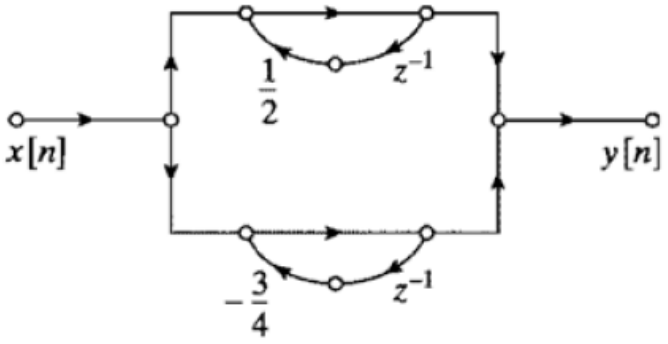
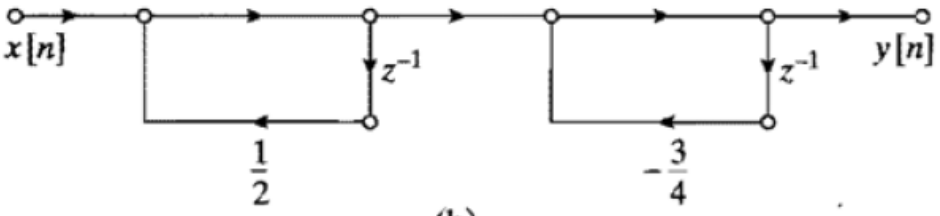
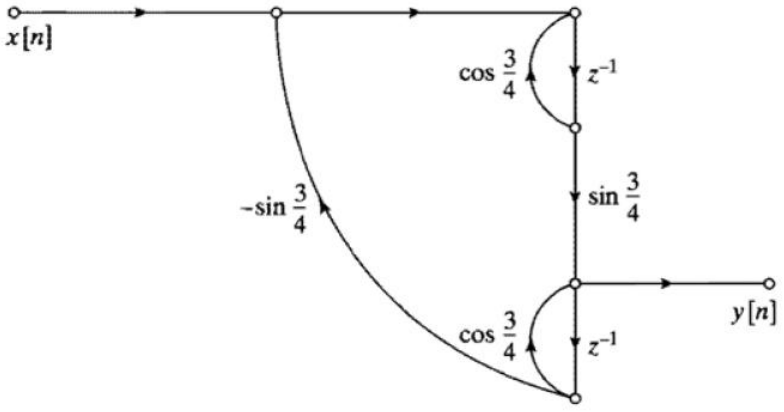
6.3. Figure P6.3 shows six systems. Determine which one of the last five, (b)–(f), has the same system function as (a). You should be able to eliminate some of the possibilities by inspection.



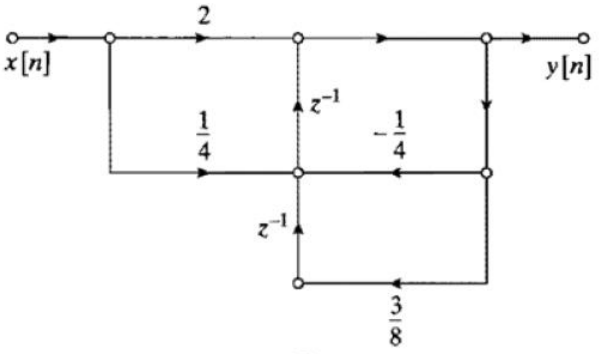
(a)



(b)

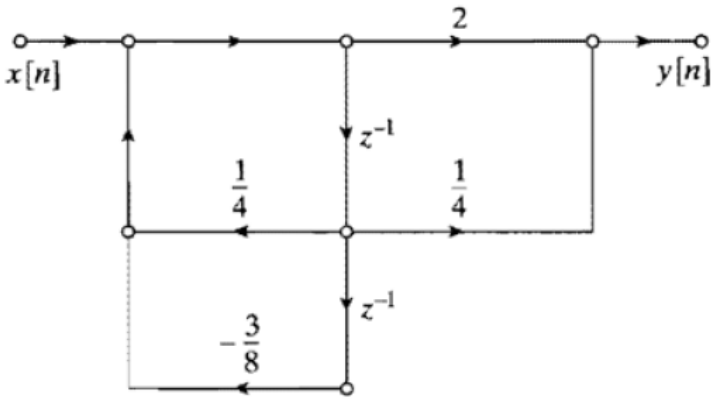


(c)

