Performance Comparison between DPSK and OQPSK modulation approaches in multi environments channels with Matlab Simulink models

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Performance Comparison between DPSK and OQPSK modulation approaches in multi environments channels with Matlab Simulink models

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Abstract: Phase shift keying modulation approaches are widely used in the communication industry. Differential phase shift keying (DPSK) and Offset Quadrature phase shift keying (OQPSK) schemes are chosen to be investigated is multi environment channels, where both systems are designed using MATLAB Simulink and tested. Cross talk and unity of signals generated from DPSK and OQPSK are examined using Cross-correlation and auto-correlation, respectively. In this research a proposed system included improvement in bit error rate (BER) of both systems in the additive white Gaussian Noise (AWGN) channel, by using the convolutional and block codes, by increasing the ratio of energy in the specular component to the energy in the diffuse component (k) and the diversity order BER in the fading channels will be improved in both systems.

Keywords:- digital modulation, DPSK, Matlab Simulink, OQPSK

مقارنة الاداء بين طرق التضمين من نوع مفتاح ازاحة الطور التفاضلي و مفتاح ازاحة الطور الرباعي المزحف تحت بيئة عدة قنوات مع وجود موديلات المحاكاة بالماتلاب

فاطمة فايض العزاوي ،فائزة عباس عبد , زينب فايض العزاوي

الخلاصة :طرق التضمين من نوع مفتاح ازاحة الطور تستخدم بشكل واسع في صناعة الاتصالات, تم اختيار التضمين من نوع مفتاح ازاحة الطور التفاضلي ومفتاح ازاحة الطور الرباعي المزحف ليتم المقارنة بينهما تحت بيئة متعددة القنوات، حيث تم تصميم النموذج لكلا النظامين باستخدام المحاكاة بالماتلاب وفحصهما. تم فحص التداخل عبر القنوات والوحدانية للاشارات الناتجة من النظامين اعلاه باستخدام الارتباط المتقاطع و الذاتي، في هذا البحث النظام المقترح يتظمن تحسين نسبة معدل الخطأ لكلا النظامين تحت قناة ضوضاء كاوزين البيضاء المضافة باستخدام شفراة من نوع الشفرة الملتوية وشفرة الكتلة، وبزيادة نسبة الطاقة في المكونات المنظارية الى الطاقة في المكونات المنتشرة (K) و رتبة التباعد تم تقليل معدل نسبة الخطأ تحت القنوات الخامدة وتم تحسين اداء كلا النظامين

I. INTRODUCTION

Phase shift keying (PSK) is one of digital modulation techniques that is used in communication systems, for identification of a modulated signal at the receiver, after noisy channels in the communication, which is a complex issue, before receiving a modulation classification is done, in order to recover the transmitted signal at the receiver. PSK is a digital modulation scheme that conveys data by changing (modulating) the phase of a reference signal (the carrier wave)[1,2].

The Differential PSK (DPSK) scheme depends on the difference between successive phases that can be significantly simpler to implement than ordinary PSK, as there is no need for the demodulator to have a copy of the reference signal to determine the exact phase of the received signal (it is a non -coherent scheme). In exchange, it produces more erroneous demodulation [3].

Offset quadrature phase –shift keying (OQPSK) is a variant of phase –shift keying modulation using 4 different values of the phase to transmit. It is sometimes called Staggered quadrature phase-shift keying (SQPSK). Taking four values of the phase (two bits) at a time to construct a QPSK symbol can allow the phase of the signal to jump by as much as 180° at a time [4-7]. When the signal is low-pass filtered (as is typical in a transmitter), these phase-shifts result in large amplitude fluctuations, which is an undesirable quality in communication systems [8-10]. By offsetting the timing of the odd and even bits by one a bit-period, or half a symbol-period, the in –phase and quadrature components will never change at the same time. In the constellation diagram shown on the right, it can be seen that at this will limit the phase-shift to no more than 90° degrees at a time. This yields much lower amplitude fluctuations than the non -offset QPSK and is sometimes preferred in practice[11,12].

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Identification of the modulation of DPSK and OQPSK will be used as modulation techniques in the proposed communication system.
In this article a comparison in performance of the performance of both systems in a multi-channel environment is proposed with design and implementation of DPSK and OQPSK in Matlab Simulink and also decreasing BER of both systems under AWGN, Rayleigh and Rician channels, inequality and cross-talk in multi-signal systems have been examined using auto-correlation and cross-correlation.

