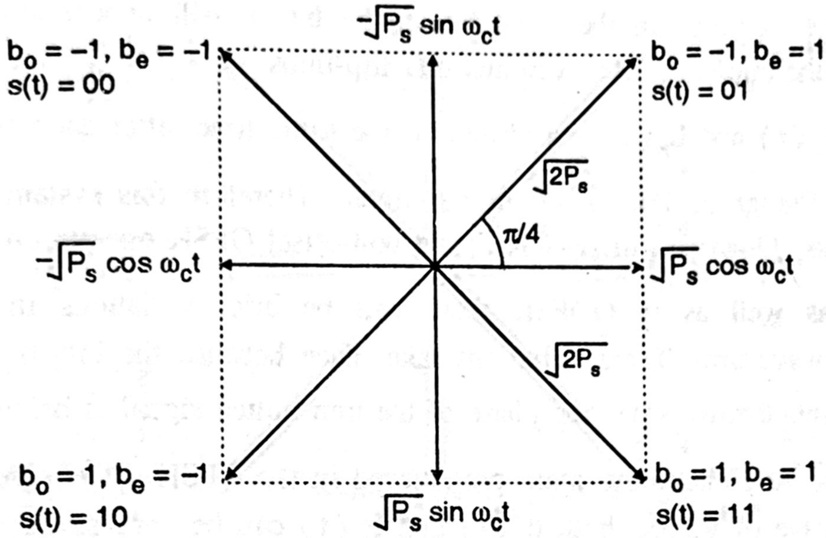

Fig. 6.11.6 : Phasor diagram

Symbol transmission rate :

In QPSK two bits are grouped together to form a symbol. Therefore when the symbols are transmitted, the signal changes occur at the symbol rate which is half the bit rate.

$\therefore$ The symbol time $T_s = 2\,T_b$ ...(6.11.2)

6.11.2 Non-offset QPSK :

The block diagram of non-offset QPSK transmitter is shown in Fig. 6.11.7.

- The transmitter of the non-offset QPSK is exactly same as that of the offset QPSK except for one change. The odd bit stream $b_o(t)$ has been delayed by one bit period T_b, by adding a delay block as shown in Fig. 6.11.7. The non-offset QPSK is simply called as QPSK.

