

# **MODULATION AND DEMODULATION OF PSK**

Project Report submitted in partial fulfillment of the requirement for the degree of  
Bachelor of Technology.

in

**Electronics and Communication Engineering**

Under the Supervision of

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By

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To



Jaypee University of Information and Technology

Waknaghat, Solan – 173234, Himachal Pradesh

## **Certificate**

This is to certify that project report entitled “**Modulation and Demodulation of PSK**”, submitted by *Suraj Mishra(101104)* in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Wanknaghat, Solan has been carried out under my supervision.

This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

**Date:**

**Prof.Dr.Sunil V.Bhooshan**

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## Abstract

Living in the era of communication every thing may be video, audio or any information in the form of electrical signal is termed as data and there is an enormous requirement of data transfer between two or more point through the world wide web, every moment of the clock, which is a big threaten to the existing communication systems because of the problems like spectral congestion, severe adjacent and co-channel interference problems and noise corrupted data reception etc. This has resulted in serious need for the research work all around the world for the development of the communication systems which can handle the above said problems, where each aspect of the communication systems is dealt with the development of new encoding techniques, modulation techniques, possibilities for newer transmission channels and of course the demodulation and decoding techniques.

The design of a communication system is application oriented and is dependent on the type of the signal. The choice of digital communication technique over its analog counter part becomes more evident of the fact that it provide larger immunity to noise for even at the price of large bandwidth requirements, where as the requirement of video, audio and data over the computer network or the mobile telephony network termed as the third generation (3G) mobile communication poses a serious problem for the bandwidth. So the existing modulation techniques need to be modified for the purpose where it can handle both the situations of noise and bandwidth efficiency. The major advantage of using digital modulation technique is that the use of digital signals reduces hardware noise and interference problems as compared to the analogue signal where large number of waveforms will be required resulting in a larger bandwidth for the symbol to be transmitted.

## Chapter1: Digital modulation

Although a significant portion of communication today is in analog form, it is being replaced rapidly by digital communication. Within the next decade most of the communication will become digital, with analog communication playing a minor role. To begin with we shall consider the binary case, where the data consists of only two symbols: 1 and 0. We assign a distinct waveform (pulse) to each of these two symbols. The resulting sequence of these pulses is transmitted over a channel. At receiver, these pulses are detected and are converted back to binary data (1s and 0s).

In digital modulation, a digital bit stream modulates an analog carrier signal. Digital modulation methods can be considered as digital to analog conversion, and the corresponding demodulation or detection as analog to digital conversion. The changes in the carrier signal are chosen from a finite number of  $M$  alternative symbols. The maximum rate of information transfer through a baseband channel is given by:

Capacity  $f_b = 2 W \log_2 M$  bits per second

Where  $W$  = bandwidth of modulating baseband signal

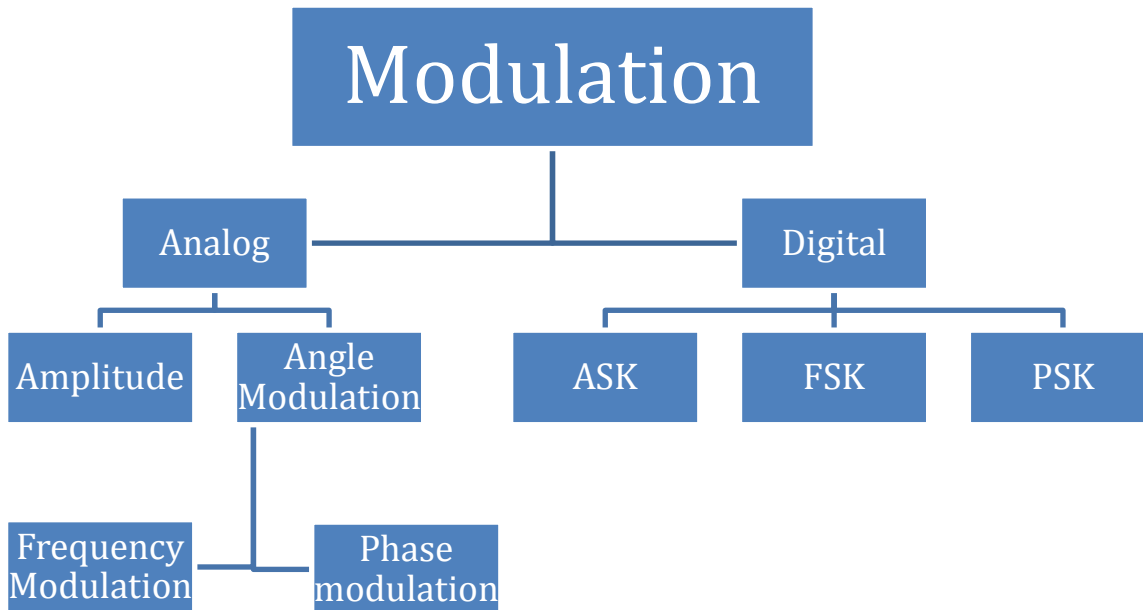


Fig: 1.1 classification of Modulation

### 1.1 Aspects of Digital-to-Analog Conversion

A signal unit is composed of 1 or more bits. Bit rate is the number of bits per second and Baud rate is the number of signal units per second. Bit rate equals the baud rate times the number of bits represented by each signal unit and Baud rate equals the bit rate divided by the number of bits represented by each signal unit. Baud rate is less than or equal to the bit rate and determines the bandwidth required to send the signal.

## 1.2 Carrier Wave

In analog signal, the sending device produces a high-frequency signal that acts as a basis for the information signal. This base signal is called the carrier signal or carrier frequency. Receiving device is tuned to the frequency of the carrier signal that it expects from the sender. Digital information then modulates the carrier signal by modifying one or more of its characteristics (amplitude, frequency, or phase). This kind of modification is called modulation (or shift keying, and the information signal are called the modulating signal. Figure 1.1 shows the example of carrier wave form.

In telecommunications, a carrier signal, carrier wave, or just carrier, is a waveform (usually sinusoidal) that is modulated (modified) with an input signal for the purpose of conveying information. This carrier wave is usually a much higher frequency than the input signal. The purpose of the carrier is usually either to transmit the information through space as an electromagnetic wave (as in radio communication), or to allow several carriers at different frequencies to share a common physical transmission medium by frequency division multiplexing (as, for example, a cable television system). The term is also used for an unmodulated emission in the absence of any modulating signal.

Frequency modulation (FM) and amplitude modulation (AM) are common modes of modulating the carrier. In the case of single-sideband modulation (SSB), the carrier is suppressed (and in some forms of SSB, eliminated). The carrier must be reintroduced at the receiver by a beat frequency oscillator (BFO). The frequency of a radio or television station is actually the carrier wave's centre frequency.

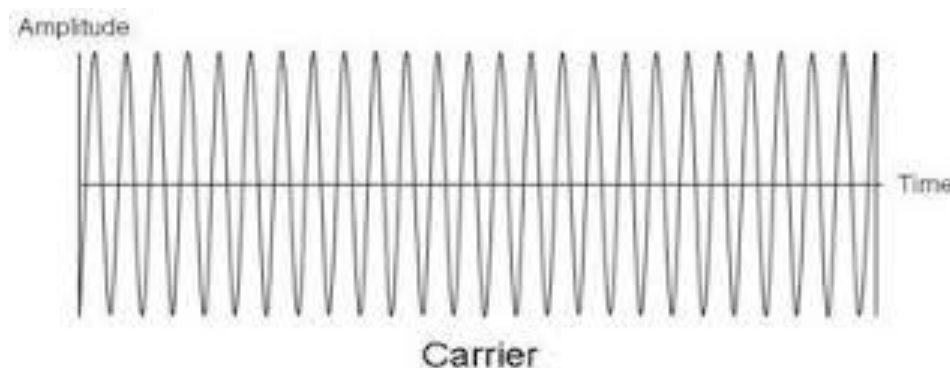


fig: 1.2 carrier wave

## 1.3 Modulation and Demodulation

Modulation is the process of varying one or more properties of a high-frequency periodic waveform, called the carrier signal, with a modulating signal, which typically contains information to be transmitted.

Modulation of a sine waveform is used to transform a baseband message signal into a passband signal. A device that performs modulation is known as a modulator and a device that performs the inverse operation of modulation is known as a demodulator (sometimes detector or demod). A device that can do both operations is a modem (from "modulator–demodulator").



Demodulation is extraction of the original information-bearing signal from a modulated carrier wave. These terms are traditionally used in connection with radio receivers, but many other systems use many kinds of demodulators. Another common one is in a **modem**, which is a contraction of the terms modulator/demodulator. There are several ways of demodulation depending on how parameters of the base-band signal are transmitted in the carrier signal, such as amplitude, frequency or phase.

