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Comparing the Performance of Phase Shift Modulation types and Their Efficiency in a Digital Communication System

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Abstract

The power spectral density (PSD) of a modulated signal is a direct indication of the bandwidth efficiency of the modulation scheme. A modulated signal with wider PSD consumes more transmission bandwidth compared to a signal that has narrower PSD. This research will provide expression for high power spectral density without increasing in the transmission bandwidth by using of M-ary PSK signals, which can be specialized for M _ 2 (BPSK) , M _ 4(QPSK) ,M-8(OPSK) and M-16. To simplify things, it use the fact that for pass band signals with certain properties. the performance of M-ary PSK modulation will be introduced with a generated noise , in additive white Gaussian noise channel(AWGN) :and compare between the performance of the types above .

مقارنة الأداء لأنواع تعديل الترحيف الزاوي وكفائتها في نظام اتصالات رقمي

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الخلاصة:

ان كثافة طيف القدرة للإشارة المحملة هي دلالة مباشرة على كفاءة عرض الحزمة لخطة التحميل . ان الموجة المحملة ذات كثافة طيف قدرة واسع يستهلك عرض حزمة أكثر للإرسال ، بالمقارنة مع الموجة ذات كثافة طيف قدرة اضيق . هذا البحث يدرس كثافة طيف قدرة عالي بدون الحاجة الى زيادة حزمة الطيف وذلك باست خدام التحميل بطريقة تزحيف زاوية الموجة ،وسيتم هنا دراسة طريقة تزحيف زاوية الموجة الثنائي والرباعي والثماني والمستويات العالية للتزحيف .ولتسهيل العملية سيتم استخدام عرض الموجة المركزي و سيتم عرض أداء تزحيف زاوية الموجة باستخدام قناة الضوضاء كاوس والمقارنة بين أداء الأنواع أعلاه.

1-Introduction

The sequence of binary digits from the source encoder is to be transmitted through a channel to the intended receiver. In general , no real channel is ideal , there are noise disturbances and other interference that corrupt the signal transmitted through the channel . The thermal noise generated in the electronic equipment such As amplifiers and filter used in the transmitter and in the receiver.

Such disturbances corrupt the transmitted signal and cause error in the received digital sequence.[1]

The introduction of redundancy in the information sequence for the purpose of combating detrimental effects of noise in the channel is the second function of the channel encoder . To elaborate on the function performed by the modulator , suppose the information is to be transmitted 1 bit at a time at some uniform rate R bits/s the modulator may simply map the binary digit 0 into a waveform S1 (t) and the binary digit 1 into a waveform S2(t) in this manner , each bit from the channel encoder is transmitted separately . We call this binary modulation . alternatively the modulator may transmitted k information bits at a time by using $M=2^k$ distinct waveforms S1(t),I=1,2,……..M one waveform for each of the $M=2^k$ possible k-bit sequence .we call this M-ary modulation .we note that a new k-bit sequence enters the modulator every K/R second . Hence the amount of time available to transmit one of the M waveforms corresponding to a k-bit sequence is k times the time period in a system which uses binary modulation..At the receiving end of the communications system , the digital demodulator processes the channel corrupted transmitted waveform and reduces each waveform to a single number that represents an estimate of the transmitted data symbol (binary or M)-ary for example , when binary modulation is used , the demodulator may process the received waveform and decide on whether the transmitted bit is a 0 or 1 .in such a case we say that the demodulator has made a binary decision. [2]

The average probability of a bit error at the output of the decoder is a measure of the performance of the demodulator - decoder combination . As a final step ,the source decoder accepts the output sequence from the channel decoder and from knowledge of the source encoding method used ,attempts to reconstruct the original signal from the source . due to channel decoding error and possible distortion introduced by the source encoder and perhaps the source decoder the signal at the output of the source decoder is an approximation to the original source output.[1]

2-Phase shift keying (PSK) [2]

The phase of the carrier is discretely varied in relation either to a reference phase or to the phase of the immediately preceding signal element, in accordance with data being transmitted. Phase of carrier signal is shifted to represent '0' , '1'. As shown in fig(1)

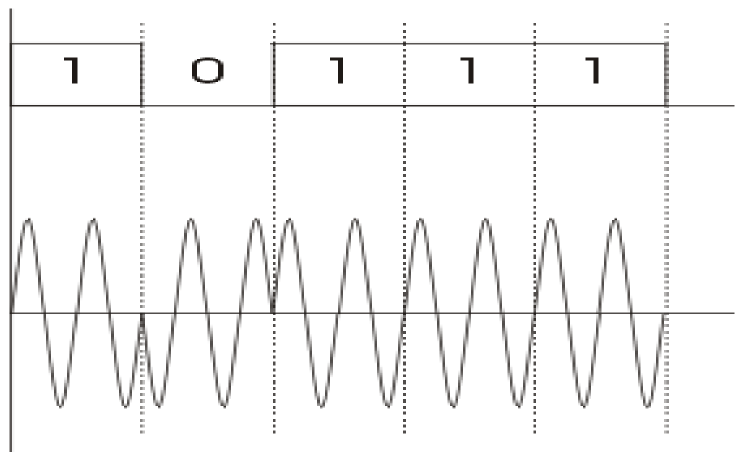


Figure (1): Phase shift keying

2-1Binary phase shift keying (BPSK) [3]

BPSK (also sometimes called PRK, Phase Reversal Keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at 0° and 180°. This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol and so is unsuitable for high data-rate applications when bandwidth is limited.
In the presence of an arbitrary phase-shift introduced by the communications channel, the demodulator is unable to tell which constellation point is which. As a result, the data is often differentially encoded prior to modulation.

