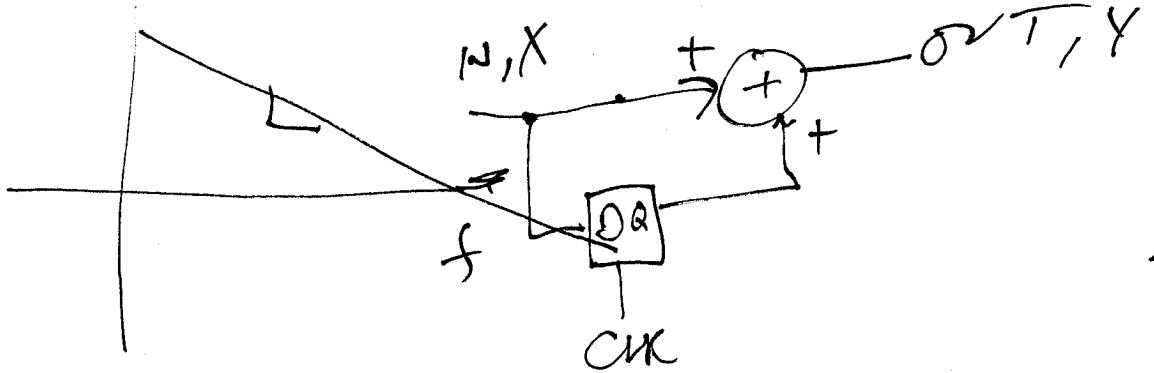
BOISE STATE UNIVERSITY

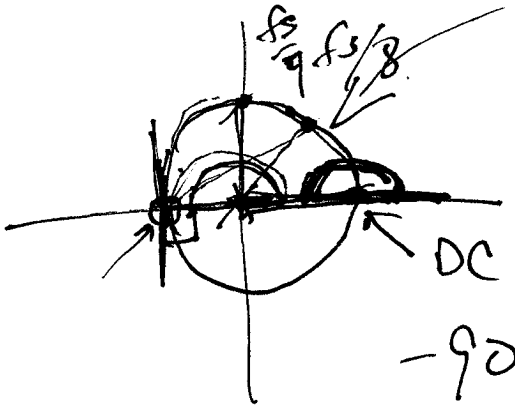
Averager

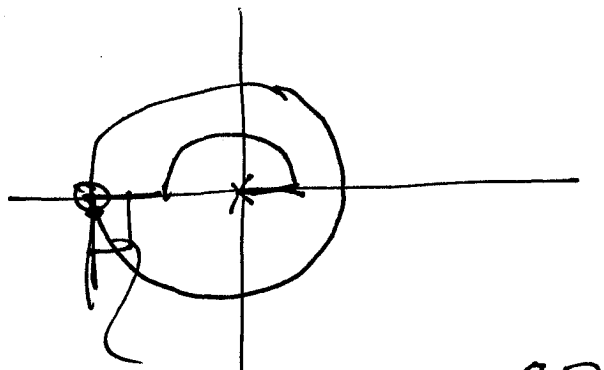
$$1+z^{-1} = \frac{Y(z)}{X(z)} = H(z) \quad \frac{z+1}{z}$$



