MODULE - III

Multiple Choice Type Questions

1. Smart transmitter allows [WBUT 2009, 2016]
   a) one-way communication
   b) two-way communication
   c) both (a) and (b)
   d) none of these

Answer: (b)

2. The design of TDM system is better with which of the following? [WBUT 2010, 2016]
   a) JFET
   b) Bipolar transistor
   c) MOSFET
   d) Gunn diode

Answer: (b)

3. A TDM system compromises twenty-four channels with quantization level of 0.5 mV and maximum analog signal of 2.048 V. What will be the frame length in terms of number of bits? Assume one channel is allotted for synchronization. [WBUT 2010]
   a) 25
   b) 150
   c) 300
   d) 600

Answer: (c)

4. A special digital modulation technique that achieves high data rates in limited bandwidth channels is called [WBUT 2014]
   a) delta modulation
   b) Pulse-Coded Modulation (PCM)
   c) Quadrature Amplitude Modulation (QAM)
   d) Pulse Amplitude Modulation (PAM)

Answer: (c)

5. FSK systems are much superior to two-tone amplitude-modulation systems with respect to [WBUT 2014]
   a) noise performance
   b) bandwidth requirements of the channel
   c) ionospheric fading characteristics
   d) power consumption

Answer: (c)

6. In the frequency multiplexing system, if the subscriber frequency deviations are proportional to the center frequency, the scheme is referred to having [WBUT 2015, 2017]
   a) a proportional bandwidth format
   b) a constant bandwidth format
   c) a variable bandwidth format
   d) a consistent bandwidth format

Answer: (a)

7. Time division multiplexing requires [WBUT 2017]
a) constant data transmission
b) transmission of data samples
c) transmission of data at random
d) transmission of data of only one measurand

Answer: (d)

Short Answer Type Questions

1. Explain the operation of a QPSK receiver with the help of a block diagram. [WBUT 2010, 2011, 2015]

Answer:
Coherent detection of QPSK signal is shown in the block diagram below.

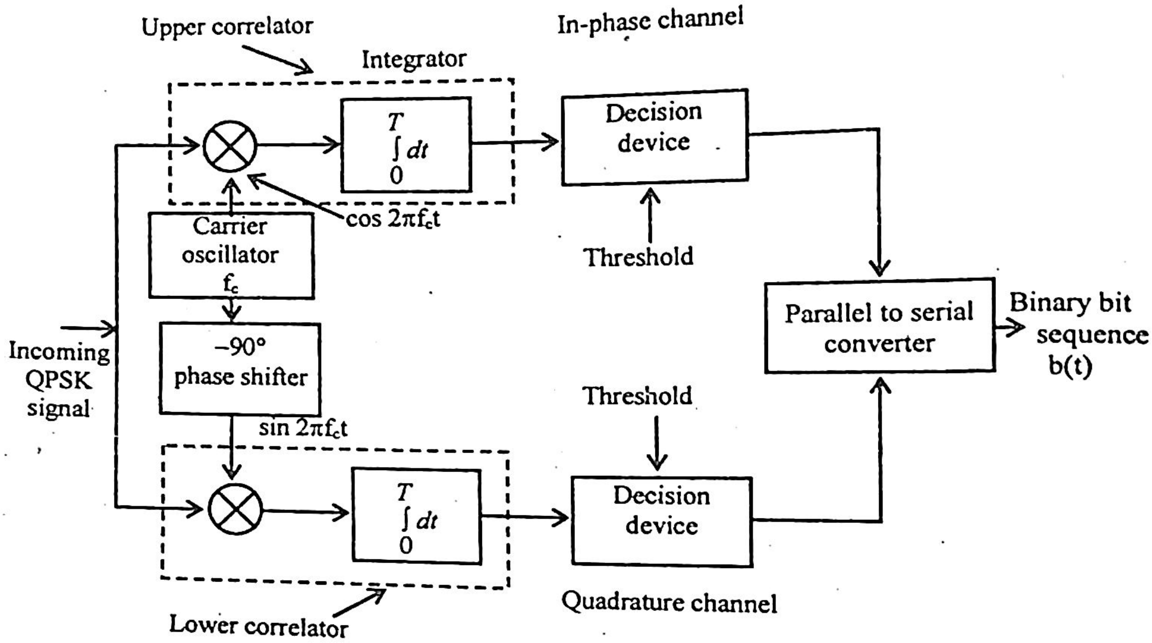


Fig: Block diagram of a coherent QPSK receiver

The detection scheme uses a pair of correlators connected in parallel. The cosine of the carrier phase is computed by the upper correlator and the sine of the carrier phase is computed by the lower correlator. The two decision devices compare the sign of the two correlator outputs. This enables unique resolution of the four transmitted phase angles. Interleaving of the decisions made by the two decision devices in the in-phase and quadrature channels is made by the parallel to serial converter which results in the reconstruction of the binary data stream.

2. What are BASK, BFSK and BPSK? Describe with diagrams needed. [WBUT 2011]

OR

What are ASK, FSK and PSK? Describe with diagrams needed. [WBUT 2015]

OR,

What are BASK, BFSK and BPSK? Describe with diagrams needed. [WBUT 2018]

Answer:

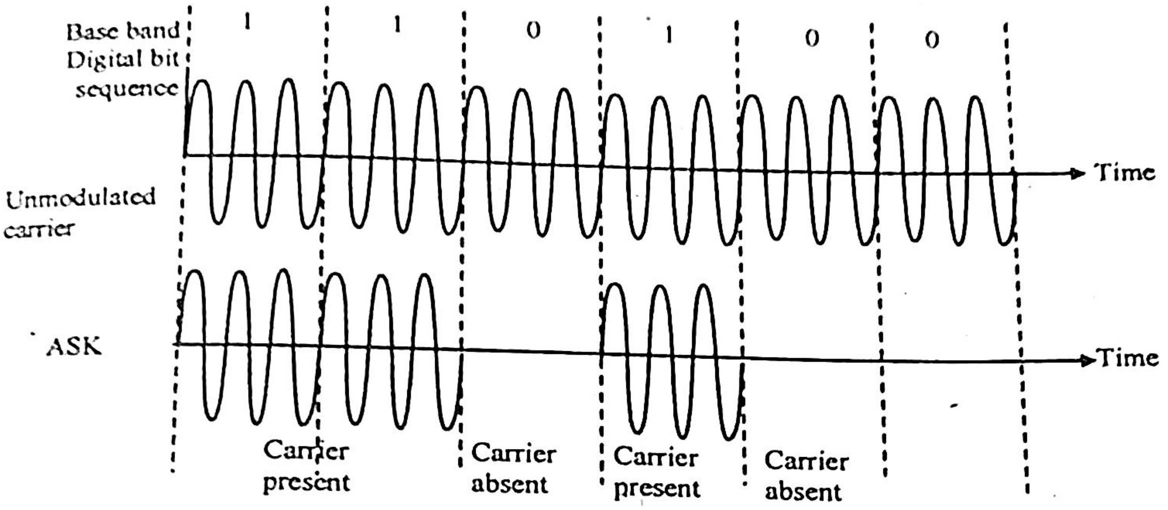
Generation of Amplitude Shift Keying Signal

Let the sinusoidal carrier is $c(t) = A_c \cos 2\pi f_c t$

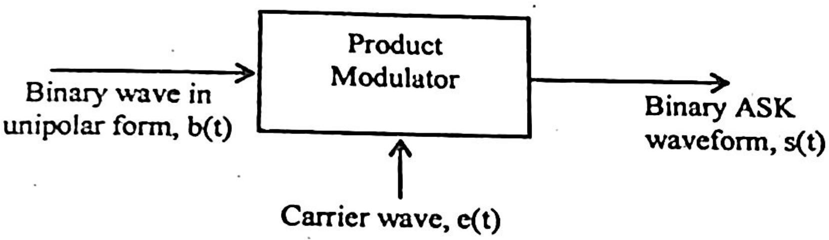
where A_c is the amplitude and f_c is the frequency of the carrier. The binary ASK signal is represented by

$$S(t) = A_c \cos 2\pi f_c t \quad \text{for symbol 1}$$
$$= 0 \quad \text{for symbol 0}$$

Binary ASK is also called on-off keying (OOK).



ASK signal is generated by applying the incoming binary data in unipolar form and the sinusoidal carrier to a product modulator as shown below.



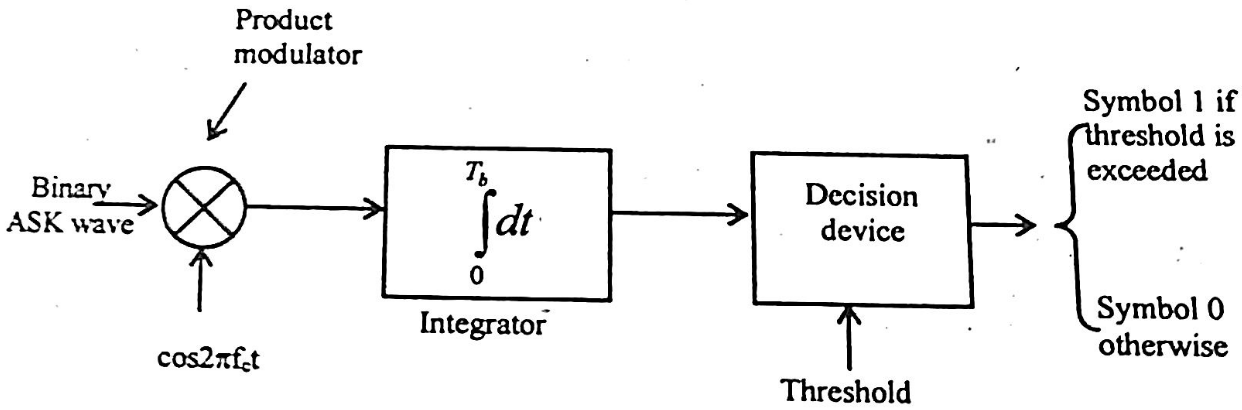


Fig: Coherent detection of binary ASK signals

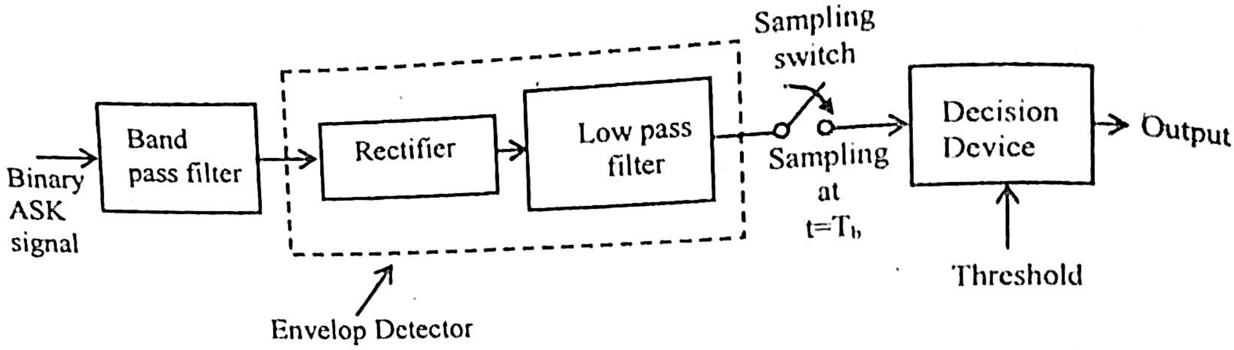


Fig: Non-Coherent ASK defector

In **Frequency Shift Keying (FSK)**, we have two sinusoidal carrier waves of same amplitude A_c but different frequencies f_1 and f_2 are used to represent binary symbols 1 and 0 respectively. The binary FSK wave (BFSK) is represented by S(t) as

$$S(t) = A_c \cos 2\pi f_1 t \quad \text{for symbol } 1$$
$$= A_c \cos 2\pi f_2 (t) \quad \text{for symbol } 0$$

A binary FSK(BFSK) signal for the bit sequence 10110100 is shown below,

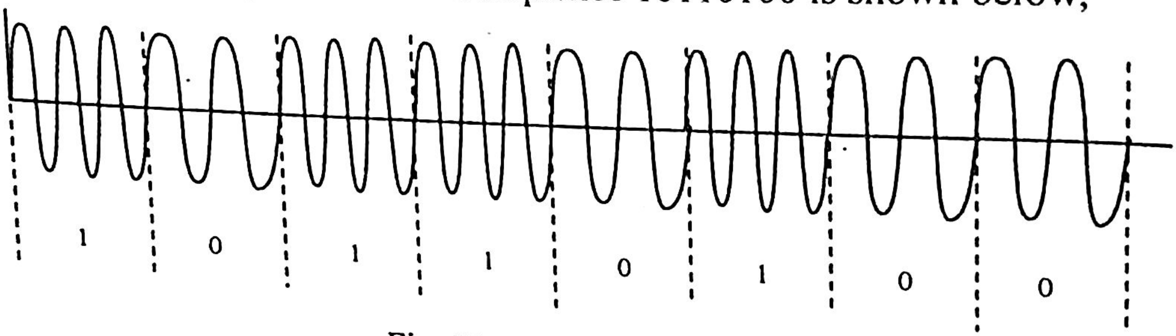


Fig: BFSK waveform

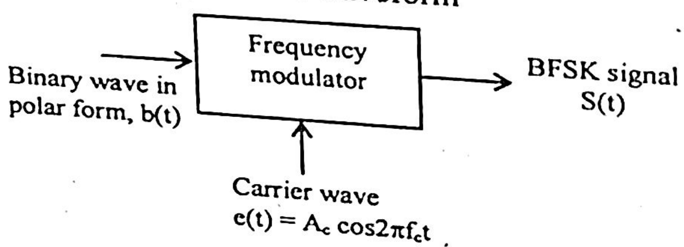


Fig: A BFSK Transmitter

Binary FSK signals can be generated by using a Frequency Modulator as shown in the diagram below:

