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The Performance of OFDM with Blanking Nonlinearity in Impulsive and Gaussian Noise

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Abstract

The aim of this paper is to investigate the effect of impulsive noise on the performance of the OFDM (orthogonal frequency division Multiplexing) system. The employed model of impulsive noise consists of Bernoulli distributed impulsive arrivals and Gaussian distributed amplitudes of the impulses. A simple method of improving OFDM receiver performance in an impulsive noise environment is to precede a conventional OFDM demodulator with blanking nonlinearity.

The effect of changing impulsivity of noise and different relative power of impulsive noise are investigated and are compared with Additive Whit Gaussian Noise (AWGN) case. Also the performance of the OFDM receiver with blanking nonlinearity in the presence of impulsive noise will be studied.

Closed form analytical expressions for the signal-to-noise ratio (SNR) at the output of blanking nonlinearity and the optimal blanking threshold that maximizes SNR are derived.

الخلاصـــــــة

الهدف من هذا البحث هو دراسة تأثير الضوضاء الاندفاعي على منظومة التعدد التقسيمي الترددي المتعامد (OFDM). النموذج المستخدم للضوضاء المندفعة يشمل توزيع برنولي للوصول الاندفاعي وتوزيع (Gaussian) للقيم الاندفاعية. أبسط الطرق لتَحسين أداءِ (OFDM) المستلمِ في بيئةِ ضوضاءِ أندفاعية بواسطة وضع مسح غير خطي(blanking nonlinearity) قبل المستلم لـ(OFDM).

تم تناول تأثير تغيير اندفاعية (impulsivity) الضوضاء والقدرة النسبية للضوضاء الاندفاعية ومقارنة النتائج مع (AWGN). كذلك تم دراسة تمثيل المستلمة (OFDM) مع المسح غير الخطي بوجود الضوضاء الاندفاعي.

تم أيجاد التمثيل التحليلي لنسبة الضوضاء للإشارة (SNR) عند المخرج للمسح غير الخطي وإيجاد أفضل عتبة مسح تزيد (SNR).

1. Introduction

Orthogonal Frequency Division Multiplexing (OFDM) also called Multicarrier (MC) technique is a modulation method that can be used for high-speed data communications. In this modulation scheme transmission is carried out in parallel on different frequencies. This technique is desirable for transmission of the digital data through the multipath fading channels. Since by the parallel transmission, the deleterious effect of fading is spread over many bits, therefore, instead of a few adjacent bit completely destroyed by the fading, it is more likely that several bits are only slightly affected by the channel. The other advantage of this technique is its spectral efficiency. In the MC method the spectra of subchannels overlap each other while satisfying orthogonality, giving rise to the spectral efficiency [1].

One of the challenging problems in practical applications of wireless digital communication techniques is a data transmission over channels with man-made noise that appears in typical urban environments. The man-made noise created by vehicle ignition systems, power lines, heavy current switches and other sources cannot be assumed to be Gaussian, and has to be represented by impulsive models [2-4].

In general, OFDM systems are less sensitive to impulsive noise than single carrier systems. The longer OFDM symbol duration provides an advantage, since the impulsive noise energy is spread among simultaneously transmitted OFDM subcarriers. However, it has been recently recognized that this advantage turns into a disadvantage if impulsive noise energy exceeds a certain threshold [5]. A simple method of reducing the adverse effect of impulsive noise is to precede a conventional OFDM demodulator with blanking nonlinearity. This method is widely used in practice, because it is very simple to implement and provides an improvement over conventional OFDM demodulator in impulsive noise channels [5].

It should be noted that the idea of using blanking nonlinearity (also referred to as a blanker or hole puncturer) for impulsive noise cancellation is not new. It was shown over four decades ago that the locally optimal detector for arbitrary signals in impulsive noise under a low signal-to-noise ratio (SNR) assumption comprises of a conventional detector (optimal in Gaussian noise environment) proceeded by a memoryless nonlinearity [6]. Generally, the shape of the optimal memoryless nonlinearity is determined by the probability density function of the impulsive noise process [6]. However, it is shown that the blanking nonlinearity is one of the best (and the simplest) approximations to the locally optimal nonlinear preprocessor [7]. Recently, the idea of using (suboptimal) blanking nonlinearity for impulsive noise cancellation has been successfully applied to modern OFDM communication systems [6]. It should also be noted that the performance of the receivers with blanking nonlinearity was analyzed in [8].

In this paper, a Bernoulli-Gaussian model for the impulsive noise is employed and is shape by a proper filter. The bit error rate performance results are provided using different impulsivity of the noise and different relative power of impulsive noise. Besides from impulsive noise, AWGN is also considered. The problem of optimal threshold selection and performance characterization of the OFDM receiver that uses blanking nonlinearity for impulsive noise cancellation is also considered.

2. Basic Principles of OFDM

OFDM is a parallel transmission scheme, where a high-rate serial data stream is split up into a set of low-rate sub streams, each of which is modulated on a separate subcarrier (SC) (frequency division multiplexing). Thereby, the bandwidth of the subcarriers becomes small compared with the bandwidth of the channel [9].

The “orthogonal” part of the OFDM name indicates that there is a precise mathematical relationship between the frequencies of the carriers in the system. In a normal FDM system, the many carriers are spaced apart in such way that the signals can be received using conventional filters and demodulators. In such receivers, guard bands have to be introduced between the different carriers, and the introduction of these guard bands in the frequency domain results in a lowering of this efficiency. It is possible, however, to arrange the carriers in an OFDM signal so that the sidebands of the individual carriers overlap and the signals can still be received without adjacent carrier interference as shown in **Fig.(1)**.