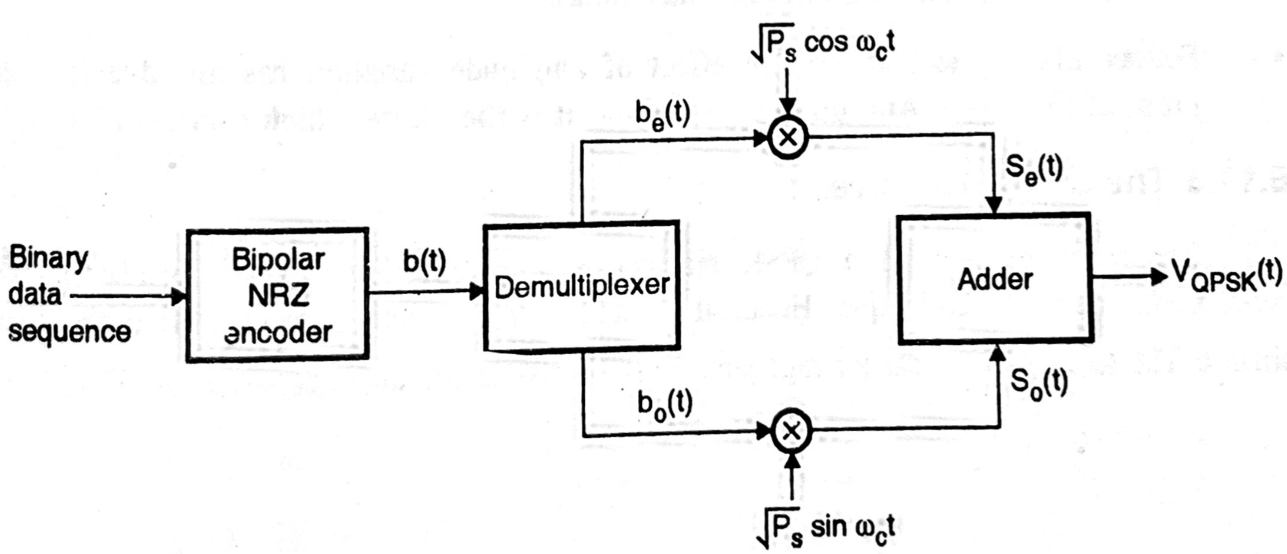

Fig. 6.11.7 : Block diagram of non-offset QPSK transmitter

- As a result of this additional time delay, we shall find that two bits which occur in time sequence (i.e. serially) in the input bit stream $b(t)$, will appear at the same time (i.e. in parallel) in the outputs of the even and odd flip-flops.

- Therefore $b_o(t)$ and $b_e(t)$ can change at the same time, after each time $2T_b$ and there can be a phase change of 180° in the output signal. Therefore this system is called as non-offset QPSK system. Otherwise offset QPSK and non-offset QPSK operate on the same principle.

- In QPSK as well as in OQPSK there will be brief variations in the amplitude of the transmitted waveform. These variations take place because the bits $b_o(t)$ and $b_e(t)$ cannot change instantaneously when the phase of the transmitted signal is being changed.

- These amplitude changes are more pronounced in the QPSK system than the OQPSK system, because in case of QPSK, both $b_o(t)$ and $b_e(t)$ can be zero simultaneously and the signal amplitude may be reduced to zero temporarily.

- The amplitude variations in the transmitted signal can be due to one more reason. In QPSK as in BPSK a filter is used to suppress the sidebands. When the waveforms which exhibit abrupt phase changes are filtered, the amplitude variations in the waveforms is observed at the instants of abrupt phase changes. Thus larger amplitude variations are observed for the QPSK signal as the phase shift involved is 180°.

- These amplitude variations can cause difficulties in QPSK communication systems which employ repeaters. The repeaters generally employ output power stages which operate nonlinearly.

- Due to this nonlinearity, the amplitude variations will result into generation of spectral components outside the range of the main lobe. This will wash away the effect of band limiting filter to cause interchannel interference.

- Further filtering to suppress the effect of amplitude variation has an adverse effect on the phase of the signal. **And do not forget that it is the phase which carries information.**

6.11.3 The QPSK Receiver :

The block diagram of a QPSK receiver is shown in Fig. 6.11.8. As shown, we use the synchronous detection technique. Hence it is necessary to locally generate the carriers $\cos \omega_c t$ and $\sin \omega_c t$. The technique for carrier regeneration is similar to the one employed for BPSK system.

