

4.39. The system shown in Figure P4.39-1 approximately interpolates the sequence  $x[n]$  by a factor  $L$ . Suppose that the linear filter has impulse response  $h[n]$  such that  $h[n] = h[-n]$  and  $h[n] = 0$  for  $|n| > (RL - 1)$ , where  $R$  and  $L$  are integers; i.e., the impulse response is symmetric and of length  $(2RL - 1)$  samples.

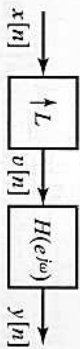


Figure P4.39-1

- (a) In answering the following, do not be concerned about the causality of the system; it can be made causal by including some delay. Specifically, how much delay must be inserted to make the system causal?
- (b) What conditions must be satisfied by  $h[n]$  in order that  $y[n] = x[n/L]$  for  $n = 0, \pm L, \pm 2L, \pm 3L, \dots$ ?
- (c) By exploiting the symmetry of the impulse response, show that each sample of  $y[n]$  can be computed with no more than  $RL$  multiplications.
- (d) By taking advantage of the fact that multiplications by zero need not be done, show that only  $2R$  multiplications per output sample are required.

4.40. In the system of Figure P4.40-1,

$$X_c(j\Omega) = 0, \quad |\Omega| \geq \pi/T,$$

and

$$H(e^{j\omega}) = \begin{cases} e^{-j\omega}, & |\omega| < \pi/L, \\ 0, & \pi/L < |\omega| \leq \pi. \end{cases}$$

How is  $y[n]$  related to the input signal  $x_c(t)$ ?

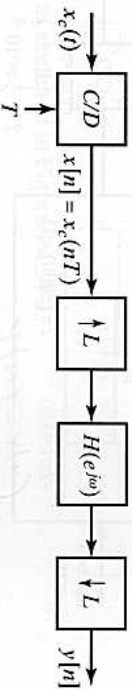


Figure P4.40-1

4.41. Consider the system shown in Figure P4.41-1. The input to this system is the bandlimited signal whose Fourier transform is shown in Figure P4.20-1 with  $\Omega_0 = \pi/T$ . The discrete-time LTI system in Figure P4.41-1 has the frequency response shown in Figure P4.41-2.

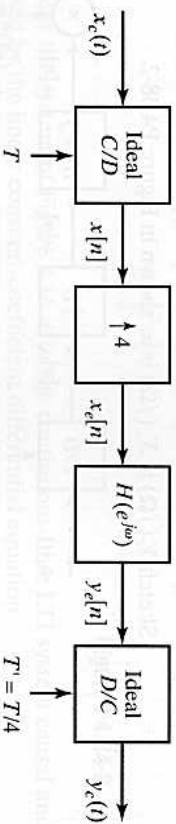
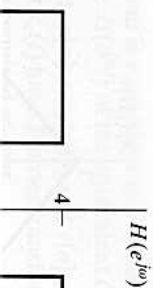


Figure P4.41-1



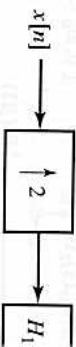
(a) Sketch the Fourier transforms  $X_c(e^{j\omega})$  and  $X_c'(e^{j\omega})$ . For the general case when  $X_c(j\Omega) = X_c'(j\Omega)$  Also, give a general expression for  $y_c(t)$  limited in this manner.

4.42. Let  $x_c(t)$  be a real-valued continuous-time signal with Fourier transform  $X_c(j\Omega)$ . Let  $y_c(t) = x_c(t)$  for  $|t| \leq 1$  and  $y_c(t) = 0$  for  $|t| > 1$ . Let  $y[n]$  be the sequence of samples of  $y_c(t)$  at  $t = nT$ . Let  $y_c(t)$  be the reconstructed signal from  $y[n]$  using a single LTI system with frequency response  $H_1(e^{j\omega})$ .

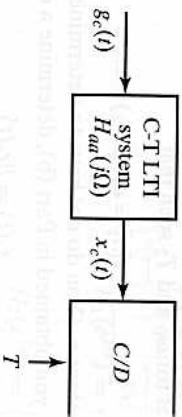
(a) If  $x[n] = x_c(n/500)$ , is it theoretical answer.

