Comparison of $\pi/6$ and $\pi/4$ QPSK Modulation Technique in Wireless Communication Systems

Digital Modulation - EE5837

Paper implementation of "Design of an improved QPSK modulation technique in wireless communication systems"

Siddharth Gupta
Electrical Engineering, IIT Hyderabad
ee18mtech01003@iith.ac.in

***Abstract*—This article is comparison between π/6 - QPSK and π/4 - QPSK modulation techniques. BER (bit error rate) is the comparison criteria between the two schemes. Simulation results of MATLAB shows that the BER performance of proposed π/6-QPSK is worse than that of conventional π/4-QPSK modulation scheme which is counter question to[1] as the paper[1] discusses the improved results based on the signal spectral performance of their proposed $\pi/6$-QPSK modulation scheme.**

***Index Terms*—QPSK, PSK, Modulation, Wireless, π/4 - QPSK, π/6 - QPSK**

I. Introduction

Digital transmission system uses different modulation schemes based on several factors, such as, bandwidth efficiency, power efficiency, low sensitivity to multi path fading and so on[2]. Some of the modulation techniques are ASK, FSK and PSK[3] which changes the carrier amplitude based on amplitude, frequency and phase respectively. PSK is bandwidth efficient and has BER curves of higher types than FSK. Particularly, the performance of QPSK is better than that of BPSK in case of bandwidth but it has a limitation of 180 phase shift, which destroy the constant envelope property [4]. Here we are using PSK modulation schemes, PSK is also called as M-ary PSK. As M increase the density of signal constellation increases which results in better bandwidth efficiency but worse BER. We are explaining QPSK modulation schemes $\pi/4$ and $\pi/6$. for M=4. QPSK stands for Quadrature PSK where quadrature represents M=4. In paper[4] the comparison is made between the two QPSK schemes $\pi/4$ and $\pi/6$, the paper indicates that $\pi/6$-QPSK scheme is better performing in terms of envelop variation since it is less than $\pi/4$- QPSK scheme.

II. Theoretical Background

A. PSK

In Phase shift keying (PSK), the phase of carrier is changed with respect to the message data. The general analytical expression for PSK [1] can be defined as

$$s_{\mathrm{i}}(t) = \sqrt{2E/T}cos[2\pi f_{\mathrm{c}}t + \phi_{\mathrm{i}}(t)] \tag{1}$$

$$0 \leq t \leq T \; and \; i = 1, 2, 3, ..., M$$

Where, E refers to transmitted signal energy per symbol, T refers to symbol duration, f_c is the carrier frequency, ϕ_i(t) denotes the phase of the modulated signal having M discrete values according to the expression

B. $\pi/6$ QPSK

In $\pi/6$ QPSK, three constellations are used, which are $\pi/6$ shifted pattern of the QPSK constellation, i.e., successive constellations are apart by $\pi/6$ degrees. These three constellations denoted by A, B and C shown in Fig. 1. In $\pi/6$ - QPSK, constellation is not changed after every symbol. The constellation selection is depended on input dibit. The selection of constellation is shown in Table I.

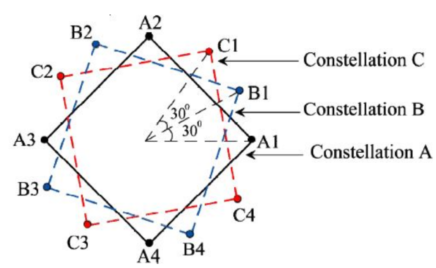

Fig. 1. Three constellations of proposed π/6-QPSK scheme

It is clear from Table I that, the π/6-QPSK is a differential modulation process, where the transmitted signal is chosen

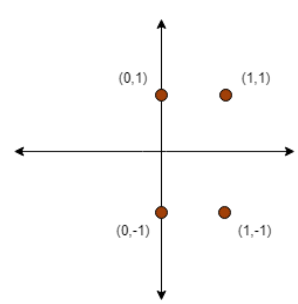

Fig. 2. Constellation diagram after modulation

Dibit	Constellation Selection
00	Constellation is unchanged but message point shifted by -90 on existing constellation
01	Constellation is unchanged but message point shifted by +90 on existing constellation
10	Constellation is changed, the constellation changing sequence is ACBA cycle and message point shifted by -30
11	Constellation is changed, the constellation changing sequence is ABCA cycle and message point shifted by +30

TABLE I
π/6-QPSK CONSTELLATION SELECTION AND PHASE TRANSITION FOR DIBIT

Dibit	$\Delta\theta_{\mathbf{k}}$
00	-$\pi/2$
01	+$\pi/2$
10	-$\pi/6$
11	+$\pi/6$

TABLE II
SIGNAL PHASE DIFFERENCE OF π/6-QPSK SCHEME

from one of three QPSK constellations, which are successively apart by π/6 degree. Hence, the phase transition between two successive symbols have the values in between π/6, π2. Here, the dibit with corresponding signal phase difference $\Delta\theta_{\mathrm{k}}$ of π/6-QPSK is shown in Table IV. Therefore, the signal space diagram of π/6-QPSK is two-dimensional with twelve message points shown in Fig. 2

