# DESIGN AND DEVELOPMENT OF A QPSK MODULATOR


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# DECLARATION

This is to certify that the thesis contains our original work towards the degree of Bachelor of Science in Electronics and Communication Engineering at BRAC University. Materials of work found by other researcher are mentioned by reference. Furthermore, this thesis has not been submitted elsewhere for a degree.

…………………………………………………..

Signature of Supervisor

(Dr. Satya Prashad Majumder)

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# ABSTRACT

QPSK or Quadrature Phase-Shift Keying is a higher order modulation scheme used in digital modulation. In this project, we will be implementing a QPSK modulator for a wireless communication link. The carriers will be chosen as orthogonal frequencies to reduce the bandwidth of the output signal. Later the design will be simulated by PSPICE and will be fabricated on a PCB. The output signal waveform will be measured and tested to find the signal quality and the SNR or Signal to Noise Ratio.

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# CHAPTER I

# INTRODUCTION

In satellite or telecommunication system, modulation is the process of conveying a message signal over a medium. To extend the range of the analog signal or digital data, we need to transmit it through a medium other than air. The process of converting information so that it can be successfully transmitted through a medium is called modulation. We are working with QPSK modulation which is kind of a digital modulation. Before going into the main focus we shall have a brief discussion on modulation, different types of modulation and the analysis of it. This chapter gives a brief and basic idea on modulation and different types of modulation techniques.

## 1.1 Analysis of Modulation

Base band signals produced by various information sources are not always suitable for direct transmission over a given channel. This signals are usually further modified to facilitate transmission. This conversion process in known as modulation. In this process the baseband signal is used to modify some parameter of a high frequency carrier signal.

A carrier is a sinusoid of high frequency, and one of its parameters - such as amplitude, frequency or phase – is varied in proportion to the base band signal. Accordingly, we have amplitude, frequency modulation or phase modulation.

## 1.2 Purposes of Modulation

### 1.2.1 Ease of Radiation:

For efficient radiation of electromagnetic energy, the radiating antenna should be on the order of one-tenth or more the wavelength of the signal radiated. For many baseband signals, the wavelengths are too large for reasonable antenna dimensions. For example, the power in a speech signal is concentrated at frequencies in the range of 100 to 300Hz. The corresponding wave length is 100 to 3000km. This large wavelength would necessitate an impracticably huge antenna. So to avoid this problem, we modulate the signal with a high frequency carrier to translate the signal spectrum to the region of carrier frequencies that corresponds to a much smaller wavelength. For example, a 1 MHz carrier frequency corresponds to the wave length of only 300m and requires an antenna of size 30m.

### 1.2.2 Simultaneous Transmission of Several Signals:

In the case of several radio stations broadcasting audio baseband signals directly, without any modification they would interfere with each other because the spectra of all the signals occupy more or less the same bandwidth. Thus it would be possible to broadcast from only one radio or television station at a time which is a waste because the channel bandwidth may be larger than that of the signal. One way to solve this problem is to use modulation. We can use various audio signals to modulate different carrier frequencies, thus translating each signal to a different frequency range. If the various carriers are chosen sufficiently far apart in frequency, the spectra of the modulated signals will not overlap and thus will not interfere with each other. The method of transmitting several signals simultaneously is known as Frequency Division Multiplexing. Here the bandwidth of the channel is shared by various signals without any overlapping.

### 1.3 Analog modulation methods

In analog modulation, the modulation is applied continuously in response to the analog information signal. Common analog modulation techniques are:

- Angular modulation
- Phase modulation (PM)
- Frequency modulation (FM)
- Amplitude modulation (AM)
- Double-sideband modulation (DSB)
- Double-sideband modulation with unsuppressed carrier (DSB-WC)
- Double-sideband suppressed-carrier transmission (DSB-SC)
- Double-sideband reduced carrier transmission (DSB-RC)
- Single-sideband modulation (SSB)

### 1.4 Digital Modulation Methods

In digital modulation, an analog carrier signal is modulated by a digital bit stream. 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 alternative symbols. There are four types of basic digital modulation schemes. These are:

- Amplitude-Shift Keying (ASK)
- Frequency-Shift Keying (FSK)
- Phase-Shift Keying (PSK)
- Quadrature amplitude modulation (QAM)

In ASK, a finite number of amplitude is used for modulation. Similarly, for FSK, a finite number of frequencies, phase for PSK and a finite number of at least two phases, and at least two amplitudes are used in QAM.

In the case of QAM, as in phase signal (the I signal, for example a cosine waveform) a quadrature phase signal (the P signal, for example a sine wave) are amplitude modulated with a finite number of amplitudes. It can be seen as a two channel system. The resulting signal is the combination of PSK and ASK, with a finite number of at least two phases, and a finite number of at least two amplitudes.

Each of these phases, frequencies or amplitudes are assigned a unique pattern of binary bits. Usually, each phase, frequency or amplitude encodes an equal number of bits. This number of bits comprises the symbol that is represented by the particular phase.

If the alphabet consists of M = $2^N$ alternative symbols, each symbol represents a message consisting of N bits. If the symbol rate is $f_s$ symbols/second, the data rate is $Nf_s$ bit/second.

Most commonly in all digital communication systems, the design of both the modulator and demodulator must be done simultaneously. Digital modulation schemes are possible because the transmitter-receiver pair have prior knowledge of how data is encoded and represented in the communications system.

In all digital communication systems, both the modulator at the transmitter and the demodulator at the receiver are structured so that they perform inverse operations.

The most common digital modulation techniques are:

- Phase-shift keying (PSK)
- Frequency-shift keying (FSK) (see also audio frequency-shift keying)
- Amplitude-shift keying (ASK) and its most common form, (OOK)
- Quadrature amplitude modulation(QAM) a combination of PSK and

- Polar modulation like QAM a combination of PSK and ASK
- Continuous phase modulation (CPM) Minimum-shift keying (MSK)
- Gaussian minimum-shift keying (GMSK)
- Orthogonal Frequency division multiplexing (OFDM) modulation.

MSK and GMSK are particular cases of continuous phase modulation (CPM). Indeed, MSK is a particular case of the sub-family of CPM known as continuous-phase frequency-shift keying (CPFSK) which is defined by a rectangular frequency pulse (i.e. a linearly increasing phase pulse) of one symbol-time duration (total response signaling).

OFDM is based on the idea of a Frequency Division Multiplex (FDM), but is utilized as a digital modulation scheme. The bit stream is split into several parallel data streams, each transferred over its own sub-carrier using some conventional digital modulation scheme. The sub-carriers are summarized into an OFDM symbol. OFDM is considered as a modulation technique rather than a multiplex technique, since it transfers one bit stream over one communication channel using one sequence of so-called OFDM symbols.

OFDM can be extended to multi-user channel access method in the Orthogonal Frequency Division Multiple Access (OFDMA) and MCOFDM schemes, allowing several users to share the same physical medium by giving different sub-carriers to different users.

# CHAPTER II

# ANALYSIS OF QUADRATURE PHASE SHIFT KEYING (QPSK)

## 2.1 Phase-Shift Keying

Phase-shift keying or PSK is a digital modulation scheme that conveys data by changing, or modulating, the phase of a reference signal or the carrier wave

Every 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 forms the symbol that is represented by the particular phase. The demodulator is designed specifically for the symbol-set used by the modulator and it determines the phase of the received signal and maps it back to the symbol it represents. Thus it recovers the original data. This requires the receiver to be able to compare the phase of the received signal to a reference signal.

Alternatively, instead of using the bit patterns to set the phase of the wave, it can instead be used to change it by a specified amount. The demodulator then determines the changes in the phase of the received signal rather than the phase 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. In exchange, it produces more erroneous demodulations. The exact requirements of the particular scenario under consideration determine which scheme is used.

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 module 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 i.e. 4, 8 or 16.

**2.2 Binary Phase-Shift Keying (BPSK)**

BPSK is the simplest form of phase shift keying or PSK. It uses two phases which are separated by 180°. It does not particularly matter exactly where the constellation points are positioned, as in this figure they are shown on the real axis, at 0° and 180°. 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 and so is unsuitable for high data-rate applications when bandwidth is limited.

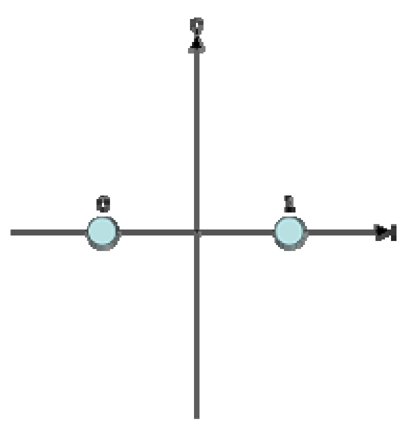


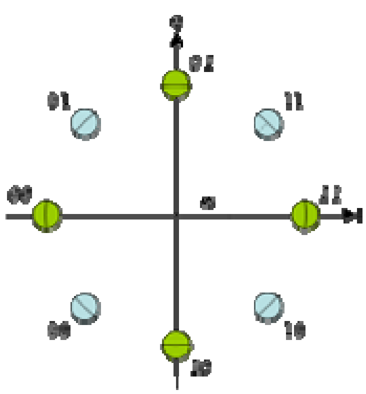

**Figure 2.1: Constellation diagram for BPSK**

### 2.3 QPSK Modulation

Since the early days of electronics, as advances in technology were taking place, the boundaries of both local and global communication began eroding, resulting in a world that is smaller and hence more easily accessible for the sharing of knowledge and information. The pioneering work by Bell and Marconi formed the cornerstone of the information age exists today and paved the way for the future of telecommunications.

Traditionally, local communications was done over wires, as this presented a cost-effective way of ensuring a reliable transfer of information. For long-distance communications, transmission of information over radio waves was needed. Although this was convenient from a hardware standpoint, radio-waves transmission raised doubts over the corruption of the information and was often dependent on high-power transmitters to overcome weather conditions, large buildings, and interference from other source of electromagnetic.

#### 2.3.1 Quadrature phase-shift keying (QPSK)



| Phase of QPSK | 2bits Inputs |
|---|---|
| π/4 | 10 |
| 3π/4 | 00 |
| 5π/4 | 01 |
| 7π/4 | 11 |

**Figure 2.2: Constellation diagram for QPSK with Gray coding. Each adjacent symbol only differs by one bit.**

Sometimes known as quaternary or quadriphase PSK, 4-PSK, or 4-QAM [6], 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 BER — twice the rate of BPSK. Analysis shows that this may be used either to double the data rate compared to a BPSK system while maintaining the bandwidth of the signal or to maintain the data-rate of BPSK but halve the bandwidth needed.

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, with two bits per symbol, the symbol error rate is increased.

The symbol error rate is given by:

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

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

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

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

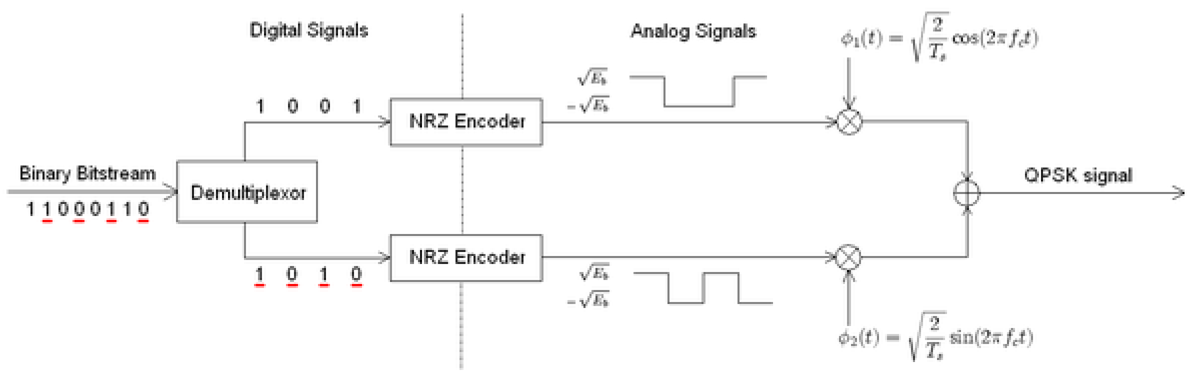



**Figure 2.3: Block diagram of QPSK Modulator**

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.

## 2.4 QPSK Demodulation

The block diagram of a QPSK Demodulator is given below.

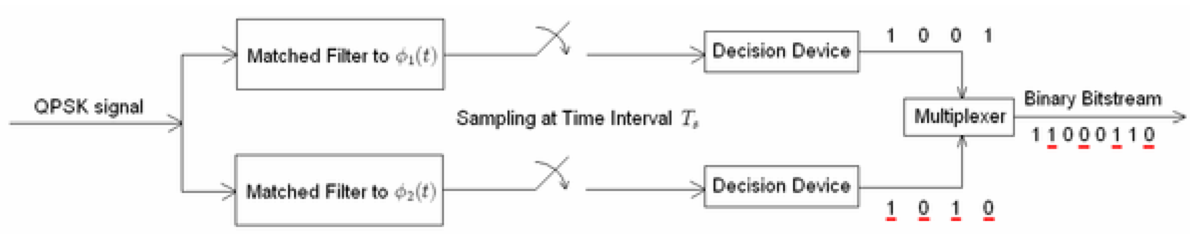



**Figure 2.4: Block diagram of QPSK Demodulator**

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.

## 2.5 QPSK Signal in the Time Domain

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. The signal graph is given in the following page.

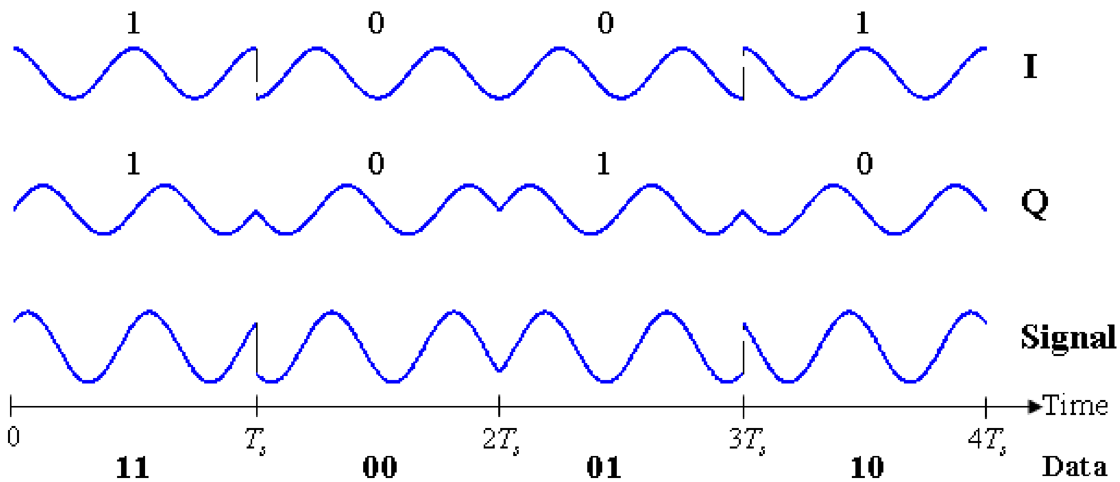



**Figure 2.5: Timing diagram for QPSK**

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**

## 2.6 Offset QPSK (OQPSK)

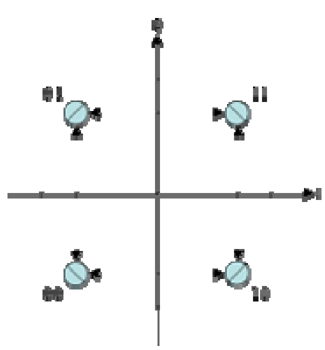


**Figure 2.6: Constellation diagram of OQPSK**

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).