## 1.4 Advantages of Digital Modulation over Analog Modulation

The main advantage of digital modulation over analog modulation is that in digital modulation, all input and output is in binary form. The modulator rejects anything that isn't a 1 or a 0. This filters out a lot of noise that analog modulation lets through, which may not be related to the intended message. Digital modulation can easily detect and correct the noise. Whereas analog modulation has little complexity and security is more in digital modulation. Signals can be transmitted over long or short distances without picking up noise. Figure 1.2 shows one of the uses of digital modulation



Fig: 1.3 use of digital modulation

# Chapter 2:Phase Shift Keying

## 2.1 Phase-shift keying (PSK)

Phase shift keying is a digital communication scheme that conveys data by changing, or modulating, the phase of a reference signal (the carrier wave).

Any digital modulation scheme uses a finite number of distinct signals to represent digital data. PSK uses a finite number of phases, each assigned a unique pattern of binary digits. Usually, each phase encodes an equal number of bits. Each pattern of bits is represented by the particular phase. The demodulator, which is designed specifically for the symbol-set used by the modulator, determines the phase of the received signal and maps it back to the symbol it represents, thus recovering the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal — such a system is termed coherent (and referred to as CPSK). Alternatively, instead of operating with respect to a constant reference wave, the broadcast can operate with respect to itself. Changes in phase of a single broadcast waveform can be considered the significant items. In this system, the demodulator determines the changes in the phase of the received signal rather than the phase (relative to a reference wave) itself. Since this scheme depends on the difference between successive phases, it is termed **differential phase-shift keying (DPSK)**. DPSK can be significantly simpler to implement than ordinary PSK since 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.

Enter The Input data Sequence : [1 0 1 0 1 1 0 0]

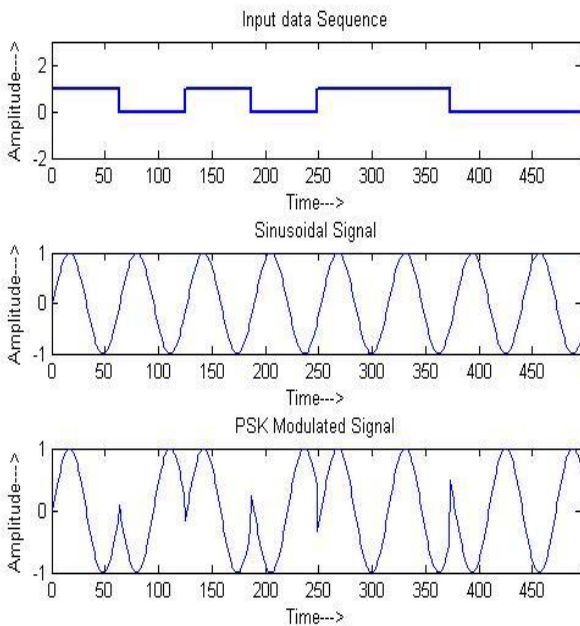


Fig 3.1 Input, carrier and modulated wave .

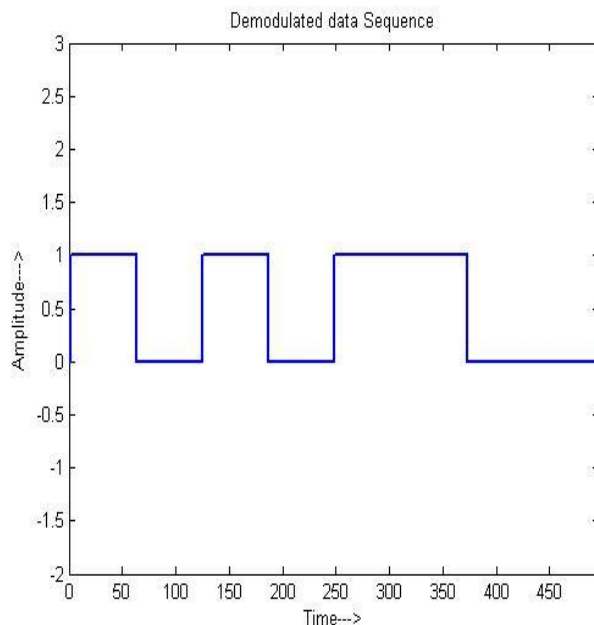


Fig 3.2 Demodulated data sequence

All convey data by changing some aspect of a base signal, the carrier wave (usually a sinusoid), in response to a data signal. In the case of PSK, the phase is changed to represent the data signal. There are two fundamental ways of utilizing the phase of a signal in this way:

- By viewing the phase itself as conveying the information, in which case the demodulator must have a reference signal to compare the received signal's phase against; or
- By viewing the *change* in the phase as conveying information — *differential* schemes, some of which do not need a reference carrier (to a certain extent).

A convenient way to represent PSK schemes is on a constellation diagram. This shows the points in the complex plane where, in this context, the real and imaginary axis are termed the in-phase and quadrature axes respectively due to their  $90^\circ$  separation. Such a representation on perpendicular axes lends itself to straightforward implementation. The amplitude of each point along the in-phase axis is used to modulate a cosine (or sine) wave and the amplitude along the quadrature axis to modulate a sine (or cosine) wave.

In PSK, the constellation points chosen are usually positioned with uniform angular spacing around a circle. This gives maximum phase-separation between adjacent points and thus the best immunity to corruption. They are positioned on a circle so that they can all be transmitted with the same energy. In this way, the moduli of the complex numbers they represent will be the same and thus so will the amplitudes needed for the cosine and sine waves. Two common examples are "binary phase-shift keying" (BPSK) which uses two phases, and "quadrature phase-shift keying" (QPSK) which uses four phases, although any number of phases may be used. Since the data to be conveyed are usually binary, the PSK scheme is usually designed with the number of constellation points being a power of 2.

## 2.2 Binary phase –shift keying (BPSK)

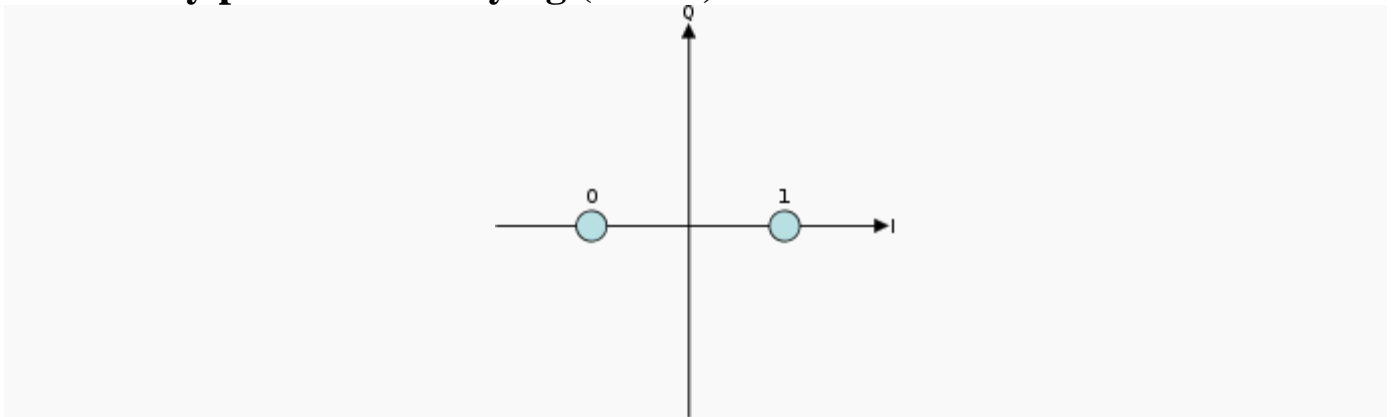


fig 3.3

Constellation diagram of BPSK

BPSK (also sometimes called PRK, phase reversal keying, or 2PSK) is the simplest form of phase shift keying (PSK). It uses two phases which are separated by  $180^\circ$  and so can also be termed 2-PSK. It does not particularly matter exactly where the constellation points are positioned, and in this figure they are shown on the real axis, at  $0^\circ$  and  $180^\circ$ . This modulation is the most robust of all the PSKs since it takes the highest level of noise or distortion to make the demodulator reach an incorrect decision. It is, however, only able to modulate at 1 bit/symbol (as seen in the figure) and so is unsuitable for high data-rate applications.

In the presence of an arbitrary phase-shift introduced by the communications channel, the demodulator is unable to tell which constellation point is which. As a result, the data is often differentially encoded prior to modulation.

