

"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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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
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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."

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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 $\pi/4$ -shift Differential Quadrature Phase Shift (DQPSK). $\pi/4$ -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 $\pi/4$ -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 $\pi/4$ -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 $\pi/4$ - Pembezaan Pengekodan Anjakan Fasa Seperempat ataupun $\pi/4$ -shift Differential Quadrature Phase Shift Keying (DQPSK). $\pi/4$ 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 $\pi/4$ 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 $\pi/4$ DQPSK ini.

CONTENTS

CHAPTER	TITLE	PAGE NUMBER
	TITLE PAGE	i
	CONFESSION	ii
	ACKNOWLEDGEMENT	iii
	ABSTRACT	iv
	ABSTRAK	v
	CONTENTS	vi
	LIST OF TABLE	ix
	LIST OF FIGURE	x
	LIST OF APPENDIXES	xiii
	NOMENCLATURE	xiv
1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Problem Statements	2
	1.3 Objectives	3
	1.4 Scopes of work	3
2	LITERATURE REVIEW	
	2.1 Basic Concept of Digital Modulation	4
	2.2 Amplitude Shift Keying	5
	2.3 Frequency Shift Keying	6

2.4	Phase Shift Keying	7
2.5	The Concept of I and Q Channels	7
2.6.	Binary Phase Shift Keying	9
2.7	Quadrature Phase Shift Keying	11
2.8	Offset QPSK modulation	21
2.9	$\pi/4$ - Differential Quadrature Phase Shift Keying	23
2.91	$\pi/4$ -shift DQPSK in mathematical terms	24
2.10	Differential Encoding Rules	30
2.11	Comparison between QPSK and $\pi/4$ DQPSK	33

3 PROJECT METHODOLOGY

3.1	Project Methodology	35
3.2	Project Flowchart	37

4 SIMULATION

4.1	MATLAB simulations	38
4.1.1	Effect of AWGN	39
4.1.2	Rayleigh fading effect	40
4.1.3	Eye diagram	41
4.1.4	Bit Error Rate (BER)	43
4.1.5	Effect of Differential encoding	44
4.1.6	Effect of non-linear amplifier	46
4.2	MULTISIM simulation	47
4.2.1	Pseudo Random Noise Generator	47
4.2.2	90° Phase Shifter	48

5	SOFTWARE IMPLEMENTATION	
	5.1 PIC microcontroller	51
6	HARDWARE IMPLEMENTATION	
	6.1 Transmitter Hardware Descriptions	54
	6.2 Procedures and Results	56
	6.3 Discussion	59
7	CONCLUSION	
	7.1 Conclusion	60
	7.2 Future Works	61
	REFERENCES	63
	APPENDIX	

LIST OF TABLE

Table number number	Title	Page
2.6	Mapping rules for BPSK	10
2.7.1	Mapping rules for QPSK	17
2.7.2	Mapping results for the arbitrary integer stream of Signal 1	19
2.9.1	Relationship between dibit, $A_k B_k$ and phase difference, $\Delta\theta$	24
2.9.2	Relationship between input data and $\text{Cos } \Delta\theta$, $\text{Sin } \Delta\theta$	26
2.9.3	$\pi/4$ DQPSK symbol mapping to I and Q	27
2.10.1	Signal Mapping rules	30
5.1	Signal Mapping for Differential Encoding Rules	52

