



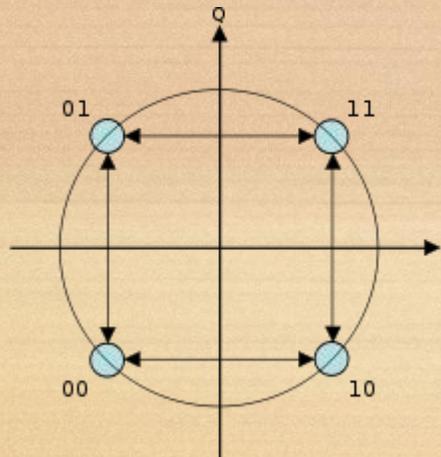
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MINIMUM SHIFT KEYING (MSK)

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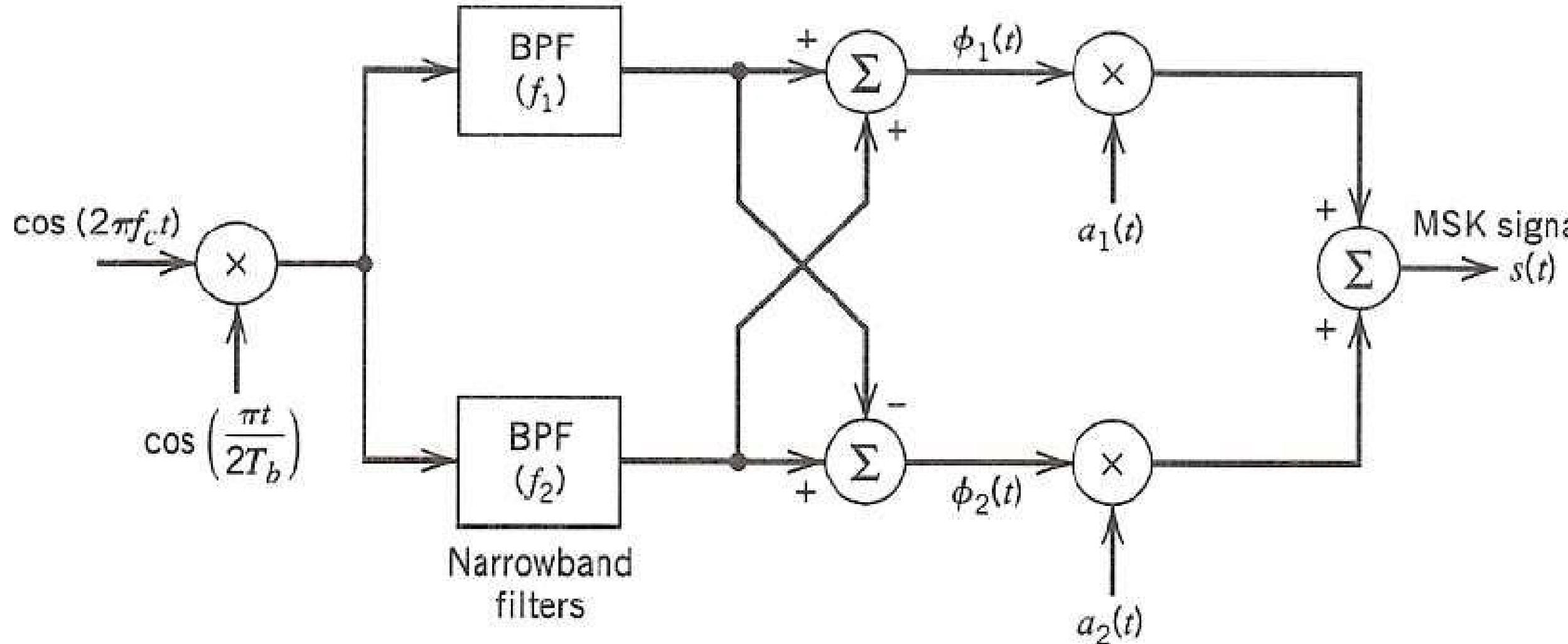
INTRODUCTION

- In digital modulation, **minimum-shift keying (MSK)** is a type of continuous-phase frequency-shift keying that was developed in the late 1950s and 1960s.
- Similar to OQPSK (Offset quadrature phase-shift keying), **MSK** is encoded with bits alternating between quadrature components, with the Q component delayed by half the symbol period.



