PAPR Reduction with Wavelet Transform and Different PAPR Reduction Tecniques in MIMO-OFDM Systems

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Abstract

A new technique which is Wavelet transform based, is investigated in order to decrase the major drawback of MIMO-OFDM systems (Multiple Input-Multiple Output-Ortogonal Frequency Division Multiplexing) is the high peak-to-average-power ratio (PAPR).SLM (Selective Mapping) and PTS (Partial Transmiting Sequence) tecniques are applied in order to decrase PAPR in MIMO-OFDM systems. SLM and PTS tecniques are transmitted most powerful signal.In this study, SLM and PTS techniques are used that assures reduction on PAPR . In the system, Wavelet transform is used instead of Fourier transform and a new tecnique is proposed to reduce PAPR at a rate of 20 percent

Keywords: MIMO (Multiple input-multiple output), OFDM (Ortogonal frequency division multiplexing), SLM(selective mapping), PTS(partial transmitting sequence), PAPR(peak-to average-power ratio), WT(Wavelet transform).

1.Introductıon

Wireless communication systems need high data rate, secure communication and band width efficiency. In order to corresppond these needs, OFDM systems is a suggested techniques in the frequency selective fading bands[1].

OFDM systems has advantages such as high rate transmission rate band width gain. Moreover, OFDM system ensures countless paralel narrow bands and it could be used with MIMO systems so that transmitted data rate, diversity earning and system capasity are raised[2,3].

In this study, MIMO-OFDM systems are assesed as the key technology for high data rate communication and it could be used in DSL, IEEE802.11, IEEE802.16 and IEEE 802.15.3a and 4G technology and satelitte link[4].

There are also disadvantages of MIMO-OFDM systems. The most important disadvantages of these systems is PAPR and many solutions are suggested in order to solve[5-7].

These techniques could be categorited into two subcategories. In the first category, clipping and peak windowing are listed. For example, clipping technique is the most basic tecnique to reduce PAPR. But, this tecnique corrupts the sign because of propagation and interference[8].

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In the second category, interference techniques are listed. Among these tecniques, using block coding technique PAPR and data rate reduce[9], but signal energy increases. In this study, PAPR reduce tecniques and SLM[10], and PTS [17,19] are applied on MIMO-OFDM system. In order to reduce PAPR, simulation studies are conducted by DWT blocks are added instead of FFT blocks into the MIMO-OFDM system.

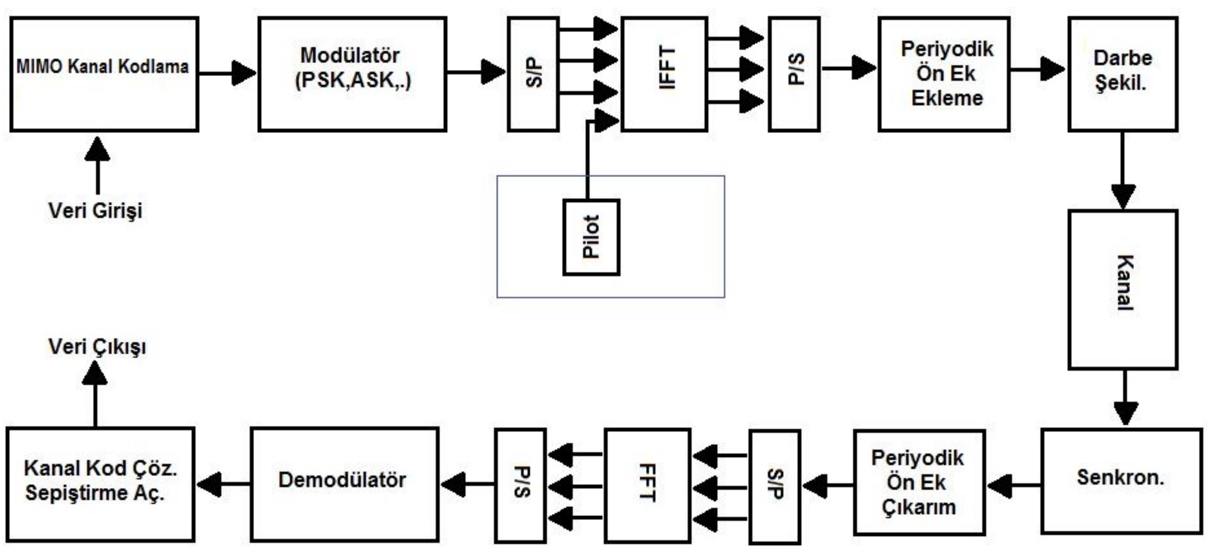
This study explores the results of the manipulation of the number of subblock and the number of sub-carrier ,which are important in SLM techniques and for the two parameters, %20 reduce of PAPR value is obtained.