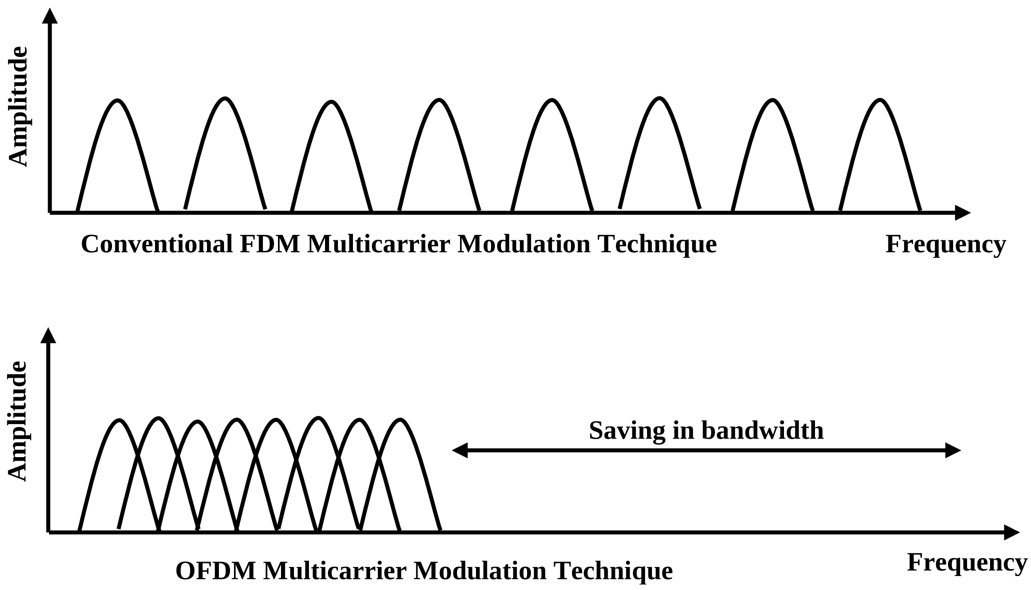

Figure (1) Transmitted signal spectrum of FDM system

The transmitted spectral shape is chosen so that Inter Carrier Interference (ICI) does not occur; that is, the spectra of the individual subcarriers are maximum at their frequency and zero at other subcarrier frequencies. The N serial data elements (spaced by T=1/R where R is the symbol rate) modulate N subcarrier frequencies, which are then frequency division multiplexed. The symbol duration (T_s) has been increased to (NT), which makes the system less susceptible to delay spread impairments [9].

The subcarrier frequencies are separated by the multiples of (1/NT) so that, with no signal distortion in transmission, the coherent detection of a signal element in any subcarrier of OFDM system gives no output for a received element in any other subcarriers. Hence, the N received signal elements, corresponding to the N subcarriers of OFDM system, are said to be orthogonal. So, no further filtering is needed to separate the different subcarriers. In other words, the power density spectrum has a central positive peak at an individual carrier frequency, and zeros at all other subcarrier frequencies [9].

Using digital modulation format, the transmitted OFDM symbol waveform can be represented as [9]:

$$\mathbf{S(t) = Re\left\{\sum_{k=0}^{N-1} d(k)\, exp\left(j2\pi f_k t\right)\right\}} \quad \textbf{(1)}$$

where:

d(k): is the modulated data symbol

f_k: is subcarrier frequency of k^{th} subcarrier which is equal to ($f_c + k\Delta f$).

Δf : is subcarrier spacing (bandwidth) equal to (1/NT).

f_c: is the carrier frequency.

This expression represents the passband OFDM signal, if the equivalent complex baseband notation is used which is given by [9]:

$$\mathbf{S(t) = \sum_{k=0}^{N-1} d(k)\, exp\left(j2\pi k\Delta f\, t\right)} \quad \textbf{(2)}$$

Equation (2) represents the general form of complex baseband OFDM signal. At the receiver, all operations in the transmitter are reversed.

It is shown that an OFDM signal is effectively the inverse Fourier Transform of original data stream, and the bank of coherent demodulators is effectively the Fourier Transform.

If the signal is sampled at a rate of (T), then (t=nT), and for orthogonality ($\Delta f = 1/NT$), then Equation (2) can be rewritten as [9]:

$$\mathbf{s(n) = \sum_{k=0}^{N-1} d(k)\, exp\left(j2\pi kn/N\right)} \quad \textbf{(3)}$$

Equation (3) is exactly the Inverse Discrete Fourier Transform (IDFT) of the data sequence d(k) [9]. Further reductions in complexity are possible by using the Fast Fourier Transform (FFT) algorithm to implement the DFT.

3. Impulsive Noise Model

The model discussed in the following is a Bernoulli-Gaussian (BG) model of an Impulsive Noise (IN) process. The random time of occurrence of the impulsive is modeled by a Bernoulli process b(k), where k is the time point and b(k) is a binary-valued process that takes a value of "1" with a probability of α and a value of "0" with probability of ($1-\alpha$). The amplitude of the impulsive is modeled by a Gaussian process g(k) with mean zero and variance σ^2. Each impulsive is shaped by a filter with the impulsive response h(k). The

Bernoulli-Gaussian model of impulsive noise is illustrated in **Fig.(2)**. The IN can be expressed as [1]:

$$\mathbf{n(k)=\sum_{i=0}^{P-1} h(i)g(k-i)b(k-i)} \quad \ldots\ldots (4)$$

where:

P: is the length of the impulsive response of the impulsive shaping filter.

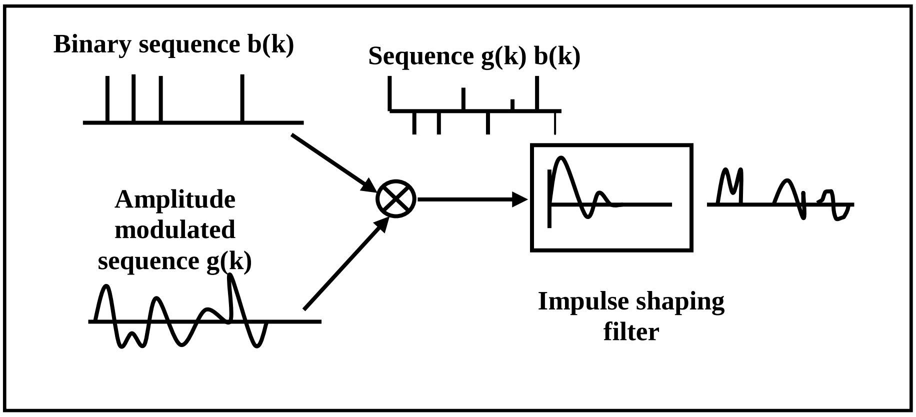

Figure (2) Impulsive noise model

In a Bernoulli-Gaussian model the probability density function (pdf) of impulsive noise n(k) is given by [1]:

$$\mathbf{pdf_N^{BG}(n(k)) = (1-\alpha)\delta(n(k)) + \alpha pdf_N(n(k))} \quad \ldots\ldots (5)$$

where:

$\delta(n(k))$: is the Kronecker delta function and:

$$\mathbf{pdf_N(n(k)) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{1}{2}\left(\frac{n(k)}{\sigma}\right)^2}} \quad \ldots\ldots (6)$$

is the probability density function of a zero Gaussian process.