BPSK is functionally equivalent to 2-QAM modulation

## 2.3 Circuit diagram of PSK

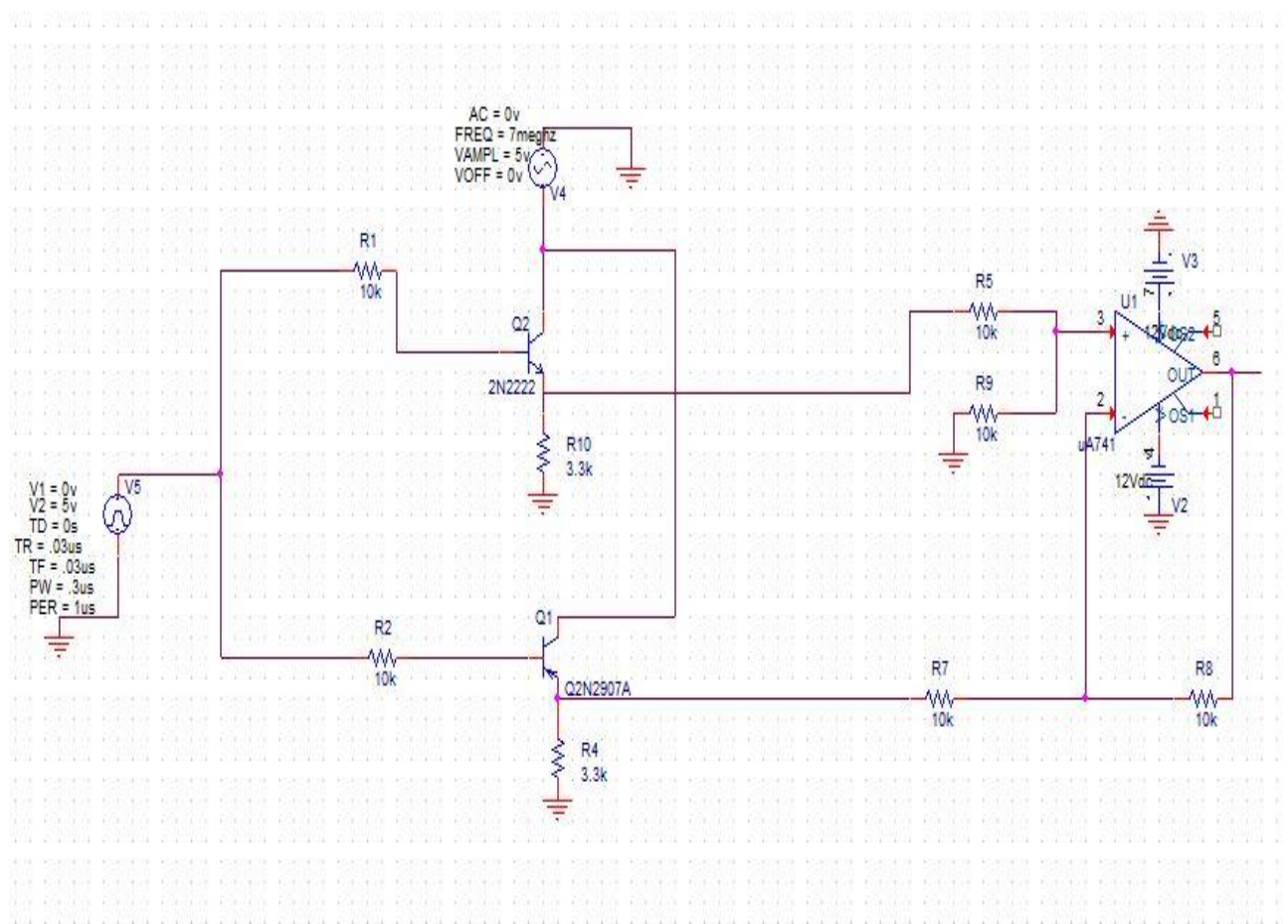
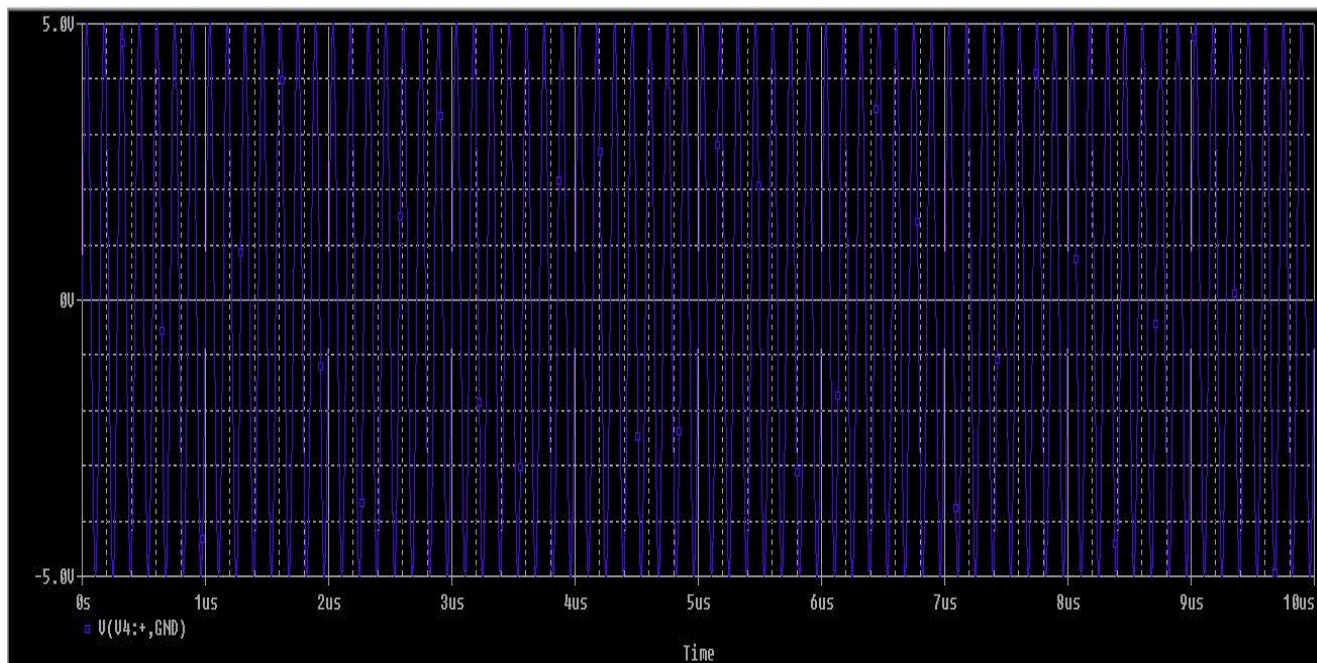


Fig 3.4 circuit diagram of BPSK

A sine wave of amplitude 5V and 7MHz is fed to the collector of the pnp and npn transistors as carrier and the message signal, a square wave of amplitude 5V and 3MHz is fed to the base of the transistors. The transistors are switched on alternatively and their outputs are summed using an op-amp. The BPSK wave is observed at pin 6 of the op-amp IC 741.

