulating a passband signal, we have to relate it to a time-period, 1/Rs, that considers at least twice the carrier frequency. For simplicity, we use an integer relation, Rs=40/T. This relation gives a carrier frequency close to 90 MHz, which is in the range of a VHF channel five, a common TV channel in any city.

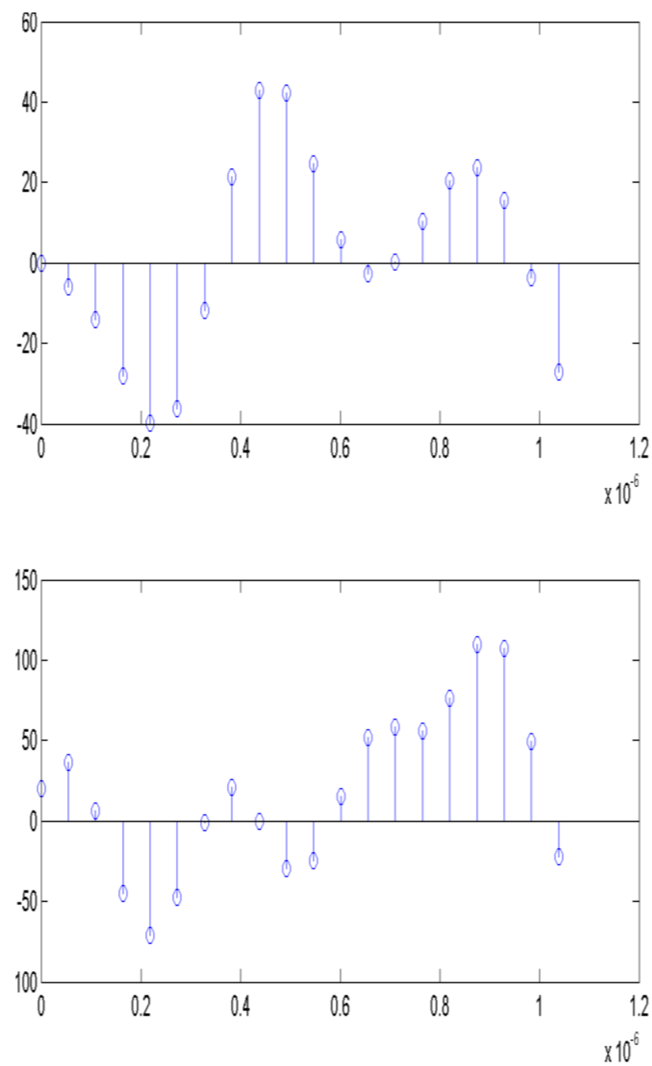

Figure 2. Time response of signal carriers after IFFT operation

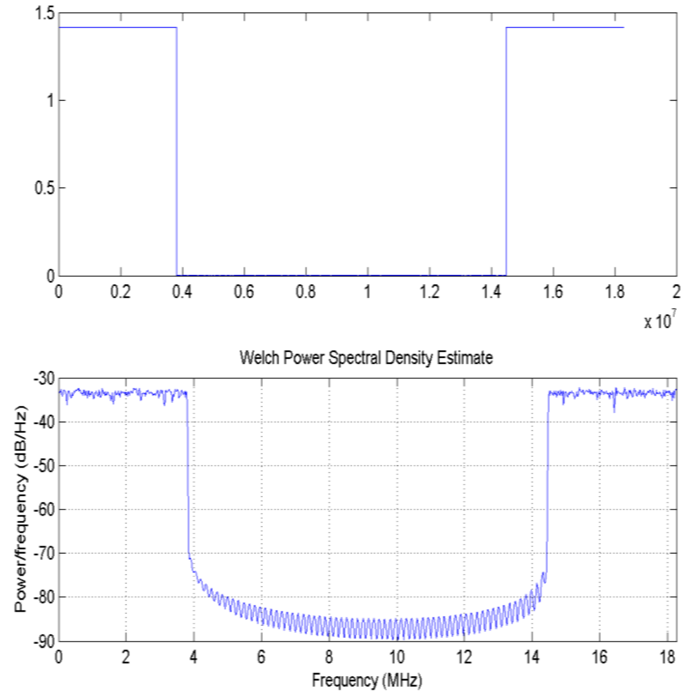

Figure 3. Frequency response of signal carriers

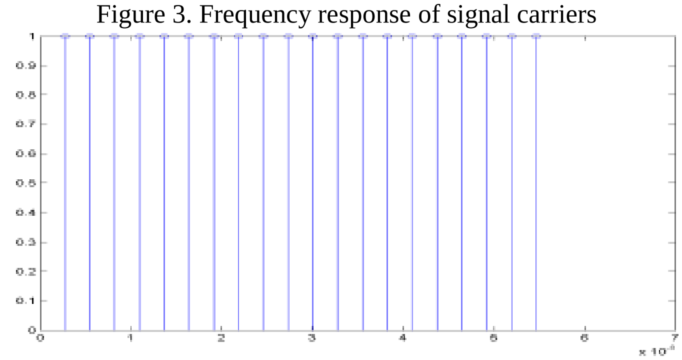

Figure 4. Pulse shape g(t)

The output of this transmit filter is shown in Figure 5 in the time-domain and in Figure 6 in the frequency-domain. The frequency response of Figure6 is periodic as required of the frequency response of a discrete-time system , and the bandwidth of the spectrum shown in this figure is given by Rs. U(t).s period is2/T, and we have (2/T=18.286)-7.61=10.675 