The value of α is a measure of impulsivity of the impulsive noise. By decreasing α the noise becomes more impulsive (α<1). The real world there is not the impulsive noise only but a mixture of impulsive noise and AWGN. In the simulation both IN and AWGN are considered. In this regard we also define a parameter that controls the power ratio of the AWGN part and the "impulsive" part of the total noise as [1]:

$$\gamma = \frac{\mathbf{power\ (impulsive\_component)}}{\mathbf{power\ (AWGN\_component)}} \quad \ldots\ldots (7)$$

with the definition of γ the noise impinging the system consists of IN and AWGN with a manageable ratio of power.

4. System Model

Figure (3) shows the block diagram of a typical OFDM transceiver. In the transmitter section, the input serial data stream is formatted into the word size required for transmission, e.g. 2 bits/word for QPSK, and shifted into a parallel format. The data is then transmitted in parallel by assigning each data word to one carrier in the transmission. Then the information bits are mapped into baseband symbols S_k using DQPSK scheme.

An IFFT is then used to convert this signal to the time domain, and to produce the orthogonality between subcarriers, allowing it to be transmitted. In practice, these samples are not enough to make a real OFDM signal. The reason is that there is no oversampling present, which would introduce intolerable aliasing if one would pass these samples through a digital-to-analog converter. To introduce oversampling, a number of zeros can be added to the input data vector. Hence, if oversampling is used, the zeros should be added in the middle of the data vector rather than appending them at the end. These are also used to center the spectrum. This ensures the zero data values are mapped onto frequencies close to plus and minus half the sampling rate, while the nonzero data values are mapped onto the subcarriers around 0Hz [9].

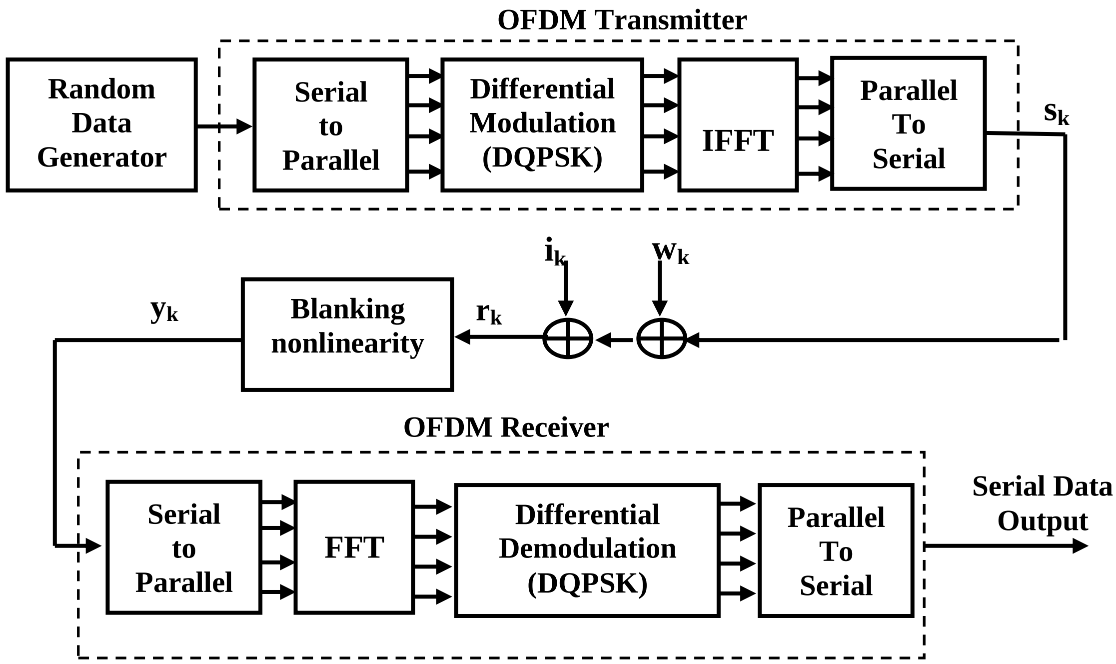

Figure (3) Block diagram of OFDM transceiver

It then digital-to-analog conversion is applied to the complex baseband OFDM signal as Equation (2). The time-domain received signal after down-conversion, analog-to-digital conversion, and perfect synchronization can be expressed as [11]:

$$\mathbf{r_k = s_k + w_k + i_k}, \qquad k=0,1,\ldots,N-1 \quad \textbf{(8)}$$

where:

$s_k = s(kT/N)$.

w_k: is the additive white Gaussian noise (AWGN), and

i_k: is the impulsive noise (s_k, w_k and i_k are assumed to be mutually independent).

The noise term $u_k = w_k + i_k$ in Equation (8), can also be expressed in terms of the two-component mixture-Gaussian model, which is widely accepted and frequently used for performance analysis of various transmission schemes in impulsive noise environment .

To reduce energy of the impulsive noise, *the blanking nonlinearity* can be applied to the received baseband signal r_k before the conventional OFDM demodulator [11]:

$$\mathbf{y_k = \begin{cases} r_k & \text{if } |r_k| < \lambda \\ 0 & \text{otherwise} \end{cases}} \quad \textbf{(9)}$$

where:

λ: is threshold value.

Nonlinearity of Equation (9) reduces the effect of large received signal values as these are assumed to be the result of impulsive noise.

The receiver performs the reverse operation of the transmitter. Fast Fourier Transform (FFT) is used to analyses the signal in the frequency domain. The amplitude and phase of the subcarriers are then picked out and converted back to digital data, then decoded to produce binary output data.

