

Subject Code/Subject Name : CS6403/ANALOG AND DIGITAL COMMUNICATION)

Answer Key
Common Internal Test-1

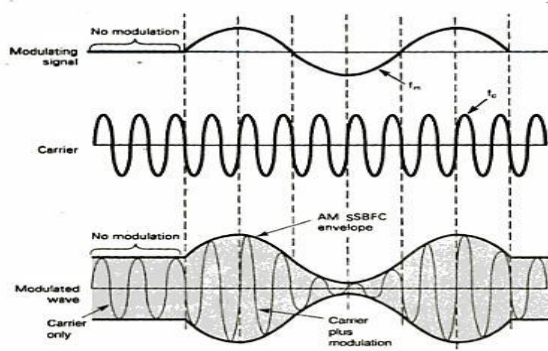
PART – A

10× 2 = 20 Marks

Answer all the questions

1. Build the 100% modulated AM and its spectrum.

[K3]



2. Define Deviation ratio.

[K1]

It is the **worst-case modulation index** which is the ratio of maximum permitted frequency deviation and maximum modulating signal frequency.

$$\text{Deviation ratio} = \Delta f_{(\max)} / f_{m(\max)}$$

3. What are the advantages of SSB –SC modulation?

[K1]

The bandwidth requirement of the single sideband system is half than required by double sideband system. Since SSB system utilizes half the bandwidth than DSB, the thermal noise power is reduced to half that of DSB system. The full carrier DSB wave has poor efficiency since the major transmitted power is concentrated in the carrier which contains no information. Thus the total power in SSB is less than the total power in DSB. % power saving in SSB is 83.33%.

4. Comparison of AM & FM.

[K2]

The amplitude of FM is constant. Hence transmitter power remains constant in FM where it varies in AM.

Since amplitude of FM is constant, the noise interference is minimum in FM. Any noise superimposing on modulated carrier can be removed with the help of amplitude limiter.

The depth of modulation has limitation in AM. But in FM, the depth of modulation can be increased to any value.

Since guard bands are provided in FM, there is less possibility of adjacent channel interference.

Since space waves are used for FM, the radius of propagation is limited to line of sight (LOS). Hence it is possible to operate several independent transmitters on same frequency with minimum interference.

5. Define Minimum Shift Keying.

[K 1]

Minimum shift keying uses two orthogonal signal to transmit '0' and '1' in such a way the difference between these two frequencies is minimum. Hence, there is no abrupt change in the amplitude and the modulated signal is continuous and smooth.

6. Define Baud rate.

[K1]

The rate of change at the output of the modulator is called baud rate. Baud= 1/ts, where, ts- time of one signaling element (seconds).

7. Distinguish coherent and noncoherent methods.

[K4]

Coherent (synchronous) detection: In coherent detection, the local carrier generated at the receiver is phase locked with the carrier at the transmitter. The detection is done by correlating received noisy signal and locally generated carrier. The coherent detection is a synchronous detection.

Non-coherent (envelope) detection: This type of detection does not need receiver carrier to be phase locked with transmitter carrier. The advantage of such a system is that the system becomes simple, but the drawback is that error probability increases

8. What is meant by QAM?

[K1]

Quadrature amplitude modulation is a form of digital modulation where the digital information is contained in both the amplitude and phase of the transmitted carrier.

9. List out any four advantage of digital modulation over analog.

[K1]

The advantages of digital communication are,

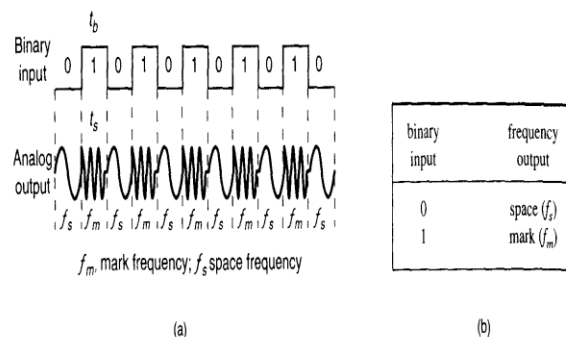
- (a) Ruggedness to channel noise and external interference.
- (b) Flexible operation of the system.
- (c) Multiplexing of various sources of information into a common format.
- (d) Security of information.
- (e) Digital circuits are more reliable, lower cost than analog circuits.
- (f) Errors may be corrected by the use of coding