2-2Quadrature phase-shift keying (QPSK):- [3]

Sometimes this is known as quaternary PSK, quadric phase (4-PSK) can encode two bits per symbol, to minimize the bit error rate (BER) sometimes misperceived as twice the BER of BPSK.

The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the same bandwidth of the signal, or to maintain the data-rate of BPSK but halving the bandwidth needed. Given that radio communication channels are allocated by agencies such as the Federal Communication Commission giving a prescribed (maximum) bandwidth, the advantage of QPSK over BPSK becomes evident: QPSK transmits twice the data rate in a given bandwidth compared to BPSK - at the same BER.

For determining error-rates mathematically, some definitions will be needed:

Fc = carrier frequency

t = signal duration

n=1,2,3,… [if n=1,then the phase shift is $\frac{\pi}{4}$]

Es= energy of the signal

As with BPSK, there are phase ambiguity problems at the receiving end, and differentially encoded QPSK is often used in practice. the implementation of QPSK is;

$$\mathbf{n(t)}=\sqrt{\frac{2Es}{T}}\,cos\left(2\pi Fc\,t+(2n-1)\frac{\pi}{4}\right),\ n=1,2,3,4. \qquad \text{------(1)}$$

2-3octal PSK [3]

With 8 phases, the error-rate becomes too high and there are better, though more complex, modulations available such as quadrature amplitude modulation (QAM). Although any number of phases may be used, the fact that the constellation must usually deal with binary data means that the number of symbols is usually a power of 2 — this allows an equal number of bits-per-symbol.

2-4The higher –order PSK:- [4]

Any number of phases may be used to construct a PSK constellation but 16-psk is usually the highest order PSK constellation deployed.

3-The bit error rate (BER):- [4]

In Digital transmission the number of bit errors is the number of received bits of a data stream over a communication channel that has been altered due to noise, interference, distortionor bit synchronization errors. The bit error rate or bit error ratio (BER) is the number of bits in error divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure; often expressed as a percentage. The bit error probability Pb is the expectation value of the BER.

(P_b

4-M-ary PSK:- [5]

A Convenient set of signals for M-ary PSK is the set

$$\emptyset i(t) = A\cos(Wct + \theta i) \qquad \ldots\ldots(2)$$

$0 \le t \le ts$

Where the M possible phase angles

$$\theta i(t) = 0, \frac{2\pi}{M}, \frac{4\pi}{M}, \ldots\ldots, \frac{2(M-1)\pi}{M} \qquad \ldots\ldots\ldots(3)$$

The one-side power spectral density of M-ary PSK,for a random binary input with equiprobable 1's&0's at a bit rate.

$F_b = 1/T_b$;

$$S\emptyset(w) = A^2\, Ts\, Sa^2\, [(w - wc)\frac{Ts}{2})] \qquad \ldots\ldots\ldots..(4)$$

Where Ts is the unit symbol duration given by:

$$Ts = Tb \log_2 M \qquad \ldots\ldots\ldots(5)$$

Because the minimum required band width is (B=fs) the potential band width efficiency of M-ary PSK is

$$\frac{fb}{B} = \log_2 M \quad bps/Hz \qquad \ldots\ldots\ldots..(6)$$

5-AWGN channel

AWGN is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude.[6]

Review of Gaussian signal if (n) in continuous channel (gaussion) [7]. then

$$)= \frac{Number\ of\ bit\ in\ erroe}{Total\ number\ of\ transfered\ bits}$$

$$P(n) = (1/\sqrt{2\mu}*\sigma) * e^{(-1/2*((n-\mu/\sigma)^2))} \qquad \ldots\ldots\ldots\ldots(7)$$

