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Performance Analysis of Quadratic Phase Shift Keying Bandpass Modulation Using Simulink

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Abstract—According to the range of frequencies communication systems can be classified into two schemes used to transmit information or data such as baseband and bandpass commutation systems. Baseband transmission sends the information signal as it is without frequency shifting while bandpass transmission shifts the signal to be transmitted from low frequency to a higher frequency and then sends it, where at the receiver side the signal is moved back to its original frequency. Once a digital communication systems becomes complex and sophisticated , a detailed study and investigation is needed in order to understand the different digital modulation techniques to be implemented in the communication system.

In this paper one of the digital modulation techniques known as Quadratic Phase Shift Keying BandPass modulation(QPSKBP) is being investigated to evaluate its performance in terms of Bit Error Rate over the AWGN channel using Matlab with Simulink package. The obtained simulation results are very encouraging. This modulation technique is suitable for transmission and in the same time can save the power and bandwidth.

Keywords—Bandpass Modulation, Bit Error Rate (BER), QPSKBP.

I. INTRODUCATION

Bandpass Modulation (BPM) or sometimes called Passband Modulation (PBM) which refers to modulation of signal over a carrier frequency. In these modulation techniques the signal needs to be transmitted is sent by modulating either one or more of the three properties of carrier signal i.e amplitude together with phase, that is Quadrature Amplitude Modulation (QAM) or Frequency Shift Keying (FSK) or Phase Shift Keying (PSK) of the carrier signal.The Phase Shift keying Band Pass modulation (PSKBP) is one of the main schemes of the M-ary carrier digital modulation. In this type of modulation technique the data bits select one of M-aryphase shifted versions of the carrier to transmit data. Thus, the M possible waveforms all have the same amplitude and frequency but different phases. The use of multiple levels can be extended beyond taking two bits at a time. It is possible to transmit three, four, five bits ... etc. at a time using eight , sixteen, thirty two …. etc of different phase angles respectively .[1,2, 6].

II. BANDPASS MODULATION

The process of converting a data signal to a sinusoidal waveform where its amplitude, phase or frequency, or a combination of them, are varied in accordance with the transmitted data while the result of this processing are representing the amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), quadrature amplitude modulation (QAM) respectively.

The main different between baseband and bandpass modulation is that the baseband does not requiremodulation while the bandpass needs modulation .The bandpass modulation technique is needed for several reasons such as transmittingthe Information for long distance without interference, noise immunity, modulation for bandwidth alteration, modulation to reduce noise and interference ,modulation to increase efficiency of radiation. , modulation to overcome equipment limitation, …etc. [3,4]

III. QUADRATIC PHASE SHIFT KEYING BANDPASS MODULATION

The QPSKBP is one of the M-ary carrier digital modulation schemes and widely used in several communication area application. The mathematical representation and some of the main parameters of the QPSKBP modulation are described briefly in the following points.[1, 5]

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A. Mathematical Representation

An QPSKBP mathematical formula is given by:

$$v_n\left(t\right) = A\cos\left(\omega_c t + \alpha_n\right) \qquad (1)$$

Where :

$$\alpha_n = \frac{2(n-1)\pi}{M}$$

n = an integer number i.e. n = 2

A = Carrier amplitude

ω_c = Carrier frequency in (rad)

M = number of the levels-4

B. Parameters of an QPSK Passband Modulation

The most important parameter of QPSKBP modulation is the bit rate (f_b) which is defined as an amount allowed by a system to transmit data over a communication channel and it is measured by unit bit per second (bps) and baud rate (D) refers to the rate of change of a signal on the transmission medium after encoding and modulation have occurred. Hence, baud is a unit of transmission rate, modulation rate, or symbol rate.i.e

Bit rate $(f_b) = .2$ baud (D).

Also the probability error of QPSKPB calculation involves analyzing the received phase at the receiver in the presence of noise, and comparing it to the actual phases. In an QPSKPB modulation technique the probability of the error rate can be written mathematically as follows :

$$P(e) = \left(\frac{1}{2}\right)\operatorname{erf}\left(\sqrt{\frac{E_b}{N_o}}\right) \qquad (2)$$

Where (erf) is an error function, (E_b) energy per bit

and (N_0) Noise power

IV. QPSKBP SIMULATION MODEL

The QPSKBP transmitter /receiver model is constructed using Simulink as shown in figure 1. This simulation model contains the following parts; random integer generator,M-PSK modulator baseband, raised cosine transmit filter, up-converter, AWGN channel, down-converter, raised cosine receive filter, M-PSK demodulator baseband, error rate calculation.

