ECE 615 CMOS Mixed Signal

BOISE STATE UNIVERSITY

Lecture 15

Oct. 13 2010

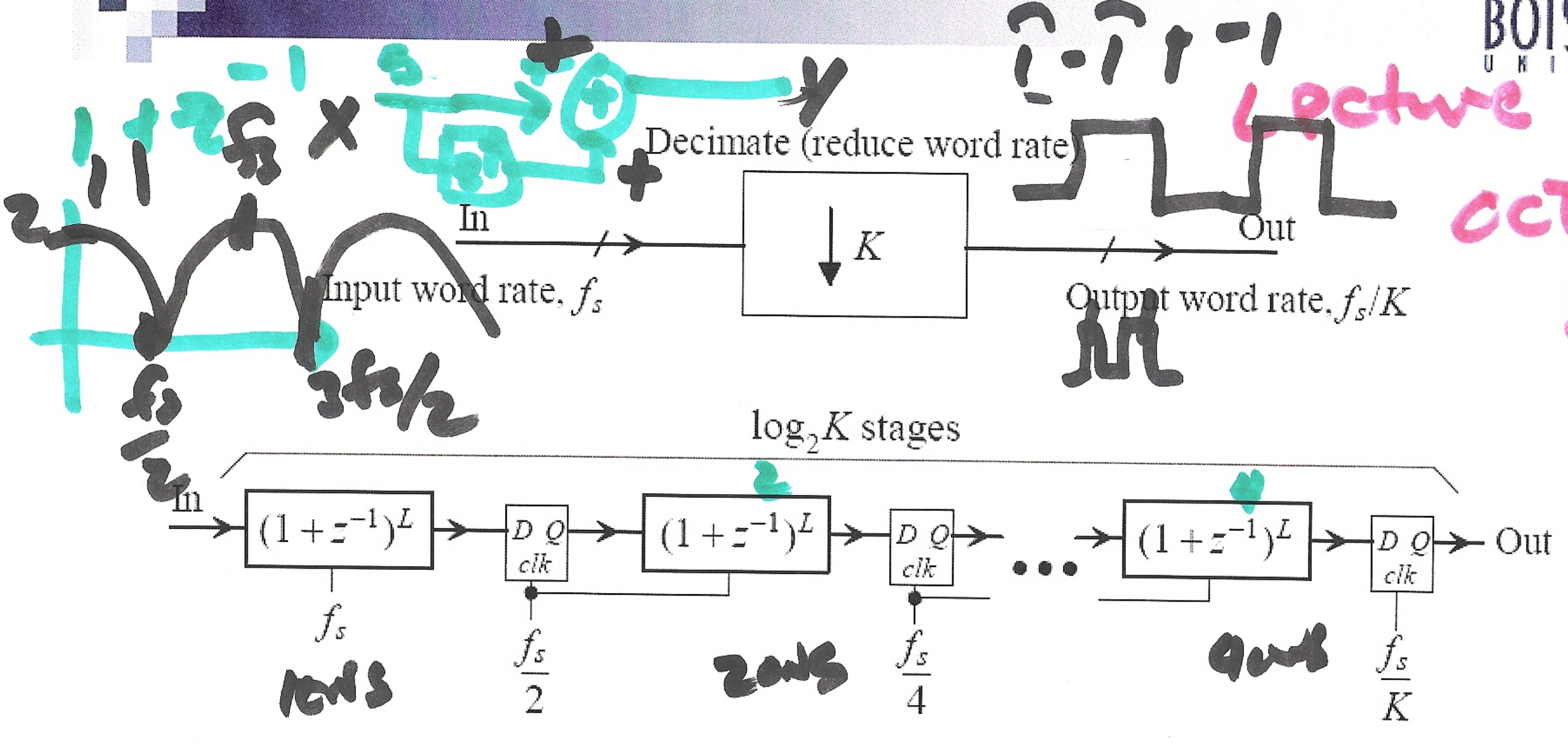
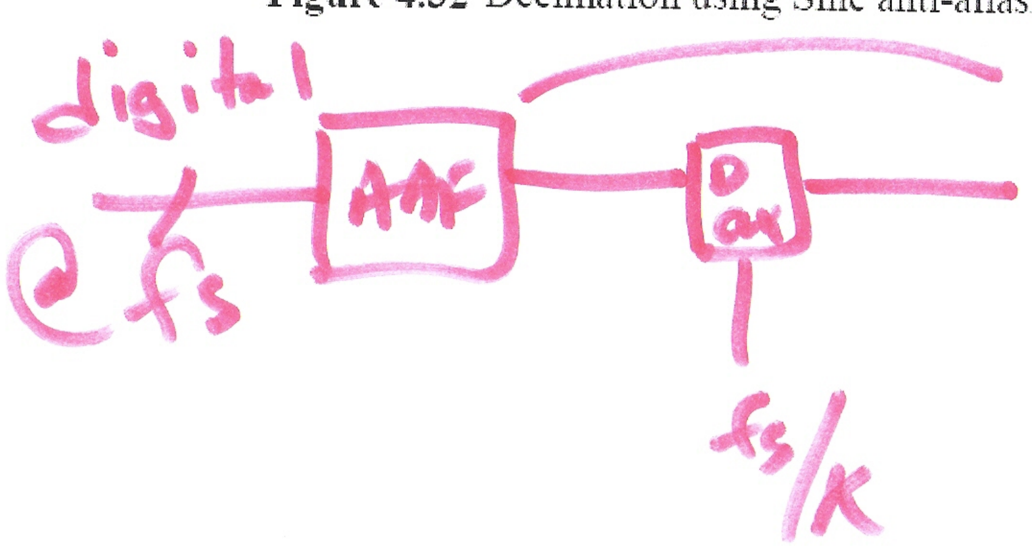