5. Signal to Noise Ratio at the Output of Nonlinearity

5.1 SNR Definition

To assess the receiver performance we should first represent the output of nonlinear preprocessor Equation (9) as:

$$\mathbf{y_k = K_0\, s_k + d_k}, \qquad k = 0,\ldots,N-1 \quad \textbf{(10)}$$

where: the first term on the right-hand side of Equation (10) represents the scaled replica of information-bearing signal, d_k is the cumulative noise/distortion term, and K_0 is the appropriately chosen scaling factor. It is usually desirable to have a zero-mean noise process ($dk = y_k - K_0\, s_k$) uncorrelated with the useful signal, i.e. $E\,[\,d_k s_k^*\,] = 0$.

The optimal scaling factor in Equation (10), which satisfies E $[d_k s_k^*] = 0$ can be found as [11]:

$$\mathbf{K_0 = \frac{E[y_k s_k^*]}{E[|s_k|^2]} = \frac{1}{2}E\left[y_k s_k^*\right]} \qquad \textbf{(11)}$$

When K_0 is chosen in accordance with Equation (11), the signal-to-noise ratio (SNR) after impulsive noise preprocessing can be expressed as [11]:

$$\boldsymbol{\psi} = \mathbf{\frac{E[|K_0 s_k|^2]}{E[|y_k - K_0 s_k|^2]} = \left(\frac{E[|y_k|^2]}{2K_0^2} - 1\right)^{-1}} \qquad \textbf{(12)}$$

where:

$E[|y_k|^2]$: represent the total signal power (i.e. useful signal power plus noise/distortion power) at the output of blanking nonlinearity.

In accordance with the system model presented in Section (4), s_k, w_k and i_k are mutually uncorrelated white spectrum sequences. Therefore, the noise process d_k is also white, and SNR is constant for all OFDM subchannels. Note that ψ can also be used to characterize output of OFDM demodulator, since SNR at the input of OFDM demodulator (DFT) and SNR at its output are equal [12].

The following analysis relies on the assumption that the number of OFDM subcarriers is sufficiently large ($N \to \infty$), and the OFDM signal can be modeled as a complex Gaussian process with Rayleigh envelope distribution [11,12].

5.2 Optimal Scaling Factor and the Total Signal Power at the Output of Blanking Nonlinearity

Using representation of the signal at the output of blanking nonlinearity given by Equation (9), it is straightforward to express Equation (11) as [11]:

$$\begin{aligned}\mathbf{K_0} &= \mathbf{\frac{1}{2}E\left[(s_k + w_k)s_k^* \middle| \bar{C}, \bar{I}\right]P(\bar{C}, \bar{I}) + \frac{1}{2}E\left[(s_k + w_k + g_k)s_k^* \middle| \bar{C}, I\right]P(\bar{C}, I)} \\ &= \mathbf{\frac{1}{2}E\left[|s_k|^2 \middle| \bar{C}, \bar{I}\right]P(\bar{C}, \bar{I}) + \frac{1}{2}E\left[|s_k|^2 \middle| \bar{C}, I\right]P(\bar{C}, I)} \\ &\quad \mathbf{+ \frac{1}{2}E\left[w_k s_k^* \middle| \bar{C}, \bar{I}\right]P(\bar{C}, \bar{I}) + \frac{1}{2}E\left[(w_k + g_k)s_k^* \middle| \bar{C}, I\right]P(\bar{C}, I)} \qquad \textbf{(13)}\end{aligned}$$

where:

C: is the event of clipping a signal above level λ,

λ: is threshold value,

g_k: is a Gaussian process with mean zero and variance σ^2 (see Equation (4)) and

I: is the event of impulsive noise occurring (and $\bar{C}$ and $\bar{I}$ are their complements).

Joint probabilities P($\overline{C}, \overline{I}$), P($\overline{C}$, I) can easily be expressed analytically, due to the fact that the amplitude of received samples (r_k) is Rayleigh-distributed. In particular, if received sample r_k is not contaminated with impulsive noise, A_r has a Rayleigh distribution with parameter $\sigma^2 = 1+\sigma_w^2$, and hence joint probability P($\overline{C}, \overline{I}$) can be expressed as [11]:

$$\mathbf{P(\overline{C},\overline{I}) = P(A_r < T|\overline{I})(1-\alpha) = (1-\alpha)\left(1-e^{\frac{-\lambda^2}{2(1+\sigma_w^2)}}\right)} \quad \textbf{.............................. (14)}$$

On the other hand, if received sample is affected by impulsive noise, A_r has a Rayleigh distribution with parameter $\sigma^2 = 1+\sigma_w^2+\sigma_g^2$, and, as a consequence, P($\overline{C}$,I) is expressed as:

$$\mathbf{P(\overline{C},I) = P(A_r < T|I)\alpha = \alpha\left(1-e^{\frac{-\lambda^2}{2(1+\sigma_w^2+\sigma_g^2)}}\right)} \quad \textbf{....................................... (15)}$$

The closed-form expression for K_0 (*):

$$\mathbf{K_0 = 1-\left(1+\frac{\lambda^2}{2(1+\sigma_w^2)}\right)(1-\alpha)e^{\frac{-\lambda^2}{2(1+\sigma_w^2)}} - \left(1+\frac{\lambda^2}{2(1+\sigma_w^2+\sigma_g^2)}\right)(1-\alpha)e^{\frac{-\lambda^2}{2(1+\sigma_w^2+\sigma_g^2)}}} \quad \textbf{.................................... (16)}$$

It is worth noting that the optimal K_0 is a real constant, which means that the signal constellation at the input of the decision device is not rotated. On the other hand, there is constellation shrinking after blanking nonlinearity, since $K_0 \leq 1$.

The total signal power at the output of blanking nonlinearity can be expressed as:

$$\mathbf{E[|y_k|^2] = E\left[|y_k|^2 \middle| \overline{C},\overline{I}\right]P(\overline{C},\overline{I}) + E\left[|y_k|^2 \middle| \overline{C},I\right]P(\overline{C},I)} \quad \textbf{.............................. (17)}$$

Finally, substituting Equation (16) and Equation (17) in Equation (12), immediately results in a closed-form expression for SNR at the output of blanking nonlinearity [11].

The closed-form expression for E [$|y_k|^2$] (*):

$$\mathbf{E\left[|y_k|^2\right] = 2(1+\sigma_w^2+\alpha\sigma_g^2) - (1-\alpha)\left\{\lambda^2 + 2(1+\sigma_w^2)\right\}e^{\frac{-\lambda^2}{2(1+\sigma_w^2)}} - \alpha\left\{\lambda^2 + 2(1+\sigma_w^2+\sigma_g^2)\right\}e^{\frac{-\lambda^2}{2(1+\sigma_w^2+\sigma_g^2)}}} \quad \textbf{................................. (18)}$$

(*) The analytical derivation of K_0 and $E[|y_k|^2]$ are summarized in [11].