MHz of transition bandwidth for the reconstruction filter. If we were to use an N-IFFT, we would only have (1/T=9.143)-7.61=1.533 MHz of transition bandwidth; therefore, we would require a very sharp roll-off, hence high complexity, in the reconstruction filter to avoid aliasing. The proposed reconstruction or D/A filter response is shown in Figure7. It is a Butterworth filter of order 13 and cut-off frequency of approximately 1/T. The filters output is shown in Figure 8 and Figure9. The first thing to notice is the delay of approximately 2x10-7 produced by the filtering process. Aside of this delay, the filtering performs as expected since we are left with only the baseband spectrum. We must recall that subcarriers 853 to 1,705 are located at the right of 0 Hz, and subcarriers 1 to 852 are to the left of 4 *c f* Hz.

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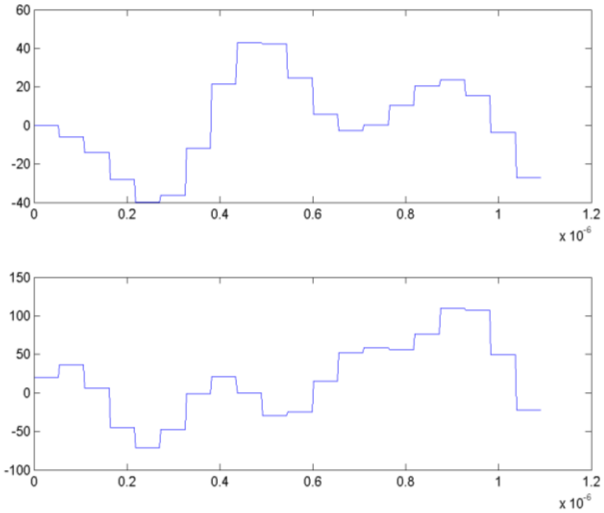