C. $\pi/6$ Modulator

$\pi/6$ QPSK Modulator The $\pi/6$QPSK is a deferentially encoded and decoded system. The $\pi/6$-DQPSK modulator is shown in Fig.9. The differential encoder of $\pi/6$ DQPSK modulator encodes I_k and Q_k into signal u_k and v_k according to the following rules:

$$\mathrm{u}_k = 1/2\sqrt{2}[u_{k-1}(\sqrt{3+3I_k}) - v_{k-1}Q_k(\sqrt{5-3T_k})]$$

$$\mathrm{v}_k = 1/2\sqrt{2}[u_{k-1}Q_k(\sqrt{5-3T_k}) + v_{k-1}(\sqrt{3+3I_k})$$

D. $\pi/6$ De-Modulator

It is seen in Fig. 1 that, the signal space diagram of $\pi/6$QPSK has twelve message points. However, at instant, $\pi/6$QPSK works only on four message points and the decision region for selecting symbol of $\pi/6$QPSK is shown in Fig. 2. Therefore, in $\pi/6$QPSK, the following decisions can be made as,

$$I_k = \begin{cases} 1, & \text{if } \sqrt{3}x_k > |y_k| \\ 0, & \text{if } \sqrt{3}x_k < |y_k| \end{cases} \tag{2}$$

$$Q_k = \begin{cases} 1, & \text{if } y_k > 0 \\ 0, & \text{if } y_k < 0 \end{cases} \tag{3}$$

Where, $|y_k|$ is the absolute or modulus value of y_k.

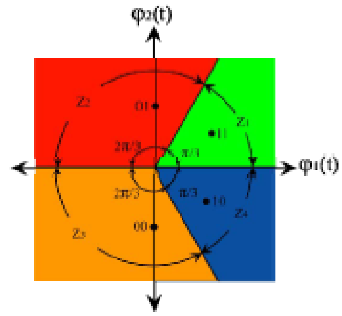

Fig. 3. Decision region of $\pi/6$QPSK for symbol selections.

III. Results

Following results are obtained from MATLAB simulation where Fig. 1 is representing the BER curve of 1000 samples for $\pi/4$ QPSK scheme and $\pi/6$ QPSK scheme. Similarly the same is represented in Fig. 2 for 10000 samples and, for 10^6 samples in Fig. 3

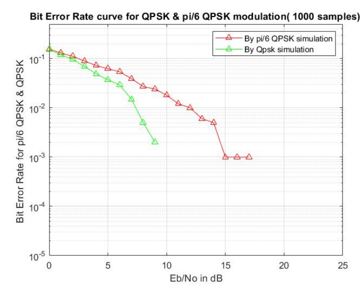

Fig. 4. BER curve for 1000 samples.

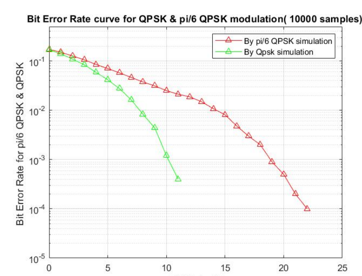

Fig. 5. BER curve for 10000 samples.

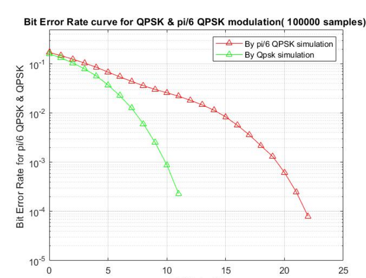

Fig. 6. BER curve for 100000 samples.

IV. CONCLUSION

Figure 3, 4 and 5 represents BER curve of both the schemes. Bit error rate for $\pi/6$ QPSK scheme is much higher than the $\pi/4$ QPSK scheme for same (Eb/No) signal to noise ratio, for all the three iterations over different samples (1000,10000,100000). For 100000 samples the drop is around 10^{-4} at 23db for $\pi/6$ QPSK and same BER is attained at 12db for $\pi/4$ QPSK, hence the performance of $\pi/4$ QPSK is better than $\pi/6$ QPSK scheme.

REFERENCES

[1] M. A. N. Chowdhury, M. R. U. Mahfuz, S. H. Chowdhury and M. M. Kabir, "Design of an improved QPSK modulation technique in wireless communication systems," 2017 3rd International Conference on Electrical Information and Communication Technology (EICT), Khulna, 2017, pp. 1-6

[2] D. Sai Brunda, B. Geetha Rani, Design of QPSK Digital Modulation Scheme Using Turbo Codes for an Air Borne System, International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE),vol. 5, issue 8, August 2016.

[3] Simon Haykin, Digital Communication, Wiley Press, 2013

[4] J. Webber, N. Dahnoun, Implementing a $\pi/4$-Shifted DQPSK Baseband Modem Using the TMS320C50, ESIEE, Paris, September 1996