Moreover, %20 reduce of the number of subblock and different phase values in the PTS tecnique are obtained.

2. Mımo-Ofdm Systems And Papr

Mostly used MIMO-OFDM systems are the systems combination of MIMO and OFDM, which is modulation of multiplxing.MIMO structure of this system has an advantages that is obtained by discrimination of spatıal satellites in multiple propagation enviroment. MIMO systems occurs in both transmıtter and receiver side of satellite sequences.Bunun amacı işaretlerin düzgün iletilip karşı taraftan alınmasında birçok alıcı tarafından algılanması önerisine dayanmaktadır

This is based on the regular symbols are which detected by many receiver [13,14].MIMO system is a significant technique that overcomes diversity gain and sembol fadings. Combining this tecnique and OFDM modulation system, performance is tried to increase with the system shown in Graph1.



Şekil 1. MIMO-OFDM Blok Diyagramı

Denoting the signs that will be transmit in the OFDM system, In the data block with the length N, k subcarrier data block is established as [2]:
Corresponding all sub-carriers.

$$X_k = (X_0, X_1, \dots \dots, X_{N-1}) \quad (1)$$

All X_k modulate in frequency range of the subcarrier $f_k(k = 0, \dots\dots, N-1)$, if $f_k = k\Delta f$ then N sub data blocks are ortogonal. Here, $f_k = \frac{1}{T}$ .. and T is the period of OFDM[11].

Complex base band OFDM sign x(t) is denoted :

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi f_k t}, \ t\epsilon[0,T] \quad (2)$$

X complex symbols are transmitted x=[x_0, $x_{1,\dots\dots\dots,}$ x_{N-1}].

$$x = IDFT(X) \quad (3)$$

All sub-carriers of these transmitted signs are statictical independent so that sign samples complex gaussian distribution and high amplitude in the time dimension[11].

High amplitude value in the OFDM systems creates a disadvantege PAPR value in x(t) symbol of OFDM system.

$$PAPR\{x(t)\} = \frac{max|x(t)|^2}{E\{|x(t)^2|\}} \quad (4)$$

E[.] is a expectation operation. If PAPR is denoted as distributed time

$$x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi\frac{kn}{NL}}, \quad n=0,\dots, N-1 \quad (5)$$

Here, L is oversampling factor. İf Q_L is an IDFT matrix with NL dimension and L scale, equation (3) can be written as:

$$x = Q_L(X) \quad (6)$$

In this situation, PAPR can be written as:

$$PAPR\{x\} = \frac{\max_{0\le k\le N-1}|x(t)|^2}{E\{|x_k|^2\}} \quad (7)$$

Since PAPR can have random variable value, it can be denoted as complementary cumulatif distribution function:CCDF

When CCDF, $PAPR_0$ threshold is exceed, PAPR value of OFDM sign can be expressed as:

$$CCDF(PAPR(x(n)))=Pr(PAPR(x(n)))>PAPR_0 \quad (8)$$

Depending to the independent N data block, SISO OFDM in the sign PAPR CCDF can be denoted as the following:

$$P = P_r\big(PAPR\big(x(n)\big) > PAPR_0\big) = 1 - (1 - e^{-PAPR_0})^N \quad (9)$$

If this equation is composed for MIMO-OFDM system, PAPR value on the i.th transmitted satelitte , PAPRi is :

$$P_r(PAPR_{MIMO-OFDM} > PAPR_0) = 1 - (1 - e^{-PAPR_0})^{M_t N} \quad (10)$$

şeklindedir. Burada M_tN.

Here, M_tN is the number of the samples on time plane (platform). With the literature support, looking at the PAPR values of SISO-OFDM and MIMO-OFDM systems, MIMO-OFDM systems has better performance[11].

