3.5Quadrature Phase Shift Keying

QUADRATURE PHASE SHIFT KEYING (QPSK) TECHNIQUES AND ITS BLOCK DIAGRAM:

Advantages of QPSK

- Very good noise immunity
- Effective utilization of available bandwidth
- Low error probability
- Very high bit rate data transmission

Quadrature phase shift keying (QPSK)

QPSK Transmitter

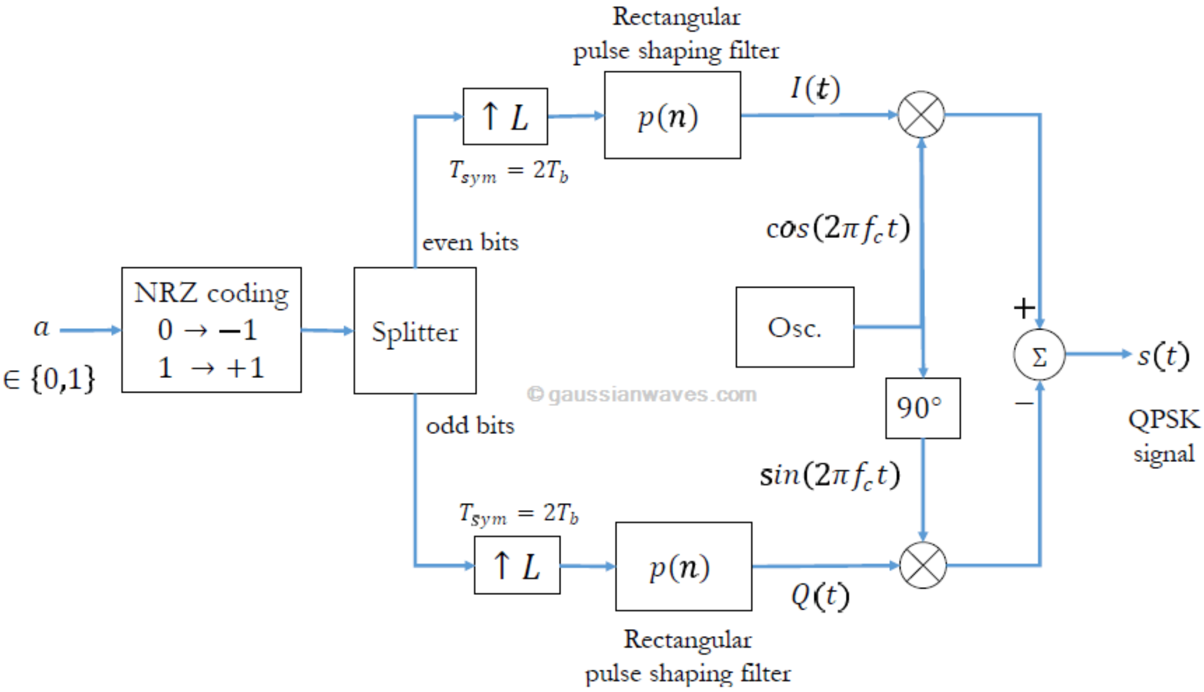

Figure 3.5.1 QPSK Transmitter

Quadrature Phase Shift Keying (QPSK) is a form of phase modulation technique, in which two information bits (combined as one symbol) are modulated at once, selecting one of the four possible carrier phase shift states. The QPSK signal within a symbol duration T_{sym} is defined as

$$s(t) = A\cos\left[2\pi f_c t + \theta_n\right] \qquad ,0 \leq t \leq T_{sym},\ n = 1,2,3,4 \qquad (1)$$

where the signal phase is given by

$$\theta_n = (2n-1)\frac{\pi}{4} \qquad (2)$$

Therefore, the four possible initial signal phases are $\pi/4, 3\pi/4, 5\pi/4$ and $7\pi/4$ radians. Equation (1) can be re-written as

$$\begin{aligned} s(t) &= A\, cos\theta_n\, cos(2\pi f_c t) - A\, sin\theta_n\, sin(2\pi f_c t) \\ &= s_{ni}\phi_i(t) + s_{nq}\phi_q(t) \qquad (3) \end{aligned}$$

The above expression indicates the use of two orthonormal basis functions: $\langle \phi_i(t), \phi_q(t) \rangle$ together with the inphase and quadrature signaling points: $\langle s_{ni}, s_{nq} \rangle$. Therefore, on a two dimensional co-ordinate system with the axes set to $\phi_i(t)$ and $\phi_q(t)$, the QPSK signal is represented by four constellation points dictated by the vectors $\langle s_{ni}, s_{nq} \rangle$ with $n = 1, 2, 3, 4$.