Figure 4.32 Decimation using Sinc anti-aliasing filters.



$$\left(\frac{1-z^{-K}}{1-z^{-1}}\right)^L$$

Sinc filter

1)

$$\left(\frac{1-z^{-K}}{1-z^{-1}}\right)^{L} = \left[\sum_{N=0}^{K-1} z^{-n}\right]^{L} =$$

$$\left[\overset{z^{0}}{1} + z^{-1} + z^{-2} + \ldots z^{1-K}\right]^{L}$$

$$\left[\left((1+z^{-1})(1+z^{-2}) + \ldots (1+z^{-2^{\log_2 K-1}})\right)\right]^{L}$$

$$K=8$$

$$\left[(1+z^{-1})^{L}(1+z^{-2})^{L}(1+z^{-3})^{L}(1+z^{-4})^{L}\right]^{2}$$

2)

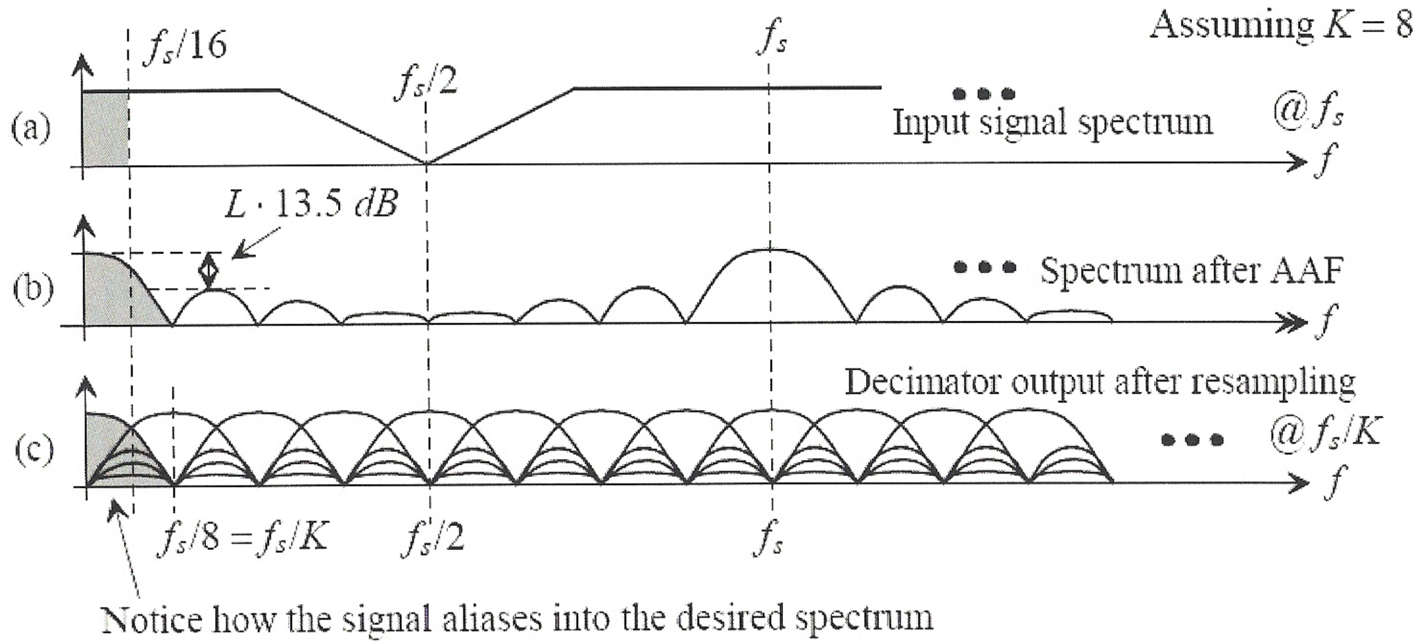


Figure 4.33 Spectrums when decimating and a Sinc anti-aliasing filter used.

3)

Filtering topologies

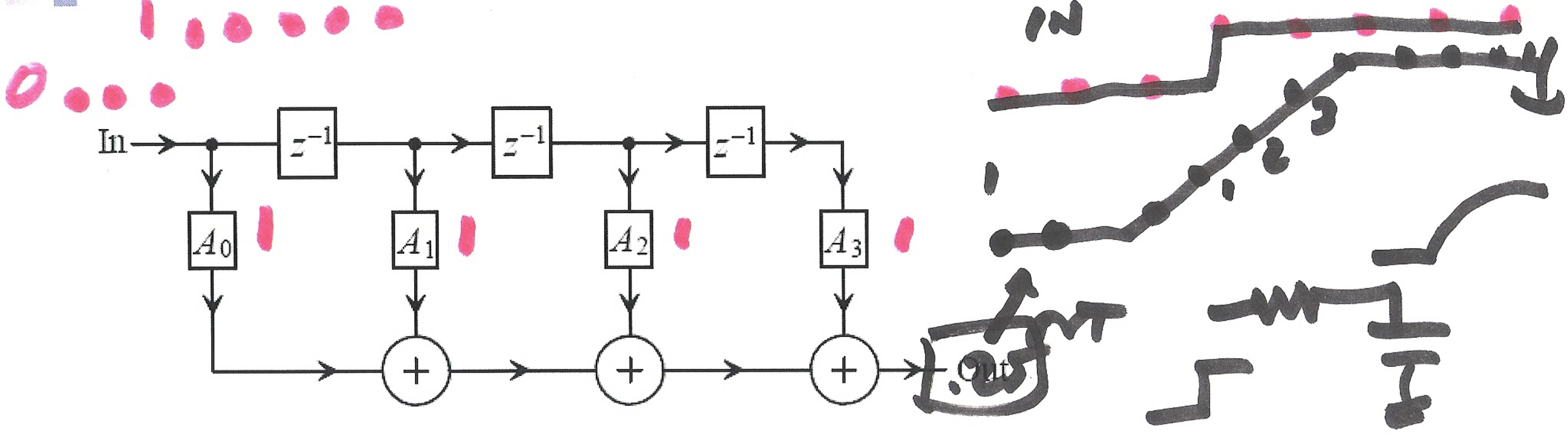


Figure 4.35 A four-stage FIR filter.

