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Peak to Average Power Ratio (PAPR) Reduction Techniques in OFDM for Optic Communications

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Ousama M Abdulwanes Awad*, Muhammed Fatih Kilicaslan, Javad Rahebi

Aziziye Mah. Refik Belendir Sk. No. 45 F/5 Cankaya Ankara, Turkey.

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ABSTRACT

In this study, benefits of orthogonal frequency division based on nonlinear amplify and forward relay system are examined. OFDM is a modulation technique that utilizes the communication band efficiently by dividing the high-speed information sequence into parallel arms and lifting the frequency selectivity of the multi-carrier channel at the same time and using vertically selected carriers at the same time. Also relay protocol preference is an important issue. Amplify and forward relay system is proper according to the other relay protocols because it only amplify the signal.

1. INTRODUCTION

When the demand of mobile communication services is increase which brings the concern of multi-carrier communication that uses the transmission band effectively. As the number of users increases, the speed of information access should also increase. Bandwidth must be high for data exchange to be of the desired quality. However, there is a certain limit in bandwidth. Orthogonal frequency division multiplexing is a next-generation transmission technology which can be developable. (OFDM) is a bandwidth efficient signaling scheme for digital communications that was first proposed by Chang [1] As a result of research on the synthesis of band limited signals for multi-channel transmission, OFDM systems have a history since mid of 60’s which published by Chang. The OFDM, which is a special case of multi-carrier communication, is to use the transmission band and to transmit information faster in a separated band. On multiple carriers’ frequencies, numerical data can be coding with orthogonal frequency-division multiplexing. OFDM is been using in a large area in digital communication. In technology that develops to day-to-day, applications are desired to be delivered at high speed and at the same time high quality. Because of a very large demand, it reduces the speed and quality. OFDM is being used to prevent this and to provide more efficient transmission. OFDM has developed into a popular scheme for wideband digital communication used in applications such as digital television and audio broadcasting, DSL internet access wireless networks, power line networks, and 4G mobile communications. The OFDM technique is a data transmission technique that divides a high bit rate data stream into several parallel low bit rate data streams and uses these low bit rate data streams to modulate several carriers. There are other frequency division multiplexing systems but OFDM systems are more useful than all. There are advantages of OFDM includes. It can against to multipath and multipath propagation can be minimized. OFDM resists to damping and narrow band interference. It increases frequency selective fading. OFDM is easier to implement comparing with other frequency division multiplexing systems. OFDM does not require any filtering and its demodulation process retrieving the information signal modulated onto a carrier over the carrier, is very easy. Due to these advantages, OFDM is very useful for high-speed local area networks (WLAN). The OFDM technique divides the available bandwidth of multiuser access into multiple channels and allocates each to different users. In OFDM, the spectra are used much more efficiently in order that all the carriers can be placed perpendicular to each other to prevent them from being too close to each other and disturbing adjacent channels. OFDM systems, which are currently being developed to transmit data at the highest speed and transmit the data in full, are used today in every field of technology. The OFDM system has a technique for converting frequencies. In a broadband channel there are selective frequencies that can be converted on the non-selective narrowband channel. The system does this to maintain the vertical range in the frequency domain and thus to prevent any delay in data transmission. Ensuring that there are no delays in the data transfer can cause the frequency of the data not to reach the receiver well. However, it tries to reduce the probability of fading to the lowest level, maintaining the frequency fidelity. Generally, OFDM systems are used with rectangular pulses, but then designing with pulse shaping is more useful because using pulse shaping is better for localized in frequency that is more helpful for interference point of views. The main objective of OFDM systems is to ensure that all transmitted data information is transmitted to the receiver in a complete and rapid manner. For this reason, the logic of OFDM systems comes from several subchannel divisions. It aims to simplify data transmission by narrowing the spectrum into sub-channels. In order to obtain high visual efficiency, the frequencies coming from the channels are superimposed and orthogonalized. This