6.1-3 The pulse train is a periodic signal with fundamental frequency $2B$ Hz. Hence, $\omega_s = 2\pi(2B) = 4\pi B$. The period is $T_0 = 1/2B$. It is an even function of $t$. Hence, the Fourier series for the pulse train can be expressed as

$$p_{T}(t) = C_0 + \sum_{n=1}^{\infty} C_n \cos n\omega_st$$

Using Eqs. (2.72), we obtain

$$a_0 = C_0 = \frac{1}{T_0} \int_{-1/16B}^{1/16B} dt = \frac{1}{4} \quad a_n = C_n = \frac{2}{T_0} \int_{-1/16B}^{1/16B} \cos n\omega_st \ dt = \frac{2}{n\pi} \sin \left( \frac{n\pi}{4} \right), \quad b_n = 0$$

Hence,

$$y(t) = g(t)p_{T}(t) = \frac{1}{4} g(t) + \sum_{n=1}^{\infty} \frac{2}{n\pi} \sin \left( \frac{n\pi}{4} \right) g(t) \cos n\omega_st$$

6.1-6 (a) When the input to this filter is $\delta(t)$, the output of the summer is $\delta(t) - \delta(t - T)$. This acts as the input to the integrator. And, $h(t)$, the output of the integrator is:

$$h(t) = \int_{0}^{t} [\delta(\tau) - \delta(\tau - T)] \ d\tau = u(t) - u(t - T) = \text{rect} \left( \frac{t - \frac{t}{2}}{T} \right)$$

The impulse response $h(t)$ is shown in Fig. S6.1-6a.

(b) The transfer function of this circuit is:

$$H(\omega) = T \text{sinc} \left( \frac{\omega T}{2} \right) e^{-j\omega T/2}$$

and

$$|H(\omega)| = T \left| \text{sinc} \left( \frac{\omega T}{2} \right) \right|$$

The amplitude response of the filter is shown in Fig. S6.1-6b. Observe that the filter is a lowpass filter of bandwidth $2\pi/T$ rad/s or $1/T$ Hz.

The impulse response of the circuit is a rectangular pulse. When a sampled signal is applied at the input, each sample generates a rectangular pulse at the output, proportional to the corresponding sample value. Hence the output is a staircase approximation of the input as shown in Fig. S6.1-6c.

Figure S6.1-6

6.2-3

(a) The Nyquist rate is $2 \times 4.5 \times 10^6 = 9$ MHz. The actual sampling rate $= 1.2 \times 9 = 10.8$ MHz.

(b) $1024 = 2^{10}$, so that 10 bits or binary pulses are needed to encode each sample.

(c) $10.8 \times 10^6 \times 10 = 108 \times 10^6$ or 108 Mbits/s.

6.2-5 Nyquist rate for each signal is 200 Hz.

The sampling rate $f_s = 2 \times$ Nyquist rate $= 400$ Hz

Total number of samples for 10 signals $= 400 \times 10 = 4000$ samples/second.

Quantization error \( \leq \frac{1}{100} = 0.01 \)

Moreover, quantization error $\leq \frac{\Delta u}{2L} = \frac{2\Delta u}{L} \Rightarrow \frac{\Delta u}{L} = \frac{\Delta u}{400} \Rightarrow L = 400$

Because $L$ is a power of 2, we select $L = 512 = 2^9$, that is, 9 bits/sample.

Therefore, the minimum bit rate $= 9 \times 4000 = 36$ kbits/second.

The minimum cable bandwidth is $36/2 = 18$ kHz.

6.2-8 Here $\mu = 100$ and the SNR $= 45$ dB $= 31,622.77$. From Eq. (6.18)

$$\frac{S_0}{N_0} = \frac{3L^2}{(\ln 10)^2} = 31,622.77 \implies L = 473.83$$

Because $L$ is a power of 2, we select $L = 512 = 2^9$. The SNR for this value of $L$ is

$$\frac{S_0}{N_0} = \frac{3(512)^2}{(\ln 10)^2} = 36922.84 = 45.67 \text{ dB}$$