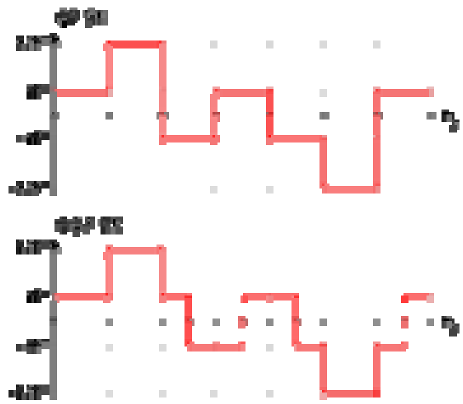


**Figure 2.7: Difference of the phase between QPSK and OQPSK**

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° at a time. When the signal is passed through a low-pass filter (as it is typical in a transmitter), large amplitude fluctuation causes which is 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° 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° at once, while in OQPSK the changes are never greater than 90°.

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.

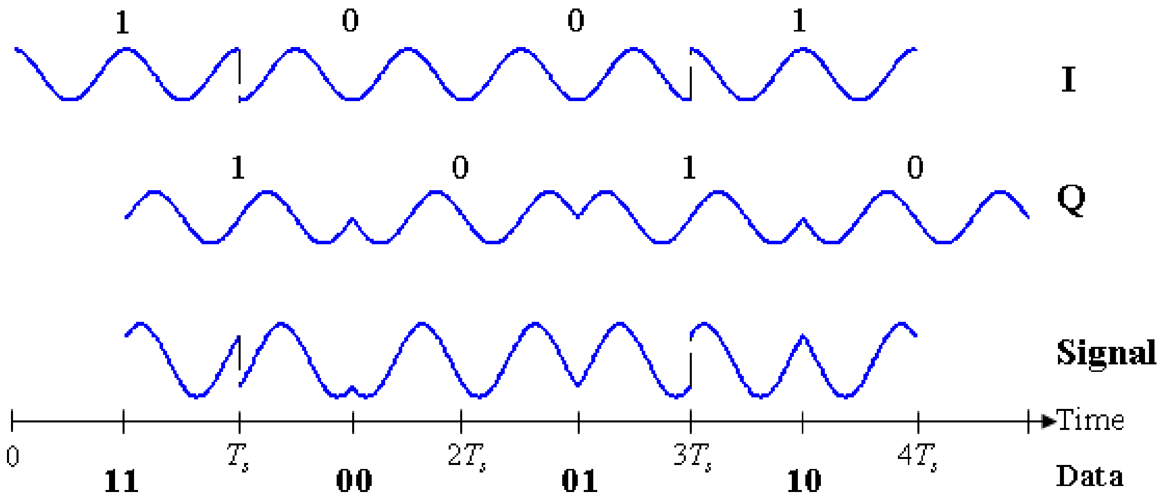



**Figure 2.8: Timing diagram for offset-QPSK.**

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.

### 2.7 π/4–QPSK

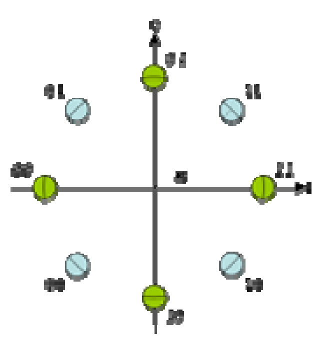


**Figure 2.9: Dual constellation diagram for π/4-QPSK.**

Figure 2-i shows the two separate constellations with identical Gray coding but each is rotated by 45° with respect to each other.

This final variant of QPSK uses two identical constellations which are rotated by 45° (π / 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°, but only to a maximum of 135° and so the amplitude fluctuations of π / 4–QPSK are between OQPSK and non-offset QPSK.

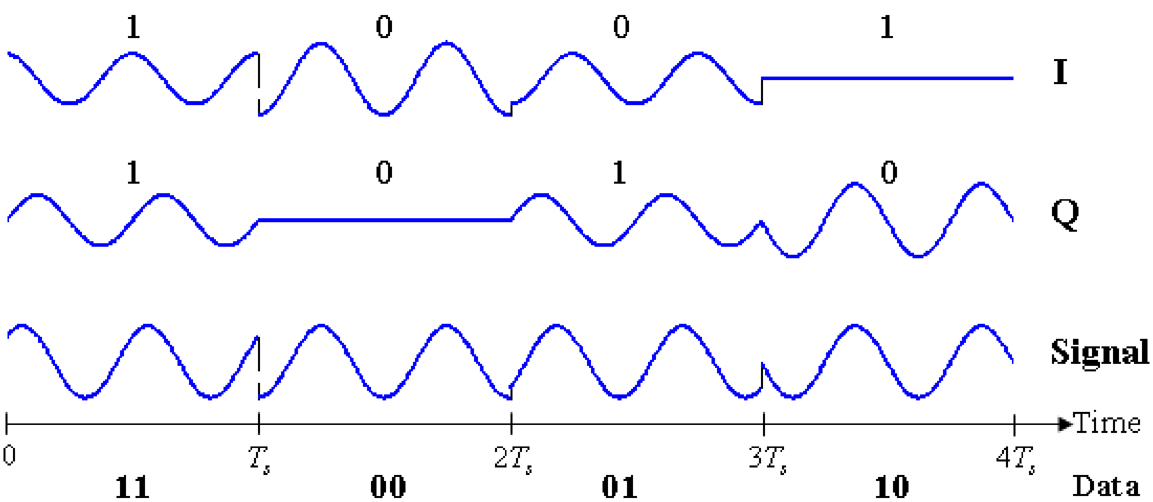



**Figure 2.10: Timing diagram for π/4-QPSK.**

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.

### 2.8 Higher Order PSK

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 which allows an equal number of bits-per-symbol.

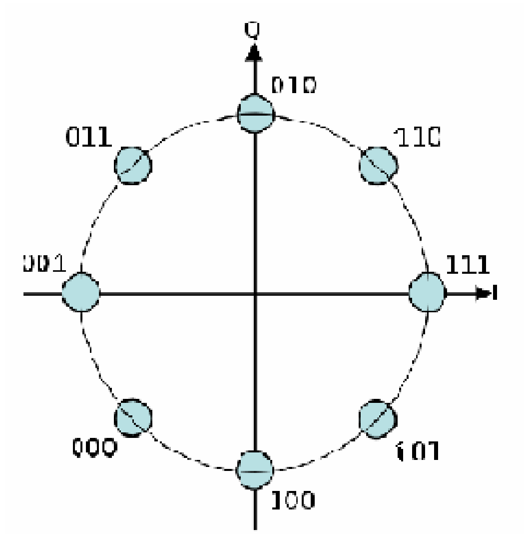



**Figure 2.11: Constellation diagram for 8-PSK**

## 2.9 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 communication channel through which the signal passes. We can overcome this problem by using the data to change rather than setting the phase.

For example, in differentially-encoded BPSK a binary '1' may be transmitted by adding 180° to the current phase and a binary '0' by adding 0° to the current phase. In differentially-encoded QPSK, the phase-shifts are 0°, 90°, 180°, 270° 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.

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 phase, and so there is a phase shift in both signals at $t = 0$. For the binary data stream 11000110 the DBPSK and DQPSK timing diagram is given below. The individual bits of the DBPSK signal are grouped into pairs for the DQPSK signal, which only changes every $T_s = 2T_b$.

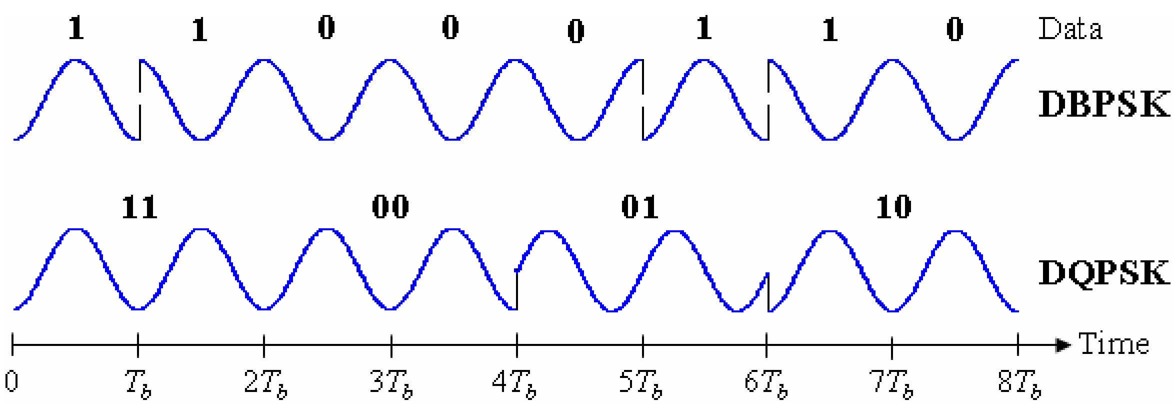



**Figure 2.12: Timing diagram for DBPSK and DQPSK**

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 $E_b / N_0$. Moreover, this analysis is based on a system in which the only corruption is Additive White Gaussian Noise. However, there will also be a physical channel between the transmitter and receiver in the communication system. This channel will introduce an unknown phase-shift to the PSK signal. In these cases the differential schemes can yield a better error-rate than the ordinary schemes which rely on precise phase information.

# CHAPTER III

# IMPLEMENTATION OF QPSK MODULATOR

In this chapter, we shall discuss about the basic block and circuit diagram of QPSK modulator. We will discuss each block and the corresponding circuit and will also try to discuss the integrated circuit or IC required constructing the basic blocks.

## 3.1 QPSK MODULATOR

QPSK modulated signal is a system with M=4 levels, which means 2 of its data will be transmitted at the same time. The modulated signal can be expressed as:

XQPSK (t) = $\cos\left[wct + (2m-1)\pi/4\right]$ ; where m = 1, 2, 3, 4………N ------- (1)

By expanding the equation we get,

XQPSK (t) = $A\cos\left[\frac{(2m-1)\pi}{4}\right]\cos(wct) - A\,sin\left[\frac{(2m-1)\pi}{4}\right]\sin(wct)$ ---------------- (2)

Let,

$$\Phi_1\ (t) = A\cos(wct)$$

$$\Phi_2\ (t) = A\sin(wct)$$

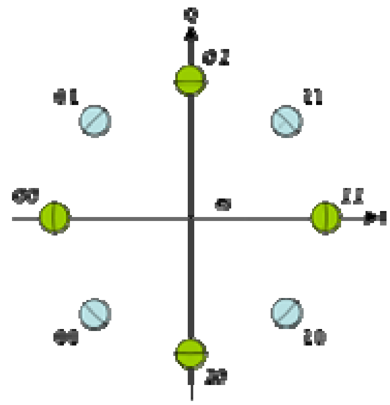


**Figure 3.1: The signal constellation diagram of QPSK modulation**

So now the QPSK modulated signal can be simplified

XQPSK (t) = $A \cos\left[\frac{(2m-1)\pi}{4}\right] \Phi 1 - \sin\left[\frac{(2m-1)\pi}{4}\right] \Phi 2$ -------------------------- (3)

From equation no. 3, QPSK modulated signal can be assumed as a combination of two BPSK modulated signals.

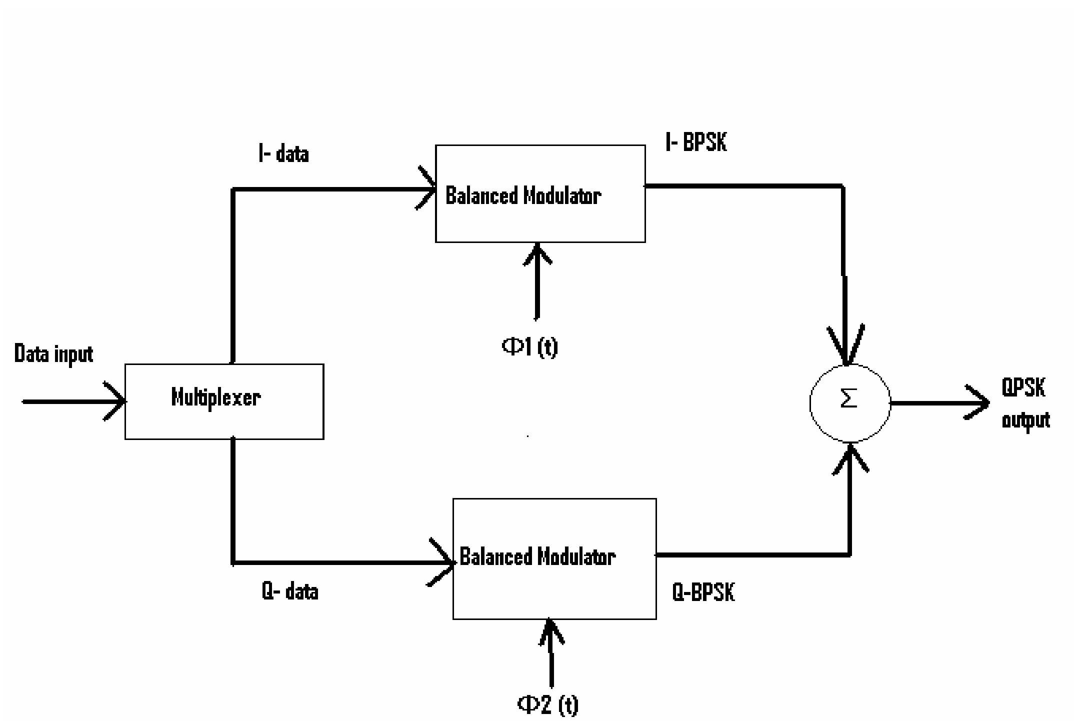



**Figure 3.2: Basic block diagram of a QPSK modulator**

Figure- 3b is the basic block diagram of a QPSK modulator. From the diagram, the input data signal has to be converted into parallel output by the multiplexer. The outputs of the multiplexer are the I-data and the Q-data, which will be multiplied with the orthogonal functions and the balanced modulator to obtain the I-data and Q-data of BPSK modulating signal. These two groups of data will be summed up to produce the QPSK modulated signal.

### 3.2 BASIC QPSK TRANSMITTER

Following Figure- 3c shows the circuit block diagram of a QPSK modulator. Two bit data is sent to the bit splitter at the same time. These two groups of data will be split into parallel data. One of which will lead to I channel and gradually will transfer into I-data and the other one will proceed to Q channel to become Q-data. The phase of I-data is similar to the carrier of the reference oscillator, which will be modulated to become I-BPSK. Similarly the Q-data will become a Q-BPSK modulated signal.