II. SYSTEM MODELS

(1) DPSK model

Matlab Simulink is used to build both the proposed systems of DPSK and OQPSK, figure 1 shows the DPSK system (transmitter and receiver), input data is generated and then differentiated using XOR, and one delay block is then modulated with a PSK modulator, which modulatedes the input data with two digital carriers with a phase shift of 180 degrees. figure 2 illustrates waveforms of input signal, differentiated signal and DPSK signal. At the receiver input, data is recovered using the PSK demodulator and de-differentiator, with full recovery.

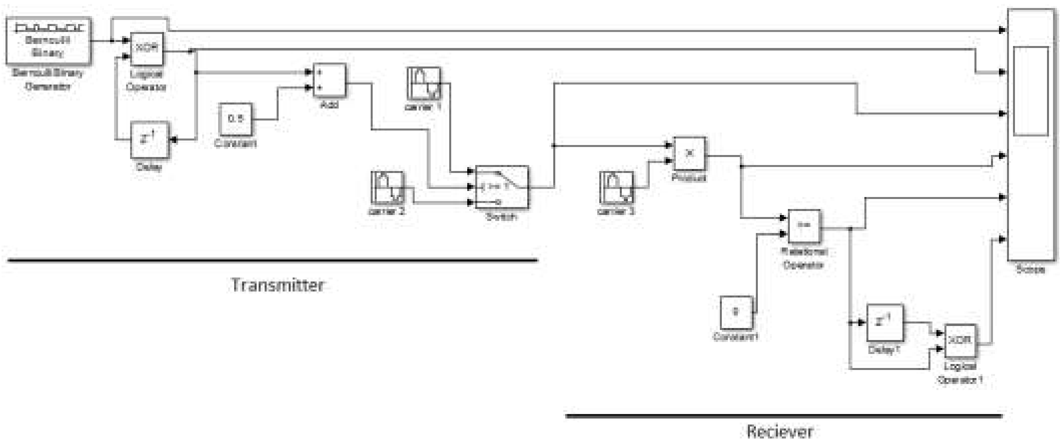

Figure 1: DPSK system using Simulink

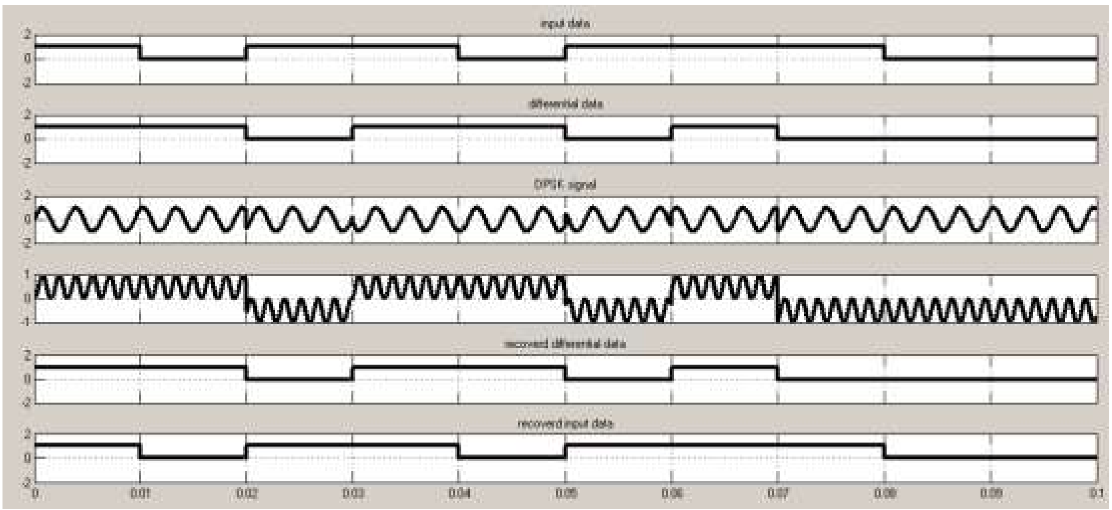

Figure 2 : DPSK waveforms

(2) OQPSK model

The OQPSK design was proposed using Matlab Simulink as shown in figure 3, where input data are generated by using the Bernoulli binary generator. First (tree) D flip-flop and j-k flip-flop will generate the quadrature for the modulation process, which means there will be two lines of data, real and imaginary, or in-phase and quadrature phase. The last D flip-flop will be making the offset action of modulation where an imaginary line will be delayed by pi/2 on the real line. Following that the input data (real and imaginary) will be modulated using PSK. As a result the OQPSK signal will be generated as shown in figure 4.

