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Comparative Performance Analysis of BER vs SNR in SC/IFDMA

Anis Suliman Ali Bakouri

Om-Alaranb College of Science & Technology, Libya

Abstract: ***OFDM is a form of transmission that uses a large number of closely spaced carriers that are modulated with low rate data. Normally these signals would be expected to interfere with each other, but by making the signals orthogonal to each another there is no mutual interference. Single carrier frequency division multiplexing technique is a most efficient and well-known modulation technique for transmission of digital data with high data rate. It is a multicarrier modulation technique where a high data rate signal is divided in to the number of lower data rate signal and these lower data rate signal are placed on the different sub bands where each lower data rate signal is modulated through an individual sub carriers so by combining all modulated signal we get the OFDM transmitted signal. It is most effective technique for overcome the problem of multipath fading, immunity to delay spread Increasing signal to noise ratio (SNR) with negligible Inter carrier interference (ICI) and Inter symbol interference (ISI).High peak to average power ratio(PAPR) is main problem with OFDM that degrade the performance of system. There are various techniques has been demonstrated to reduce PAPR like signal scrambling or signal distortion technique and also improving the bit error rate of the system. In this paper, we have evaluated the BER vs SNR performance of SC/IFDMA with and without NCT after reducing PAPR.***

Keywords: Single carrier frequency division multiplexing, Peak to average power ratio, BER, SNR

1. Introduction

Orthogonal frequency-division multiple access (OFDMA) is a feature of Wi-Fi 6 (802.11ax) that allows access points to serve multiple clients at the same time. OFDMA follows a set of rules created for the transmission of data between more than one terminals (any device at the end of a transmission channel, such as a computer or phone) over a transmission medium (such as a wireless network).

An example of how OFDMA works is when two phones send data over the same phone line. A time-interval may be assigned to each phone, and they will take turns sending their signal over the line at each assigned interval. However, these time frames are imperceptibly small, making the data transfer seem to happen simultaneously and seamlessly.

OFDMA is an updated version of frequency-division multiplexing (FDM) technology used to divide packets of information into separate bands that are carried by separate signals. This form of communication is an upgrade that parallels the switch of internet carriers to Wi-Fi 6 wireless, as well as the upgrade of phone carriers to 4G and 5G LTE. Instead of the traditional analog modulation used in multiplexing, OFDMA uses carrier signal waves, called subcarriers, to move small bits of information in a more streamlined fashion

There are lots of technologies developed in the field of both wired and wireless communication but nowadays, demand of high speed communication system is increasing day by day. Due to the increased demand in the mobile applications next generation wireless mobile system is designed in such way that they supports voice calls but also high performance data applications over radio wave communication system. A new technique orthogonal frequency division multiplexing has been introduced which fulfills this need and widely accepted by fourth generation.OFDM is a most efficient and well-known modulation technique for transmission of digital data with high data rate with up to 20 mbps data rate and 3Mbps for moving vehicle at low latency and good spectral efficiency [1] .It is a multicarrier modulation technique [2] where a high data rate signal is divided in to the number of lower data rate signal and these lower data rate signal are placed on the different sub bands where each lower data rate signal is modulated through an individual sub carriers so by combining all modulated signal we get the OFDM transmitted signal. OFDM modulation technique overcome the drawback of multipath fading and provides resistance against frequency selective fading channel, immunity to delay spread, low implementation complexity, uniform average power spectral density, very much capable to handle strong echoes and less occurrence of non-linear distortion Increasing signal without degrading BER of the signal In OFDM system, to avoid inter carrier interference number of carrier in the system are orthogonally modulated with each other and all of them follow orthogonal principle. orthogonality means that each carrier has an integer number of cycles over a symbol period. It ensures that center frequency of each carrier is located on the other subcarriers zero crossing points in the system.

OFDM system has a lot of uses in the field of wireless and wired communication. It has been used in DAB, Digital television DVB-T(terrestrial), DVBH(handheld), digital television and high-definition television [3] (HDTV, high-bit-rate digital subscriber lines (HDSL), and also in wireless LAN and MAN applications, including IEEE 802.11a/g/n, WiMAX and Mobile phone 4G [4].