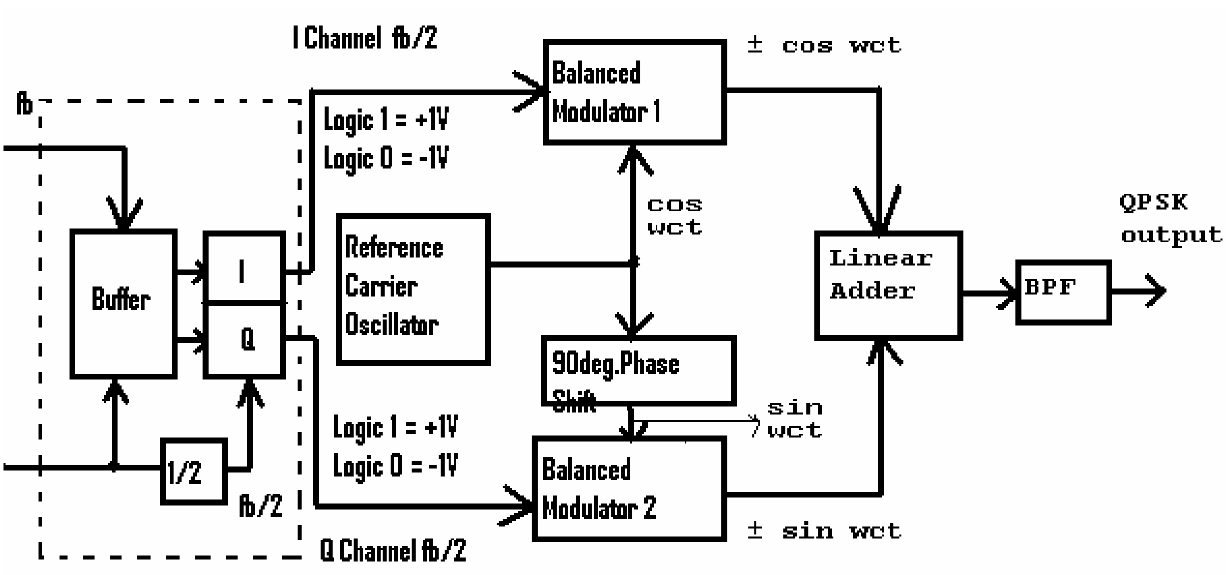


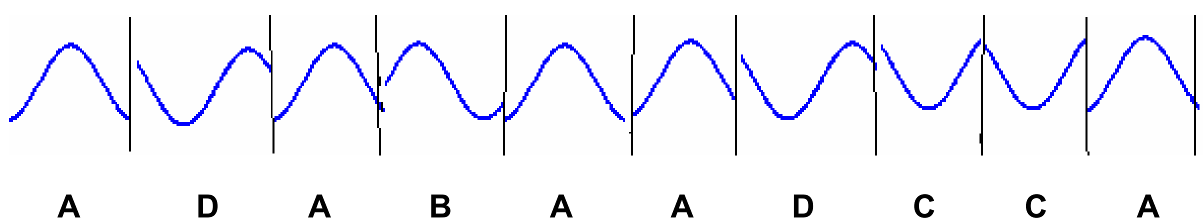

**Figure 3.3: Circuit block diagram of a QPSK modulator**

QPSK modulator is a combination of two BPSK modulators. Thus, at the output terminal of the I balanced modulator, there are two types of phases produced, which are $+\cos w_c t$ and $-\cos w_c t$. Similarly at the output terminal of the Q balanced modulator, again two phases are produced as $+\sin w_c t$ and $-\sin w_c t$. When the linear adder combines these two groups of orthogonal BPSK modulated signals, there will be four possible phases which are $+\sin w_c t + \cos w_c t$, $+\sin w_c t - \cos w_c t$, $-\sin w_c t + \cos w_c t$, $-\sin w_c t - \cos w_c t$.

| PHASE CHANGE (Degree) | Example state change | Dibit |
|---|---|---|
| 0 | A-to-A | 01 |
| 90 | A-to-B | 00 |
| 180 | B-to-D | 10 |
| 270 | D-to-C | 11 |

In the following figure, a carrier is shifted through the phases **ADABAADCCA**

QPSK WAVEFORM




Two bits of information are conveyed in the transition between time slots.

The signal has undergone the following phase transitions:

| Phase | A | D | A | B | A | A | D | C | C | A |
|---|---|---|---|---|---|---|---|---|---|---|
| Change | - | A-to-D | D-to-A | A-to-B | B-to-A | A-to-A | A-to-D | D-to-C | C-to-C | C-to-A |
| Degrees | - | 270 | 90 | 90 | 270 | 0 | 270 | 270 | 0 | 180 |
| Dibit | - | 11 | 00 | 00 | 11 | 01 | 11 | 11 | 01 | 10 |

The corresponding information transmitted is therefore: **110000110111110110**

### 3.4 Circuit Description

#### 3.4.1 Function generator

For modulation purpose we have to generate carrier of high frequency. We can use various types of oscillator circuits such as Colpitts oscillator, Hartley oscillator. For our convenience, we have used AT-700 Portable Analog/Digital Laboratory from where we have used the function generator feature to give clock pulse input as square wave of 200 KHz frequency and ± 5Vp-p. For the carrier frequency we have used 1 MHz frequency from the frequency generator.

#### 3.4.2 Frequency divider

As we are talking the carrier and the data clock from the same source, the frequency of both signals is the same which is not desirable. The data frequency should be less than the carrier frequency. For this purpose, we use counter 74390 as a frequency divider. Fig 3-d: shows the circuit diagram of a frequency divider which can divide by 2, 4, 8 or 10.

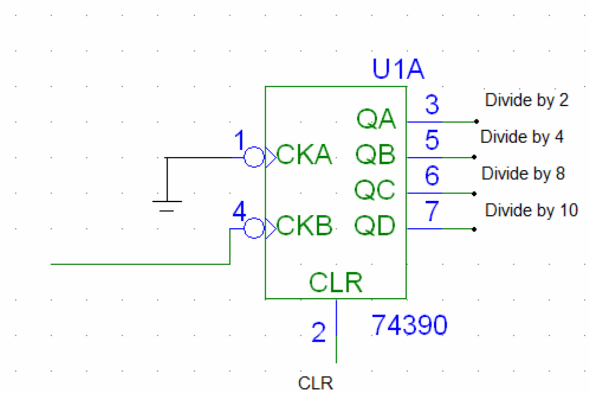



**Figure 3.4: Frequency Divider**

### 3.4.3 PN-Sequence generator

The random bit generator generates a bit sequence (PN-sequence) that is used as input data for our QPSK modulator. A PN-sequence generator circuit is an array of D-flip flops. Various combination of X-OR gates can be used to get various bit sequences. We use 4 D flip-flops and 2 X-OR gates so we can generate 15 bits and then the bits will be repeated from the initial bit value of the sequence. The data will be equal of the clock pulse operating the D flip-flops. We have used flip-flop 74175 and X-OR 7486 as a PN-sequence generator. Figure 3-e: shows the circuit of a PN-sequence Generator.

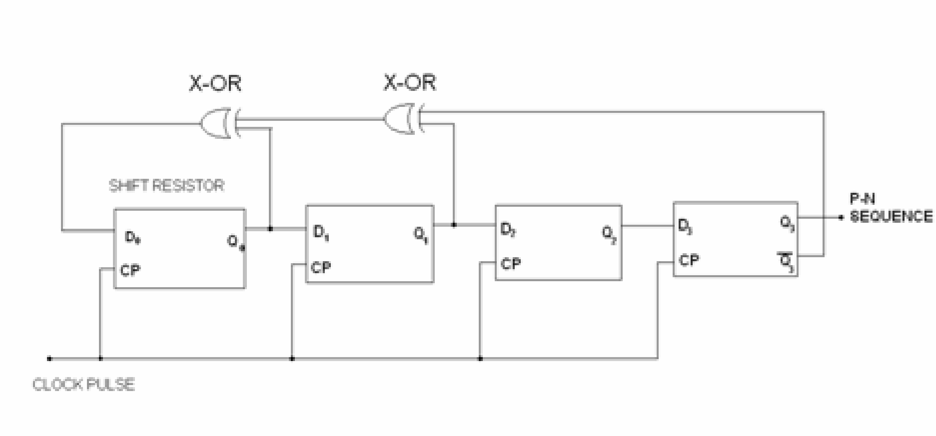



**Figure 3.5: PN-Sequence Generator**

### 3.4.4 Bit splitter

Bit splitter is comprised by four D flip-flops and one JK flip-flops. D flip-flop 1(DFF1) and D flip-flop 2(DFF2) include a shift register of which the transmission rate is the same as the data rate. JK flip-flop 1(JKFF1) and XOR gate comprise an inverter. The objective is to invert the clock signal, then it will pass through the capacitor so that the D flip-flop 3(DFF3) and the D-flip-flop 4(DFF4) will be able to convert the serial data input to parallel output which are I-data and Q-data. The duty cycle of I-data and Q-data are double the original data signal. For the implementation we have used two flip-flops IC74175 and one 74393. Figure 3-f: shows the IC circuit diagram of the bit splitter.

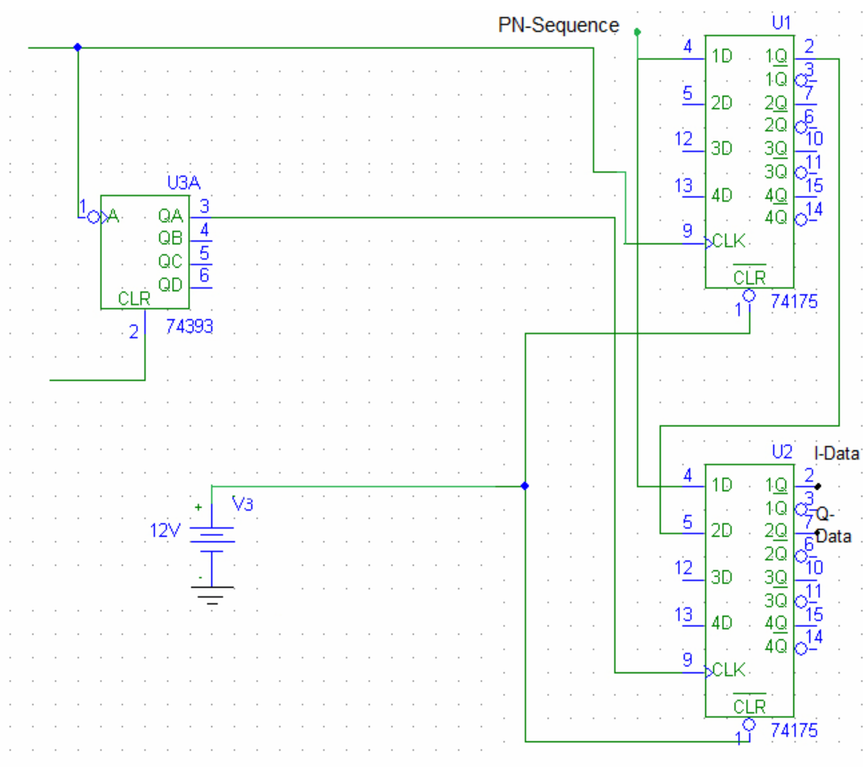



**Figure 3.6: Bit Splitter**

### 3.4.5 Unipolar to Bipolar converter

Figure 3-g shows the unipolar to bipolar converter. The objective of this circuit is to convert the unipolar I-data and unipolar Q-data to bipolar I-data and bipolar Q-data. After that, these signals will be inputted to pin 1 of MC1496. The operation theory is to invert the digital signal by inverter and then pass two followers to split the signal into two. These two signals will pass through the switch.

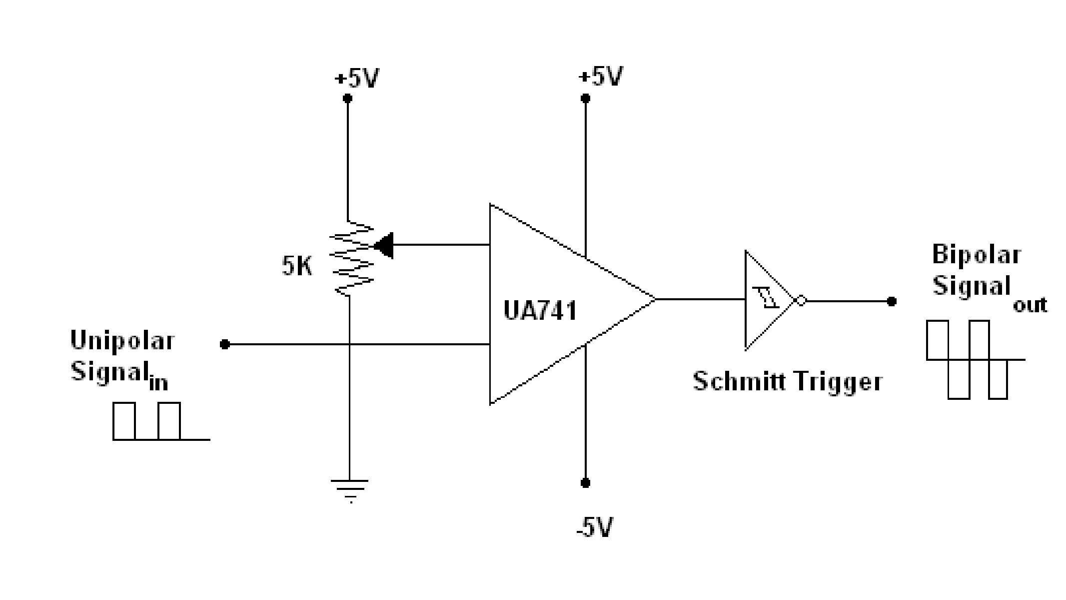



**Figure 3.7: The circuit diagram of unipolar to bipolar converter.**

### 3.4.6 Balanced modulator

Figure 3-h shows the detailed circuit diagram of balanced modulator. The balanced modulator is comprised by MC1496. Both the carrier and data signal are single-ended inputs. The carrier signal is inputted at pin 10 and the data signal is inputted at pin 1. The R13 & R14 determine the gain and the bias current of the circuit, respectively. If we adjust VR1 or the amplitude digital signal, we may prevent the modulated signal from distortion. Then this signal will pass through the filter, which is comprised by uA741, C3, C5, R17, R 18 and R 19. The objective is to remove the high frequency signal in order to obtain the optimum PSK signal.