Where

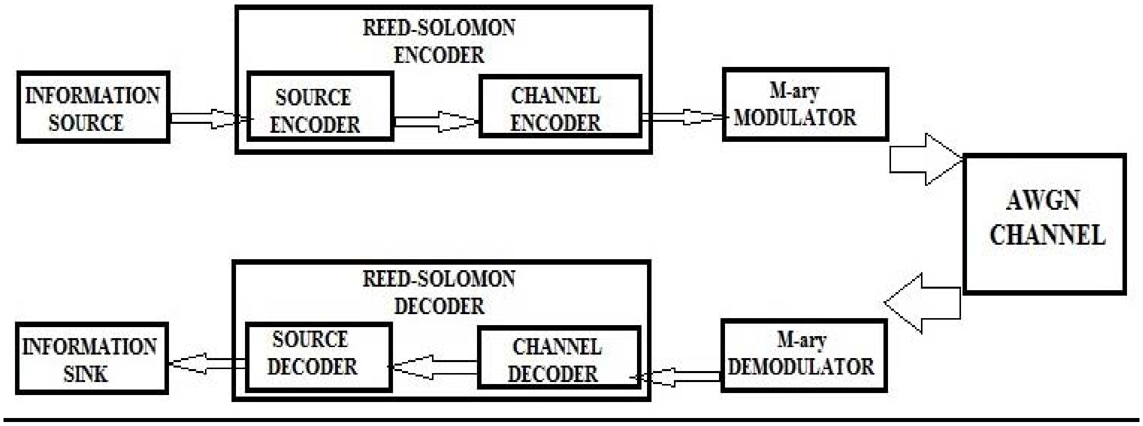
$\mu = \bar{n}$

$\sigma^2 = n^2 - (\overline{n})^2$

σ^2=variance

6-Block Diagram of Experimental System Mode.

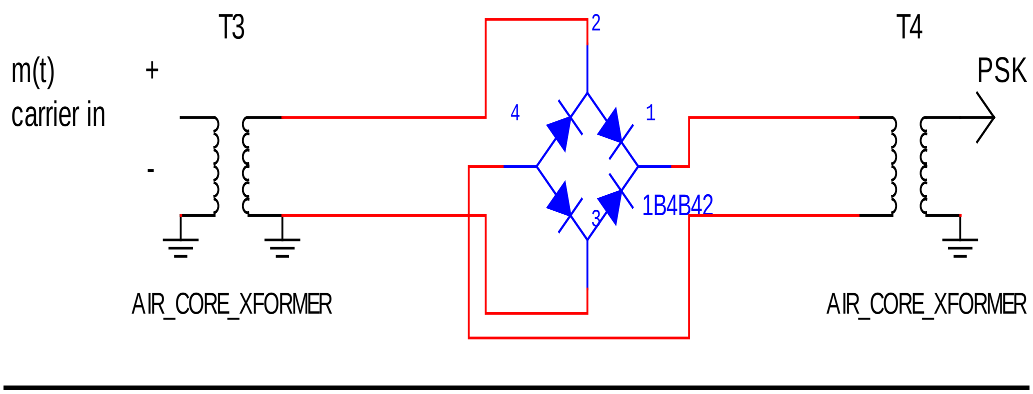
Figure(2) shows the communication system which is used in this paper .It used Reed-Solomon encoder and decoder . Then it presents the part in the system where the M-ary modulation and demodulation in AWGN channel is happened.



Figur (2) Block Diagram of Experimental System Model

7-The experimental circuit for modulation:

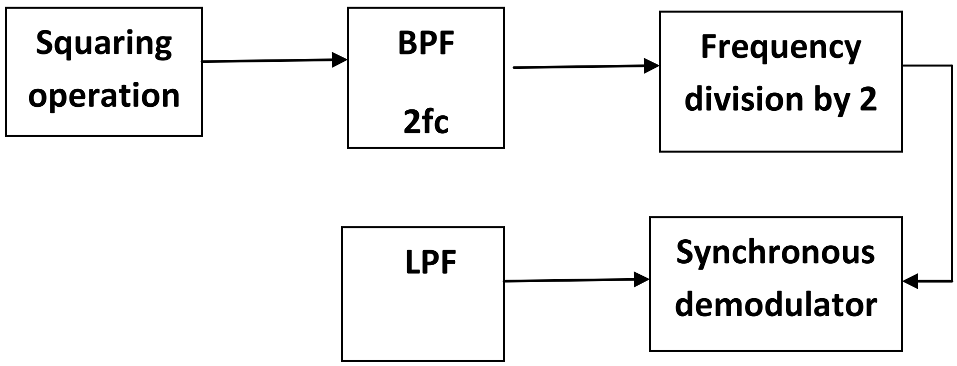
The modulated signal is shown in figure (5-a and 5-b) for a short segment of a random binary data-stream .this signal is the output of the circuit in figure (3).