6. Threshold Optimization

Output SNR (ψ) in Equation (12) is a non-monotonic function of the threshold value (λ). When λ too small, significant portion of the OFDM signal is replaced with zeros and, as a result, the output SNR is significantly decreased. On the other hand, if λ approaches infinity the impulsive noise may considerably degrade system performance. As a consequence, there is an optimal threshold value λ_{opt} that maximizes output SNR (ψ) the optimal threshold value (λ_{opt}) can be found as the solution of the equation [11]:

$$\frac{\partial}{\partial\lambda}\left\{\frac{\mathbf{E}[|\,\mathbf{y_k}\,|^2]}{\mathbf{K_0^2}}\right\} = \mathbf{0} \quad \text{.......} \quad \mathbf{(19)}$$

Computationally it is more desirable to take logarithm of $E[|\,y_k\,|^2]/K_0^2$ and replace Equation (19) with equivalent equation [11]:

$$\frac{\partial \ln \mathbf{E}[|\,\mathbf{y_k}\,|^2]}{\partial\lambda} - 2\frac{\partial \ln \mathbf{K_0^2}}{\partial\lambda} = \mathbf{0} \quad \text{.......} \quad \mathbf{(20)}$$

Derivatives in left-hand side of Equation (20) can easily be evaluated analytically.

7. Simulation Results

After the proposed system for the OWDM has been designed as shown in **Fig.(3)**, the simulation of this system y using MATLAB version 7 is achieved. Simulations of the OFDM system with various impulsivities (α) and power of impulsive noise to respect to AWGN (γ) are considered and the BER performance is evaluated. Typical values for α are 0.1, 0.01, 0.001, and 0.0001 and that for γ are 1, 5 and 10. The impulse response of the filter h(t) is 9th order low pass filter with cutoff frequency 5MHz. In this simulation the OFDM signal have subcarriers number N=1024, transmitted in AWGN and impulsive noise channel, number of transmission bits are about 30000 bits. **Figure (4)** shows the flowchart of blanking nonlinearity that is used in this work.

Figure (5) shows BER performance versus the threshold value as percentage of maximum absolute value of the received signal for SNR=15 dB, γ=10 and different values of α. It can see from this figure for α=0.001 the best chosen of threshold when it equals 90% of maximum absolute received signal with BER=4*10^{-4}, while BER=0 when blanking nonlinearity is used. Similarly for α=0.1 where the best chosen of threshold equals 40% of maximum absolute received signal with BER=0.1089, while BER=0.1095 when blanking nonlinearity is used. This means that threshold values depends on the level of the received signal and parameters of the impulsive noise and blanking nonlinearity gives good estimation for the optimum threshold.