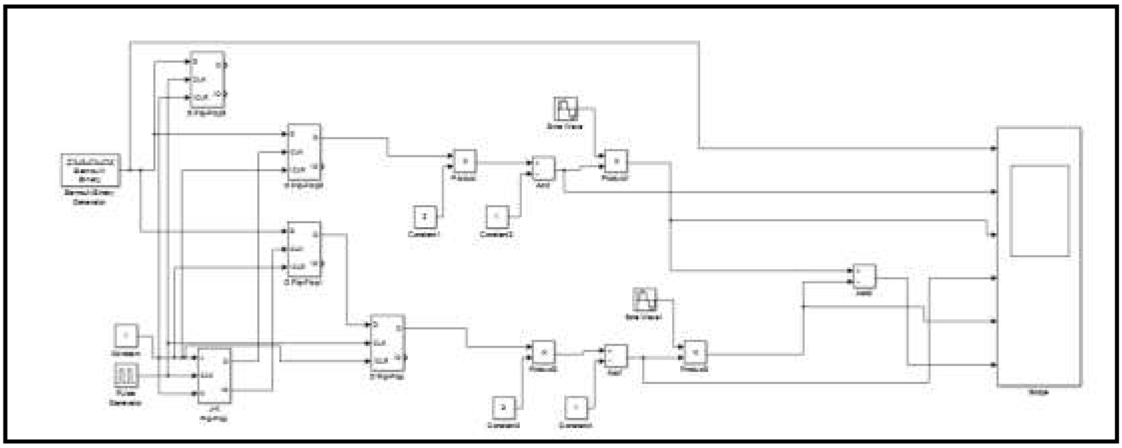

Figure 3: OQPSK modulator

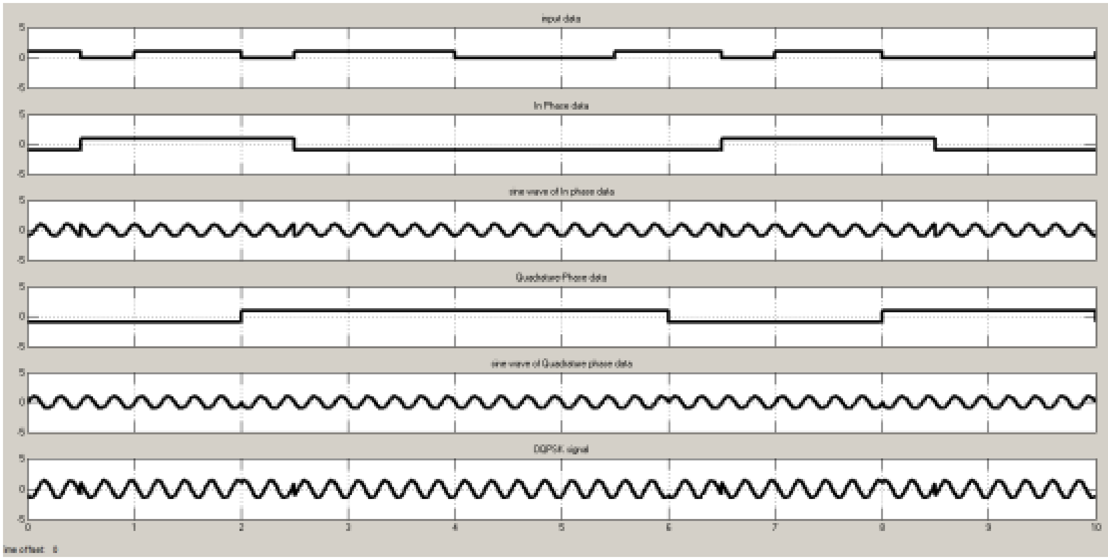

Figure 4: Input data, In-phase data, sine wave of in-phase data, Quadrature-phase data, Sinewave Quadrature-phase data, OQPSK signal

III. BER EQUATIONS OF DPSK IN MULTICHANNEL ENVIRONMENTS AND CODING

1. *DPSK in AWGN*

M-DPSK under AWGN BER equation is [2]:

$$P_s = \frac{\sin(\pi /M)}{2\pi} \int_{-\pi/2}^{\pi/2} \frac{\exp\left(-(kE_b /N_o)(1 - \cos(\pi/M)\cos\theta)\right)}{1-\cos(\pi /M)\cos\theta} d\theta \ldots (1)$$

The following expression is very close, but not strictly equal to the exact BER [3]:

$$P_b = \frac{1}{k} \left(\sum_{i=1}^{M/2} (\acute{\omega}_i)\, A_i\right) \ldots\ldots.. (2)$$

Where

P_s :-Symbol error rate (SER)

P_b :-Bit error rate (BER)