$z = e^{jwT_s}$

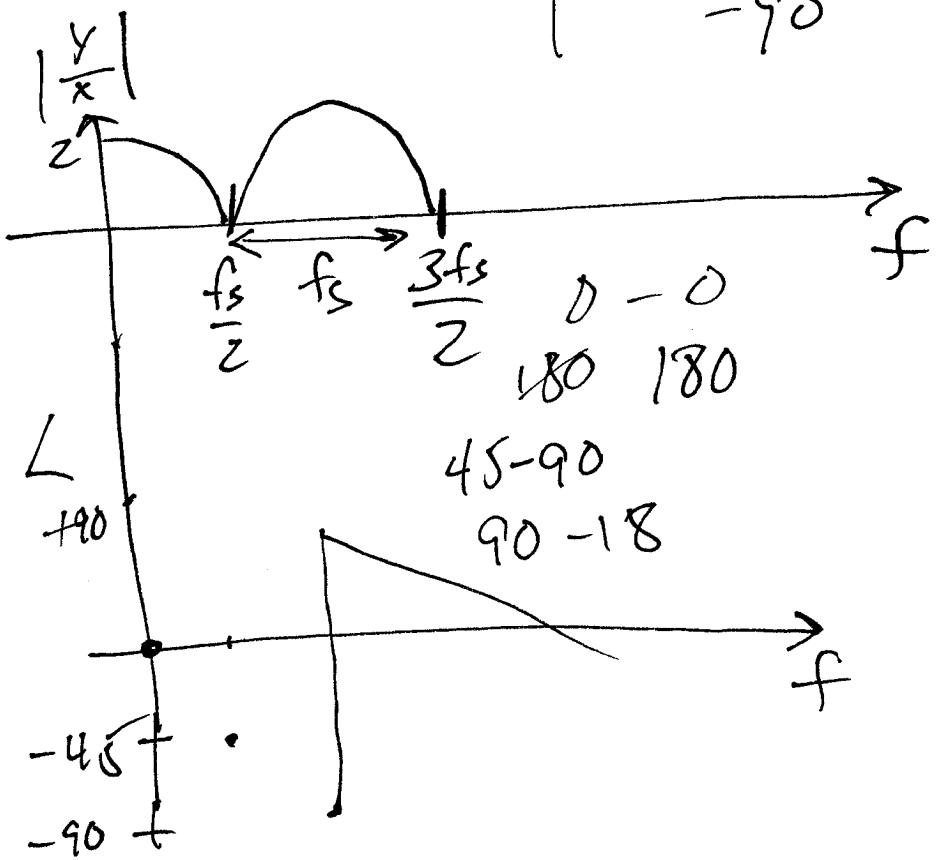
$z = x + jy$



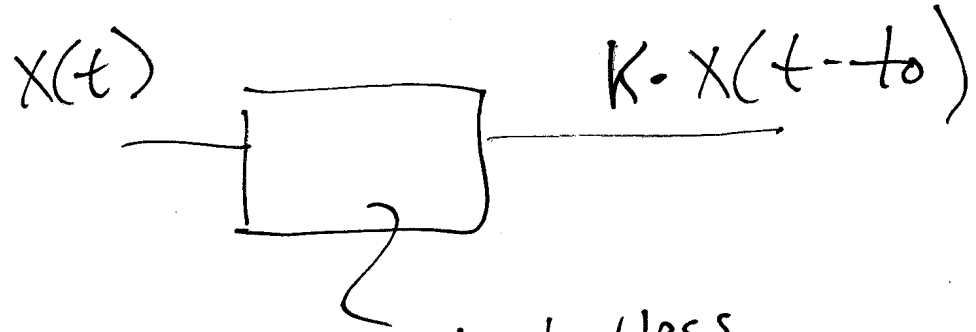


$-90 - 180 = -270$

$= +90$



1)