$$y = x\left(A_0 + z^{-1} \cdot A_1 + z^{-2} \cdot A_2 + z^{-3} A_3\right)$$

$$\frac{Y}{X} = A_0 + A_1 z^{-1} + A_2 z^{-2} + A_3 z^{-3}$$

4)

$A_0 = A_1 =$
$A_2 = A_3 = 0.25$

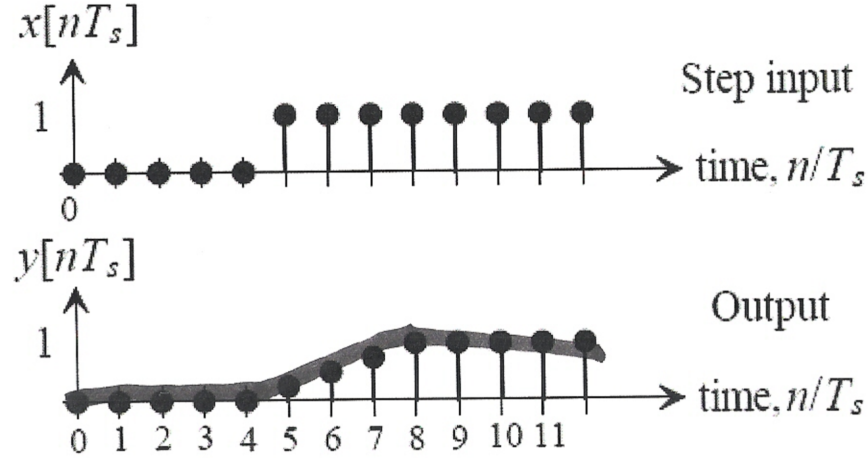
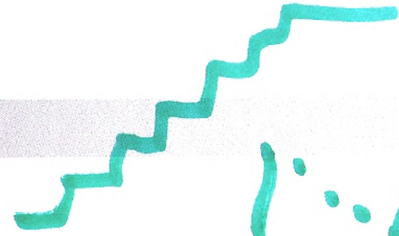
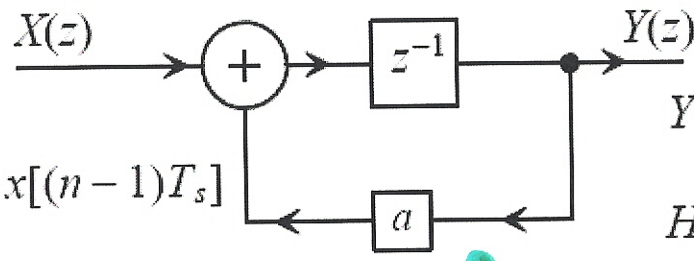


Figure 4.36 Step response of a 4-stage FIR filter with all coefficients set to 0.25.

5)

1 .9 .81 .7 .6 .5 .4





$$y(nT_s) = a \cdot y[(n-1)T_s] + x[(n-1)T_s]$$

$$Y(z) = [aY(z) + X(z)]z^{-1}$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{z^{-1}}{1 - a \cdot z^{-1}}$$