Figure(3): BPSK modulator

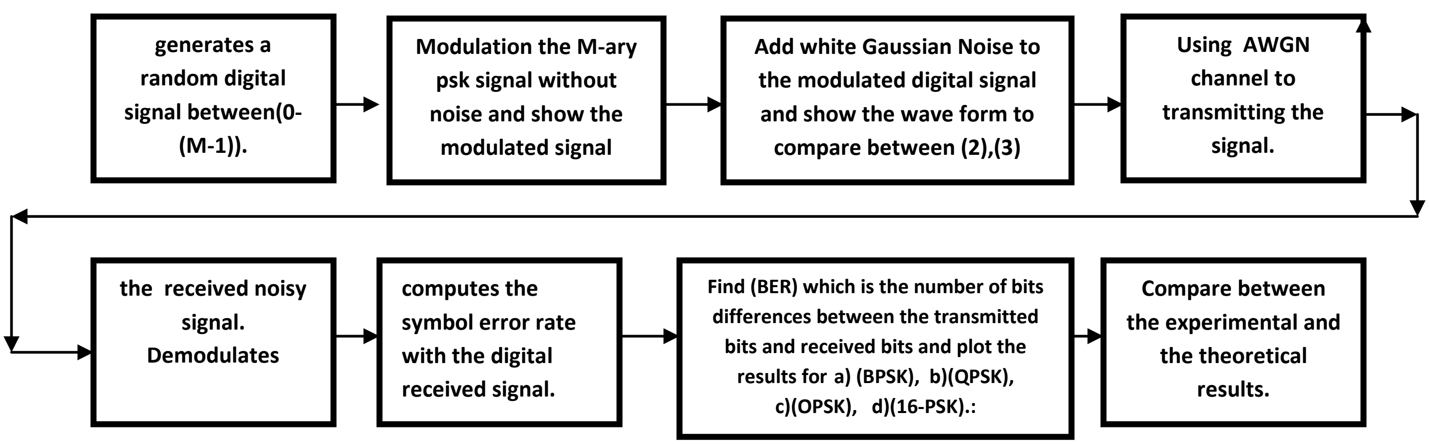
8-Block Diagram of Experimental System for Demodulation.

At figure (4),the signal is demodulated by taking the band pass values of the frequencies ,and at last take the output of high values of frequencies by filtering the low values using low pass filter.



Figure(4): BPSK demodulator

9- Flow chart of the work.



10-Experimental Values:

put symbol rate=2000 .

fd=1{signal frequency}

Fs=2{sampling frequency}

Fs>= fd (nyquist theorem)

3-input any value of $M = 2^i$ where i=1.2.3……..

4-using the equation $m = \log(M)/\log(2)$ to find the number of bits used to the M-ary PSK modulation

5-bit rate=symbol rate*number of modulation bits

6-make transmitted bit =600000 .

7-make (SNR)from(0db)to(1db).

8-generate a vector of random transmitted bit

9-modulate the M-ary PSK signal.

10-apply (AWGN) channel

Note:-the modulated data is a complex data having real and image parts .the signal after(AWGN)channel is the sum of new real and image parts to modulated signal .

11- demodulate the signal after(AWGN)channel.

12-find bit error rate (BER)using

13-compare between the theory and practical results for binary ,quadratic, octal and high order PSK modulation .

11- The Results and Discussion :

Output of the circuit in fig.(3)BPSK modulation with and without AWGN (noise)