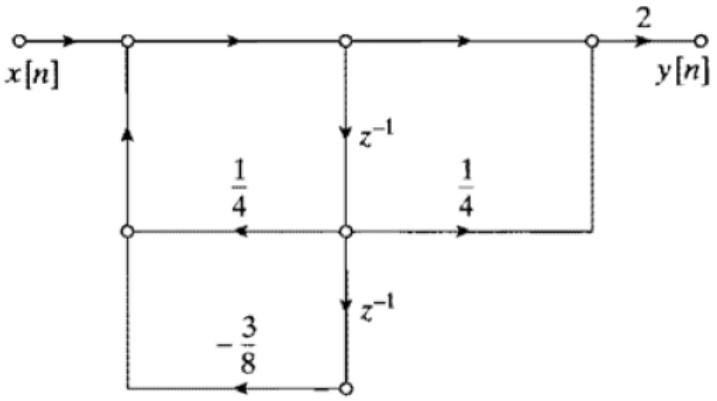


(d)

Figure P6.3



(e)



(f)

Figure P6.3 *(continued)*

6.5. An LTI system is realized by the flow graph shown in Figure P6.5.

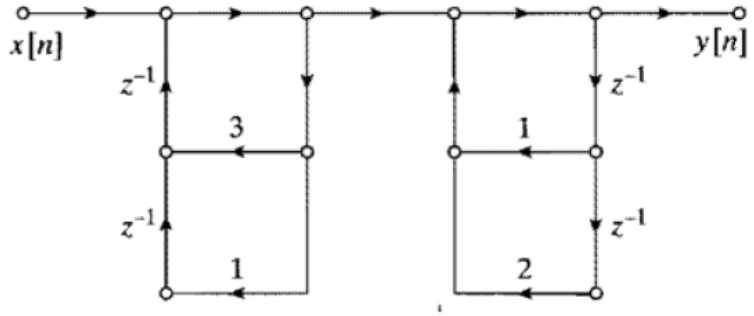


Figure P6.5

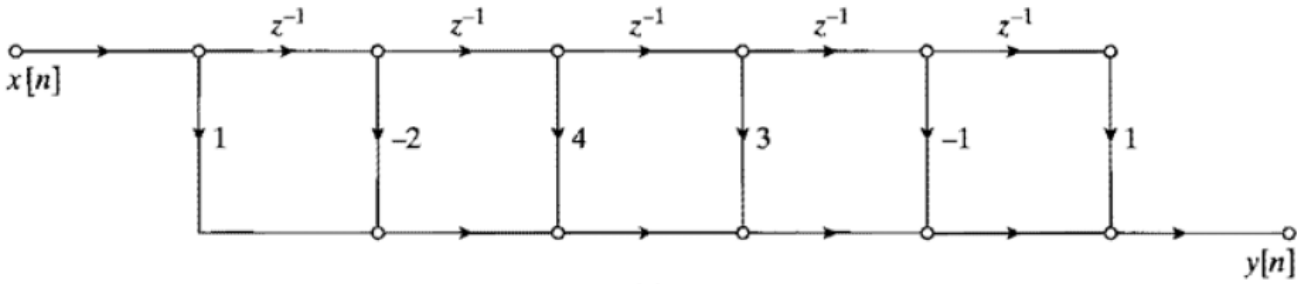
(a) Write the difference equation relating $x[n]$ and $y[n]$ for this flow graph.

(b) What is the system function of the system?

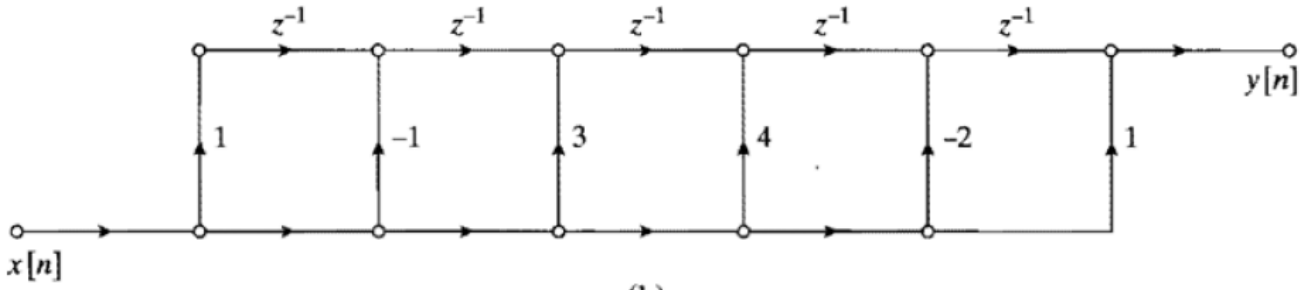
(c) In the realization of Figure P6.5, how many real multiplications and real additions are required to compute each sample of the output? (Assume that $x[n]$ is real, and assume that multiplication by 1 does not count in the total.)