A major drawback with OFDMA system is high PAPR and sensitive to frequency offset and phase noise. The problem of PAPR comes from the nature of modulation of OFDM where number of sinusoidal subcarrier may get added up the same time constructively that causes such a high power to transmit it, compared to overall average power of the OFDM system.

The PAPR of the signal is given as the ratio between the peak instantaneous power and the average power occur in OFDM symbol transmission

$$PAPR = \frac{\text{Peak power}}{\text{Average power}}$$

PAPR= Number of sub-carrier (N)

PAPR in terms of decibel may be calculated as follows:
PAPR = 10 log (N)

Hence, PAPR increases with increasing number of sub-carrier.

In OFDMA system the information symbol are loaded on to the sub-carrier and passes through the IFFT block which convert frequency domain information symbol into the time domain. Hence, signal generation in OFDM system based on IFFT operation on transmitter side and each sub-carrier only carries information related to one specific symbol.

Transmitter side

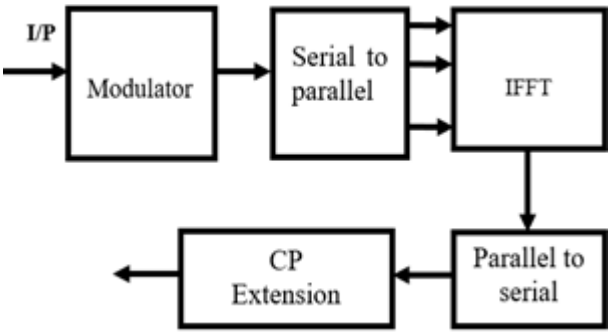

Figure 1: Transmitter structure of OFDMA.

Receiver side

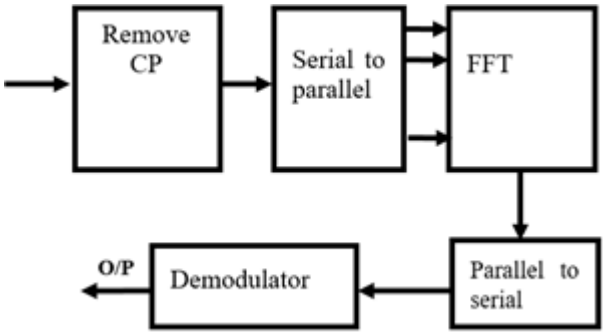

Figure 2: Receiver structure of OFDMA.

PAPR in OFDMA system occur due to the IFFT operation because Information symbol are randomly loaded onto the number of sub-carrier and add up receiver to produce high peak value signal. While PAPR depends on number of sub carrier i.e. PAPR increases with increasing number of sub carrier. High PAPR reduces the performance of the system, increases complexity and reduces efficiency of the RF power amplifier.

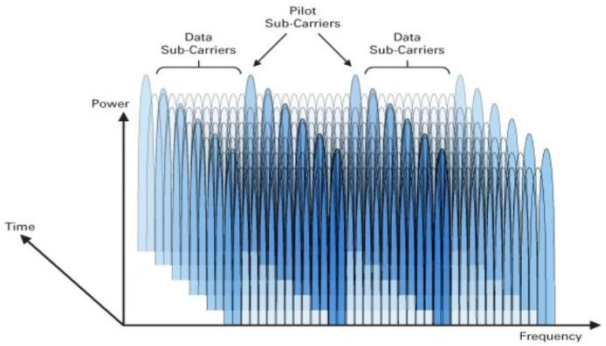

Figure 3: LTE OFDMA Carriers

To reduce the problem of PAPR in OFDM system the technique of SCFDMA is employed [5].In SCFDMA each sub-carrier contains information of all transmitted symbol. It is an improved version of OFDMA system which has two new block FFT and carrier mapping but for further reduction of PAPR we also employed the technique of NCT over SCFDMA.

2. Simulation Setup

TO Evaluate the BER vs SNR performance of SC/IFDMA with & without NCT technique, MATLAB simulator tool is used.