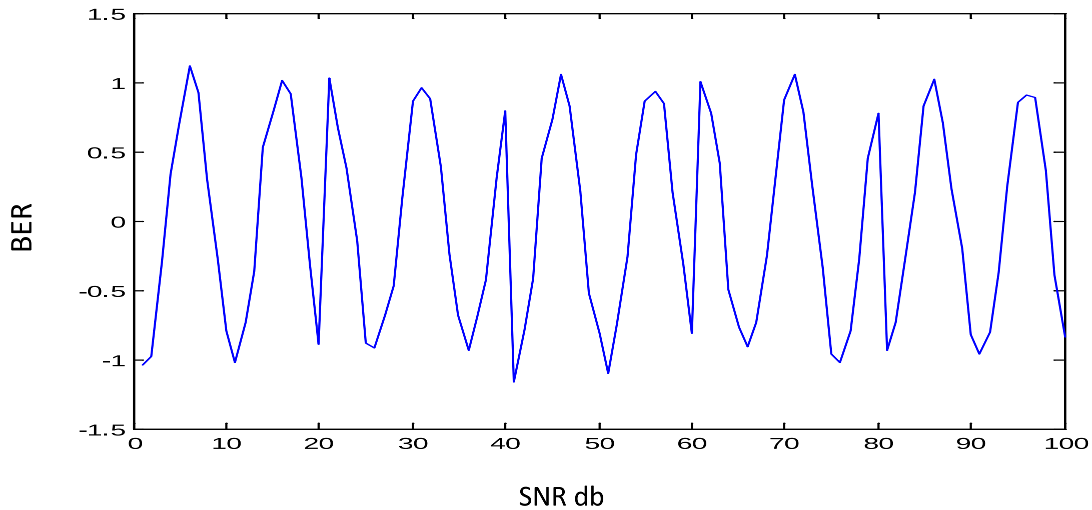
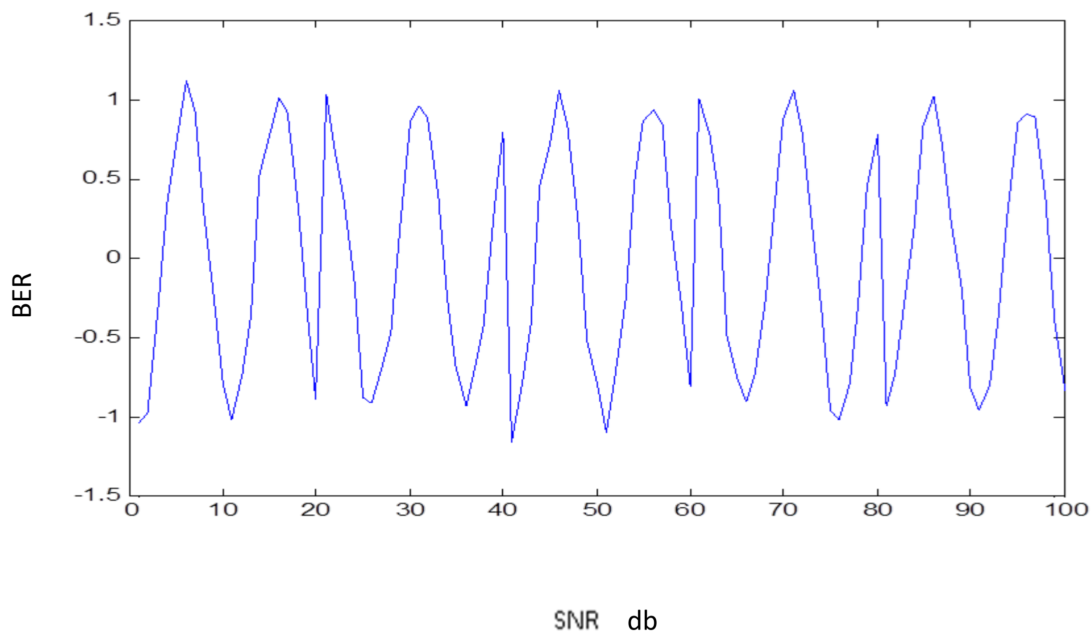
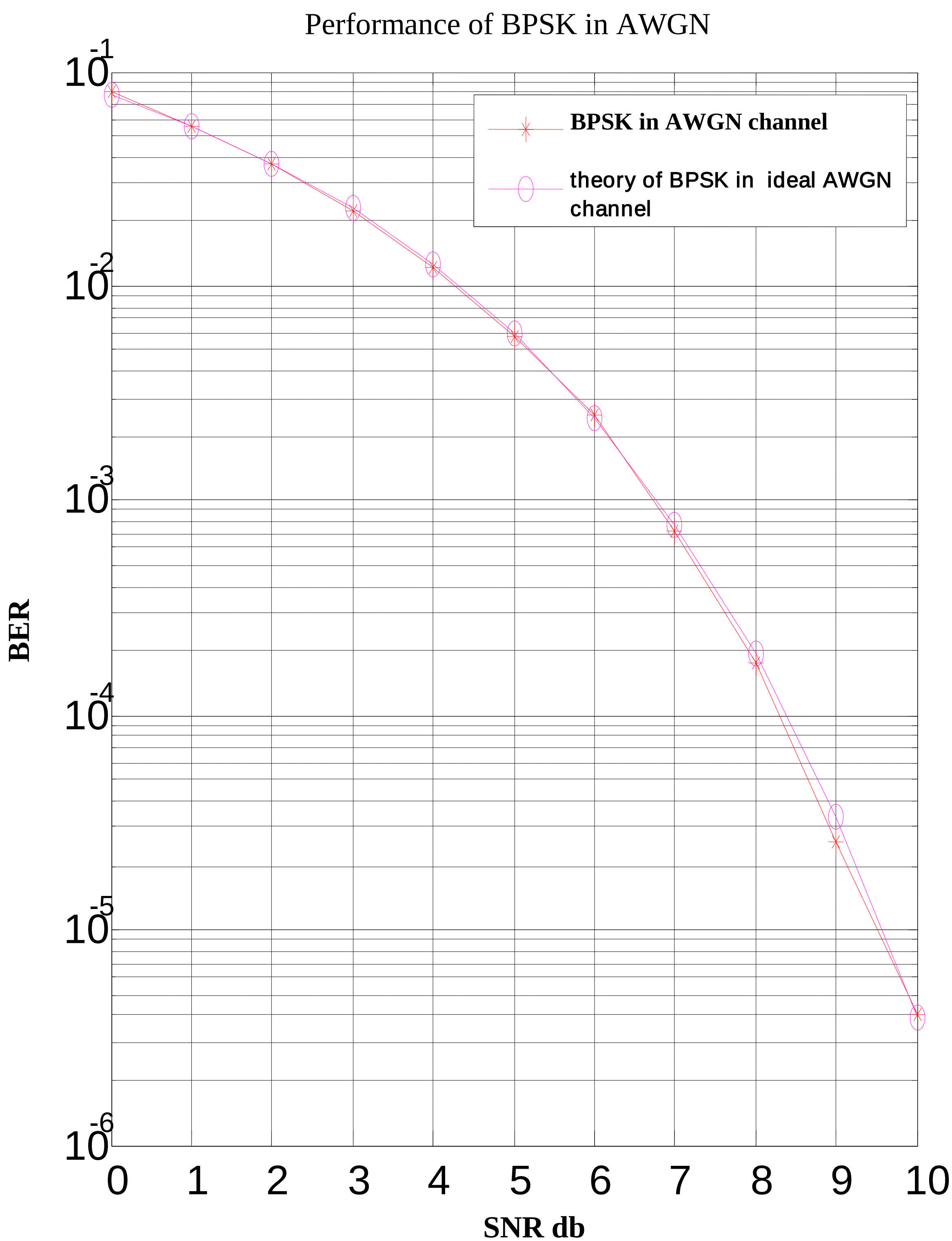