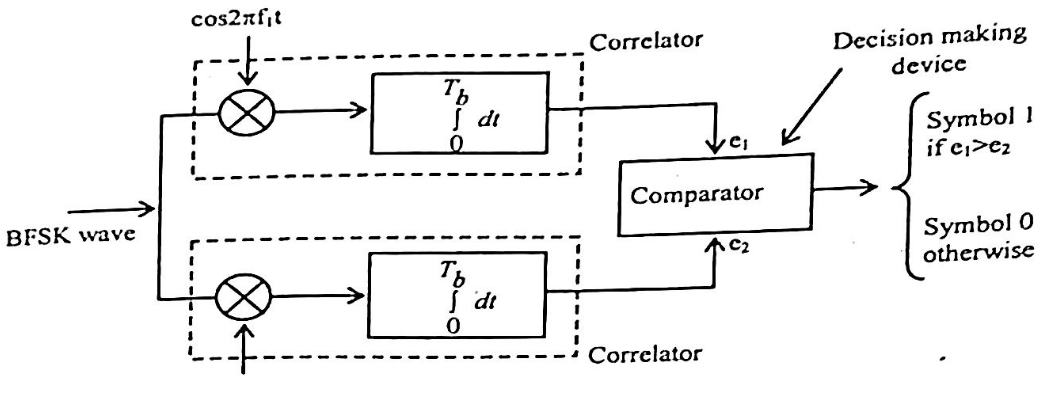


Fig: A coherent BFSK Detector

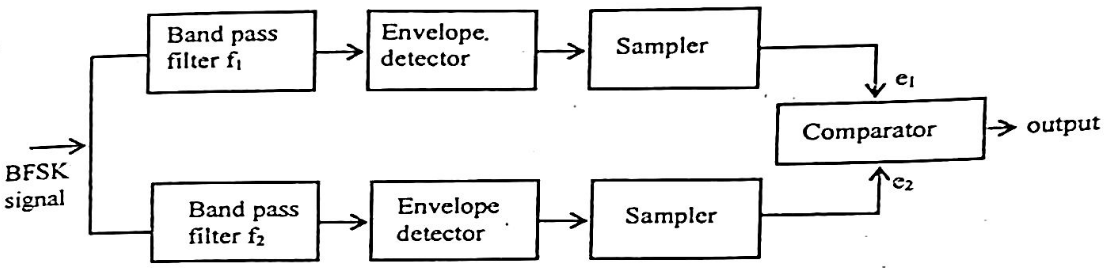


Fig: A non-coherent BFSK Detector

Binary Phase Shift Keying (BPSK)

It is a form of suppressed carrier, square wave modulation of a continuous wave signal. In BPSK, one output phase represents a logic 1 and other a logic 0. As the input digital signal changes state from 0 to 1 or 1 to 0, the

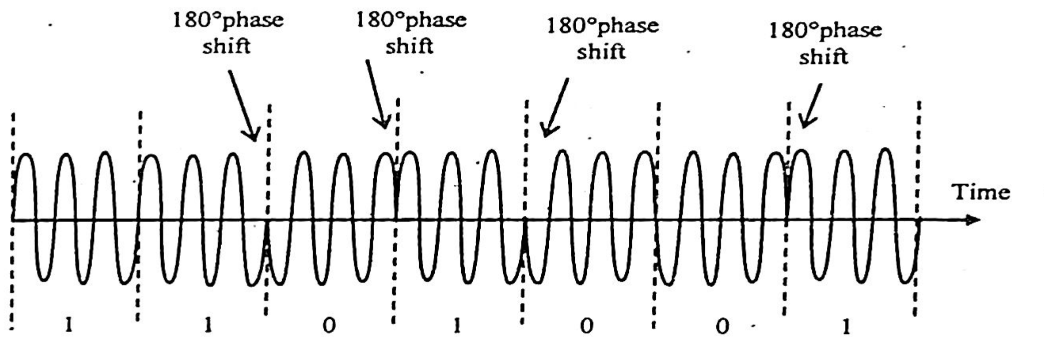


Fig: Binary phase shift keying waveform

BPSK signal can be generated by a product modulator as shown below. Here the binary signal wave b(t) is in polar form whereas in the ASK this is in unipolar form.

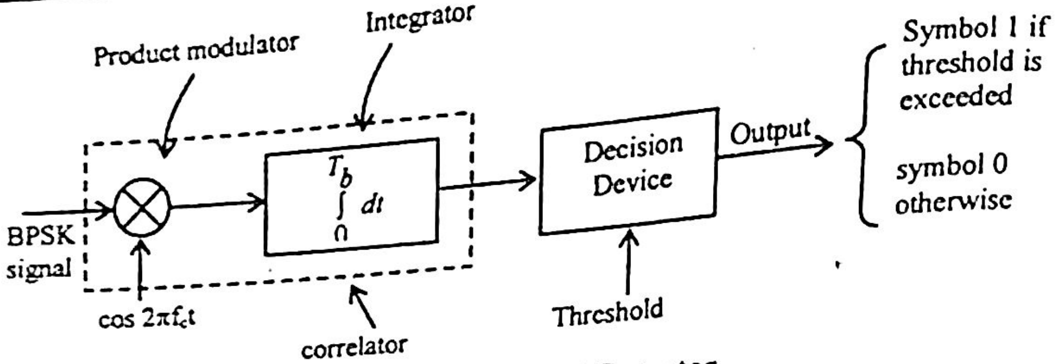


Fig: A coherent BPSK Detector

[WBUT 20

3. **Draw the TDM-PCM system and explain it.**

Answer:

Working Operation of the TDM-PCM System

The working operation of TDM-PCM system shown in figure (i) can be explained in form of few points as under:

(i) This system has been designed to accommodate 24 voice channels marked S_1 to Each signal is bandlimited to 3.3 kHz, and the sampling is done at a standard rate 8 kHZ. This is higher than the Nyquist rate. The sampling is done by the commuta switch SW_1.

(ii) These voice signals are selected one by one and connected to a PCM transmitter the commutator switch SW_1.

(iii) Each sampled signal is then applied to the PCM transmitter which converts it into digital signal by the process of A to D conversion and companding, as explain earlier.

(iv) The resulting digital waveform is transmitted over a co-axial cable.

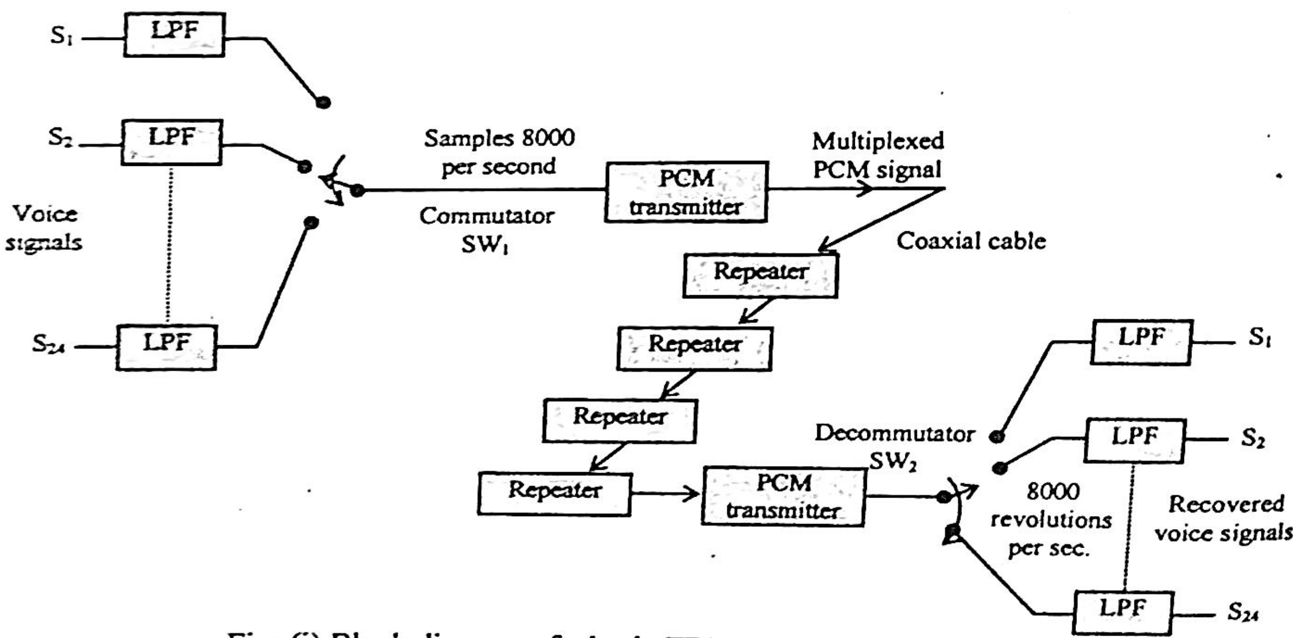


Fig: (i) Block diagram of a basic TDM-PCM system

(v) Periodically, after every 6000 ft, the TDM-PCM signal is regenerated by amplifiers called Repeaters. They eliminate the distortion introduced by the channel and remove the superimposed noise and regenerate a clean TDM-PCM signal at their output. This ensures that the received signal is free from the distortions and noise.

(vi) At the destination, the signal is companded, decoded and demultiplexed, using a PCM receiver. The PCM receiver output is connected to different low pass filters via the decommutator switch SW_2.

(vii) Synchronization between the transmitter and receiver commutators SW_1 and SW_2 is essential in order to ensure proper communication.

4. Explain the operation of a DPSK receiver with the help of a block diagram.
[WBUT 2012, 2016]

Answer:

We know there is a need for phase synchronization of coherent receiver with BPSK. There is no discrete carrier term in the BPSK signal. A phase lock loop circuit may be used to extract the carrier reference only if a low level pilot carrier is transmitted along with the BPSK signal. In absence of a carrier, a Costas loop or a squaring loop may be used to synchronize the carrier reference from this BPSK signal for providing coherent detection. But this introduces a 180° phase ambiguity. In order to eliminate this problem of 180° phase ambiguity a differential coding technique is used at the transmitter and a differential decoding is used at the receiver. This signaling technique that combines differential encoding with phase shift keying is called differential phase shift keying or DPSK. In DPSK the input sequence of binary bits is modified in such a way that the next bit depends upon the previous bit. In the receiver, the previous received bits are used to detect the present bit.

Detection of DPSK

Detection of DPSK is done as shown in the diagram below:

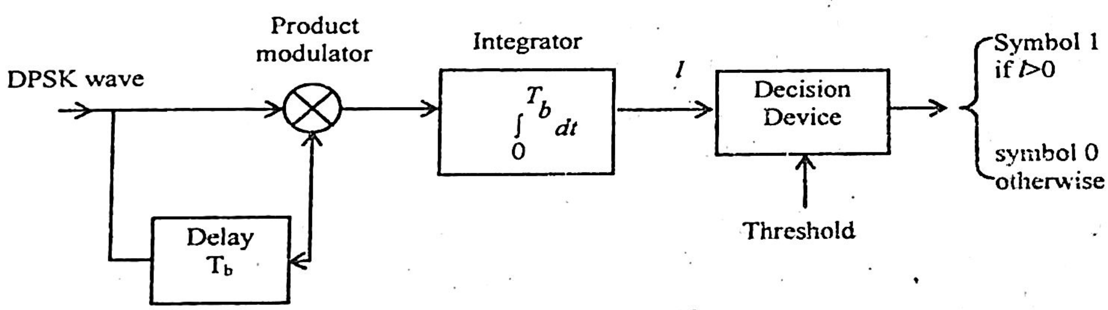


Fig: DSPK Receiver

The detection process can be explained from the timing diagram shown below:

Binary data sequence $\{b_k\}$		1	0	1	1	1	0	0	0	1	1
Differentially encoded data $\{d_k\}$	0	0	1	1	1	1	0	1	0	0	0
	Reference bit										
Phase of DPSK	π	π	0	0	0	0	π	0	π	π	π
Shifted differentially encoded data $\{d_{k-1}\}$		0	0	1	1	1	1	0	1	0	0
Phase of shifted DPSK		π	π	0	0	0	0	π	0	π	π
Phase comparison output		+	−	+	+	+	−	−	−	+	+
Detected binary sequence		1	0	1	1	1	0	0	0	1	1

In the fourth row above, the delayed version of the received DPSK signal is shown. The phase angles of the DPSK signal and its delayed version are shown in the 3rd and 5th rows respectively. Let ϕ is the difference between the carrier phase angle of the received DPSK signal and its delayed version in the same bit interval. The output of the difference is proportional to $\cos\phi$. When $\phi = 0$, the integrator output is positive and when $\phi = \pi$, the integrator output is negative. The integrator output is compared with a threshold level of zero volt in the decision device. We get symbol 0 for negative output and symbol 1 for positive output. The detected binary sequence is shown in the last row. It is seen that the reconstructed binary sequence (7th row) is exactly the same as the input data sequence at the transmitter (1st row). It may be noted we have assumed absence of channel noise in the above analysis. Also the reconstruction is independent of the choice of the initial reference bit.

5. Describe a PAM/PM/PM system. **[WBUT 2014]**

OR,

Describe a PAM/PM/PM system with proper block diagram. **[WBUT 2018]**

nswer:

ometimes, a number of PAM signals are used to phase-modulate the sub-carrier
scillator outputs which are then mixed of summed and the composite signal is again uses
o phase-modulate an appropriate RF carrier. This modulated carrier is then amplified and
ransmitted through the RF channel. Such a system is called the PAM/PM/PM system.
This is schematically shown in figure (i). Thus, it becomes a combination of TDM and
FDM systems for obtaining the signal to be transmitted.
The composite transmitted signal is received at the receiving side and then demodulated –
in one level for PAM/PM system and in two levels for PAM/PM/PM system – and then
demultiplxed and filtered by lowpass filters for recovering the original signals. The
demultiplexer through which the demodulated PAM signal passes through, in short called
DEMUX, is a reverse multiplexer – a single-input, multi-output device, each output
channel corresponding to the original signal channel. As a number of signals are to be
obtained from a single input to the demultiplexer, synchronization has to be there on the
receiving side with respect to the transmitting side. This involves:

a) identical clock frequency,

b) sequence in demultiplexing which should be identical to that in multiplexing maintaining, also the channelwise time identity.

Synchronization may be achieved by including what is known as a synchronizing pulse in each time format/frame. This is a special pulse or a blank. In fact, it is possible to obtain the demultiplexer sync. Pulse from the PAM signal received.

