Lecture Eight

Objective of Lecture:

- **Quadrature Phase Shift Keying (QPSK),**
- **Offset QPSK,**
- **Minimum Shift Keying**

1- Quadrature Phase Shift Keying (QPSK):

There are two important points in communication system, transmission power and channel bandwidth. The channel bandwidth depends upon the bit rate or signaling rate f_b. The carrier is used as bandpass transmission over a channel. If two or more bits are combined in some symbol instead of one bit, then the signaling rate is reduced and the transmission channel bandwidth is reduced. In quadrature shift keying, two successive bits in the data sequence are grouped together.

In BPSK the phase shift occurs in two level only, the carrier is change by 180^0. In QPSK the combination of two bits form four distinct symbols, so that the change of carrier phase is 45^0 ($\frac{\pi}{4} radians$) from one symbol to the next one.

Table 1: Symbol and corresponding phase shift in QPSK

Sr. No.	Input successive bits		Symbol	Phase shift in carrier
$i = 1$	$1(1V)$	$0(-1V)$	S_1	$\pi/4$
$i = 2$	$0(-1V)$	$0(-1V)$	S_2	$3\pi/4$
$i = 3$	$0(-1V)$	$1(1V)$	S_3	$5\pi/4$
$i = 4$	$1(1V)$	$1(1V)$	S_4	$7\pi/4$

5-1 QPSK generator:

There are two type of QPSK:

5-1-1 Offset QPSK (OQPSK):

Fig. 17 shows the block diagram of OQPSK generator. The input signal is converted to NRZ and called b(t), the demultiplexer divides b(t) into separated bit streams of odd numbered and even numbered.

