"I admit that I had read this report and in my opinion, this report had fulfilled all scope and quality for the Bachelor Degree of Electronic Engineering (Computer Engineering)

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Supervisor : MUHAMMAD SYAHRIR JOHAL

Date : 5/5/2006

DESIGN OF $\pi/4$ – SHIFT DQPSK TRANSMITTER FOR WIRELESS PERSONAL COMMUNICATION

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This Report Is Submitted In Partial Fulfillment of Requirements For The Bachelor Degree of Electronic Engineering (Computer Engineering)

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April 2006

"I hereby declared that this report is a result of my own work except for the works that have been cited clearly in the references."

Signature : ....

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ABSTRACT

This project deals with the design of transmitter for wireless personal communication. The type of modulation for the transmitted signal is in the form of Quadrature Phase Shift Keying (QPSK), which has been differentially shifted by 45°, leading it to be called π/4 –shift Differential Quadrature Phase Shift (DQPSK). π/4 – shift Differential Quadrature Phase Shift (DQPSK) is a four level modulation which a form of Phase Shift Keying (PSK) digital modulation scheme. This report will consist of 3 major parts. Firstly, the comparison and analysis between π/4 –shift DQPSK modulation scheme and its counter part QPSK modulation scheme. The comparison will be in a form of simulation using Matlab software to simulate the performance on both transmitted signal schemes along the communication channel. Secondly, software implementation is developed using PIC16F84A to produce an algorithm which performs the Differential Phase Encoding. Lastly, this report will reveal the hardware development of the π/4 –shift Differential Quadrature Phase Shift (DQPSK) transmitter.

ABSTRAK

Projek ini merujuk kepada merekabentuk sistem penghantaran untuk kegunaan perhubungan peribadi tanpa wayar. Jenis modulasi yang digunakan untuk menghantar isyarat ialah Pengekodan Anjakan Fasa Seperempat atau Quadrature Phase Shift Keying (QPSK) yang mana isyarat telah dianjakan dengan perbezaan fasa sebanyak 45° dan sekaligus dikenali sebagai anjakan π/4- Pembezaan Pengekodan Anjakan Fasa Seperempat ataupun π/4 -shift Differental Quadrature Phase Shift Keying (DQPSK). π/4 DQPSK ini adalah modulasi empat tahap yang berada dalam kategori sistem modulasi Pengekodan Anjakan Fasa atau Phase Shift Keying (PSK). Laporan ini mengandungi 3 bahagian utama. Pertama iaitu perbandingan dan analisis diantara sistem modulasi π/4 DQPSK dengan QPSK. Analisis ini dibuat secara simulasi dengan menggunakan perisian MATLAB yang mana perisian ini mampu menjalankan simulasi prestasi isyarat hantaran untuk kedua-dua jenis modulasi tersebut di sepanjang saluran komunikasi. Kedua ialah pembangunan program perisian menggunakan PIC16F84A untuk menghasilkan algoritma yang boleh beroperasi sebagai Pengekodan Pembezaan Fasa. Akhir sekali, laporan ini akan menunjukkan pembangunan perkakasan untuk sistem penghantaran π/4 DQPSK ini.

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NOMENCLATURE

π	-	pi
θ	-	phase
Δ	-	phase difference
f_c	-	carrier frequency
I	-	In-phase
Q	-	Quadrature
ASK	-	Amplitude Shift Keying
FSK	-	Frequency Shift Keying
PSK	-	Phase Shift Keying
BPSK	-	Binary Phase Shift Keying
QPSK	-	Quadrature Phase Shift Keying
DQPSK	-	Differential Quadrature Phase Shift Keying
$\pi/4$ DQPSK	-	pi over 4 Differential Quadrature Phase Shift Keying
PRNG	-	Pseudo Random Noise Generator
PIC	-	Programmable Integrated Circuit
DSP	-	Digital Signal Processor
AWGN	-	Adaptive White Gaussian Noise
BER	-	Bit Error Rate
dB	-	decibel
Mbps	-	Mega bits per second

CHAPTER 1

INTRODUCTION

1.1 Application Background

The quadrature modulator is a fundamental radio component for worldwide digital wireless communication standards such as Global System for Mobile Communication (GSM), Digital Communications System-1800 MHz (DCS1800), Digital European Cordless Telecommunications (DECT), American and Personal Digital Cellular (ADC/PDC) and Japanese Personal Handy Phone (PHP RCR28).