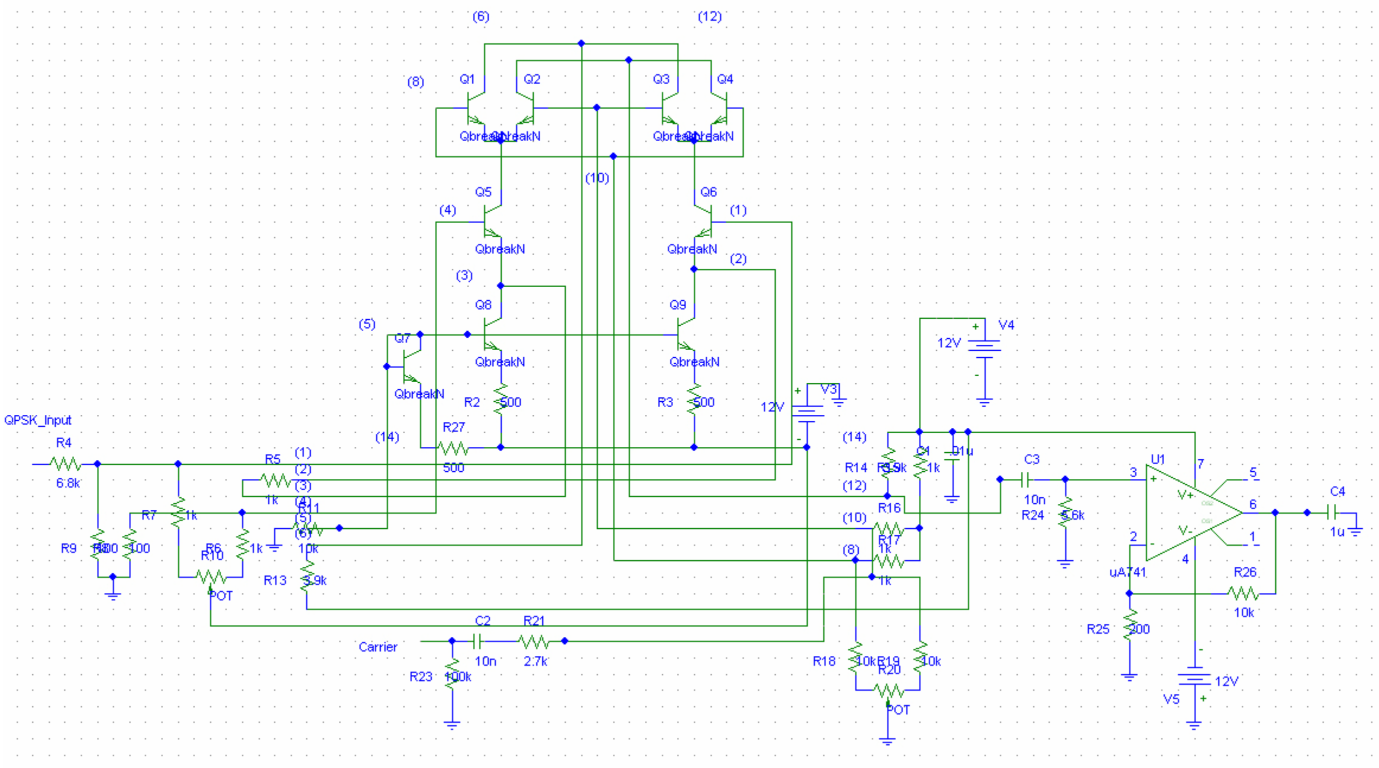



**Figure 3.8: Circuit diagram of a balanced modulator**

### 3.4.7 Phase Shifter

Figure 3-i shows the phase shifter, which is used to shift the phase of carrier signal. The situation will produce a group of orthogonal carrier signal, which will supply to the balanced modulator of I-channel and Q-channel. The phase angle (θ) is related to $R_i$, $C_i$ and the frequency of carrier. The expression

$$R_i = \tan(\theta/2)/(2 * \pi * f * Ci)$$

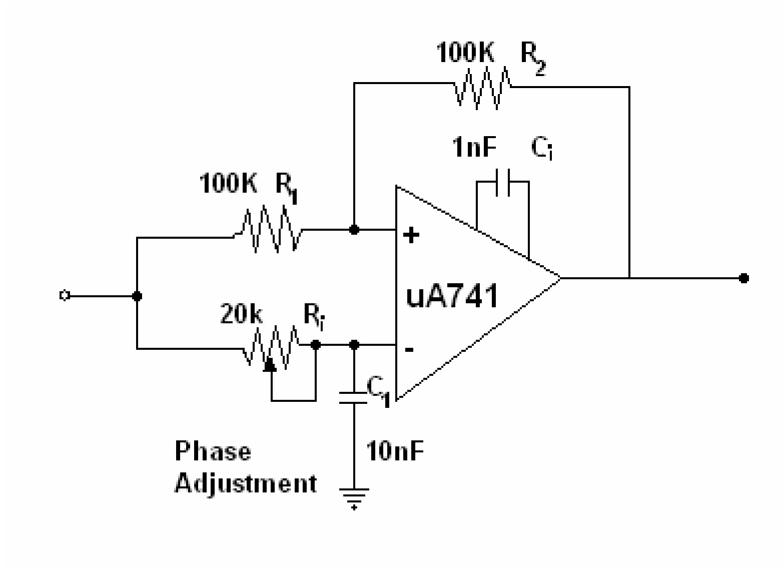



**Figure 3.9: The circuit diagram of phase shifter**

### 3.4.8 Linear summer

The following figure shows the circuit diagram of a linear summer. The objective of the linear summer is to combine the two groups of the orthogonal BPSK modulation signal to become a QPSK signal.

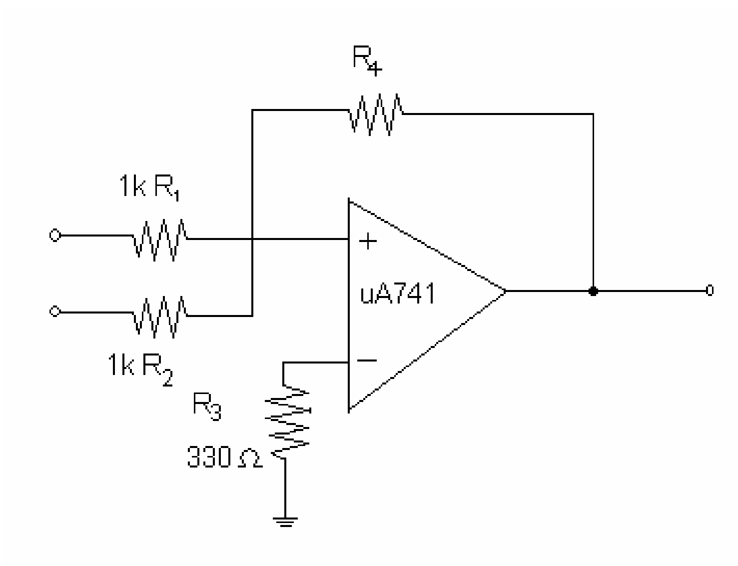



**Figure 3.10: Circuit diagram of a linear summer**

## 3.5 EXPERIMENTAL CIRCUIT DIAGRAM

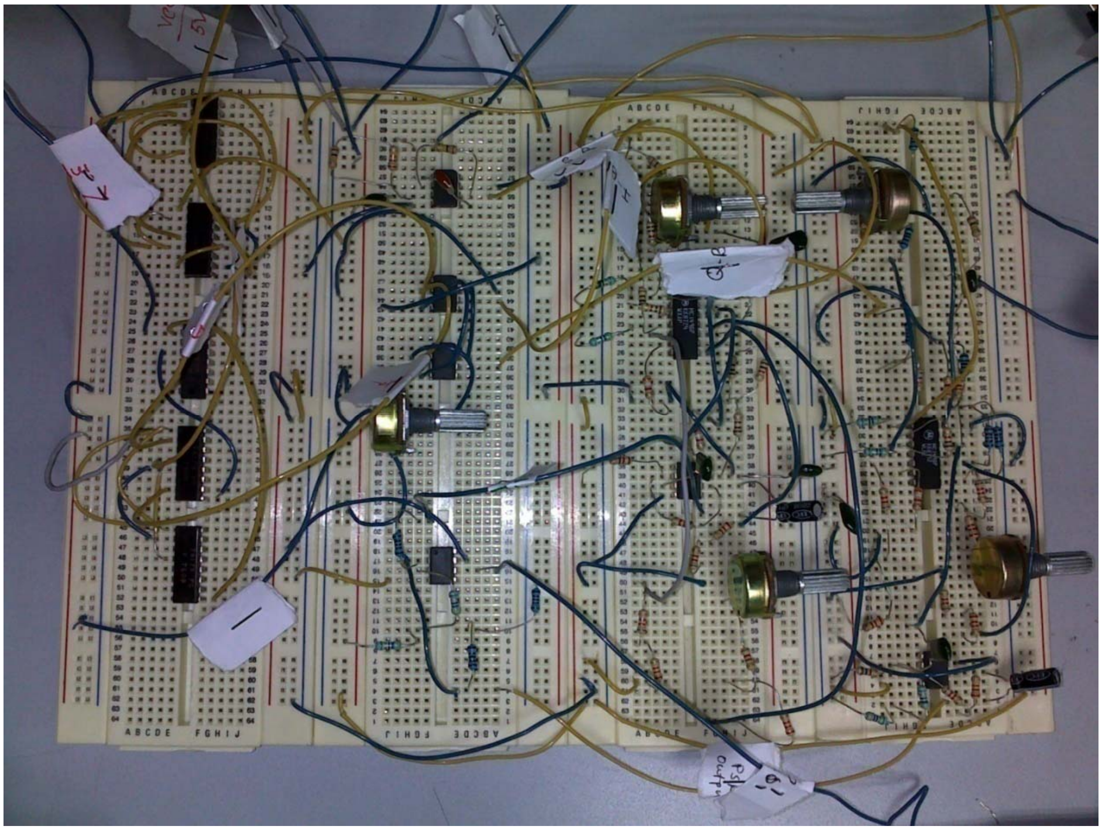


**Figure 3.11: QPSK modulator circuit**

## 3.6 EXPERIMENTAL WAVE SHAPES

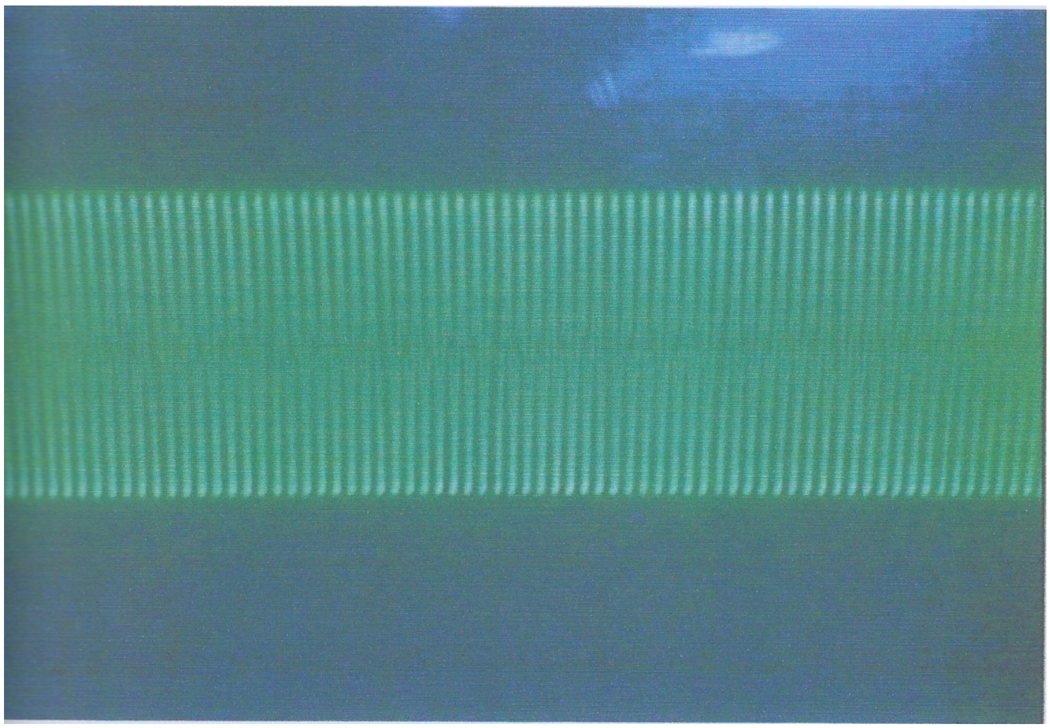


Figure 3.6.1: Carrier wave (Sine wave)

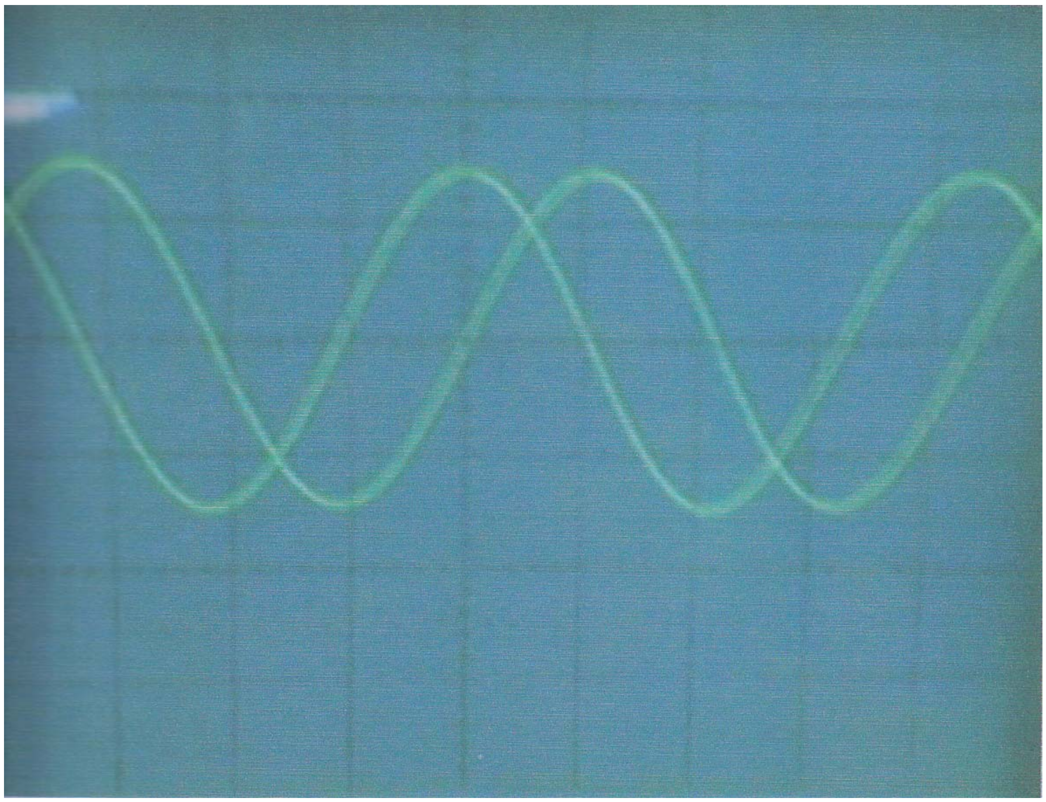


Figure 3.6.2: Sine wave and 90 degree shifted wave (cosine wave)