The QPSK transmitter, shown in Figure 1, is implemented as a matlab function ***qpsk_mod***. In this implementation, a splitter separates the odd and even bits from the generated information bits. Each stream of odd bits (quadrature arm) and even bits (in-phase arm) are converted to NRZ format in a parallel manner.

The timing diagram for BPSK and QPSK modulation is shown in Figure 2. For BPSK modulation the symbol duration for each bit is same as bit duration, but for QPSK the symbol duration is twice the bit duration: $T_{sym} = 2T_b$. Therefore, if the QPSK symbols were transmitted at same rate as BPSK, it is clear that QPSK sends twice as much data as BPSK does. After oversampling and pulse shaping, it is intuitively clear that the signal on the I-arm and Q-arm are BPSK signals with symbol duration $2T_b$. The signal on the in-phase arm is then multiplied by $cos(2\pi f_c t)$ and the signal on the quadrature arm is multiplied by $-sin(2\pi f_c t)$. QPSK modulated signal is obtained by adding the signal from both in-phase and quadrature arms.

Timing diagram for BPSK and QPSK modulation

The oversampling rate for the simulation is chosen as $L = 2f_s/f_c$, where f_c is the given carrier frequency and f_s is the sampling frequency satisfying Nyquist sampling theorem with respect to the carrier frequency ($f_s \geq fc$). This configuration gives integral number of carrier cycles for one symbol duration.