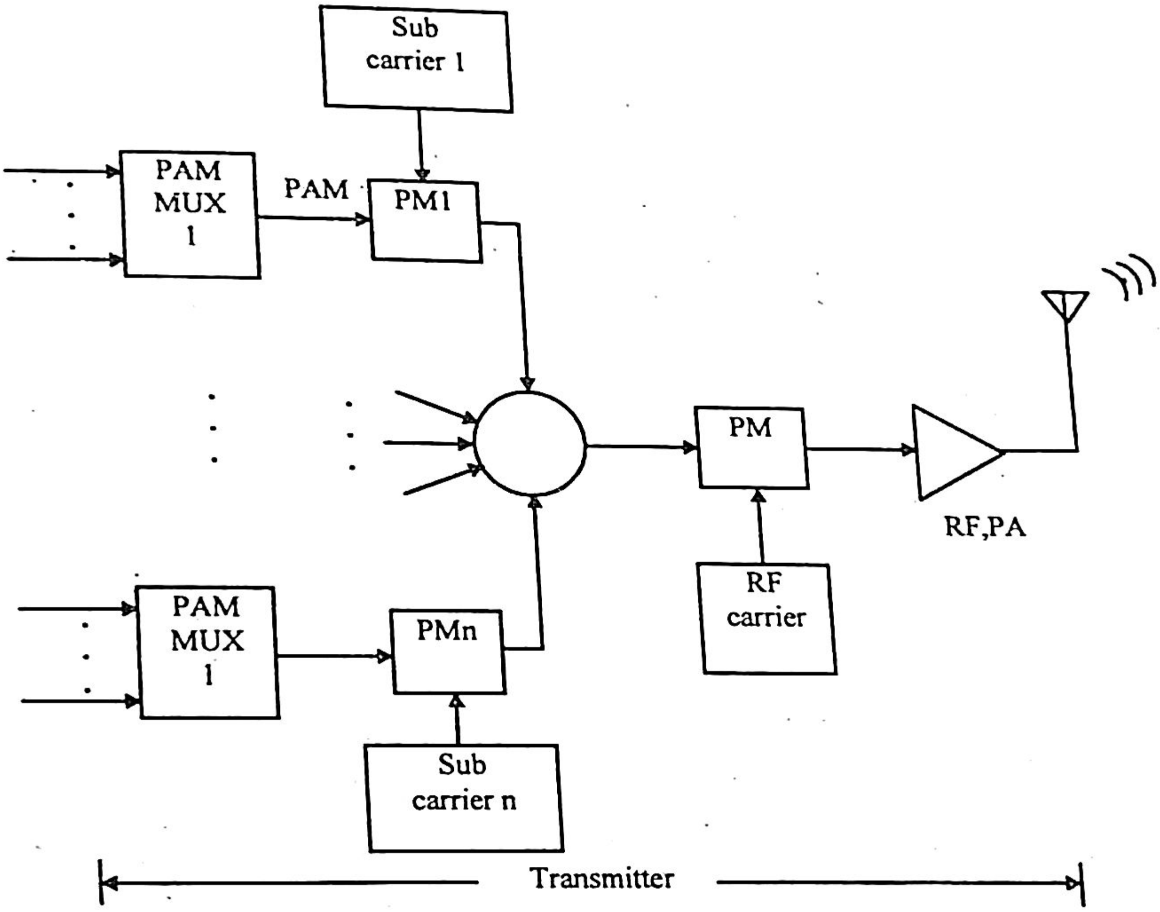


Fig: (i) The PAM/PM/PM system

6. What are the basic differences between FDM and TDM system? **[WBUT 201**

Answer:

Comparison between FDM and TDM

There are two methods of multiplexing, viz. FDM (Frequency Division Multiplexin and TDM (Time Division Multiplexing). The basic difference between them is that FDM the frequency scale is shared by different signals; as shown in Fig. 1, whereas, TDM the time scale is shared by different signals, as shown in Fig. 2. The bandwid requirement of AM/SSB and PAM is nf_M Hz, and that of AM/DSB and PAM/AM $2nf_M$ Hz. Thus, it can be said that the bandwidth requirement of the FDM and TDM system is the same.

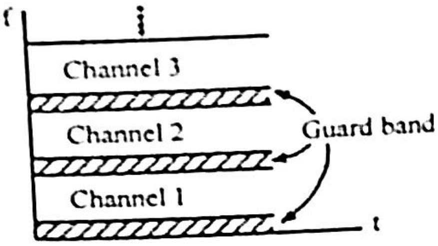


Fig: 1 FDM

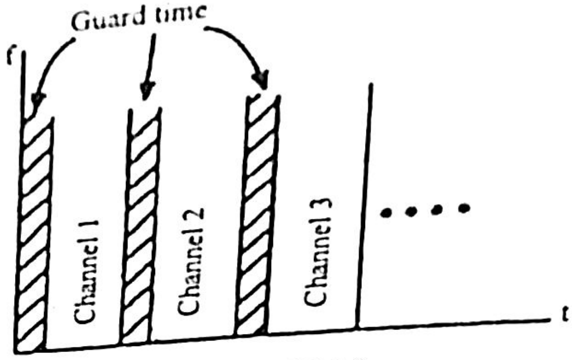


Fig: 2 TDM

Long Answer Type Questions

1. a) Draw the block schematic diagram of TDM/PCM/FM system of telemetering and make appropriate lebels, both on the transmitting and receiving sides. **[WBUT 2009, 2016]**

b) What do you mean by time frame in TDM/PAM system? **[WBUT 2009]**

c) How is synchronization done in TDM system? Explain with a circuit diagram for synchronization pulse generation with input blank synchronization channel. **[WBUT 2009, 2013, 2015, 2016]**

Answer:

a) Block diagram of TDM/PCM/FM system-

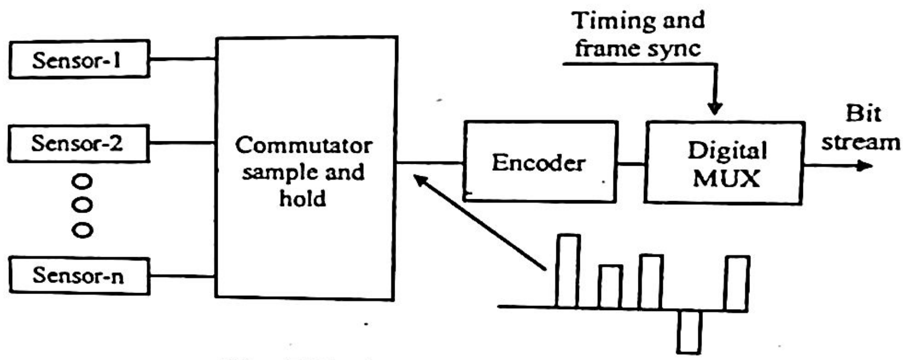


Fig: TDM/PCM/FM Transmitter

In the demultiplexing of TDM-PCM/FM, it is necessary to separate in the time domain the binary words representing the signals from the N sensors, once the bit sequence has been stripped from the IF carrier. This is performed with a decommutator.

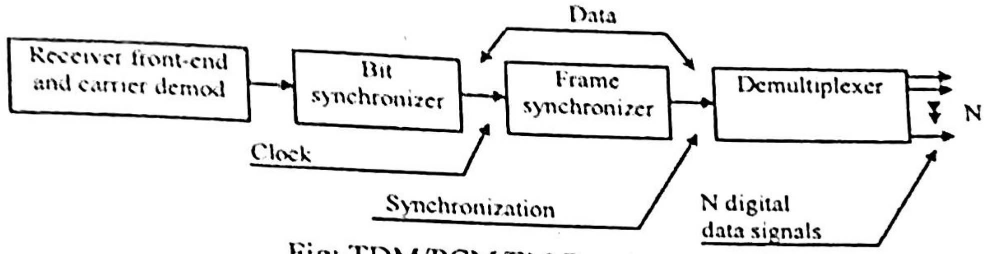
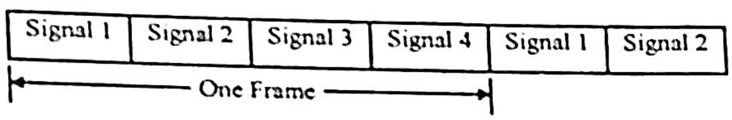


Fig: TDM/PCM/FM Receiver

b) In TDM the signal to be multiplexed are transmitted sequentially on after another. so, the complete BW of communication channel is available to each signal being transmitted.

One frame corresponds to the time period required to transmit all the signals once on tranmission channel as shown in figure below-



c) 1st Part:

In case of PAM/TDM system the multiplexed PAM signals can be received properly if and only if the transmitter and receiver commutators are synchronized to each other in terms of the speed and the position. In order to ensure synchronization, a marker pulse is introduced at the end of each frame in the transmitted signals as shown in figure.

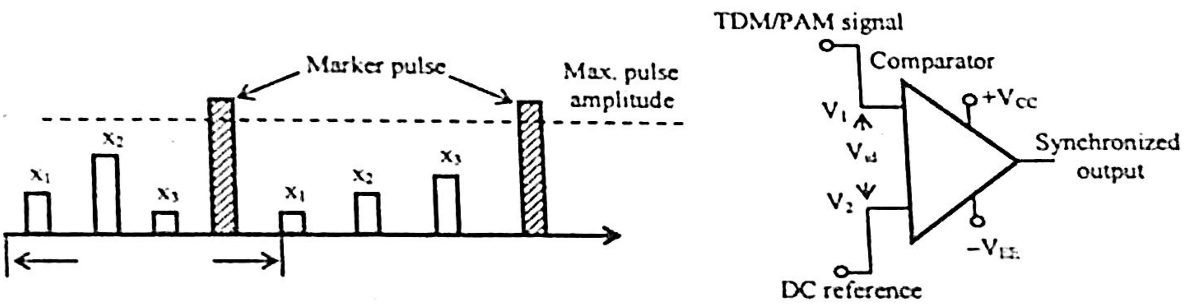


Fig: 1 Illustration of frame synchronization and detection

The amplitude of this pulse is kept higher than the maximum permissible amplitude of the multiplexed channels. At the receiver end, the received signal is compared with a DC reference level. The comparator responds to only the marker pulse to produce output. Thus, the marker pulse is separated from the remaining multiplexed channels. Due to the introduction of synchronizing pulse, only three signals instead of four can now be transmitted.

2nd Part:
The blank pulse synchronization is made effective only when a sync pulse is obtained with appropriate circuity. The objective is to generate sharp pulses for every signal pulse and also for the absence of a pulse in the frame and then kept this last pulse at the end of the frame and eliminate all others by complementation. The figure is shown in fig(i). The PAM pulses of varying amplitudes are first given equal heights and then inverted so that the gaps between the pulses are actually pulses of larger widths, the largest being for the gap between the last pulse of the frame and the first one of the next frame. The output from the inverter is summed with a series of narrow clock pulses which are produced from the same clock but delayed first by ½ width of the PAM pulses and their widths are controlled to be kept narrow both the functions are performed by one shot multi vibrator as shown in fig:. The summed output is fed to a comparator which is given a dc threshold as reference input.

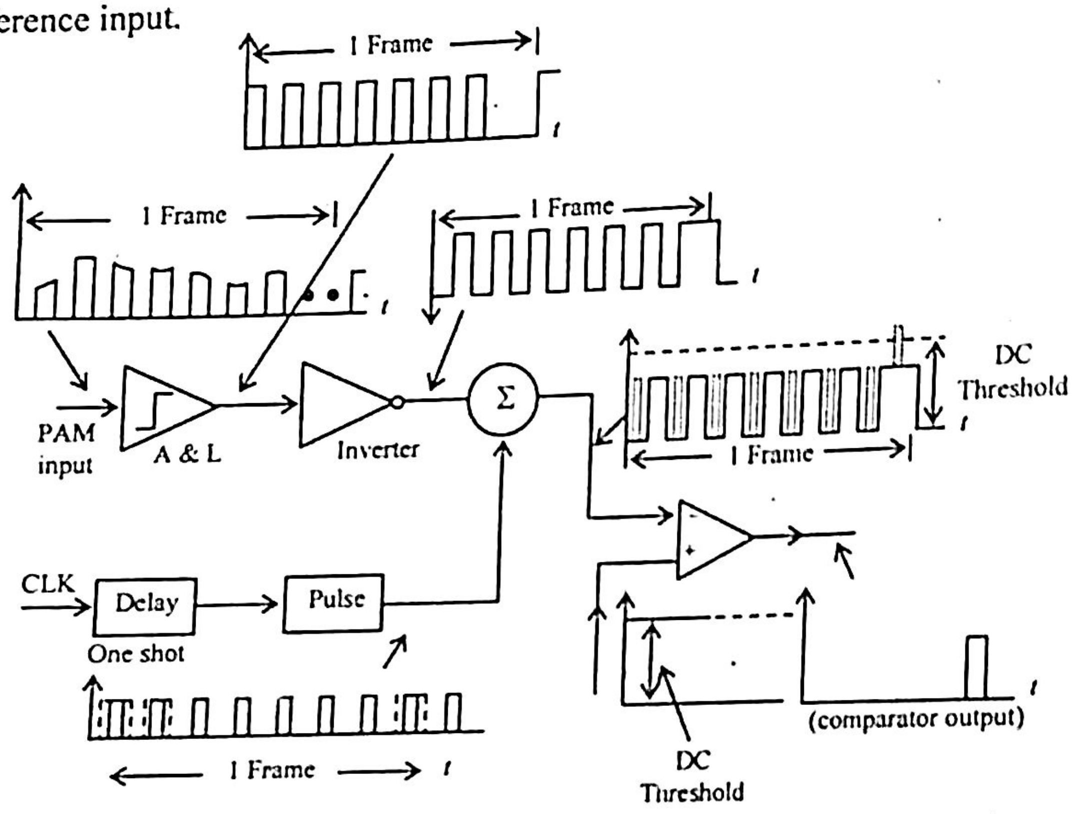


Fig: Circuit for sync pulse generation with input blank sync channel

2. a) Describe QPSK. Why is it adopted in digital data transmission? Demonstrate by carrier sine wave mixing how QPSK can be obtained?
b) Draw and explain the block diagram of QPSK receiver.
c) Write down the flow-chart of eight level serial quantizer and 3-bit encoder.
[WBUT 2009]

Answer:
a) In communication system, we have two main resources. These are the transmission power and the channel bandwidth. The channel bandwidth depends upon the bit rate or signaling rate f_b. In digital bandpass transmission, we use a carrier for transmission. This carrier is transmitted over a channel. If two or more bits are combined in some symbols, then the signaling rate will be reduced. Thus, the frequency of the carrier

needed is also reduced. This reduces the transmission channel bandwidth. Hence, because of grouping of bits in symbols, the transmission channel bandwidth can be reduced. In quadrature phase shift keying (QPSK), two successive bits in the data sequence are grouped together. This reduces the bits rate or signaling rate (i.e., f_b) and thus reduces the bandwidth of the channel.