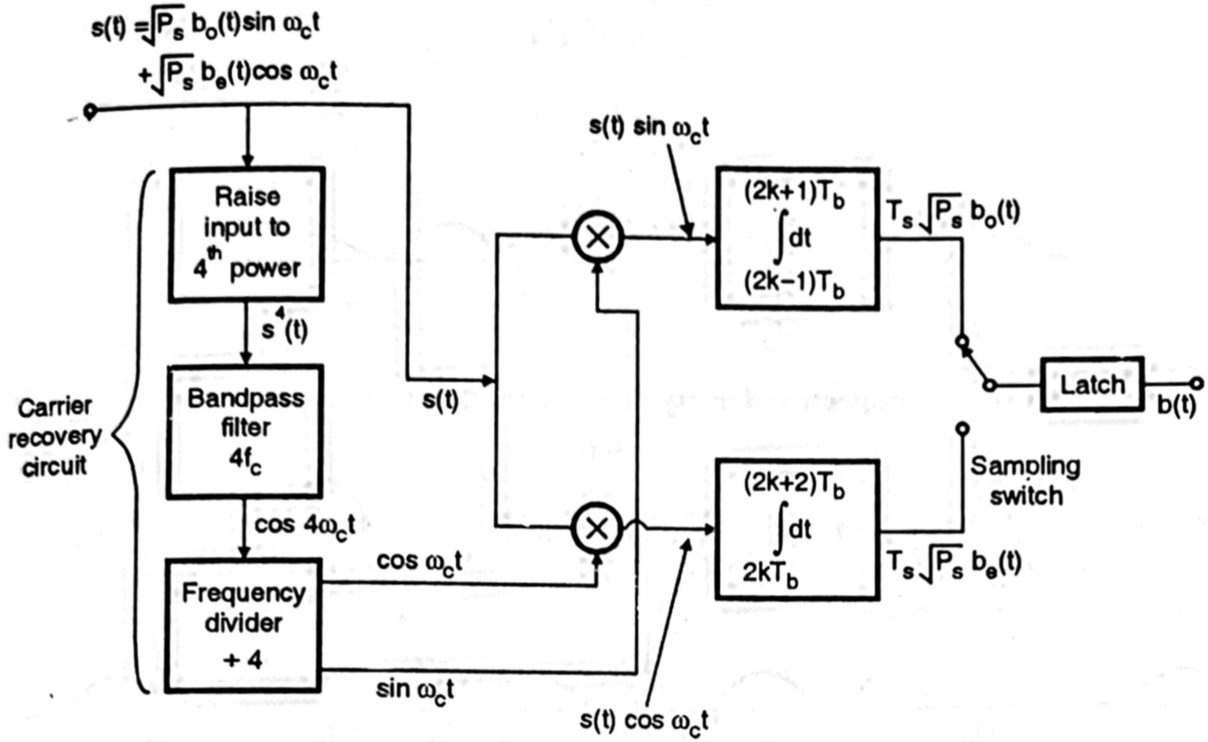

Fig. 6.11.8 : A QPSK receiver

Operation :

- Let us represent the received QPSK signal by $s(t)$ instead of $V_{QPSK}(t)$. The received QPSK signal $s(t)$ is raised to fourth power i.e. $s^4(t)$. This signal is then filtered by using a bandpass filter with a center frequency of $4\,\omega_c t$. The output of bandpass filter is $\cos 4\,\omega_c t$.

- A frequency divider which divides the frequency at the filter output by 4 generates the two carrier signals $\sin \omega_c t$ and $\cos \omega_c t$.

- The incoming signal $s(t)$ is applied to two synchronous demodulators consisting of a multiplier (balanced modulator) followed by an integrator. Each integrator integrates over a two-bit interval of duration $T_s = 2\,T_b$.

- One synchronous demodulator uses $\cos \omega_c t$ as carrier signal and the other one uses $\sin \omega_c t$ as a carrier signal.

Ex. 6.11.1 : For the following input binary sequence. $b(k) = \{1, -1, 1, -1, -1, -1, 1, 1\}$ find the transmitted phase sequence and sketch the transmitted waveform for QPSK.

Soln. : The required waveforms are as shown in Fig. P. 6.11.1.