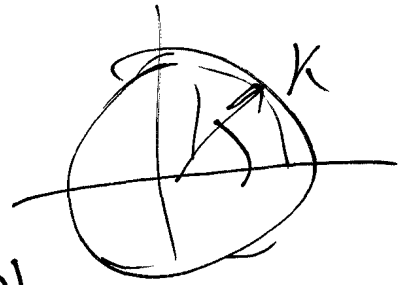


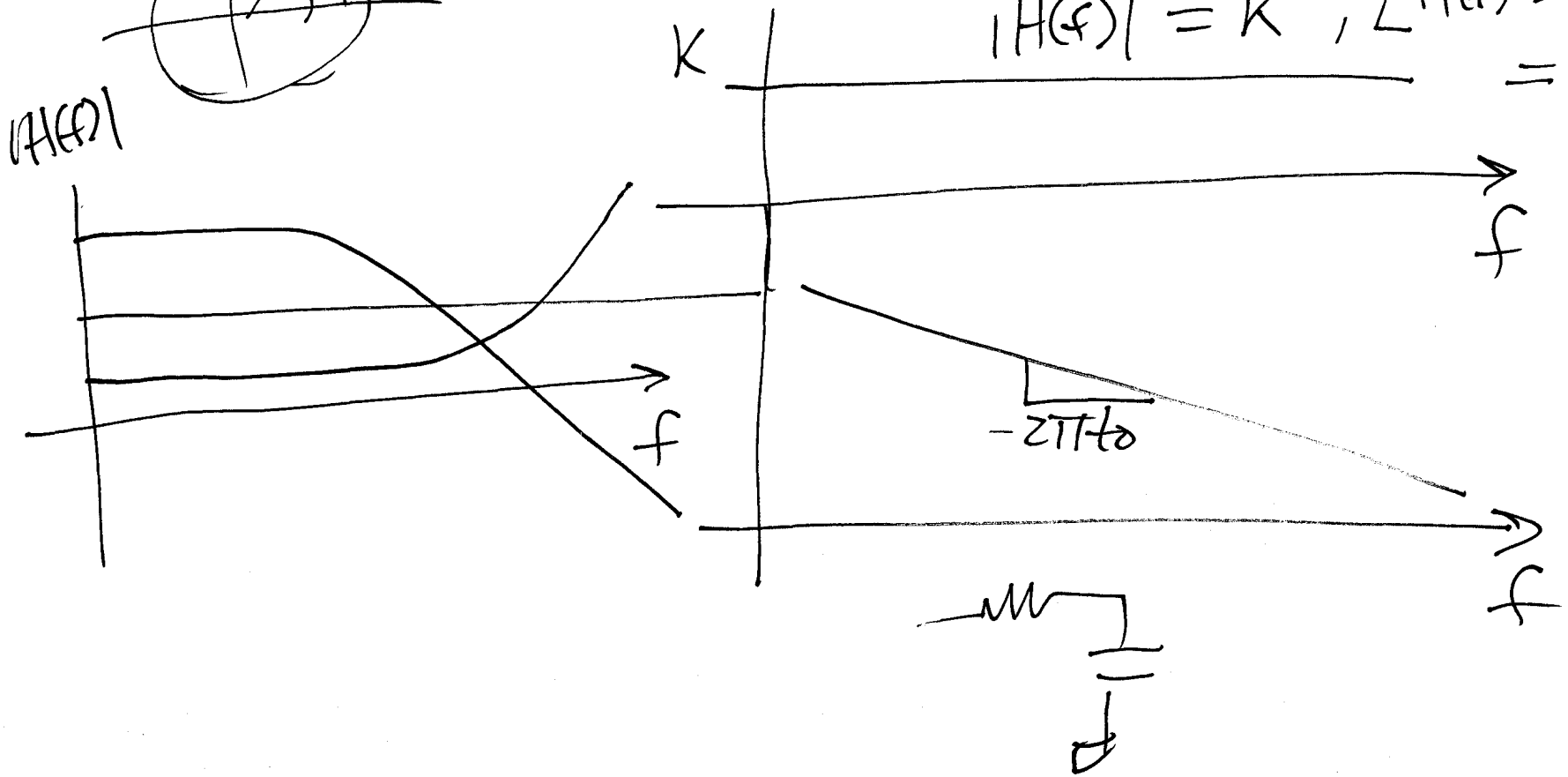
distortionless

$$H(f) = K \cdot e^{-j2\pi f \cdot t_o}$$

$A = 2\pi f t_o$

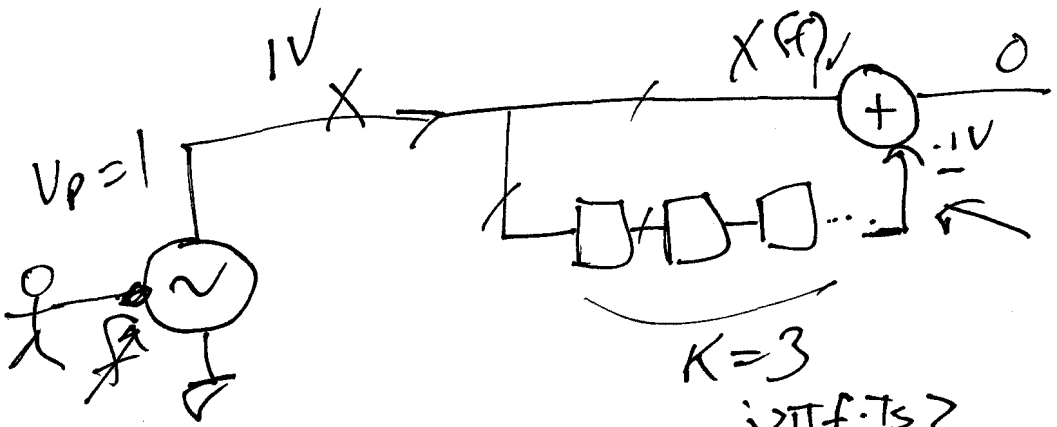
$$|H(f)| = K, \quad \angle H(f) = -2\pi f t_o = -A \cdot f$$





2)