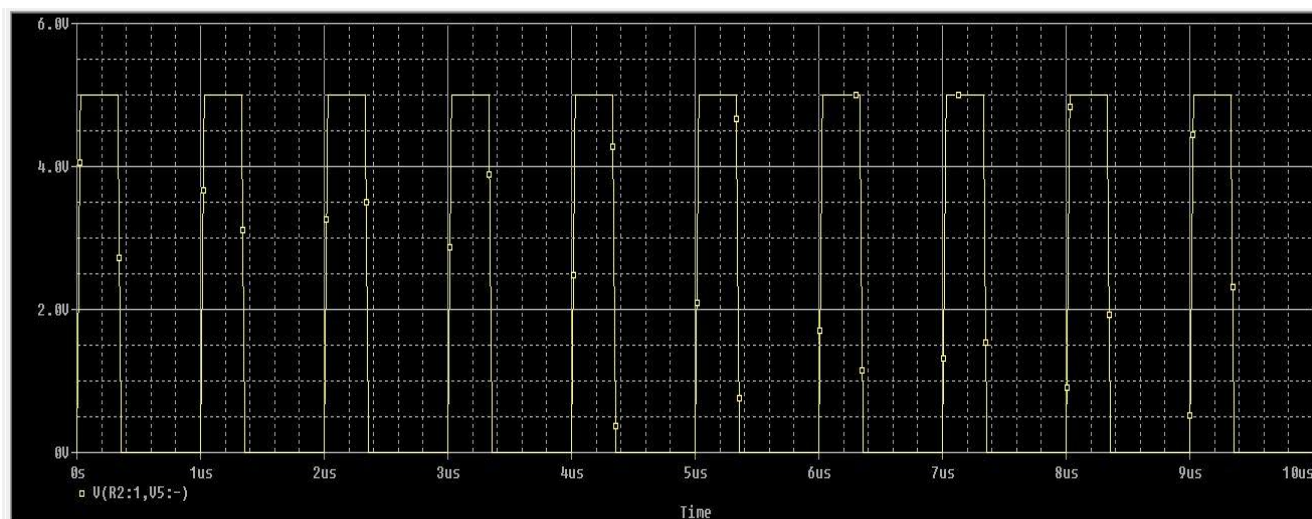
## 2.4 Simulation in Pspice software

### Waveforms of carrier



**Fig 3.5**

### Waveforms of input message



**Fig 3.6**

### Waveforms of input message and carrier



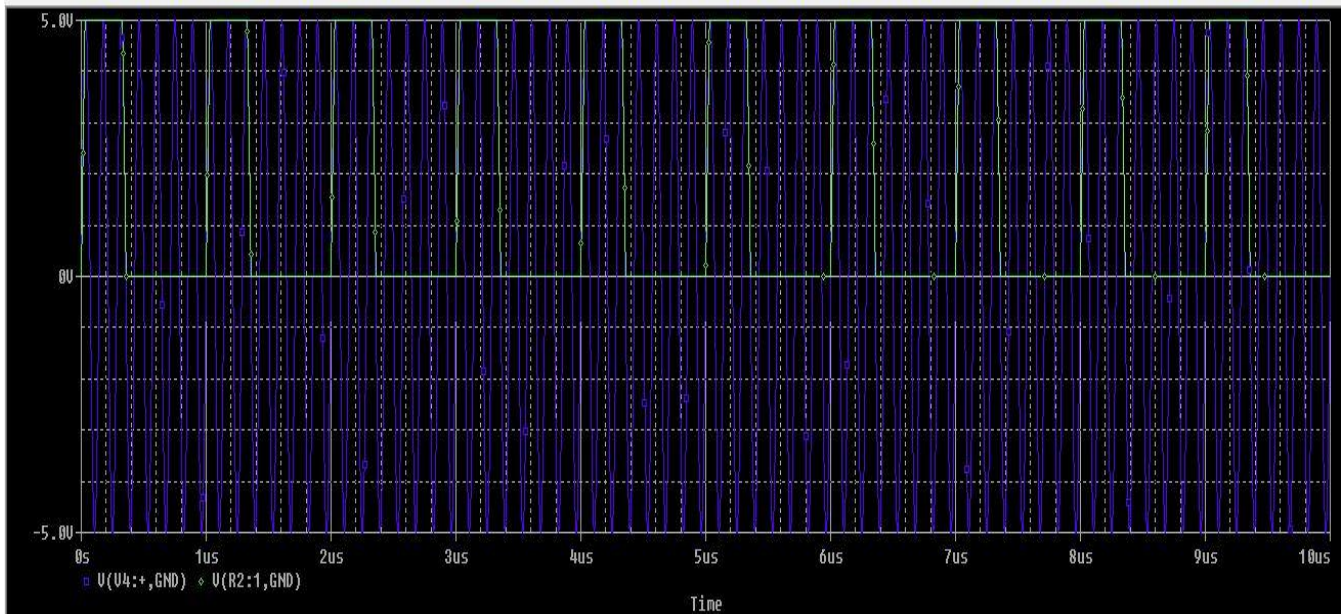


Fig 3.7

### Waveforms of output at pin 6

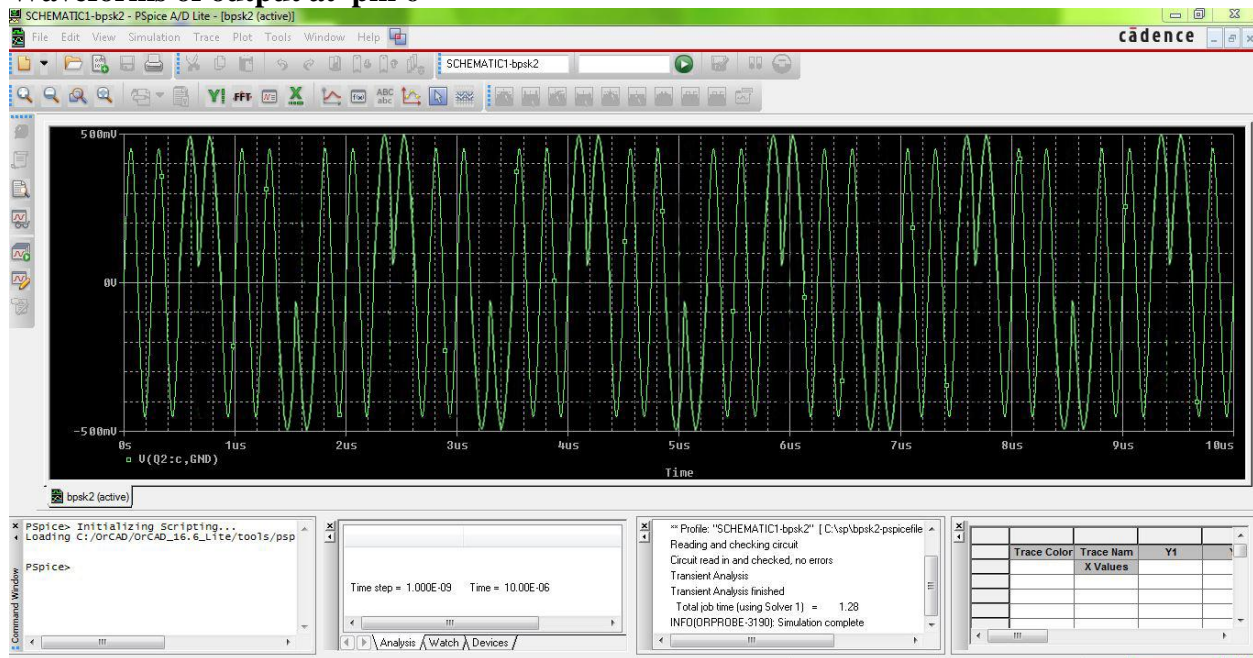


Fig 3.8

## 2.5 Implementation

The general form for BPSK follows the equation:

$$s_n(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi(1 - n)), n = 0, 1.$$

This yields two phases, 0 and  $\pi$ . In the specific form, binary data is often conveyed with the following signals:

$$s_0(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi) = -\sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t) \quad \text{for binary "0"}$$
$$s_1(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t) \quad \text{for binary "1"}$$

where  $f_c$  is the frequency of the carrier-wave.

Hence, the signal-space can be represented by the single basis function

$$\phi(t) = \sqrt{\frac{2}{T_b}} \cos(2\pi f_c t)$$

where 1 is represented by  $\sqrt{E_b}\phi(t)$  and 0 is represented by  $-\sqrt{E_b}\phi(t)$ . This assignment is, of course, arbitrary.

This use of this basis function is shown at the end of the next section in a signal timing diagram. The topmost signal is a BPSK-modulated cosine wave that the BPSK modulator would produce. The bit-stream that causes this output is shown above the signal (the other parts of this figure are relevant only to QPSK).

## 2.6 Bit error rate

The bit error rate (BER) of BPSK in AWGN can be calculated as:

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right) \quad \text{or} \quad P_b = \frac{1}{2} \operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)$$

Since there is only one bit per symbol, this is also the symbol error rate.

## 2.7 Quadrature phase shift keying (QPSK)

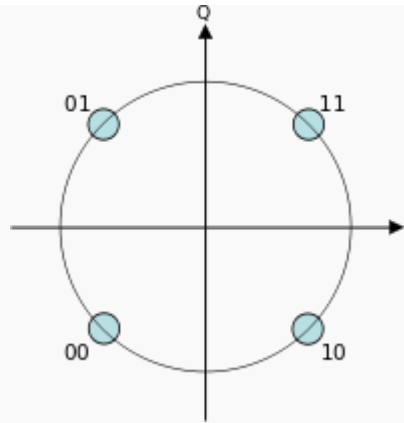


Fig 3.9

Constellation diagram for QPSK with Gray coding.

Each adjacent symbol only differs by one bit.

Sometimes this is known as *quaternary PSK*, *quadriphase PSK*, 4-PSK, or 4-QAM. (Although the root concepts of QPSK and 4-QAM are different, the resulting modulated radio waves are exactly the same.) QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with gray coding to minimize the bit error rate (BER) — sometimes misperceived as twice the BER of BPSK.

The mathematical analysis shows that QPSK can be used either to double the data rate compared with a BPSK system while maintaining the *same* bandwidth of the signal, or to *maintain the data-rate of BPSK* but halving the bandwidth needed. In this latter case, the BER of QPSK is *exactly the same* as the BER of BPSK - and deciding differently is a common confusion when considering or describing QPSK.