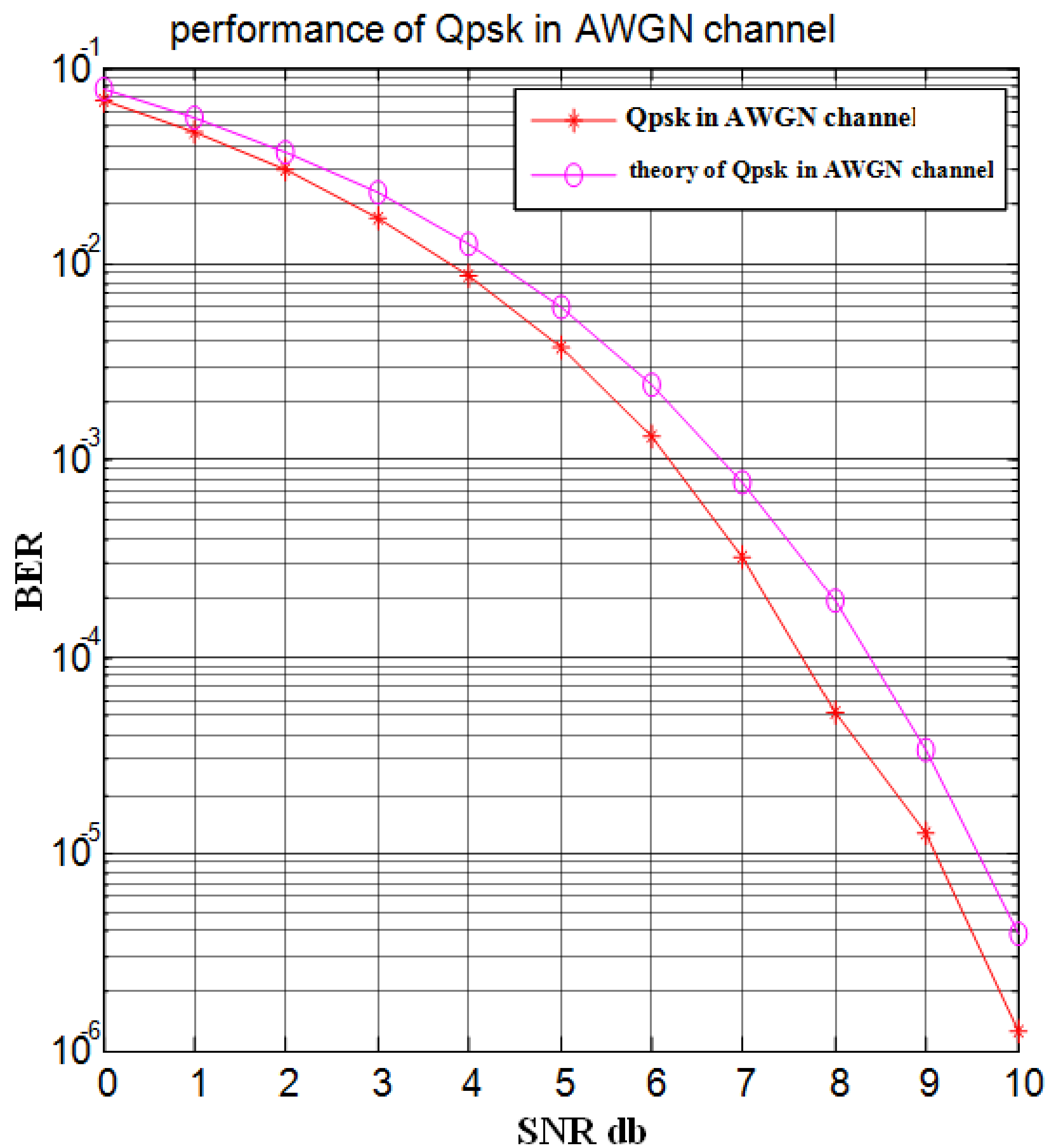
Figure (5-a) The output BPSK modulation with AWGN (noise)