3. Papr Reductıon Tecnıques

3.1. Selective Mapping (SLM) and Partial Transmiting Sequence (PTS) Tecnıques:

In this study there are many tecniques are used to reduce PAPR for PAPR reduction in MIMO-OFDM systems.

These are clipping, coding, selective mapping(SLM) ,partial transmitting sequence (PTS) e.t.

This study SLM and PTS are used for PAPR reduction in MIMO-OFDM.

In the SLM[12, 16] technique, 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 favorable for transmission [14,15].

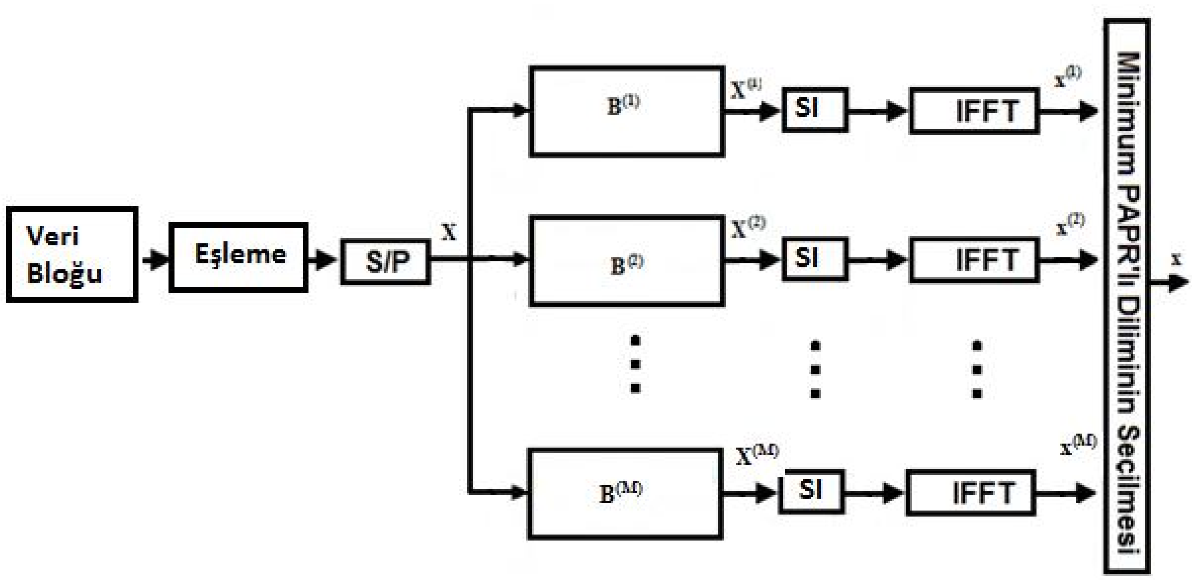


Figure 2. SLM Tecnigue Block Dıagram

A block diagram of the SLM technique is shown in Fig. 2. Each data block is multiplied by *U*different phase sequences, each of length *N*,

$$B^{(m)} = [b_{m,0}, b_{m,1}, \dots, b_{m,N-1}] \text{ ,m=1,2,…,M} \quad (11)$$

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*[16].. Let us denote the modified data block for the *u*th phase sequence is $X^{(m)}_k = [X_0 b_{m,0}, \dots, X_{N-1} b_{m,N-1}]$, m=1,2,…,M

After applying SLM to X, the multicarrier signal becomes ;

$$x^{(m)}(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k\, b_{m,k} e^{j2\pi k \Delta f_k t}, \ 0 \le t \le NT \quad (12)$$

Among the modified data blocks $\mathbf{X}(u)$, $u = 1, 2,\dots, U$, 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. For implementation, the SLM technique needs U IDFT operations, and the number of required side information bits is $\log_2 M$ for each data block. This approach is applicable with all types of modulation and 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. In [32] an SLM technique without explicit side information is proposed.