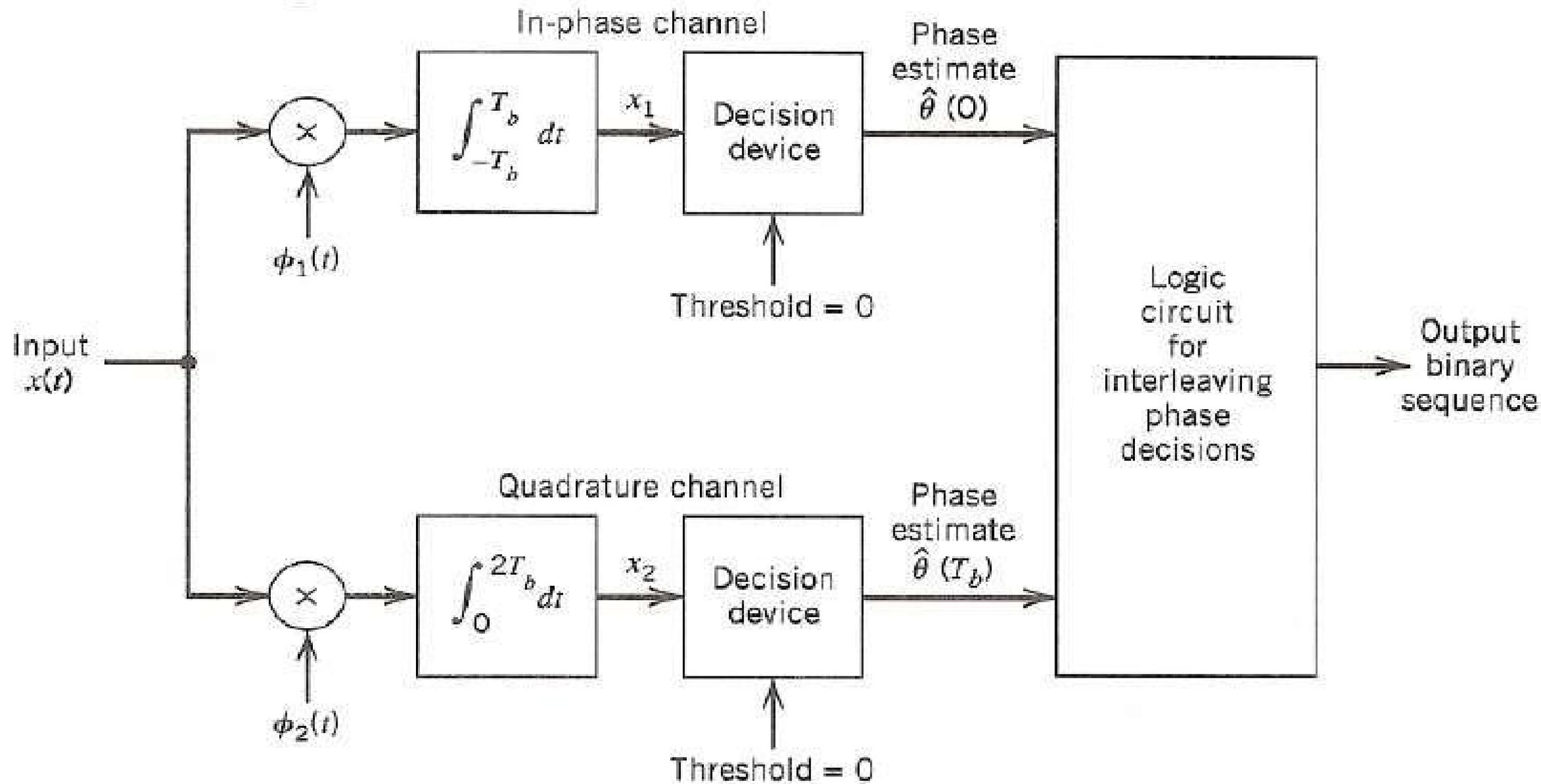
Minimum-shift keying (MSK) (Haykin)

- Block diagrams for MSK transmitter



Minimum-shift keying (MSK) (Haykin)