Given that radio communication channels are allocated by agencies such as the Federal Communication Commission giving a prescribed (maximum) bandwidth, the advantage of QPSK over BPSK becomes evident: QPSK transmits twice the data rate in a given bandwidth compared to BPSK - at the same BER. The engineering penalty that is paid is that QPSK transmitters and receivers are more complicated than the ones for BPSK. However, with modern electronics technology, the penalty in cost is very moderate.

As with BPSK, there are phase ambiguity problems at the receiving end, and differentially encoded QPSK is often used in practice.

## 2.8 Implementation

The implementation of QPSK is more general than that of BPSK and also indicates the implementation of higher-order PSK. Writing the symbols in the constellation diagram in terms of the sine and cosine waves used to transmit them:

$$s_n(t) = \sqrt{\frac{2E_s}{T_s}} \cos\left(2\pi f_c t + (2n - 1)\frac{\pi}{4}\right), \quad n = 1, 2, 3, 4.$$

This yields the four phases  $\pi/4$ ,  $3\pi/4$ ,  $5\pi/4$  and  $7\pi/4$  as needed.



This results in a two-dimensional signal space with unit basis functions

$$\phi_1(t) = \sqrt{\frac{2}{T_s}} \cos(2\pi f_c t)$$

$$\phi_2(t) = \sqrt{\frac{2}{T_s}} \sin(2\pi f_c t)$$

The first basis function is used as the in-phase component of the signal and the second as the quadrature component of the signal.

Hence, the signal constellation consists of the signal-space 4 points

$$\left( \pm\sqrt{E_s/2}, \pm\sqrt{E_s/2} \right).$$

The factors of 1/2 indicate that the total power is split equally between the two carriers.

Comparing these basis functions with that for BPSK shows clearly how QPSK can be viewed as two independent BPSK signals. Note that the signal-space points for BPSK do not need to split the symbol (bit) energy over the two carriers in the scheme shown in the BPSK constellation diagram.

QPSK systems can be implemented in a number of ways. An illustration of the major components of the transmitter and receiver structure is shown below.

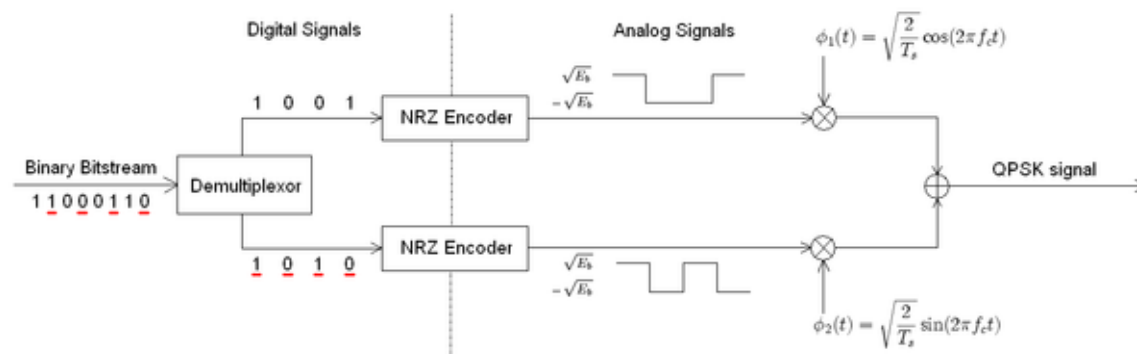


Fig 3.10 Conceptual transmitter structure for QPSK.

The binary data stream is split into the in-phase and quadrature-phase components. These are then separately modulated onto two orthogonal basis functions. In this implementation, two sinusoids are used. Afterwards, the two signals are superimposed, and the resulting signal is the QPSK signal. Note the use of polar non-return-to-zero encoding. These encoders can be placed before for binary data source, but have been placed after to illustrate the conceptual difference between digital and analog signals involved with digital modulation.

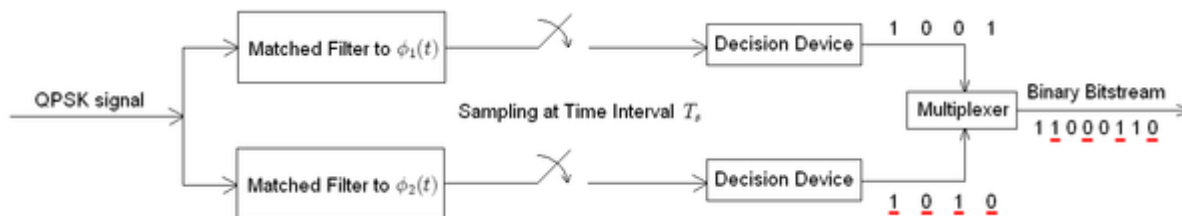


Fig 3.11 Block diagram of QPSK

Receiver structure for QPSK. The matched filters can be replaced with correlators. Each detection device uses a reference threshold value to determine whether a 1 or 0 is detected.

## 2.9 Bit error rate

Although QPSK can be viewed as a quaternary modulation, it is easier to see it as two independently modulated quadrature carriers. With this interpretation, the even (or odd) bits are used to modulate the in-phase component of the carrier, while the odd (or even) bits are used to modulate the quadrature-phase component of the carrier. BPSK is used on both carriers and they can be independently demodulated.

As a result, the probability of bit-error for QPSK is the same as for BPSK:

$$P_b = Q\left(\sqrt{\frac{2E_b}{N_0}}\right).$$

However, in order to achieve the same bit-error probability as BPSK, QPSK uses twice the power (since two bits are transmitted simultaneously).

The symbol error rate is given by:

$$\begin{aligned} P_s &= 1 - (1 - P_b)^2 \\ &= 2Q\left(\sqrt{\frac{E_s}{N_0}}\right) - \left[Q\left(\sqrt{\frac{E_s}{N_0}}\right)\right]^2. \end{aligned}$$

If the signal-to-noise ratio is high (as is necessary for practical QPSK systems) the probability of symbol error may be approximated:

$$P_s \approx 2Q\left(\sqrt{\frac{E_s}{N_0}}\right)$$

The modulated signal is shown below for a short segment of a random binary data-stream. The two carrier waves are a cosine wave and a sine wave, as indicated by the signal-space analysis above. Here, the odd-numbered bits have been assigned to the in-phase component and the even-numbered bits to the quadrature component (taking the first bit as number 1). The total signal — the sum of the two components — is shown at the bottom. Jumps in phase can be seen as the PSK changes the phase on each component at the start of each bit-period. The topmost waveform alone matches the description given for BPSK above.

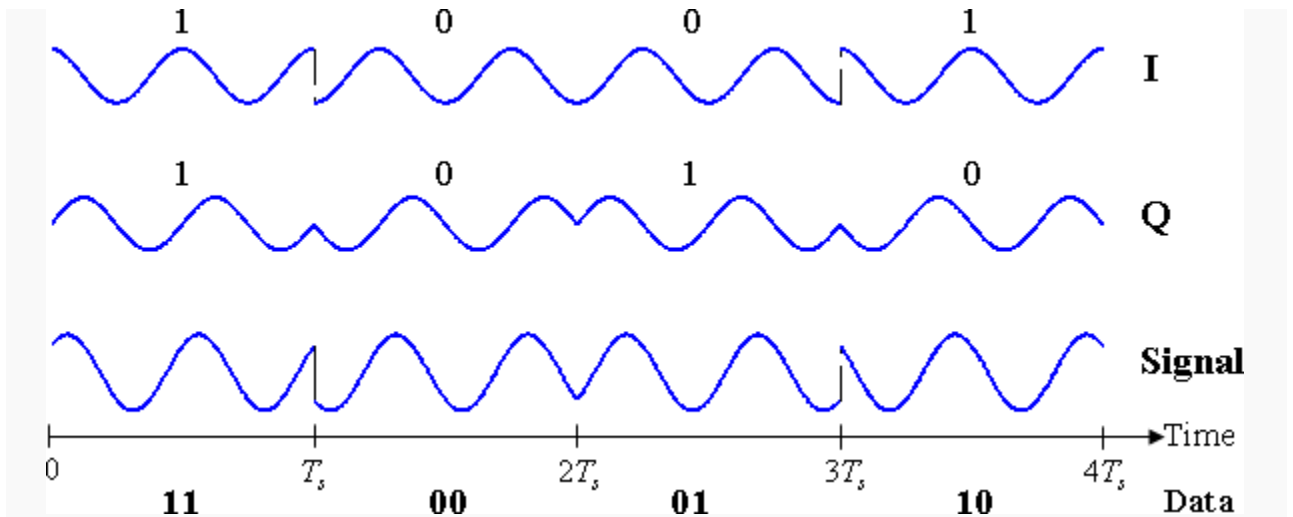


Fig:3.12 Timing diagram for QPSK

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note the abrupt changes in phase at some of the bit-period boundaries.