The disadvantages of digital communication are,

- (a) Digital Communication has completely ignored the human touch. A personal touch cannot be established because all the computers will have the same font
- (b) The establishment of Digital Communication causes degradation of the environment in some cases. "Electronic waste" is an example

10. Build the ASK waveform for a data stream 110101.

[K3]



PART – B

2 × 15 = 30 Marks

11. a) i) Explain about Internal Noise

(8) [K2]

“In common use, the word noise means any unwanted sound”. Unwanted signal are called noise. Classification of Noise:

There are several way to classify Noise, but conveniently Noise is classified as

- 1) External Noise
- 2) Internal Noise

External Noise:

External noise is defined as the type of Noise which is general externally due to communication system. External Noise are analysed qualitatively. Now, External Noise may be classified as

a) Atmospheric Noise :

Atmospheric Noise is also known as static noise which is the natural source of disturbance caused by lightning, discharge in thunderstorm and the natural disturbances occurring in the nature.

b) Industrial Noise :

Sources of Industrial noise are auto-mobiles, aircraft, ignition of electric motors and switching gear. The main cause of Industrial noise is High voltage wires. These noises is generally produced by the discharge present in the operations.

c) Extraterrestrial Noise :

Extraterrestrial Noise exist on the basis of their originating source. They are subdivided into

i) Solar Noise

ii) Cosmic Noise

Internal Noise:

Internal Noise are the type of Noise which are generated internally or within the Communication System or in the receiver. They may be treated qualitatively and can also be reduced or minimized by the proper designing of the system. Internal Noises are classified as

1) Shot Noise :

These Noise are generally arises in the active devices due to the random behaviour of Charge particles or carries. In case of electron tube, shot Noise is produces due to the random emission of electron form cathodes.

2) Partition Noise :

When a circuit is to divide in between two or more paths then the noise generated is known as Partition noise. The reason for the generation is random fluctuation in the division.

3) Low- Frequency Noise :

They are also known as FLICKER NOISE. These type of noise are generally observed at a frequency range below few kHz. Power spectral density of these noise increases with the decrease in frequency. That why the name is given Low- Frequency Noise.

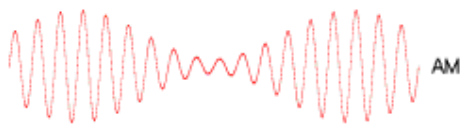
4) High- Frequency Noise :

These noises are also known TRANSIT- TIME Noise. They are observed in the semi-conductor devices when the transit time of a charge carrier while crossing a junction is compared with the time period of that signal.

5) Thermal Noise : Thermal Noise are random and often referred as White Noise or Johnson Noise. Thermal noise are generally observed in the resistor or the sensitive resistive components of a complex impedance due to the random and rapid movement of molecules or atoms or electrons.

11.a.ii) Assume that the modulation by several sine wave simultaneously, in AM, the bandwidth required is twice the highest modulating frequency .Prove this concept using appropriate expressions. (7) [K4]

The antenna needed for transmitting signals should have size at least $\lambda/4$, where, λ is the wavelength. The information signal, also known as baseband signal is of low frequency (and therefore the wavelength is high). If we need to transmit such a signal directly, the size of the antenna will be very large and impossible to build. Hence direct transmission is not practical.(2) The radiated power by an antenna is inversely proportional to the square of the wavelength. So, if we use high frequency signals, the power radiated will be increased.(3) If we transmit the baseband signals directly, the signals from different transmitters will get mixed up and the information will be lost.



Modulation index is the ratio of frequency deviation and modulating signal frequency.

$$m = \Delta f / f_m$$

Δf = frequency deviation in Hz

f_m = modulating signal frequency in Hz

Frequency Modulation	Phase Modulation
The maximum frequency deviation depends on amplitude and frequency of modulating signal	The maximum frequency deviation depends on amplitude and frequency of modulating signal
Noise immunity is better than AM and PM	Noise immunity is better than AM but worse than FM
Frequency of the carrier is modulated by modulating signal	Phase of the carrier is modulated by modulating signal

11.b. ii) Analyze with relevant the phasor diagram of a wideband FM and explain about the bandwidth

of FM signal .