Block diagrams for coherent MSK receiver



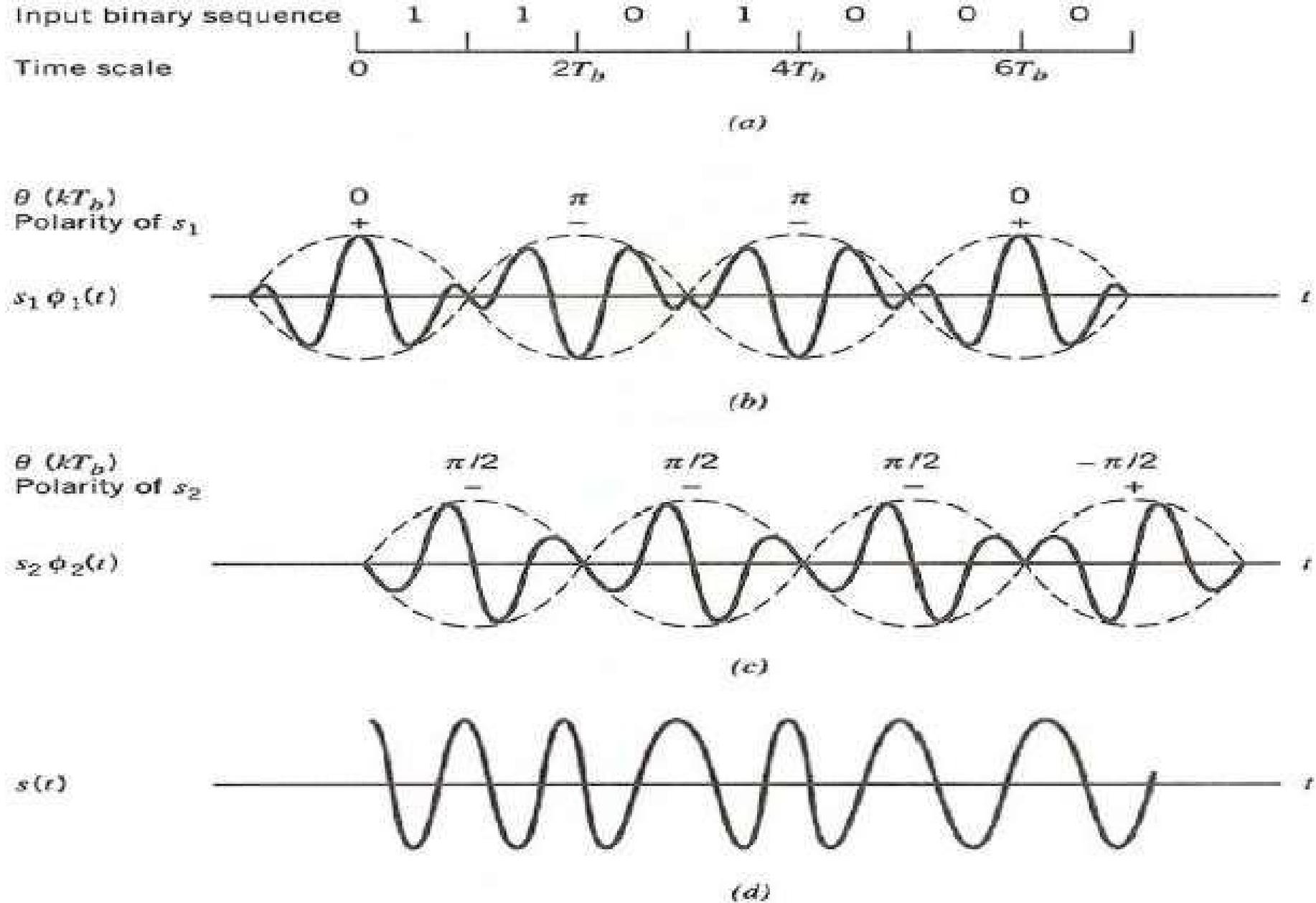


FIGURE 6.30 (a) Input binary sequence. (b) Waveform of scaled time function $s_1 \phi_1(t)$. (c) Waveform of scaled time function $s_2 \phi_2(t)$. (d) Waveform of the MSK signal $s(t)$ obtained by adding $s_1 \phi_1(t)$ and $s_2 \phi_2(t)$ on a bit-by-bit basis.

Minimum-shift keying (MSK) (Haykin)

Coherent detection of the MSK signal

- In the case of an AWGN channel, the received signal is given by

$$x(t) = s(t) + w(t)$$

where $s(t)$ is the transmitted MSK signal, and $w(t)$ is the sample function of a white Gaussian noise process of zero mean and power spectral density $N_0/2$.