Figure 1 shows the block diagram of QPSK transmitter. Hence, the input binary sequence is first converted to a bipolar NRZ type signal. This signal is denoted by $b(t)$. It represents binary '1' by +1 V and binary '0' by −1 V. This signal has been shown in figure 2(a). The demultiplexer divides $b(t)$ into two separate bit streams of the odd numbered and even numbered bits. Here, $b_e(t)$ represents even numbered sequence and $b_0(t)$ represents odd numbered sequence. The symbol duration of both of these odd and even numbered sequences is $2T_b$. Hence, each symbol consists of two bits. Figure 2(b) and (c) illustrate the waveform of $b_e(t)$ and $b_0(t)$.

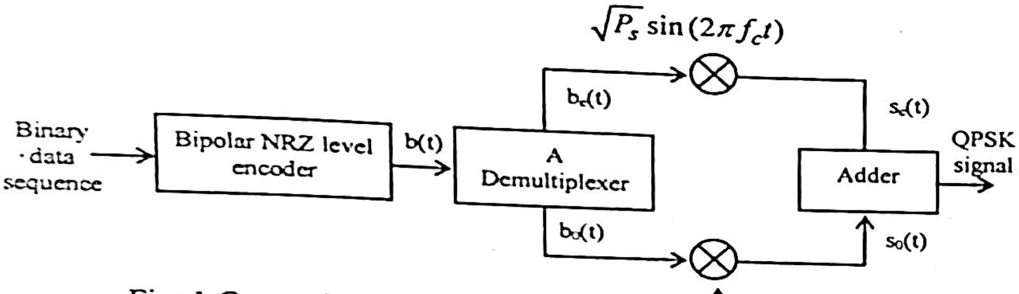


Fig: 1 Generation of QPSK

It may be observed that the first even bit occurs after the first odd bit. Hence, even numbered bit sequence $b_e(t)$ starts with the delay of one bit period due to first odd bit. Thus, first symbol of $b_e(t)$ is delayed by one bit period 'T_b' with respect to first symbol of $b_0(t)$. This delay of T_b is known as offset. This shows that the change in levels of $b_e(t)$ and $b_0(t)$ cannot occur at the same time due to offset or staggering.

Also the bit steam $b_e(t)$ modulates carrier $\sqrt{P_s}\cos(2\pi f_c t)$ and $b_0(t)$ modulates $\sqrt{P_s}\sin(2\pi f_c t)$. These modulators are the balanced modulators. The two carriers $\sqrt{P_s}\cos(2\pi f_c t)$ and $\sqrt{P_s}\sin(2\pi f_c t)$ have been shown in figure 2 (d) and (e). There carriers are also known as quadrature carriers.

The two modulated signals can be written as,

$$s_e(t)=b_e(t)\sqrt{P_s}\sin(2\pi f_c t)$$

and $$s_0(t)=b_0(t)\sqrt{P_s}\cos(2\pi f_c t)$$

Hence, $s_e(t)$ and $s_0(t)$ are basically BPSK signals. The only difference is that $T=2T_b$ here. The value of $b_e(t)$ and $b_0(t)$ would be +1V or −1V. Figure 2 (f) and (g) shows the waveforms of $s_e(t)$ and $s_0(t)$. The adder in figure 1 adds these two signals $b_e(t)$ and $b_0(t)$.

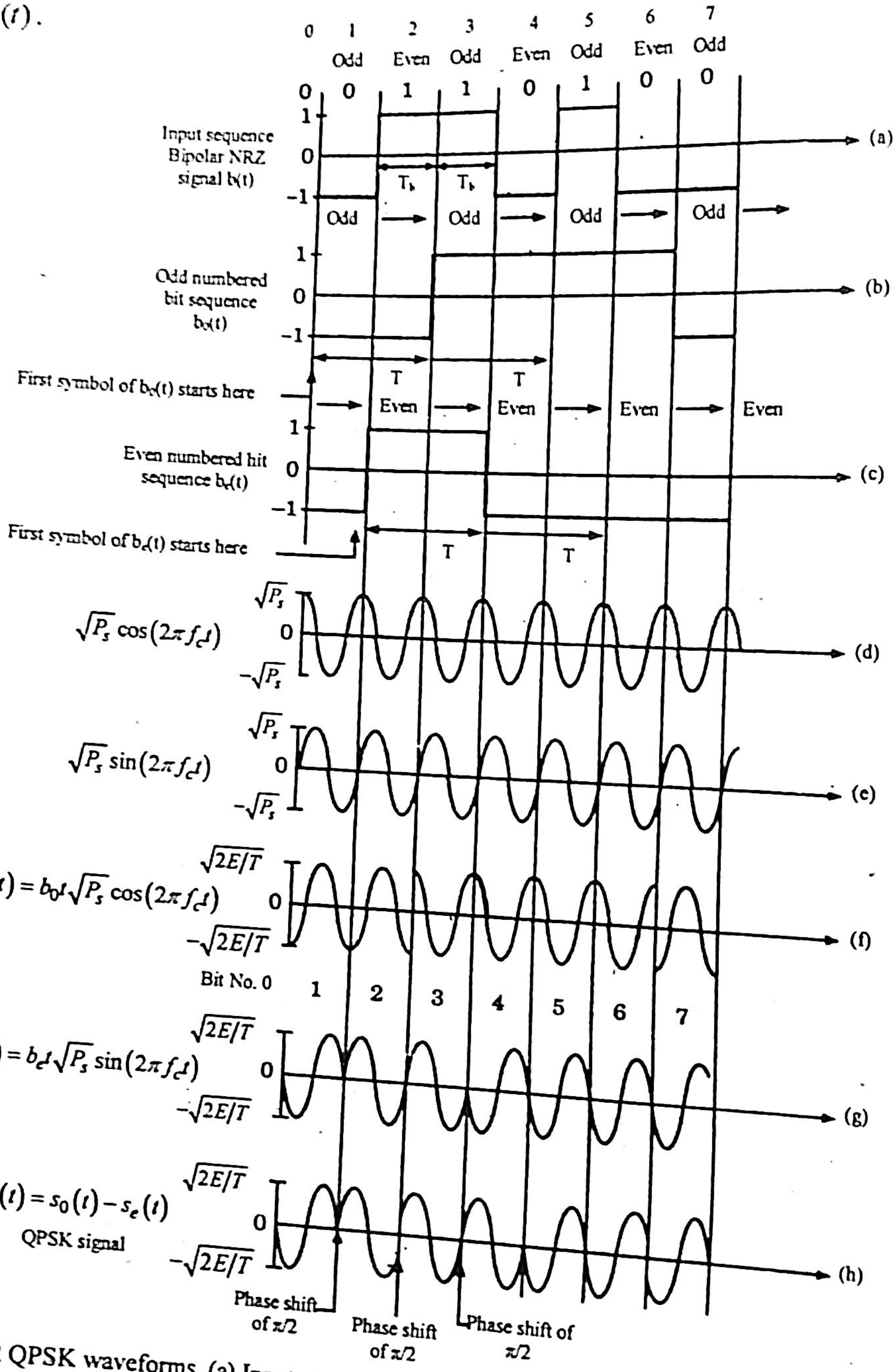


Fig: 2 QPSK waveforms, (a) Input sequence and its corresponding NRZ waveform, (b) Odd numbered bit sequence and its corresponding waveform, (c) Even numbered bit sequence and its NRZ waveform, (d) Basis function $f_1(t)$, (e)Basis function $f_2(t)$, (f) Binary PSK waveform for odd numbered channel, (g) Binary PSK waveform for even numbered channel, (h) Final QPSK waveform

The output of the adder is QPSK signal and it is given by,

$$s(t)=s_0(t)+s_e(t)$$

or $$s(t)=b_0(t)\sqrt{P_s}\cos(2\pi f_c t)+b_e(t)\sqrt{P_s}\sin(2\pi f_c t)\quad \ldots(a)$$

Figure 2 (h) shows the QPSK signal represented by equation (a). In QPSK signal in figure 2(h), if these is any phase change, it occurs at minimum duration of T_b. This is because the two signals $s_e(t)$ and $s_0(t)$ have an offset of 'T_b'. Due to this offset, the phase shift in QPSK signal is $\frac{\pi}{2}$.

$$s(t)=-\sqrt{P_s}\cos(2\pi f_c t)-\sqrt{P_s}\sin(2f_c t)$$

$$b_0(t)=-1$$

$$b_e(t)=-1$$

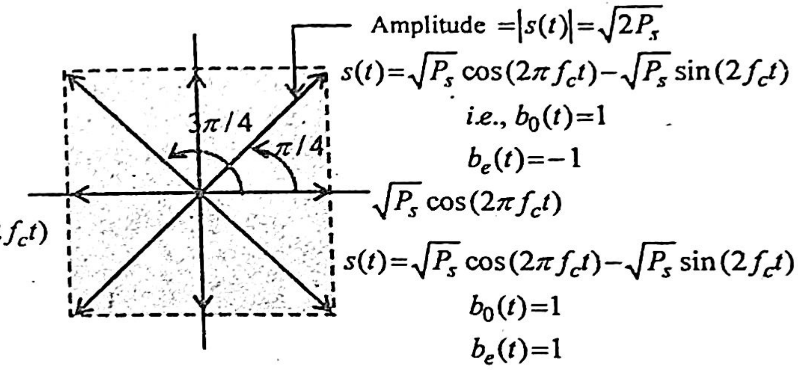


Fig: 3 The Phasor diagram of QPSK signal

b) ***Refer to Question No. 1 of Short Answer Type Questions.***

c) Flowchart of eight level serial quantizer and 3-bit encoder:.

The serial conversion process for $n=3$ is illustrated by the flow chart shown in figure below.

In the three-bit serial quantizer, the input sample $m(NT)$ is shifted and scaled to have a range between 0 and V_p. When $m(NT)$ is applied to the first comparator, a decision is made as to whether $m(NT)$ is above or below $V_p/2$. If it is above, the most significant bit, b_2, is set to 1 and $-1/2\ V_p$ is subtracted from $m(NT)$, reducing it to fall between 0 and $-1/2\ V_p$. If $m(NT)$ is less than ½ V_p, b_2 is set to 0, and $m(NT)$ is sent to the next comparator, which now must decide if the input pulse is above or below $1/4\ V_p$. The process is repeated and the results applied to the next comparator. Although the A/D converter illustrated is a 3-bit encoder, it is relatively simple to add another stage.

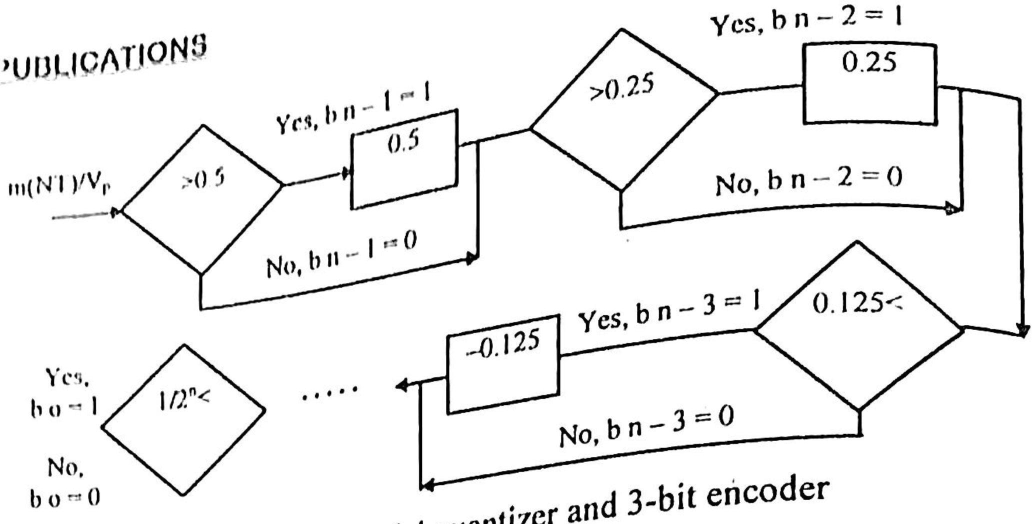


Fig: Eight-level serial quantizer and 3-bit encoder

3. a) How does TDM system differ from FDM system? **[WBUT 2010, 2014]**
OR,
Make a comparison between TDM & FDM systems. **[WBUT 2013, 2015]**
b) Draw a hardware circuit and explain the operation of a 8-channel TDM-PAM telemetering transmitter system and draw the pulse waveforms at the outputs of the clock generator, counter, multivibrator and gates for one time-frame. **[WBUT 2010, 2013, 2014]**
c) If the sampling frequency is 8 kHz and we use 8-bit ADC then calculate line speed of two channels TDM-PCM. **[WBUT 2010, 2014]**

Answer:

a) ***Difference between TDM & FDM***

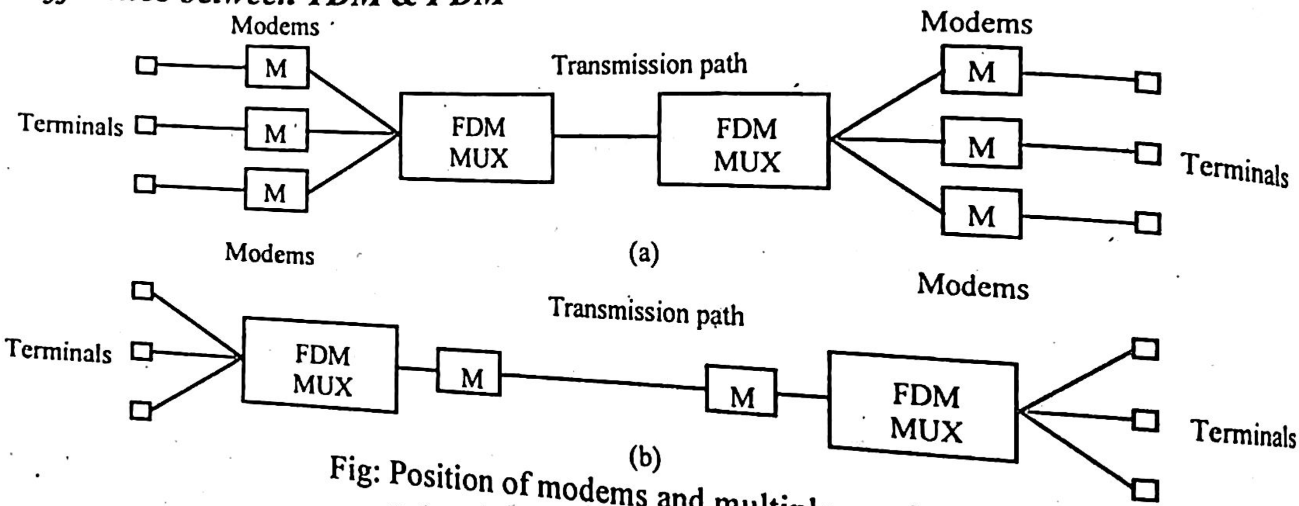


Fig: Position of modems and multiplexers in the network for (a) FDM and for (b) TDM

A comparison of FDM and TDM

Function	FDM	TDM
Type of signal	Analogue – each channel contains the original waveform	Digital – each channel contains samples of the waveform
Terminals speed	Slow – variable to 2.000 bps depending on bandwidth available	High – depending on channels and modem available
Terminal location	Isolated terminals	Clustered terminals
Type of transmission	Parallel	Serial
Position of mux	After modems	Near terminals before modem

b) In fig: (1) shows how the bpck schematic can be implemented with the actual hardware for a TDM-PAM system.
FET switches capable of turning off and an at high speed are used for channel selection via AND gates each of which has four inputs, one from the one-shot multicontrolled by the clock, three others from the three F-F counters as decoder gates triggered again by the clock.
In total, 8 channels are considered with eight AND Gates, 0, 1, ... 7, for which 3 F-Fs are necessary. There are 8FET switches in line with eight resistances R_1 to R_8 and a summer circuit. The 8 binary combinations with 3 decoders are 000, 001, 010 , 011, 100, 101, 110, 111. Waveforms of the clocks, counters one shot multi and gate outputs are shown for the above TDM/PAM system in fig: (2) for 1 frame only.