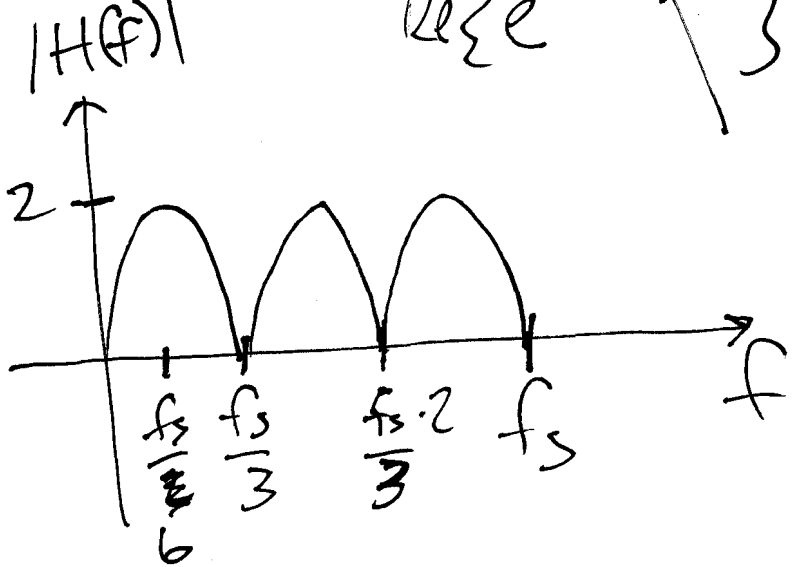
Comb filters



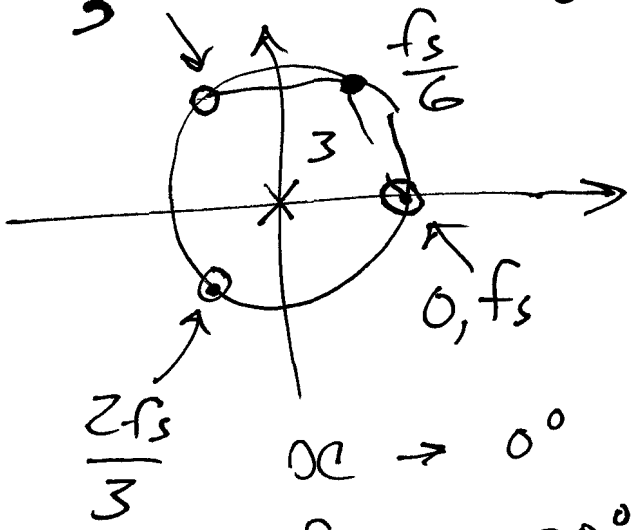
$$y(f) = X(f) - X(f)\cdot z^{-3}$$

$$\frac{y(f)}{X(f)} = 1 - z^{-3} = \frac{z^3 - 1}{z^3}$$

$$Re\{e^{-j2\pi f \cdot T_s}\}$$



$$\frac{2 \cdot 1 \cdot 1}{3 \cdot 1 \cdot 1}$$

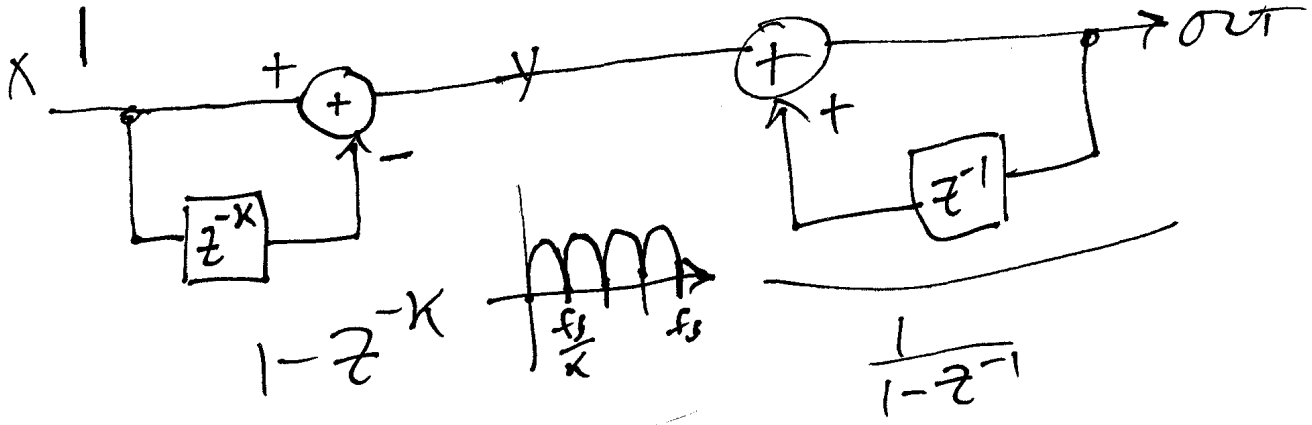


DC → 0°

$\frac{f_s}{4}$ → 270°

$\frac{f_s}{2}$ → 540°

3)