The binary data that is conveyed by this waveform is: 1 1 0 0 0 1 1 0.

The odd bits, highlighted here, contribute to the in-phase component: 1 1 0 0 0 1 1 0

The even bits, highlighted here, contribute to the quadrature-phase component: 1 1 0 0 0 1 1 0

## 2.10 Offset QPSK (OQPSK)

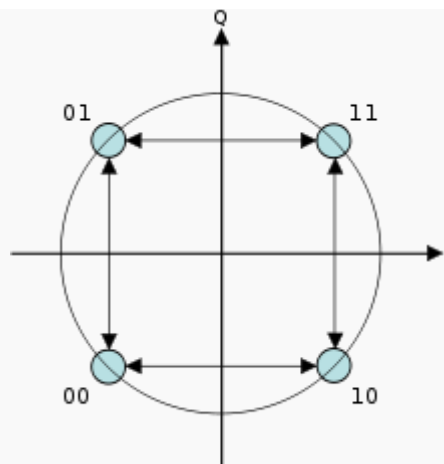


Fig 3.13 constellation diagram of offset QPSK

Signal doesn't cross zero, because only one bit of the symbol is changed at a time

*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)*.

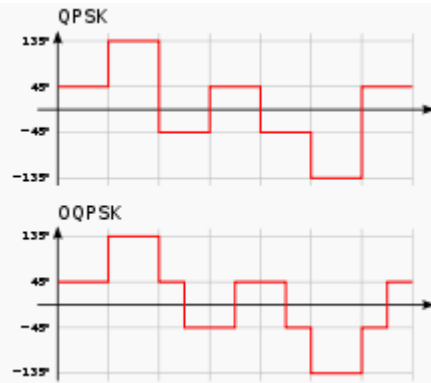


Fig 3.14

Difference of the phase between QPSK and OQPSK

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  $180^\circ$  at a time. When the signal is low-pass filtered (as is typical in a transmitter), these phase-shifts result in large amplitude fluctuations, an undesirable quality in communication systems. By offsetting the timing of the odd and even bits by one 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 this will limit the phase-shift to no more than  $90^\circ$  at a time. This yields much lower amplitude fluctuations than non-offset QPSK and is sometimes preferred in practice.

The picture on the right shows the difference in the behavior of the phase between ordinary QPSK and OQPSK. It can be seen that in the first plot the phase can change by  $180^\circ$  at once, while in OQPSK the changes are never greater than  $90^\circ$ .

The modulated signal is shown below for a short segment of a random binary data-stream. Note the half symbol-period offset between the two component waves. The sudden phase-shifts occur about twice as often as for QPSK (since the signals no longer change together), but they are less severe. In other words, the magnitude of jumps is smaller in OQPSK when compared to QPSK.

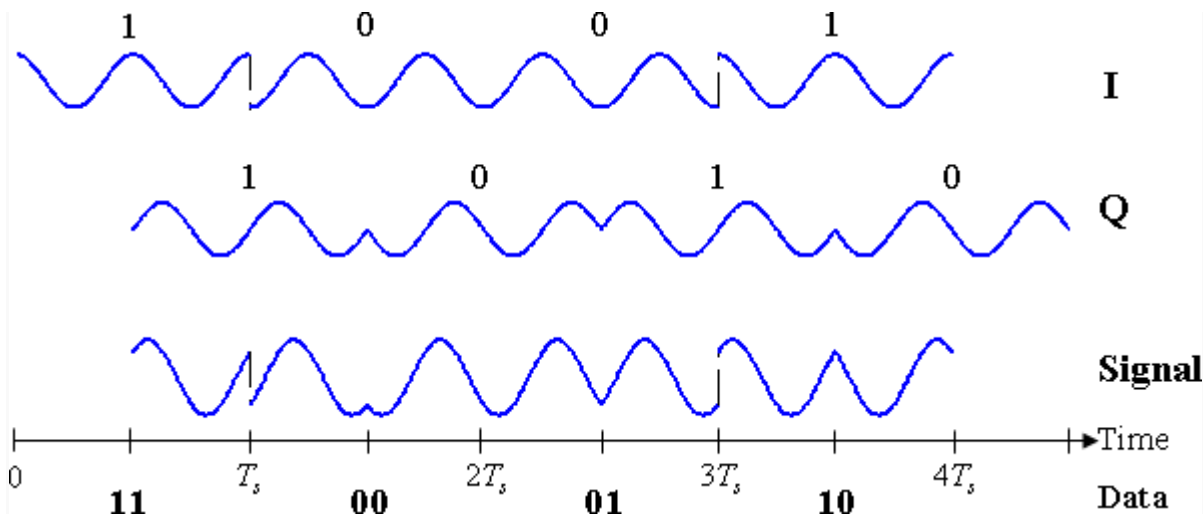


Fig 3.15 Timing diagram for offset-QPSK.

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note the half-period offset between the two signal components.

## 2.11 $\pi/4$ -QPSK

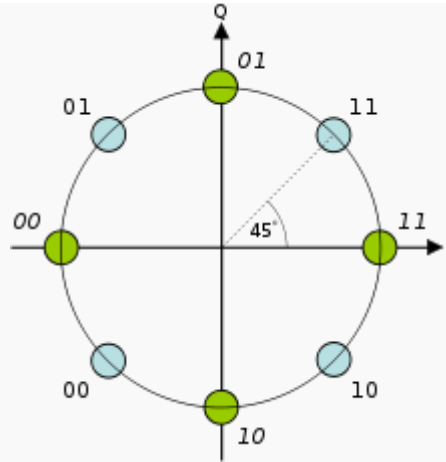


Fig 3.16 Dual constellation diagram for  $\pi/4$ -QPSK.

This shows the two separate constellations with identical Gray coding but rotated by  $45^\circ$  with respect to each other.

This variant of QPSK uses two identical constellations which are rotated by  $45^\circ$  ( $\pi/4$  radians, hence the name) with respect to one another. Usually, either the even or odd symbols are used to select points from one of the constellations or the other symbols select points from the other constellation. This also reduces the phase-shifts from a maximum of  $180^\circ$ , but only to a maximum of  $135^\circ$  and so the amplitude fluctuations of  $\pi/4$ -QPSK are between OQPSK and non-offset QPSK.

One property this modulation scheme possesses is that if the modulated signal is represented in the complex domain, it does not have any paths through the origin. In other words, the signal does not pass through the origin. This lowers the dynamical range of fluctuations in the signal, which is desirable when engineering communications signals.

On the other hand,  $\pi/4$ -QPSK lends itself to easy demodulation and has been adopted for use in, for example, TDMA cellular telephone systems.

The modulated signal is shown below for a short segment of a random binary data-stream. The construction is the same as above for ordinary QPSK. Successive symbols are taken from the two constellations shown in the diagram. Thus, the first symbol (1 1) is taken from the 'blue' constellation and the second symbol (0 0) is taken from the 'green' constellation. Note that magnitudes of the two component waves change as they switch between constellations, but the total signal's magnitude remains constant (constant envelope). The phase-shifts are between those of the two previous timing-diagrams.

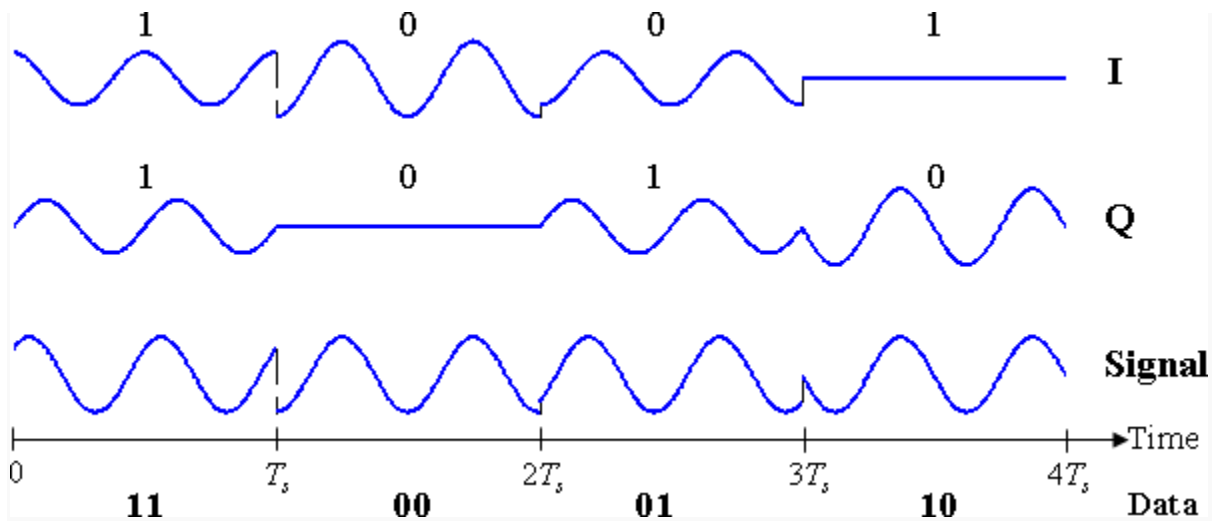


Fig 3.17 Timing diagram for  $\pi/4$ -QPSK.