orthogonalized, if the frequency signal passes through a time dispersive channel, automatically adds a cyclic prefix to it, preventing the frequency from spreading and preserving the frequency. The cyclic prefix is the last part of the system. The cyclic prefix causes signal-to-noise ratio which is a important problem but it is an significant part of the system because it can avoid inter-symbol and inter-carrier [2]. In OFDM, a data flow technique is used that divides high bit rate data streams into several parallel low bit rate data streams and modulates these low bit rate data streams by carriers. That is, by dividing the band width by the total, it can be minimized by the delay propagation that can be caused by multipath propagation. In frequency division multiplexing (FDM) systems, it is used for signal transmission in frequency selective channels. A technique is used to divide the channel bandwidth so that carriers at low speeds are multiplexed at the frequencies allocated for each carrier. However, in order for the signals sent to the receiver to be separated from each other, the frequencies must not overlap each other. For this reason, it is not possible to obtain the full efficiency from the frequency spectrum. For this reason, the OFDM system is preferred for better utilization of the bandwidth [3]. By using inverse discrete Fourier transform in OFDM systems, this digital signal processing technique ensures that the subcarriers in the system are perpendicular to each other. The periodic prefix (PC) is inserted between the frames in the OFDM by selecting it larger than the channel delay. In this mode, inter symbol interference (ISI) caused by the channel can be eliminated. There are 3 techniques in the OFDM system to reduce high peak power. The first is the deconcentrating technique, which simply reduces the peak amplitude by nonlinear distortion in the peaks. Second, the coding technique uses special advanced error correction codes, such as turbo or convolutional codes, to exclude large PAP rate OFDM signals. The third is the symbol blending method. Due to the multi-carrier structure, the source OFDM systems have a structure suitable for operating at high data rates. Network structures must be planned in such a way that they do not interfere with access point initiatives because the further the recipient moves away from the point of data access, the slower the transmission rate. OFDM systems have high bit rate data transmission, because orthogonal carriers are modulated, and parallel sub bands are present. There are only some transmission speed and quality drops due to some frequency shifts or damping. It is still in the works to reduce the weaknesses of this data transmission. In serial data communication, the frequency spectrums are lined up in sequence using the entire bandwidth, which makes it difficult to distinguish superimposed frequencies. Problems arising with such serial data are intended to be solved by parallel data communication systems. Parallel data processing system is a system in which many data sequences are transmitted and can be retrieved at the same time. It may occupy only one part of the bandwidth of the frequency spectrum of each data signal [4] - [5]. It is used in transformer OFDM systems for separating and transforming subcarriers and for converting serial information to serial parallel conversion. After the data are transformed in parallel, a reverse fast Fourier transform (IFFT) is performed, and then the parallel output is used to convert the data to serial data. This is like transmitting the same radio sound. For example, when a piece of music at the radio center is being transmitted, a singer, which can be understood by humans at first, converts the sound into a frequency by digitizing it, and when the receiver receives these frequencies, the discretized frequencies are converted back into sound and transmitted to the receiver [6-9] FDM has just started a new application, it has a very important place in communication techniques. Instead of other carrier systems, OFDM system is preferred to use in Wi-Fi, HiperLAN2 or other wireless communications because of high data rates. The OFDM is based on the principle of transmission in parallel with a certain number of different sub-channels that can be interleaved with each other. OFDM has many advantages but there are two of disadvantages about frequency offset and symbol timing. They are used to make subcarriers orthogonal which OFDM systems are needed to have much more synchronizations and Method or technique for digital signal modulation using many closely spaced subcarriers which a data split across channels of several separate narrow bands and with this way slightly less effecting to frequency selective fading, otherwise it will be more sensitive to selective fading of frequency. Each subcarrier involves several of parallel data streams and regulated traditionally at a low symbol rate. Orthogonal frequency-division multiplexing is first intended to minimize interference between channels which closed each other in frequency and signal degradation when using the conventional modulation schemes [3] [10-11].

