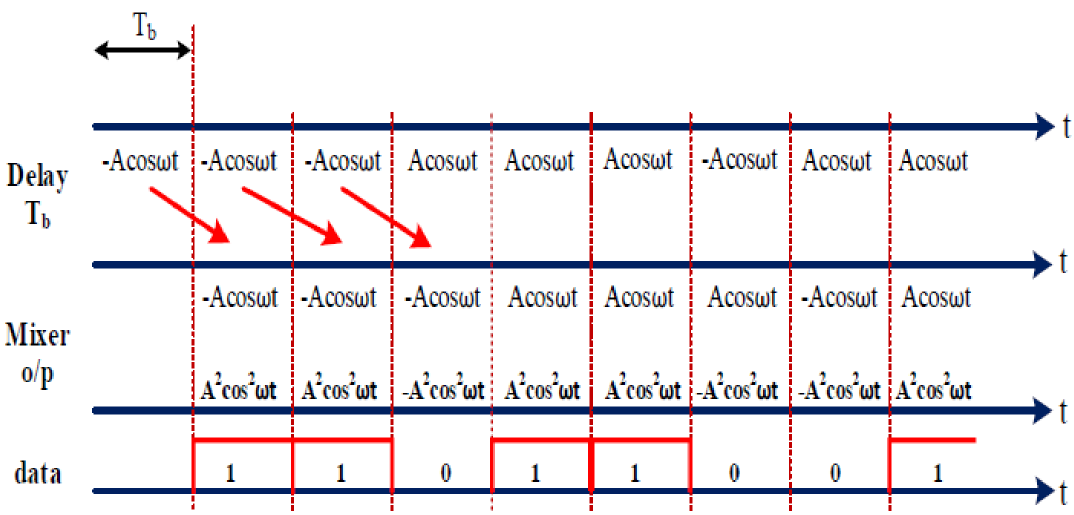
The extra requirement for DPSK noncoherent detection is the analogue delay line of T_b. The DPSK is delayed by T_b and then multiplied with itself, LPF then a threshold Comparator.

Ex 6-15:

With the help of data of previous example, explain the operation of DPSK detector.

Solution:

$-A\cos\omega t$ & $+A\cos\omega t$ will be used for 180º& 0º phase shift then;



H.W:

Repeat encoder and decoder operations when x(0)=0, and comment to the results.

Advantages of DPSK:

1- Noncoherent detection (no carrier generation)
2- No phase ambiguity (possible data complement) since the decoded data is independent of random initial choice of the state of D-FF (x(0)).

Disadvantages of DPSK:

The only disadvantage is the need of analogue delay line by T_b time. This is usually implemented using charge coupled devices (CCD) as analogue delay line.

Multilevel keying Technique (M-ary Signalling):

These are usually used for bandwidth economical systems (such as telephone channels) to increase data rate transmission over bandlimited channels.

Concept:

The concept of M-ary signaling in to group binary bits and deal with them as symbols. Hence, M is taken as $\mathbf{2^r}$ (2,4,8,16,…). For example M=4 means r=2.

data 1 0 0 1 1 1 0 0 0 1 1 1 1 0

grouping of 2-bits (r=2, M=4) i.e. 4 level

Then each successive 2-bits has grouped and considered as symbol. Hence, these will be four possible signals $\emptyset_o(t),\ \emptyset_1(t),\ \emptyset_2(t)\ and\ \emptyset_3(t)$for the possible groups of “00”, “01”,“10” and“11”. And so on for M=8, r=3, …

In general:

$$r = \log_2 M$$ bits/symbol ... (6-30)

$$M = 2^r$$ no. of channel states ... (6-31)

$$T_s = \frac{1}{R_s} = (\log_2 M).T_b$$ symbol duration ... (6-32)

$$R_s = \frac{R_b}{\log_2 M}$$ symbol rate (baud rate) ... (6-33)

M-ary ASK (MASK):

M carrier level are used for M=4 then:

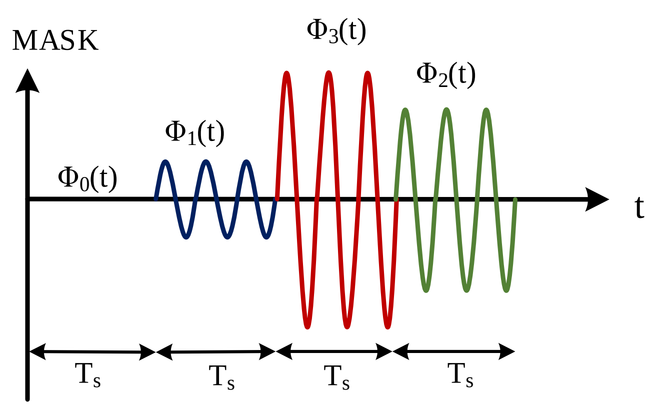
$$\begin{rcases} \emptyset_0(t) = 0 \\ \emptyset_1(t) = A\cos\omega_c t \\ \emptyset_2(t) = 2A\cos\omega_c t \\ \emptyset_3(t) = 3A\cos\omega_c t \end{rcases} \quad \ldots (6\text{-}34)$$

For data

0 0 0 1 1 1 1 0

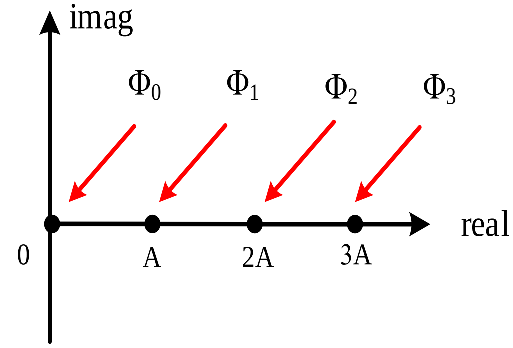
$\emptyset_0$ $\emptyset_1$ $\emptyset_3$ $\emptyset_2$

Then transmitted waveforms will be: $\emptyset_0(t)$, $\emptyset_1(t)$, $\emptyset_3(t)$, $\emptyset_2(t)$ with symbol duration **$T_s=2T_b$**



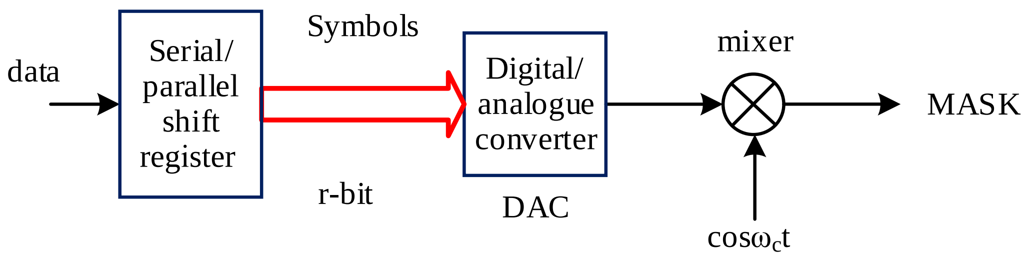
Signal State Diagram

This is a representation of carrier signals in complex plane (x-axis ≡ real part ≡ cos $\omega_c t$) & (y-axis ≡ imaginary part ≡ sin $\omega_c t$) of $e^{j\omega ct}$.