Worldwide standards for the mobile communications environment are demanding spectrally efficient digital modulation techniques. Low power, low cost, integrated quadrature modulator can be used in wireless personal communication for digital modulation such as Quadrature Phase Shift Keying (QPSK) and Pi over 4 Differential Quadrature Phase Shift Keying ($\pi/4$ DQPSK). The quadrature modulator has the advantage that any parameter of a carrier frequency (amplitude, frequency or phase) can be simultaneously manipulated to represent information. Other modulators do not have this flexibility.

1.2 Problem Statements

In QPSK modulation, phase ambiguity occurred. Data is read from one constellation to another is in 90° or 180° as pictured in the QPSK constellation diagram. For instance, data read from a 01 to 10 will passes through the origin. At the receiver, the origin might be mistaken correspond as 00. This leads to false information at the receiver.

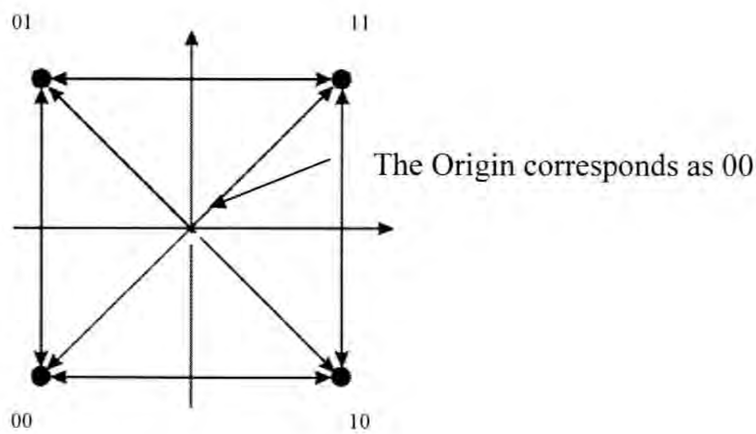


Figure 1.2 QPSK constellation diagram

Furthermore, in QPSK modulation scheme, large undesirable spectral side lobes occurred. For rectangular-shaped data pulses, the envelope of the QPSK signal is constant. There is no AM on the signal even during the data transition times, when there is a 180° phase shift, since the data switches values instantaneously. The rectangular-shaped data produce a $(\sin x/x)^2$ - type power spectrum for the QSPK signal that has large undesirable side lobes.

1.3 Objectives

The objectives of this project are:

1. to overcome the problem mentioned by using π /4-shift DPQSK modulation type.
2. to analyze performance between QPSK and π /4-shift DQPSK
3. to provide security for QPSK by employing π /4-shift DQPSK

1.4 Scopes of Work

The scopes of work for this project are:

- involve analyzing and comparison between QPSK and π/4 DQPSK modulation scheme in terms of:

    1. phase ambiguity
    2. bit error rate
    3. effect of noise in communication channels

- using Matlab software program

- involve simulation of designed transmitter circuit using Multisim software program
- implementing differential encoding algorithm using PIC
- construct additional peripheral circuit to form a complete transmitter

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Concepts of Digital Modulation

Modulation is the process of facilitating the transfer of information over a medium. Sound transmission in air has limited range for the amount of power our lungs can generate. To extend the range our voice can reach, we need to transmit it through a medium other than air such as phone line or radio. The process of converting information so that it can be successfully sent through a medium is called modulation.

There are 3 types of digital modulation techniques:

1. Amplitude Shift Keying (ASK)
2. Frequency Shift Keying (FSK)
3. Phase Shift Keying (PSK)

All these techniques vary parameter of a sinusoid to represent the information which we wish to send. A sinusoid has three different parameters that can be varied which are its amplitude, frequency and phase. Modulation is a process of mapping such that a information signal converts it into some aspect of a sine wave and then transmits the sine wave leaving the actual information signal behind. The sine wave on the other side of the receiver is remapped back to a near copy of the information signal which was transmitted earlier.

2.2 Amplitude Shift Keying (ASK)

In ASK, the amplitude of the carrier is changed in response to information and other parameters are kept fixed. Bit 1 is transmitted by a carrier of one particular amplitude. To transmit 0, we change the amplitude keeping the frequency constant.