Table 1: Simulation Parameters

Parameters	Value
sub-carrier(N)	1024
Bandwidth spreading factor	32
Transmission bandwidth	10 MHz
Input data block size	16
Modulation technique	QPSK
Pulse shape	Raised-cosine (RC) and square Raised-cosine(RRC)

The block diagram SC-IFDMA with NCT technique showing in fig-1 & Fig-2 SC-IFDMA system has two extra block FFT and sub-carrier mapping block. FFT Block converts time domain information symbol into the frequency domain symbol. Furthermore, this frequency domain information symbol passes through the sub-carrier mapping and mapped to a subset of subcarriers, then applied to the IFFT. Hence, PAPR can be reduced by using FFT block which converts the system into single carrier system. However, most important thing isM<N while the remaining part of SC-FDMA is same as modified OFDM system.

In interleaved frequency division multiple access (IFDMA) mapping scheme, the FFT outputs of the input data are placed on the entire subcarriers with zeros occupying in unused subcarriers. [9].

X(0)	0	0	X(1)	0	0	X(2)	0	0	X(3)	0	0

Figure 4: IFDMA based mapping with 9 sub-carrier.

Output of the IFFT is applied to compander .In this paper, nonlinear compander is used to reduce PAPR and Improve BER Vs SNR performance.

$$f(x) = \begin{cases} \operatorname{sgn}(x)\left(\frac{p+1}{k}\left(1 - e^{\left(-\left(\frac{|x|^2}{\sigma^2}\right)\right)}\right)\right)^{\frac{1}{p+1}}, & |x| \le \alpha \\ \operatorname{sgn}(x)\left(\frac{1 - e^{\left(-\left(\frac{|x|^2}{\sigma^2}\right)\right)}}{k(cA)^p} + \frac{pcA}{p+1}\right), & |x| > \alpha \end{cases}$$

The transform parameters such as k and p are variables that help to achieve BER and PAPR reduction result

$$k = \frac{p+1}{c^p A^{p+1}(p+1-pc)}$$

$$A = 3\sigma^2 \frac{p+3}{p+1} \cdot \frac{p(1-c)+1}{p(1-c^3)+3}$$

$$\alpha = \sigma\left(-\ln\left(1 - \frac{k(cA)^{p+1}}{p+1}\right)\right)^{\frac{1}{2}}$$

3. Result and Discussion

The performance of the SC-IFDMA technique is evaluated to reduce PAPR and improve BER Vs SNR performance of SC-IFDMA using MATLAB simulations software. PAPR of the system can be characterized by CCDF (Complementary Cumulative Distribution Function). Furthermore compared the performance of OFDMA, SCFDMA and the proposed scheme. In our simulation model we have taken the total number of subcarriers as 1024, input data block size to 16 and bandwidth spreading factor to 32.Transmission bandwidth of 10 MHz and symbol constellations QPSK.

Figure-5CCDF plot showing probability of arising BER Vs SNR of SC/IFDMA and SC/IFDMA with NCT.It can be compare that BER of the SC/IFDMA with NCT is not good than SC/IFDMA but SNR for proposed SC/IFDMA with NCT is 14.7 dB which is roughly 3.1 dB higher than SC/IFDMA so overall performance of proposed technique is good than other.

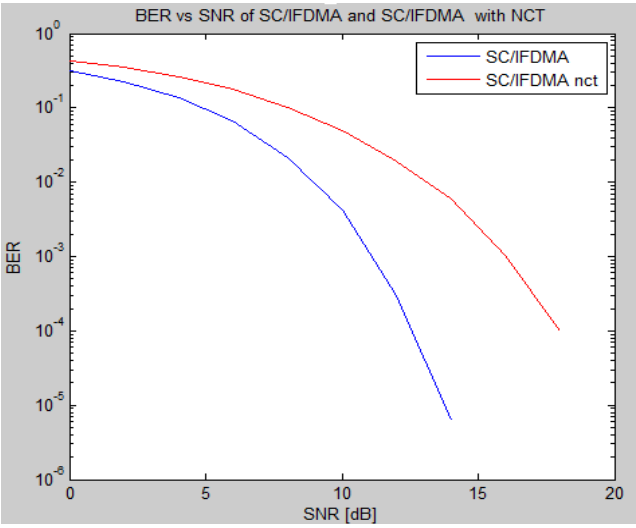

Figure 5: BER plot of SC/IFDMA and SC/IFDMA with NCT

4. Conclusion

After concluded the result it is confirmed BER Vs SNR performance of single carrier frequency division multiple access BER performance of proposed scheme is not good than IFDMA .Hence, overall performance of SCFDMA with NCT is effective and reliable than other.

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