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Effect of Adjacent and Co-Channel Interference on AWGN Channel Using 16-PSK Modulation for Data Communication

Amaal Omar Althini [1] *, Hend Hassan Ben-Hamed*[2] *and* Amer *M. Daeri*[3]

[1]*High Institute of Science and Technology, Sorman, Libya*
E-mail asial.mh2013@gmail.com
[2]*College of Electronic Technology, Communication Engineering Department*
Tripoli, Libya
E- mail hendayad1234@gmail.com
[3]Zawia University, Faculty of Engineering/ Computer Engineering Department,
Zawia, – Libya,
E-mail amer.daeri@zu.edu.ly

***Abstract*—Interference is a fundamental nature of wireless communication system that is multiple transmission often take place simultaneously over a common communication media. Interference is a major limiting factor in the performance of cellular radio. It limits capacity and increases the number of dropped calls. It has a direct correlation of quality of communication system. It is a prime issue, and has to be taken into consideration of design cellular wireless communication system. Sources of interference are another mobile in the same cell, a call in progress in neighboring cell, and other base station operating in the same frequency band. There are two major types of interference, co-channel interference (CCI), and adjacent channel interference. 16-PSK digital modulation technique has a good performance in wireless frequency band, and widely applications on wireless communication. Three interference signals are introduced on AWGN channel. The effect of this interference is analyzed, and simulated using Matlab.**

***Keywords*—CCI; ACI; 16-PSK; AWGN.**

I. INTRODUCTION

The core concept of the cellular communication is the frequency reuse. Frequency reuse is a technique of reusing channels, and frequencies within a communication channel to improve capacity and spectral efficiency, but interference is introduced due to the common use of the same channel may occur if the system is not properly planned. This type of interference is called co-channel interference (CCI), it is the most critical one, which occur in cellular radio, and it depends on the cellular traffic. At the busy hours of a cellular system, the greatest possibility of appearing of co-channel interference. [1].

The interference between two adjacent channels of the adjacent cells is known as adjacent channel interference (ACI). "Adjacent channel interference results from the equipment limitations, mainly from imperfect receiver filters, which allows near by frequencies to leak into the passband. This interference can be minimized through careful channel assignments by keeping the frequency separation between each channel in a given cell as large as possible". [2].

"Mary modulation technique is the most important technique in digital communication, where group of n-bits can be expressed into a symbol that again ismapped into one out of a set of $M=2^n$ waveforms". The main object of any modulation format of digital communication is to transmit as much information as possible with certain energy level in the transmitted signal. This modulation scheme provides low bit error rate at low received signal to noise ratios, and well performance under wireless fading environments, requires less bandwidth, and easy implementation. The existing modulation technique may not satisfy all the schemes together, but some of them depending on the application requirements. [3]

16-PSK technique is selected to represent the modulation scheme in the proposed communication system, which is simulated by using Matlab program; the interferences are modified to obtain best results.

II. WIRELESS COMMUNICATION SYSTEM

Typical wireless communication system is represented in figure (1).[2].

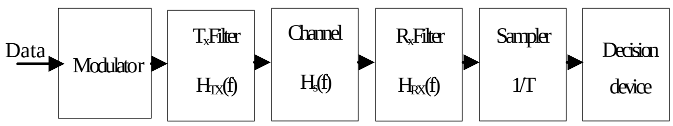

Fig. 1 typical wireless communication system

As seen in the figure the output of the modulator is filtered by the transmitter filter with frequency function $H_{TX}(f)$, which is band limiting filter, then the signal is transmitted over a radio channel, which can represented as filter with frequency function Hc(f), then the signal is filtered by the receiver filter with frequency function $H_{RX}(f)$. The target of this filter is to minimize the noise. Consider the extreme case the channel is AWGN channel. The receiver is followed by a sampler that

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provides estimates of signal once per symbol period T, then the task of the receiver filter is to maximize the signal to noise ratio (SNR) at the end of the symbol period t=T. This means the filter should maximize signal instantaneous power at time t=T and minimize noise average power. [4]

Raised cosine filter is the most common filtering technique, which is used in the most of communication applications, this filter is divided into two parts, one placed in the transmitter, and the other in the receiver, each one is called square root raised cosine filter. [5, 6].