Figure5: Output of Transmit Filter in time domain

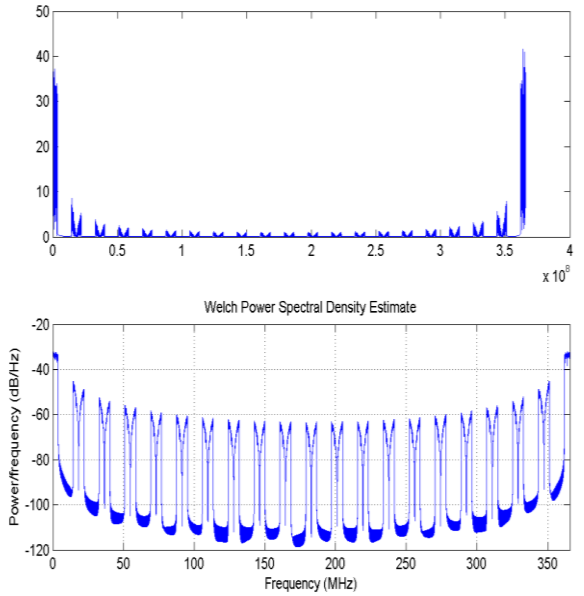

Figure 6:Output of transmit filter in Frequency domain

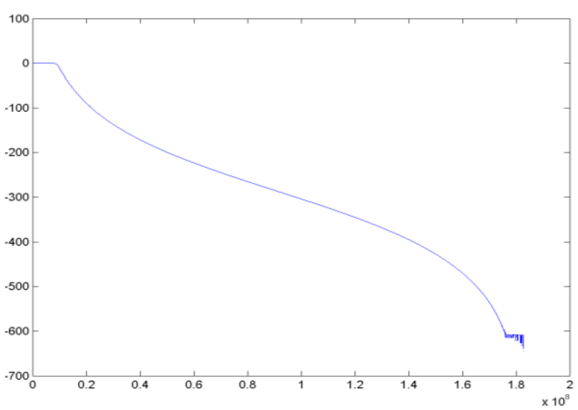

Figure 7: Response of Butterworth Filter

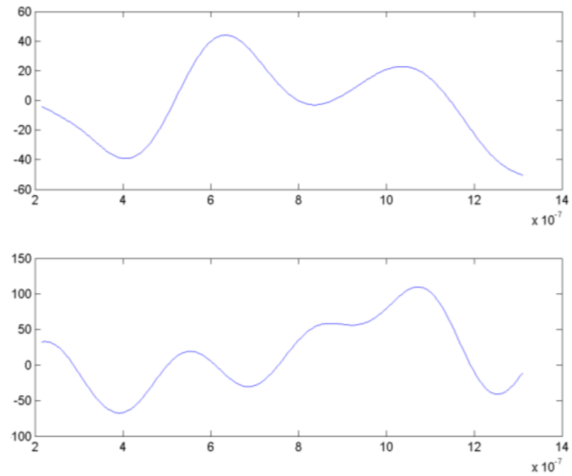

Figure8: Output of Butterworth Filter in time domain.