LIST OF FIGURE

Figure number	Title	Page number
1.2	QPSK Constellation diagram	2
2.2.1	Baseband information sequence	5
2.2.2	Binary ASK signal	5
2.3.1	Binary FSK signal	6
2.4.1	Binary PSK carrier	7
2.5.1(a)	I and Q projection	8
2.5.2(b)	Polar form	8
2.6.1	BPSK signal constellation	9
2.6.2	BPSK modulated carrier	10
2.7.1	QPSK signal constellation	11
2.7.2(a)	BPSK constellation	12
2.7.2(b)	QPSK constellation	12
2.7.2 (c)	also QPSK constellation	12
2.7.2 (d)	8-PSK constellation	12
2.7.3	An arbitrary modulated signal	14
2.7.4	Signal 1 - an arbitrary integer stream of 2 bits per integer	18
2.7.5	Signal 2 - I channel mapping	18
2.7.6	Signal 3 - Q channel mapping	18
2.7.7	Signal 4 - I carrier, a cosine wave of frequency 1 kHz	19
2.7.8	Signal 5 - result of Signal 4 multiplied by Signal 2	19
2.7.9	Signal 6 – Q carrier, a sine wave of frequency 1 kHz	19
2.7.10	Signal 7 – result of Signal 6 multiplied by Signal 3	20
2.7.11	Signal 8 – real modulated signal of I and Q channel	20
2.7.12	Block diagram of a typical QPSK modulator	20
2.8.1	$\pi/4$ DQPSK constellation	21

2.8.2(a)	Offset QPSK constellation	22
2.8.2(b)	QPSK constellation	22
2.8.3(a)	Offset QPSK – all phase shift are 90°	22
2.8.3(b)	QPSK - 180° phase shift occur	22
2.9.1	$\pi/4$ DQPSK constellation	24
2.9.2	Gray coded phases	26
2.9.3	I and Q mapping of $\pi/4$ DQPSK symbols	28
2.9.4	$\pi/4$ DQPSK signal transitions	28
2.9.5	$\pi/4$ DQPSK modulated I and Q channels	29
2.9.6	$\pi/4$ DQPSK modulated carrier	29
2.10.1	Differential encoding	31
2.10.2	Illustration of $\pi/4$ DQPSK differential encoding	31
2.10.3	Block diagram of a typical $\pi/4$ DQPSK modulator	32
2.11.1(a)	QPSK signal constellation	33
2.11.1(b)	$\pi/4$ –shift DQPSK signal constellation	33
3.2	Project flowchart	37
4.1.1	Effect of AWGN	39
4.1.2	Rayleigh fading effect	40
4.1.3	Eye diagram	42
4.1.4 (a)	AWGN channel	43
4.1.4 (b)	Rayleigh channel	43
4.1.5.1(a)	QPSK transmit signal plot	44
4.1.5.1(b)	QPSK received signal plot	44
4.1.5.1 (c)	QPSK without differential encoding	44
4..1.5.2(a)	$\pi/4$ DQPSK transmit signal plot	45
4..1.5.2(b)	$\pi/4$ DQPSK received signal plot	45
4.1.5.2 (c)	$\pi/4$ QPSK with differential encoding ($\pi/4$ DQPSK)	45
4.1.6	Effect of non-linear amplifier	46
4.2.1	Pseudo Random Noise Generator (PRNG)	47
4.2.2	Output of the PRNG	48
4.3.1	90° Phase Shifter	49
4.3.2	In-phase modulated carrier	50
4.3.3	Quadrature modulated carrier	50

5.2	PIC Programming Flowchart	53
6.1	Block Diagram of $\pi/4$ DQPSK Transmitter	55
6.2	The circuit hardware	56
6.3	Hardware setup	56
6.4	Clock signal	57
6.5	Carrier signal	57
6.6	Random signal of PRNG	58
6.7	Transmitted signal in time domain	58
6.8	Constellation diagram of the transmitted signal	59

LIST OF APPENDIXES

NO	Title	Page number
1	7474 DATASHEET	64
2	74164 DATASHEET	65
3	7486 DATASHEET	66
4	74161 DATASHEET	67
5	74175 DATASHEET	68
6	LM741 DATASHEET	69
7	CD4051 DATASHEET	70
8	MC1496 DATASHEET	71
9	PIC16F84A DATASHEET	72

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 pass through the origin. At the receiver, the origin might be mistaken correspond as 00. This leads to false information at the receiver.

