

Design of Modem Technology Base on $\pi/4D-QPSK$

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Abstract-The $\pi/4$ -DQPSK modulation mode is being widely attention because of its high spectrum efficiency, resistance to decline outstanding characteristic such as being strong of performance. This paper briefly introduced the working principle of the $\pi/4$ -DQPSK and baseband difference of demodulation. It makes program design based on the system, program design is presented. The paper achieves $\pi/4$ -DQPSK modem system. Through simulation, the modem flow of data and input data stream is the same, just modulator delay than the 2 samples. It shows that the design method is feasible and effective.

Keywords- $\pi/4$ -dqpsk; modem; differentia

I. INTRODUCTION

For digital cellular system, the modulation determines each users send rate and utilization rate of band (refers to the channel bandwidth on the number of bits per second per Hertz can send). When choosing suitable honeycomb

modulation technology, the following elements must be considered [1]:

- High power efficiency
- High bandwidth utilization
- Low output sideband radiation
- To multipath fading and low sensitivity
- Constant envelope
- Low-cost Implement easily

Of course, it is impossibility which choose a has all the advantages of modulation method. In fact every method has some limitations, and restraining each other. For example, high bandwidth utilization must take a lot of signal device, and increase the transmission power in the signal transmission. There are three main methods: modulation Amplitude Shift Keying (Amplitude Shift Keying - ASK), Frequency Shift Keying, Frequency Shift Keying (FSK), PSK (Phase Shift Keying, PSK), and this article uses $\pi/4$ -QPSK the digital modulation demodulation. [2]

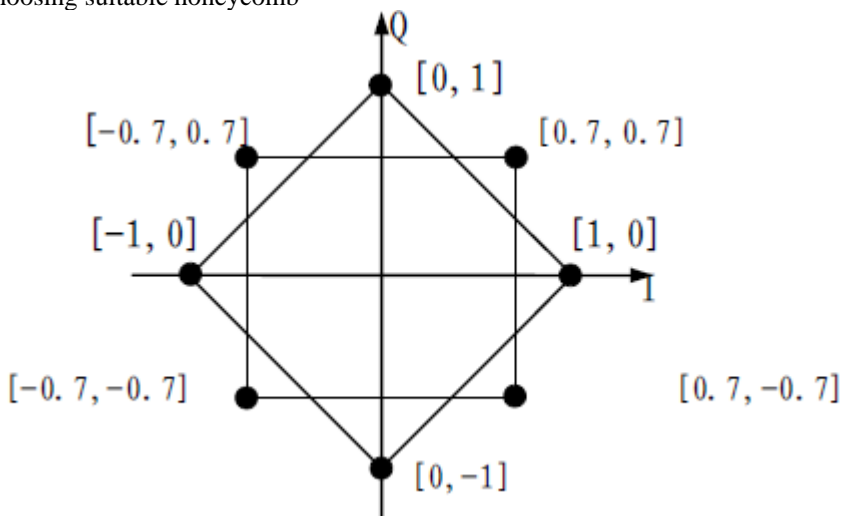
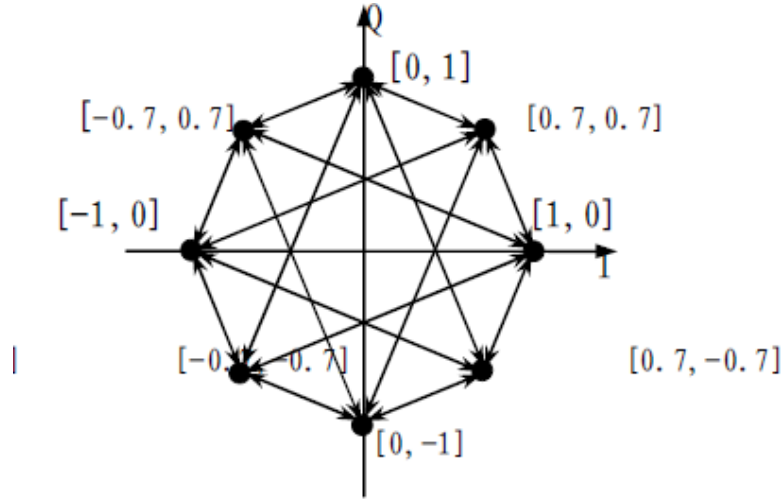