PTS tecnique [17,19] ,is proposed by S.H.Müller and J.B.Huber [18,20]. In the PTS technique, an input data block of N symbols is partitioned into disjoint subblocks.The subcarriers in each subblock are weightedby a phase factor for that subblock. The phasefactors are selected such that the PAPR of thecombined signal is minimized. Figure 3 showsthe block diagram of the PTS technique. In theordinary PTS technique [24, 25] input datablock X is partitioned into M disjoint subblocks

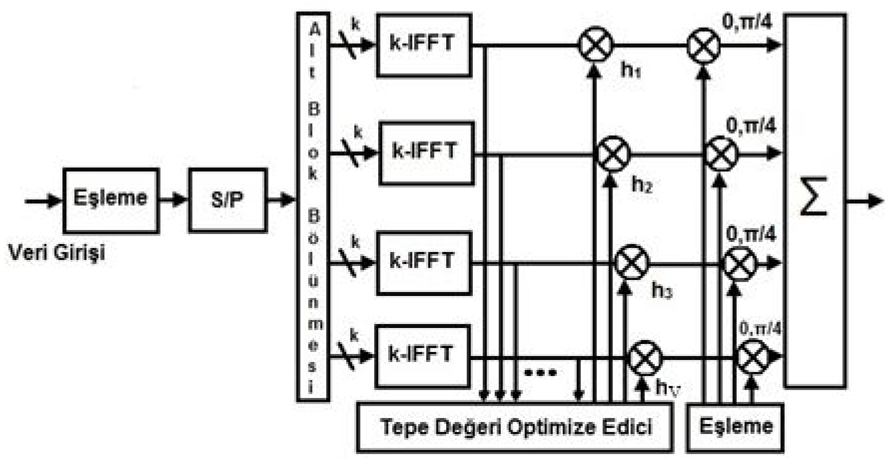


Figure 3. PTS Tecnique Block Diagram

$$Xv = [X_{v,0}, X_{v,1}, \dots, X_{v,N-1}] \quad v = 1,2,\dots,V \tag{13}$$

$$\sum_{v=1}^{V} X_v = X \tag{14}$$

The L-times oversampled time domain signal of $\mathbf{X}m$,v = 1, 2, …, V

$$x_v = [x_{v,0}, x_{v,1}, \dots, x_{v,NL-1}]^T.\ x_v \quad , \quad v = 1,2,\dots,V \tag{15}$$

This is obtained by taking an IDFT of length NL on $\mathbf{X}_m$ concatenated with $(L – 1)N$ zeros. These are called the partial transmit sequences. Complex phase factors;

$$b_v = e^{j\emptyset v}, \quad v = 1,2,\dots,V \tag{16}$$

b_v is introduced to combine the PTSs. The set of phase factors is denoted as a vector ;

$$b = [b_1, b_2, \dots, b_V]^T \quad (17)$$

The time domain signal after combining is given by;

$$x'(b) = \sum_{v=1}^{V} b_v . x_v \quad (18)$$

Where; $x'(b) = [x_0'(b),\ x_1'(b), \dots, x_{NL-1}'(b)]$ dir.

The objective is to find the set of phase factors that minimizes the PAPR. Minimization of PAPR is related to the minimization of

$$max_{0\le k\le NL-1} \left| \ x'(b) \right| \quad | \quad (19)$$

In general, the selection of the phase factors is limited to a set with a finite number of elements to reduce the search complexity. The set of allowed phase factors is written as

$$P = \{ e^{j2\pi l/W} | l = 0,1, \dots, W-1 \} \quad (20)$$

where W is the number of allowed phase factors. In addition, we can set $b1= 1$ without any loss of performance. So, we

should perform an exhaustive search for (M – 1) phase factors. Hence, WM–1 sets of phase factorsare searched to find the optimum set of phasefactors. The search complexity increases exponentiallywith the number of subblocks M. PTS needs M IDFT operations for each data block, and the number of required side information bits is $\log_2 W^{m-1}$, where [y] denotes the smallest integer that does not exceed y. The amount of PAPR reduction depends on the number of subblocks M and the number of allowed phase factors$W$. This study is used this parameters.

4. Wavelet Transform (Wt)

In this study, WT is preferred to use instead of FFT block. The reason is that FFT block has results only on the frequency platform for incoming signs, however, DWT has result fort he sign as well as fort he frequency platform. . In more resolutıon analysis of WT, h[m] and g[m] factors enable representing wavelet and scaling functions. H[m] is related with wavelet function, gm is related with scaling functions. While signs obtain on the receiver side, these filters are used. So, WT can be easily applied using discrete time filters[2]. Here is the matematical notation of WT:

$$\psi_{k+1,2p-1[m]} = \sqrt{2}\ \sum_{m'} h[m']\, \psi_{k,p[m-2^k m']} \quad (21)$$

$$\psi_{k+1,2p[m]} = \sqrt{2}\ \sum_{m'} g[m']\, \psi_{k,p[m-2^k m']} \quad (22)$$