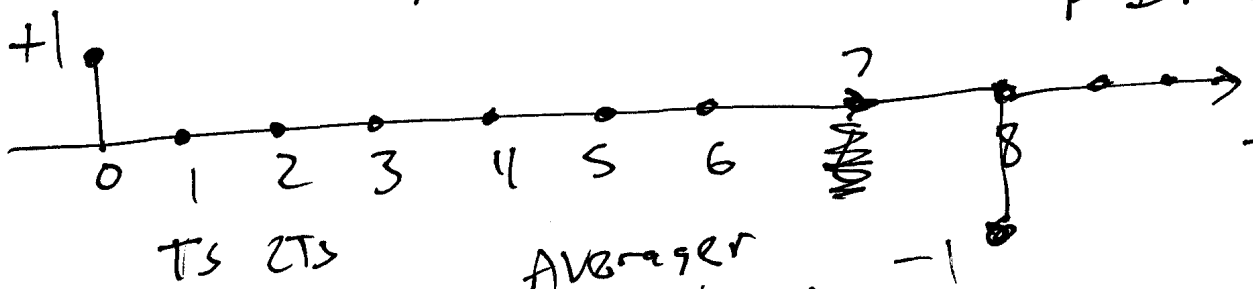
$$\frac{1-z^{-K}}{1-z^{-1}}$$

Moving Average

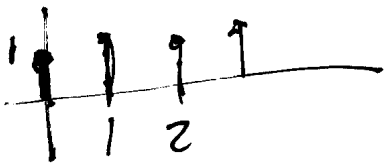
$K = 8$

Finite Impulse Response

FIR

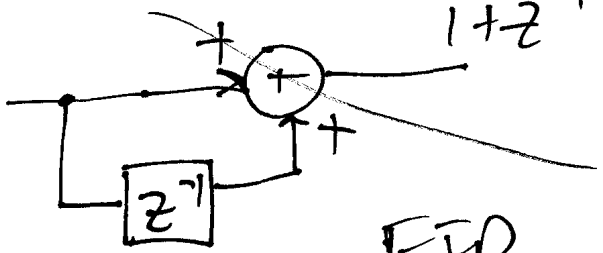


IIR

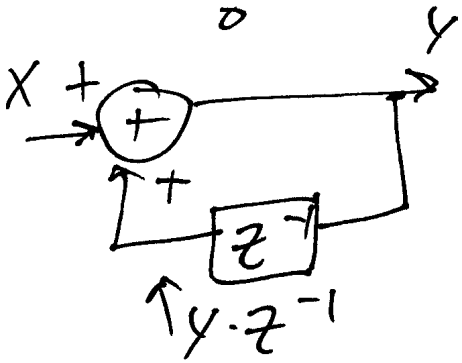


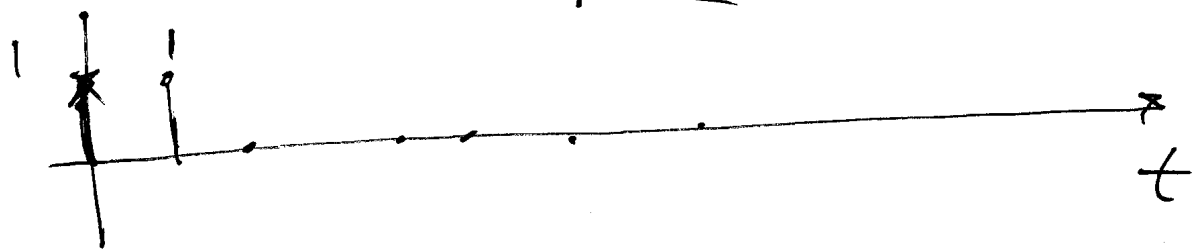
Averager

$1+z^{-1} = y$



FIR



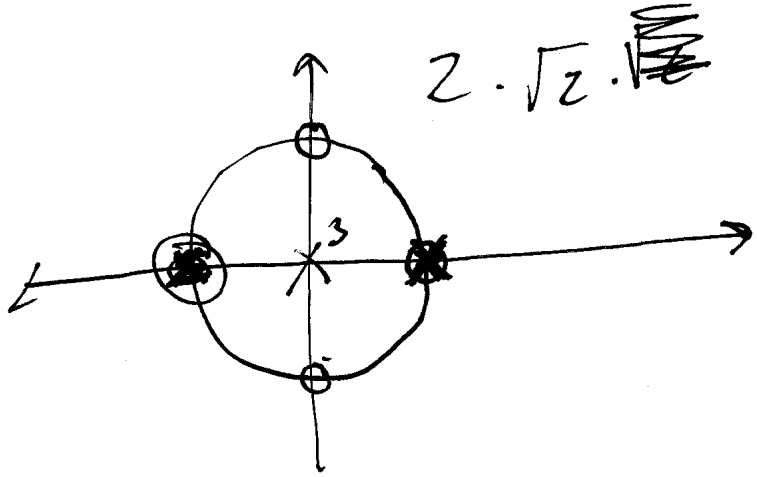