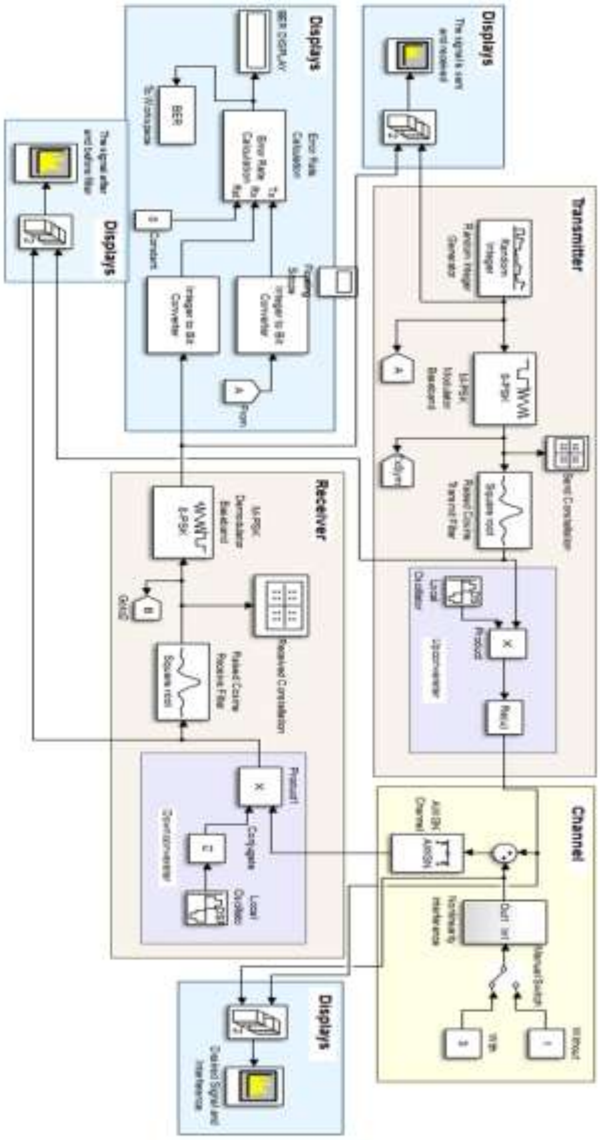

Figure 1 QPSKBP Simulation Model

After implementing and setting the simulation parameters of the transceiver of an M-ary PSK model shown in figure (1) for M=4 i.e QPSK model .Two tests with and without nonlinearity interface are carried out as illuminated in the following points:-

(a) Test I: In this test nonlinearity interface is not considered. The obtained results of simulation, where the power spectra of the transmitted and received random integer signals, the desired signal and interference signal and the power spectra of the signals after the filter at transmitter side and before the filter at the receiver side as illustrated in figures 2 to 4 respectively.

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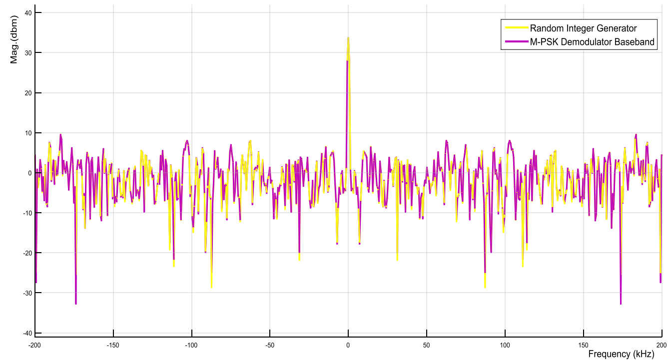

Figure 2 Power Spectra of the Transmitted and Received Random Integer Signals

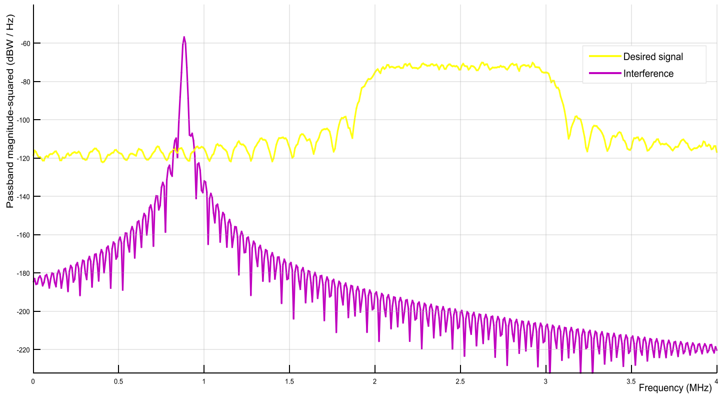

Figure 3 Desired Signal and Interference Signal

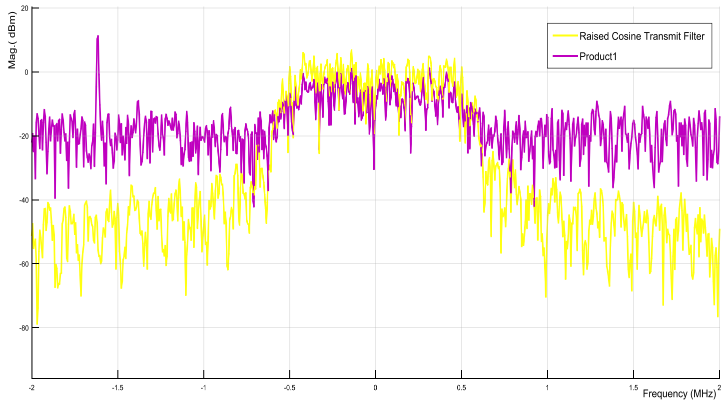

Figure 4. Power Spectra of the Signals After the Filter at Transmitter Side and Before the Filter at the Receiver Side