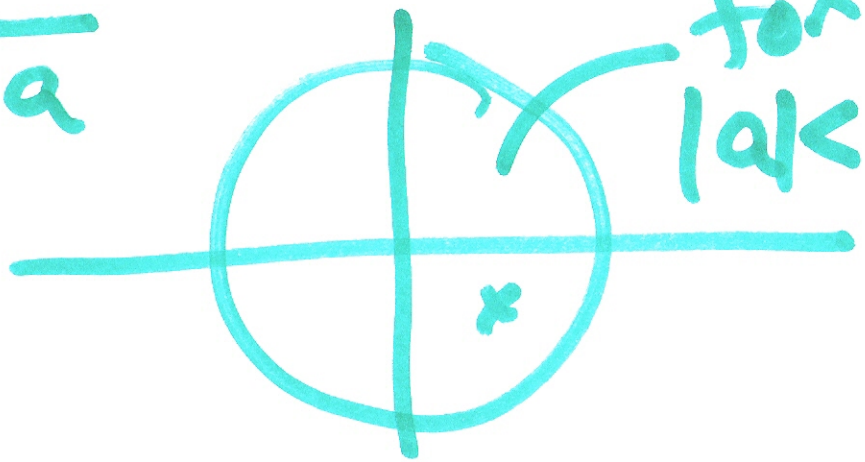
.9

Figure 4.37 A weighted integrating filter.

$$\frac{1}{z-a}$$

stability

$a<1$

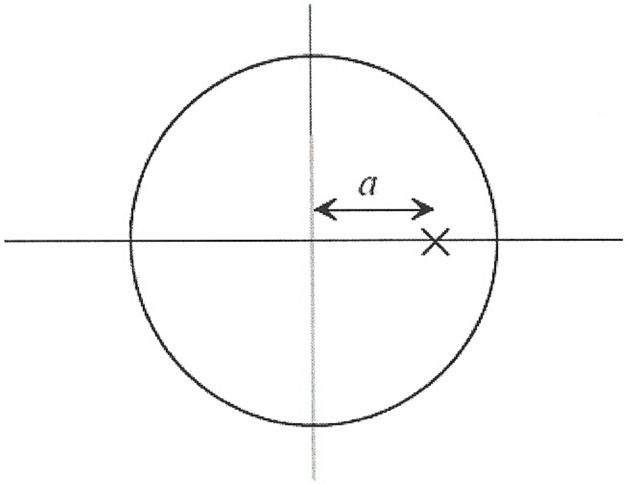


for stability

$|a|<1$

6)

$$H(z) = \frac{z^{-1}}{1 - az^{-1}} = \frac{1}{z-a} \qquad z\text{-plane}$$



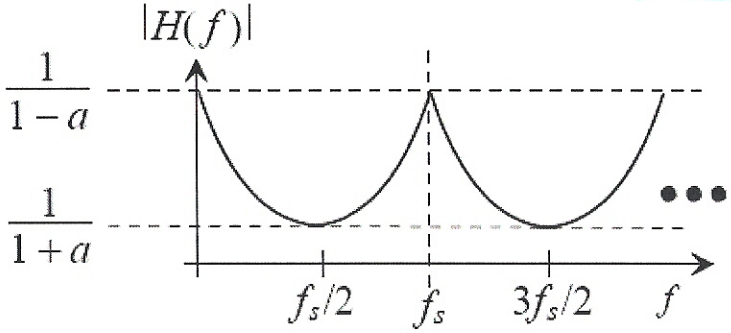
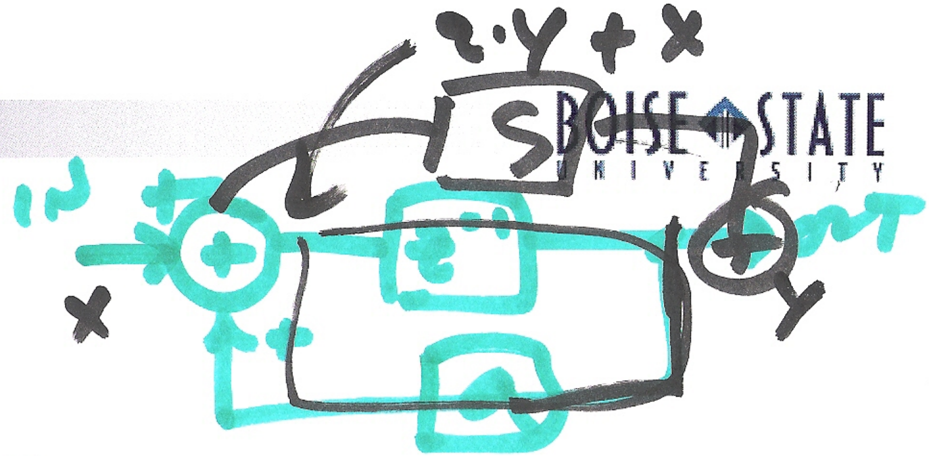