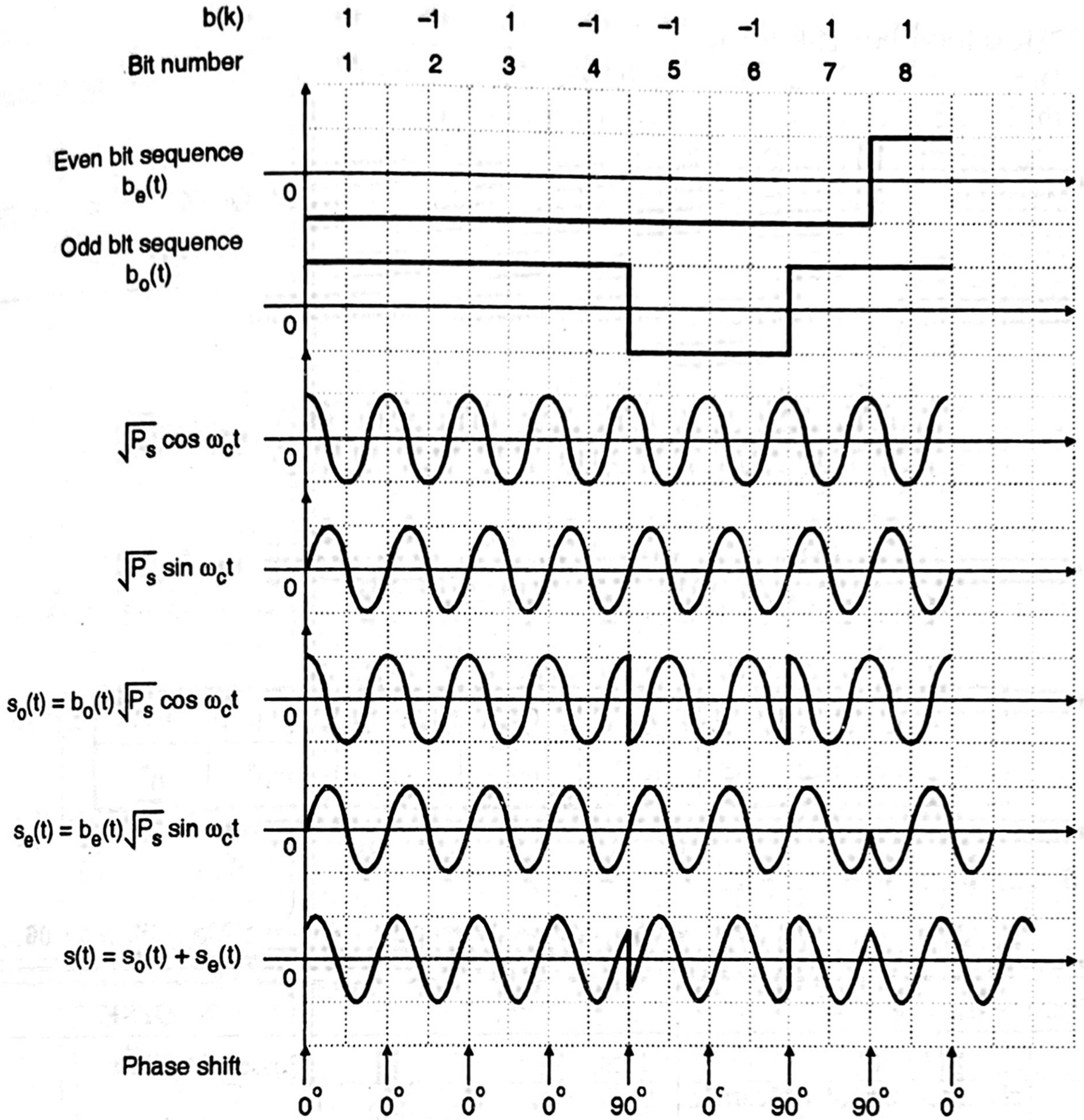

Fig. P. 6.11.1

6.11.6 Advantages of QPSK :

- Very good noise immunity.
- Baud rate is half the bit rate therefore more effective utilization of the available bandwidth of the transmission channel.
- Low error probability.

Due to these advantages the QPSK is used for very high bit rate data transmission.

6.11.7 Disadvantage :

The generation and detection of QPSK is complex.

6.11.8 QPSK is better than PSK :

The QPSK is better than PSK because :

1. Due to multilevel modulation used in QPSK, it is possible to increase the bit rate to double the bit rate of PSK without increasing the bandwidth.
2. The noise immunity of QPSK is same as that of PSK system.
3. Available channel bandwidth is utilized in a better way by the QPSK system than PSK system.

Ex. 6.11.2 : What are the phase states of the carrier when the bit stream.
1 0 0 1 1 0 1 1 0 0
is applied to a QPSK modulator.