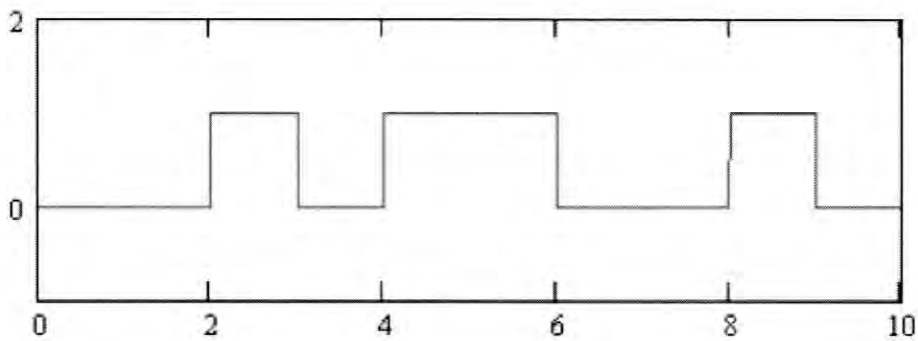


Figure2.2.1 Baseband information sequence 0010110010

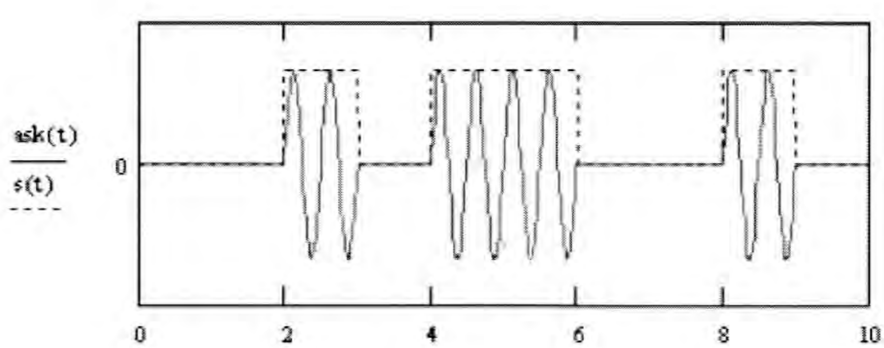


Figure 2.2.2 Binary ASK signal

$$ASK(t) = s(t)\sin(2\pi ft)$$

2.3 Frequency Shift Keying (FSK)

In FSK, we change the frequency in response to information, one particular frequency to for a 1 and another frequency for 0 as shown below for the same bit sequence in Figure 2.3.1. In this example, frequency f1 for bit 1 is higher than f2 which is used for 0 bit.

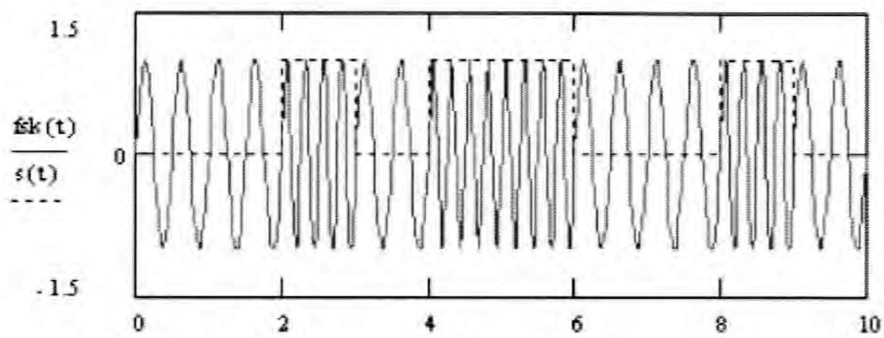


Figure 2.3.1 Binary FSK signal

$$FSK(t) = \begin{cases} \sin(2\pi f_1 t) & for\ bit\ 1 \\ \sin(2\pi f_2 t) & for\ bit\ 0 \end{cases}$$

2.4 Phase Shift Keying (PSK)

In PSK, we change the phase of the sinusoidal carrier to indicate information. Phase in this context is the starting angle at which the sinusoidal starts. To transmit 0, we shift the phase of the sinusoidal by 180°. In this case, phase shift represents the change in the state of the information.