OFDM system block architecture can draw as:

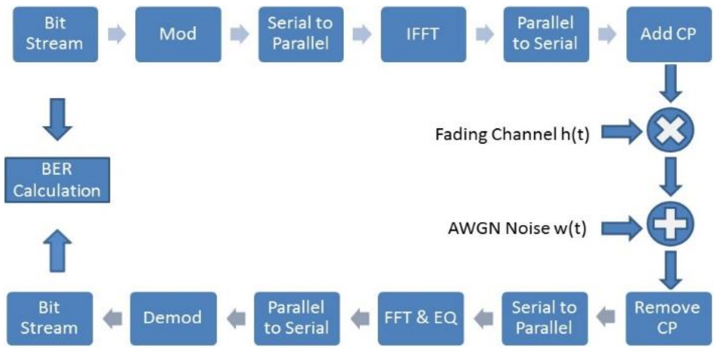

Figure 2. 1.OFDM System Block Diagram [12]

OFDM system can classify in 3 sections which are transmitter, the channel and the receiver. Which are transmitter, physical channel and receiver.

2. Transmitter

A transmitter is an electronic device that generates many waves to transmit data to the antenna. The transmitter takes energy from power supplies and generates the radio frequency, which is an alternating current to the antenna, to propagate the radio waves. The changing a radio frequency to alternating current happens in milliseconds and changing millions of times. There are a wide variety of transmitters available, which vary according to usage standards and types, some of which are wifi, bluetooth or nfc. A transmitter is formed of power supply, electronic oscillator, modulator, RF amplifier and antenna tuner.

We have formulas;

N: Numbers of subcarriers

W: Bandwidth in Hz

T: Symbol length in seconds

T_{cp}: Length of the cycle prefix

$\emptyset_k\ (t)$: Transmitter filter

$$\emptyset_k = \begin{cases} \frac{1}{\sqrt{T-T_{cp}}}\ e^{ik(t-T_{cp})2\pi\frac{W}{N}} & if\ t \epsilon\ [0,T] \\ 0 & otherwise \end{cases} \quad (2.1)$$

Where T = N / W + Tcp.

For modulation $\emptyset_k\ (t)$ is used and to calculate symbol number or time index '*l*' with considering transmitted base band signal. Where *x*0*, x1,……..,xN-1* are complex numbers, the formula is;

$$s_1(t) = \sum_{k=0}^{N-1} x_{k.1} \emptyset_k\ (t - lT) \quad (2.2)$$

When the OFDM symbol is transmitted too far beyond the sequence, the OFDM symbols are placed side by side from output from transmitter. Which can be calculated with the formula;

$$s(t) = \sum_{l=-\infty}^{\infty} s_1\ (t) = \sum_{t=-\infty}^{\infty} \sum_{k=0}^{N-1} x_{k,1}\ \emptyset_k(t - lT) \quad (2.3)$$

3. Physical channel

A physical channel can carry different messages according to the information to be sent, and these messages are called logical channels. Physical channels can be matched to RF channels in a true sense and some definitions can be made as an example.

$g(\tau; t)$: Impulse response of the physical channel

$\tau\ \epsilon\ [0, T_{cp}]$: Intervals

n(t) : Gaussian channel noise

The received signal will be;

$$r(t) = (g * s)(t) = \int_0^{T_{cp}} g(\tau; t) s(t - \tau) d\tau + \tilde{n}\ (t)$$

(2.4)

4. Receiver

A receiver is a device used to receive many types of signals depending on the transmitted message. When it receives a signal, it resolves them and directs these resolved signals in such a way that the device to be transmitted can understand.

Receivers are mostly used in wireless communications today and are also used in the reception of electromagnetic signals, electrical signals, sound waves, digital cable signals and even light.