$\psi_{k,p[m]}$ is the pth wavelet package function on the kth platform[21].

when sign has transformed with IDWT Instead of IFFT, transformed sign is denoted :

$$x = IDWT(X) \quad (23)$$

$$x(t) = \sum_{p=0}^{N=1} \sum_{l=0}^{\infty} X(l) \psi_{k,p}^{sym}(t - lN) \quad (24)$$

P, l represent location data indexes, $\psi_{k,p}^{sym}$ represents the wavelet package function for p^{th} subchannel, and X(l) represents data signs.

5. Sımulatıon Results

In this study, IFFT is removed on the transmitter side of the MIMO-OFDM system and IDWT is added and system is analyzed.

Using the same way, FFT is removed on the receiver side of MIMO-OFDM system and DWT is added and system is analysed.

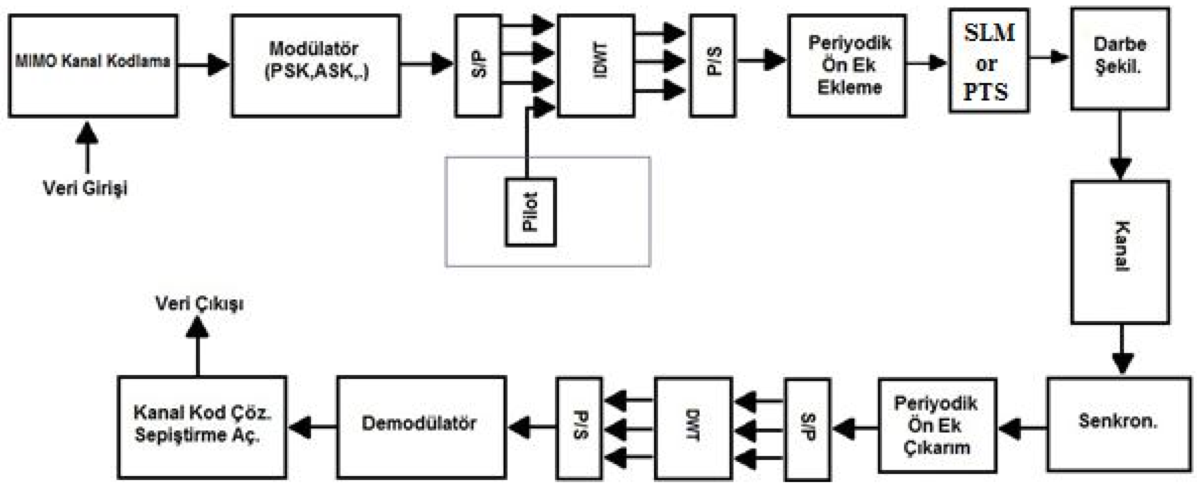


Figure 4. MIMO-OFDM Model

Using (SLM), Results that are obtained changing “M sub block numbers” in the system and result that is obtainned applying WT are compared in order to reduce PAPR value in MIMO-OFDM system.

Here we see that WT has better results observing the corresponding PAPR values to M values (M=2,4,8,16).