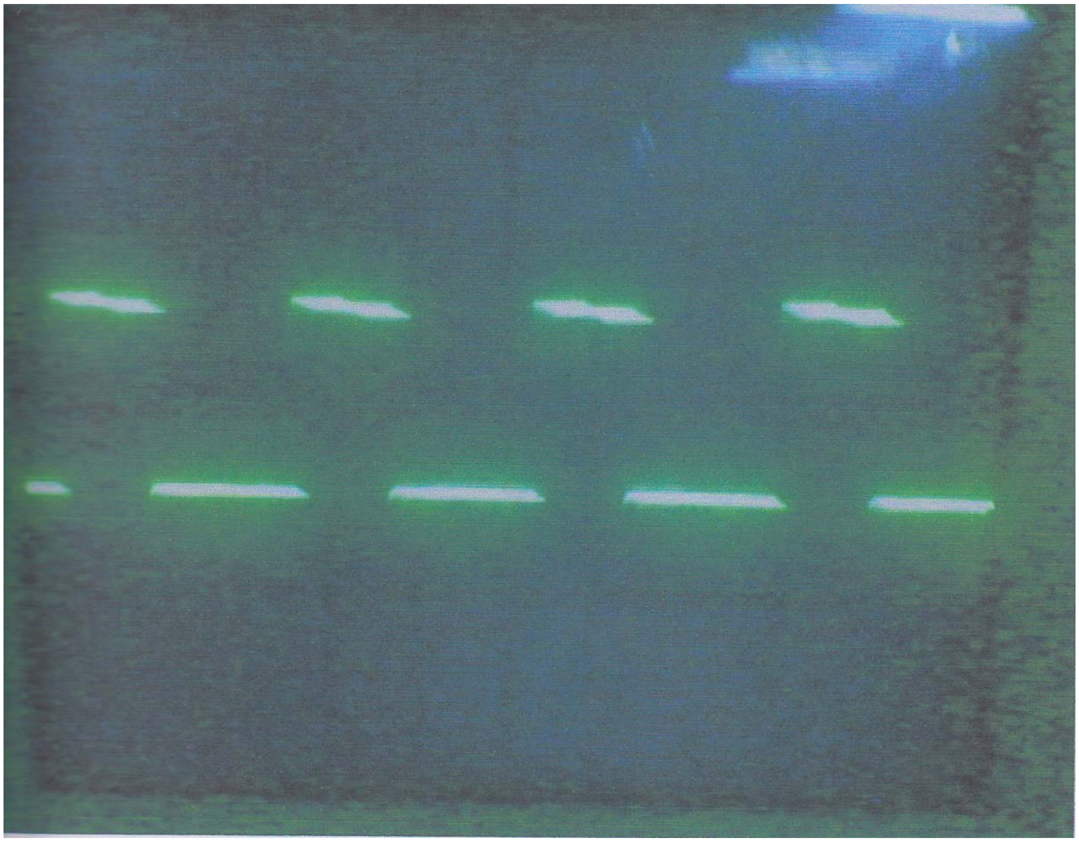


Figure 3.6.3: Data clock

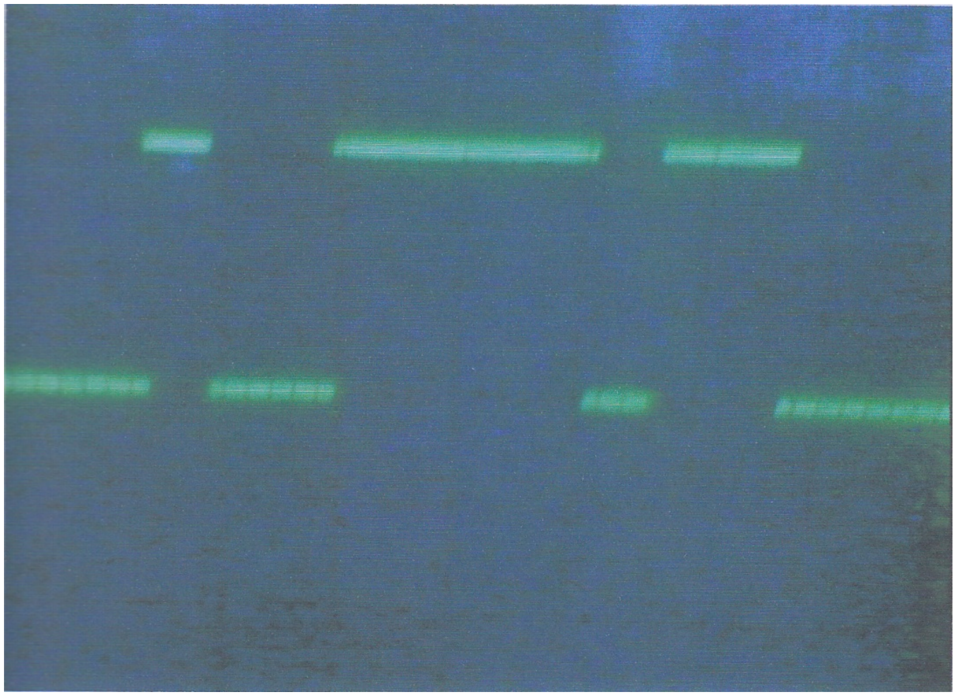


Figure 3.6.4: PN- sequence

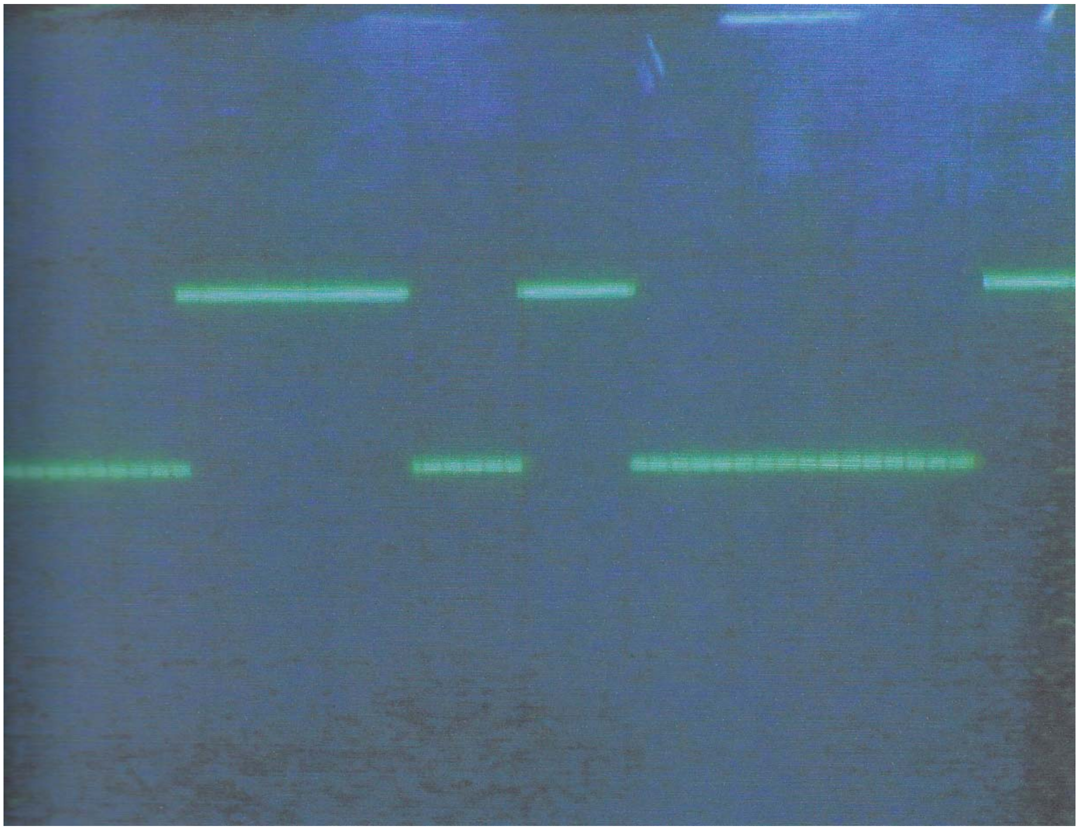


Figure 3.6.5: Unipolar I-Data

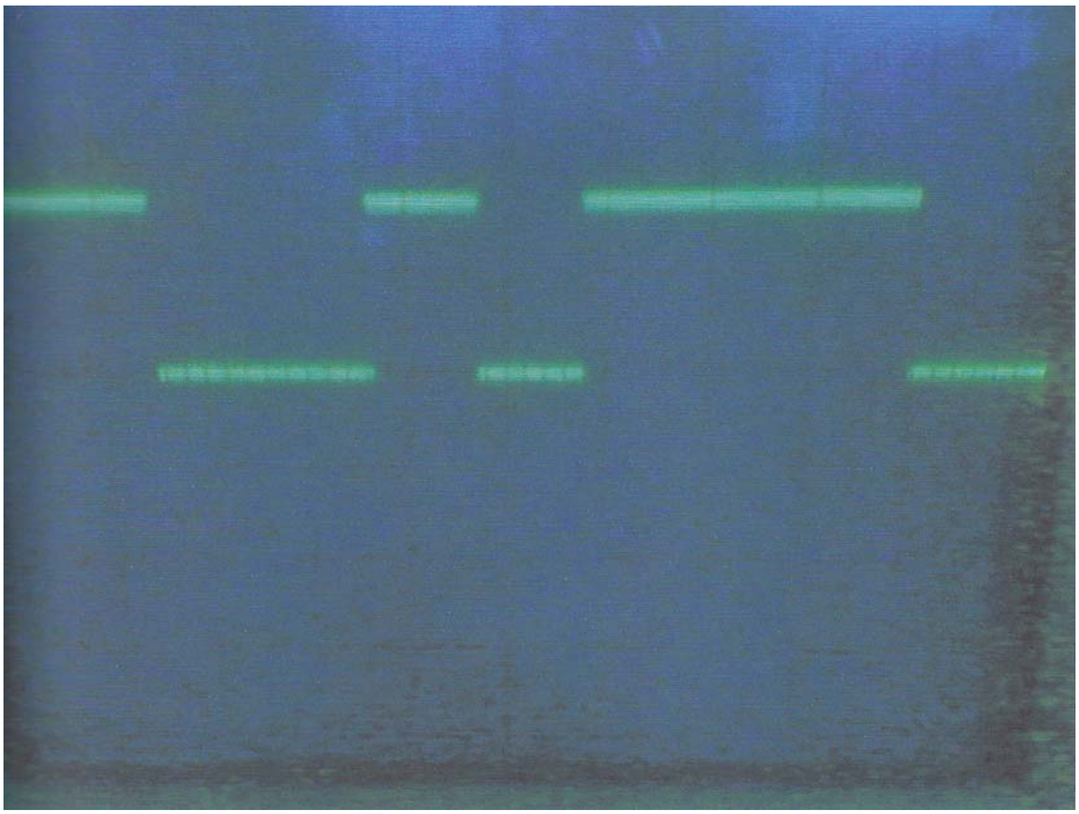


Figure 3.6.6: Unipolar Q-Data

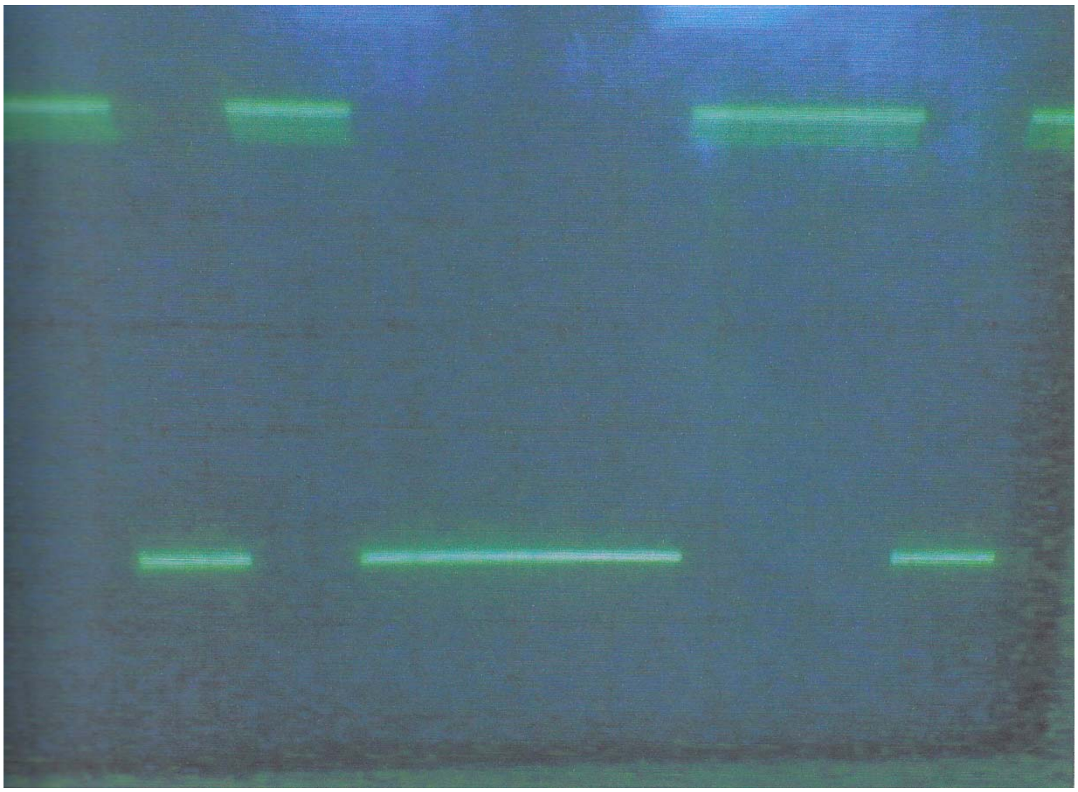


Figure 3.6.7: Bipolar I-Data

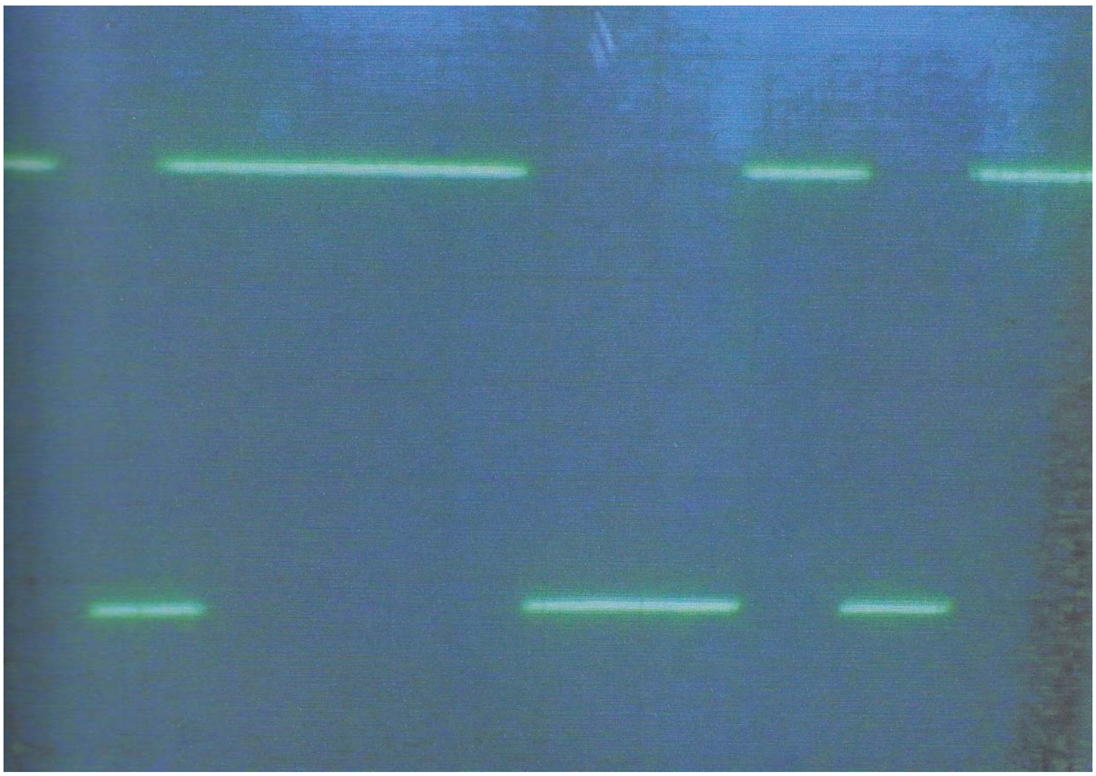


Figure 3.6.8: Bipolar Q-Data

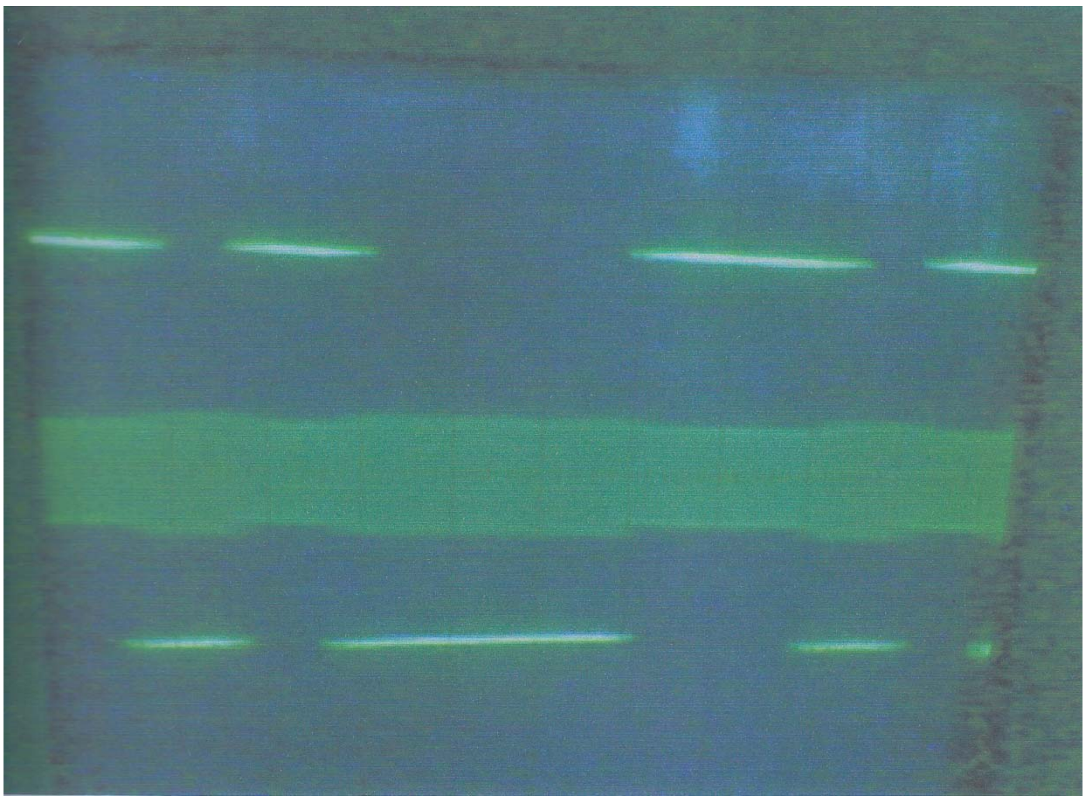


Figure 3.6.9: I-BPSK and Bipolar I-data

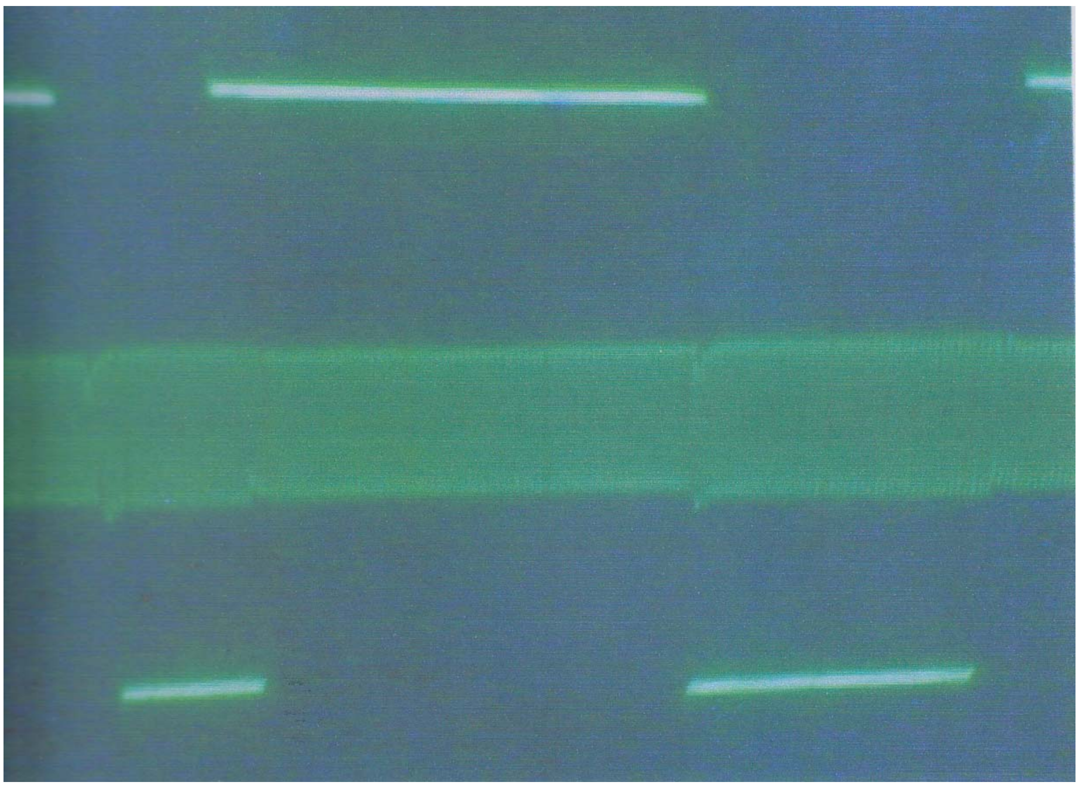


Figure 3.6.10: Q-BPSK and Bipolar Q-data

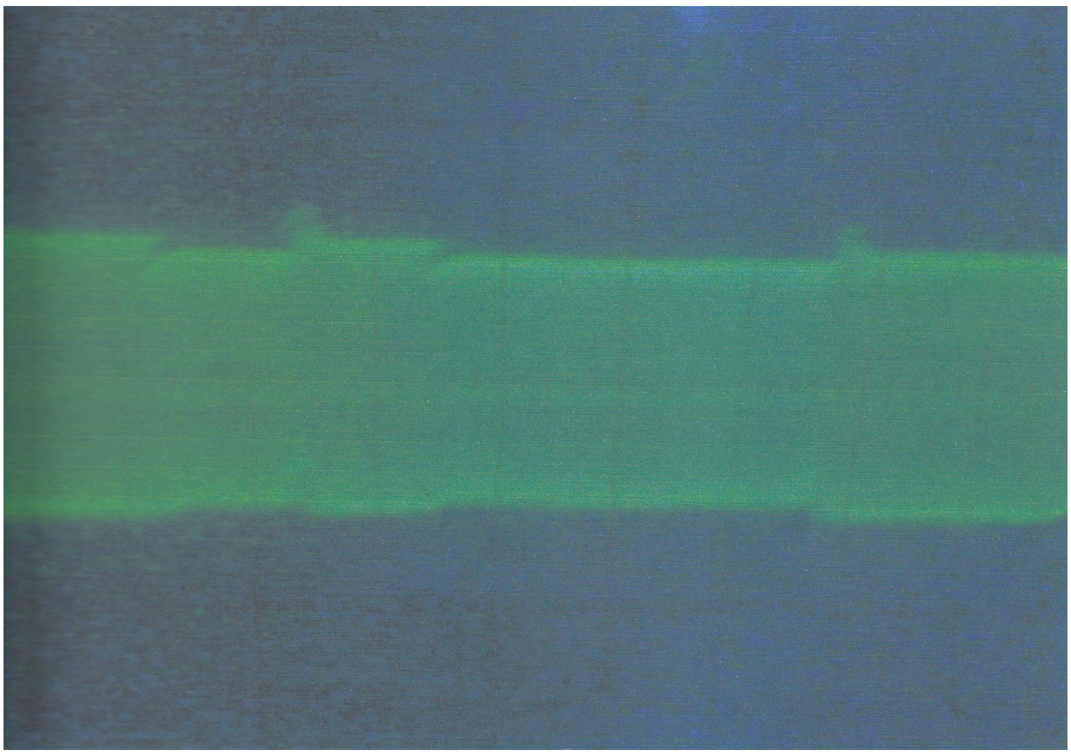


Figure 3.6.11: QPSK signal

# CHAPTER IV

## SIMULATION AND SIMULATED DIAGRAM OF QPSK BY PSPICE

### Schematic version 9.2

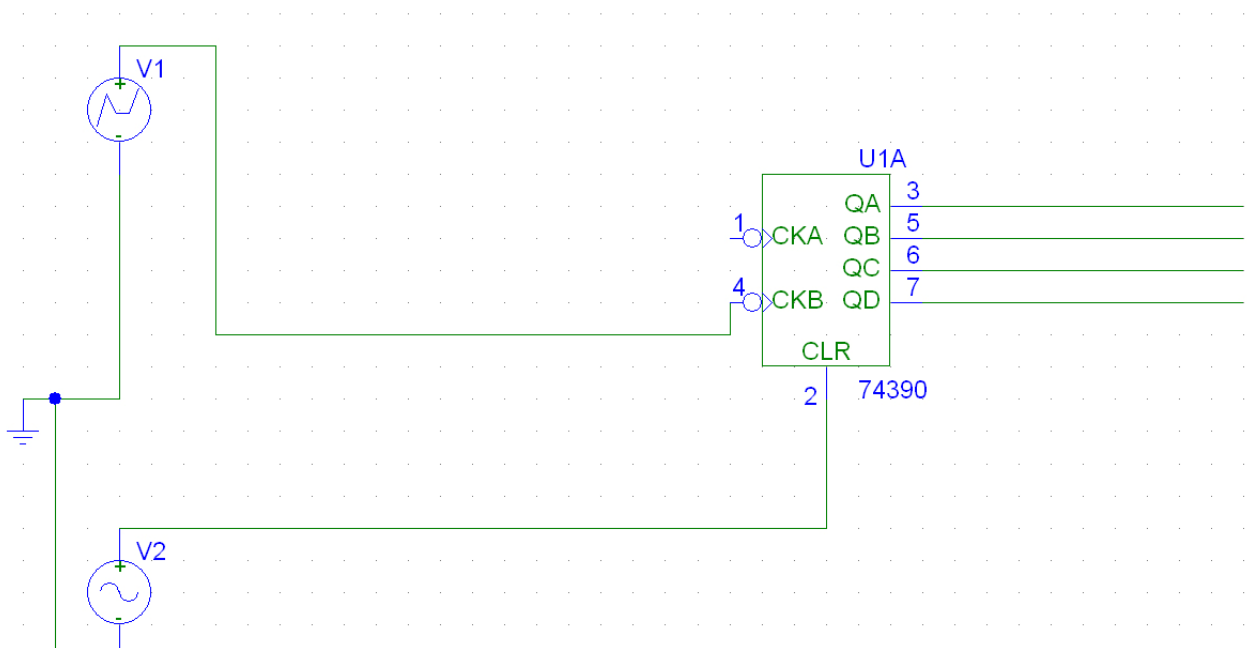



**Figure 4.1: Frequency divider**

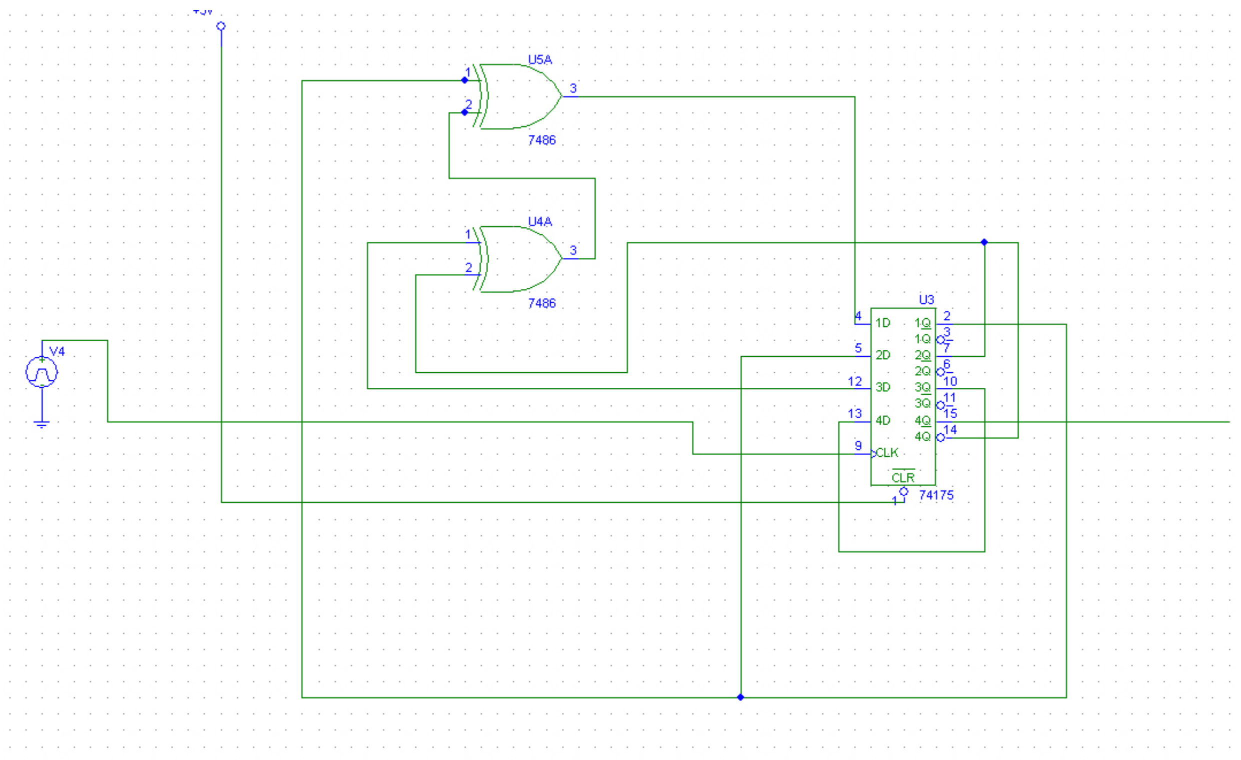



**Figure 4.2: PN-sequence generator**

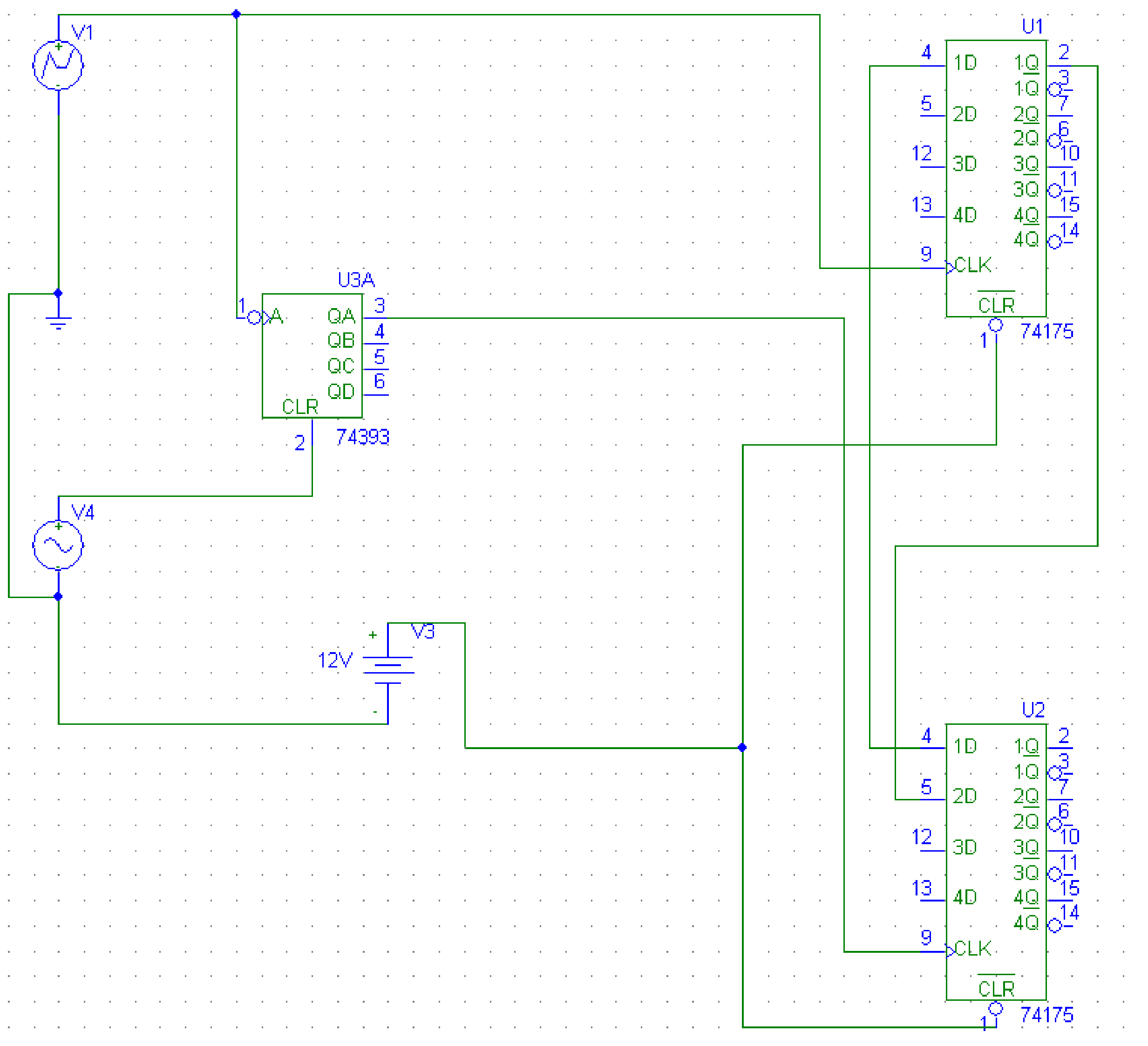



**Figure 4.3: Bit splitter**

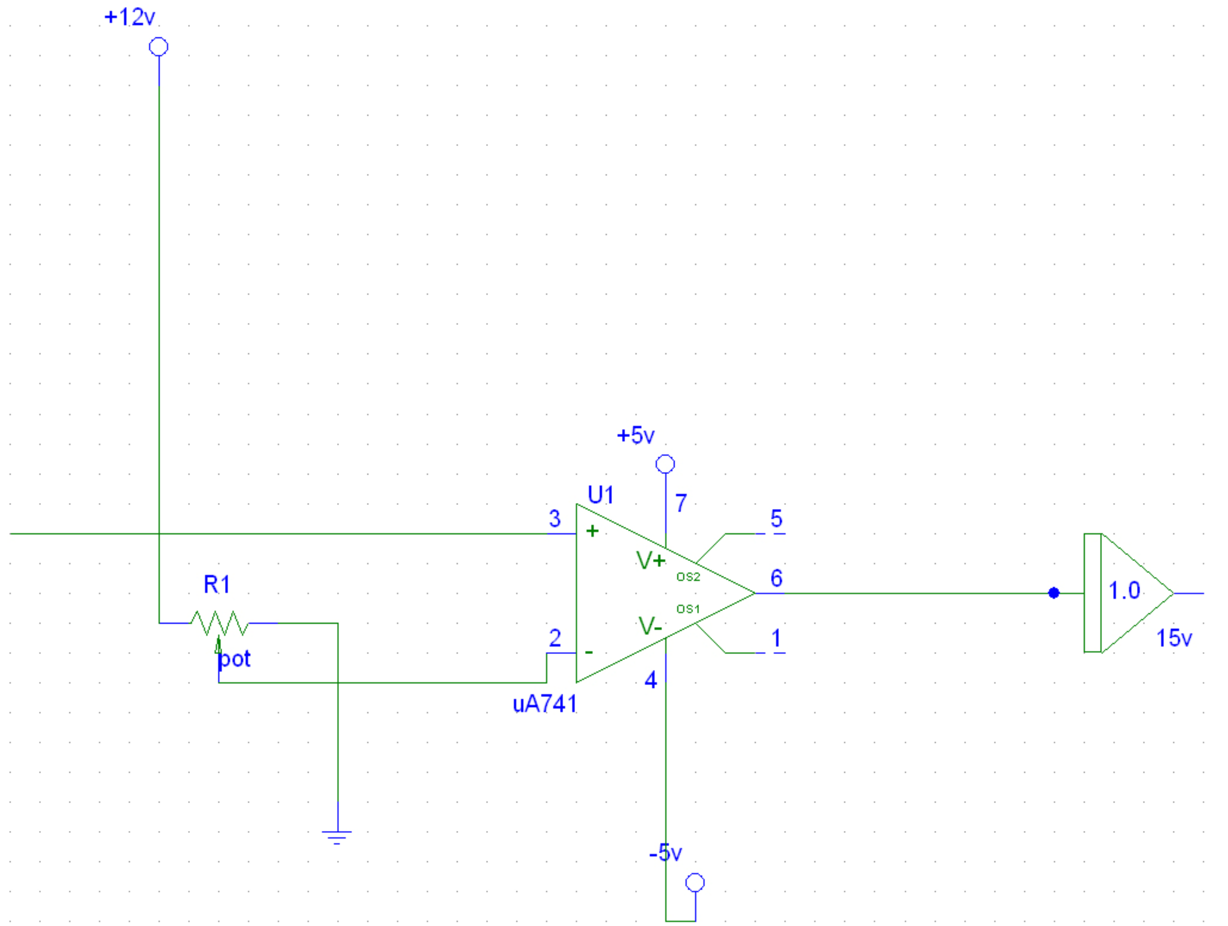