The binary data stream is shown beneath the time axis. The two signal components with their bit assignments are shown the top and the total, combined signal at the bottom. Note that successive symbols are taken alternately from the two constellations, starting with the 'blue' one.

## 2.12 SOQPSK

The license-free **shaped-offset QPSK** (SOQPSK) is interoperable with Feher-patented QPSK (**FQPSK**), in the sense that an integrate-and-dump offset QPSK detector produces the same output no matter which kind of transmitter is used.

These modulations carefully shape the I and Q waveforms such that they change very smoothly, and the signal stays constant-amplitude even during signal transitions. (Rather than traveling instantly from one symbol to another, or even linearly, it travels smoothly around the constant-amplitude circle from one symbol to the next.)

The standard description of SOQPSK-TG involves ternary symbols.

## 2.13 High order PSK

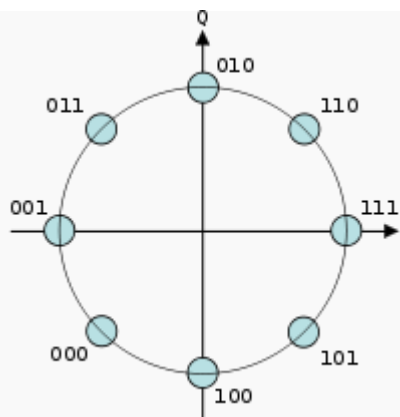


Fig 3.18 Constellation diagram for 8-PSK with Gray coding.

Any number of phases may be used to construct a PSK constellation but 8-PSK is usually the highest order PSK constellation deployed. With more than 8 phases, the error-rate becomes too high and there are better, though more complex, modulations available such as quadrature amplitude modulation (QAM). Although any number of phases may be used, the fact that the constellation must usually deal with binary data means that the number of symbols is usually a power of 2 — this allows an equal number of bits-per-symbol.

## 2.14 Differential phase shift keying (DPSK)

### Differential encoding

Differential phase shift keying (DPSK) is a common form of phase modulation that conveys data by changing the phase of the carrier wave. As mentioned for BPSK and QPSK there is an ambiguity of phase if the constellation is rotated by some effect in the communications channel through which the signal passes. This problem can be overcome by using the data to *change* rather than *set* the phase.

For example, in differentially encoded BPSK a binary '1' may be transmitted by adding  $180^\circ$  to the current phase and a binary '0' by adding  $0^\circ$  to the current phase. Another variant of DPSK is Symmetric Differential Phase Shift keying, SDPSK, where encoding would be  $+90^\circ$  for a '1' and  $-90^\circ$  for a '0'.

In differentially encoded QPSK (DQPSK), the phase-shifts are  $0^\circ$ ,  $90^\circ$ ,  $180^\circ$ ,  $-90^\circ$  corresponding to data '00', '01', '11', '10'. This kind of encoding may be demodulated in the same way as for non-differential PSK but the phase ambiguities can be ignored. Thus, each received symbol is demodulated to one of the  $M$  points in the constellation and a comparator then computes the difference in phase between this received signal and the preceding one. The difference encodes the data as described above. Symmetric Differential Quadrature Phase Shift Keying (SDQPSK) is like DQPSK, but encoding is symmetric, using phase shift values of  $-135^\circ$ ,  $-45^\circ$ ,  $+45^\circ$  and  $+135^\circ$ .

The modulated signal is shown below for both DBPSK and DQPSK as described above. In the figure, it is assumed that the *signal starts with zero phases*, and so there is a phase shift in both signals at  $t = 0$ .

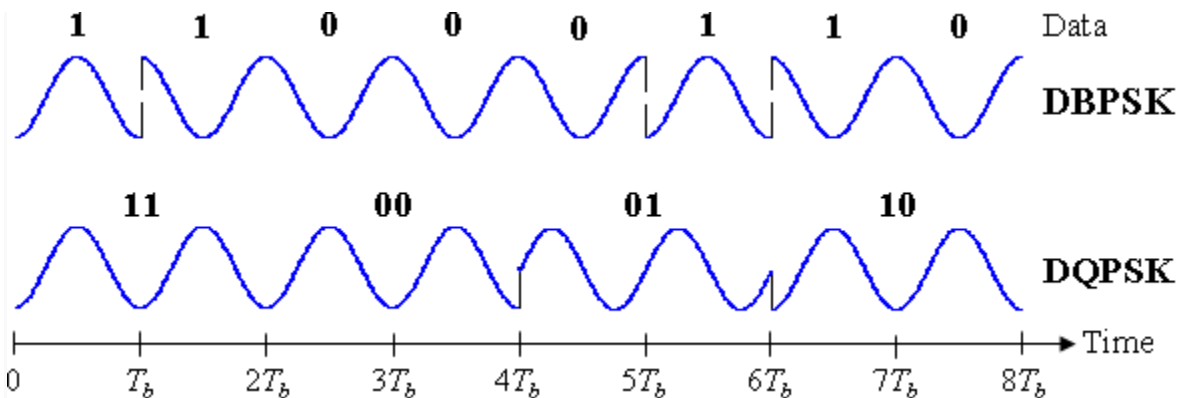


Fig 3.19 Timing diagram for DBPSK and DQPSK.

The binary data stream is above the DBPSK signal. The individual bits of the DBPSK signal are grouped into pairs for the DQPSK signal, which only changes every  $T_s = 2T_b$ .

Analysis shows that differential encoding approximately doubles the error rate compared to ordinary  $M$ -PSK but this may be overcome by only a small increase in  $E_b/N_0$ . Furthermore, this analysis (and the graphical results below) are based on a system in which the only corruption is additive white Gaussian noise (AWGN). However, there will also be a physical channel between the transmitter and receiver in the communication system. This channel will, in general, introduce an unknown phase-shift to the PSK signal;

## **2.15 Demodulation**

Demodulation is the act of extracting the original information-bearing signal from a modulated carrier wave. A demodulator is an electronic circuit (or computer program in a software-defined radio) that is used to recover the information content from the modulated carrier wave[1] The demodulator takes the digital data and, using the staircase maker and the delay unit, creates the analog signal. The created analog signal, however, needs to pass through a low-pass filter for smoothing

These terms are traditionally used in connection with radio receivers, but many other systems use many kinds of demodulators. Another common one is in a modem, which is a contraction of the terms modulator/demodulator

There are several ways of demodulation depending on how parameters of the base-band signal are transmitted in the carrier signal, such as amplitude, frequency or phase. For example, for a signal modulated with a linear modulation, like AM (amplitude modulation), we can use a synchronous detector. On the other hand, for a signal modulated with an angular modulation, we must use an FM (frequency modulation) demodulator or a PM (phase modulation) demodulator. Different kinds of circuits perform these functions.

Many techniques—such as carrier recovery, clock recovery, bit slip, frame synchronization, rake receiver, pulse compression, Received Signal Strength Indication, error detection and correction, etc., are only performed by demodulators, although any specific demodulator may perform only some or none of these techniques.

Many things can act as a demodulator, if they pass the radio waves on nonlinearly: for example, near a powerful radio station, it has been known for the metal sides of a van to demodulate the radio signal as sound.

## **2.16 Types of Demodulation**

### **(a) Coherent Demodulation**

Coherent Detection is a technique of phase locking to the carrier wave that improves detection. Having knowledge of the carrier phase will improve the performance of the demodulator. Coherent Detection is also known as coherent demodulation.



(i) Carrier recovery for demodulation

- Receiver signal  $\hat{S}(t) = A \cos(\omega_c t + \theta_c) + N(t)$

- Local carrier  $\cos(\omega_c t + \theta_c)$

- Carrier recovery (e.g. phase lock loop) circuit

$\theta_c = \theta_c - \theta_c \rightarrow 0$  i.e.  $\theta_c \rightarrow \theta_c$

- Demodulation leads to recovered baseband signal

$Y(t) = X(t + \theta_c) + N(t)$

where  $X(t)$  is transmitted baseband signal

(ii) Timing recovery for sampling

- Align receiver clock with transmitter clock, so that sampling

$Y_k = X_k + N_k$

where  $X_k$  are transmitted symbols, and  $N_k$  noise samples

## (b) Non Coherent Demodulation

This type of detection doesn't need receiver carrier to be phase locked with transmitter carrier.

