CHAPTER 3

Data and Signals

Solutions to Odd-Numbered Review Questions and Exercises

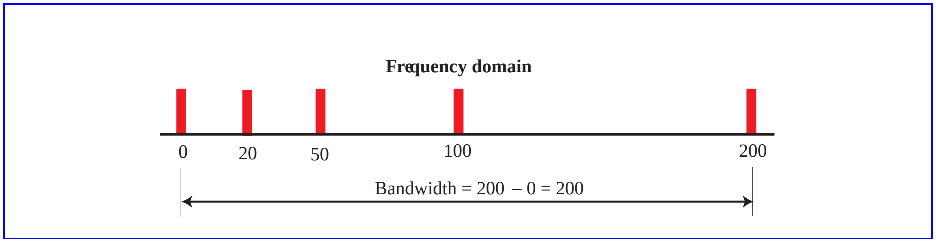
Review Questions

1. ***Frequency*** and ***period*** are the inverse of each other. T = 1/ f and f = 1/T.
3. Using Fourier analysis. ***Fourier series*** gives the frequency domain of a periodic signal; ***Fourier analysis*** gives the frequency domain of a nonperiodic signal.
5. ***Baseband transmission*** means sending a digital or an analog signal without modulation using a low-pass channel. ***Broadband transmission*** means modulating a digital or an analog signal using a band-pass channel.
7. The ***Nyquist theorem*** defines the maximum bit rate of a noiseless channel.
9. ***Optical signals*** have very high frequencies. A high frequency means a short wave length because the wave length is inversely proportional to the frequency ($\lambda = v/f$), where v is the propagation speed in the media.
11. The frequency domain of a voice signal is normally ***continuous*** because voice is a ***nonperiodic*** signal.
13. This is ***baseband transmission*** because no modulation is involved.
15. This is ***broadband transmission*** because it involves modulation.

Exercises

17.
    a. **f = 1 / T** = 1 / (5 s) = 0.2 Hz
    b. **f = 1 / T** = 1 / (12 μs) =83333 Hz = 83.333×10^3 Hz = **83.333 KHz**
    c. **f = 1 / T** = 1 / (220 ns) = 4550000 Hz = 4.55×10^6 Hz = **4.55 MHz**
19. See Figure 3.1
21. Each signal is a simple signal in this case. The bandwidth of a simple signal is zero. So the bandwidth of both signals are the same.
23.
    a. (10 / 1000) s = **0.01 s**
    b. (8 / 1000) s = 0. 008 s = **8 ms**

Figure 3.1 *Solution to Exercise 19*

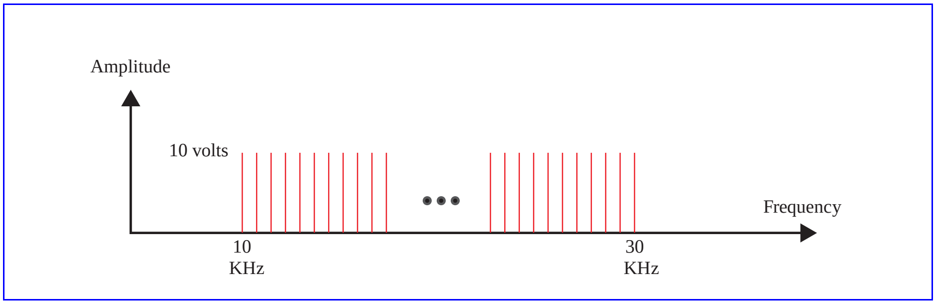


c. ((100,000 × 8) / 1000) s = **800 s**

25. The signal makes 8 cycles in 4 ms. The frequency is 8 /(4 ms) = **2 KHz**

27. The signal is periodic, so the frequency domain is made of discrete frequencies. as shown in Figure 3.2.

Figure 3.2 *Solution to Exercise 27*



29.

Using the first harmonic, data rate = 2 × 6 MHz = **12 Mbps**
Using three harmonics, data rate = (2 × 6 MHz) /3 = **4 Mbps**
Using five harmonics, data rate = (2 × 6 MHz) /5 = **2.4 Mbps**

31. $-10 = 10 \log_{10} (P_2 / 5) \rightarrow \log_{10} (P_2 / 5) = -1 \rightarrow (P_2 / 5) = 10^{-1} \rightarrow P_2 =$ **0.5 W**

33. 100,000 bits / 5 Kbps = **20 s**

35. 1 μm × 1000 = 1000 μm = **1 mm**

37. We have

$$\mathbf{4{,}000 \log_2 (1 + 10 / 0.005) = 43{,}866 \text{ bps}}$$

39. To represent 1024 colors, we need $\log_2 1024 = 10$ (see Appendix C) bits. The total number of bits are, therefore,

$$\mathbf{1200 \times 1000 \times 10 = 12{,}000{,}000 \text{ bits}}$$

41. We have

SNR= (signal power)/(noise power).

However, power is proportional to the square of voltage. This means we have

$$\mathbf{SNR = [(signal\ voltage)^2] / [(noise\ voltage)^2] =}$$
$$\mathbf{[(signal\ voltage) / (noise\ voltage)]^2 = 20^2 = 400}$$

We then have

$$\mathbf{SNR_{dB} = 10 \log_{10} SNR \approx 26.02}$$

43.

a. The data rate is doubled ($C_2 = 2 \times C_1$).

b. When the SNR is doubled, the data rate increases slightly. We can say that, approximately, ($C_2 = C_1 + 1$).

45. We have

$$\mathbf{transmission\ time = (packet\ length)/(bandwidth) =}$$
$$\mathbf{(8{,}000{,}000\ bits) / (200{,}000\ bps) = 40\ s}$$

47.

a. Number of bits = bandwidth × delay = 1 Mbps × 2 ms = **2000 bits**

b. Number of bits = bandwidth × delay = 10 Mbps × 2 ms = **20,000 bits**

c. Number of bits = bandwidth × delay = 100 Mbps × 2 ms = **200,000 bits**