$$\frac{y}{x} = \frac{1}{1-z^{-1}}$$

4)

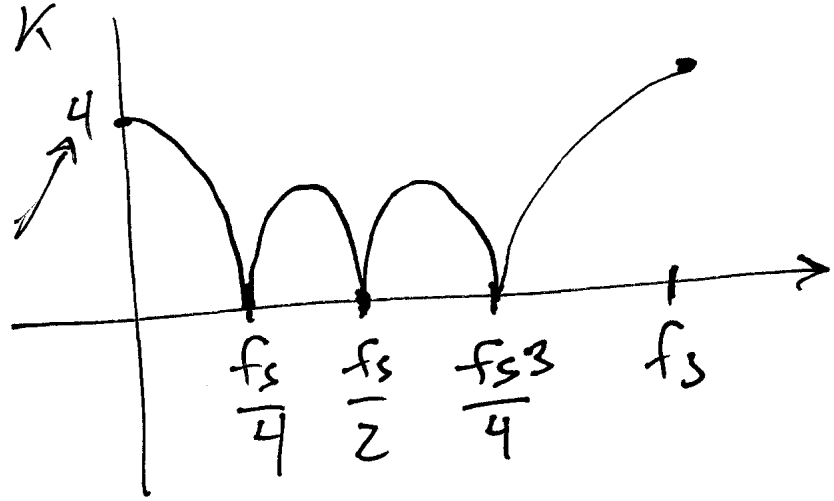
$$\frac{1-z^{-K}}{1-z^{-1}} \qquad K = 4$$

$$\frac{z^K - 1}{z^K - z^{K-1}} = \frac{z^{K-1}}{z^{K-1}(z-1)}$$

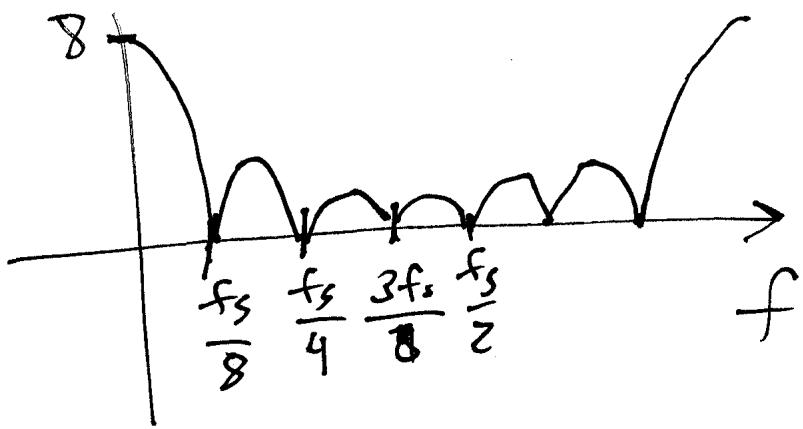


$$2 \cdot \sqrt{2} \cdot \sqrt{2}$$

$$4 = \sqrt{2} \cdot \sqrt{2} \cdot 2$$



$$\frac{1-z^{-8}}{1-z^{-1}}$$



5)