**Figure 4.4: Unipolar to Bipolar converter**

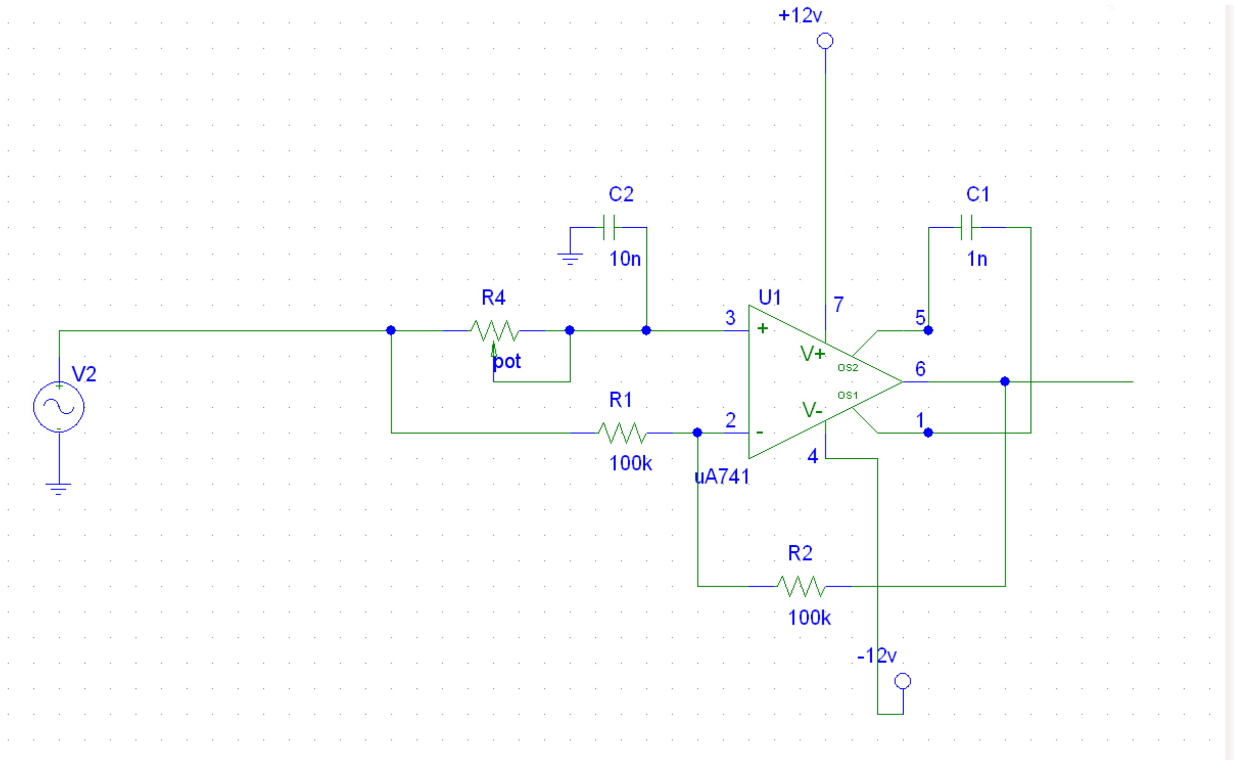



**Figure 4.5: Phase shifter**

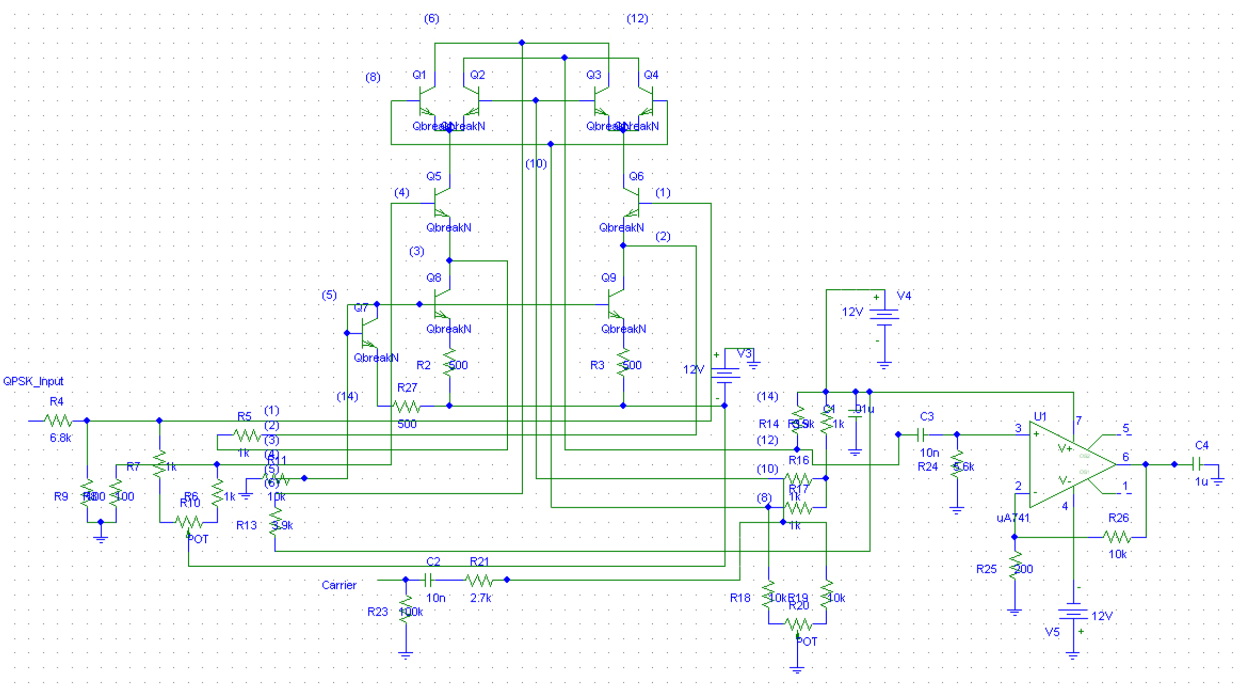


**Figure 4.6: Balanced modulator circuit**

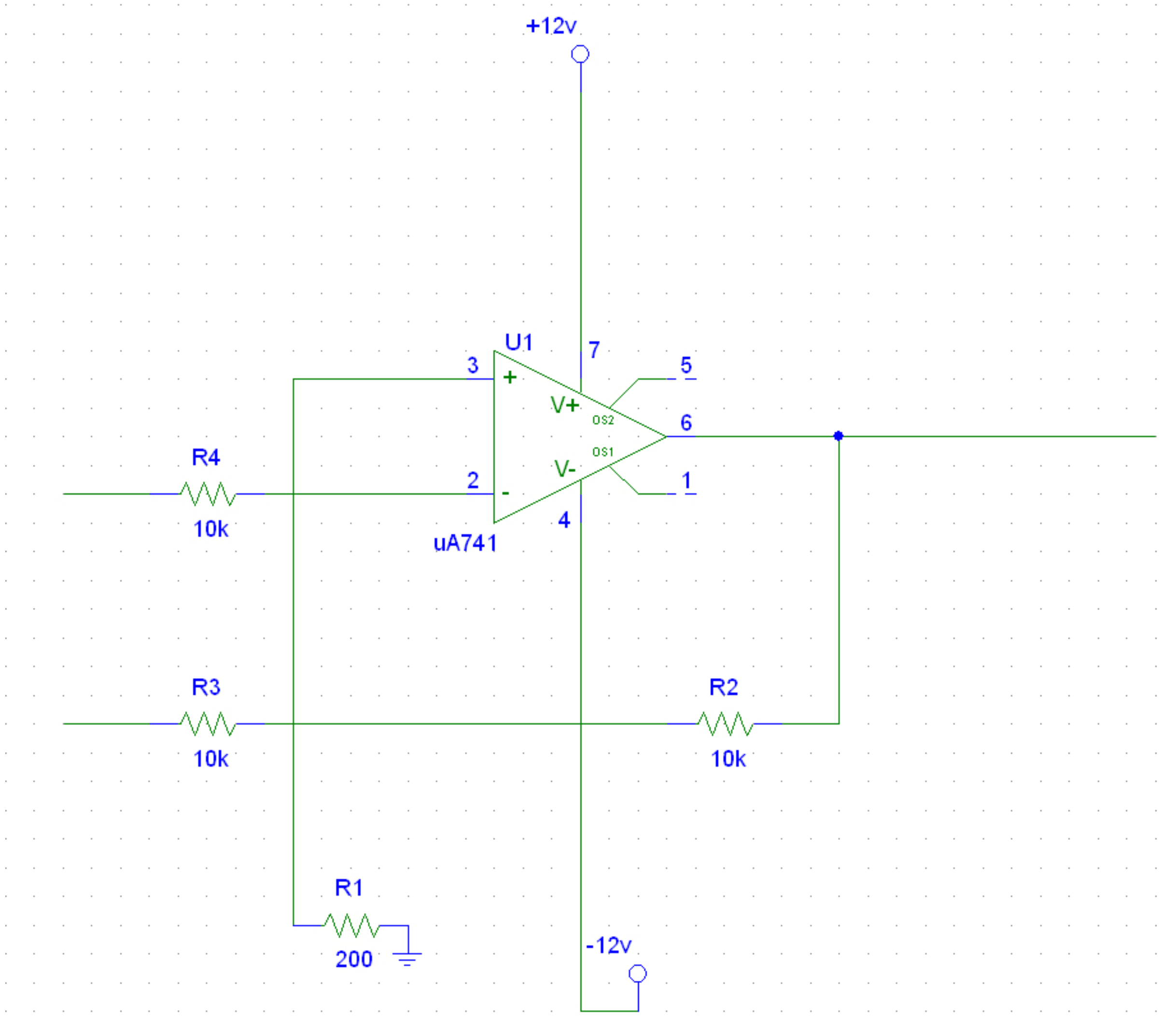



**Figure 4.7: Linear summer**

## SIMULATION DIAGRAM OF QPSK MODULATION

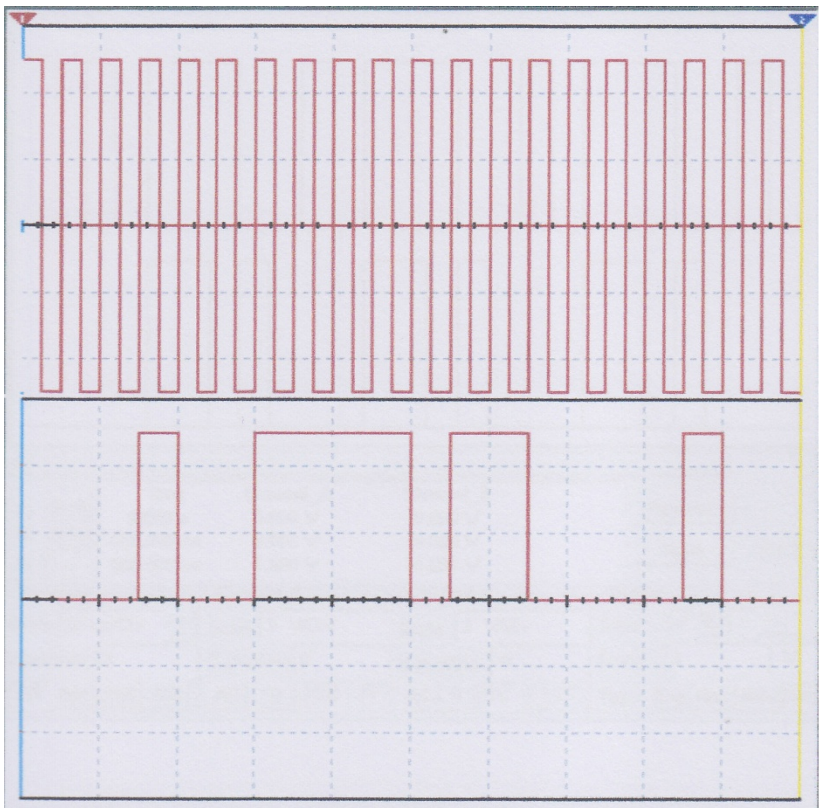


Figure 4.8: Clock pulse and PN sequence

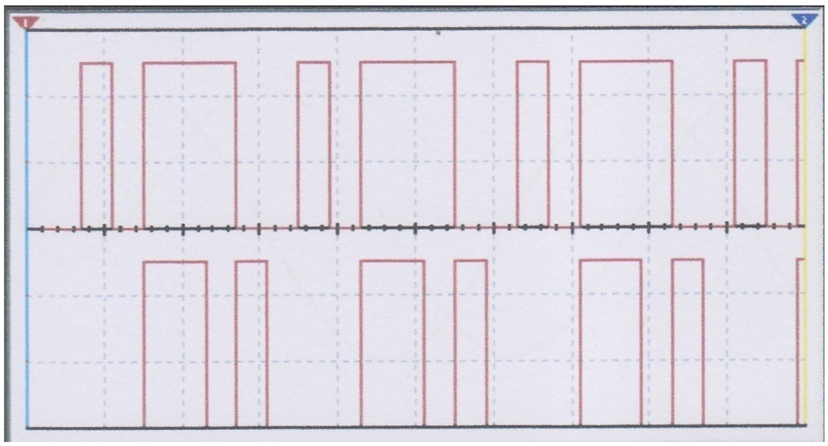


Figure 4.9: Splitted I- Data and Q- Data

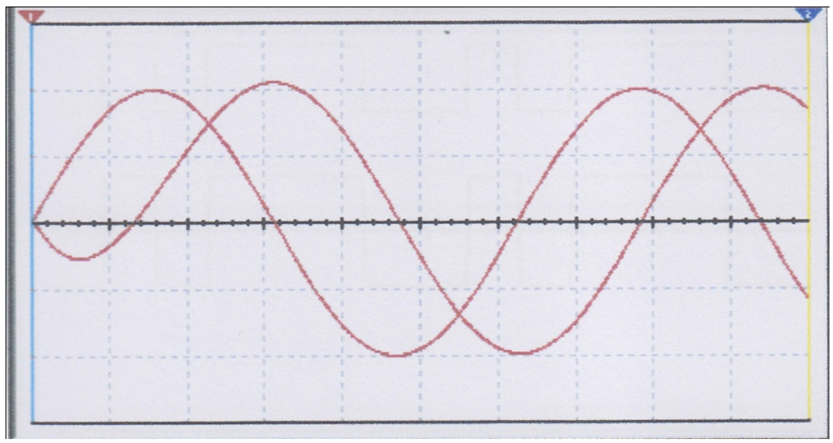


Figure 4.10: Sine carrier and 90 degree shifted carrier (cosine carrier)

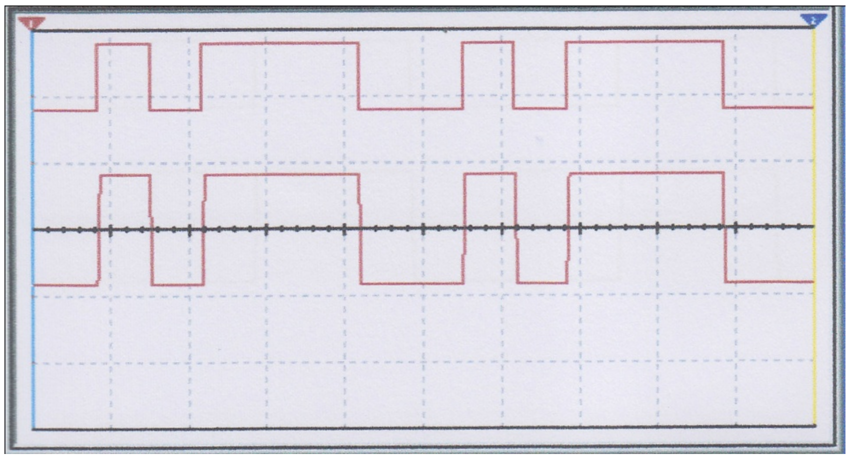


Figure 4.11: Unipolar I-Data and Bipolar I-Data

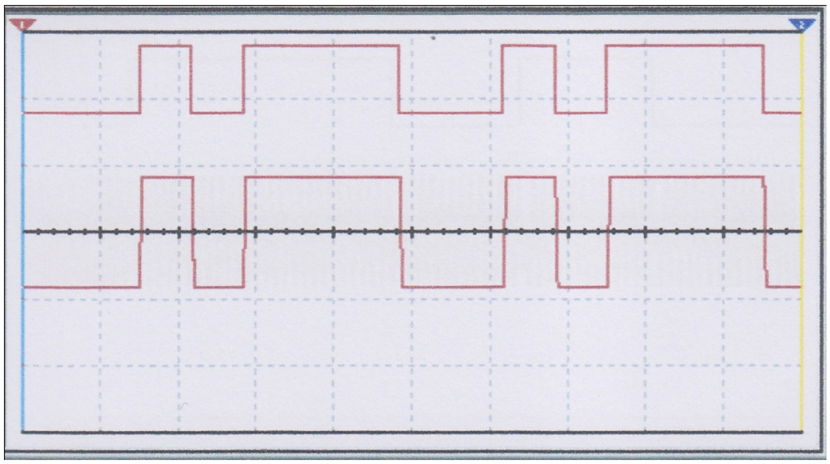


Figure 4.12: Unipolar Q-Data and Bipolar Q-Data

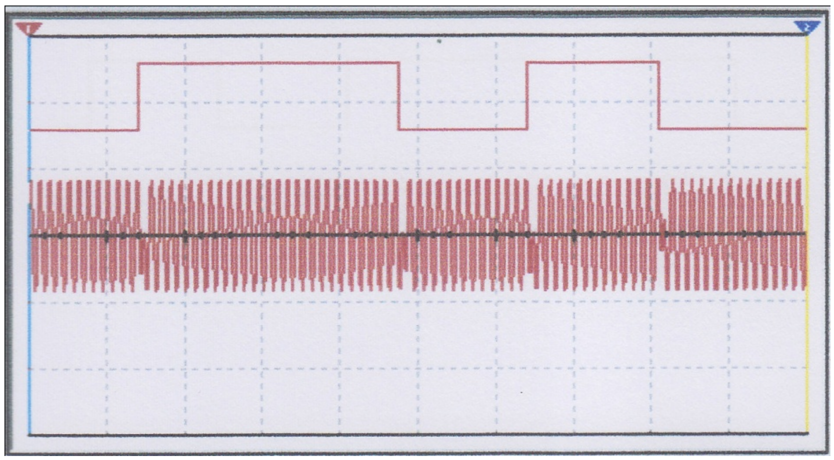


Figure 4.13: Bipolar I-Data and I-BPSK signal

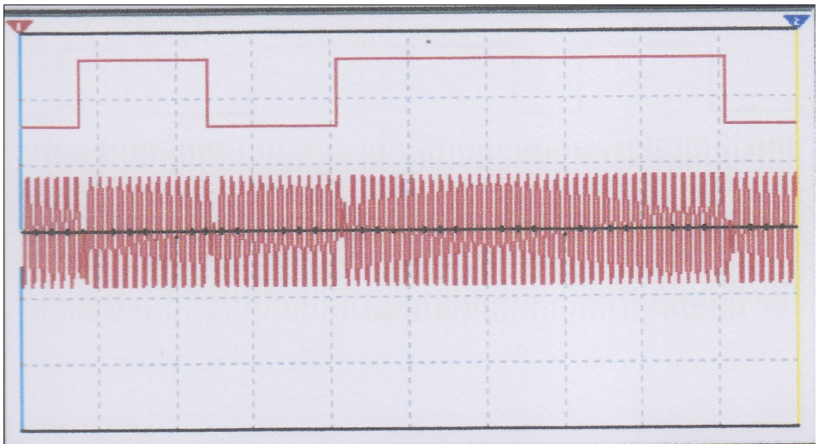


Figure 4.14: Bipolar Q-Data and Q-BPSK signal

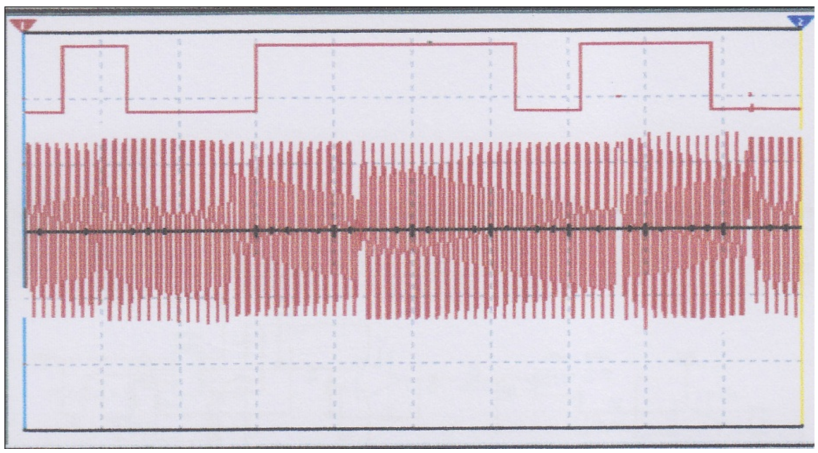