M :- Size of modulation constellation

K :- Number of bits per symbol → $k = \log_2 M$

$\frac{E_b}{E_0}$:- Energy per bit –to -noise power –spectral –density ratio

θ:- is the phase angle from $-\pi/2$ to $\pi/2$

Where $\acute{\omega_i} = \omega_i + \omega_{M-i}, \omega'_{M/2} = \omega_{M/2}, \omega_i$ is the Hamming weight of bits assigned to symbol i , and

$$A_i = F\left(\left(2i+1\right)\frac{\pi}{M}\right) - F\left(\left(2i-1\right)\frac{\pi}{M}\right) \ldots\ldots\ldots (3)$$

$$F(\Psi) = -\frac{\sin\Psi}{4\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \frac{\exp\left(-\frac{kE_b}{N_O(1-\cos\Psi cost)}\right)}{1-\cos\Psi cost}\, dt \ldots\ldots\ldots (4)$$

- Block Coding for DPSK [1].

$$P_b = \leq \frac{1}{2}\frac{2^K-1}{2^{2d_{min-1}}} exp(-\gamma_b R_c d_{min})$$

$$\sum_{i=0}^{d_{min}-1}(-\gamma_b R_c d_{min})^i \frac{1}{i!}\sum_{r=0}^{d_{min}-1}\binom{d_{min}-1}{r} \ldots\ldots\ldots (5)$$

- Convolutional Coding DPSK [1],[4]:

$$P_b \sum_{d=d_{free}}^{\infty} a_d f\ (d)\ P_2(\ d) \ldots\ldots\ldots (6)$$

With transfer function

$$T\ (D\ ,N\ ) = \sum_{d=d_{free}}^{\infty} a_d D^d N^{f(d\ )} \ldots\ldots\ldots (7)$$

$$\left.\frac{dT(D\ ,N)}{dN}\right|_{N\ =1} = \sum_{d=d_{free}}^{\infty} a_d f(d\ )D^d \ldots\ldots\ldots (8)$$

Where f (d) is the exponent of N as a function of d .

d_{free} is the free distance of the code, and a_d is the number of paths of distance d from the all –zero path that merge with the all –zero path for the first time.

2. *DPSK in Rayleigh fading channels*

M-DPSK Post detection equal-gain combining with EGC[2,3]:

$$P_s = \frac{\sin(\pi/M)}{2\pi}\int_{-\pi/2}^{\pi/2} \frac{1}{[\ 1-\cos\ (\ \pi/M\ )cos\theta]} \prod_{l=1}^{L} M_{\gamma_l}(-[\ 1 - \ \cos(\ \pi/M\ )cos\theta])d\theta \ldots\ldots\ldots (1)$$

$$P_b = \frac{1}{k}\left(\sum_{i=1}^{M/2}(w'_i)\overline{A}_i\right) \ldots\ldots\ldots (2)$$

Where, $w'_i = w_i + w_{M-i}, w'_{M/2} = w_{M/2}, w_i$, is the Hamming weight of bits assigned to symbol i, and

$$\overline{A}_i = \overline{F}((\ 2i + \ 1)\frac{\pi}{M}) - \overline{F}((\ 2i - \ 1)\frac{\pi}{M}) \ldots\ldots\ldots (3)$$

$$\overline{F}(\psi) = -\frac{\sin\psi}{4\pi}\int_{-\pi/2}^{\pi/2} \frac{1}{(1-\cos\psi cost)} \prod_{l=1}^{L} M_{\gamma_l}(-[1-\cos\psi cost])dt \ldots\ldots\ldots (4)$$

3. *BER equation of DPSK under Rician fading channel*

$$M_{\gamma_1}(s) = \frac{1+K}{1+K-s\overline{\gamma}_1} e^{[\frac{Ks\overline{\gamma}_1}{(1-k)-s\overline{\gamma}_1}]} \ldots\ldots\ldots (5)$$

Where K is the ratio of energy in the specular component to the energy in the diffuse component (linear scale).
For identically-distributed diversity branches:
$M_{\gamma_l}(s) = M_{\gamma}(s)$ for all l .