- For the optimal decision of $\theta(0)$,

$$x_1 = \int_{-T_b}^{T_b} x(t) \phi_1(t) dt = s_1 + w_1, \quad -T_b \leq t \leq T_b$$

$$\text{If } x_1 > 0 \implies \hat{\theta}(0) = 0$$

$$\text{If } x_1 < 0 \implies \hat{\theta}(0) = \pi$$

Minimum-shift keying (MSK) (Haykin)

- Coherent detection of the MSK signal (cont.)

- For the optimum detection of $\theta (T_b)$,

$$x_2 = \int_0^{2T_b} x(t) \phi_2(t) dt = s_2 + w_2, \quad 0 \leq t \leq 2T_b$$

$$\text{If } x_2 > 0 \Rightarrow \hat{\theta}(T_b) = -\pi / 2$$

$$\text{If } x_2 < 0 \Rightarrow \hat{\theta}(T_b) = \pi / 2$$

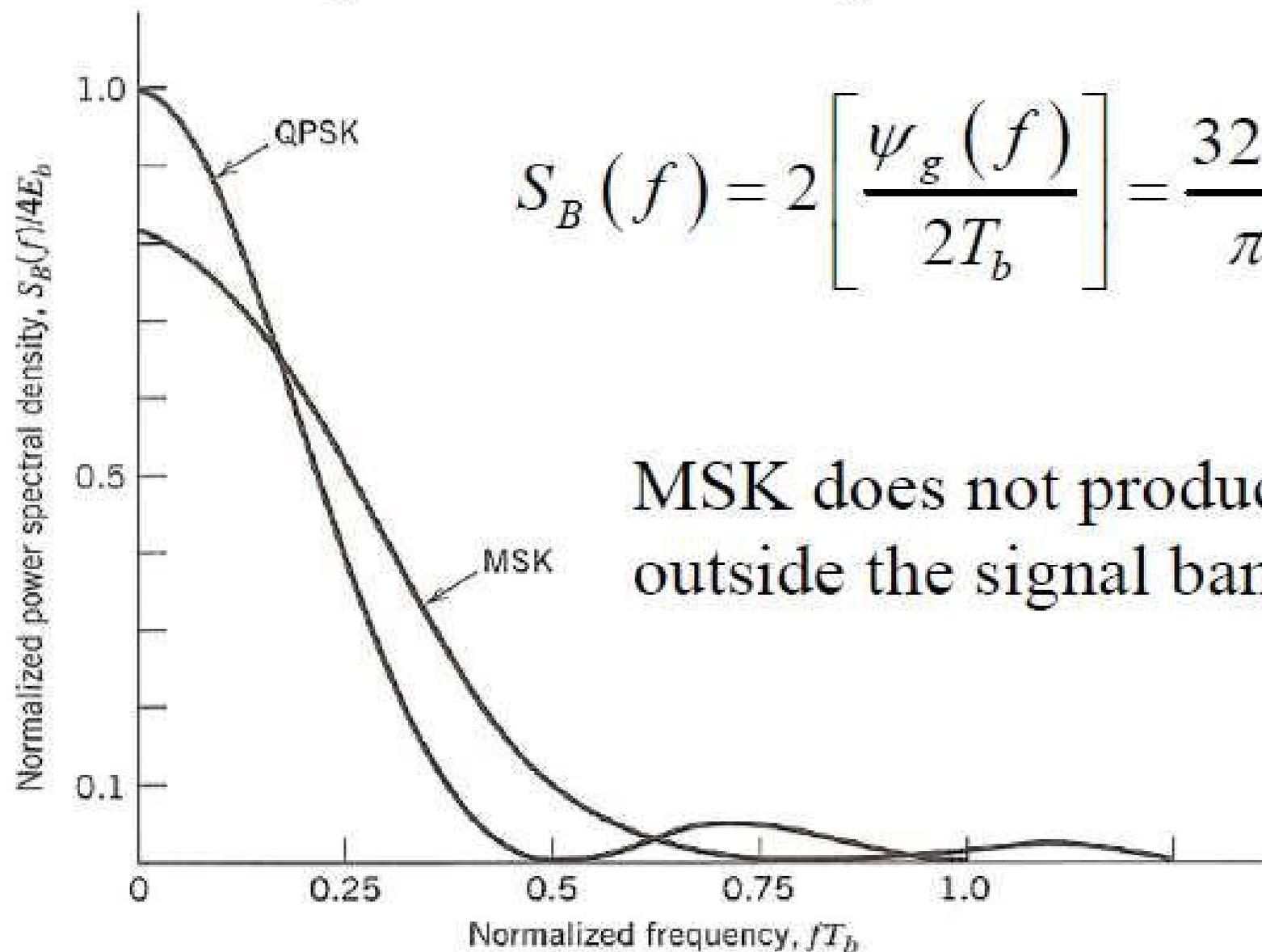
- Error probability of MSK

$$P_e = \frac{1}{2} \operatorname{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right)$$

which is exactly the same as that for binary PSK and QPSK.