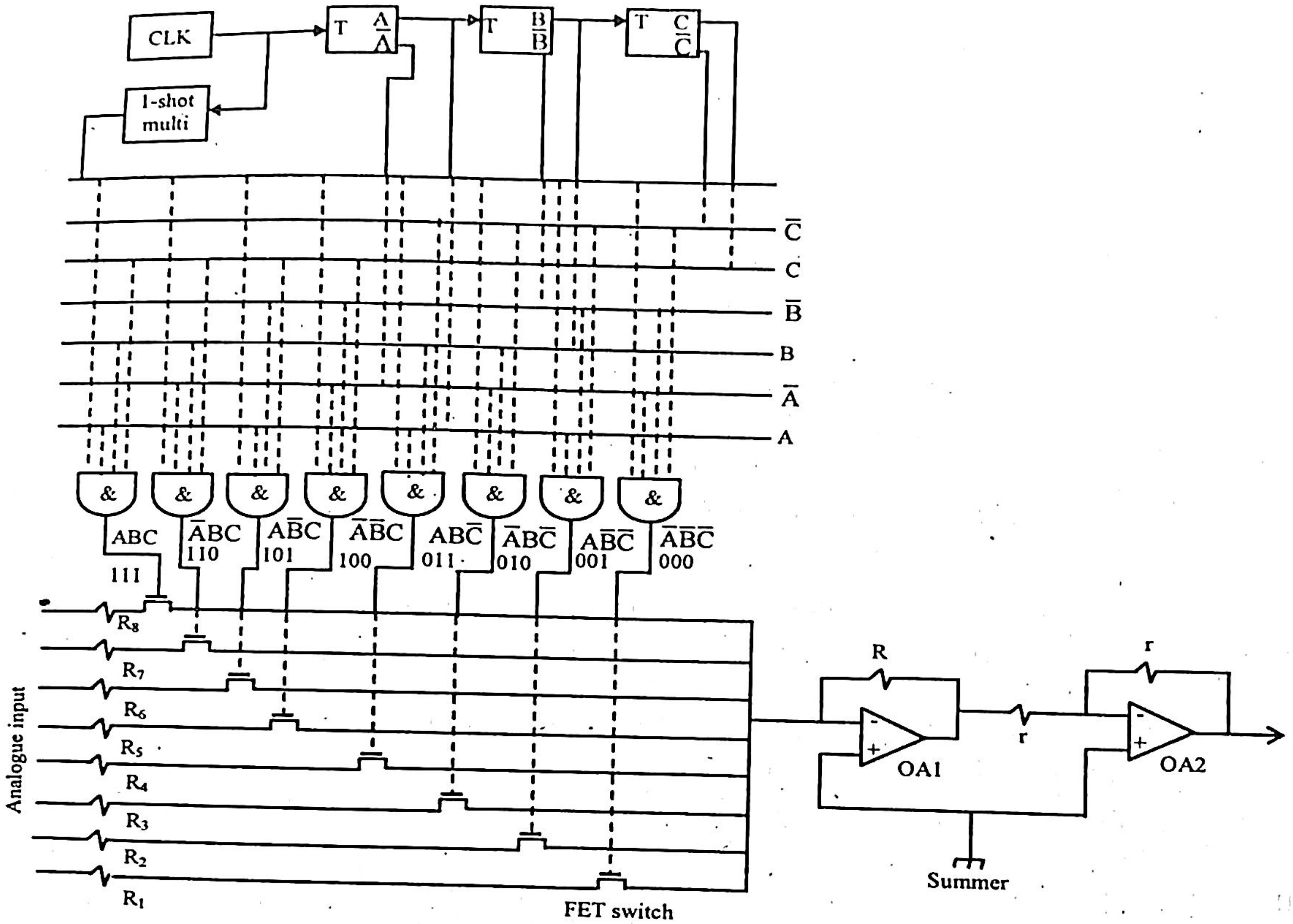


Fig: (1) The hardware for TDM-PAM system

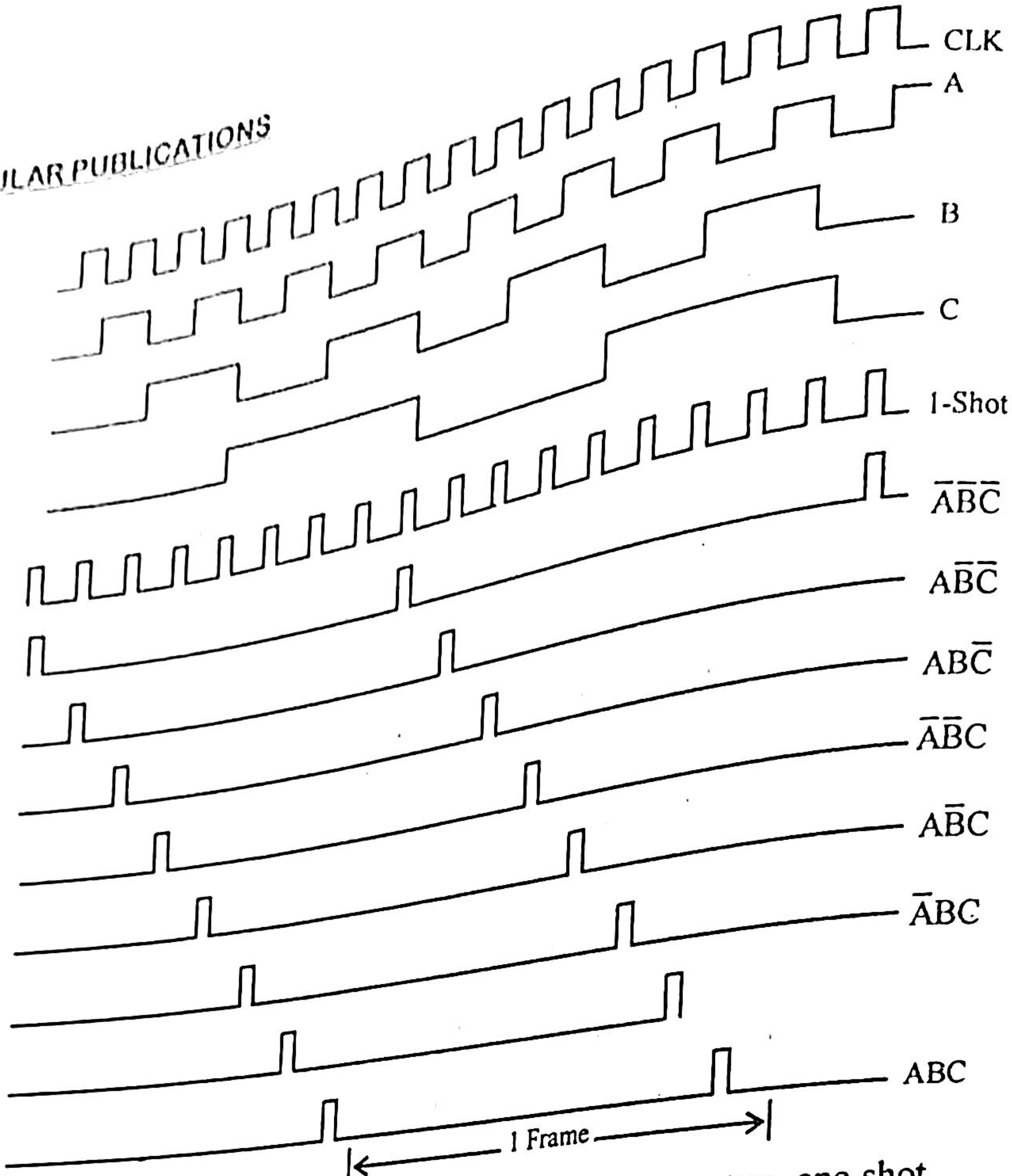


Fig 2: Sketches of waveforms of the clock, counters, one-shot multi and gate outputs of the TDM-PAM system of (1)

c) A sample is taken from each channel during each frame; therefore, the time allocated to transmit the PCM bits from each channel is equal to the half of the total frame time. Therefore, eight bits from each channel must be transmitted during each frame (a total of 16 PCM bits per frame). Thus, the line speed at the o/p at the multiplexer is

$$\frac{2\text{ channel}}{\text{frame}} \times \frac{8000\text{ frames}}{\text{second}} \times \frac{8\text{bits}}{\text{channel}} = 128\text{kbps}$$

Although each channel is producing and transmitting only 64 kbps, the bits must be clocked out onto the line at a 128 kHz rate to allow eight bits from each channel to be transmitted in a 126 μs time slot.

4. Draw and explain the block diagram of QPSK transmitter and receiver.

[WBUT 2013, 2018]

Answer:

A four-phase PSK called quadrature phase shift keying (QPSK) (also called quadra-phase or quaternary phase shift keying) uses a pair of digital bits in the word being assigned a phase so that four-phase conditions are possible. For example, a pair of bits called dibit may occur in four probable ways 00, 01, 11 and 10; these are assigned phases of 45°, 135°, 225° and 315° respectively, each being separated by 90°. The carrier sinewave phasor is shown in Fig. 1.

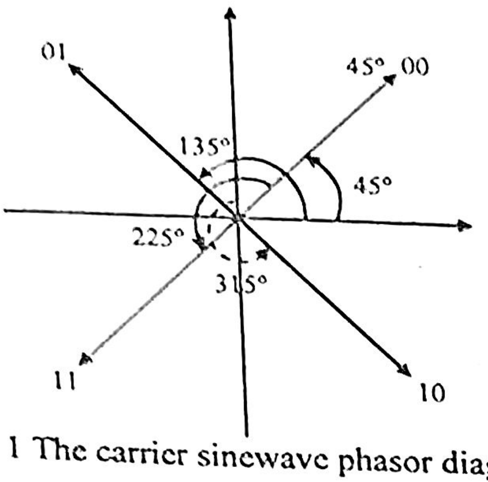
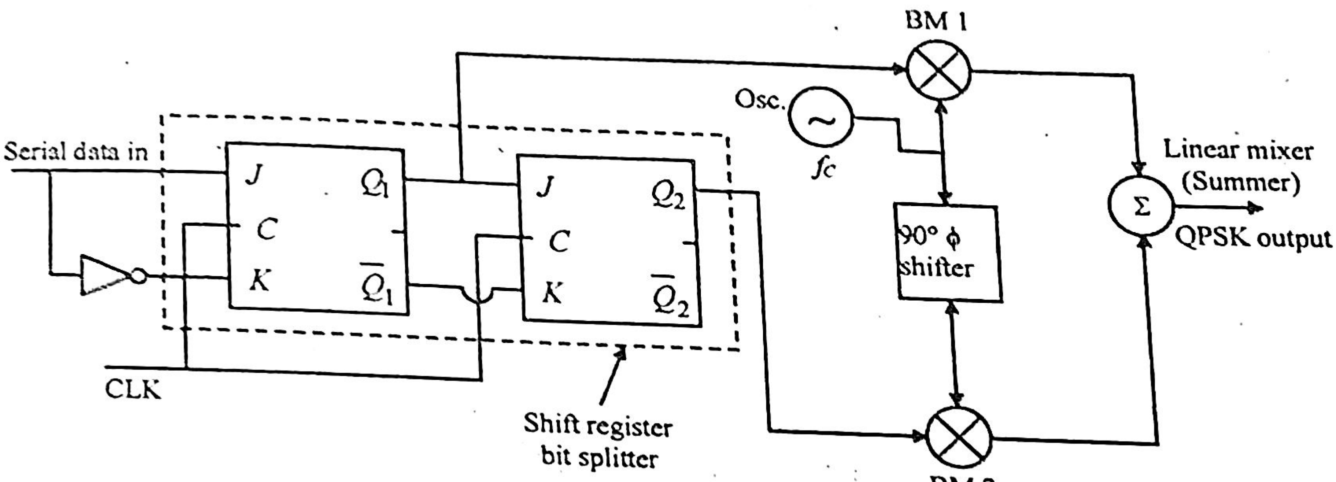
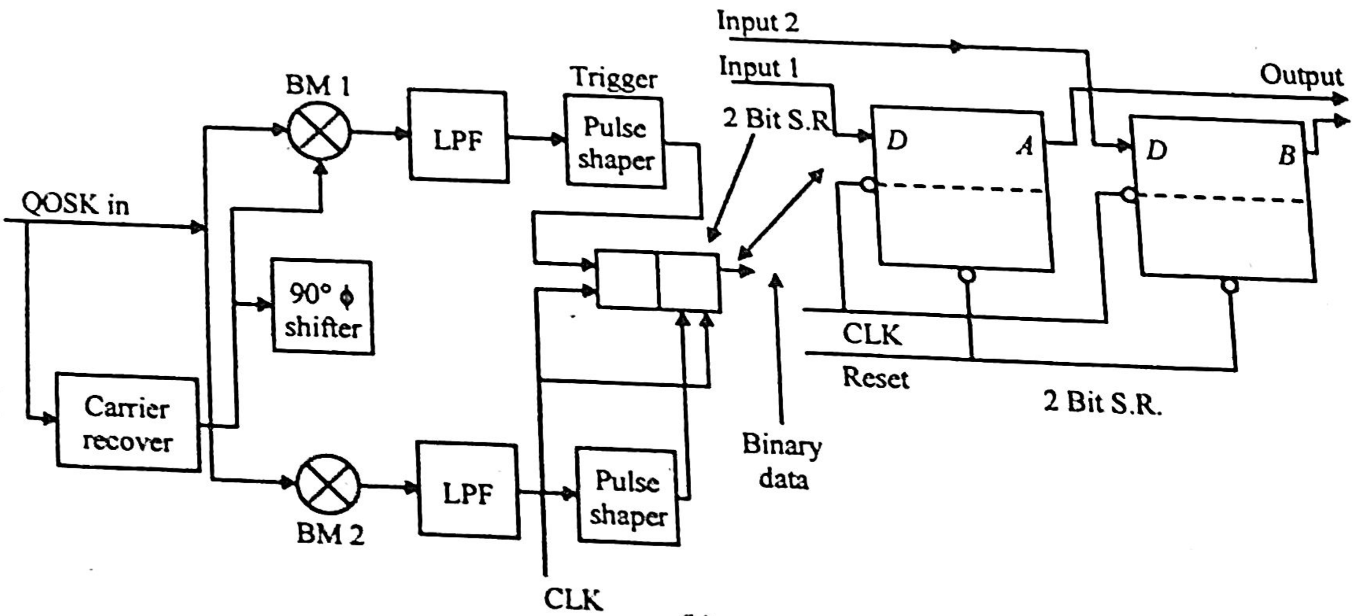