IV. BER EQUATION OF OQPSK IN MULTI CHANNEL ENVIRONMENTS AND CODING

1. *OQPSK in AWGN*

BER of OQPSK in AWGN is the same as that of PSK [2]

$$P_s = \frac{1}{\pi}\int_0^{(M-1)\pi/M} \exp\left(-\frac{kE_b}{N_O}\frac{sin^2[\pi/M]}{sin^2\theta}\right)d\theta \ldots\ldots\ldots (6)$$

The following expression is very close, but not strictly equal , to the exact BER [3][2]:

$$P_b = \frac{1}{k}\left(\sum_{i=1}^{M/2}(\ w'_i)\overline{P}_i\right) \ldots\ldots\ldots (7)$$

where , $w'_i = w_i + w_{M-i}, w'_{M/\ 2} = w_{M/2}, w_i$, is the Hamming weight of bits assigned to symbol i , and

$$P_i = \frac{1}{2\pi}\int_0^{\pi\ (1-(2i-1)/M)} \exp\left(-\frac{kE_b}{N_O}\frac{sin^2\left[\frac{(2i-\ 1)\pi}{M}\right]}{sin^2\theta}\right)d\theta - \frac{1}{2\pi}\int_0^{\pi(1-(2i-1)/M)} \exp\left(-\frac{kE_b}{N_O}\frac{sin^2\left[\frac{(2i+1)\pi}{M}\right]}{sin^2\theta}\right)d\theta \ldots\ldots\ldots (8)$$

- OQPSK in AWGN with block coding [1]

$P_b \leq \frac{1}{2}(2^k - 1)Q(\sqrt{2\gamma_b R_c d_{min}})$ .... (9)

$\gamma_b = \frac{E_b}{N_o}$ Energy -per -information bit -to -noise power -spectral -density ratio

d_{min} is the minimum distance of the code.

- OQPSK in AWGN with convolutional code

BER of OQPSK in AWGN with convolutional code equation is the same with DPSK [1,6]

2. *OQPSK with Rayleigh fading channel environment*

BER of OQPSK in AWGN with convolutional code equation is the same with DPSK [2,4]

V. RESULTS

1. *Auto correlation test of DPSK and OQPSK*

Auto correlation test on both systems types are shown in figure 5 and 6, from both figures DPSK shows better results on the auto correlation test, where the difference between the main loop and side loop is below the threshold line in DPSK while in OQPSK it is above the threshold line, this proves inequality between the DPSK signals in the multi-signal system using DPSK as a modulation approach more than in systems using the OQPSK modulation.

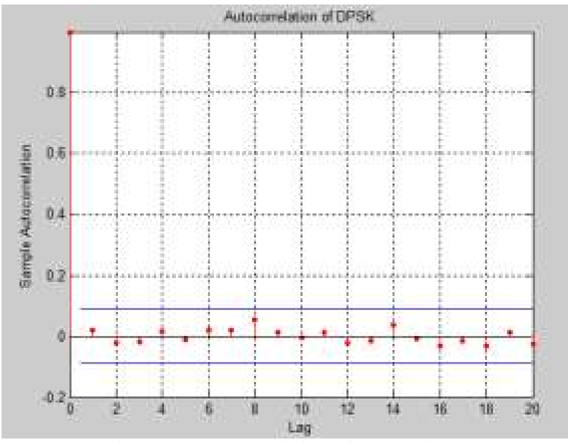

Figure 5 : auto correlation of DPSK signal

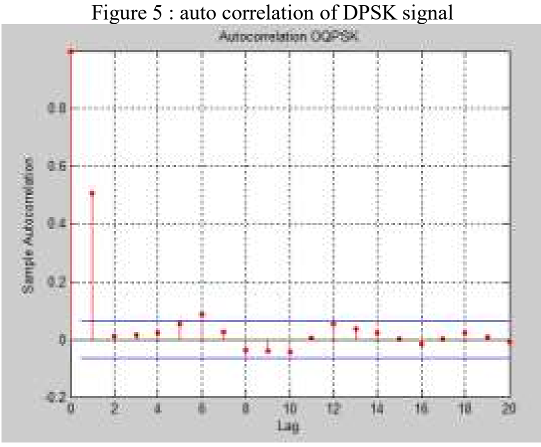

Figure 6 : auto correlation of OQPSK signal

2. *Cross correlation test*

Cross correlation between DPSK and OQPSK signals is shown in figure 7, where the result shows less than 0.06, which is below the threshold effect of 0.1, so cross-talk betwwen DPSK and OQPSK signals is very low therfore both systems are efficient in multi-user systems.