Figure 4.15: Data and QPSK signal

# CHAPTER V

# CONCLUSION

As a QPSK modulator circuit is not a new invention, there are lots of classical QPSK modulator circuit designs available. But not all of them can be implemented because of the unavailability of required IC chips in the local market. That is why we are implementing a simple circuit which includes shift registers, binary counters and multiplexer IC chips which are available in the local market and possible to work within our electronic laboratory.

The project we have submitted can be improved in the following ways:

In our limitations, we have tried to construct a simple QPSK modulator circuit of low cost. The cost can be reduced as well as the performance of the total circuit can be improved by using integrated circuits instead of using large circuits with lots of components.

The final QPSK modulated signal that we have got is distorted due to system loss. Also the strength of the signal is very low so it cannot be transmitted by wireless system. We have used 1MHz frequency for the carrier signal. If higher frequency could be used and if we can use frequency spectrum the project can be developed for wireless transmission.

## APPENDIX

| | |
|---|---|
| ASK | Amplitude Shift Keying |
| BPSK | Binary Phase Shift Keying |
| CDMA | Code Division Multiple Access |
| COFDM | Coded Orthogonal Frequency Division Multiplexing |
| FDM | Frequency Division Multiplexing |
| FDMA | Frequency Division Multiple Access |
| FFT | Fast Fourier Transform |
| FSK | Frequency Shift Keying |
| IC | Integrated Circuit |
| IFFT | Inverse Fast Fourier Transform |
| OFDM | Orthogonal Frequency Division Multiplexing |
| QAM | Quadrature Amplitude Modulation |
| QPSK | Quadrate Phase Shift Keying |
| PCB | Printed Circuit Board |
| PCM | Pulse Code Modulation |
| PM | Phase Modulation |
| PSK | Phase Shift Keying |
| PSPICE | Simulation Program Integrated Circuit Emphasis |
| SNR | Signal to Noise Ratio |

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