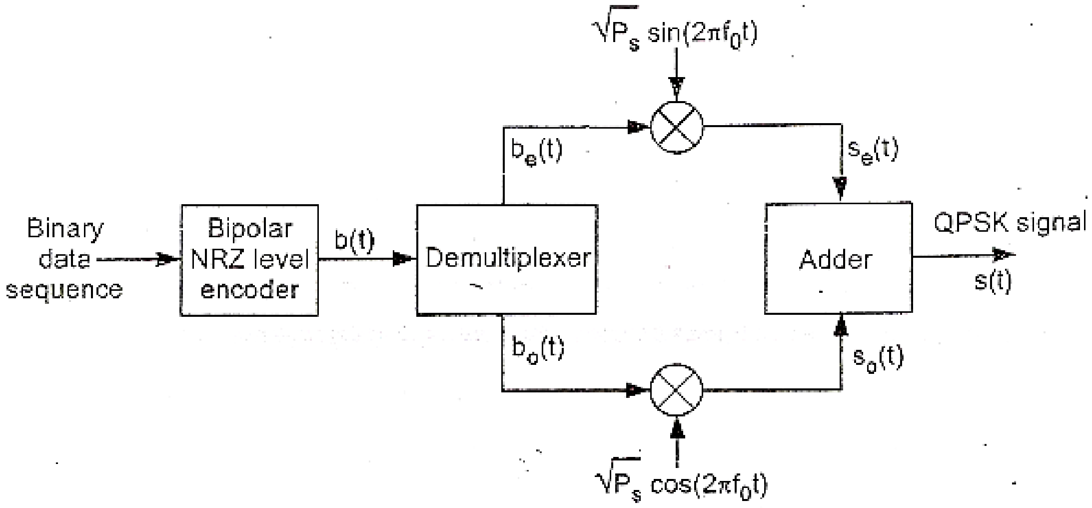
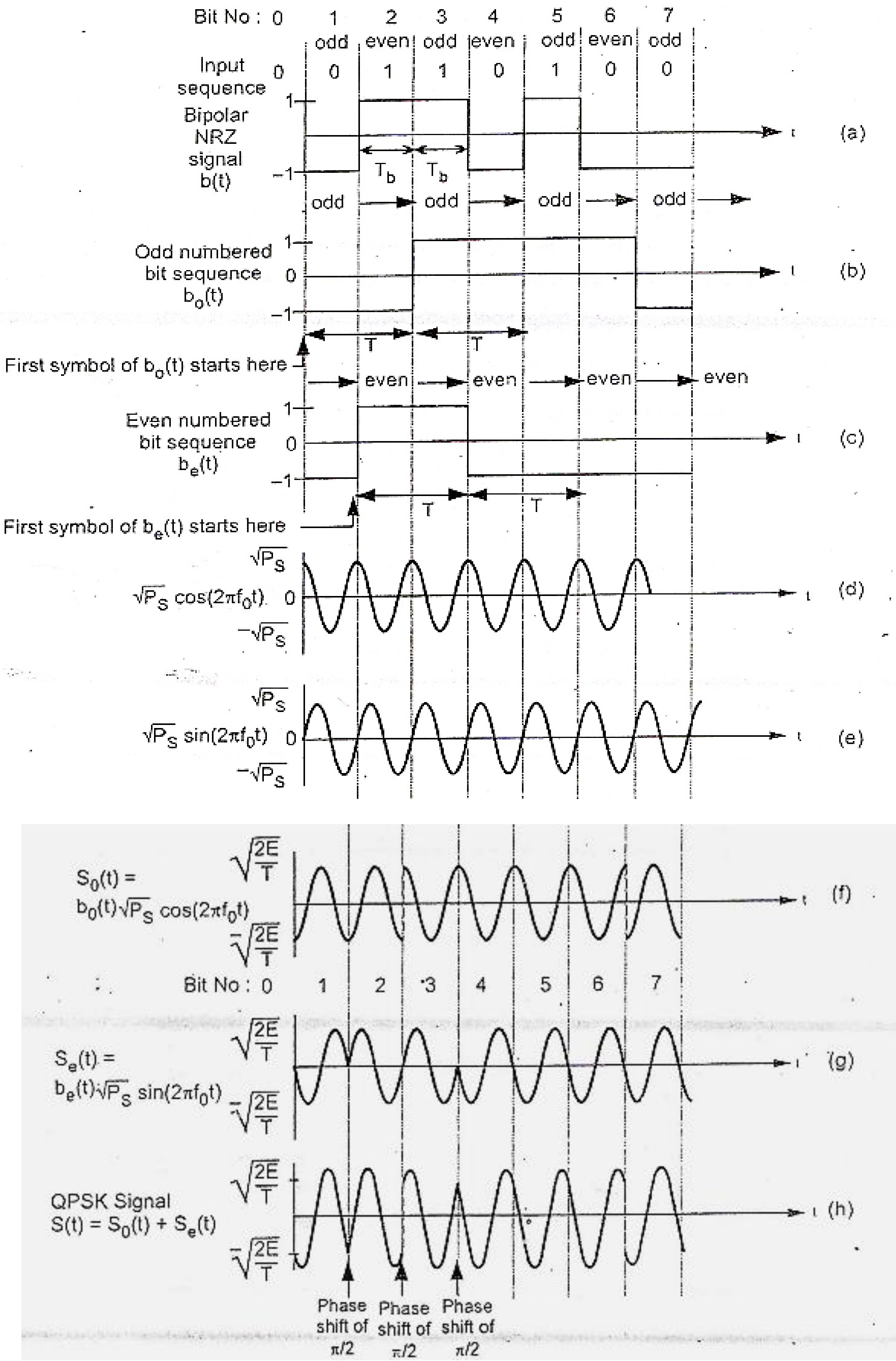


Figure 17: OQPSK generator

The symbol duration of both $b_o(t)$and $b_e(t)$ are $2T_b$ as shown in Fig. 18. Note that the first symbol of $b_o(t)$ is delayed by one bit period with respect to symbol of $b_e(t)$. This delay of $T_b$is called offset so that the change in level cannot occur in the same time. Each $b_e(t)$ and $b_0(t)$ are modulate a carrier $\sqrt{2p_s}\sin(2\pi f_0 t)$ and $\sqrt{2p_s}\cos(2\pi f_0 t)$ respectivlly.