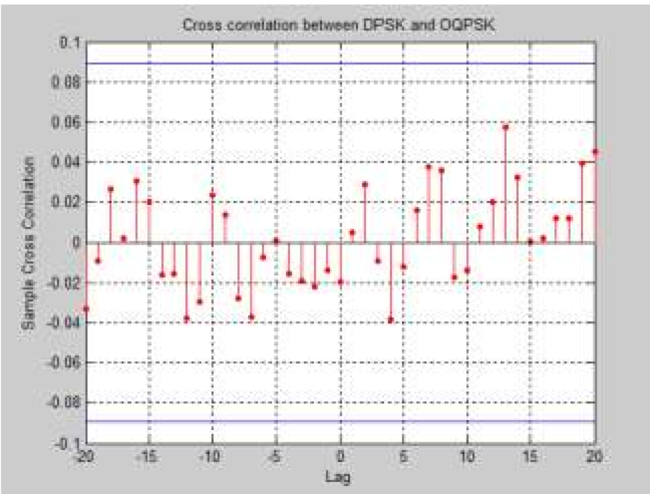

Figure 7: Cross correlation between DPSK and OQPSK signals

3. *DPSK and OQPSK in AWGN*

Both systems are tested in AWGN channel as shown in figure 8, where DPSK shows better results than OQPSK with a gain in E_b/N_o equal to 2.2.5 dB in BER 10^{-8}

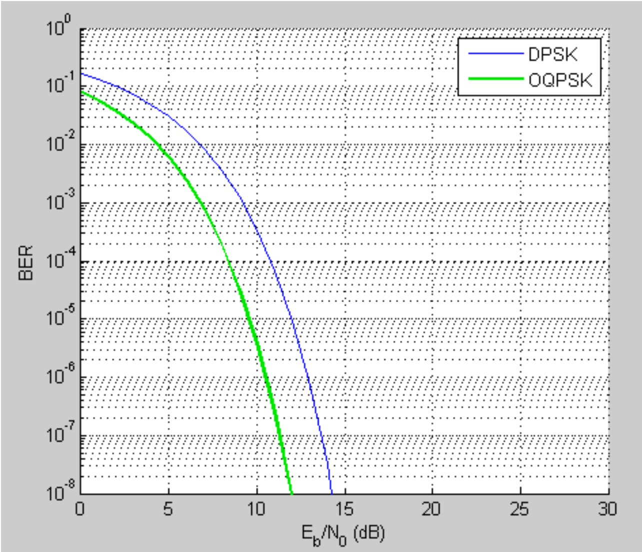

Figure 8: DPSK and OQPSK in AWGN

4. *DPSK and OQPSK in AWGN with convolutional and block code*

Both systems' performances under the AWGN channel improved with the convolution code. In DPSK modulation the gain in E_b/N_o is 3 dB at 10^{-8} and in OQPSK at 10^{-8} BER the gain in E_b/N_o, equal to 3.5 dB, as shown in figure 9. Figure 10 shows the performance of both systems under the block code, where a good performance was noticed with a gain in E_b/N_o 4 dB at 10^{-8} in DPSK and 4 dB in OQPSK modulation.