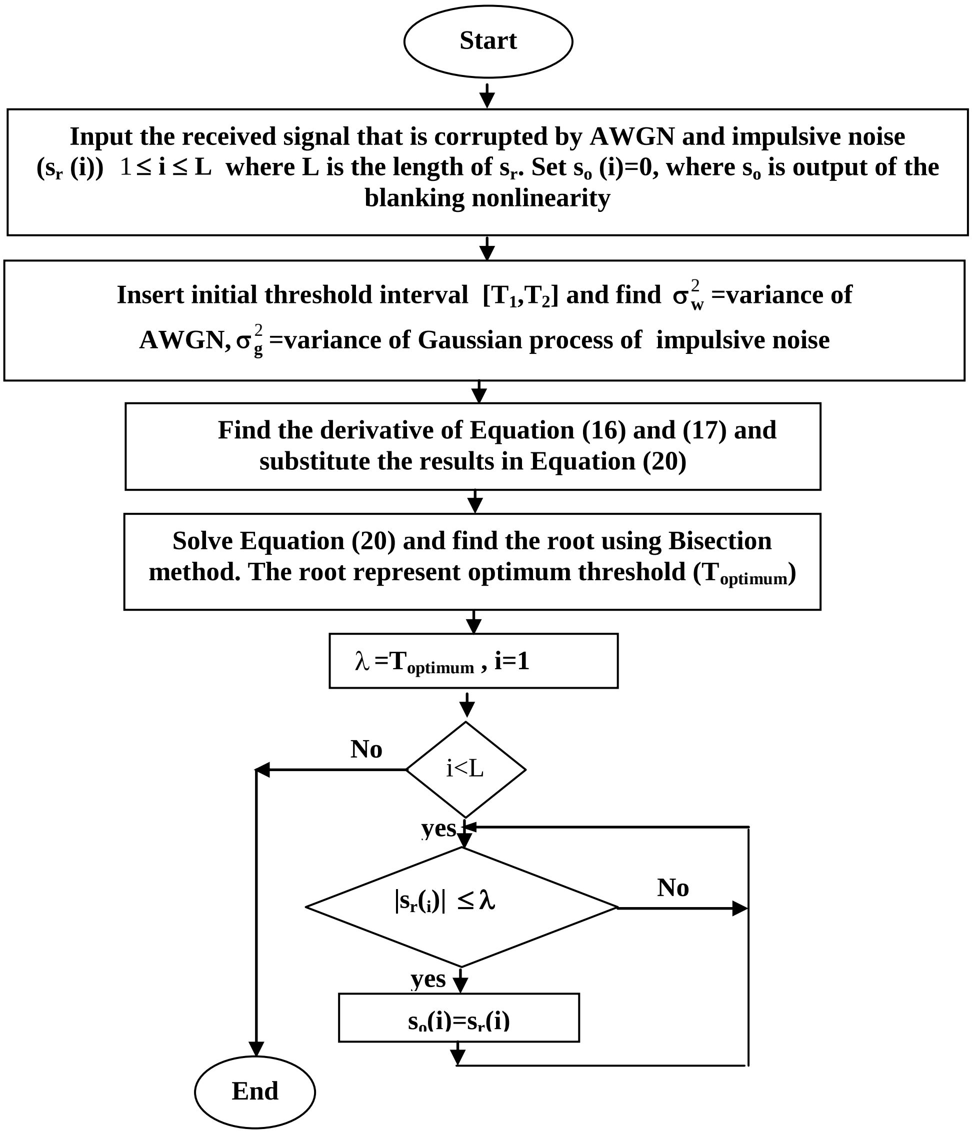

Figure (4) Flowchart of blanking nonlinearity

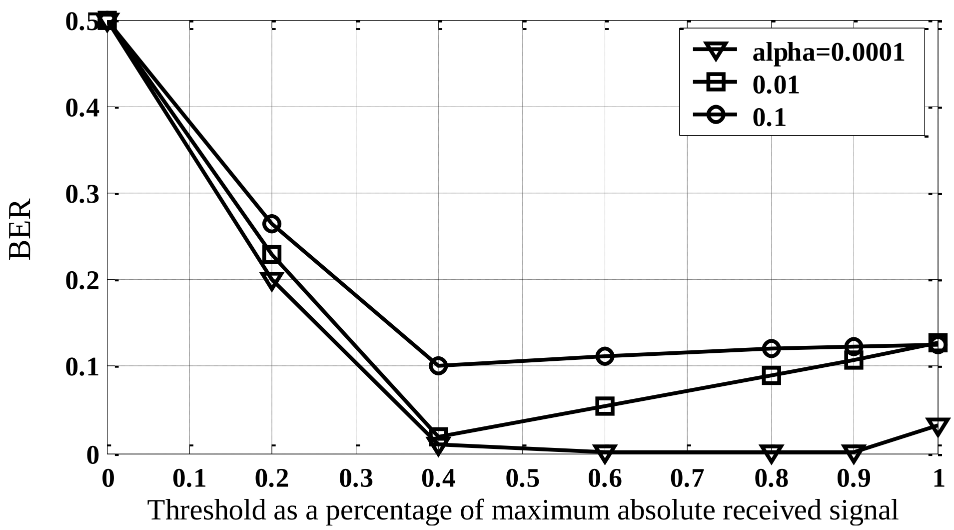

Figure (5) BER performance versus threshold value for SNR=15 dB γ =10 and different values of α

Figures (6, 7 and 8) show the influence of α on the BER performance of an OFDM system with γ=1, 5 and 10 respectively. **Figure (9)** show the effect of γ on the BER performance of an OFDM system with α =0.001. From these figures can be noticed that:

- For high impulsivity (α=0.0001), BER increase and required more SNR to obtain BER about 10^{-4} comparing with AWGN only (i.e. about 2 dB is required for γ=1 and about 6 dB for γ=5).
- Any further increase of α value will increase BER.
- For given γ, when α increase more and more has no effect (or small effect) on BER performance (as can be seen for α=0.01 and 0.1).
- Any increase in γ, will increase BER.