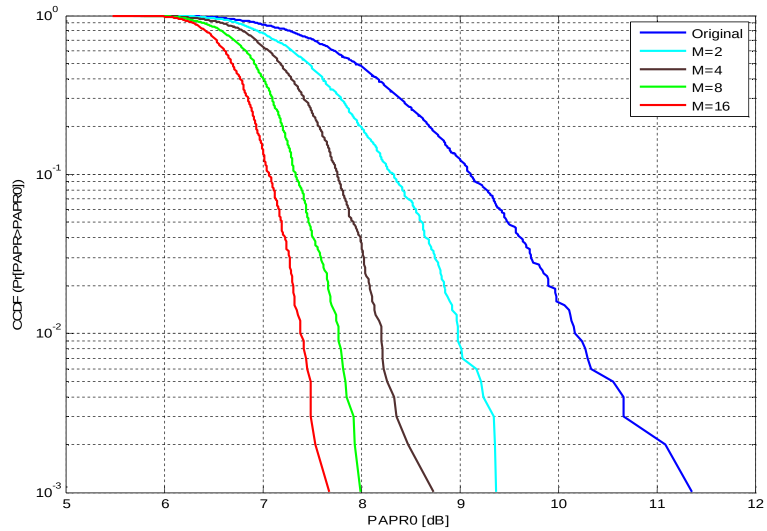


Figure 5: Different M (sub carriers) values in MIMO-OFDM Systems with SLM

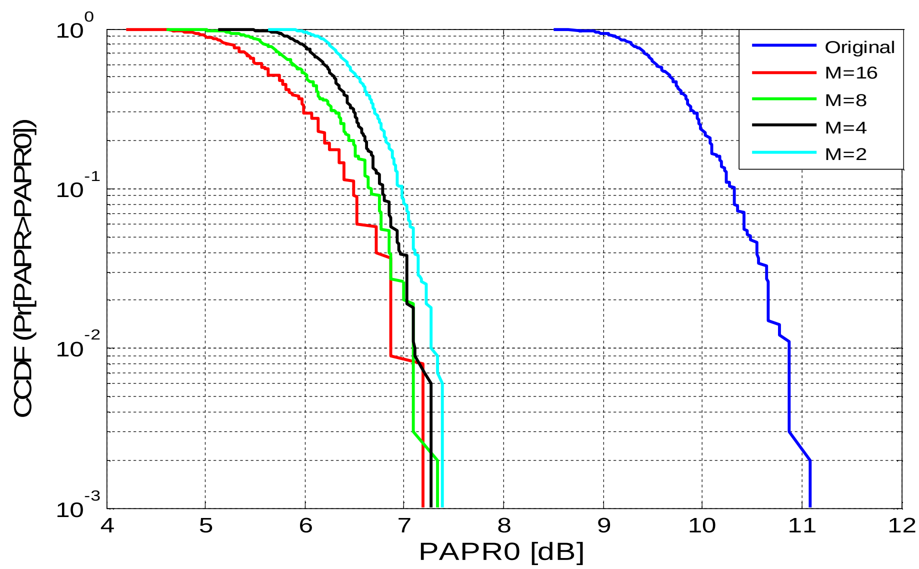


Figure 6: Different M (sub carriers) values in MIMO-OFDM Systems with WT and SLM

According to the graphs, while PAPR value is approximately 9.5 at M=2 for normal IFFT, it is 7.5 for IDWT.

Similarly, while PAPR value is approximately 8.7 at M=4 for IFFT, it is 7.4 for IDWT. while PAPR value is approximately 8 at M=8 for IFFT, it is 7.45 for IDWT. while PAPR value is approximately 7.8 at M=16 for IFFT, it is 7.3 for IDWT.

Using SLM tecniques, PAPR reducing is observed according to the number of subcarriers "N" (N= 256,128,64) where number of sub block "M" is constant and adding IDWT results better that IFFT.