(d) The realization of Figure P6.5 requires four storage registers (delay elements). Is it possible to reduce the number of storage registers by using a different structure? If so, draw the flow graph; if not, explain why the number of storage registers cannot be reduced.

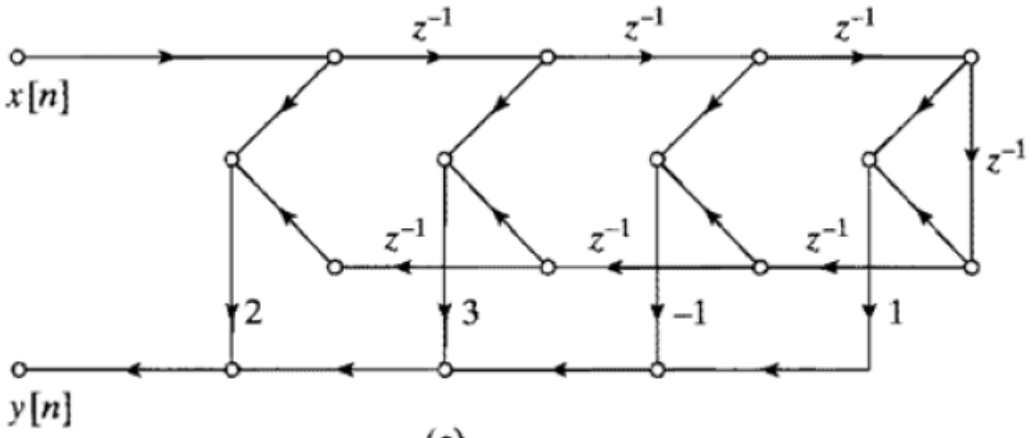
6.6. Determine the impulse response of each of the systems in Figure P6.6.



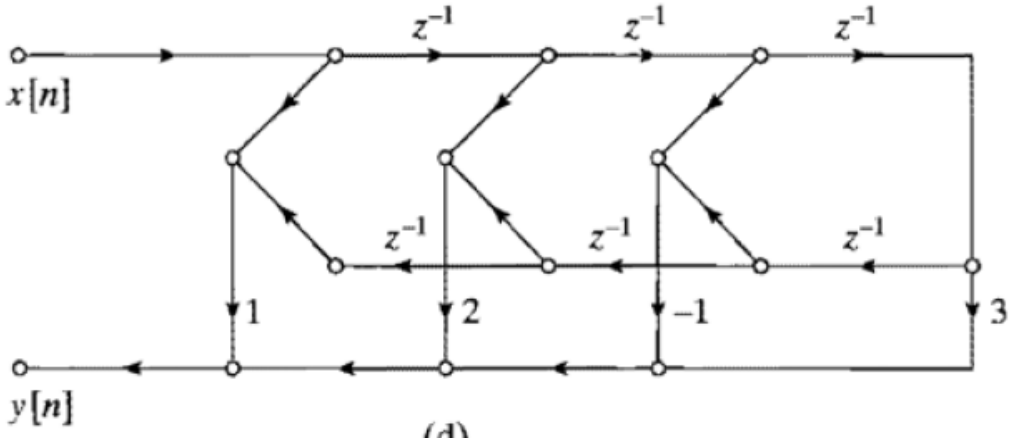
(a)



(b)



(c)



(d)

Figure P6.6

6.12. For the LTI system described by the flow graph in Figure P6.12, determine the difference equation relating the input $x[n]$ to the output $y[n]$.