Figure 4.38 The z-plane representation and magnitude response for a weighted integrating filter.



$$y = z^{-1}(a\cdot y + x)$$

$$+x(z^{-1}+s_1)$$

$$y(1 - z^{-1}a) = z^{-1}x$$

$$\frac{y}{x} = \frac{z^{-1}}{1 - z^{-1}a} = \frac{1}{z-a}$$

7)

$-G_2 v_{out} + v_{in} + (1-z^{-1})G_{3D} v_{in}$

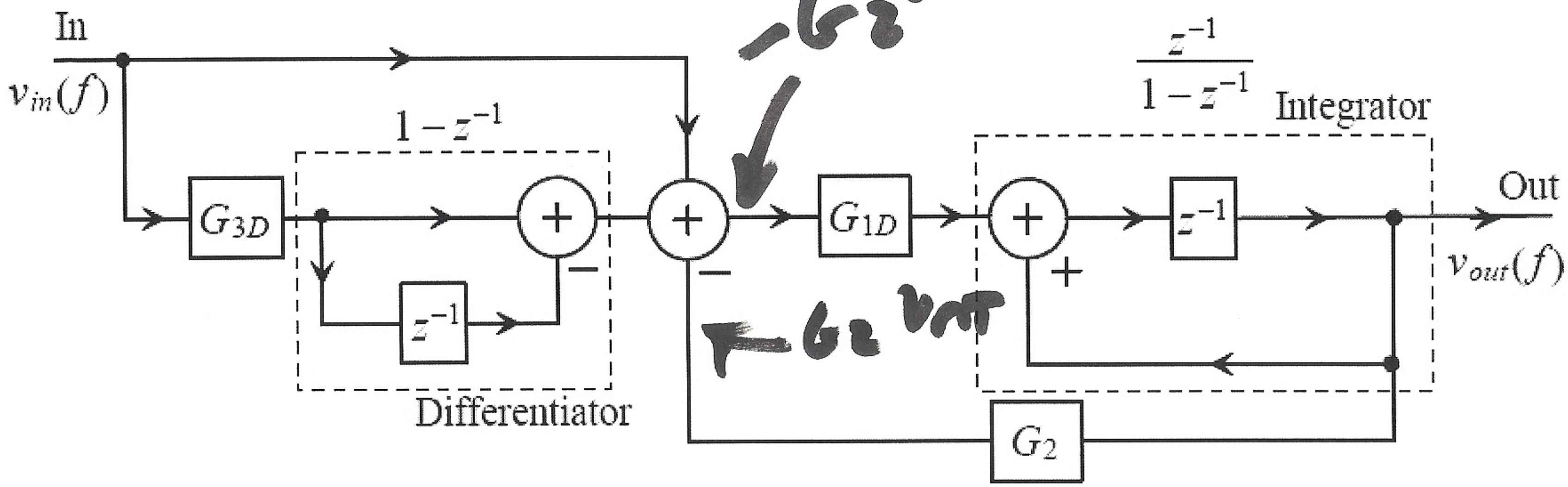


Figure 4.41 Digital implementation of the bilinear transfer function.

$$v_{out} = G_{1D}\left(v_{in} + v_{in}(1-z^{-1})G_{3D} - G_2 v_{out}\right)\frac{z^{-1}}{1-z^{-1}}$$

$$\frac{v_{out}}{v_{in}} = \frac{G_{1D}(1+G_{3D})}{z-(1-G_{1D})} \cdot \frac{z - G_{3D}/(1+G_{3D})}{z}$$

$$z \simeq 1 + e^{-j2\pi \frac{f}{f_s}} \quad f \ll f_s$$

8)