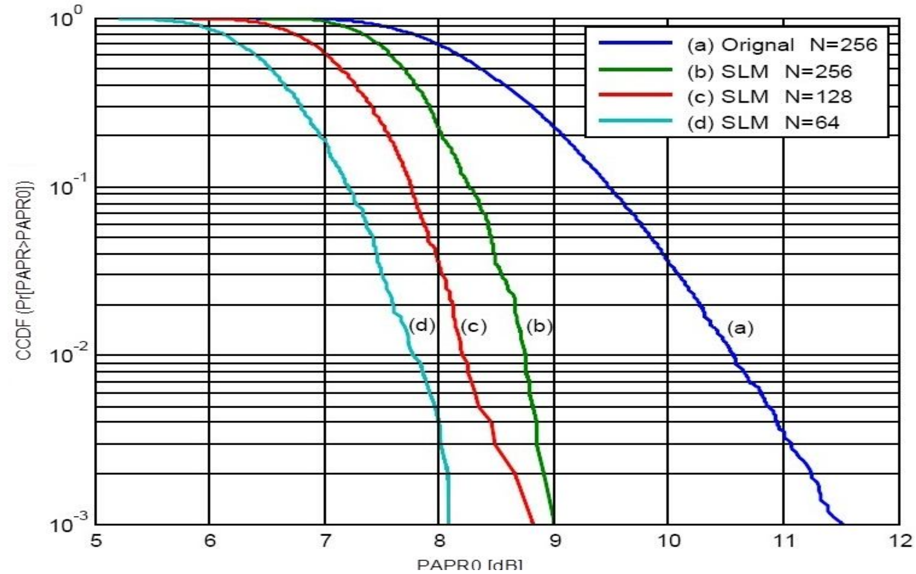


Figure 7: Different N (sub block) values in MIMO-OFDM Systems with SLM

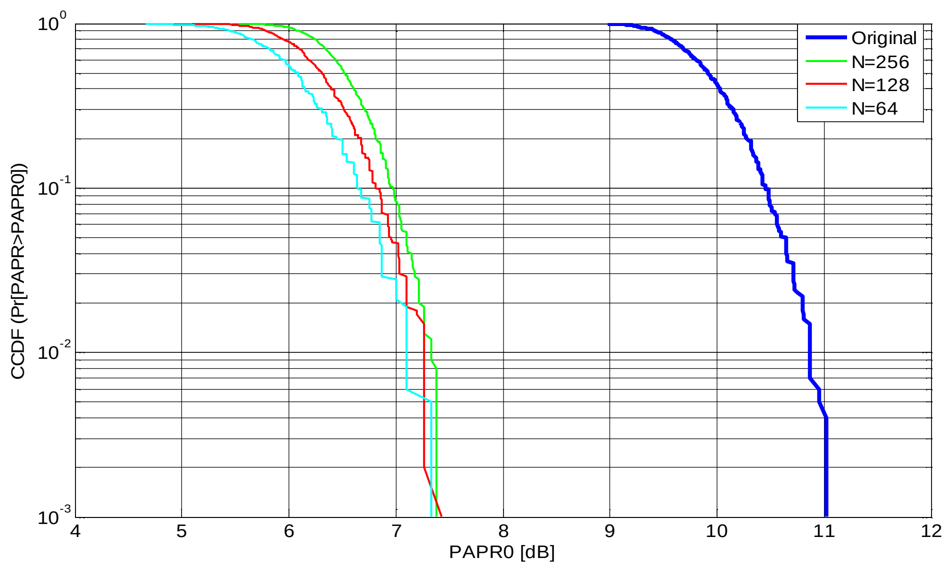


Figure 8: Different N (sub block) values in MIMO-OFDM Systems with WT and SLM

According to the graphs, IFFT FFT transformation that is used to reduce PAPR value in MIMO-OFDM system creates a PAPR value seen in figure 7. Figure 8 shows the PAPR value when IDWT/DWT is used instead of IFFT/FFT in the system. Graphs shows that IDWT/DWT enables a lower PAPR value than IFFT/FFT.

For example, for N=256 while PAPR=9 in the IFFT/FFT system, PAPR=7.4 in IDWT/DWT system.

For N=128 while PAPR=8.8 in the IFFTFFT system, PAPR=7.5 in IDWT/DWT system. For N=64 while PAPR=8.1 in the IFFTFFT system, PAPR=7.45 in IDWT/DWT system.

Using (PTS), Results that are obtained changing “V sub block numbers” in the system and result that is obtainned applying WT are compared in order to reduce PAPR value in MIMO-OFDM system.

Here we see that WT has better results observing the corresponding PAPR values to V values (V=2,4).