Minimum-shift keying (MSK) (Haykin)

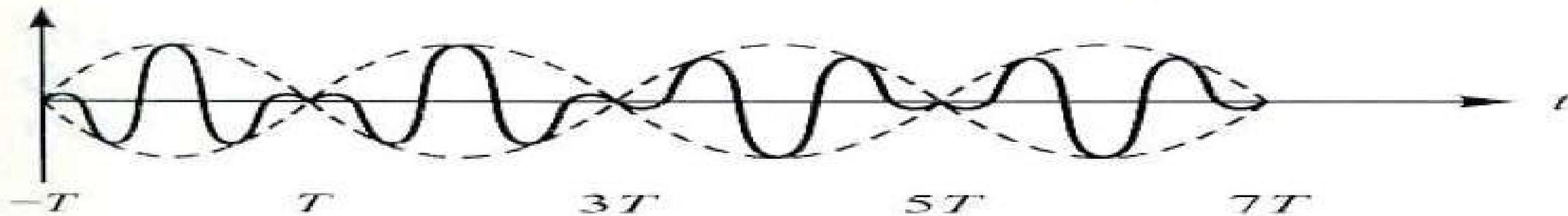
Power spectra of MSK signals



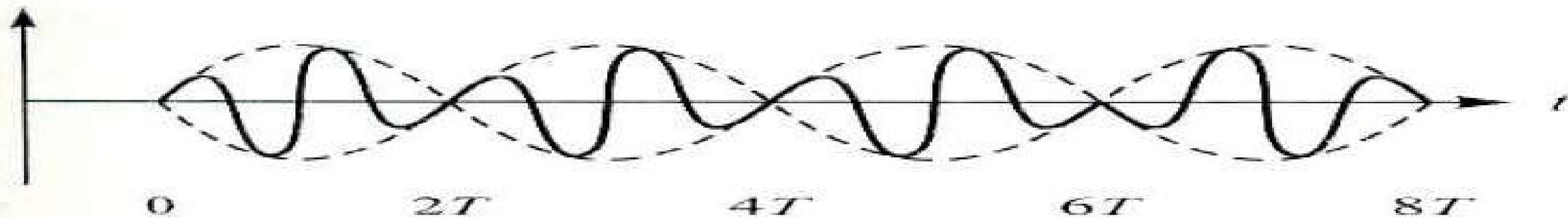
$$S_B(f) = 2 \left[\frac{\psi_g(f)}{2T_b} \right] = \frac{32E_b}{\pi^2} \left[\frac{\cos(2\pi T_b f)}{16T_b^2 f^2 - 1} \right]^2$$

MSK does not produce as much interference outside the signal band of interest as QPSK.

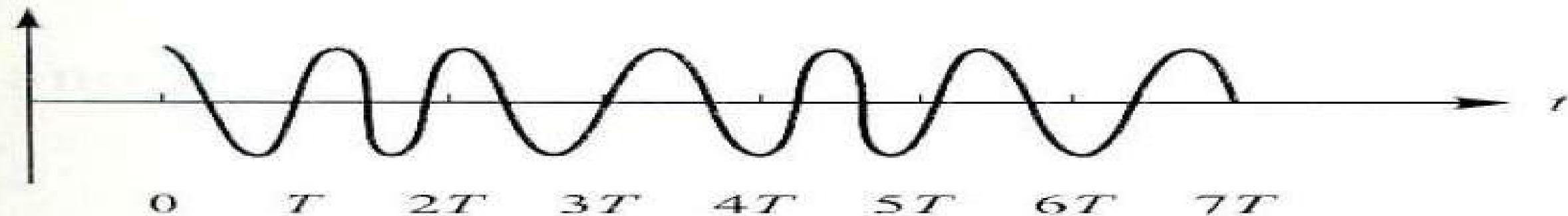
Minimum-shift keying (MSK) (cont.)