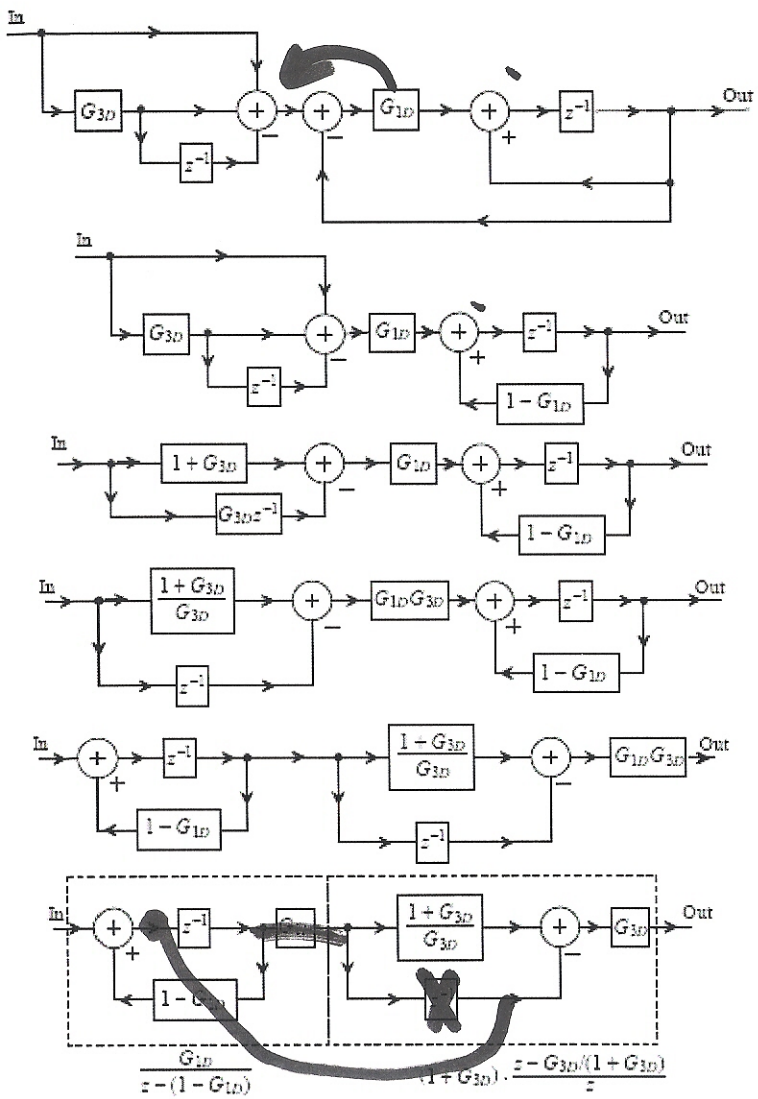
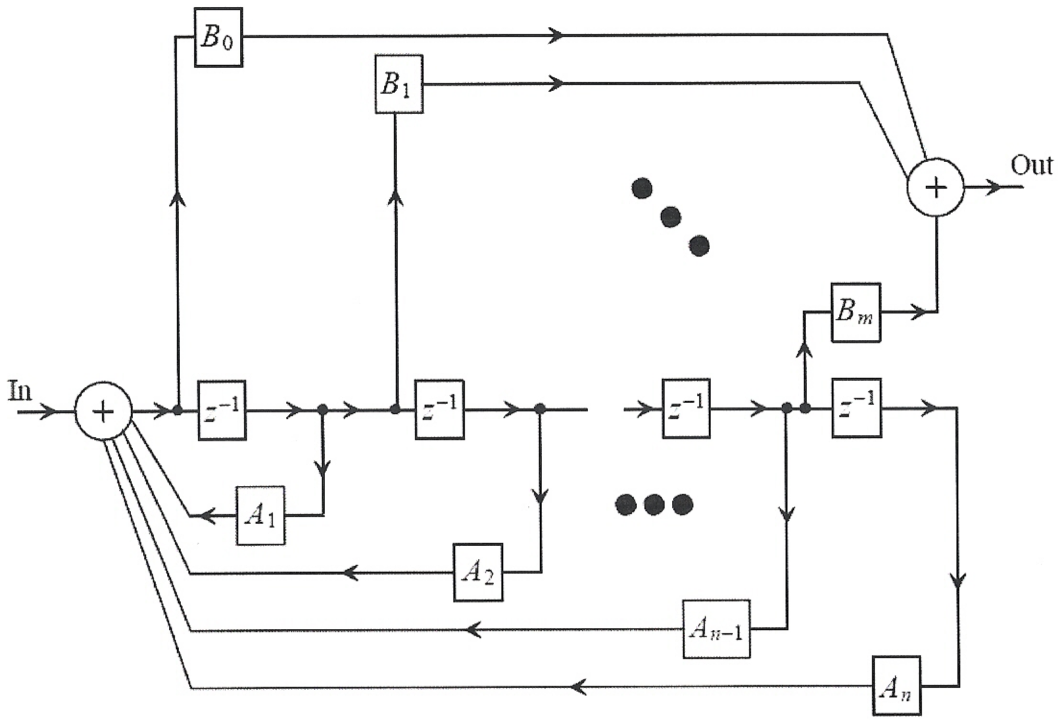