Fig: 1 The carrier sinewave phasor diagram



(a)



(b)

Fig: 2(a) A typical QPSK modulator scheme
(b) The QPSK demodulator scheme

Table 1 Truth Table of Flip-Flop

J	K	Q_t	$\overline{Q}_t$
0	1	0	1
1	0	1	0

In the QPSK modulator of Fig. 2(a), the bits from the shift register are applied to balanced modulators 1 and 2 with the carrier directly given to modulator 1 and with a phase shift of 90° to modulator 2 as has been stated already. The outputs of these modulators are summed in a linear mixer. For the same binary input '0' or '1' to the two modulators, modulator 2 has its output shifted (lagging) by another 90°. Output from each of these modulators is a BPSK signal.
More than two bits can form a word with 2^n possible encoding leading to 2^n phase changes. For $n=3$, there are 8 phase changes and with $n=4$, 16 possible phase changes are there. Higher the number of bits per carrier phase change, more bits would be there per baud that produce higher data rate without requiring widening of the bandwidth. For the case $n=2$, the QPSK occurs and typical QPSK modulator and demodulator are shown in Figs 2(a) and (b), respectively.
For the shift register of Fig. 2(a), the truth table of the first and the second flip-flops are identical and is shown in Table 2.

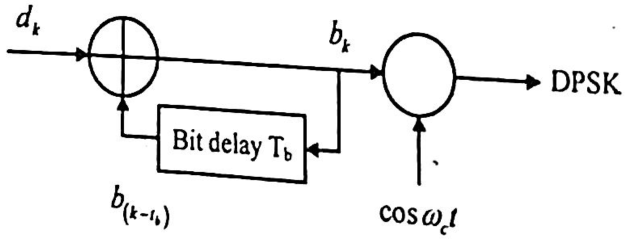
Table 2 The modulator states

p_1	p_2	$QPSK$
1	1	$\cos\omega_c t - \sin\omega_c t = \sqrt{2}\cos(\omega_c t + 45°)$
1	−1	$\cos\omega_c t + \sin\omega_c t = \sqrt{2}\cos(\omega_c t - 45°)$
−1	1	$-\cos\omega_c t - \sin\omega_c t = \sqrt{2}\cos(\omega_c t + 135°)$
−1	−1	$-\cos\omega_c t + \sin\omega_c t = \sqrt{2}\cos(\omega_c t - 135°)$

5. A binary data stream 0010010011 needs to be transmitted using DPSK technique. Prove that the reconstruction of the DPSK signal is independent of the choice of the extra bit. **[WBUT 2015]**

Answer:

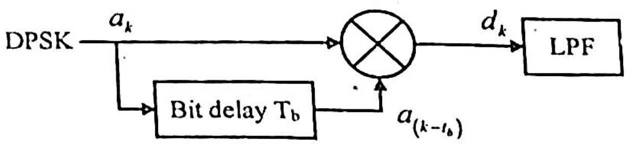
Here binary data stream 0010010011 needs to be transmitted



d_k	0	0	1	0	0	1	0	0	1	1
$b_{(k-t_b)}$	0 ↑ (initial)	0	0	1	1	1	0	0	0	1
$b_{(k)}$	0	0	1	1	1	0	0	0	1	0

b_k data bit will be transmitted.

On the receiving end, the decoder is again multiplied with the input of DPSK and the signal delayed by 1 bit.



a_k	0	0	1	1	1	0	0	0	1	0
$a_{(k-t_b)}$	0	0	0	1	1	1	0	0	0	1
d_k	0	0	1	0	0	1	0	0	1	1

After reconstruction we observe that receiving bit is same as input bit and which is independent of extra bit.

6. a) Draw and explain the practical system of an 8-channel TDM-PAM telemetering transmitter and also draw the pulse waveforms at the outputs of the clock generator, counter, multivibrator and gates for one time-frame. [WBUT 2017]

Answer:

Refer to Question No. 3(b) of Long Answer Type Questions.

b) What do you mean by synchronization in TDM? [WBUT 2017]

Answer:

Refer to Question No. 1(c) (1st part) of Long Answer Type Questions.

7. a) Draw and explain the block diagram of BPSK transmitter and receiver. [WBUT 2017]

Answer:

In binary phase shift keying (BPSK), binary symbol '1' and '0' modulate the phase of the carrier. Let, the carrier be

$$s(t) = A\cos(2\pi f_0 t)$$

'A^' represents peak value of sinusoidal carrier. In the standard 1ohm load register, the power dissipated will be, $P = \frac{1}{2}A_2$

$$A = \sqrt{2}P$$

When the symbol is changed, then the phase of the carrier is changed by 180 degrees (π radians)

Consider for example,
Symbol '1'

$$s_1(t) = \sqrt{2P}\cos(2\pi f_0 t)$$

If the next symbol is'0' then,
Symbol '0'

$$s_2(t) = \sqrt{2P}\cos(2\pi f_0 t + \pi)$$

Since $\cos(\theta + \pi) = -\cos\theta$

The above equation may be written as,

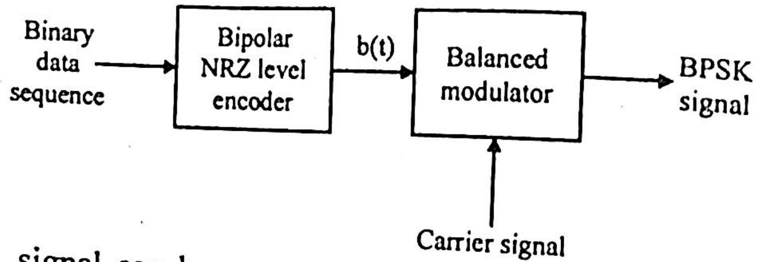
$$s_2(t) = -\sqrt{2P}\cos(2\pi f_0 t)$$

With the above equation we can define BPSK signal combinely as,

$$s(t) = b(t)\sqrt{2P}\cos(2\pi f_0 t)$$

Here, $b(t) = +1$ when binary '1' is to be transmitted.
$= -1$ when binary '0' is to be transmitted.

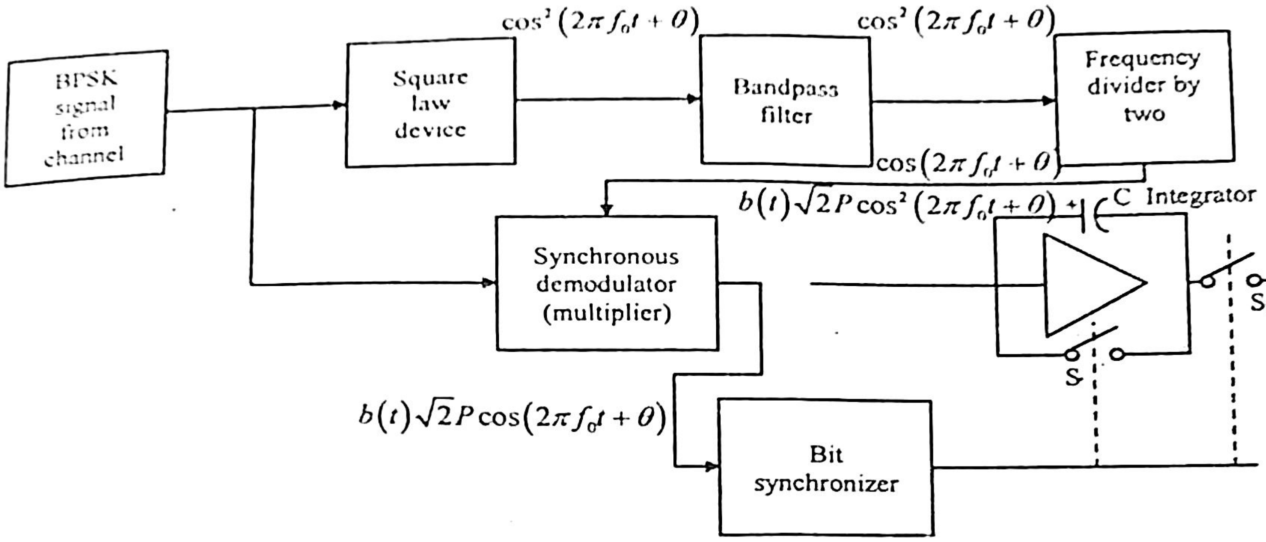
Generator of BPSK Signal



- The BPSK signal can be generated by applying carrier signal to the balanced modulator.
- The baseband signal $b(t)$ is applied as a modulating signal to the balanced .The block diagram of BPSK signal generator is shown
- The NRZ level encoder converts the binary data sequence into bipolar NRZ signal.
- Reception of BPSK signal

The block diagram shows scheme to recover baseband signal from BPSK signal. The transmitted BPSK signal is,

$$s(t) = b(t)\sqrt{2P}\cos(2\pi f_0 t)$$



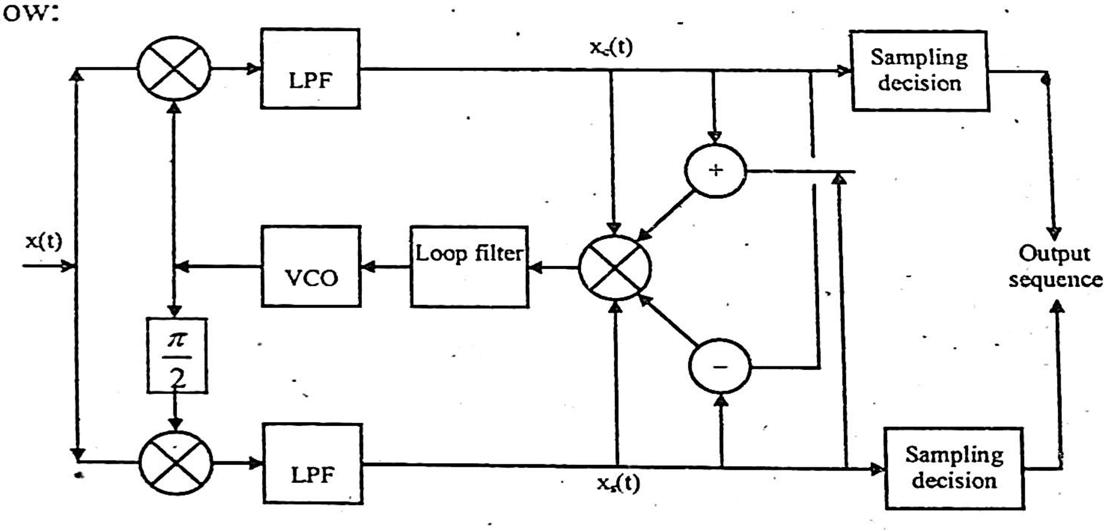
Operation of the receiver

Phase shift in received signal:
This signal undergoes the phase change depending upon the time delay from the transmitter to receiver. This phase change is normally fixed phase shift in the transmitted signal .Let the phase shift be θ. Therefore the signal at the input of the receiver is,

$$s(t) = b(t)\sqrt{2P}\cos(2\pi f_0 t + \theta)$$

b) How carrier is recovered in QPSK system? **[WBUT 2017]**

Answer:
For a signal containing a dominant carrier spectral line, carrier recovery can be accomplished with a simple BPF at f_c or a PLL. However, in many modulation schemes, most signal (where the information is present and not the carrier) power is devoted to modulation, reducing the carrier power results in greater transmitter efficiency. One of the methods employed to recover the carrier is QPSK cost as loop whose arrangement is shown below:



In this scheme, carrier is recovered through a combination of a phase locked loop, a remodulator and demodulator. Basic operation is the multiplication of the input signal by its demodulated baseband to retrieve the carrier.

8. a) Describe a TDM-PAM system with actual hardware circuit diagram.
b) Why synchronization is necessary in such system and how is it done. [WBUT 2018]

Answer: *Refer to Question No. 6(a) & (b) of Long Answer Type Questions.*

9. Write short notes on the following: [WBUT 2009, 2011, 2013]
a) MODEM protocols [WBUT 2018]
OR,
Modem [WBUT 2009, 2010]
b) Comparison between TDM and FDM [WBUT 2009, 2013, 2015]
c) DPCM [WBUT 2013, 2017, 2018]
d) Quadrature Amplitude Modulation (QAM) [WBUT 2013, 2016]
e) Quadrature Pulse Shift Keying (QPSK) [WBUT 2014]
f) FSK [WBUT 2015]
g) Frequency Division Multiplexing [WBUT 2017]
h) DPSK

Answer:

a) MODEM protocols:

A binary coded signal when desired to be transmitted through a link, say, a telephone network, it would not pass as the circuitry involved basically is for ac application and dc signal, i.e. pulses would not get through these. Also, high speed binary data would, most likely, be filtered out of the system that has a finite small bandwidth. For this reason, binary data are converted into so-called analogue signals by modulation which, when received, are demodulated and reconstructed into binary data. When the telemetry system uses the telephone channel, a device called a MODEM is often used for the purpose. This does the dual job of data Modulation for transmission as also Demodulation of the received data over the telephone link. The binary dc pulses actually modulate a sine wave carrier that is compatible with the tele-link.

