Problem 6.15

The codeword consists of $\log_2(128) = 7$ bits. With an additional bit added for synchronization, the overall codeword consists of 8 bits. The method of data transmission is quaternary (i.e., 4-level) PAM, and the roll-off factor $\alpha = 1$.

(a) For binary PAM, the signaling rate is defined by (see Eqs. (6.13) and (6.21))

$$\frac{1}{T_b} = \frac{2B_T}{1+\alpha} \tag{1}$$

For $\alpha = 1$ and $B_T = 13$ kHz, the use of Eq. (1) yields

$$\begin{aligned}\frac{1}{T_b} &= \frac{2 \times 13}{1+1} \\ &= 13 \text{ kilobits/s}\end{aligned}$$

The signaling rate of the quaternary PAM system is therefore

$$\begin{aligned}\frac{1}{T} &= \frac{\log_2 4}{T_b} \\ &= 2 \times 13 \text{ kilosymbols/s}\end{aligned}$$

(b) Each element of the overall codeword of the PCM signal must fit into the bit duration

$$\begin{aligned}T_b &= \frac{1}{13 \times 10^3} \text{seconds} \\ &= 77 \ \mu\text{s}\end{aligned}$$

With each code-word consisting of 8 bits, the code-word occupies the duration

$$\begin{aligned}T_s &= 8T_b \\ &= 8 \times 77 = 616 \ \mu\text{s}\end{aligned}$$

The sampling rate applied to the analog signal is therefore

$$\begin{aligned}f_s &= \frac{1}{T_s} \\ &= \frac{10^6}{616} \text{Hz} \\ &= 162 \text{ kHz}\end{aligned}$$

The highest frequency component of the analog signal is therefore

$$W = \frac{f_s}{2} = 81 \text{ kHz}$$