CHAPTER 4

PRACTICE SET

Questions

Q4-1. The three different techniques described in this chapter are *line coding*, *block coding*, and *scrambling*.

Q4-3. The *data rate* defines the number of data elements (bits) sent in 1s. The unit is bits per second (bps). The *signal rate* is the number of signal elements sent in 1s. The unit is the baud.

Q4-5. When the voltage level in a digital signal is constant for a while, the spectrum creates very low frequencies, called *DC components*, that present problems for a system that cannot pass low frequencies.

Q4-7. In this chapter, we introduced *unipolar*, *polar*, *bipolar*, *multilevel*, and *multi-transition* coding.

Q4-9. *Scrambling*, as discussed in this chapter, is a technique that substitutes long zero-level pulses with a combination of other levels without increasing the number of bits.

Q4-11. In *parallel transmission* we send data several bits at a time. In serial transmission we send data one bit at a time.

Problems

P4-1. We use the formula $s = c \times N \times (1/r)$ for each case. We let $c = 1/2$.

a. $r = 1 \rightarrow s = (1/2) \times (1\text{ Mbps}) \times 1/1 =$ 500 kbaud

b. $r = 1/2 \rightarrow s = (1/2) \times (1\text{ Mbps}) \times 1/(1/2) =$ 1 Mbaud

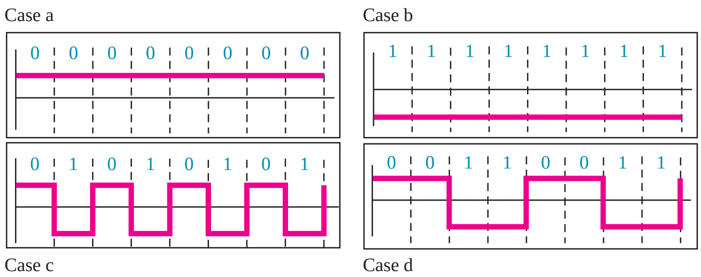
c. $r = 2 \rightarrow s = (1/2) \times (1\text{ Mbps}) \times 1/2 =$ 250 Kbaud

d. $r = 4/3 \rightarrow s = (1/2) \times (1\text{ Mbps}) \times 1/(4/3) =$ 375 Kbaud

P4-3. See the following figure. Bandwidth is proportional to (3/8)N which is within the range in Table 4.1 (B = 0 to N) for the NRZ-L scheme.

Average Number of Changes = (0 + 0 + 8 + 4) / 4 = 3 for N = 8

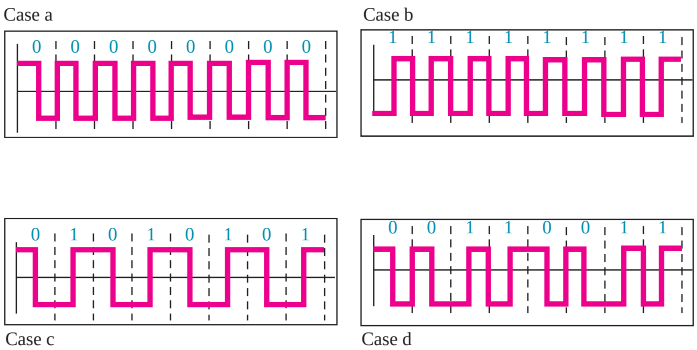
B → (3 / 8) N



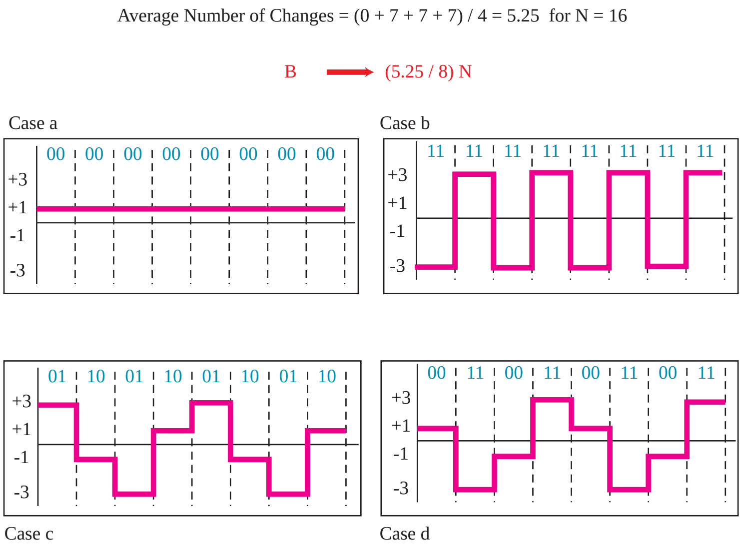
P4-5. See the following figure. Bandwidth is proportional to (12.5 / 8)N which is within the range in Table 4.1 (B = N to B = 2N) for the Manchester scheme.

Average Number of Changes = (15 + 15+ 8 + 12) / 4 = 12.5 for N = 8

B → (12.5 / 8) N



P4-7. See the following figure. B is proportional to (5.25 / 16)N which is inside range in Table 4.1 (B = 0 to N/2) for 2B/1Q.



P4-9. The data stream can be found as

a. NRZ-I: 10011001.

b. Differential Manchester: 11000100.

c. AMI: 01110001.

P4-11. The data rate is 100 Kbps. For each case, we first need to calculate the value of f / N. We then use Figure 4.8 in the text to find P (energy per Hz). All calculations are approximations.

a. f/N = 0/100 = 0 → P = 0.0

b. f/N = 50/100 = 1/2 → P = 0.3

c. f/N = 100/100 = 1 → P = 0.4

d. f/N = 150/100 = 1.5 → P = 0.0

P4-13. In 5B/6B, we have 2^5 = 32 data sequences and 2^6 = 64 code sequences. The number of unused code sequences is 64 – 32 = 32. In 3B/4B, we have 2^3 = 8 data sequences and 2^4 = 16 code sequences. The number of unused code sequences is 16 – 8 = 8.

P4-15.

a. In a low-pass signal, the minimum frequency 0. Therefore, we have

$$f_{max} = 0 + 200 = 200 \text{ KHz.} \quad \rightarrow \quad f_s = 2 \times 200{,}000 = 400{,}000 \text{ samples/s}$$

b. In a bandpass signal, the maximum frequency is equal to the minimum frequency plus the bandwidth. Therefore, we have

$$f_{max} = 100 + 200 = 300 \text{ KHz.} \quad \rightarrow \quad f_s = 2 \times 300{,}000 = 600{,}000 \text{ samples /s}$$

P4-17. The maximum data rate can be calculated as

$$N_{max} = 2 \times B \times n_b = 2 \times 200 \text{ KHz} \times \log_2 4 = 800 \text{ kbps}$$

P4-19. We can calculate the data rate for each scheme:

a. NRZ → $N = 2 \times B = 2 \times 1 \text{ MHz} = 2 \text{ Mbps}$
b. Manchester → $N = 1 \times B = 1 \times 1 \text{ MHz} = 1 \text{ Mbps}$
c. MLT-3 → $N = 3 \times B = 3 \times 1 \text{ MHz} = 3 \text{ Mbps}$
d. 2B1Q → $N = 4 \times B = 4 \times 1 \text{ MHz} = 4 \text{ Mbps}$