$$x_1 + x_2 + x_3 + x_4 + x_5 + \cdots$$

$$x(nT_s) + x((n-1)T_s)$$

$$y_1 = x_1 + x_2 + x_3 + x_4$$

$$y_2 = x_2 + x_3 + x_4 + x_5$$

$$y_3 = x_3 + x_4 + x_5 + x_6$$

$$Y(z) = X(z) + X(z)z^{-1} + X(z)\cdot z^{-2} + X(z)z^{-3}$$

$$\frac{Y(z)}{X(z)} = \left(1 + z^{-1} + z^{-2} + z^{-3}\right)$$

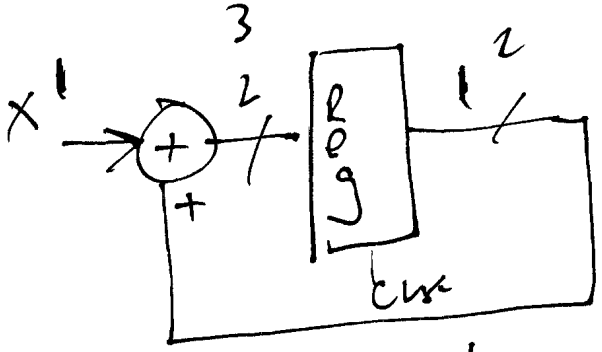
$$y(nT_s) = x(nT_s) + x((n+1)T_s) + x((n+2)T_s) + x((n+3)T_s)$$

$$y(z) = X(z) + X(z)\cdot z^{-1} + X(z)\cdot z^{-2} + X(z)\cdot z^{-3}$$

$$\frac{y(z)}{X(z)} = \left(1 + z^{-1} + z^{-2} + z^{-3}\right)\cdot\frac{1-z^{-1}}{1-z^{-1}}$$