From the obtained result's, the power spectra of transmitted and received signals are very close and the interference signal has a minimal effect on the desired signal. I.e. when there is no nonlinearity in the channel the QPSKBP performs very well.

*(b) Test II:*This test similar to the first test, but in this case a nonlinearity exist in the channel. The obtained simulation results are shown in figures 5 and 6.The obtained results indicated that there is an effect of nonlinearity on the desired signal and that quite clear from figure 5.

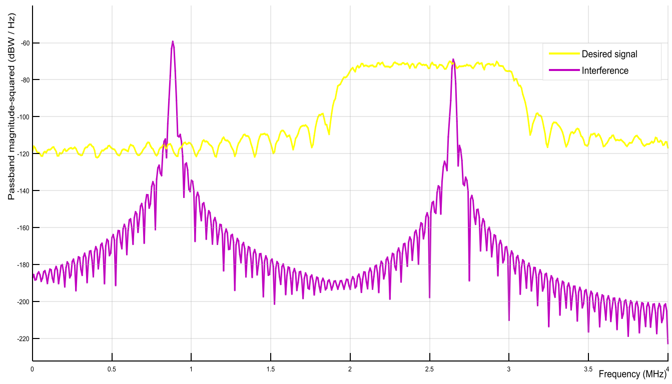

Figure 5 Desired Signal and Interference Signal

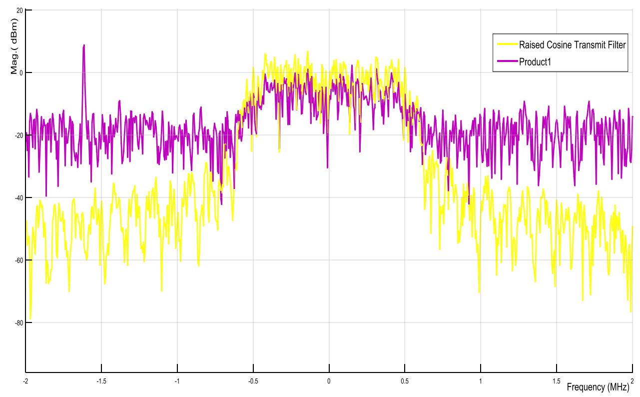

Figure 6 Spectra of the Signals After the Filter at Transmitter Side and Before the Filter at the Receiver Side

V . Performance Evaluation of QPSKBP

The simulation was run several times by varying the E_b/N_o value for both cases with and without nonlinearity interface using the model in fig 1.The range for E_b/N_o at which the BER values are calculated is 0to 8 dB . as shown in figure 7. From the obtained results a comparison chart was generated for the BER for QPSKBP for both test cases with and without nonlinearity interface. From the figure it can be seen that QPSKBP without nonlinearity interface performs better over the QPSKBP with nonlinearity interface. At BER value of 10^{-4}, the AlE_b/N_ovalue was nearly 8 for the case without nonlinearity interference and was close to 10 for the case when nonlinearity interference existed.

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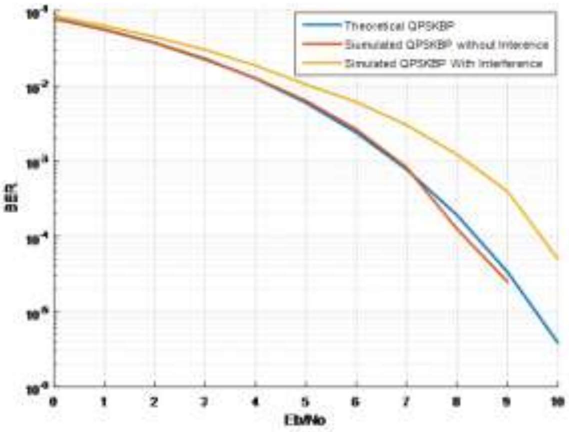

Figure 7 *Bit error rate probability for QPSKBP over AWGN Channel*

VI CONCLUSION

From the obtained results it can be concluded that QPSKBP without nonlinearity interference performs better than QPSKBP modulation with nonlinearity interference in terms of BER, which indicates that QPSKBP without interference has a better bandwidth efficiency and hence it can be used for systems with less power since it has a better channel frequency error.

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