Figure 1. $\pi/4$ -QPSK


Figure 2. $\pi/4QPSK$ envelope

II. $\pi/4QPSK$ PRINCIPLE

We use QPSK constellations point to make odd number symbols, another $\pi/4$ offset modulation accidentally number symbols (figure 1), the biggest instantaneous phase is 135° (figure 2), the biased QPSK 90° and unbiased QPSK 180° is in the middle. And, $\pi/4QPSK$ is a better than biased QPSK advantages: it can is used to detect the difference, the same data flow of full 1 or 0 will always produce phase change. [3]

III. THE GENERATION OF THE $\pi/4D-QPSK$

For every two position group, there are four possible values. And each of the possible values corresponding to a different phase displacement (see table 1).Phase corresponding to the I - Q the points on the graph, the phase can be used from the origin to the points on the graph form I - Q Angle between the axis of the vector and I = 0. [4]

Because the current phase θ_k can be equivalent to the original phase θ_{k-1} and phase displacement $\Delta\theta$, so through $[I_{k-1} Q_{k-1}]$ the expression of the original phase and double receives a group, we can understand the current phase. [5]

In the modulation method of $\pi/4D-QPSK$, the data is sent when the carrier for encoding phase change. Making S_{k-1} corresponding to a symbol before sending carrier, θ is equal to the absolute phase.

$$S_{k-1} = A \cos(\omega t - \theta) \quad (1)$$

So, for the current carrier for symbols:

$$S_k = A \cos(\omega_c t - (\theta + \Delta\theta)) \quad (2)$$

is a phase change

$$S_k = A \cos(\theta + \Delta\theta) \cos \omega t + \sin(\theta + \Delta\theta) \sin \omega t$$

$$S_k = I_k \cos \omega t + Q_k \sin \omega t$$

so:

$$\begin{aligned} I_k &= A \cos(\theta + \Delta\theta) \\ &= A \cos \theta \cos \Delta\theta - A \sin \theta \sin \Delta\theta \\ &= I_{k-1} \cos \Delta\theta - Q_{k-1} \sin \Delta\theta \end{aligned} \quad (3)$$

$$\begin{aligned} Q_k &= A \sin(\theta + \Delta\theta) \\ &= A \sin \theta \cos \Delta\theta + A \cos \theta \sin \Delta\theta \\ &= Q_{k-1} \cos \Delta\theta + I_{k-1} \sin \Delta\theta \end{aligned} \quad (4)$$

If the input data is gray code, the value of $(\sin \Delta\theta)$ and $(\cos \Delta\theta)$ is obtained according to table 2. It would be noted t 0 corresponding A_{KG} and B_{KG} corresponding -1, $A_k B_k$ corresponding to the logical value of the gray code.

From the table, you can see that if $(\cos \Delta\theta) < 0$, $A_{KG} = -1$; If $(\sin \Delta\theta) < 0$, $B_{KG} = -1$. So the equation (3) and (4) can be written as:

$$I_k = (I_{k-1} * A_{KG} - Q_{k-1} * B_{KG}) * 0.707 \quad (5)$$

$$Q_k = (Q_{k-1} * A_{KG} + I_{k-1} * B_{KG}) * 0.707 \quad (6)$$

TABLE 1. $\pi/4$ PHASE-SHIFT

$A_k B_k$	$\Delta\theta$
0 0	$+5\pi/4$
0 1	$+3\pi/4$
1 1	$+7\pi/4$
1 0	$+\pi/4$

 TABLE 2. THE RELATIONSHIP BETWEEN THE INPUT DATA AND $\sin \Delta\theta$, $\cos \Delta\theta$

$A_k B_k$	$A_{KG} B_{KG}$	$\Delta\theta$	$\cos \Delta\theta$	$\sin \Delta\theta$
0 0	-1 -1	$5\pi/4$	-0.7	-0.7
0 1	-1 +1	$3\pi/4$	-0.7	+0.7
1 0	+1 -1	$\pi/4$	+0.7	-0.7
1 1	+1 +1	$7\pi/4$	+0.7	+0.7