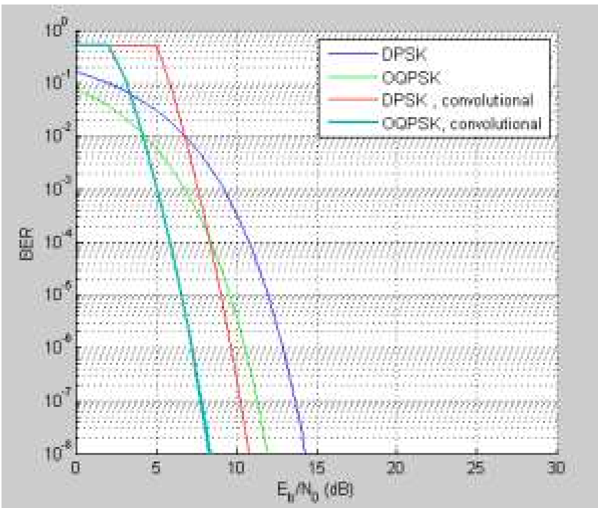

Figure 9: DPSK and OQPSK in AWGN with convolution code

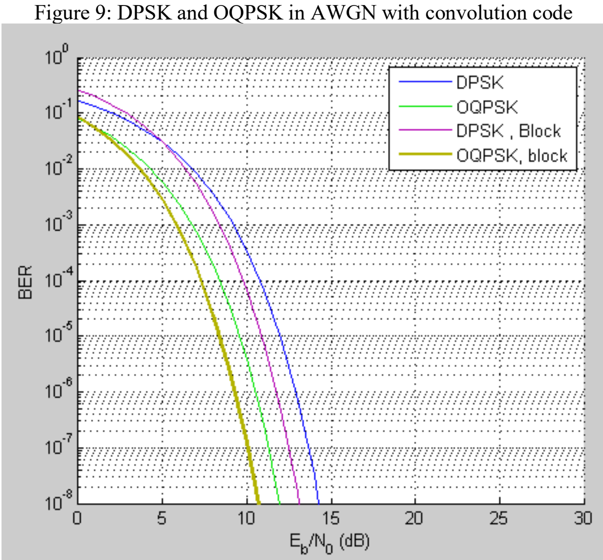

Figure 10: DPSK and OQPSK in AWGN with block code

5. *DPSK and OQPSK in Rayleigh fading channel*

Under Rayleigh fading channel OQPSK shows a better performance with a gain in E_b/N_o 3 dB 10^{-3}, as shown in figure 11. To improve the performance of both systems multi-diversity order are increasing orders used 1, 2, 4 as shown in figures 12 and 13. Increasing the diversity order improves the BER performance in both systems with gain in E_b/N_o 11 dB at 10^{-3} BER, when diversity order is equal to 2, as shown in figure 12, even as 15 dB is gained when increasing the diversity order to 4 in both systems as shown in figure 13.

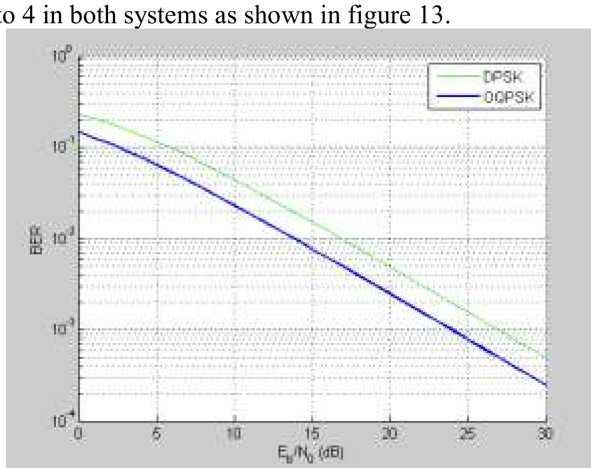

Figure 11: DPSK and OQPSK in Rayleigh fading channel

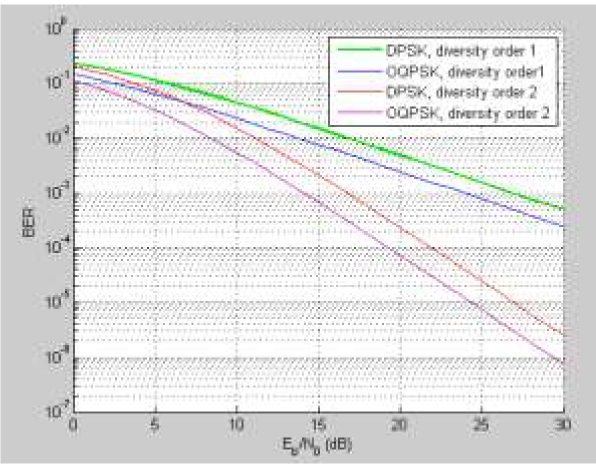

Figure 12: DPSK and OQPSK in Rayleigh fading channel with multi-diversityi order

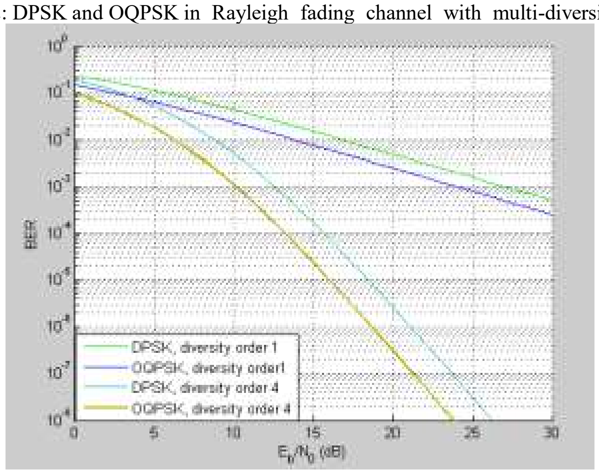

Figure 13: DPSK and OQPSK in Rayleigh fading channel with multi-diversity order

6. DPSK AND OQPSK IN RICIAN FADING CHANNEL

The Rician channel was tested in both systems where OQPSK showed a good performance with a gain in E_b/N_o 2.5 dB at 10^{-3} as shown in figure 14. To improve the performance of both systems under the Rician channel, the ratio of energy in the specular component to the energy in the diffuse component K factor was increased, 0, 2, 6 as shown in figure 14 and 15. By increasing the K factor the performance of both system improved with a gain of 3 dB at k equal to 2, as shown in figure 15 even as it was 12 dB at k equal to 6 as shown in figure 16.