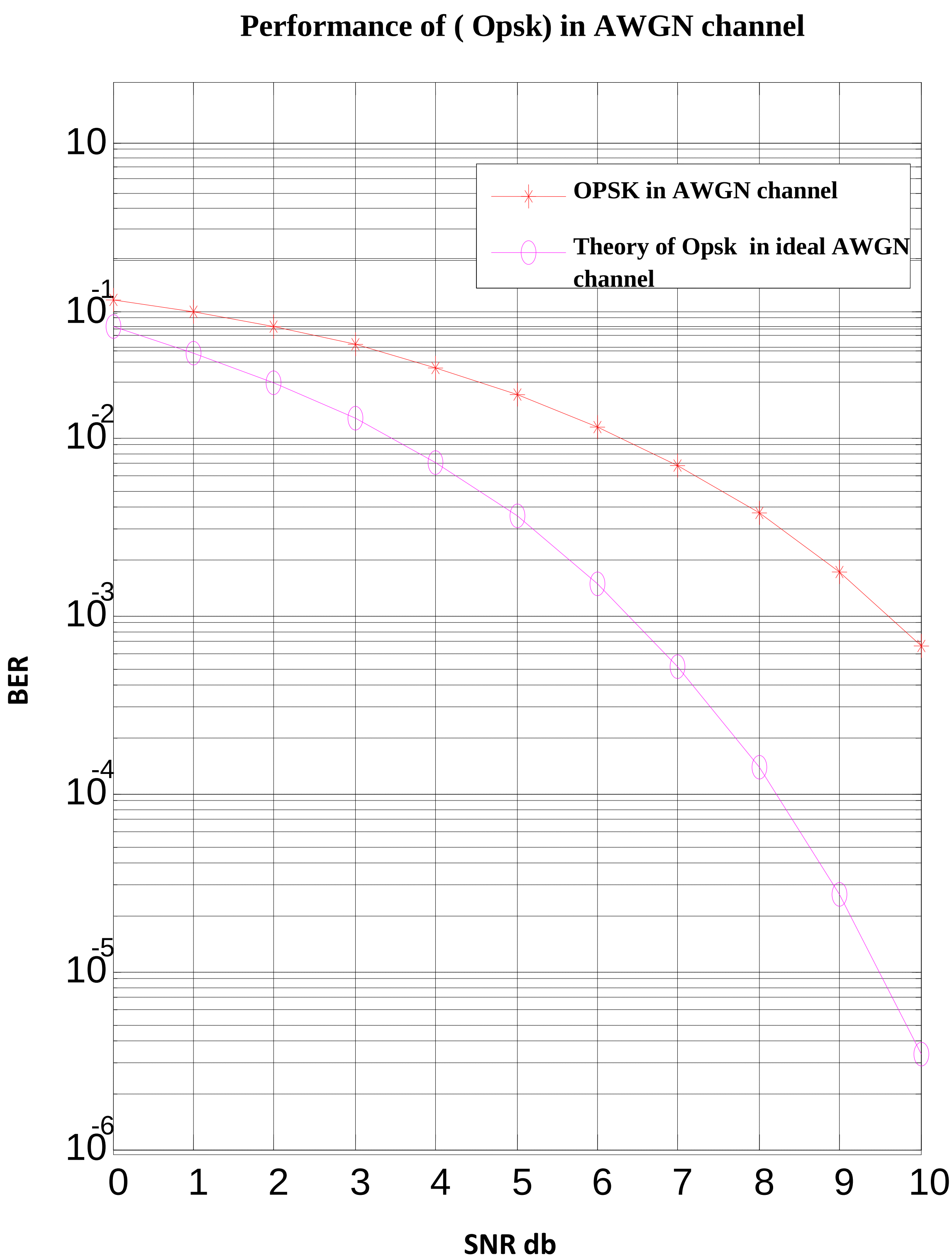
Figur(5-b)The output of BPSK modulation without AWGN (noise)