(a) In-phase signal component



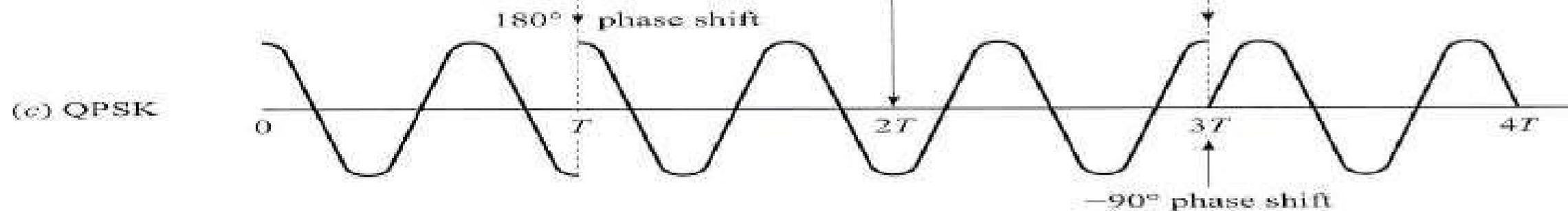
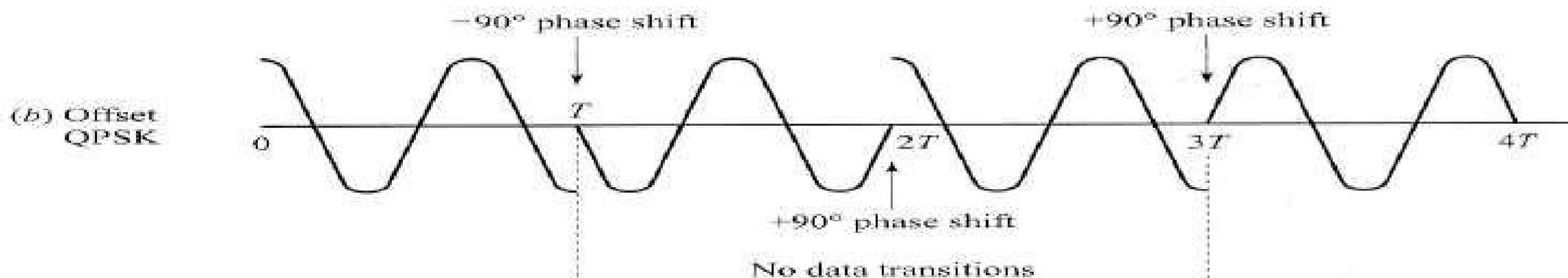
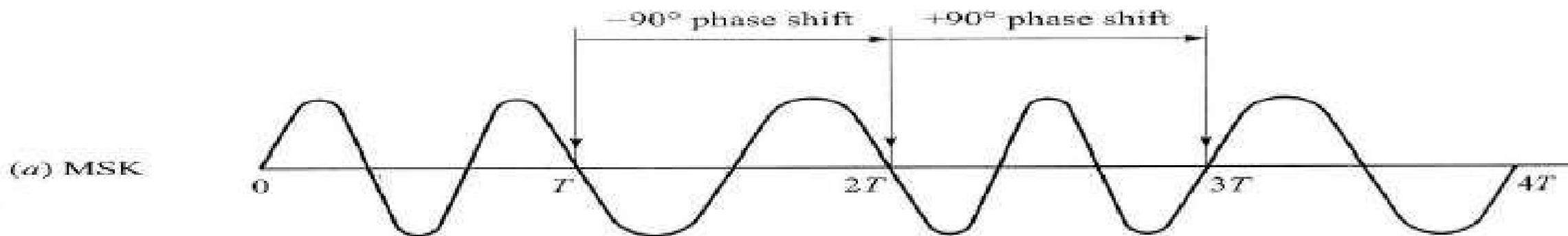
(b) Quadrature signal component



(c) MSK signal [sum of (a) and (b)]