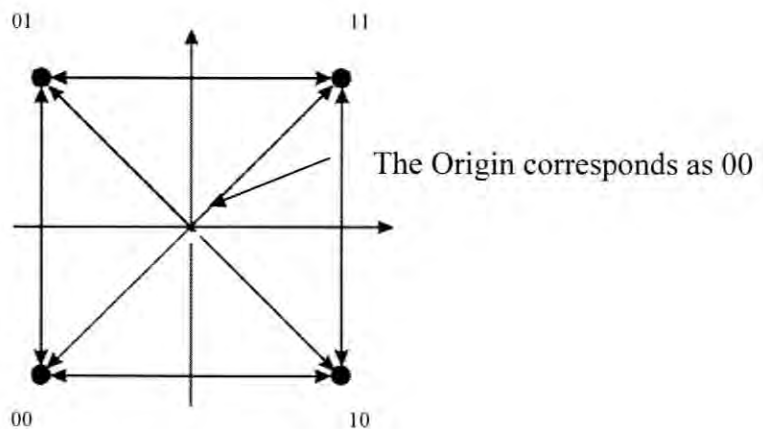


Figure 1.2 QPSK constellation diagram

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 QPSK signal that has large undesirable side lobes.

1.3 Objectives

The objectives of this project are:

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

1.4 Scopes of Work

The scopes of work for this project are:

- involve analyzing and comparison between QPSK and $\pi/4$ 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.

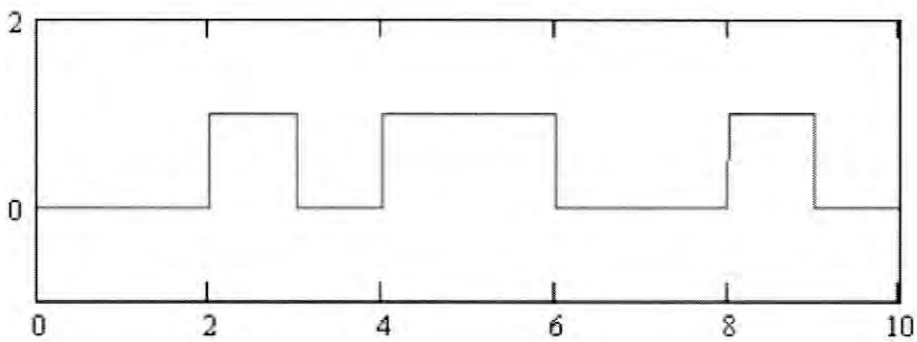


Figure 2.2.1 Baseband information sequence 0010110010

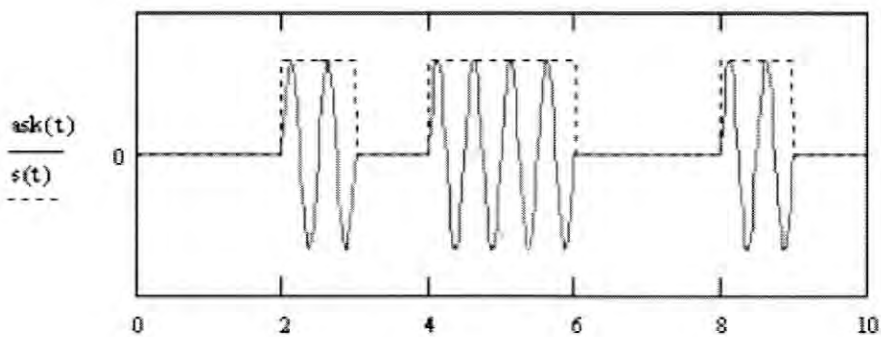


Figure 2.2.2 Binary ASK signal

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

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 f_1 for bit 1 is higher than f_2 which is used for 0 bit.

