Problem 3.5

The spectrum of the flat-top pulses is given by

\[ H(f) = T \text{sinc} (fT) \exp(-j\pi fT) \]

\[ = 10^{-4} \text{sinc} (10^{-4} f) \exp(-j\pi f 10^{-4}) \]

Let \( s(t) \) denote the sequence of flat-top pulses:

\[ s(t) = \sum_{n=-\infty}^{\infty} m(nT_s) h(t - nT_s) \]

The spectrum \( S(f) = F[s(t)] \) is as follows:

\[ S(f) = f_s \sum_{k=-\infty}^{\infty} M(f - kf_s) H(f) \]

\[ = f_s H(f) \sum_{k=-\infty}^{\infty} M(f - kf_s) \]

The magnitude spectrum \( |S(f)| \) is thus as shown in Fig. 1c.
$1/T = 10,000\text{Hz}$

$f_s = 1,000\text{Hz}$

$W = 400\text{Hz}$

Figure 1
Problem 3.14

(a) +A
   0
   -A
(b) +A
   0
   -A
(c) +A
   0
   -A
(d) +A
   0
   -A
(e) +A
   0
   -A

Time t
Problem 3.18

(a) Let the message bandwidth be \( W \). Then, sampling the message signal at its Nyquist rate, and using an \( R \)-bit code to represent each sample of the message signal, we find that the bit duration is

\[
T_b = \frac{T_s}{R} = \frac{1}{2WR}
\]

The bit rate is

\[
\frac{1}{T_b} = 2WR
\]

The maximum value of message bandwidth is therefore

\[
W_{\text{max}} = \frac{50 \times 10^6}{2 \times 7}
\]

\[
= 3.57 \times 10^6 \text{ Hz}
\]

(b) The output signal-to-quantizing noise ratio is given by (see Example 2):

\[
10 \log_{10}(\text{SNR})_0 = 1.8 + 6R
\]

\[
= 1.8 + 6 \times 7
\]

\[
= 43.8 \text{ dB}
\]
4. Problem 3.13

(a)

(b)

\[ S(t) = \cos \left( \frac{\pi t}{T_b} \right) \quad I \left[ -\frac{T_b}{2}, \frac{T_b}{2} \right] \]

\[ \text{where } I \left[ -\frac{T_b}{2}, \frac{T_b}{2} \right] = \begin{cases} 1 & -\frac{T_b}{2} \leq t \leq \frac{T_b}{2} \\ 0 & \text{otherwise} \end{cases} \]

\[ \mathcal{F} \quad T_b \cdot \text{sinc} \left( f T_b \right) \]

\[ I \left[ -\frac{T_b}{2}, \frac{T_b}{2} \right] = \frac{T_b}{2} \left( \text{sinc} \left( T_b \left( f - \frac{1}{2T_b} \right) \right) + \text{sinc} \left( T_b \left( f + \frac{1}{2T_b} \right) \right) \right) \]

Power spectral density:

\[ G_n(f) = \frac{1}{T_b} \left| S(f) \right|^2 \]

\[ = \frac{T_b}{4} \left[ \text{sinc}^2 \left( T_b \left( f - \frac{1}{2T_b} \right) \right) + \text{sinc}^2 \left( T_b \left( f + \frac{1}{2T_b} \right) \right) + 2 \text{sinc} \left( T_b \left( f - \frac{1}{2T_b} \right) \right) \text{sinc} \left( T_b \left( f + \frac{1}{2T_b} \right) \right) \right] \]
When using rectangular pulse, there is a significant DC component. When using cosine pulse, the energy at DC has been shifted to the frequencies $\pm \frac{1}{2T_b}$. 

\[ S(f) = A^2 T_b \text{sinc}^2 (f T_b) \]