

EE 302 PS 23 - SOLUTIONS

Chapter 11

Questions: 23, 24, 42

Problems: None

Critical Thinking: None

Additional Problems: 1-3

Question 23

Transmission speed (baud rate in symbols per second) and the number of coding levels (bits per symbol).

Question 24

True. Multilevel or multisymbol coding schemes permit more data to be transmitted in less time, assuming a constant symbol interval.

Question 42

For 16 distinct phases, each phase shift represents a combination of **four bits**:

$$\log_2 16 = 4$$

Additional Problem 1

1.a.

$$C = 2B = 2 \times 10,000 = 20 \text{ kbps}$$

1.b.

$$C = B \log_2(1 + \text{SNR}) = (10,000 \text{ Hz}) \log_2(1 + 10^{30/10}) = 99.672 \text{ kbps}$$

1.c.

$$C = 2B \log_2 N \longrightarrow N = 2^{\frac{C}{2B}} = 2^{\frac{99.672}{20000}} = 31.638 \longrightarrow N = 32 \text{ states}$$

For N states or symbols, there are $\log_2 N = \log_2 32 = 5$ bits per symbol.

1.d. First, determine the required capacity C . We need to transmit samples that occur at 44.1 kHz, each represented by a string of 16 bits:

$$C = \left(\frac{44,100 \text{ samples}}{1 \text{ s}} \right) \left(\frac{16 \text{ bits}}{1 \text{ sample}} \right) = 705,600 \text{ bits/s} = 705.6 \text{ kbps}$$

Now determine required bandwidth:

$$C = B \log_2(1 + \text{SNR}) \longrightarrow B = \frac{C}{\log_2(1 + \text{SNR})} = \frac{705.6 \text{ kbps}}{\log_2(1 + 10^{30/10})} = 70.792 \text{ kHz}$$

Now solve for the required number of states S given C and B :

$$C = 2B \log_2 S \longrightarrow S = 2^{\frac{C}{2B}} = 2^{\frac{705,600}{2 \times 70,792}} = 31.638 \longrightarrow S = 32 \text{ states}$$

Additional Problem 2

2.a. See Figure 1.

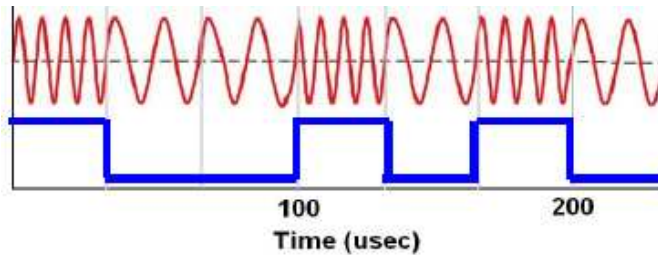


FIGURE 1. The FSK signal (red) with the corresponding digital waveform (blue) for Additional Problem 2.a.

2.b.

$$\frac{7 \text{ bits}}{233.3 \mu\text{s}} = 30042.9 \text{ bps} = 30 \text{ kbps}$$

2.c.

$$N = \log_2 S = \log_2 4 = 2 \text{ bits per symbol}$$

Additional Problem 3

3.a.

$$T = \frac{1}{f_B} = \frac{1}{150 \text{ bps}} = 6.6\bar{6} \text{ ms/bit}$$

3.b.

$$m = \Delta f \cdot T = (f_{\text{mark}} - f_{\text{space}})T = (200 \text{ Hz})(6.6\bar{6} \text{ ms/bit}) = 1.3\bar{3}$$

3.c.

$$BW = 2(f_B + \Delta f) = 2(150 \text{ bps} + 200 \text{ Hz}) = 700 \text{ Hz}$$

3.d.

$$BW = 2(f_B + \Delta f) = 2(300 \text{ bps} + 200 \text{ Hz}) = 1000 \text{ Hz}$$