III. 16-PSK

16- Phase Shift Keying is Mary modulation technique, which is instead of sending one bit as in binary digital modulation technique, here n-bit can be sent at a time, where one symbol would represent n number of bits.

$M = 2^n$ (1)

Where M represent the number of symbols.

For 16-PSK four bits are combined to form 16 symbol, therefore phase shift is:

$$= \frac{2\pi}{16} = \frac{\pi}{8} = 22°$$

The duration of each symbol of 16-PSK will be $4T_b$, where T_b The duration of each bit.

The transmitted signal in Mary is represented as:

$$s(t) = \sqrt{2P_s}\ \cos(2\pi f_0 t + \emptyset_m) \qquad (2)$$

Symbol phase angle $\emptyset_m = (2m+1)\frac{\pi}{M}$ (3)

Where: m=0, 1, 2,…, M-1

P_s power of the symbol.

F_o frequency of the transmitted signal.

The power spectral density is:

$$S_b(f) = 2P_S T_S \left[\frac{\sin(\pi f n\, T_b)}{\pi f n\, T_b}\right]^2 \qquad (4)$$

Where: T_S symbol duration.[7].

IV. CONSTELLATION DIAGRAM

The transmitted digital signal refers to a point in the vector, space that called constellation point. All these constellation points are shown in a diagram, known as constellation diagram. It provides a geometrical representation of all possible symbol states in amplitude and phase. The x-axis represent in phase components, while y-axis represents the quadrature-phase components.”Different modulation schemes result in different magnitude of distance between the constellation points. The distance between the constellation points is a measure of how well a receiver can define a possible symbol when a signal is received. It implies how well a receiver can identify the correct symbol and differentiate from all other possible symbols. The distance between the constellation points refers to the degree of probability of error”.

The constellation diagram of 16-PSK is shown in figure (2).

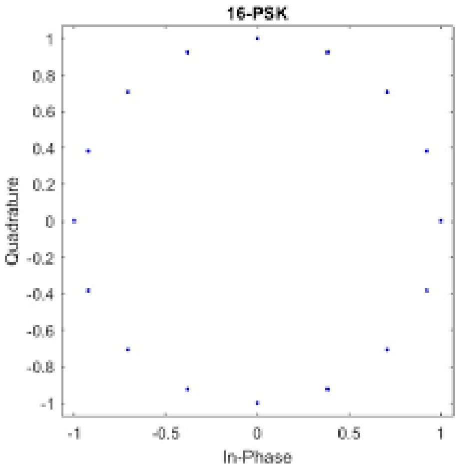

Fig.2 constellation diagram of 16-PSK

As shown in the above figure a 16-PSK would consist of 16 small bright dots that fall in the circle where the permitted phase are $\emptyset(t)=22^o$. But because of radio hardware, generally system imperfection, noise, and interference, the display actually may consist of 16 small clusters. [10,11].

V.AWGN CHANNEL

Digital communication system’s performance is quantified by the probability of bit detection errors in the presence thermal noise. The addition of random signal raising from the vibration of atoms in the receiver electrons is the main source of thermal noise in wireless communication. [8]

It is a basic noise model used in information theory to simulate the effect of many random processes, which is occur in nature. This noise is called additive white Gaussian noise (AWGN) due to the following reason:

- Additive: because it is added to any noise, which might be intrinsic to the information system.
- White: refers to the ideal that it has uniform power across the frequency band for the information system, it is analogy to the color white that has uniform emission at all frequencies in the visible spectrum.
- Gaussian: because it has a normal distribution in the time domain with an average time domain value of zero. [9]

VI. SIMULATION MODEL

The system model can be built in simulink using its libraries of blocks that represent submodules and component. These libraries contain a wide variety of sources, sinks, connectors, and components. Blocks depending on the level of detail required by the design, modeling, or simulation problem. These models can be modified by changing their internal design. [12].

