Problem 1. ‘Z’ is 0x5A in hex, or in binary, 0101 1010

Problem 2.

a.

b. 3 bits take 100 μsec, so \( T_b = 33.333 \) μsec, and \( R_b = 1/T_b = 30 \text{ kbps} \)

c. \( N = \log_2 M = \log_2 4 = 2 \)

Problem 3.

a. 11010010

b. 4 bits take 10 msec, so \( T_b = 2.5 \) msec, and \( R_b = 1/T_b = 400 \text{ bps} \)

c. \( \text{BW} = 2 R_b = 800 \text{ Hz} \)

Problem 4. Amplitude Shift Keying and Phase Shift Keying

Problem 5.

a. ASK because there are 2 different amplitudes of the carrier (it is actually it is OOK with noise in the signal)

b. \( T_b = 496 \) μsec, and \( R_b = 1/T_b = 2016 \text{ bps} \)

c. 0 111 0 111 0 111 0 111 0 111 0 111 0 111 0 111 0 111 0
Problem 6.

a. \( N = \log_2 M = \log_2 16 = 4 \)

b. Two possible constellations:

c. One possible constellation:

\[ \text{BW} = 2 \frac{R_b}{N} = 2 \left( \frac{1.2 \times 10^6}{4} \right) = 600 \text{ kHz} \]

Problem 7

Advantage: lower bandwidth required to transmit a given bit rate, or if bandwidth is fixed, you can transmit a higher bit rate

Disadvantage: Symbols are closer together making errors in decoding more likely. Also, system is more complex.

Problem 8.

a. FSK, with frequency deviation 200 kHz. \( \text{BW} = 2 (\Delta f + R_b) = 2 (200 \times 10^3 + 100 \times 10^3) = 600 \text{ kHz} \)

b. OOK. \( \text{BW} = 2 R_b / N = 2 \left( \frac{100 \times 10^3}{1} \right) = 200 \text{ kHz} \)

c. QPSK. \( \text{BW} = 2 R_b / N = 2 \left( \frac{100 \times 10^3}{2} \right) = 100 \text{ kHz} \)

d. 16-PSK. \( \text{BW} = 2 R_b / N = 2 \left( \frac{100 \times 10^3}{4} \right) = 50 \text{ kHz} \)

e. 16-QAM. \( \text{BW} = 2 R_b / N = 2 \left( \frac{100 \times 10^3}{4} \right) = 50 \text{ kHz} \)

f. 512-QAM. \( \text{BW} = 2 R_b / N = 2 \left( \frac{100 \times 10^3}{9} \right) = 22.2 \text{ kHz} \) (Note: \( N = \log_2 M = \log_2 512 = 9 \))

Problem 9

For this problem, bandwidth = 1.3 MHz – 1.2 MHz = 100 kHz

a. FSK, with \( f_{mark} = 1.27 \) MHz and \( f_{space} = 1.23 \) MHz.

For FSK, \( \text{BW} = f_{mark} - f_{space} + 2 R_b \), so \( R_b = (\text{BW} - (f_{mark} - f_{space})) / 2 \)

\( R_b = (100 \times 10^3 - (1.27 \times 10^6 - 1.23 \times 10^6)) / 2 = 30 \text{ kbps} \)

For the following modulation types, \( \text{BW} = 2 R_b / N \), so \( R_b = N \times \text{BW} / 2 \)

b. ASK. \( R_b = N \times \text{BW} / 2 = 1 \times 100 \times 10^3 / 2 = 50 \text{ kbps} \)

c. BPSK. \( R_b = N \times \text{BW} / 2 = 1 \times 100 \times 10^3 / 2 = 50 \text{ kbps} \)

d. 8-PSK. \( R_b = N \times \text{BW} / 2 = 3 \times 100 \times 10^3 / 2 = 150 \text{ kbps} \) (Note: \( N = \log_2 M = \log_2 8 = 3 \))

e. 32-QAM. \( R_b = N \times \text{BW} / 2 = 5 \times 100 \times 10^3 / 2 = 250 \text{ kbps} \) (Note: \( N = \log_2 M = \log_2 32 = 5 \))

f. 256-QAM. \( R_b = N \times \text{BW} / 2 = 8 \times 100 \times 10^3 / 2 = 400 \text{ kbps} \) (Note: \( N = \log_2 M = \log_2 256 = 8 \))