(i) No carrier recovery for demodulation

- Receiver signal  $\hat{S}(t) = A \cos(\omega_c t + \theta_c) + N(t)$

- Local carrier  $\cos(\omega_c t + \theta_c)$

- No carrier recovery,

$\theta_c = \theta_c - \theta_c \neq 0$  i.e.  $\theta_c \neq \theta_c$

- Demodulation leads to recovered baseband signal

$Y(t) = X(t + \theta_c) e^{j\theta_c} + N(t)$

(ii) Timing recovery for sampling

- Align receiver clock with transmitter clock, sampling results in

$$Y_k = X_{k\epsilon j} + N_k$$

Could not recover transmitted symbols properly from  $Y_k$  !

## 2.17 Demodulation of Phase Shift Keying

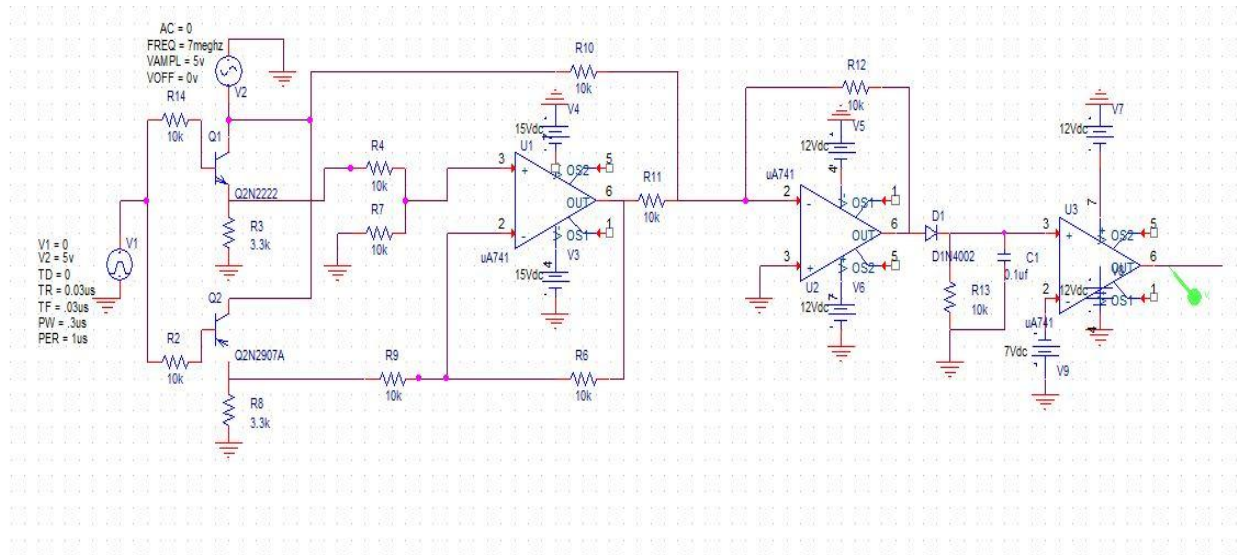


Fig 3.20 circuit diagram modulation and demodulation

The modulated wave and carrier is summed up and inverted firstly. Then the diode clips 0 part and allows only 1 part. Then it's filtered by low pass filter which is made by RC circuit. And finally comparator compares the output with reference voltage 7V and gives output. The output we get is same signal that we have fed in input but little change in magnitude.

### Waveforms of demodulated wave

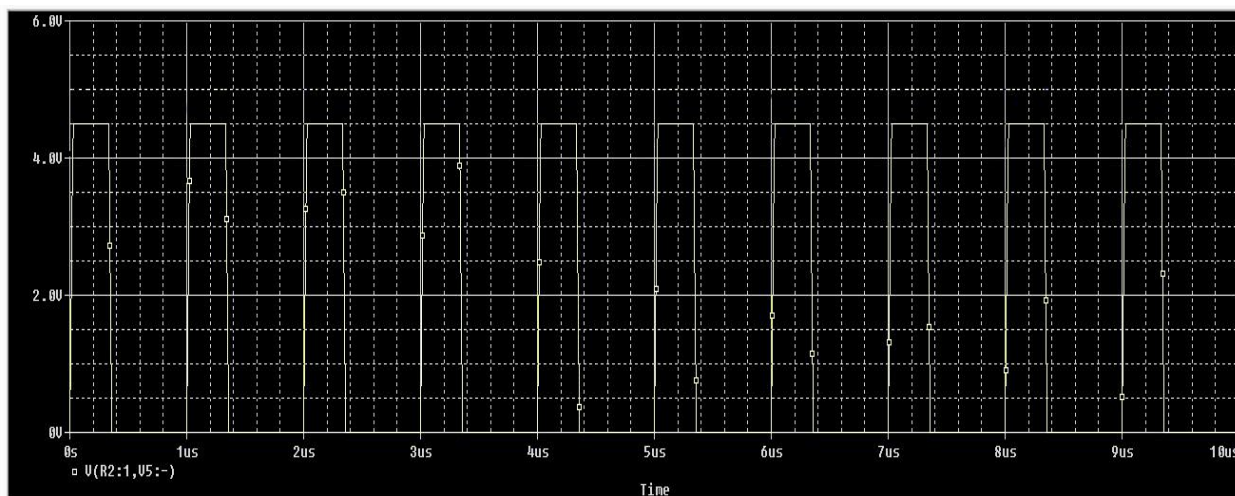


Fig 3.21 Resultant waveform after demodulation

## 2.18 Applications

Owing to PSK's simplicity, particularly when compared with its competitor quadrature amplitude modulation, it is widely used in existing technologies.

The wireless LAN standard, IEEE 802.11b-1999, uses a variety of different PSKs depending on the data-rate required. At the basic-rate of 1 Mbit/s, it uses DBPSK (differential BPSK). To provide the extended-rate of 2 Mbit/s, DQPSK is used. In reaching 5.5 Mbit/s and the full-rate of 11 Mbit/s, QPSK is employed, but has to be coupled with complementary code keying. The higher-speed wireless LAN standard, IEEE 802.11g-2003 has eight data rates: 6, 9, 12, 18, 24, 36, 48 and 54 Mbit/s. The 6 and 9 Mbit/s modes use OFDM modulation where each sub-carrier is BPSK modulated. The 12 and 18 Mbit/s modes use OFDM with QPSK. The fastest four modes use OFDM with forms of quadrature amplitude modulation.

Because of its simplicity BPSK is appropriate for low-cost passive transmitters, and is used in RFID standards such as ISO/IEC 14443 which has been adopted for biometric passports, credit cards such as American Express's express pay, and many other applications.

Bluetooth 2 will use  $\pi/4$ -DQPSK at its lower rate (2 Mbit/s) and 8-DPSK at its higher rate (3 Mbit/s) when the link between the two devices is sufficiently robust. Bluetooth 1 modulates with Gaussian minimum-shift keying, a binary scheme, so either modulation choice in version 2 will yield a higher data-rate. A similar technology, IEEE 802.15.4 (the wireless standard used by ZigBee) also relies on PSK. IEEE 802.15.4 allows the use of two frequency bands: 868–915 MHz using BPSK and at 2.4 GHz using OQPSK.

Notably absent from these various schemes is 8-PSK. This is because its error-rate performance is close to that of 16-QAM — it is only about 0.5 dB better but its data rate is only three-quarters that of 16-QAM. Thus 8-PSK is often omitted from standards and, as seen above, schemes tend to 'jump' from QPSK to 16-QAM (8-QAM is possible but difficult to implement).

Included among the exceptions is Hughes Net satellite ISP. For example, the model HN7000S modem (on KU-band satcom) uses 8-PSK modulations.

## Conclusion

One of the things that we have learned personally from this project is to adopt a methodical approach to problem solving. From the outset of the project the aim was to design and simulate a complete PSK modulation and demodulation.

Knowledge of analogue design of circuits greatly helped in the design of the project. DC formulae and circuits configurations studied in the process of three years of Electronics gave good background knowledge of the type of circuits to be implemented in modulation of PSK. Another aspect that helped was the previous use of the Pspice simulation package. Now having spent the duration of the project working with Pspice, we would have to say that our knowledge of the package has been greatly enhanced, as too is our understanding of digital modulation and other circuits in general.

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## **Appendix: software used**

- i. OrCAD Capture CSI lite 16.6- By Cadence Design System, Inc.
- ii. Microsoft word 2007
- iii. Microsoft windows version 6.1(Build 7600)
- iv. LTspice IV