This communication system simulation model as shown in figure (3) includes the following parameter:

- Bernoulli Binary Generator block: generates random binary numbers using a Bernoulli distribution.

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- 16-PSK modulator: modulate the input signal using the phase shift keying method, when the input type parameter is set to bits, the input width must an integer multiple of the number of bits per symbol.
- Raised cosine transmit filter: up sample and filter the input signal using a square root raised cosine FIR filter.
- AWGN channel: Add white Gaussian noise to the input signal.
- Root Raised cosine receive filter: filter the input, and using the square root raised cosine FIR filter.
- Down sampler: use to decrease the sampling rate by an integer factor.
- 16-PSK demodulator: demodulate the input signal using the phase shift keying method.
- Three interference: each of them has a similar to the transmitted signal but has a modified frequency offset and power gain as indicated in thefigure.
- Constellation diagram: display constellation diagram of the received signal.

VII. RESULT AND ANALYSIS

After running the matlab program the following results of the simulated model are accomplished, figure (4)shows the transmitted signal with three interference, includes the additive white Gaussian noise.

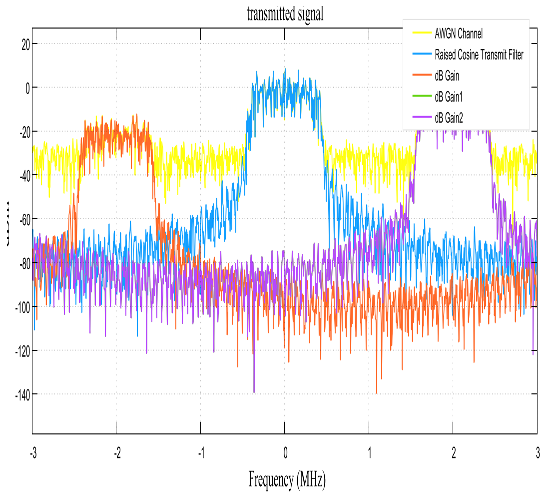


Fig. 4 Power spectrum of transmitted signal.

Figure (5) shows the received signal that the interferences is minimized in this model by using the root square raised cosine filter.

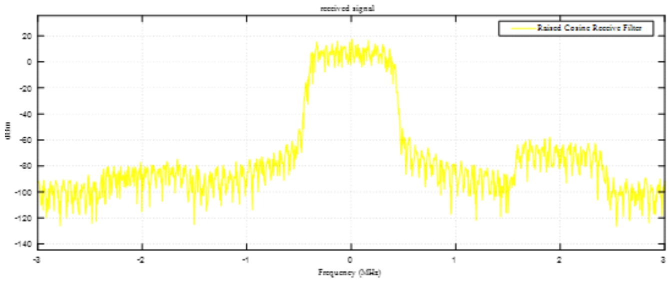


Fig. 5 Power spectrum of received signal

Figure (5) shows the received constellation diagram.