There is a filter bank in every OFDM receivers and it has a formula;

$$\varphi_k(t) = \begin{cases} \emptyset_k(T-t) & if\ t \in [0, T - T_{cp}] \\ 0 & otherwise \end{cases} \qquad ()$$

In the receiver there is no cyclic prefix. With ignoring the *' l '*, there is formula to find sampled output for the *k*th matched filter;

$$y_k = (r * \varphi_k)(t)|_{t=T} = \int_{-\infty}^{\infty} r(t)\varphi_k\ (T-t)dt$$

$$= \int_{T_{cp}}^{T} \left(\int_{0}^{T_{cp}} g(\tau;t)\left[\sum_{k'=0}^{N-1} x_{k'}\emptyset_{k'}\ (t-\tau)\right] d\tau\right) \emptyset_k^*\ (t)\ dt + \int_{T_{cp}}^{T} \tilde{n}\ (T-t)\ \emptyset_k^*(t)dt$$

If channel is fixed through wih OFDM symbol interval, it shows as $g(\tau)$, there is a formula;

$$y_k = \sum_{k'=0}^{N-1} x_{k'} \int_{T_{cp}}^{T} \left(\int_{0}^{T_{cp}} g(\tau)\emptyset_{k'}\ (t-\tau)d\tau\right) \emptyset_k^*(t)dt + \int_{T_{cp}}^{T} \tilde{n}\ (T-t)\ \emptyset_k^*(t)dt$$

When Tcp < t < T and 0 < τ < Tcp. So inner integral is written as

$$\int_{0}^{T_{cp}} g(\tau)\,\emptyset_{k'}(t-\tau)d\tau = \int_{0}^{T_{cp}} g(\tau)\frac{e^{j2\pi k'(t-\tau-T_{cp})W/N}}{\sqrt{T-T_{cp}}}\,d\tau$$

$$= \frac{e^{j2\pi k'(t-T_{cp})W/N}}{\sqrt{T-T_{cp}}} \int_{0}^{T_{cp}} g(\tau)e^{-j2\pi k'\tau W/N}\,d\tau$$

hk: the sampled frequency response of the channel

Where the frequency: f = k'W/N

k' is for the subcarrier frequency which is k'th and the formula is

$$h_{k'} = G\left(k'\frac{W}{N}\right) = \int_{0}^{T_{cp}} g(\tau)e^{-j2\pi k'\tau W/N}d\tau$$

G (*f*): The Forier transform of $g(\tau)$, with this, the simplified formula of outputting from the recipient filter bank is as follows

$$y_k = \sum_{k'=0}^{N-1} x_{k'} \int_{T_{cp}}^{T} \frac{e^{j2\pi k'(t-T_{cp})W/N}}{\sqrt{T-T_{cp}}} h_{k'} \emptyset_k^*(t)dt + \int_{T_{cp}}^{T} \tilde{n}(T-t)\emptyset_k^*(t)dt$$

$$= \sum_{k'=0}^{N-1} x_{k'} h_{k'} \int_{T_{cp}}^{T} \emptyset_{k'}(t)\,\emptyset_k^*(t)dt + n_k$$

Where $n_k = \int_{T_{cp}}^{T} \tilde{n}(T-t)\emptyset_k^*(t)dt$ and if transmitter filter will be orthogonal, the formula will be as;

$$\int_{T_{cp}}^{T} \emptyset_{k'}(t)\,\emptyset_k^*(t)dt = \int_{T_{cp}}^{T} \frac{e^{j2\pi k'(t-T_{cp})W/N}}{\sqrt{T-T_{cp}}} \frac{e^{-j2\pi k(t-T_{cp})W/N}}{\sqrt{T-T_{cp}}} dt = \delta[k-k']$$