As the computers, mainframes or personal, have digital outputs, transmission and reception between two such computers may be made through two modems and the link as shown in Figure.

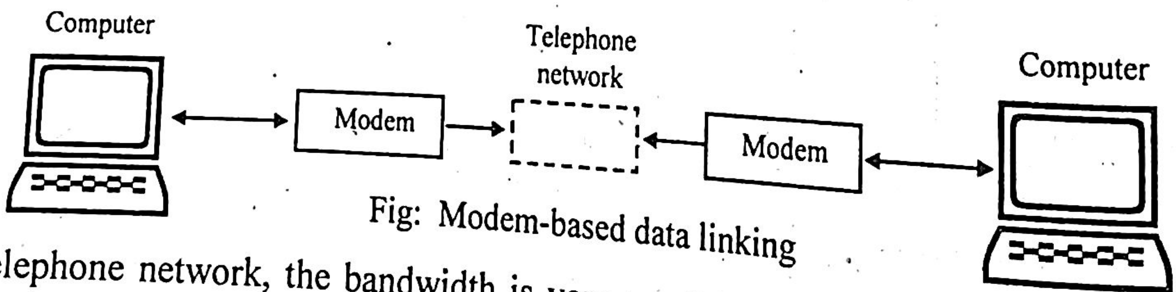


Fig: Modem-based data linking

For telephone network, the bandwidth is very much limited – only up to about 3 kHz. The major techniques used in modems are (i) Frequency shift keying (FSK), (ii) Phase shift keying (PSK) and (iii) Quadrature amplitude modulation (QAM) for transmitting data at a high rate, of about 15 kbps in spite of small carrier bandwidths.

b) Comparison between TDM and FDM:

Refer to Question No. 3(a) of Long Answer Type Questions.

c) DPCM:

In a typical PCM system, there are successive samples taken in which there is little difference between the amplitudes of the two samples. In such a case several identical PCM codes are transmitted which are redundant. The figure below illustrates the redundant information in PCM system.

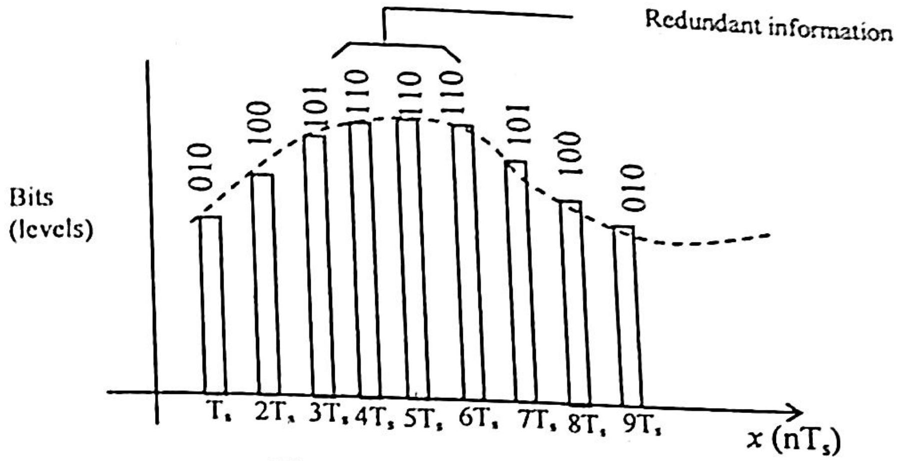


Fig: Redundant information

Here 3 bit (8 levels) PCM is used. The successive samples at $t = 4T_s$, $t = 5T_s$ and $t = 6T_s$ have the same value 110 and are redundant. If this redundancy is reduced, the overall bit rate will decrease and the number of bits required to transmit one sample will also be reduced. This type of digital pulse modulation scheme is known Differential Pulse Code Modulation (DPCM).

With DPCM, the difference in the amplitude of two successive samples is transmitted rather than the actual sample. Because the range of sample differences is typically less than the range of individual samples, fewer bits are required for DPCM than conventional PCM. For example, let at sample time k, the sample value = m(k). At sample time (k-1), the sample value = m(k-1). Instead of transmitting m(k) at time k we can transmit the change m(k) – m(k-1) at time k. It is obvious that m(k) – m(k-1) will be smaller than the sample value m(k) or m(k-1). Let us suppose $(V_H - V_L)$ is such that 8 bits are required to have $2^8 = 256$ levels. But the difference m(k) – m(k-1) may extend over only $\pm 2\Delta$ (i.e., Δ, $-\Delta$, 2Δ and -2Δ) so that only four levels are there which will require only 2 bits.

DPCM Transmitter

DPCM works on the principle of prediction, which states that the value of the present sample can be predicted from the past samples. The diagram below shows a DPCM transmitter using predictor.

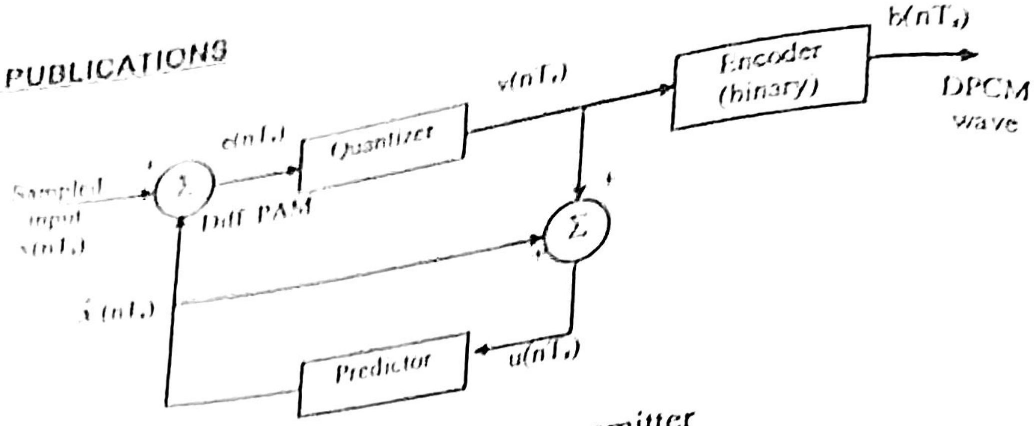


Fig: A DPCM Transmitter

Let a baseband signal x(t) is sampled at the rate $f_s = \frac{1}{T_s}$ to produce a correlated sequence denoted by x (n T_s) where n have integer values. The input to the quantizer is the output of the summer and is given by

$$e(nT_s) = x(nT_s) - \hat{x}(nT_s)$$

where $\hat{x}(nT_s)$ is the prediction output of $n(T_s)$ and

e(n T_s) is called a prediction error.

$v(nT_s) = e(nT_s) + q(nT_s)$ where $q(nT_s)$ is the Quantization error.

Also $u(nTs) = \hat{x}(nTs) + v(nTs) = \hat{x}(nT_s) + e(nT_s) + q(nT_s)$

But $\hat{x}(nT_s) + e(nT_s) = x(nT_s)$ and hence $u(nT_s) = x(nT_s) + q(nT_s)$

Thus u(nT_s) is nothing but the quantized version of x(nT_s). Also u(nT_s) is independent of the prediction filter characteristics.

DPCM Receiver

Figure below shows the block diagram of a DPCM receiver.

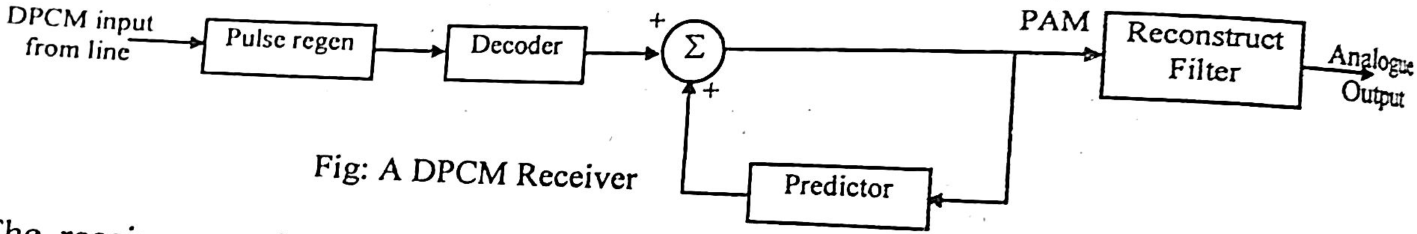


Fig: A DPCM Receiver

The receiver consists of a decoder to reconstruct the quantized error signal from the incoming DPCM signal. The quantized version of the original input is reconstructed from the decoder output using a predictor. The prediction filter output and quantized error signals are summed up in a summer circuit to give the quantized version of the original signal.

The prediction filter used in the DPCM transmitter and DPCM receiver can be realized by using a tapped-delay-line filter.

d) Quadrature Amplitude Modulation (QAM):

Quadrature amplitude modulation (QAM) combines both phase and amplitude modulation. If the phase is modulated to have n distinct values and the amplitude is modulated to have m distinct values, then the system is nm-QAM system. It is the carrier that is so modulated with the input signal. A popular 8 QAM system has a QPSK system associated with two different carrier amplitudes. As there are 8 different states, $2^k = 8, k = 3$ bits can be encoded for each baud symbol to be transmitted. In addition to the carrier being phase shifted by 90° to be fed to the balanced modulator 2 for obtaining four-phase conditions, two bit combination words are also first converted into four-level dc voltages, which come to the modulators as inputs. The scheme is shown in Fig.1. The converters used are usually D/A converters whose outputs are equally spaced voltage levels — the magnitudes in the four spaces are related to the different combinations of the two input bits. Obviously, the output levels must precisely be obtained for combining in the linear summer to produce the desired amplitude and phase. The QPSK diagram of Fig. 2 may be extended for the 8 QAM amplitude phasor diagram. This is known as constellation diagram and is shown in Fig. 2. The two amplitude levels are A and A' and the phases are as in Fig. 2.

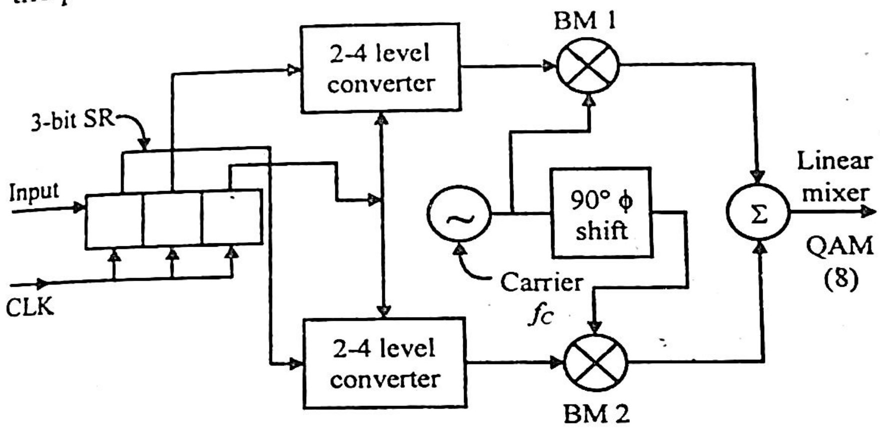


Fig: 1 QAM modulation scheme

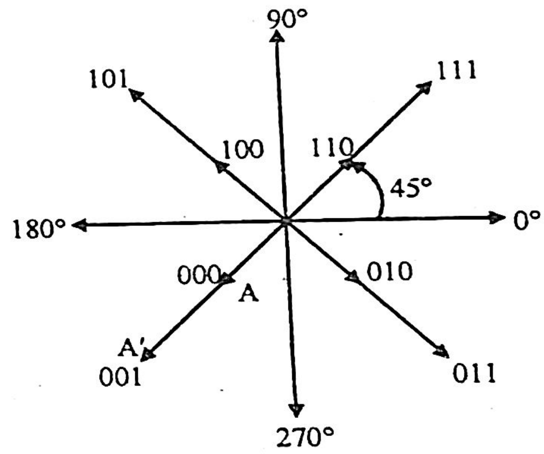


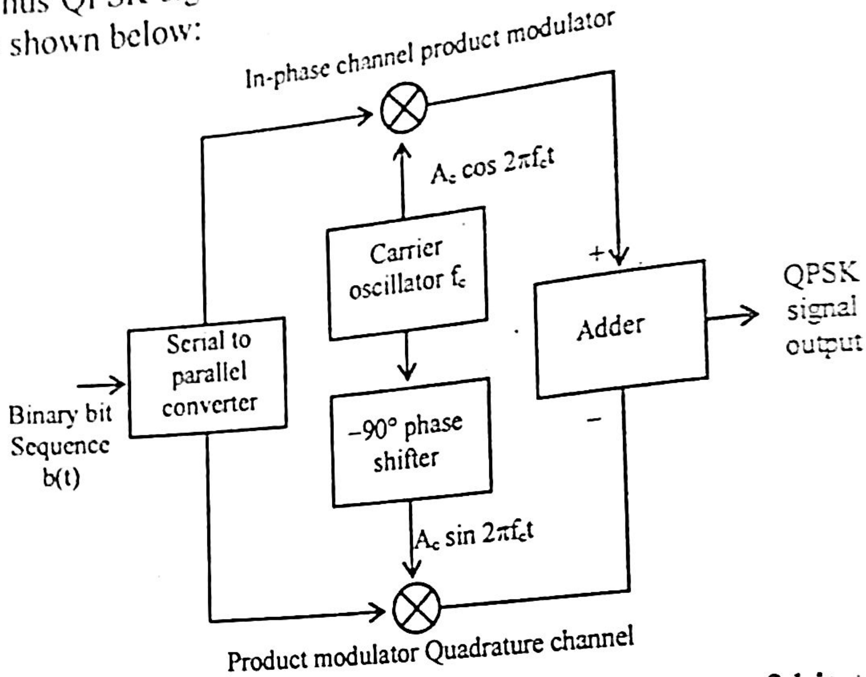
Fig: 2 The constellation diagram

Table 1 shows the amplitudes and phase shifts corresponding to the three-bit information.

