- *Global system for mobile (GSM) communication*, which embodies a modification of MSK known as Gaussian-filtered minimum shift-keying (GMSK).
- *Digital television*, the objective of which is to provide high-quality video and audio using channel parameters similar to analog television.

One last comment is in order. Throughout the discussion of receivers in this chapter, be they of the coherent or noncoherent kind, we ignored a practical reality: the unavoidable presence of additive channel noise. Inevitably, the transmitted signal is perturbed by this reality, which, in turn, has the effect of producing errors in the estimated binary data stream at the receiver output. The effect of channel noise is discussed in Chapter 10, but we have to first study the characterization of random signals and noise, which we do in the next chapter.

Additional Problems

7.11 The binary sequence 11100101 is applied to an ASK modulator. The bit duration is 1 μs, and the sinusoidal carrier wave used to represent symbol 1 has a frequency equal to 7 MHz.

(a) Find the transmission bandwidth of the transmitted signal.

(b) Plot the waveform of the transmitted ASK signal.

Assume that the line encoder and the carrier-wave oscillator are controlled by a common clock.

7.12 Repeat Problem 7.11, assuming that the line encoder and the carrier-wave generator operate independently of each other. Comment on your results.

7.13 (a) Repeat Problem 7.11 for the case when the binary sequence 11100101 is applied to a PSK modulator, assuming that the line encoder and sinusoidal carrier-wave oscillator are operated from a common clock.

(b) Repeat your calculations, assuming that the line encoder and carrier-wave oscillator operate independently.

7.14 The binary sequence 11100101 is applied to a QPSK modulator. The bit duration is 1 μs. The carrier frequency is 6 MHz.

(a) Calculate the transmission bandwidth of the QPSK signal.

(b) Plot the waveform of the QPSK signal.

7.15 Repeat Problem 7.14 for the signaling case of OQPSK.

7.16 The binary sequence 11100101 is applied to Sunde's BFSK modulator. The bit duration is 1 μs. The carrier frequencies used to represent symbols 0 and 1 are 2.5 MHz and 3.5 MHz, respectively.

(a) Calculate the transmission bandwidth of the BFSK signal.

(b) Plot the waveform of the BFSK signal.

7.17 As remarked previously, the waveform plotted in Fig. 7.1(*d*) is an example of MSK. Determine

(a) The frequency excursion δf of the MSK.

(b) The frequency parameter f_0.

7.18 The binary sequence 11100101 is applied to a MSK modulator. The bit duration is 1 μs. The carrier frequencies used to represent symbols 0 and 1 are 2.5 MHz and 3 MHz, respectively. Plot the waveform of the MSK signal.

7.19 Consider an MSK modulator that uses a sinusoidal carrier with frequency $f_c = 50$ MHz. The bit rate of the incoming binary stream is 20×10^3 bits/s.

(a) Calculate the instantaneous frequency of the MSK modulator for a data sequence in which symbols 0 and 1 alternate.

(b) Repeat the calculation in part (a) for a data sequence that consists of all 0s. What if the sequence consists of all 1s?

7.20 Suppose you are given an MSK signal $s(t)$. How would you extract the bit-timing signal from $s(t)$? Explain.

7.21 Consider the noncoherent receiver of Fig. 7.17 for BASK and that of Fig. 7.18 for BFSK. Roughly speaking, the noncoherent BFSK receiver is twice as complex as the noncoherent BASK receiver. What would be the advantage of the BFSK system over the BASK system, given that they operate on the same binary data stream and the same communication channel? Justify your answer. *Hint:* Refer to the pertinent phasor representations in Table 7.2.

7.22 Figure 7.29 depicts a receiver for the noncoherent detection of BFSK signals. The receiver consists of two paths; the band-pass filter in the top path is tuned to the carrier frequency f_1 representing symbol 1, and the band-pass filter in the lower path is tuned to the alternative carrier frequency f_2 representing symbol 0. These two filters are followed by a pair of *energy-level detectors*, whose outputs are applied to the comparator to recover the original binary data stream. Identify the conditions that the receiver of Fig. 7.29 must satisfy for it to be an alternative to the noncoherent BFSK receiver of Fig. 7.18.

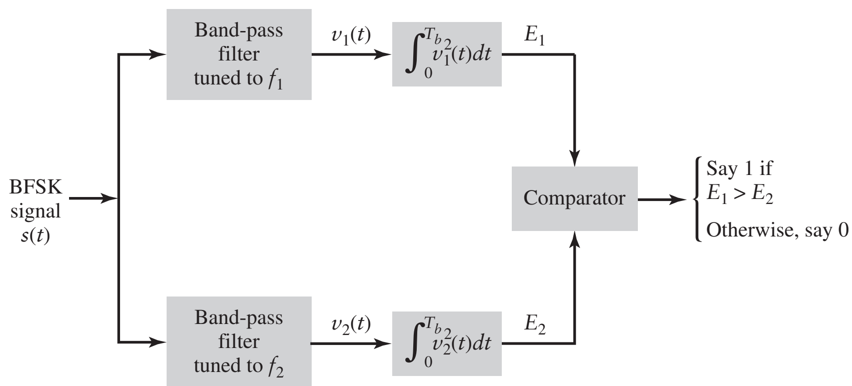

FIGURE 7.29 Problem 7.22

7.23 The binary sequence 11100101 is applied to a DPSK system. The bit duration is 1 μs. The carrier frequency is 6 MHz.

(a) Calculate the transmission bandwidth of the system.

(b) Plot the waveform of the transmitted signal.

(c) Using the transmitted sequence of part (b), plot the waveform produced by the receiver, and compare it against the original binary sequence.

ADVANCED PROBLEMS

7.24 Consider a phase-locked loop consisting of a multiplier, loop filter, and voltage-controlled oscillator (VCO); you may refer to Section 4.8 for a description of the phase-locked loop for the demodulation of analog frequency modulation. Let the signal applied to the multiplier input be a PSK signal defined by

$$s(t) = A_c \cos[2\pi f_c t + k_p b(t)]$$

where k_p is the phase sensitivity, and the data signal $b(t)$ takes on the value $+1$ for binary symbol 1 and -1 for binary symbol 0. The VCO output is

$$r(t) = A_c \sin[2\pi f_c t + \theta(t)]$$