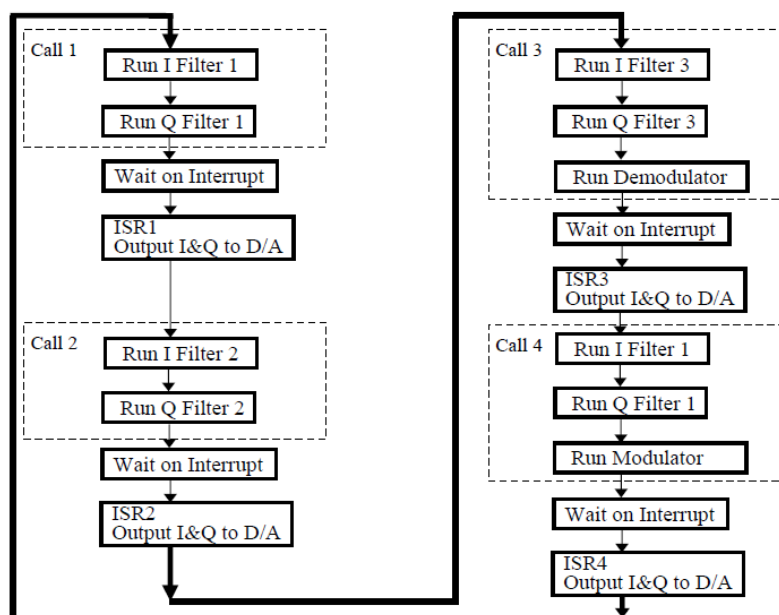


Figure 3. Program structure

 TABLE 3. USING $\cos \theta$ AND $\sin \theta$ TO RECOVERY DATA

$\cos \theta$	$\sin \theta$	$\Delta\theta$	A_{KG}	B_{KG}	A_i	B_i
+0.707	+0.707	$1\pi/4$	+1	+1	1	1
+0.707	-0.707	$7\pi/4$	+1	-1	1	0
-0.707	+0.707	$3\pi/4$	-1	+1	0	1
-0.707	-0.707	$5\pi/4$	-1	-1	0	0

IV. SYSTEM DESIGN AND PROGRAM STRUCTURE

Using pulse shaping can reduce intersymbol interference. In this design, the I and Q data flow after 20 tap FIR filter shaping, its output by D/A converter is sampling. D/A converter in the sampling rate during the period of the spectrum components don't need, need to rebuild filter to be filtered out. Useless spectrum between composition and useful spectral components of the interval, the greater the reconstruction filter series is lower. It can be used to implement by the interpolation technology. Each program cycle interrupt four been sampling output waveform I - Q symbol.

Being designed program include four interrupt structure, as shown in figure 3, rectangular plastic pulse corresponds to the I and Q channels, using ascending cosine filter at the output of the modulator pulse shaping. Of course , if the sampling rate is higher, the DSP computation is higher. If for a moment and the moment before the I and Q channels is a fixed number of pulse and the window. Then, the increase of sampling rate requires increasing the number of filter tap, increase the computational complexity. So it is used four interrupt in 20 tap filter systems typically.

V. THE REALIZATION OF THE MODULATOR

The purpose of the modem from the received baseband signal phase I and Q can recover the original data. Block diagram (figure 4) main module are given, process of figure 5 differential detection and data recovery algorithm are summarized.

VI. DIFFERENTIAL DETECTION OF $\pi/4$ D-QPSK SIGNALS

The purpose is from four to receive the phase signal $[I_k, Q_k, I_{k-1}, Q_{k-1}]$ to restore the data symbols A_k and B_k . Equation(7)- (12)]and table3 indicate, A_k and B_k cab be get from symbols $\cos \theta$ and $\sin \theta$.

According to the equation (5)and(6)can educe

$$I_k = I_{k-1} * \cos \theta_k - Q_{k-1} * \sin \theta_k \quad (7)$$

$$Q_k = Q_{k-1} * \cos \theta_k + I_{k-1} * \sin \theta_k \quad (8)$$

$$\cos \theta_k = \frac{Q_k * Q_{k-1} + I_k * I_{k-1}}{Q_{k-1}^2 + I_{k-1}^2} \quad (9)$$

$$\sin \theta_k = \frac{I_{k-1} * Q_k - I_k * Q_{k-1}}{Q_{k-1}^2 + I_{k-1}^2} \quad (10)$$

It is very time consuming to compute $\cos \theta_k$ and $\sin \theta_k$ through equation[9]and[10].By observing table 3, We noticed that:

- 1) if $\cos \theta_k > 0$, then $A_k = 1$, or else $A_k = 0$;
- 2) if $\sin \theta_k > 0$, then $B_k = 1$, or else $B_k = 0$;