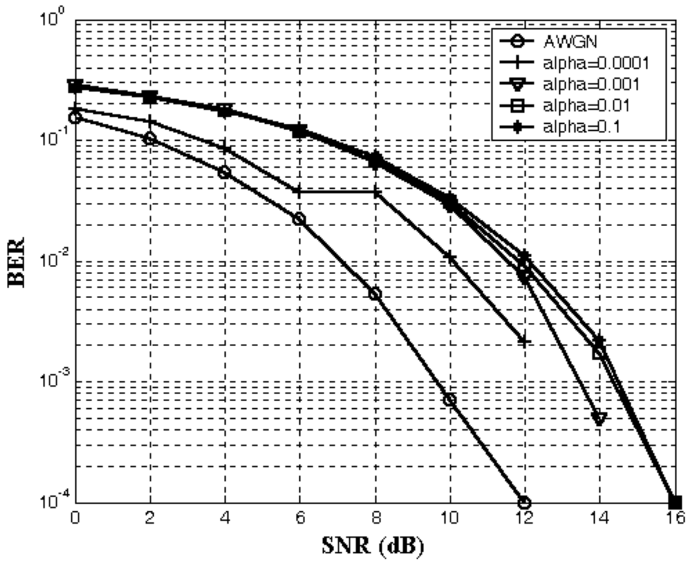

Figure (6) The influence of α on BER performance of an OFDM system with γ=1

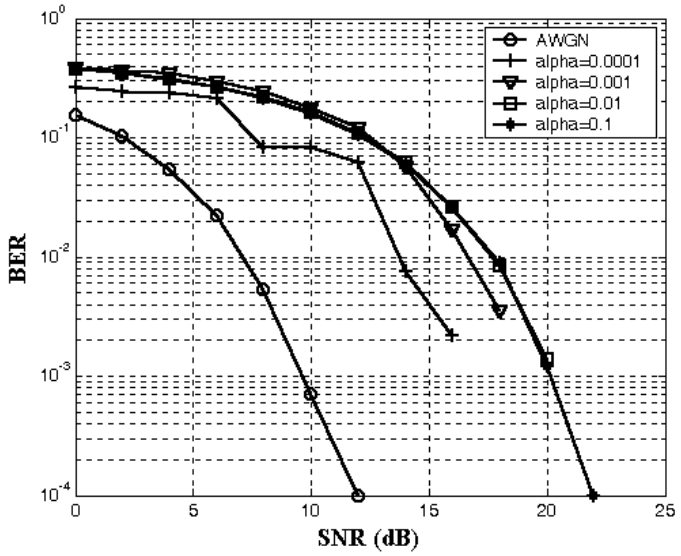

Figure (7) The influence of α on BER performance of an OFDM system with γ=5

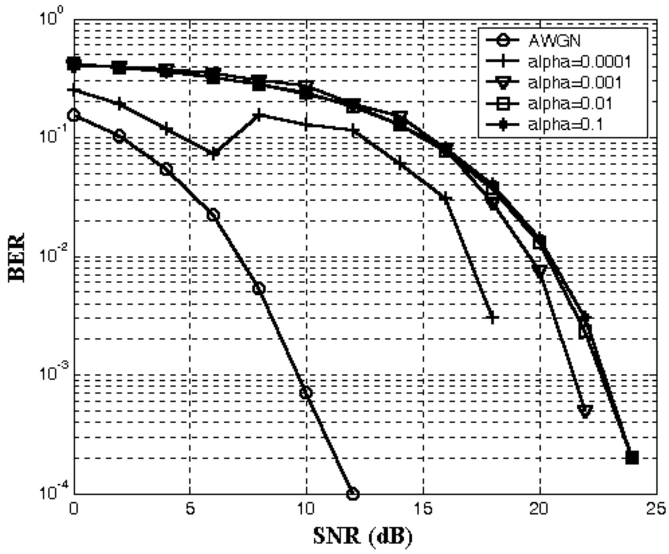

Figure (8) The influence of α on BER performance of an OFDM system with γ =10

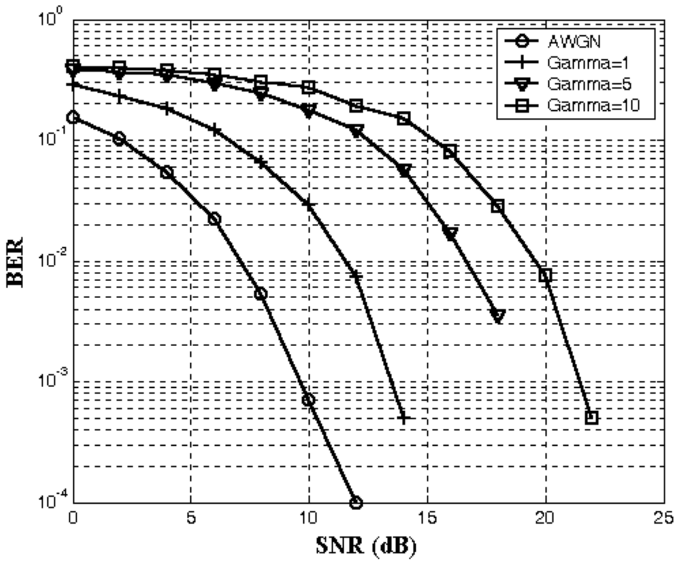

Figure (9) The influence of γ on BER performance of an OFDM system with α =0.001

Figures (10-12) show the influence of blanking nonlinearity on the BER performance of an OFDM system with different values of α and γ =1,5 and 10 respectively. **Figures (13-16)** show comparison results of an OFDM system with and without blanking non linearity method for γ =10 and α =0.0001, 0.001, 0.01 and 0.1 respectively. From these figures some points can be noticed:

- For α =0.0001 and 0.001, the impulsive noise can be suppressed by using blanking nonlinearity method, even though γ is increased.
- For α =0.01, the impulsive noise can be minimized but not fully suppressed. This minimizing becomes less when SNR is increased.
- For α =0.1, the minimizing is very small and special for high SNR.

For high values of α the characteristics of impulsive noise reaches from Gaussian noise and therefore blanking nonlinearity is failed to suppress the impulsive noise.

In general, the blanking nonlinearity is very good method when is used with an OFDM system with high noise impulsivity (α is small), for every value of γ.

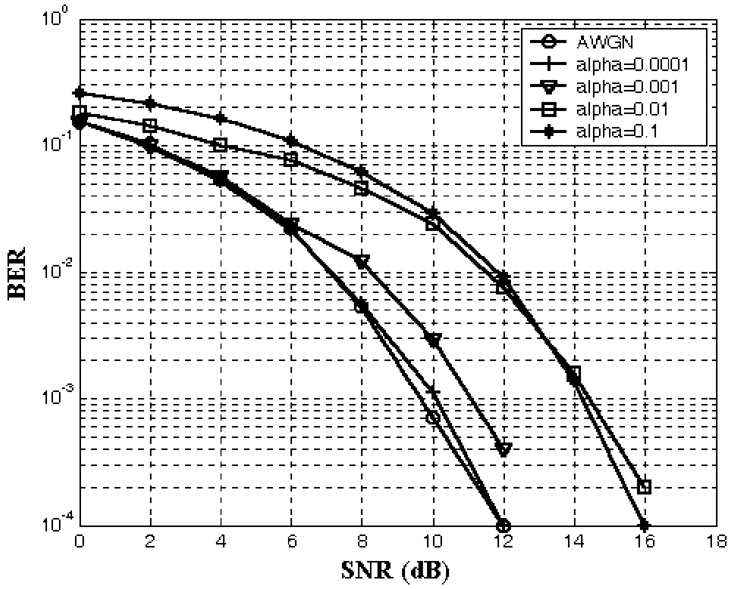

Figure (10) The influence of the blanking nonlinearity on the BER performance of an OFDM system for different values of α and γ =1

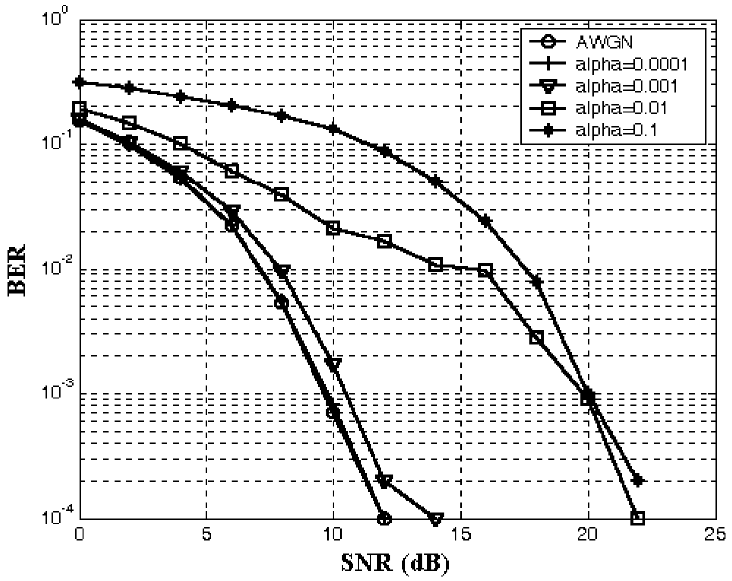

Figure (11) The influence of the blanking nonlinearity on the BER performance of an OFDM system for different values of α and γ =5