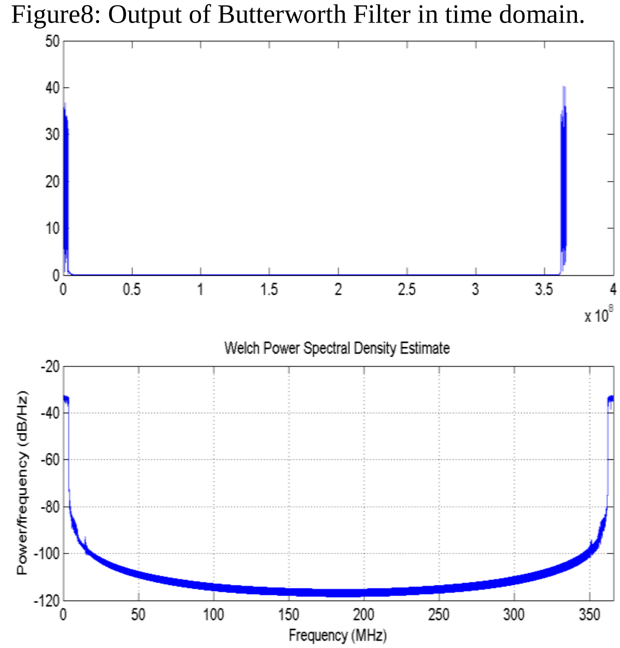

Figure9. Output of Butterworth filter in frequency domain

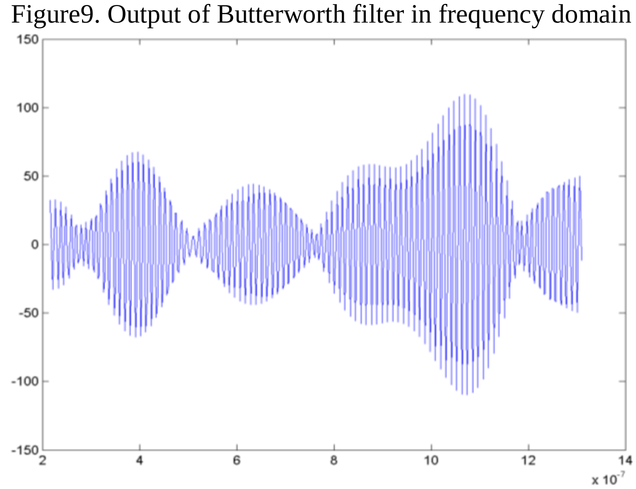

Figure10. OFDM signal

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III. **Proposed Methodology**

The proposed work is based on the Monte- Carlo simulation study carried out carried out MIMO-OFDM system using keying and coding. In case of keying algorithm technique 64 sub-carriers are chosen and oversampling factor of 8 is used. Various PSK constellation and QAM constellation symbols are selected. OFDM symbols are generated in the frequency domain as an array of 0's and 1's.The IFFT of generated signal is passed through the OSTBC Encoder having variable number of transmit antennas and different M-ary phase number are defined (M=2, 4, 8, 16 in case of PSK constellation and M=16, 32, 64, 128, 256 in case of QAM constellation symbols). A novel SLM algorithm is applied and the signal's corresponding PAPR empirical cumulative distribution function (ECDF) is calculated for each M-ary route number. The signal's complementary cumulative distribution function (CCDF) for different PAPR values is plotted in terms of graphs. In case of coding algorithm DCT and SQRT technique are applied to reduce the PAPR. The SQRT technique provides sufficient reduction in peak, hence maintaining good autocorrelation. DCT transform spreads the signal, thereby reducing the peak. The hybrid technique i.e. the combination of two techniques that is SQRT and DCT further helps in the reduction of PAPR and gives us the best possible result.

IV. Results & Discussions

Case 1. PAPR reduction for keying algorithm technique.

In this case Sixty-four carriers have been used and oversampling factor is eight. The specifications in this work have been made as per International Telecommunication Union (ITU). The graphs are plotted between CCDF and $PAPR_0$ (db). The simulation result for PSK constellation symbols using conventional SLM technique has been shown in figure11. With CCDF (Pr [$PAPR>PAPR_0$]) equal to max (i.e. 1), it can be shown that PAPR decreases with increasing values of M .For M=16 PAPR reduces to 7db as compared to original signal of 10.75db, thus there is a reduction of 3.75 db, for M=2 PAPR reduces to 9.2db, for M=4 PAPR reduces to 8db, and for M=8 PAPR reduces to 7.6 db.

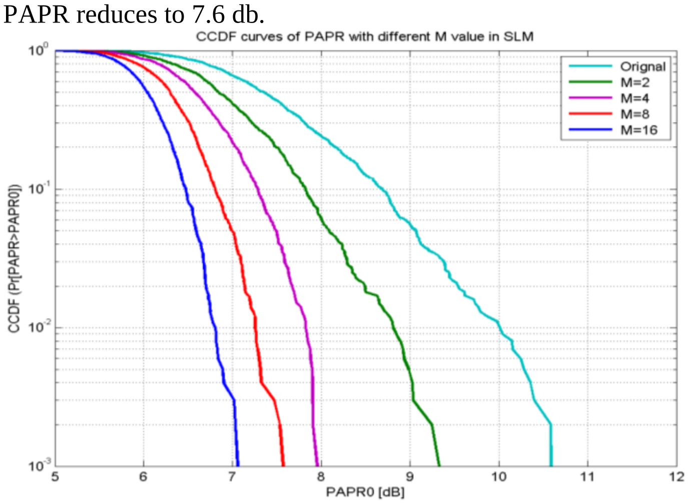

Figure 11.Plot for PSK constellations using conventional SLM

Figure 12 shows the CCDF curves of PAPR for different QAM modulations. Again it can be seen that PAPR reduces with the increasing values of M. For M=256 PAPR is minimum. The original signal is having a PAPR of 11.9 db. For M=16 PAPR reduces to 7db, for M=32 PAPR reduces to 6.7db, for M=64 PAPR reduces to 6.6 db, for M=128 PAPR reduces to 6.1 db and for M=256 PAPR reduces to 5.9 db.