So we only need to compute symbol of $\cos \theta_k$ and $\sin \theta_k$, then we can determine A_k and B_k . But we need compute equation(11)and(12) if computing A_k and B_k :

$$\text{Sign}(\cos \theta_k) = \text{Sign}(Q_k * Q_{k-1} + I_k * I_{k-1}) \quad (11)$$

$$\text{Sign}(\sin \theta_k) = \text{Sign}(I_{k-1} * Q_k - I_k * Q_{k-1}) \quad (12)$$

VII. CONCLUSION

Through simulation, the modem flow of data and input data stream is the same, just modulator delay than the 2 samples. It shows that the design method is feasible and effective. If you want to pass the baseband signal to differential encoding phase to four phase shift keying; Its frequency band in the unit of information transmission rate than 2 DPSK double, but resistance to noise performance is less than 2 DPSK. So $\pi/4$ -DQPSK can be widely used in high speed digital transmission system. [6]

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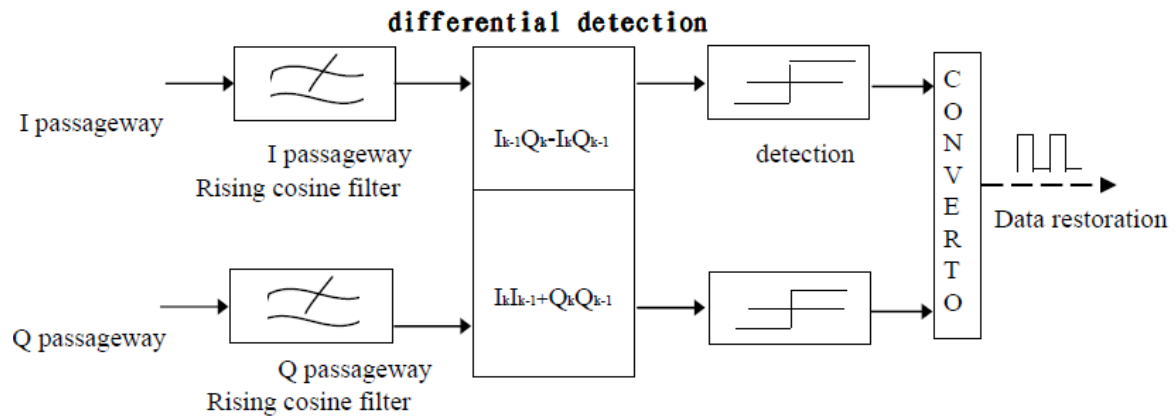


Figure 4. Baseband demodulator

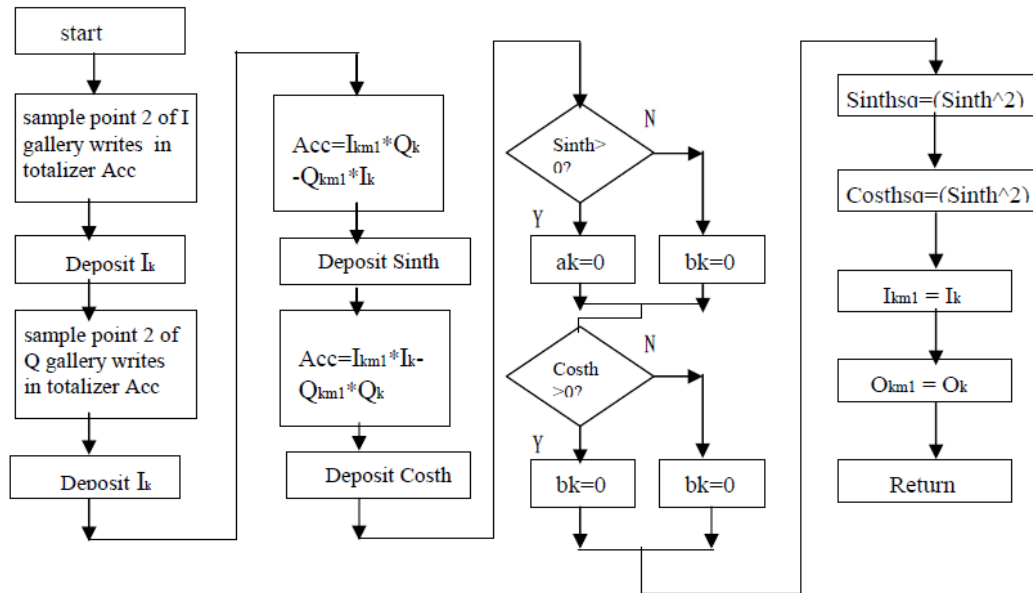


Figure 5. Modem process