Bit No : 0 1 2 3 4 5 6 7
odd even odd even odd even odd
Input sequence 0 0 1 1 0 1 0 0
Bipolar NRZ signal b(t)
T_b T_b
(a)
odd odd odd odd
Odd numbered bit sequence $b_o(t)$
(b)
T T
First symbol of $b_o(t)$ starts here
even even even even
Even numbered bit sequence $b_e(t)$
(c)
T T
First symbol of $b_e(t)$ starts here
$\sqrt{P_S}$
$\sqrt{P_S}\cos(2\pi f_0 t)$
$-\sqrt{P_S}$
(d)
$\sqrt{P_S}\sin(2\pi f_0 t)$
(e)
$S_o(t) = b_o(t)\sqrt{P_S}\cos(2\pi f_0 t)$
$\sqrt{\frac{2E}{T}}$
$-\sqrt{\frac{2E}{T}}$
(f)
Bit No : 0 1 2 3 4 5 6 7
$S_e(t) = b_e(t)\sqrt{P_S}\sin(2\pi f_0 t)$
(g)
QPSK Signal
$S(t) = S_o(t) + S_e(t)$
(h)
Phase shift of $\pi/2$
Phase shift of $\pi/2$
Phase shift of $\pi/2$

$$s_e(t) = b_e(t)\sqrt{2p_s}\sin(2\pi f_0 t)$$

$$s_0(t) = b_0(t)\sqrt{2p_s}\sin(2\pi f_0 t)$$

Thus $s_e(t)$and $s_0(t)$ are basically BPSK signals but $T = 2T_b$. The output of adder is OQPSK, given as:

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

$$= b_e(t)\sqrt{2p_s}\sin(2\pi f_0 t) + b_0(t)\sqrt{2p_s}\cos(2\pi f_0 t)$$

Fig.19 shows the phasor diagram of QPSK signal of above equation.