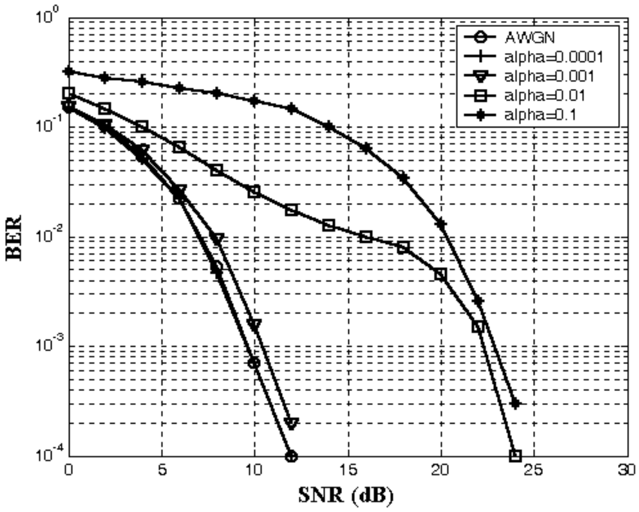

Figure (12) The influence of the blanking nonlinearity on the BER performance of an OFDM system for different values of α and γ =10

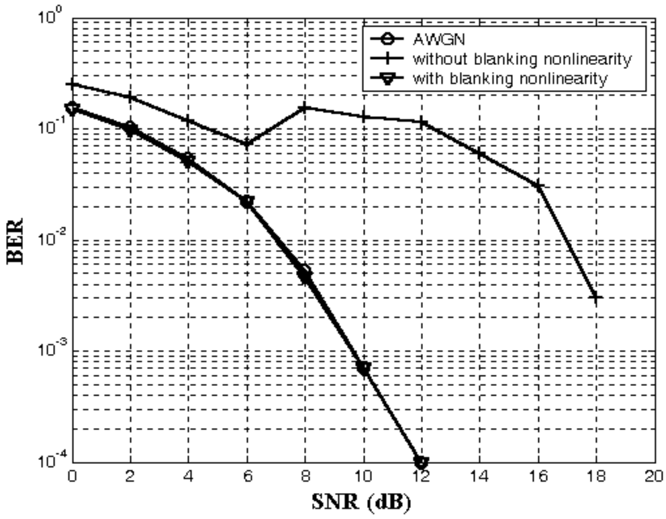

Figure (13) Comparison results of an OFDM system with and without blanking nonlinearity for γ =10 and α =0.0001

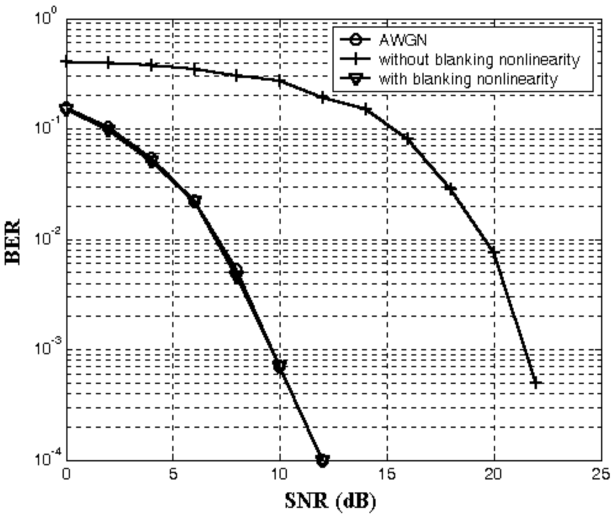

Figure (14) Comparison results of an OFDM system with and without blanking nonlinearity for γ =10 and α =0.001

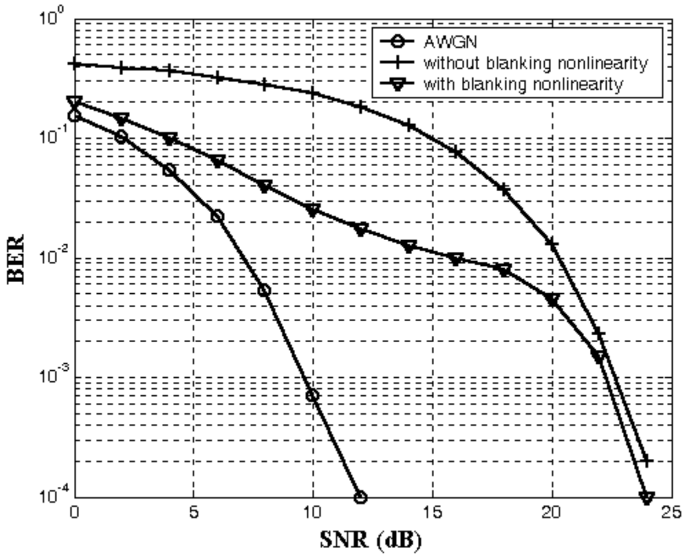

Figure (15) Comparison results of an OFDM system with and without blanking nonlinearity for γ=10 and α=0.01

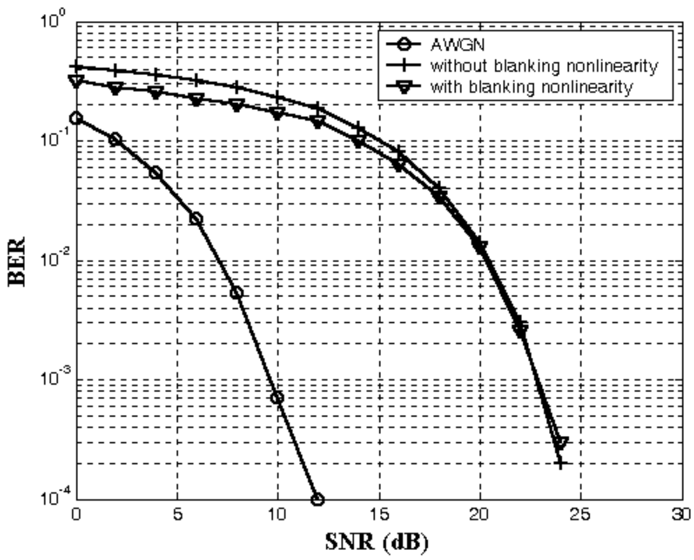

Figure (16) comparison results of an OFDM system with and without blanking nonlinearity for γ=10 and α= 0.1

8. Conclusion

Simulation results show that the performance of an OFDM system in the impulsive noisy environment depends on the impulsivity of the noise (α) and it's power relative to the AWGN (γ). The impulsive noise can be suppressed in an OFDM system by using blanking nonlinearity. But this method is not perfect method for high value of α.

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