$\delta[k]$: Kronecker delta function and *yk* = *hkxk* + *nk* which *nk* addiive white gaussian noise (AWGN). The OFDM system has a synchronization function spectrum that is formed by the side lobes. This is due to the side lobes used for overlapping the spectra of the subcarriers in the OFDM system. This overlap is made in the frequency domain. In addition to the harsh frequencies that enter the system, the initiative of the sub-carriers comes into play. This gives us a spectrum of OFDM signal frequency spectra [13-14]. Orthogonality principle is widely used in multi-channel systems, such as WIFI or telephone calls, which we use today as a wireless communication network, for example, this principle is now based on the communication network. Compared to other fdm systems, the orthogonal principle used in OFDM makes this system more complex. But the biggest reason for the widespread use of these systems is that they have improved the quality of the signal, can be improved at any time and are compatible with every electronic device [15-16]. There are a lot of information about orthogonal frequency division multiplexing systems but if there will be lists of OFDM systems there will be two different lists which one of them is advantages and the other one is disadvantages. Advantages are the most significant part of the system because they are the significant differences of the systems when comparing with other systems. Decreasing the effect of the spectrum by ensuring that the signals overlap, then he signals transmitted to the receiver are more resistant to frequency selective fading by transmitting subcarriers and signals use as much channel coding and crossover as possible for quality and can even recover these lost symbols while channel sync which any channel affected by fading can be canceled. Decoding is used against certain complexity. In OFDM systems, fft techniques are used to solve modulation and demodulation functions and provides protection against interference during transit of signals or transitions between channels. It can be used easily on wireless networks because time partitioning resistor, fast transmission, and it is developable. Although complex, it has an easy to use and adaptable to any system. But there are many disadvantages too. If there are any unaffected orthogonal signals, OFDM must refuse from those signals. The signal has noise because power ratio is too high. It need RF power amplifiers and it is more sensitive than single carrier systems. The signal has noise because power ratio is too high. [17-18]

5. Simulation result

In this paper we used.