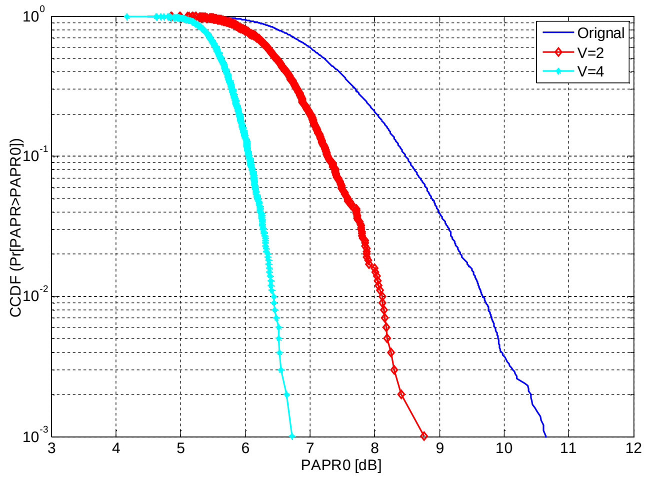


Figure 9: Different V (fase value) values in MIMO-OFDM Systems with PTS

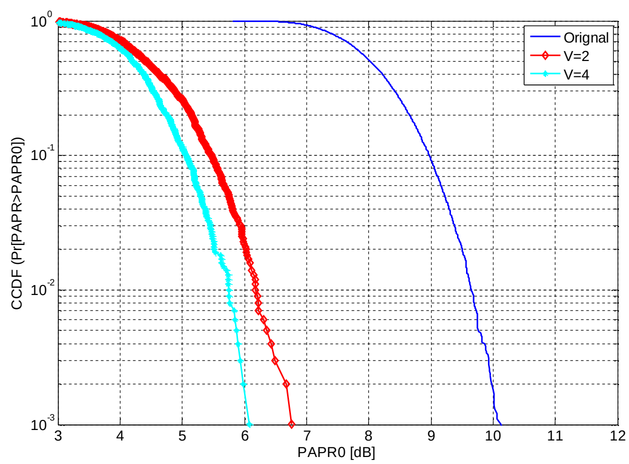


Figure 10: Different V (fase value) values in MIMO-OFDM Systems with WT and PTS

According to the graphs, while PAPR value is approximately 8.7 at V=2 for normal IFFT, it is 6.7 for IDWT.

Similarly, while PAPR value is approximately 6.8 at V=4 for IFFT, it is 6.1 for IDWT.

Using PTS tecniques, PAPR reducing is observed according to the number of subphases “W” (W= 2,4) where number of sub block “V” is constant and adding IDWT results better that IFFT.

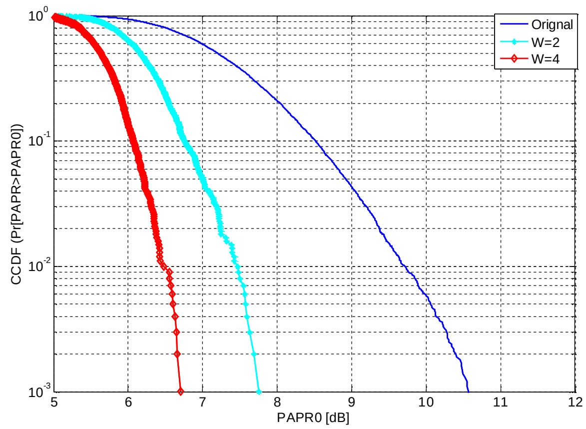


Figure 11: Different W (farklı faz) values in MIMO-OFDM Systems with PTS

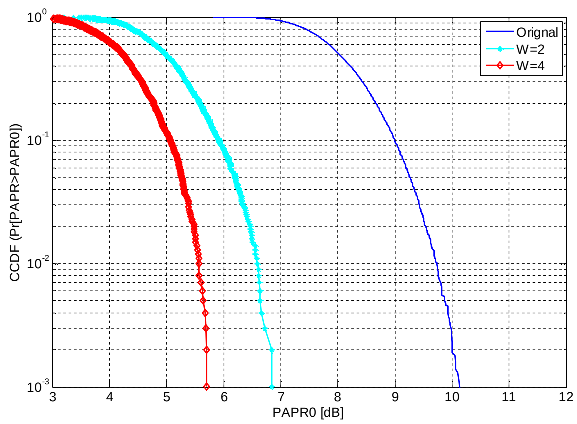


Figure 12: Different W (farklı faz) values in MIMO-OFDM Systems with WT and PTS

According to the graphs, IFFT FFT transformation that is used to reduce PAPR value in MIMO-OFDM system creates a PAPR value seen in figure 8.

Figure 9 shows the PAPR value when IDWT/DWT is used instead of IFFT/FFT in the system. Graphs shows IDWT/DWT enables a lower PAPR value than IFFT/FFT.

For example, for W=2 while PAPR=7.8 in the IFFTFFT system, PAPR=6.9 in IDWT/DWT system.

W=4 while PAPR=6.7 in the IFFTFFT system, PAPR=5.8 in IDWT/DWT system.

6. Conclusion

Using the most common tecniques, PTS and SLM, in order to reduce PAPR value that creates disadvantages on the transformed signs, fourier transformation that gives information about the values on frequency platform and wavelet transformation that gives information about the values on frequency as well as time platform are compared on the computer simulations and it is observed that WT gives a better PAPR value than FT.

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