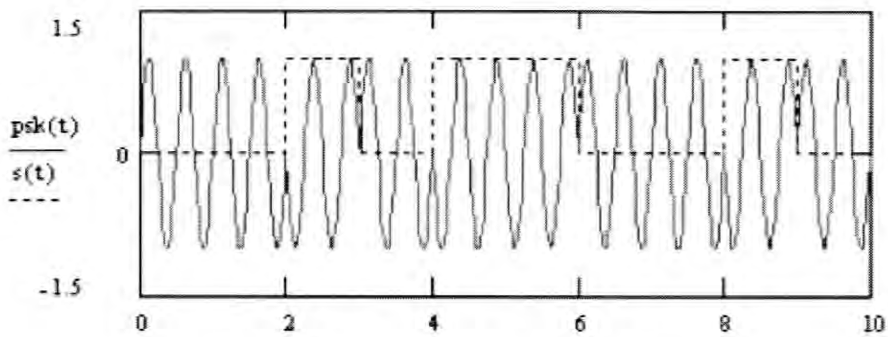
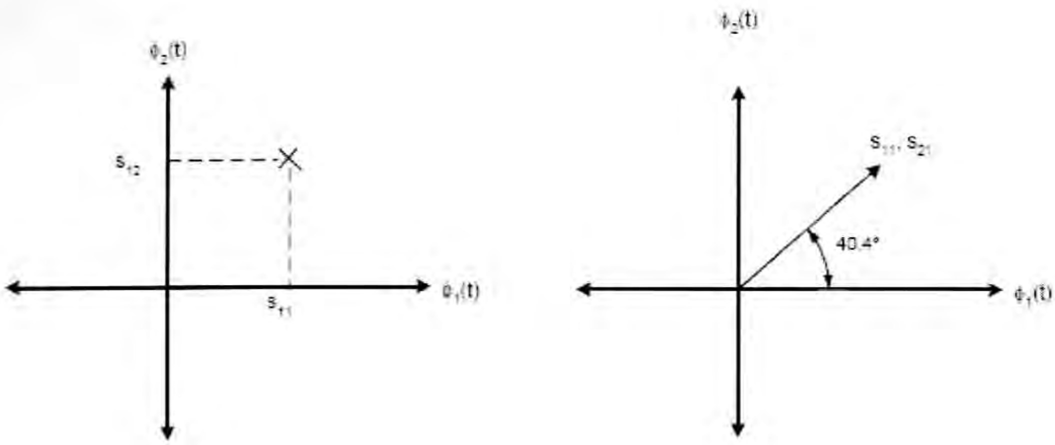


Figure 2.4.1 Binary PSK carrier

$$PSK(t) = \begin{cases} \sin(2\pi f t) & for\ bit\ 1 \\ \sin(2\pi f t + \pi) & for\ bit\ 0 \end{cases}$$

2.5 The Concept of I and Q Channels

Let's define a signal as a vector. Figure 2.5.1 shows two views of a signal space. One shows a signal in rectangular and the other in a polar form. We can describe the signal in polar form by its magnitude and its phase or by its rectangular projections such as s_{11} or s_{12}.



a) I and Q projections **b) Polar form**

Figure 2.5.1 Signal vector plotted on a signal space

In Figure 2.5.1 (a) the x and y –axis are called In-phase and Quadrature projections of the signal. Quantity s_{11} is I projection and s_{12} is the Q projection of the signal. Figure 2.5.1 (b) shows the same signal in polar form with its length equal to its amplitude and the angle is equal to its phase. These are two canonical ways of representing signals.

The coefficients s_{11} represent the amplitude of I signal and s_{12} the amplitude of the Q signal. These amplitudes when plotted on the x and y axis respectively will provide the signal vector. The angle which the signal vector makes with the x axis is the phase of the signal.

Magnitude of signal, $S = \sqrt{} I^2 + Q_2$
Phase of the signal, $\theta = \tan^{-1} (I / Q)$

2.6. Binary Phase Shift Keying (BPSK)

Imagine that a ship lost at sea with no communication system. It sees an airplane flying overhead and wants to communicate its plight to the airplane while it is overhead. The captain of the ship marks two spots on each side of the mast as shown in Figure 2.6.1. Now he holds a bright light and runs back and forth between the marked spots to signal a message. Spot to the right means a 1 and spot to the left means as a 0. (we assume that the airplane know what each light stands for).

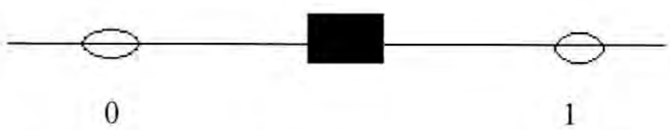


Figure 2.6.1 BPSK signal constellation

The shining of the light is a symbol. There are two light positions so those are two symbols. Let's give these two symbols names of s_1 and s_2. This method of transmitting information is essentially called Binary Phase Shift Keying (BPSK) modulation. We vary the phase of this signal to transmit information which identical in concept to the example of shining the light from the deck. Each symbol is signaled by a change in position. In BPSK we define two little packets of the cosine wave one with a zero phase and second with a 180° different phase.

The BPSK signal lies totally in one axis, x-axis. It has no y-axis projection. The vector flip-flops on the x-axis depending on the value of the bit. Table 2.6 list the two symbols and the signal used to represent them. The I and Q amplitudes are the x and y projections computed by setting $f_c = 0$ and $(\sqrt{2E_s} / \sqrt{T}) = 1$, then we get I= 1 for the first symbol and -1 for the second symbol. Q amplitude is zero for both symbols because sin of 0° and 180° is zero.