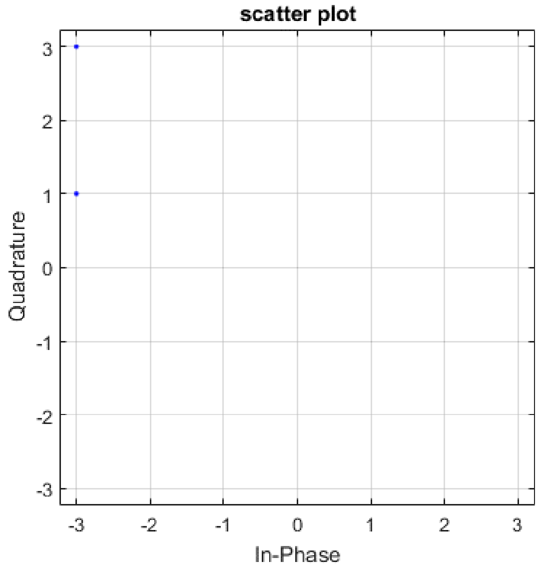

Figure 1

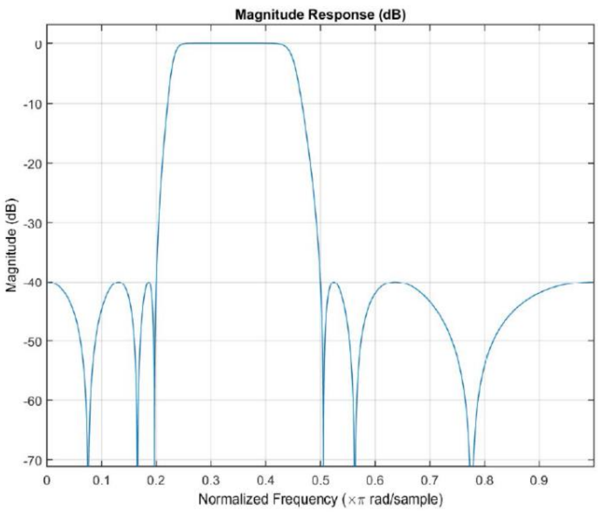

Figure 2

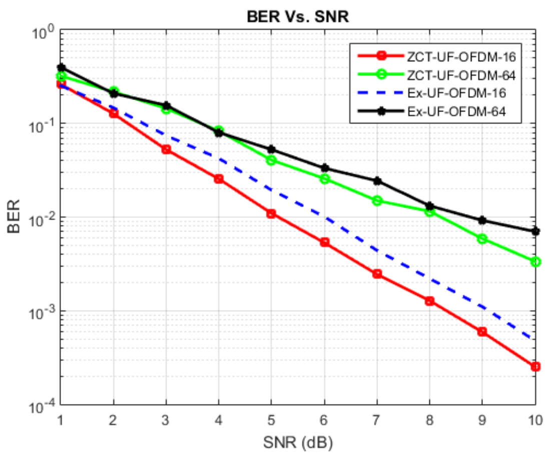

Figure 3

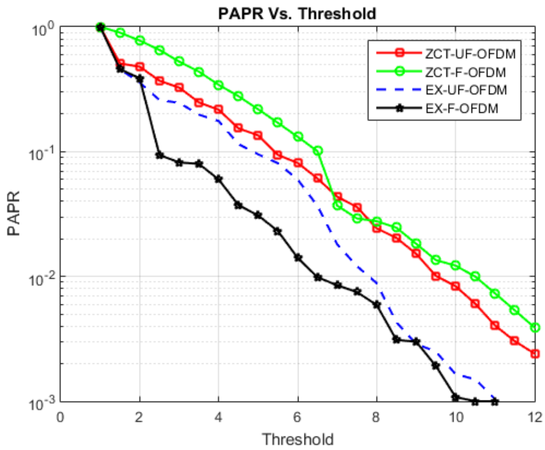

Figure 4

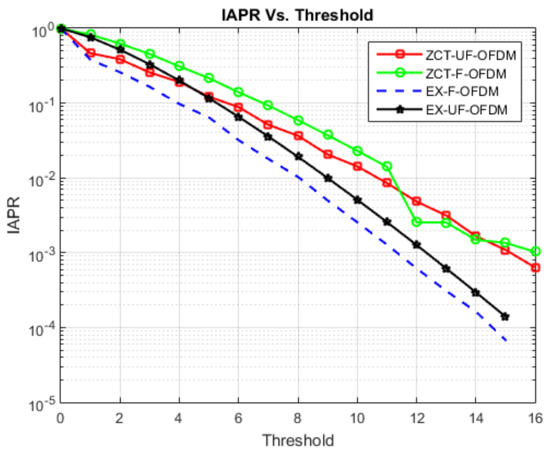

Figure 5

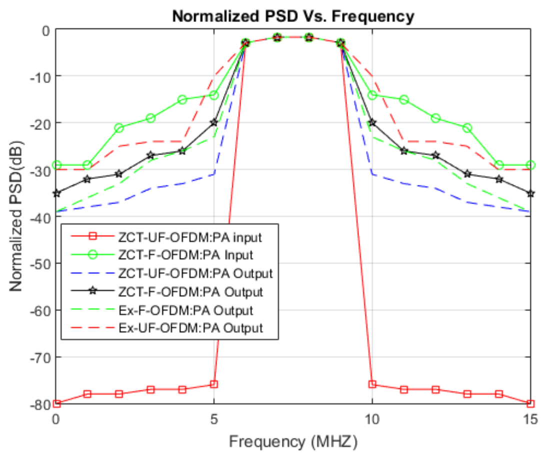

Figure 6

6. CONCLUSION

Both receiver and transmitter antennas have been proposed for use in OFDM-based next-generation wireless communication systems and error performance for different situations has been investigated. It can be seen that when the antenna selection application is compared with the non-antenna selection systems, both the error rate is reduced remarkably and the diversity gain is obtained. In general, with the choice of joint antenna, performance has been observed to be improved in all cases, only with respect to antenna selection at the transmitter side.

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