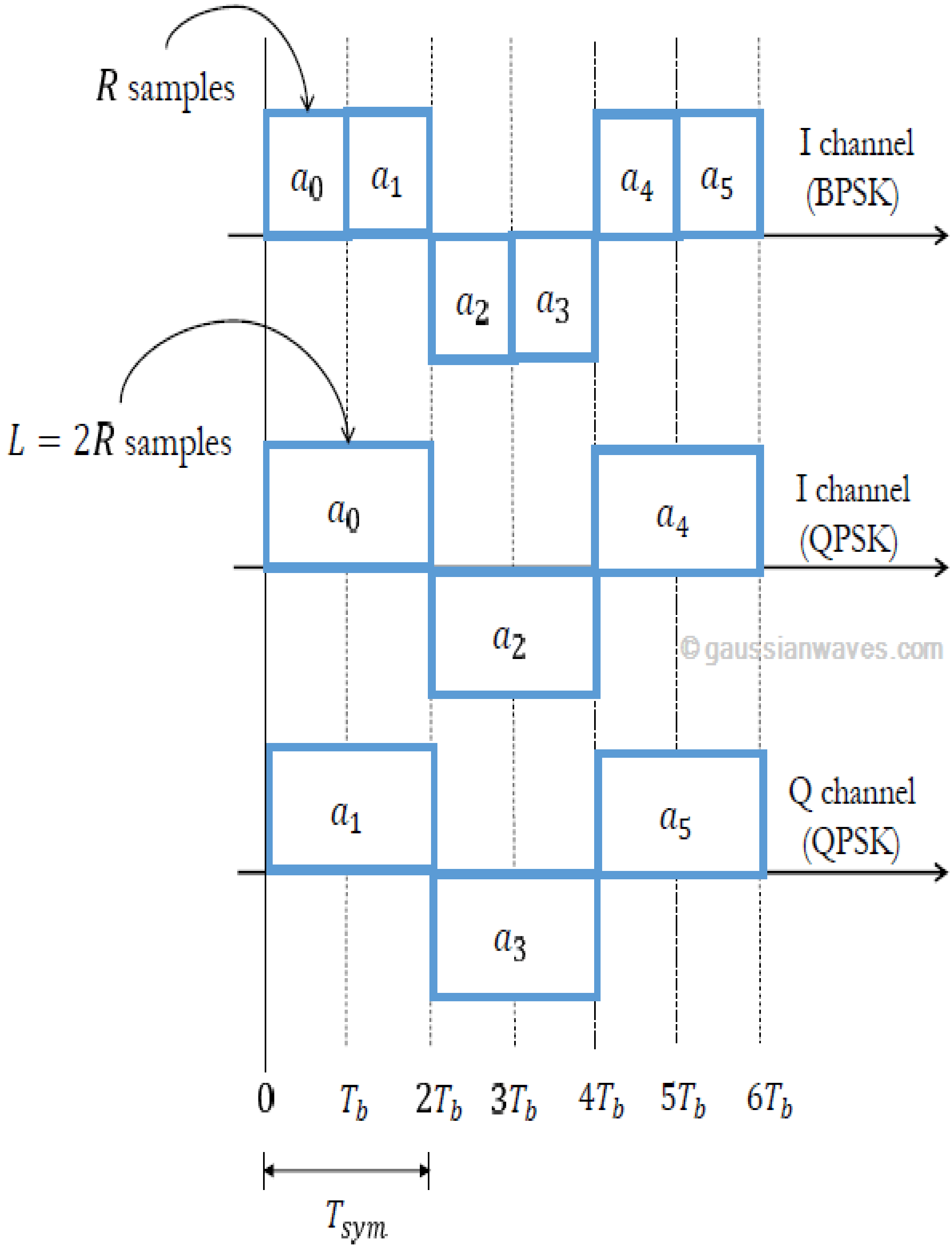

Figure 3.5.2 **Timing diagram for BPSK and QPSK modulations**

QPSK Receiver

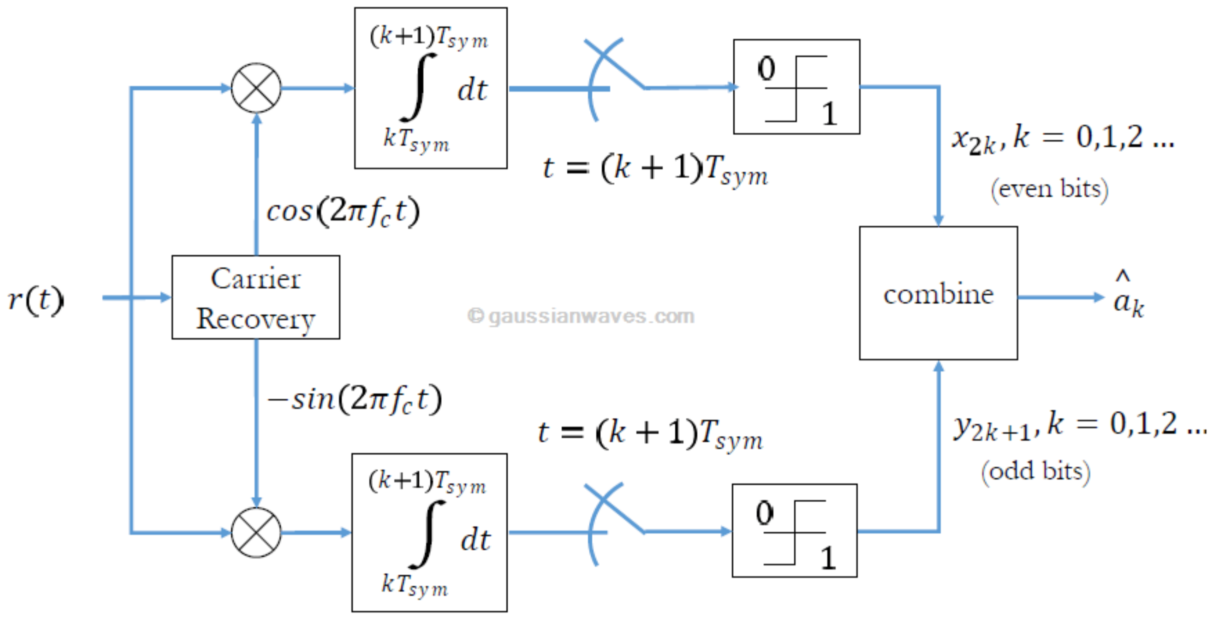

Figure 3.5.3 QPSK Receiver

Due to its special relationship with BPSK, the QPSK receiver takes the simplest form as shown in Figure 3. In this implementation, the I-channel and Q-channel signals are individually demodulated in the same way as that of BPSK demodulation. After demodulation, the I-channel bits and Q-channel sequences are combined into a single sequence. The function ***qpsk_demod*** implements a QPSK demodulator as per Figure 3.5.3

This is Synchronous reception. Therefore coherent carrier is to be recovered from the received signal s(t).

Compare binary PSK with QPSK.

BPSK QPSK

1. One bit forms a symbol. Two bits form a symbol.

2. Two possible symbols. Four possible symbols.

3. Minimum bandwidth is twice of fb. Minimum bandwidth is equal to fb.

4. Symbol duration = Tb. Symbol duration = 2Tb.

9. What are the advantages of M-ary signaling scheme?

1. M-ary signaling schemes transmit bits at a time.

2. Bandwidth requirement of M-ary signaling schemes is reduced.

The probability of error in M-Ary FSK as the value of m increases:

As the value of „M" increases, the Euclidean distance between the symbols reduces. Hence the symbols come closer to each other. This increases the probability of error in M-ary systems.

Correlative coding allows the signaling rate of 2B0 in the channel of bandwidth B0. This is made physically possible by allowing ISI in the transmitted signal in controlled manner. This ISI is known to the receiver. Hence effects of ISI are eliminated at the receiver. Correlative coding is implemented by duobinary signaling and modified duobinary signaling.