(7) [K4]

The bandwidth, spectrum and sidebands are of great importance when using frequency modulation. The sidebands of a frequency modulated signal extend out either side of the main carrier, and cause the bandwidth of the overall signal to increase well beyond that of the unmodulated carrier. As the modulation of the carrier varies, so do the sidebands and hence the bandwidth and overall spectrum of the signal.

Frequency modulation Bessel functions & sidebands

Any signal that is modulated produces sidebands. In the case of an amplitude modulated signal they are easy to determine, but for frequency modulation the situation is not quite as straightforward. They are dependent upon not only the deviation, but also the level of deviation, i.e. the modulation index M . The total spectrum is an infinite series of discrete spectral components expressed by a complex formula using Bessel functions of the first kind.

$$\text{Spectrum} = V_c \{ J_0(M) \cos \omega_c t +$$

$$J_1(M) [\cos (\omega_c + \omega_m)t - \cos (\omega_c - \omega_m)t] +$$

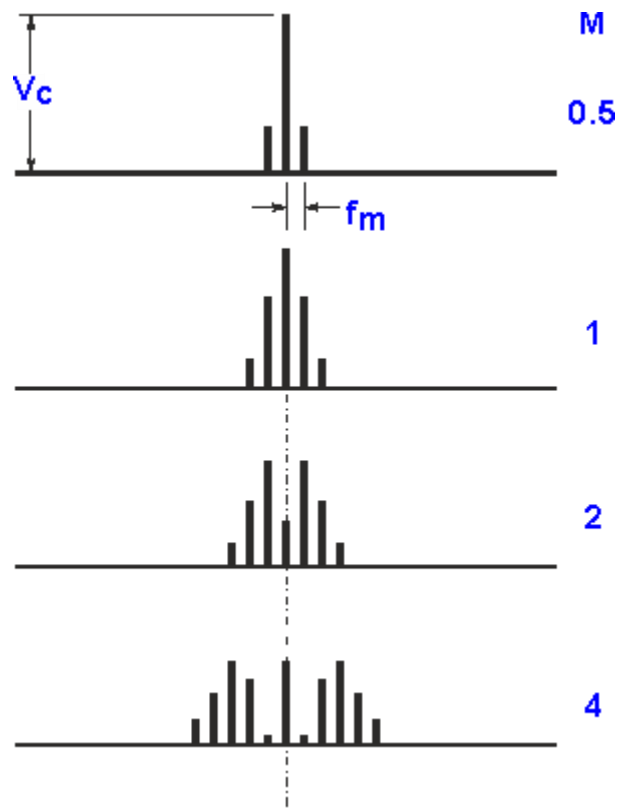
$$J_2(M) [\cos (\omega_c + 2\omega_m)t - \cos (\omega_c - 2\omega_m)t] +$$

$$J_3(M) [\cos (\omega_c + 3\omega_m)t - \cos (\omega_c - 3\omega_m)t] +$$

$$\dots \dots \dots \}$$

The total spectrum can be seen to consist of the carrier plus an infinite number of sidebands spreading out on either side of the carrier at integral multiples of the modulating frequency. The relative levels of the sidebands can be obtained by referring to a table of Bessel functions. It can be seen from the image below that the relative levels rise and fall according to the different values of modulation index. For small values of modulation index, when using narrow-band FM, the FM signal consists of the carrier and the two sidebands spaced at the modulation frequency either side of the carrier. This looks to be the same as an AM signal, but the difference is that the lower sideband is out of phase by 180 degrees.

As the modulation index increases it is found that other sidebands at twice the modulation frequency start to appear. As the index is increased further other sidebands can also be seen.



Spectra of an FM signal with differing levels of modulation index

At certain levels of modulation, where the modulation index equals figures of 2.41, 5.53, 8.65 and other higher specific levels, the carrier actually falls to a figure of zero, the signal being comprised simply of the sidebands.