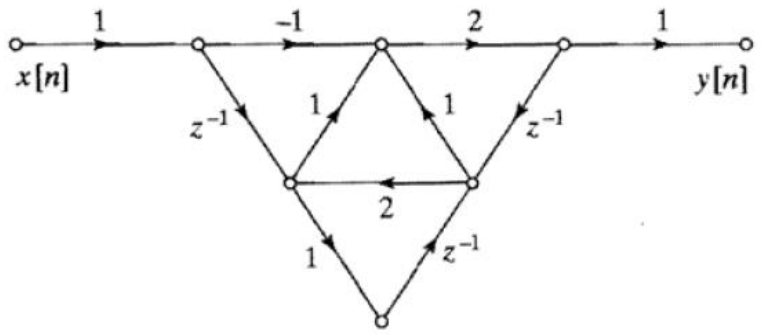


Figure P6.12

6.19. Consider the causal LTI system with the system function

$$H(z) = \frac{2 - \frac{8}{3}z^{-1} - 2z^{-2}}{\left(1 - \frac{1}{3}z^{-1}\right)\left(1 + \frac{2}{3}z^{-1}\right)}.$$

Draw a signal flow graph that implements this system as a parallel combination of 1st-order transposed direct form II sections.

6.21. For many applications, it is useful to have a system that will generate a sinusoidal sequence. One possible way to do this is with a system whose impulse response is $h[n] = e^{j\omega_0 n}u[n]$. The real and imaginary parts of $h[n]$ are therefore $h_r[n] = (\cos\omega_0 n)u[n]$ and $h_i[n] = (\sin\omega_0 n)u[n]$, respectively.

In implementing a system with a complex impulse response, the real and imaginary parts are distinguished as separate outputs. By first writing the complex difference equation required to produce the desired impulse response and then separating it into its real and imaginary parts, draw a flow graph that will implement this system. The flow graph that you draw should have only real coefficients. This implementation is sometimes called the *coupled form oscillator,* since, when the input is excited by an impulse, the outputs are sinusoidal.

6.26. Consider a causal linear time-invariant system whose system function is

$$H(z) = \frac{1 - \frac{1}{5}z^{-1}}{\left(1 - \frac{1}{2}z^{-1} + \frac{1}{3}z^{-2}\right)\left(1 + \frac{1}{4}z^{-1}\right)}.$$

(a) Draw the signal flow graphs for implementations of the system in each of the following forms:

(i) Direct form I
(ii) Direct form II
(iii) Cascade form using first- and second-order direct form II sections
(iv) Parallel form using first- and second-order direct form II sections
(v) Transposed direct form II

(b) Write the difference equations for the flow graph of (v) in Part (a), and show that this system has the correct system function.

6.32. The flow graph shown in Figure P6.32 is an implementation of a causal, LTI system.

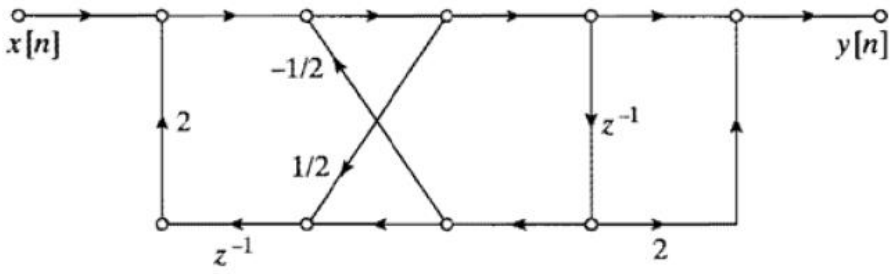


Figure P6.32

(a) Draw the transpose of the signal flow graph.
(b) For either the original system or its transpose, determine the difference equation relating the input $x[n]$ to the output $y[n]$. (*Note:* The difference equations will be the same for both structures.)
(c) Is the system BIBO stable?
(d) Determine $y[2]$ if $x[n] = (1/2)^n u[n]$.

6.38. The impulse response of an LTI system is

$$h[n] = \begin{cases} a^n, & 0 \le n \le 7, \\ 0, & \text{otherwise.} \end{cases}$$

(a) Draw the flow graph of a direct form nonrecursive implementation of the system.
(b) Show that the corresponding system function can be expressed as

$$H(z) = \frac{1 - a^8 z^{-8}}{1 - az^{-1}}, \quad |z| > |a|.$$

(c) Draw the flow graph of an implementation of $H(z)$, as expressed in part (b), corresponding to a cascade of an FIR system (numerator) with an IIR system (denominator).
(d) Is the implementation in part (c) recursive or nonrecursive? Is the overall system FIR or IIR?