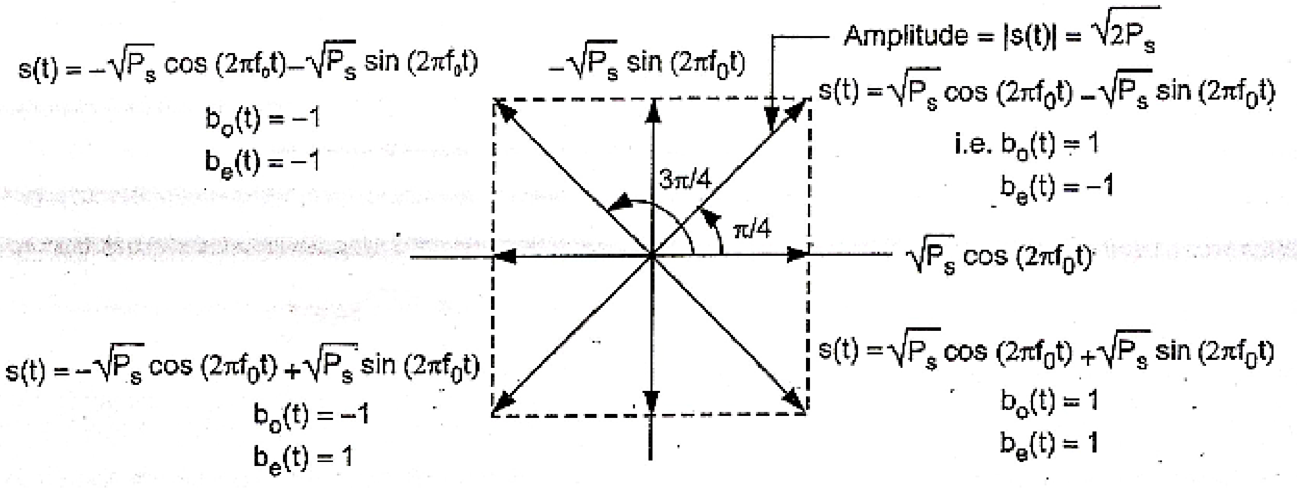
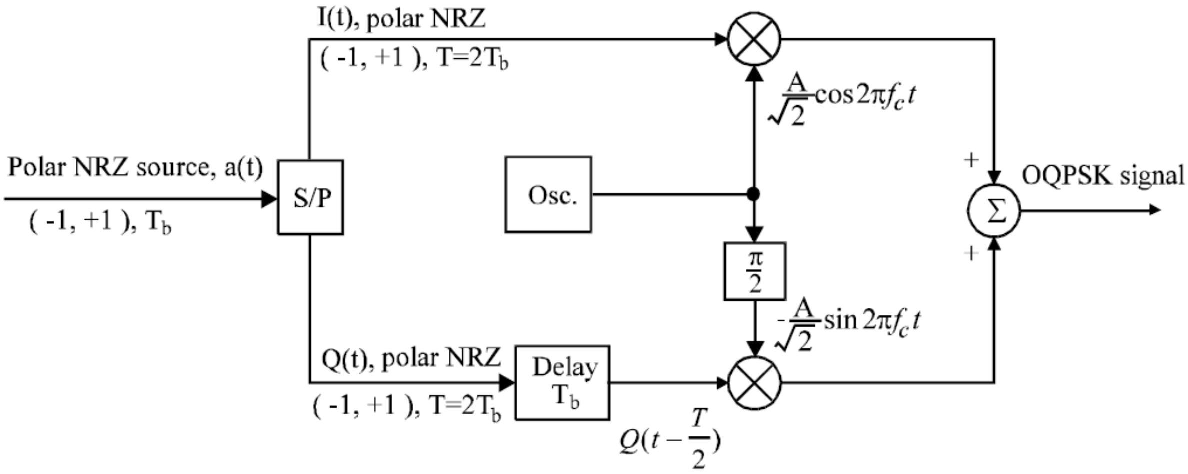
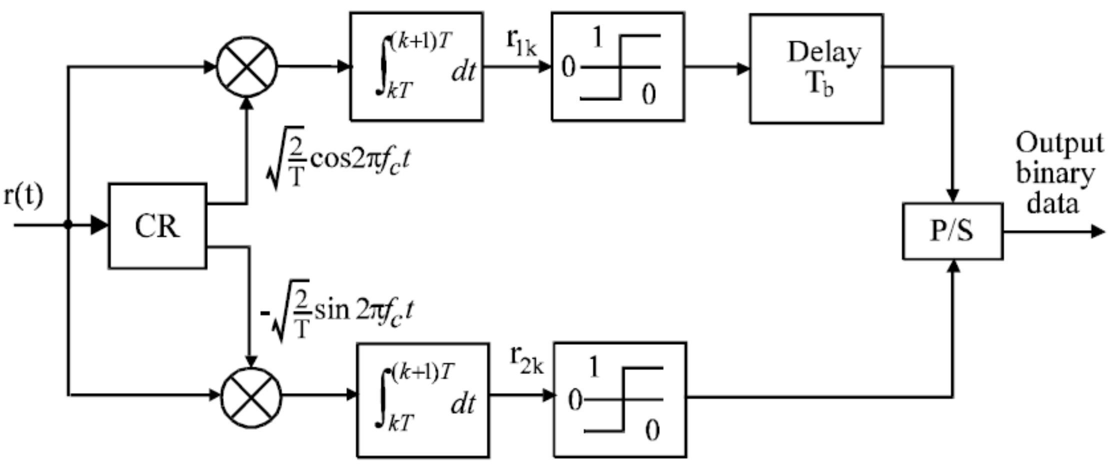


Figure 19: Phasor diagram of QPSK signal

Offset QPSK is essentially the same as QPSK except that the I- and Q-channel pulse trains are staggered. The modulator and the demodulator of OQPSK are shown in Figure 20, which differs from the QPSK only by an extra delay of T/2 seconds in the Q-channel. Its power spectral density is the same as that of QPSK, and its error performance is also the same as that of QPSK.



(a)



(b)

Fig. 20: OQPSK (a) modulator (b) demodulator