Frequency modulation bandwidth

In the case of an amplitude modulated signal the bandwidth required is twice the maximum frequency of the modulation. Whilst the same is true for a narrowband FM signal, the situation is not true for a wideband FM signal. Here the required bandwidth can be very much larger, with detectable sidebands spreading out over large amounts of the frequency spectrum. Usually it is necessary to limit the bandwidth of a signal so that it does not unduly interfere with stations either side. As a frequency modulated signal has sidebands that extend out to infinity, it is normal accepted practice to determine the bandwidth as that which contains approximately 98% of the signal power.

A rule of thumb, often termed Carson's Rule states that 98% of the signal power is contained within a bandwidth equal to the deviation frequency, plus the modulation frequency doubled, i.e.:

$$BT = 2(\Delta f + fm)$$

Normally the bandwidth of a wideband FM signal is limited to the Carson's Rule limit - this reduces interference and does not introduce any undue distortion of the signal. In other words for a VHF FM broadcast station this must be $(2 \times 75) + 15$ kHz, i.e. 175 kHz. In view of this a total of 200 kHz is usually allowed, enabling stations to have a small guard band and their centre frequencies on integral numbers of 100 kHz.

12 .a) Show with the relevant expression and figures ,describe QPSK transmitter, QPSK receiver and bandwidth consideration of QPSK. (15) [K2]

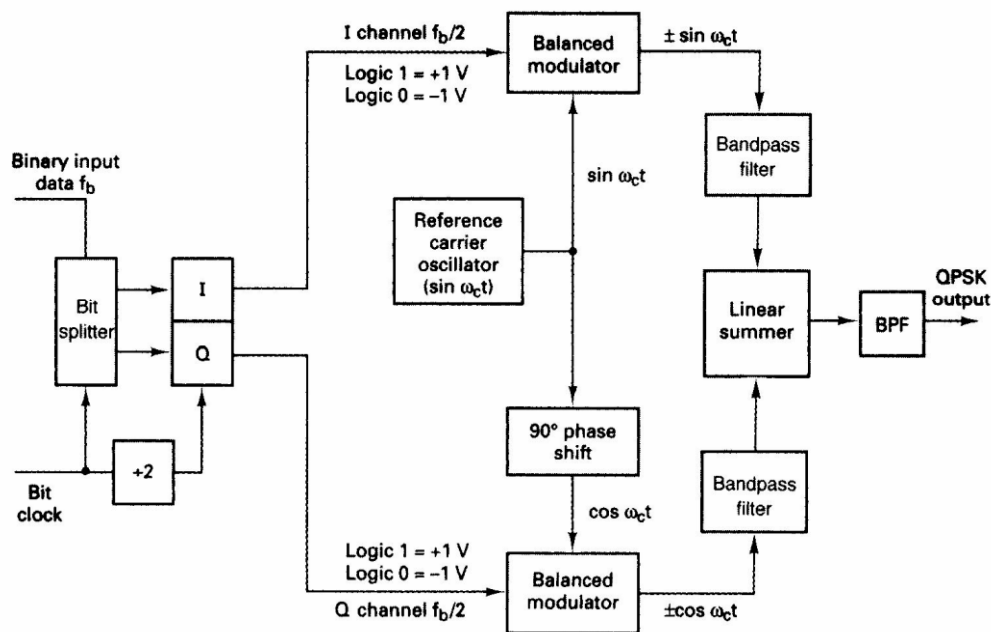
QPSK is an M-ary encoding scheme where $N = 2$ and $M = 4$ (hence, the name "quaternary" meaning "4"). A QPSK modulator is a binary (base 2) signal, to produce four different input combinations, 00, 01, 10, and 11. Therefore, with QPSK, the binary input data are combined into groups of two bits, called *dibits*. In the modulator, each dibit code generates one of the four possible output phases ($+45^\circ$, $+135^\circ$, -45° , and -135°).

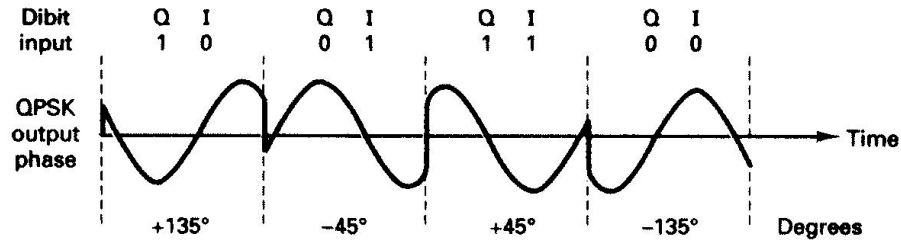
QPSK transmitter.