Figure 4.43 Simplifying the digital implementation of the bilinear filter.

$f < Cf_s$

9)



Number of poles $n \geq$ number of zeroes.

Figure 4.49 General canonic form of a digital filter.

BiquaD

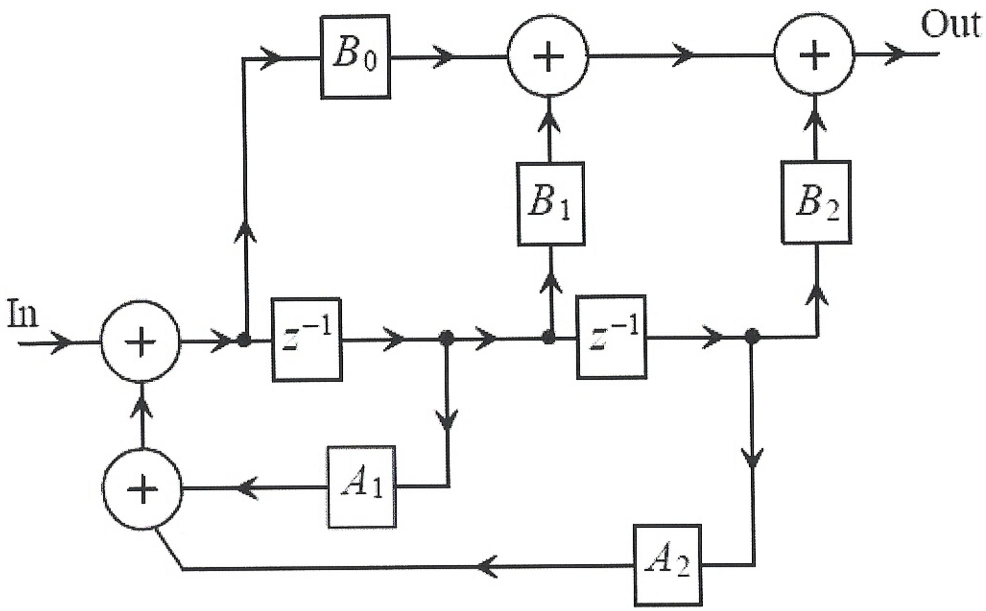


Figure 4.50 The digital biquad filter (see Fig. 4.49).

$$\frac{B_0 z^2 + B_1 z + B_2}{z^2 - A_1 z - A_2}$$

$$a_2 = B_0$$

$$a_1 = f_s(2B_0 + B_1)$$

$$a_0 = f_s^2(1 - A_1 - A_2)$$

$$\frac{2\pi f_0}{Q} = f_s(2 - A_1)$$

$$f_0 = \frac{f_s}{2\pi}\sqrt{(1 - A_1 - A_2)}$$