$$= \frac{1 - z^{-4}}{1 - z^{-1}}$$

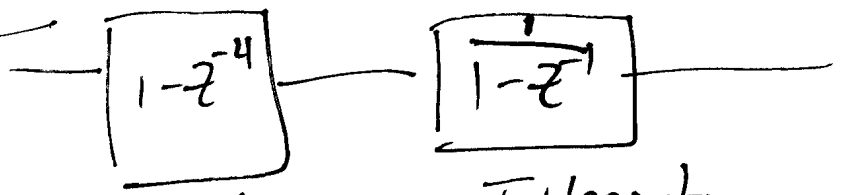
Moving Average filter



Accumulate

$x_1 + x_2 + x_3 + x_4$

$x_5 + x_6 + x_7 + x_8$



Comb filter

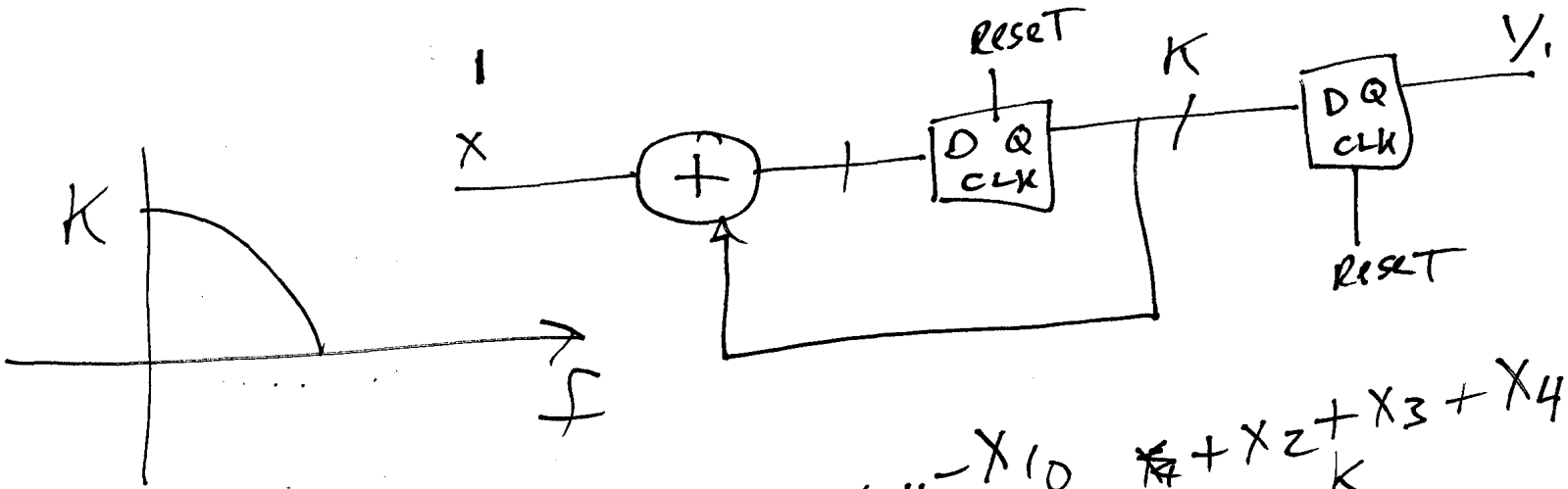
Integrator

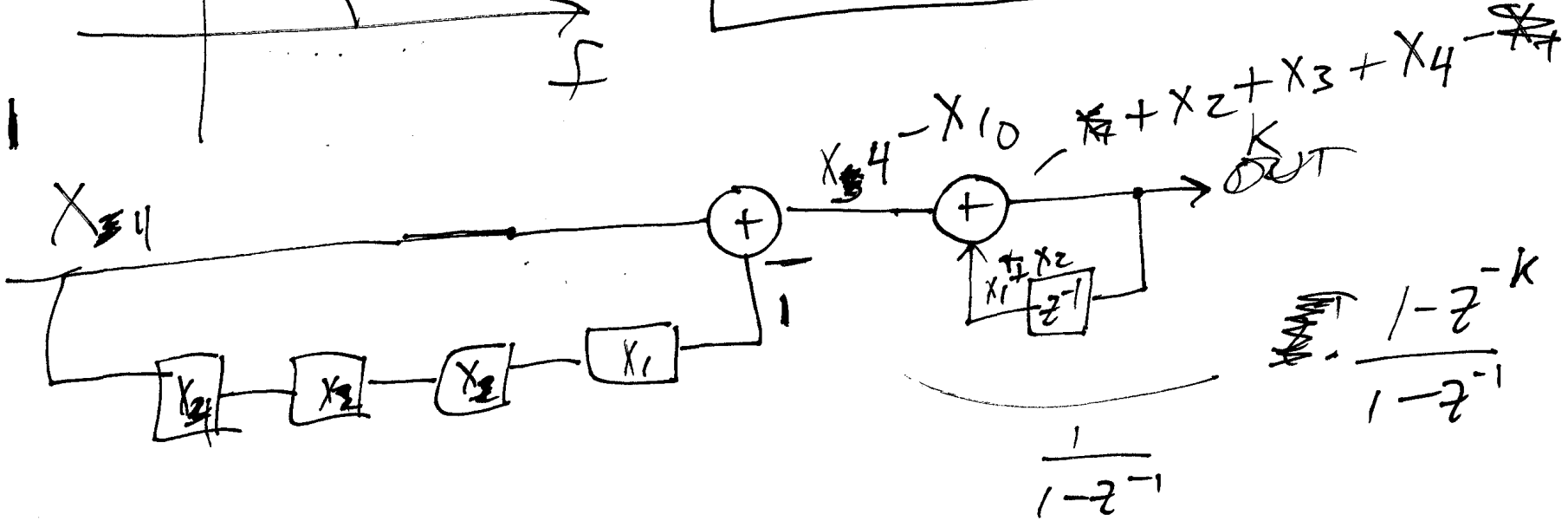
7)

$X_1 + X_2 + X_3 + X_4$ $\quad$ $X_5 + X_6 + X_7 + X_8$

Y_1 $\quad$ Y_2

Accumulate



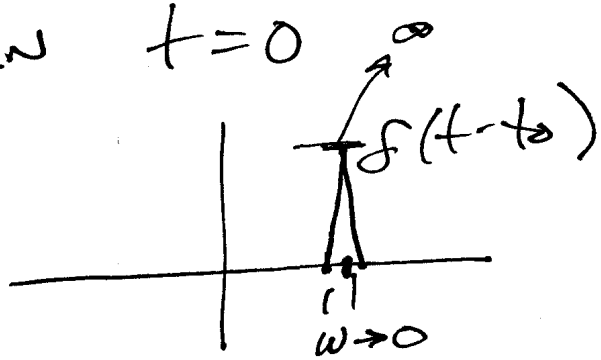


8)

dirac-delta continuos-time

$\delta(t) = \infty$ when $t = 0$

$$\int_{-\infty}^{\infty} \delta(t) \cdot dt = 1$$



$\delta(t - t_0) = \infty$, $t = t_0$

delta function

Kronecker discrete-time

$\delta(t - NT_S) = 1$, when $t = NT_S$