A block diagram of a QPSK modulator is shown in Figure 2-Two bits (a dibit) are clocked into the bit splitter. After both bits have been serially inputted, they are simultaneously parallel outputted. The I bit modulates a carrier that is in phase with the reference oscillator (hence the name "I" for "in phase" channel), and the Q bit modulate, a carrier that is 90° out of phase.

For a logic 1 = +1 V and a logic 0 = -1 V, two phases are possible at the output of the I balanced modulator ($+\sin \omega_c t$ and $-\sin \omega_c t$), and two phases are possible at the output of the Q balanced modulator ($+\cos \omega_c t$), and $(-\cos \omega_c t)$.

When the linear summer combines the two quadrature (90° out of phase) signals, there are four possible resultant phasors given by these expressions: $+\sin \omega_c t + \cos \omega_c t$, $+\sin \omega_c t - \cos \omega_c t$, $-\sin \omega_c t + \cos \omega_c t$, and $-\sin \omega_c t - \cos \omega_c t$.





In Figures 2-18b and c, it can be seen that with QPSK each of the four possible output phasors has exactly the same amplitude. Therefore, the binary information must be encoded entirely in the phase of the output signal.

Figure 2-18b, it can be seen that the angular separation between any two adjacent phasors in QPSK is 90° .

Therefore, a QPSK signal can undergo almost a $+45^\circ$ or -45° shift in phase during transmission and still retain the correct encoded information when demodulated at the receiver. Figure 2-19 shows the output phase-versus-time relationship for a QPSK modulator.

With QPSK, because the input data are divided into two channels, the bit rate in either the I or the Q channel is equal to one-half of the input data rate ($f_b/2$) (one-half of $f_b/2 = f_b/4$).

where

$$\text{output} = (\sin \omega_a t)(\sin \omega_c t)$$

$$\underbrace{\omega_a t = 2\pi \frac{f_b}{4} t}_{\text{modulating signal}} \quad \text{and} \quad \underbrace{\omega_c t = 2\pi f_c t}_{\text{carrier}}$$

$$\text{output} = \left(\sin 2\pi \frac{f_b}{4} t \right) (\sin 2\pi f_c t)$$

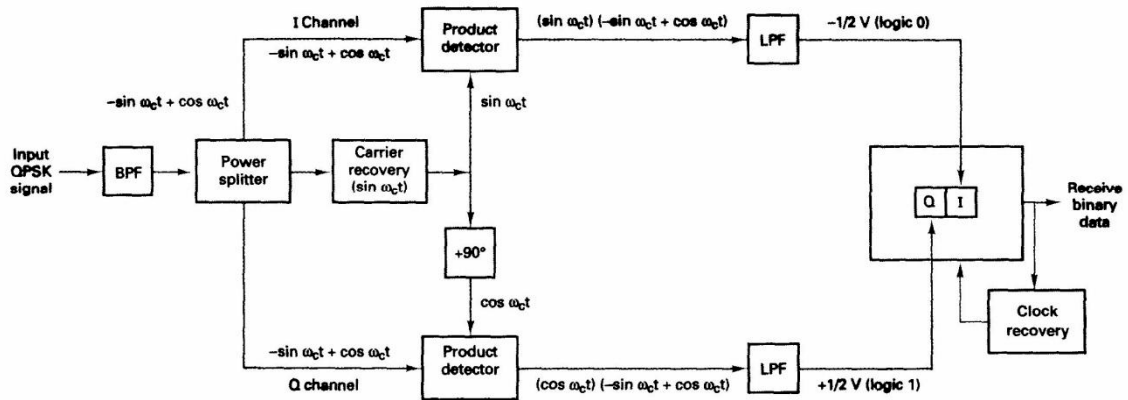
$$\frac{1}{2} \cos 2\pi \left(f_c - \frac{f_b}{4} \right) t - \frac{1}{2} \cos 2\pi \left(f_c + \frac{f_b}{4} \right) t$$

The output frequency spectrum extends from $f_c + f_b/4$ to $f_c - f_b/4$ and the minimum bandwidth (f_N) is

$$\left(f_c + \frac{f_b}{4} \right) - \left(f_c - \frac{f_b}{4} \right) = \frac{2f_b}{4} = \frac{f_b}{2}$$

QPSK Receiver

The incoming QPSK signal may be any one of the four possible output phases shown in Figure 2-18. To illustrate the demodulation process, let the incoming QPSK signal be $-\sin \omega_c t + \cos \omega_c t$. Mathematically, the demodulation process is as follows.