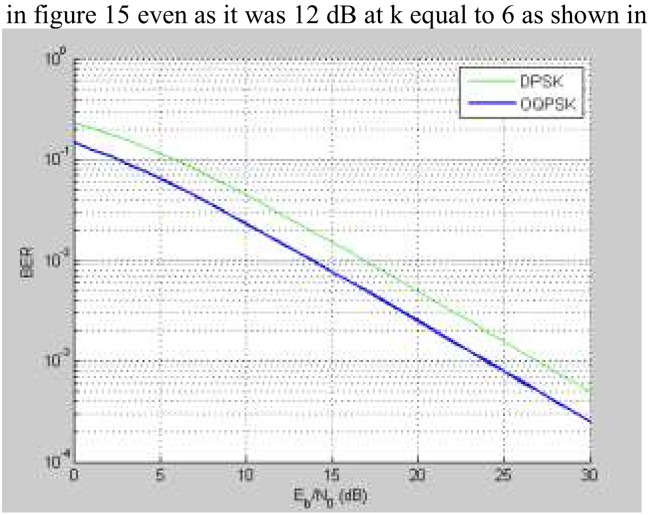

Figure 14: DPSK and OQPSK in Rician fading channel

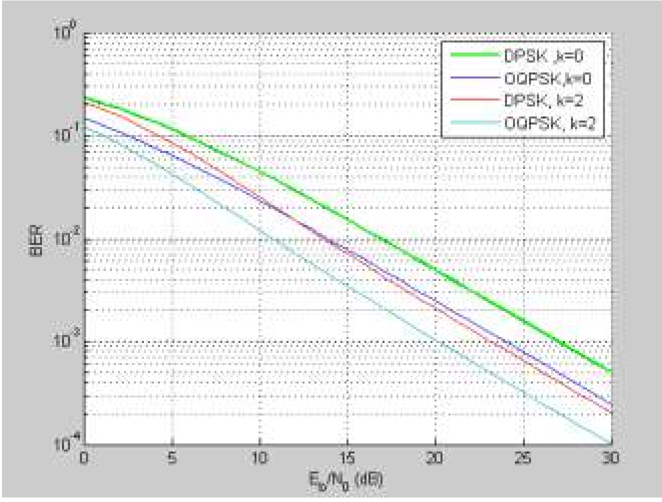

Figure 15: DPSK and OQPSK in Rician fading channel with multi K order

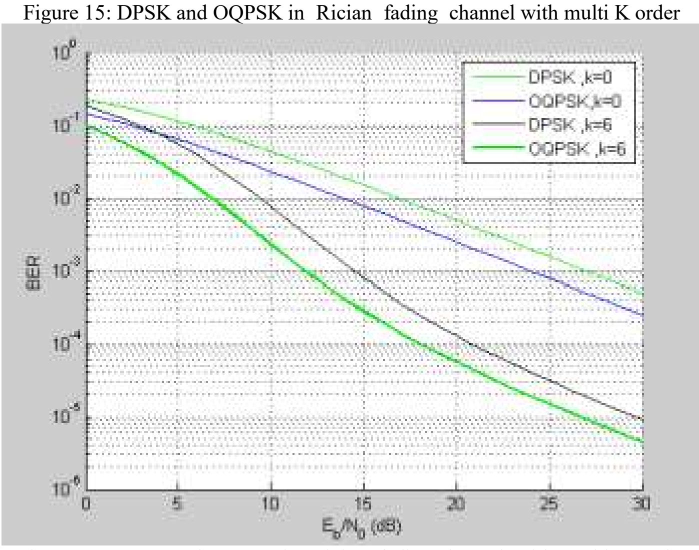

Figure 16: DPSK and OQPSK in Rician fading channel with multi K order

VI. CONCLUSION

In this article the DPSK and OQPSK systems implemented in Matlab Simulink were both models tested in muli-environment channels AWGN, Rayliegh and Rician channels. From the results DPSK shows better results than OQPSK with a gain in E_b/N_o equal to 2.2.5 dB in BER 10^{-8}. BER can be improved in both systems under AWGN by using the convolution and block codes. Under Rayleigh fading and Rician channel OQPSK shows better performance with a gain of E_b/N_o 3 dB 10^{-3}. The performance of both systems under the Rayleigh channel can be improved by increasing the diversity order whereas; under Rician channel it can be improved by increasing the K order. Auto-correlation and Cross-correlation tests have been examined in both systems to investigate the inequality and cross-talk between signals respectively. from the auto-correlation results DPSK shows better performance than OQPSK in multi signal systems, cross-talk between both signals (DPSK, OQPSK) was very low according to Cross-correlation test, finally the results prove the efficient use of both systems in multi- environment channels, each system according its applications.

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