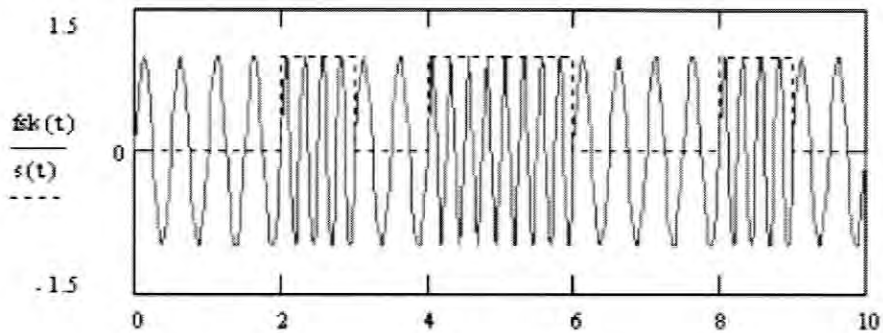


Figure 2.3.1 Binary FSK signal

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

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.

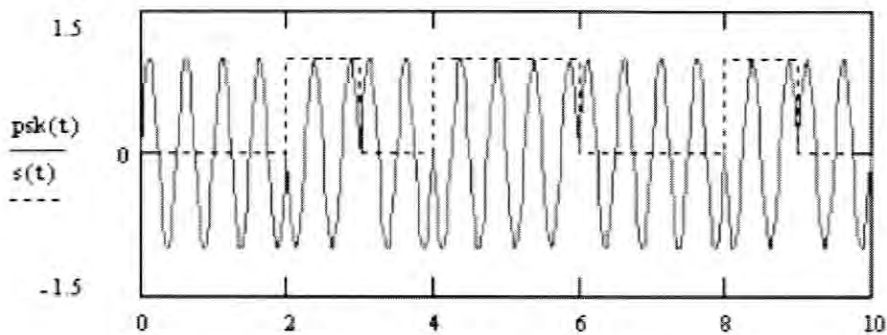


Figure 2.4.1 Binary PSK carrier

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

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} .

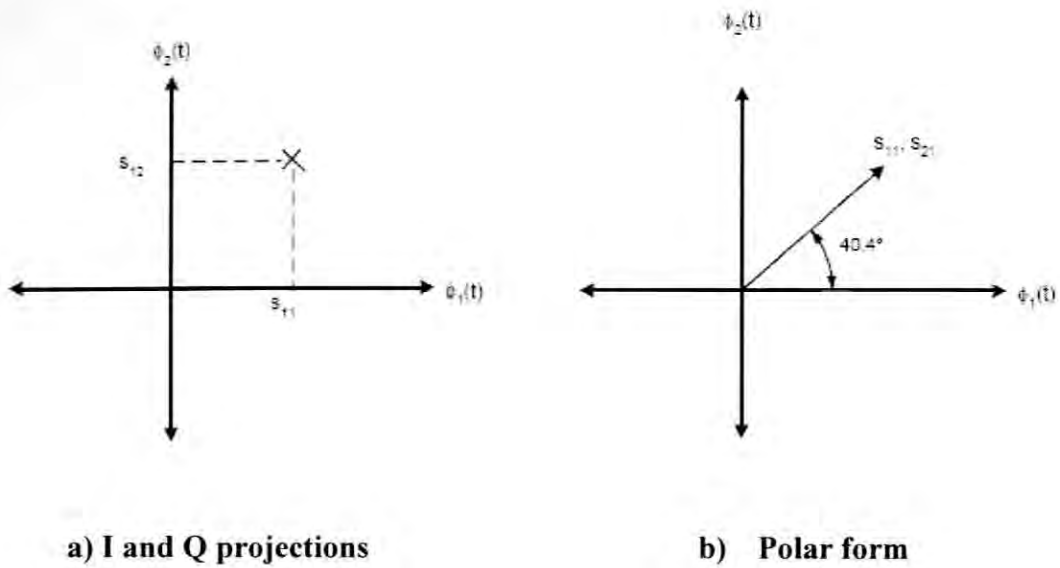


Figure 2.5.1 Signal vector plotted on a signal space

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).

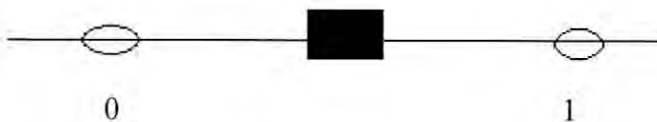


Figure 2.6.1 BPSK signal constellation

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.