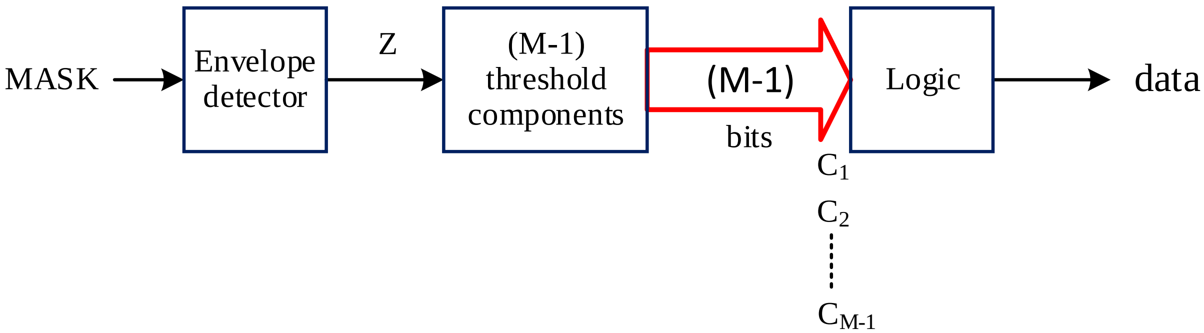


To draw the signal state diagram of 4 level MASK then on the real axis $\emptyset_0, \emptyset_1, \emptyset_2 \& \emptyset_3$ will be found since modulation is done in amplitude of the inphase component (cos $\omega_c t$) of the carrier.

Simple MASK modulator:



Simple MASK demodulator (noncoherent):



For M=4 then 3 comparator with $V_{th} = \left(\frac{A}{2}\right), \left(\frac{3A}{2}\right)$ & $\left(\frac{5A}{2}\right)$ are used and logic truth table will be:

C_1	C_2	C_3	data
0	0	0	00
1	0	0	01
1	1	0	10
1	1	1	11

C_1, C_2, C_3 are comparators outputs.

If envelope detector $Z < \frac{A}{2}$ then $C_1=C_2=C_3=0$ and $\emptyset_0(t)$ is detected. If $\frac{3A}{2} > Z > \frac{A}{2}$ then $C_1=1$, $C_2=C_3=0$ and $\emptyset_1(t)$ is detected and so on.

Application of MASK:

MASK has little application on telephone or space channels (sensitive to amplitude variation).

Multilevel PSK (MPSK):

(a) 4- Level PSK≡ QPSK≡ Quadrature PSK:

Here M=4, r=2 with constant carrier amplitude and frequency.

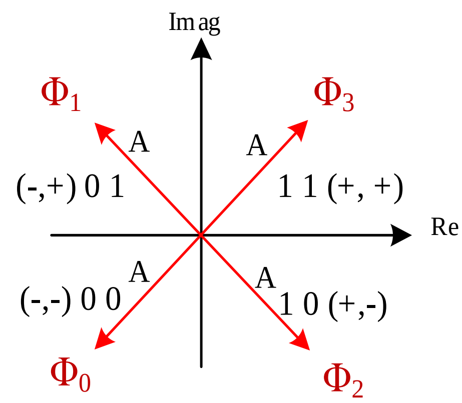
Data 0 0 0 1 1 0 1 1 $\qquad \emptyset_0(t),\ \emptyset_1(t),\ \emptyset_3(t)\ and\ \ \emptyset_2(t)\ldots,$

$\emptyset_0 \quad \emptyset_1 \quad \emptyset_2 \quad \emptyset_3$ $\qquad$ are assignments with four phases

$$\left(\frac{\pi}{4}, \quad \frac{3\pi}{4} \quad , \frac{5\pi}{4} \quad , \frac{7\pi}{4}\right)$$

$$\emptyset_3 \quad \emptyset_1 \quad \emptyset_0 \quad \emptyset_2$$

Note that the gray coding is used (symbols used at adjacent phases differ by one bit). Hence:



QPSK o/p=$\pm A\cos\omega_c t \pm A\sin\omega_c t$

i.e QPSK is the sum of two carriers in the phase Quadrature, i.e:

$$\left.\begin{aligned} \phi_3(t) &= A\cos\omega_c t + A\sin\omega_c t \\ \phi_1(t) &= -A\cos\omega_c t + A\sin\omega_c t \\ \phi_0(t) &= -A\cos\omega_c t - A\sin\omega_c t \\ \phi_2(t) &= A\cos\omega_c t - A\sin\omega_c t \end{aligned}\right\} \quad \ldots (6\text{-}35)$$

$$R_s = \frac{R_b}{2} \qquad T_s = 2T_b \qquad \ldots (6\text{-}36)$$