The receive QPSK signal $(-\sin \omega_c t + \cos \omega_c t)$ is one of the inputs to the I product detector. The other input is the recovered carrier $(\sin \omega_c t)$. The output of the I product detector is

$$\begin{aligned}
 I &= \underbrace{(-\sin \omega_c t + \cos \omega_c t)}_{\text{QPSK input signal}} \underbrace{(\sin \omega_c t)}_{\text{carrier}} \\
 &= (-\sin \omega_c t)(\sin \omega_c t) + (\cos \omega_c t)(\sin \omega_c t) \\
 &= -\sin^2 \omega_c t + (\cos \omega_c t)(\sin \omega_c t) \\
 &= -\frac{1}{2}(1 - \cos 2\omega_c t) + \frac{1}{2}\sin(\omega_c + \omega_c)t + \frac{1}{2}\sin(\omega_c - \omega_c)t \\
 I &= -\frac{1}{2} + \frac{1}{2}\cos 2\omega_c t + \frac{1}{2}\sin 2\omega_c t + \frac{1}{2}\sin 0 \\
 &\quad \begin{array}{l} \nearrow \text{(filtered out)} \\ \nearrow \text{(equals 0)} \end{array} \\
 &= -\frac{1}{2}V \text{ (logic 0)}
 \end{aligned}$$

Again, the receive QPSK signal $(-\sin \omega_c t + \cos \omega_c t)$ is one of the inputs to the Q product detector. The other input is the recovered carrier shifted 90° in phase $(\cos \omega_c t)$. The output of the Q product detector is

$$\begin{aligned}
 Q &= \underbrace{(-\sin \omega_c t + \cos \omega_c t)}_{\text{QPSK input signal}} \underbrace{(\cos \omega_c t)}_{\text{carrier}} \\
 &= \cos^2 \omega_c t - (\sin \omega_c t)(\cos \omega_c t) \\
 &= \frac{1}{2}(1 + \cos 2\omega_c t) - \frac{1}{2}\sin(\omega_c + \omega_c)t - \frac{1}{2}\sin(\omega_c - \omega_c)t \\
 Q &= \frac{1}{2} + \frac{1}{2}\cos 2\omega_c t - \frac{1}{2}\sin 2\omega_c t - \frac{1}{2}\sin 0 \\
 &= \frac{1}{2}V(\text{logic 1})
 \end{aligned}
 \tag{2.24}$$

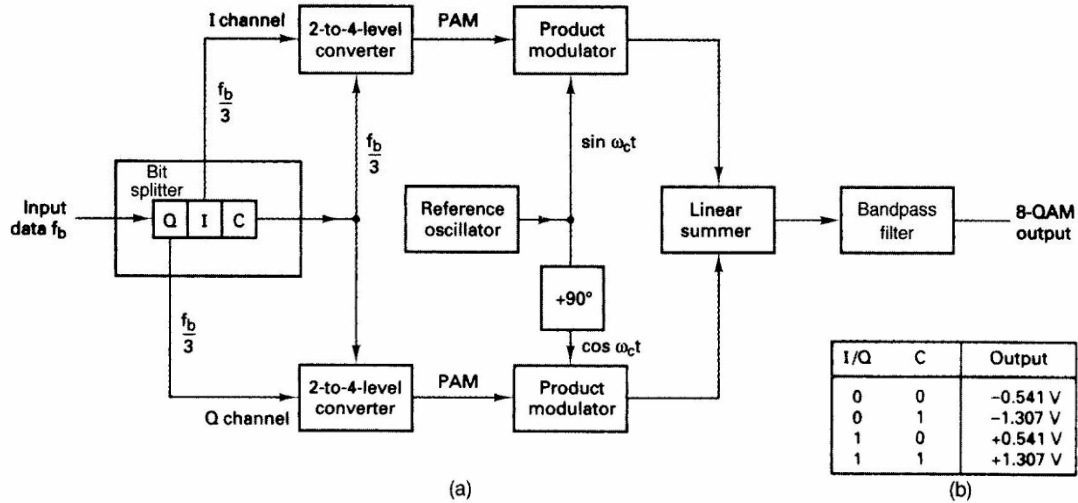
The demodulated I and Q bits (0 and 1, respectively) correspond to the constellation diagram and truth table for the QPSK modulator shown in Figure 2-18.