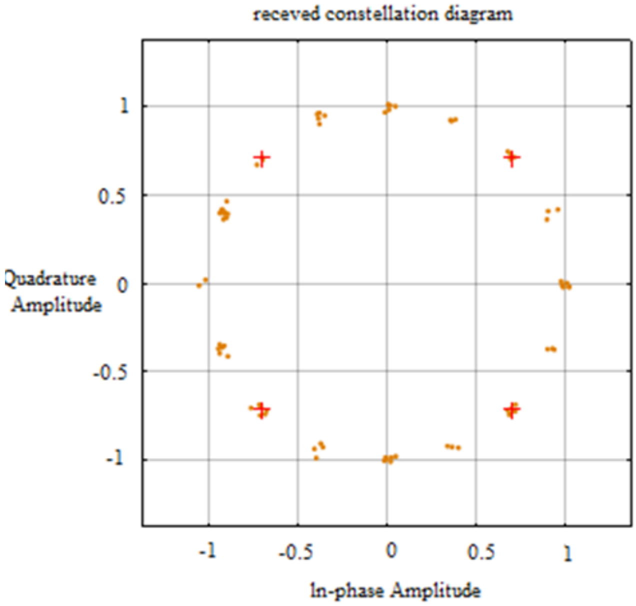


Fig. 6 constellation diagram

To decrease the frequency offset and the negative dB gain of the interference signals, the spectrum analyzer of the transmitted signal shows the interference signals moving from the adjacent channel into the frequency band of the original signal causing co-channel interference that is represented in figure (7)

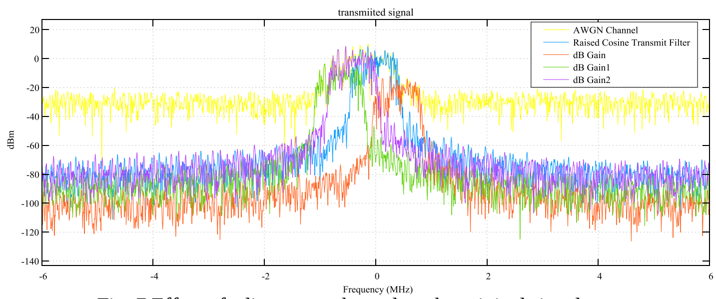
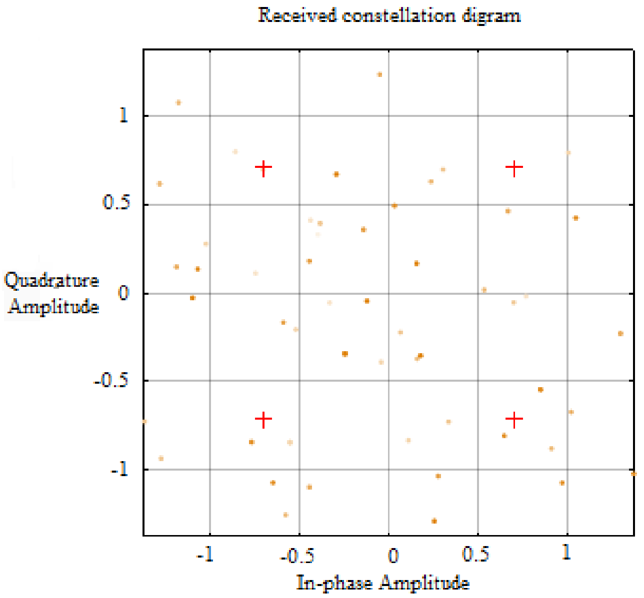


Fig. 7 Effect of adjacent co-channel on the original signal

Figure (8) shows the constellation point of 16-PSK that becomes difficult to demodulate



.Fig. 8 Constellation points of 16-PSK

VIII. CONCLUSION

Effect of adjacent and co-channel interference on additive white Gaussian noise using 16-PSK modulation technique is analyzed, and has been mitigated by using a square root raised cosine filter, which is considered here as a part of the communication system, and by modifying the frequency offset, and the power gain of each interference. Since the received signal quality can analyzed by displaying the constellation diagram of the signal at the receiver, in this case the constellation diagram is uniform, which indicate of minimum effect of interference. While decreasing the offset frequency, and power gain the adjacent channel moving into the frequency band of the original signal causing co-channel interference. In this case, the constellation diagram has a random distribution that refers to the interference.