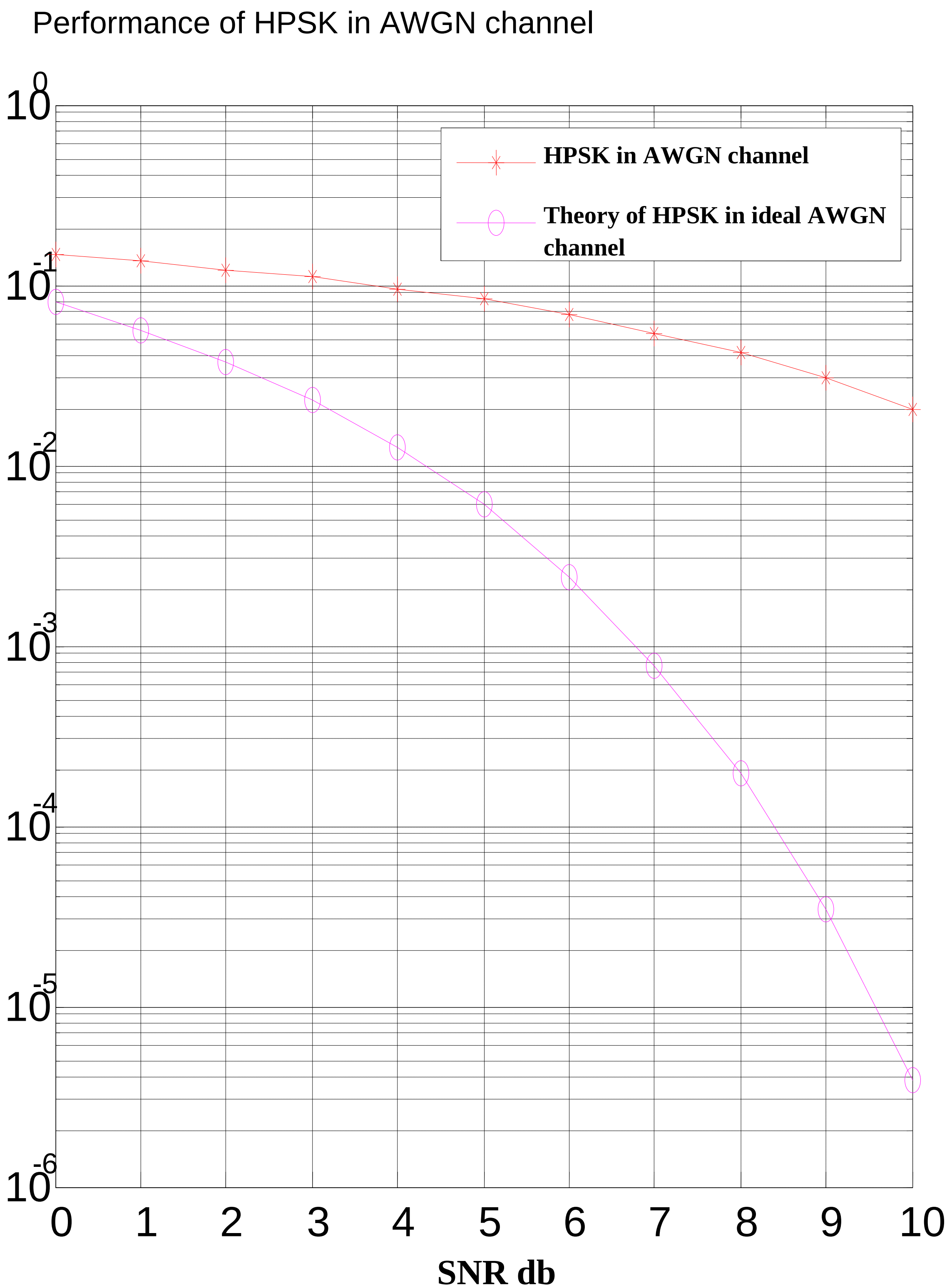
Figur(6) compare between theoretical and practical BER of BPSK in AWGN channel



Figur(7) compare between theoretical and practical BER of QPSK in AWGN channel



Figur(8) compare between theoretical and practical BER of OPSK in AWGN channel



Figur(9) compare between theoretical and practical BER of high order-PSK (M-16) in AWGN channel

Figures (5-a,5-b), shows the output of the circuit in figure (3) .These figures represent the input signal after modulating by BPSK ,with and without adding adaptive white Gaussian noise respectively . The difference between the two cases will became clear when the frequency is increased.

Figure (6),shows the bit error rate with different values of signal to noise ratio for binary phase shift modulation ,and the difference between the theoretical and practical performance of this type of M-ary modulation in AWGN channel .the results in this modulation have a little difference .these results will be more differs when the phase shift be smaller ,as shown in the cases of Quadratic ,Octal and high order phase shift modulation as shown in fig.(7),(8),(9) respectively , where the rate of transmitting information is very high .the best results are founded at QPSK case where the transmitting rate of information is good and there is no big difference between the theoretical and practical results as shown in fig.(7) .

12-Conclusion

Phase error is the instantaneous angle difference between the measured signal and the ideal reference signal. When viewed as a function of time (or symbol), it shows the modulating waveform of any residual or interfering PM signal at figure(5-a,and 5-b).

The mathematical analysis and simulations shows that there is different between the theoretical and practical results specially at the Octal and high order cases, where the rate of transmitting the information is very high. A QPSK system transmits information at twice the bit rate of a BPSK system for the same channel BW due to which QPSK is mostly used in practice. In case of 8-PSK the probability of error is greater as constellation points come closer, but BW of 8-PSK is one third of the BW of BPSK. So, a 8PSK system transmits information at thrice the bit rate of a BPSK system. It is observed from the simulation curves and the mathematical analysis of the signals that as the number of signals or number of M increases, the error probability also increases over AWGN channel. It is seen that higher-order modulations exhibit higher error-rates; in exchange however they deliver a higher raw data-rate. Increasing the data rate will increase the SNR, however, increasing Rb (Bit rate in bits /second) will also cause more noise and noise term also increases, since more bits are packed closer and sent through the channel. So, we cannot increase SNR by simply increasing Rb. We must strike a compromise between the data rate and the amount of noise our receiver can handle.

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