b) Explain the method of generation of QAM and the demodulation of the same (15) [K2]

8-QAM is an M-ary encoding technique where $M = 8$. Unlike 8-PSK, the output signal from an 8-QAM modulator is not a constant-amplitude signal.

8-QAM transmitter.

Figure 2-30a shows the block diagram of an 8-QAM transmitter. As you can see, the only difference between the 8-QAM transmitter and the 8PSK transmitter shown in Figure 2-23 is the omission of the inverter between the C channel and the Q product modulator. As with 8-PSK, the incoming data are divided into groups of three bits (tribits): the I, Q, and C bit streams, each with a bit rate equal to one-third of the incoming data rate. Again, the I and Q bits determine the polarity of the PAM signal at the output of the 2-to-4-level converters, and the C channel determines the magnitude. Because the C bit is fed uninverted to both the I and the Q channel 2-to-4-level converters, the magnitudes of the I and Q PAM signals are always equal. Their polarities depend on the logic condition of the I and Q bits and, therefore, may be different. Figure 2-30b shows the truth table for the I and Q channel 2-to-4-level converters; they are identical.



For a tribit input of $Q = 0$, $I = 0$, and $C = 0$ (000), determine the output amplitude and phase for the 8-QAM transmitter shown in Figure 2-30a.

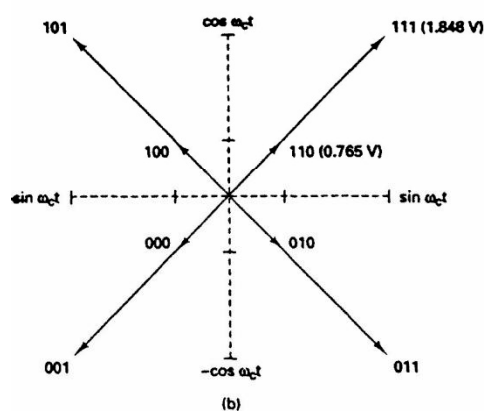
The outputs from the I and Q channel product modulators are combined in the linear summer and produce a modulated output of summer output $= -0.541 \sin \omega_c t - 0.541 \cos \omega_c t = 0.765 \sin(\cos - 135^\circ)$

For the remaining tribit codes (001, 010, 011, 100, 101, 110, and 111), the procedure is the same. The results are shown in Figure 2-31.

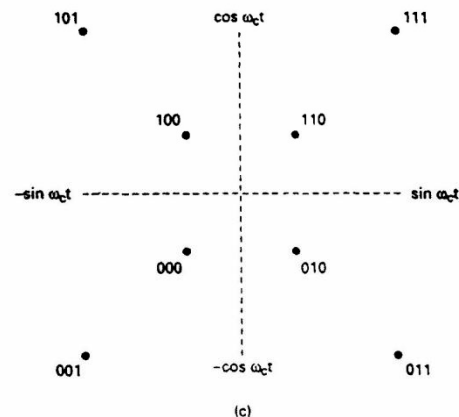
Figure 2-32 shows the output phase-versus-time relationship for an 8-QAM modulator. Note that there are two output amplitudes, and only four phases are possible.

Binary input			8-QAM output	
Q	I	C	Amplitude	Phase
0	0	0	0.765 V	-135°
0	0	1	1.848 V	-135°
0	1	0	0.765 V	-45°
0	1	1	1.848 V	-45°
1	0	0	0.765 V	+135°
1	0	1	1.848 V	+135°
1	1	0	0.765 V	+45°
1	1	1	1.848 V	+45°

(a)



(b)



(c)