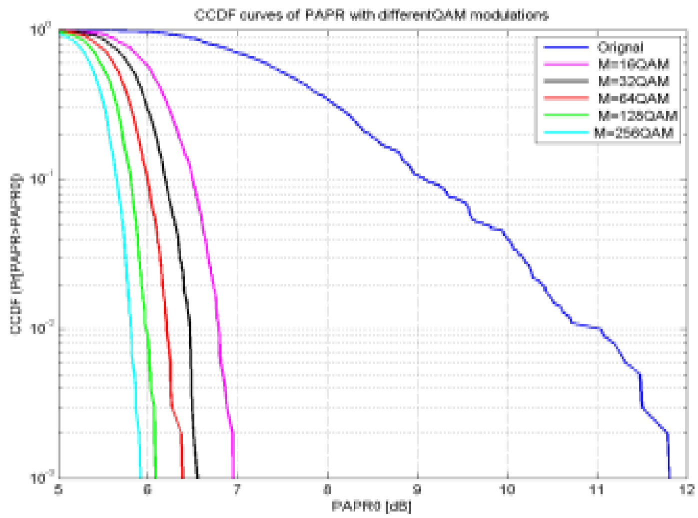

Figure 12. Plot for QAM constellations using conventional SLM

Case 2. PAPR reduction using various coding techniques.

In this case DVB-2k based MIMO-OFDM signal is generated using DVB parameters. The specifications used in our work are shown in Table 1.

Table1. Parameters of Simulation

Useful OFDM symbol period ,Tu	224e-6
Baseband elementary period T	Tu/2048
Allowed Guard Interval G	1/4, 1/8, 1/16, and 1/32
Guard band duration delta	G*Tu
Total OFDM symbol period	Ts=delta+Tu
Number of subcarriers Kmax	1705
Kmin	0
IFFT/FFT length, FS	4096
Carrier period to elementary period ratio q	10
carrier frequency, fc	q*1/T

The MIMO-OFDM signal generated after using the parameters shown in the table1 is passed through the OSTBC Encoder The encoder encodes the information symbols from the QAM Modulator by using complex orthogonal codes for two, three, and four transmit antennas. The number of transmit antenna is given to this block as an input. The basic idea to use DCT transform in MIMO-OFDM is to reduce the autocorrelation of the input sequence to reduce the peak to average power problem and it requires no side information to be transmitted to the receiver. The out-put of the OSTBC Encoder is combined with DCT matrix. The DCT matrix spreads the signal thereby reducing the peak. The proposed hybrid technique i.e., the combination of DCT and Square root reduces the PAPR significantly. The probability set is chosen between 0 and 100. Figure 13 shows the simulation result when number of transmitting antennas are changed to 2.

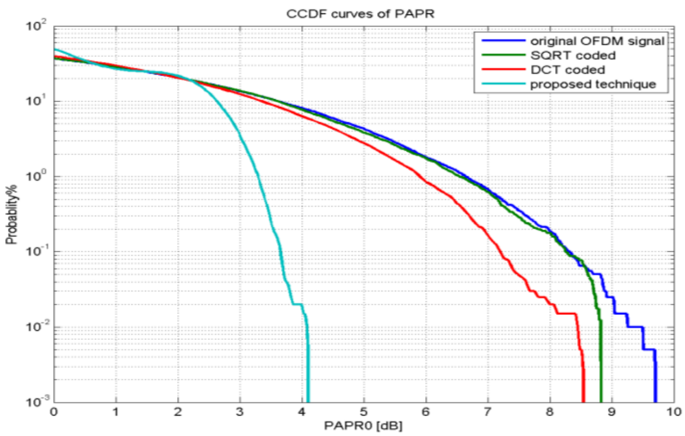

Figure 13. Plot for proposed techniques with numTx=2

The original signal is having a PAPR of 9.8db, with the implementation of square root technique the PAPR reduces to 8.9db.The DCT transform reduces the PAPR to 8.77,and the proposed technique i.e., DCT+SQRT reduces the PAPR to 4.1 db ,thus there is the reduction of 5.9 db.

