CHAPTER 4

Digital Transmission

Solutions to Odd-Numbered Review Questions and Exercises

Review Questions

1. The three different techniques described in this chapter are ***line coding***, ***block coding***, and ***scrambling***.
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.
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.
7. In this chapter, we introduced ***unipolar***, ***polar***, ***bipolar***, ***multilevel***, and ***multitransition*** coding.
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.
11. In ***parallel transmission*** we send data *several* bits at a time. In ***serial transmission*** we send data *one* bit at a time.

Exercises

13. We use the formula **s = c × N × (1/r)** for each case. We let c = 1/2.
    a. r = 1 → s = (1/2) × (1 Mbps) × 1/**1** = **500 kbaud**
    b. r = 1/2 → s = (1/2) × (1 Mbps) × 1/(**1/2**) = **1 Mbaud**
    c. r = 2 → s = (1/2) × (1 Mbps) × 1/**2** = **250 Kbaud**
    d. r = 4/3 → s = (1/2) × (1 Mbps) × 1/(**4/3**) = **375 Kbaud**
15. See Figure 4.1 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.
17. See Figure 4.2. 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.

Figure 4.1 *Solution to Exercise 15*

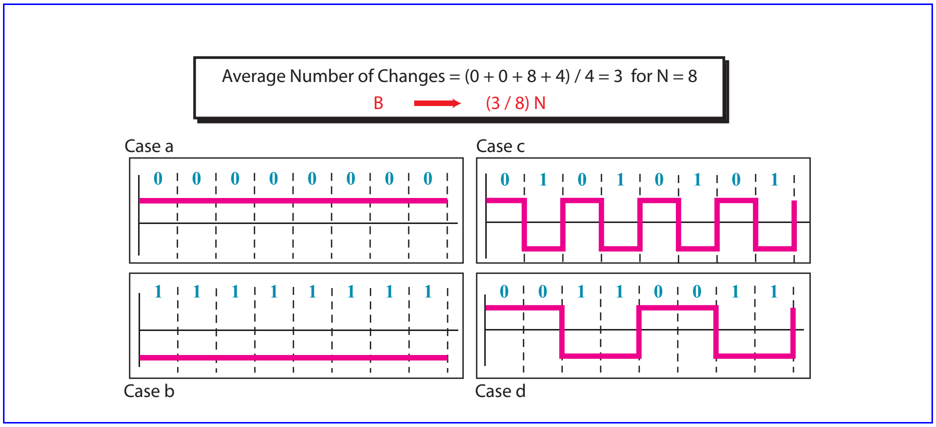
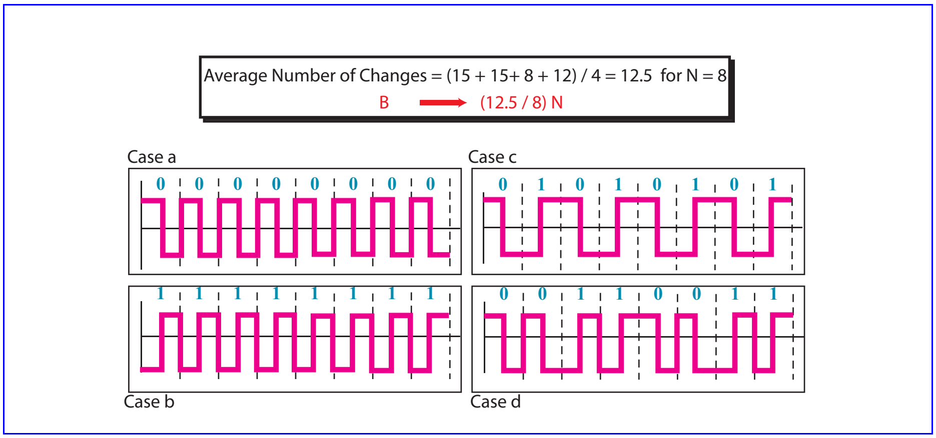


Figure 4.2 *Solution to Exercise 17*



19. See Figure 4.3. B is proportional to **(5.25 / 16) N** which is inside range in Table 4.1 (B = 0 to N/2) for 2B/1Q.

21. The data stream can be found as

    a. NRZ-I: **10011001**.

    b. Differential Manchester: **11000100**.

    c. AMI: **01110001**.

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

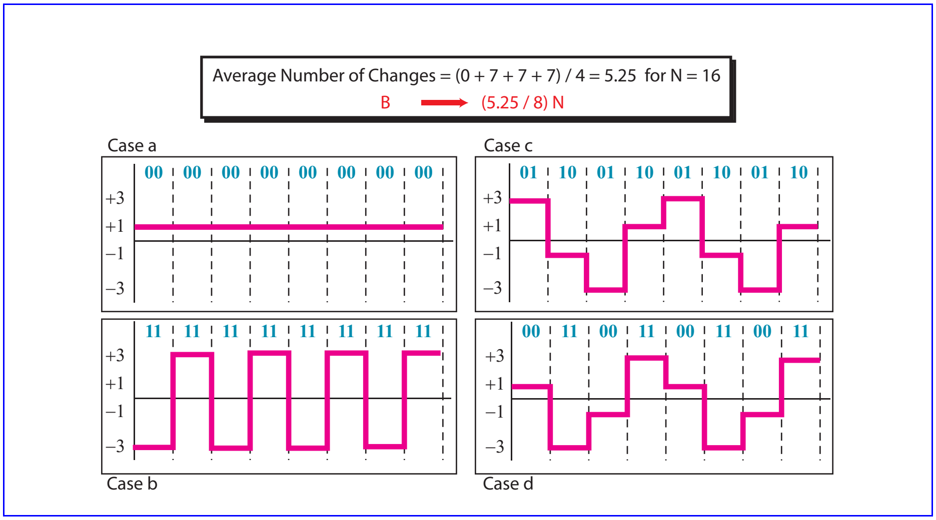
    a. f /N = 0/100 = 0 → **P = 0.0**

    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**

Figure 4.3 *Solution to Exercise 19*



25. 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**.

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

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

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

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

29. The maximum data rate can be calculated as

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

31. We can calculate the data rate for each scheme:

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