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1. A discrete-time system with system function
(20%) $H(z) = h[0] + h[1]z^{-1} + h[2]z^{-2} + \cdots + h[12]z^{-12}$
sketch the block diagram for (a) symmetric coefficients (Type I) (b) antisymmetric coefficients (Type III).

A discrete-time system with system function
$H(z) = h[0] + h[1]z^{-1} + h[2]z^{-2} + \cdots + h[13]z^{-11}$
sketch the block diagram for (c) symmetric coefficients (Type II) (d) antisymmetric coefficients (Type IV).

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2. For the decimation system ($M=4$).

(10%) $\rightarrow\boxed{H(z)}\rightarrow\boxed{\downarrow M}\rightarrow$ $H(z)$: $h_0, h_1, h_2, \cdots, h_{19}, h_{20}$

sketch the block diagram for the implementation after applying the identity in Fig 4.31 or Fig. 4.32. (in detail, delay oriented)

3. For the interpolation system ($L=3$),

(10%) $\rightarrow\boxed{\uparrow L}\rightarrow\boxed{H(z)}\rightarrow$ $H(z)$: $h_0, h_1, h_2, \cdots, h_{19}, h_{20}$

repeat 2.

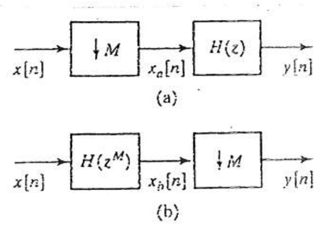

Figure 4.31 Two equivalent systems based on downsampling identities.

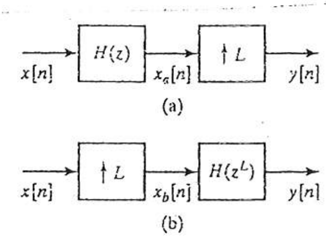

Figure 4.32 Two equivalent systems based on upsampling identities.

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6. Following 5, sketch the delay oriented block diagram in detail if (15%)

$H_0(z)$: $h_0\ h_1\ h_2\ h_3\ h_4\ h_5\ h_6\ h_6\ h_5\ h_4\ h_3\ h_2\ h_1\ h_0$.

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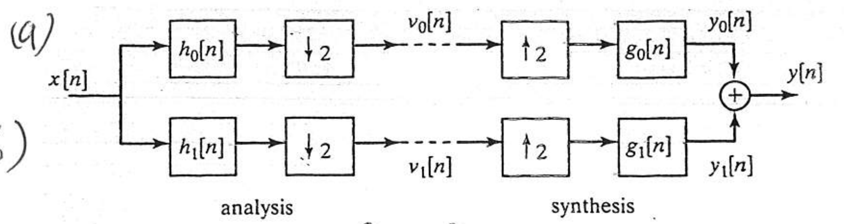
4. Describe the algorithm for the design of IIR allpass filters:

(15%) $$H(Z)=\frac{\sum_{n=0}^{N} a(N-n)Z^{-n}}{\sum_{n=0}^{N} a(n)Z^{-n}}$$

5. (a)

(5%)



For the two-channel filter bank, find $Y(e^{j\omega})$ in terms of $X(e^{j\omega})$.

(b) Find the condition for perfect reconstruction.

(2%)

(c) This condition is called the *alias cancellation condition*. One set of conditions that satisfy
is

(3%)

$$\text{(c1)} \quad \Longleftrightarrow H_1(e^{j\omega}) = H_0(e^{j(\omega-\pi)}) \tag{4.113a}$$

$$\text{(c2)} \quad \Longleftrightarrow G_0(e^{j\omega}) = 2H_0(e^{j\omega}) \tag{4.113b}$$

$$\text{(c3)} \quad \Longleftrightarrow G_1(e^{j\omega}) = -2H_0(e^{j(\omega-\pi)}). \tag{4.113c}$$

(c1):

(c2):

(c3):

The filters $h_0[n]$ and $h_1[n]$ are termed *quadrature mirror filters* since Eq. (4.113a) imposes mirror symmetry about $\omega = \pi/2$. Substituting these relations into Eq. (4.111a) leads to the relation

$$Y(e^{j\omega}) = \left[H_0^2(e^{j\omega}) - H_0^2(e^{j(\omega-\pi)})\right] X(e^{j\omega}), \tag{4.114}$$

(c4):

from which it follows that perfect reconstruction (with possible delay of M samples) requires

(c4) (4.115)

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7. Describe and derive the decimation-in-time FFT algorithm. (15%)

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8. Describe and derive the decimation-in-frequency FFT algorithm. (15%)