(b) If  $y[n] = y_c(n/500)$ , is it theoretical answer.

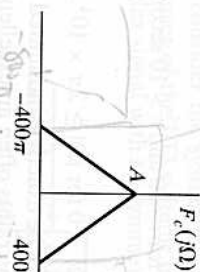
(c) Is it possible to obtain  $y[n]$  from  $x[n]$  using a single LTI system with frequency response  $H_1(e^{j\omega})$ .



4.43. Consider the system shown in Figure P4.43. The input signal  $g_c(t)$  is a real-valued continuous-time signal with Fourier transform  $G_c(j\Omega)$ . The input signal  $e_c(t)$  is a real-valued continuous-time signal with Fourier transform  $E_c(j\Omega)$ . The input signal  $x_c(t)$  is a real-valued continuous-time signal with Fourier transform  $X_c(j\Omega)$ . The input signal  $y_c(t)$  is a real-valued continuous-time signal with Fourier transform  $Y_c(j\Omega)$ . The input signal  $z_c(t)$  is a real-valued continuous-time signal with Fourier transform  $Z_c(j\Omega)$ . The input signal  $w_c(t)$  is a real-valued continuous-time signal with Fourier transform  $W_c(j\Omega)$ . The input signal  $v_c(t)$  is a real-valued continuous-time signal with Fourier transform  $V_c(j\Omega)$ . The input signal  $u_c(t)$  is a real-valued continuous-time signal with Fourier transform  $U_c(j\Omega)$ . The input signal  $t_c(t)$  is a real-valued continuous-time signal with Fourier transform  $T_c(j\Omega)$ . The input signal  $s_c(t)$  is a real-valued continuous-time signal with Fourier transform  $S_c(j\Omega)$ . The input signal  $r_c(t)$  is a real-valued continuous-time signal with Fourier transform  $R_c(j\Omega)$ . The input signal  $q_c(t)$  is a real-valued continuous-time signal with Fourier transform  $Q_c(j\Omega)$ . The input signal  $p_c(t)$  is a real-valued continuous-time signal with Fourier transform  $P_c(j\Omega)$ . The input signal  $o_c(t)$  is a real-valued continuous-time signal with Fourier transform  $O_c(j\Omega)$ . The input signal  $n_c(t)$  is a real-valued continuous-time signal with Fourier transform  $N_c(j\Omega)$ . The input signal  $m_c(t)$  is a real-valued continuous-time signal with Fourier transform  $M_c(j\Omega)$ . The input signal  $l_c(t)$  is a real-valued continuous-time signal with Fourier transform  $L_c(j\Omega)$ . The input signal  $k_c(t)$  is a real-valued continuous-time signal with Fourier transform  $K_c(j\Omega)$ . The input signal  $j_c(t)$  is a real-valued continuous-time signal with Fourier transform  $J_c(j\Omega)$ . The input signal  $i_c(t)$  is a real-valued continuous-time signal with Fourier transform  $I_c(j\Omega)$ . The input signal  $h_c(t)$  is a real-valued continuous-time signal with Fourier transform  $H_c(j\Omega)$ . The input signal  $g_c(t)$  is a real-valued continuous-time signal with Fourier transform  $G_c(j\Omega)$ . The input signal  $f_c(t)$  is a real-valued continuous-time signal with Fourier transform  $F_c(j\Omega)$ . The input signal  $e_c(t)$  is a real-valued continuous-time signal with Fourier transform  $E_c(j\Omega)$ . The input signal  $d_c(t)$  is a real-valued continuous-time signal with Fourier transform  $D_c(j\Omega)$ . The input signal  $c_c(t)$  is a real-valued continuous-time signal with Fourier transform  $C_c(j\Omega)$ . The input signal  $b_c(t)$  is a real-valued continuous-time signal with Fourier transform  $B_c(j\Omega)$ . The input signal  $a_c(t)$  is a real-valued continuous-time signal with Fourier transform  $A_c(j\Omega)$ .



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