Table 1 QAM amplitudes and phase-shifts

3-bit word	Amplitude	Phase (°)
000	A	225
001	A'	225
010	A	315
011	A'	315
100	A	135
101	A'	135
110	A	45
111	A'	45

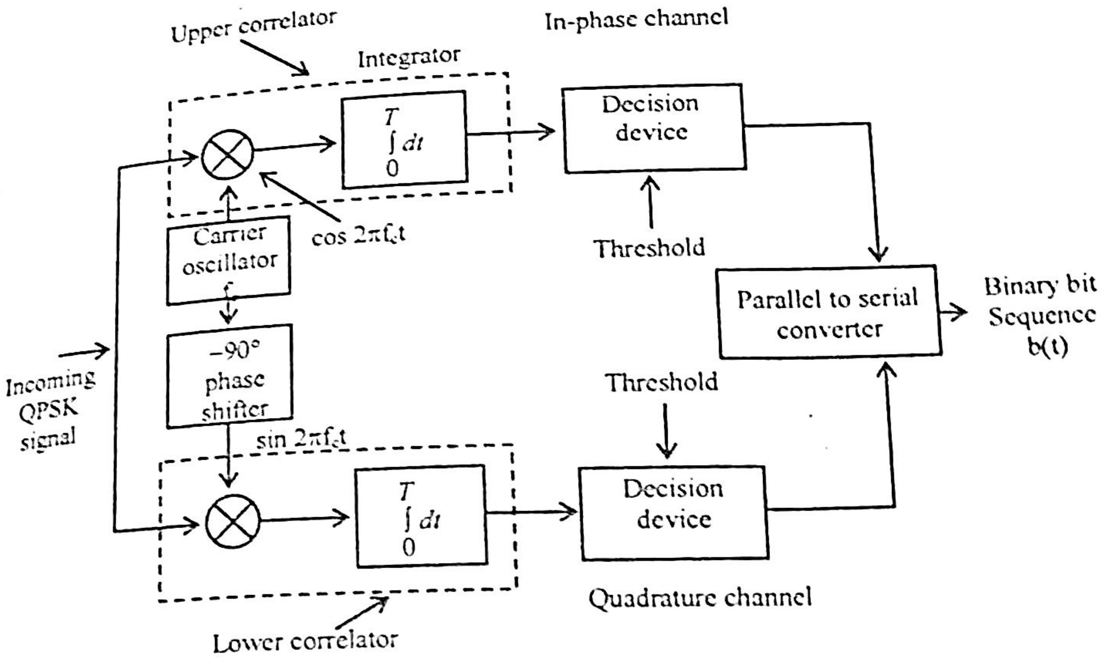
c) Generation of QPSK Signals:
QPSK signals can be expressed as
$s(t) = A_c\cos\phi\, 2\pi f_c t - A_c \sin\phi(t) \sin 2\pi f_c t$
where $A_c\cos\phi\ (t)$ forms the in-phase component and $A_c\sin\phi(t)$ forms the quadrature component. Thus QPSK signals can be generated based on the in-phase and quadrature components as shown below:



The serial to parallel converter converts each successive pair of bits of the incoming binary bit sequence as two separate bits with one bit applied to the in-phase channel and the other bit applied to the quadrature channel. The output of the serial to parallel converter in the in-phase channel is applied to one product modulator along with the in-phase carrier $A_c \cos 2\pi f_c t$. The output of the serial to parallel converter in the quadrature channel is applied to the other product modulator along with a quadrature carrier signal $A_c \sin 2\pi f_c t$ produced by a −90° phase shifter. The outputs of the two product modulation are added in a summer circuit to obtain the QPSK signal.

As signaling interval $T = 2T_b$ where T_b is the bit duration, for a given bit rate $f_b = \dfrac{1}{T_b}$, a QPSK system requires half the transmission bandwidth of corresponding BPSK system. QPSK is also called quaternary phase shift keying, the term 'quaternary' meaning 4.

Detection of QPSK Signals
Coherent detection of QPSK signal is shown in the block diagram below.



The detection scheme uses a pair of correlators connected in parallel. The cosine of the carrier phase is computed by the upper correlator and the sine of the carrier phase is computed by the lower correlator. The two decision devices compare the sign of the two correlator outputs. This enables unique resolution of the four transmitted phase angles. Interleaving of the decisions made by the two decision devices in the in-phase and quadrature channels is made by the parallel to serial converter which results in the reconstruction of the binary data stream.

f) FSK:

In Frequency Shift Keying (FSK), we have two sinusoidal carrier waves of same amplitude A_c but different frequencies f_1 and f_2 are used to represent binary symbols 1 and 0 respectively.

In Frequency Shift Keying, two specific sinewave frequencies represent a '0' bit and a '1' bit as has been specified already. Over the bandwidth, such a choice leaves the entire frequency band unutilized for data transmission. This two frequency scheme is the simplex scheme. A '1' is the mark and '0' is the space and the corresponding frequencies are f_1 and f_0, respectively, as shown in Fig. 1. The telephone network has a bandwidth of 0.3 to 3 kHz and a frequency couplet within this bandwidth is chosen. In the USA a typical choice is 1.07 kHz for '0' and 1.27 kHz for '1'. Since this leaves a large part of the bandwidth unused, a duplex, often referred to as full duplex. Operation is resorted to transmit and receive data at another set of frequencies within the bandwidth. These frequencies for binary space or '0' and for mark or '1' are f_0' (say) and f_1', respectively. In a bandwidth of 0.3 to 3 kHz, these values are 2.025 kHz and 2.225 kHz, respectively, with the frequency differences,

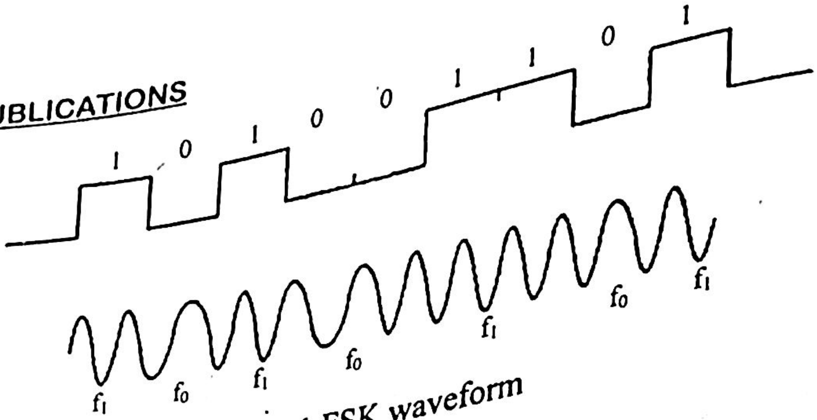


Fig: 1 FSK waveform

$f_0' - f_0 = f_1' - f_1 = 0.955$ kHz,

and $\quad f_0' - f_1 = 0.755$ kHz

The wide difference in frequency between the two set pairs has to be maintained so that selective filters can be used. In fact, the set $f_0 - f_1$ is used for transmission purpose while $f_0' - f_1'$ set is for reception. Since modern is both a transmitter and receiver, on both sides of the telephone network duplex type can be used.

g) Frequency Division Multiplexing:

The telemetry systems can, in general be classified into two broad types: (i) the frequency division multiplexed type (FDM), and (ii) the time division multiplexed type (TDM). The frequency division multiplexed type comprises a number of data channels, each of which modulates a separate sub-carrier oscillator. FDM is more of an analogue type system and the conventional frequency modulation in association with other analogue modulation methods is used in transmission of information. The outputs from all the above sub-carrier oscillators are mixed/summed to form a composite signal, which modulates a high frequency carrier and the resultant wave is transmitted by an appropriate FM transmitter system through a radio link. At the receiving end, this wave is received by an FM receiver, which is, then FM demodulated and amplified. The amplified output is passed through the same number of channels as the transmitting side data channels consisting of band-pass filters of frequencies of the sub-carriers. Output of each such channel is further demodulated or detected to obtain analogue output that has originally been transmitted. This is then stored or displayed or monitored as necessary.

Such a system is often known as FM/FM system. A scheme of the transmitting side is shown in Fig. 1(a) and that of the receiving side in Fig. 1(b).

Frequency division actually means separation of individual carrier channels in the frequency domain. These separate carriers are termed as sub-carrier frequencies, which, in turn, modulate a higher carrier frequency in the RF range. The sub-carriers can be modulated in amplitude, single side band (SSB), phase or frequency for transmission of information. In telephone systems, usually SSB modulation is used, whereas for telemetry frequency modulation is most common, mainly because of better dc response and low-cost equipment needed for the purpose.

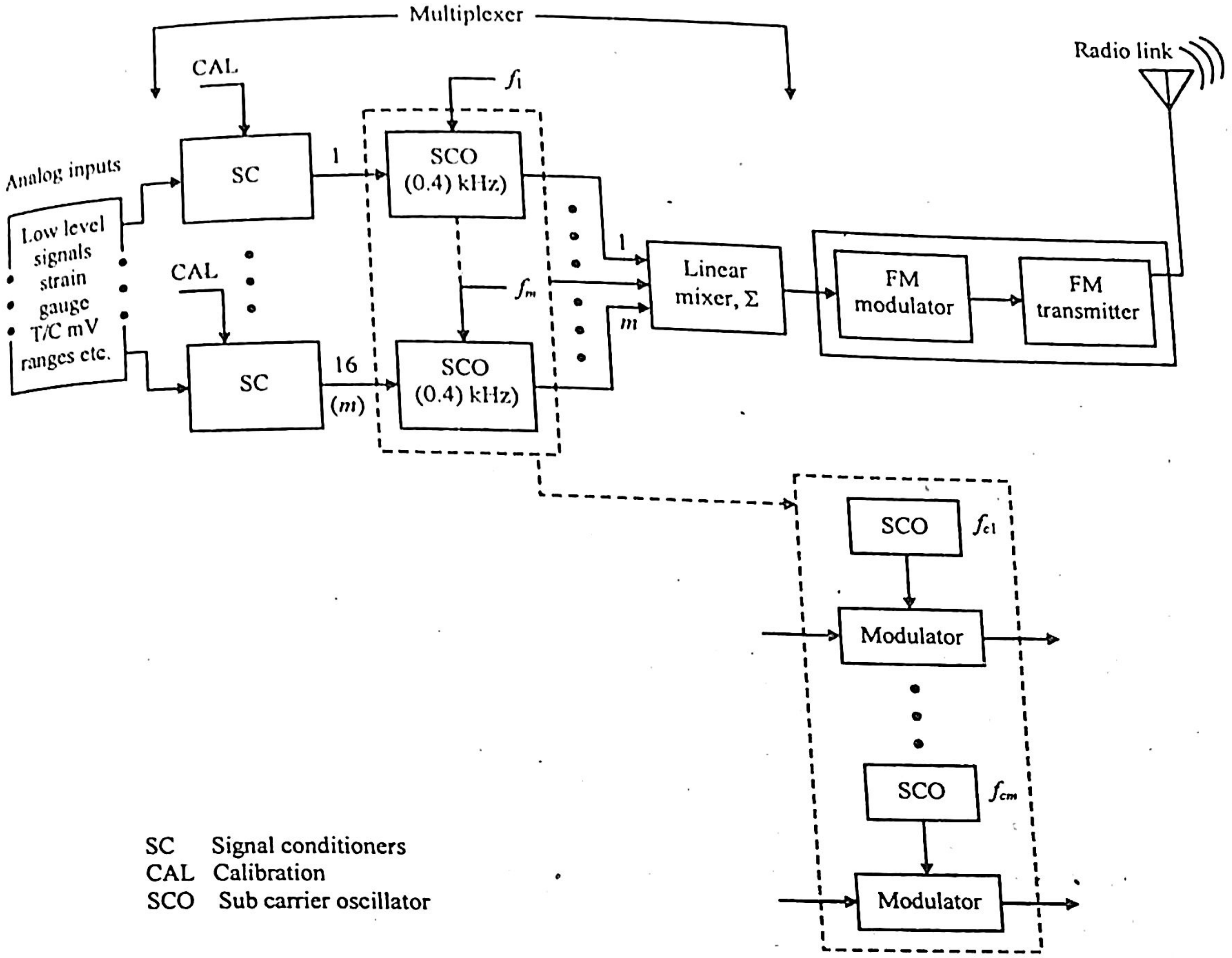


Fig: 1(a) Scheme of the transmitting side of FDM system

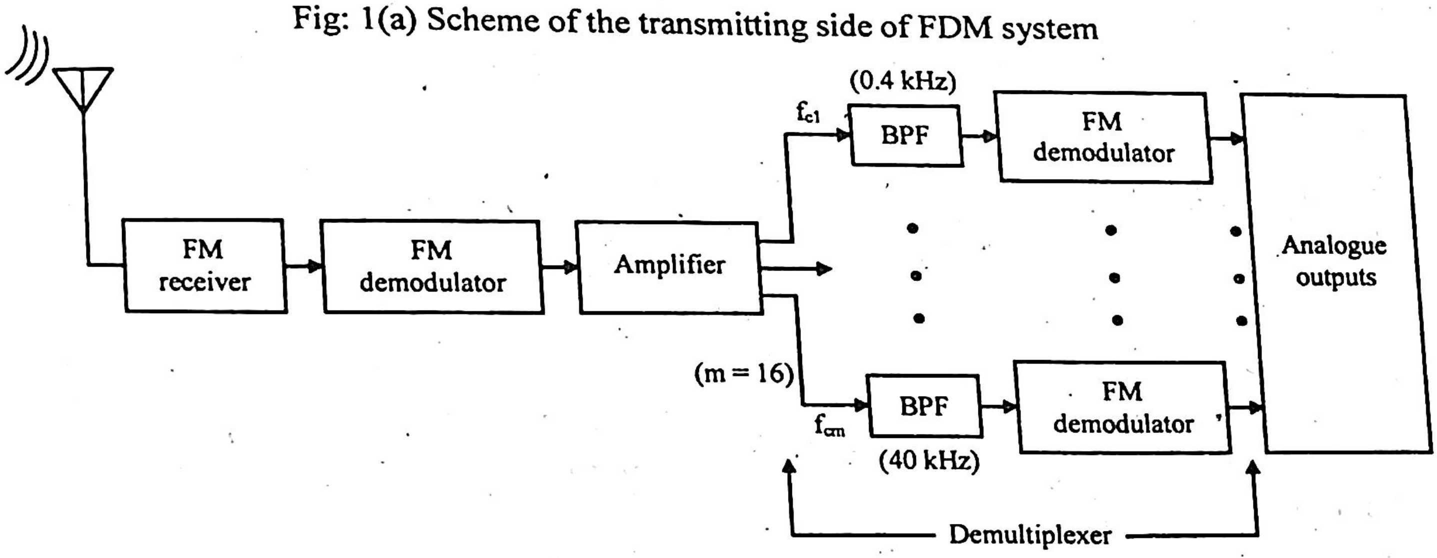


Fig: 1(b) Scheme of the receiving side of FDM system

h) DPSK:

Refer to Question No. 4 of Short Answer Type Questions.