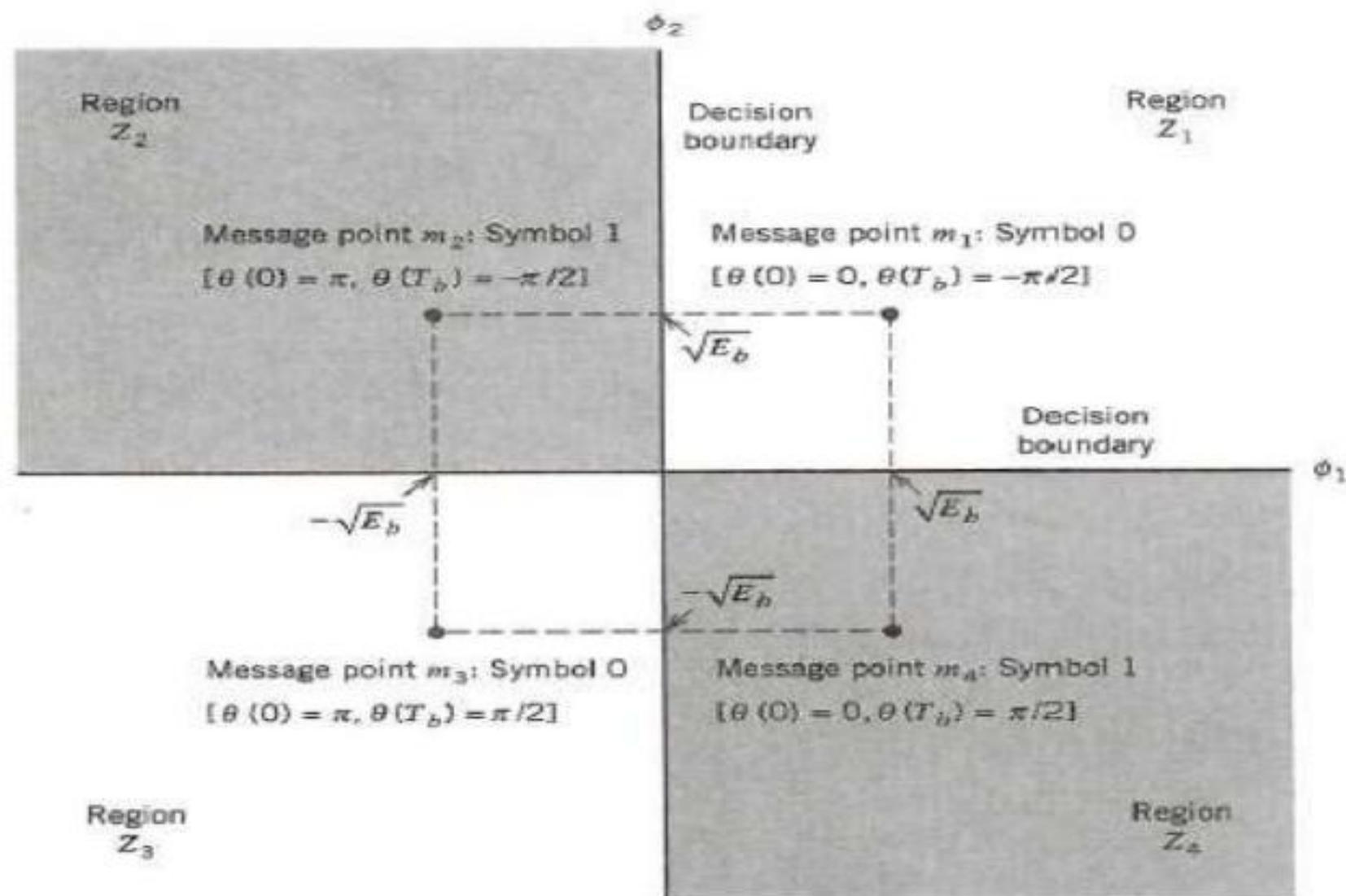
Minimum-shift keying (MSK) (cont.)

- Compare the waveforms for MSK with OQPSK and QPSK (cont.)



Minimum-shift keying (MSK) (Haykin)

- Signal space diagram for MSK system



AVANTAGES OF MSK

- The side bands of psk modulated spectrum is minimised by msk modulation technique. Hence sideband power is reduced.
- The msk spectrum is less affected by noise & hence leads to good SNR. This helps in achieving very stable & long distance.
- MSK offers advantages in terms of spectral efficiency when compared to other similar modes, & it also enables power amplifier to operate in saturation enabling them to provide high level of efficiency.

A close-up photograph of a person's hand, palm up, holding a glowing, translucent white sphere. The sphere is the central focus and contains the words "THANK YOU" in a bold, black, sans-serif font. The background is a plain, light gray surface. The lighting is soft, highlighting the contours of the hand and the glow of the sphere.

**THANK
YOU**