Soln. :

Step I : Divide the input data stream into groups of two bits i.e. dibits.

1 0 | 0 1 | 1 0 | 1 1 | 0 0 |

Step II : Phase shift to each dibit as follows :

Modulator input	1 0	0 1	1 0	1 1	0 0
Phase state	180°	90°	180°	270°	0°

6.11.9 Comparison of BPSK and QPSK :

➤➤➤ [Asked in Exam : May 05, May 06 !!!]

Sr. No.	Parameter/characteristics	BPSK	QPSK
1.	Variable characteristics of the carrier.	Phase	Phase
2	Type of modulation	Two level (binary)	Four level
3	Type of representation.	A binary bit is represented by one phase state.	A group of two binary bits is represented by one phase state.
4	Bite rate/baud rate	Bit rate = baud rate	Bit rate = 2 baud rate
5	Detection method	Coherent	Coherent
6	Complexity	Complex	Very complex
7	Applications	Suitable for applications that need high bit rate	Suitable for applications needing very high bit rates.

Ex. 6.11.3 : For the following data stream draw the QPSK (4 PSK) signal.

11010001

Soln. :

The required waveform is shown in Fig. P. 6.11.3. Note that the carrier frequency has not been changed at all. Only the phase shift is being changed according to the symbol.

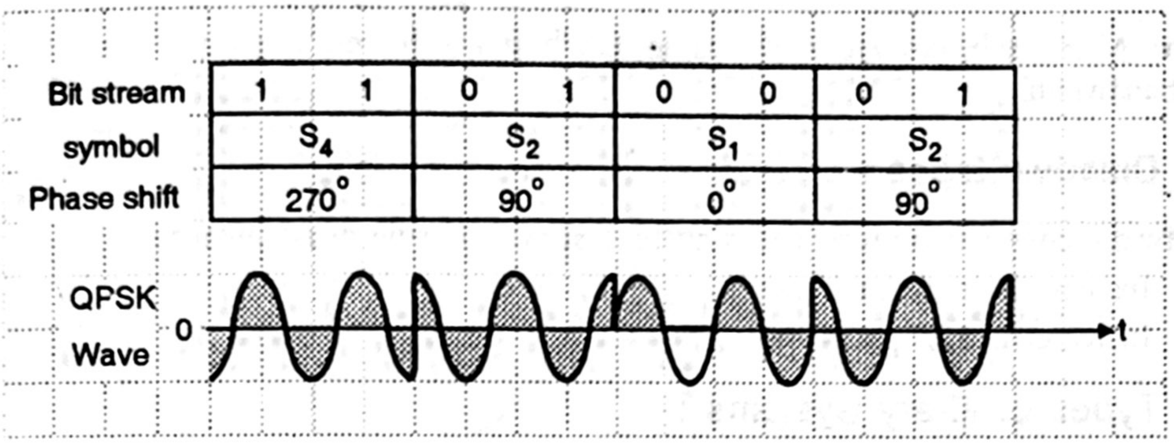

Fig. P. 6.11.3

6.11.10 Difference between OQPSK and QPSK :

Sr. No.	OQPSK	QPSK
1.	There is an offset of T_b seconds between $b_o(t)$ and $b_e(t)$.	There is no offset between $b_o(t)$ and $b_e(t)$.
2.	$b_o(t)$ and $b_e(t)$ will never change simultaneously.	$b_o(t)$ and $b_e(t)$ can change simultaneously.
3.	Maximum phase change in the output signal is 90° or $(\pi/2)$.	Maximum phase change is 180° or π.
4.	Amplitude variations at the instant of abrupt phase changes are of smaller amplitudes as compared to QPSK.	Amplitude variations at the instants of abrupt phase changes are of larger amplitudes as compared to OQPSK.

6.12 M-ary Modulation Techniques :

- In an M-ary signaling scheme, we can send one of the M possible signals such as $s_1(t)$, $s_2(t)$, ... $s_M(t)$, during each signaling interval of duration T seconds.