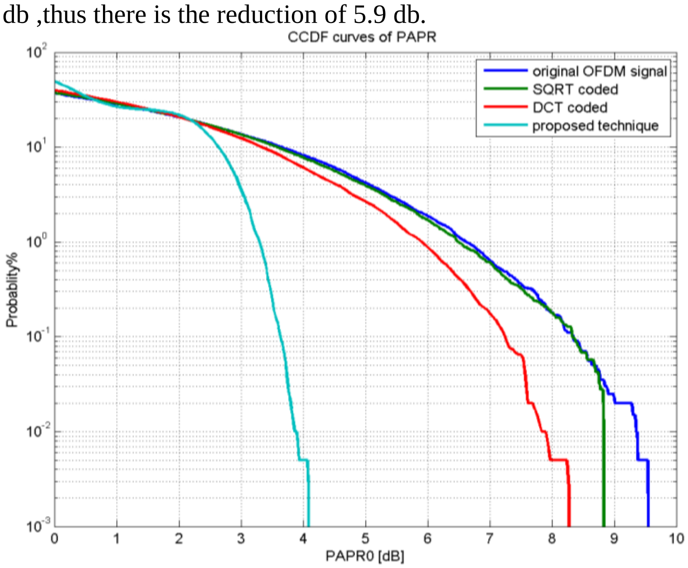

Figure 14. Plot for proposed techniques with numTx=3

Figure 14. shows the simulation result when number of transmit antennas are changed to 3. The original signal is having a PAPR of 9.7 db, SQRT technique reduces the PAPR to 8.9db.DCT technique reduces the PAPR to 8.15db and the proposed technique reduces the PAPR to 4 db, thus there is a reduction of 5.7 db as compared to original signal.

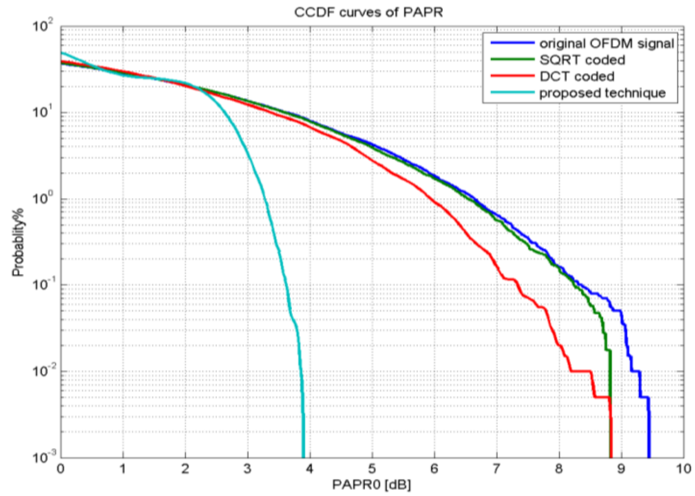

Figure 15. Plot for proposed techniques with numTx=4

Figure 15. shows the simulation result when number of transmit antennas are changed to 4.The original signal is having a PAPR of 9.5 db, SQRT technique and DCT technique reduces the PAPR to 8.9db and the proposed technique reduces the PAPR to 3.9 db, thus there is a reduction of 5.6 db as compared to original signal.

V. CONCLUSION

The above mentioned analysis represents a conservative estimate of PAPR reduction in MIMO- OFDM systems using hybrid techniques. The PAPR is one of the major drawbacks of multi-carrier communications. Various techniques have been proposed to reduce the PAPR in multi-carrier communication systems. From the simulation results it has been observed that hybrid techniques of square root and discrete cosine transform outperforms the other conventional techniques. The proposed techniques have a lot of scope in 4G LTE communications particularly in downlink.

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