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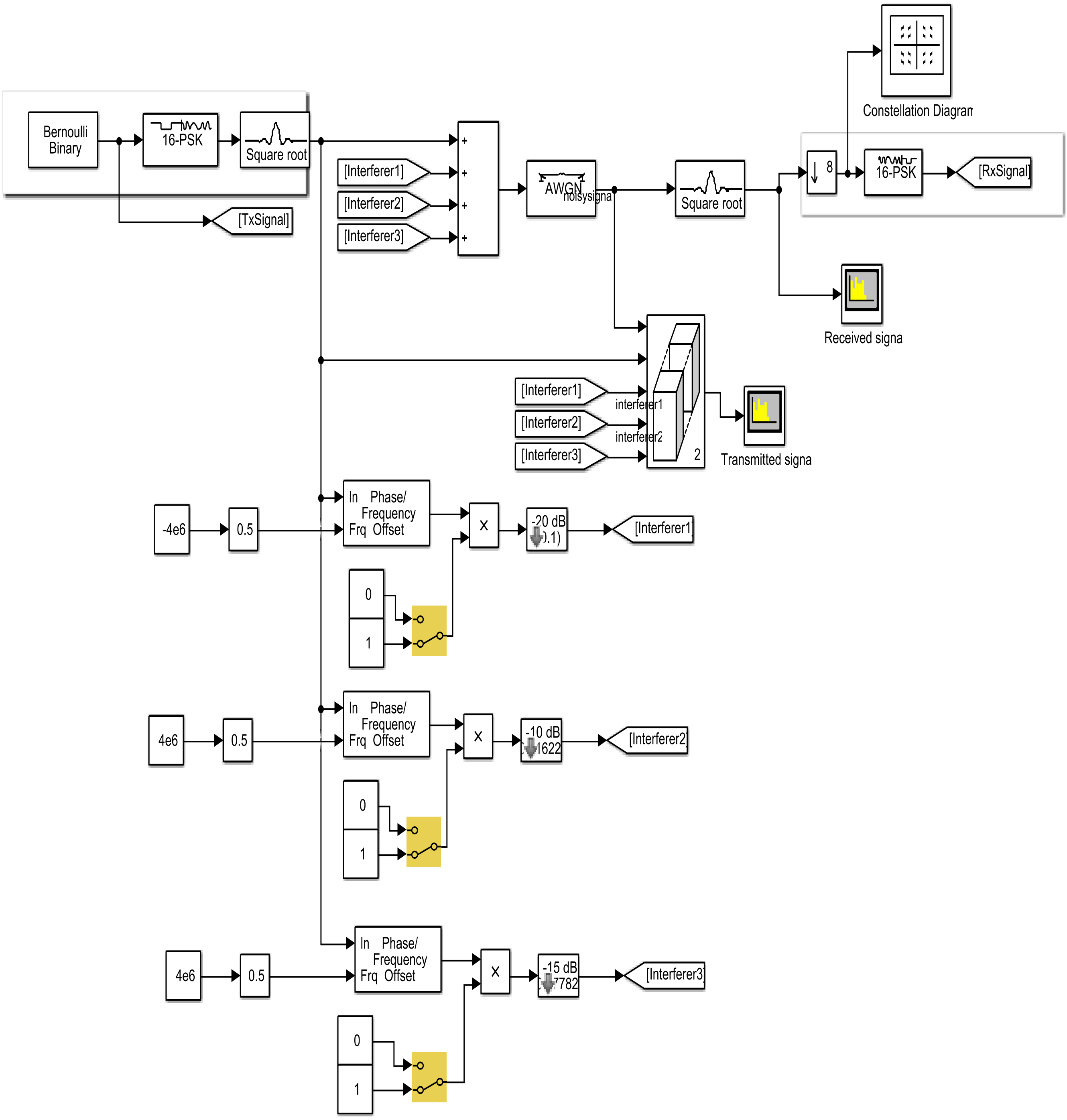

Fig.2 The proposed simulation model