

## Circuit Design

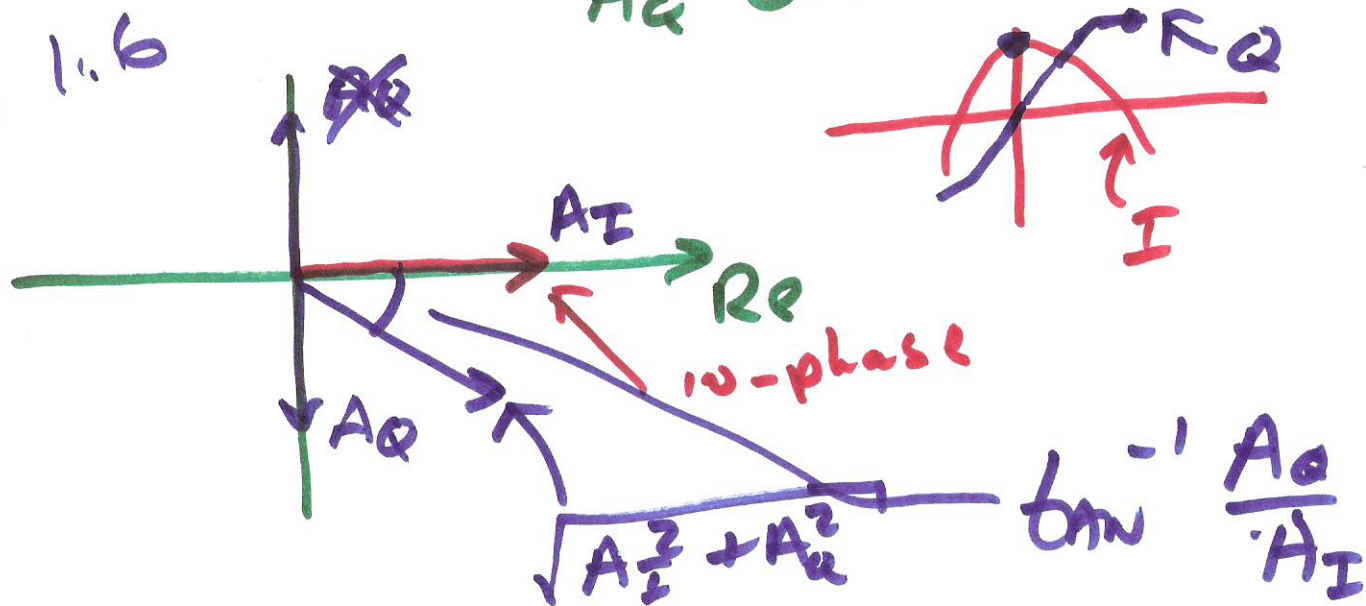
Aug. 25, 2010

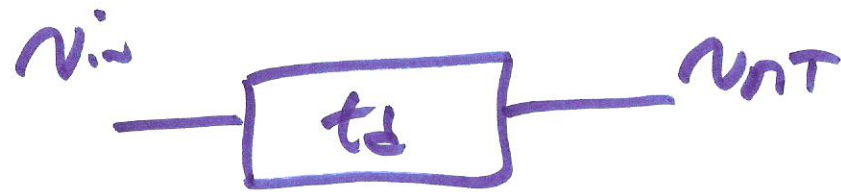
Lecture 2!

Eq. 1.10

$$S_{IQ}(t) = A_I \cos 2\pi f_0 \cdot t + A_Q \sin 2\pi f_0 \cdot t$$

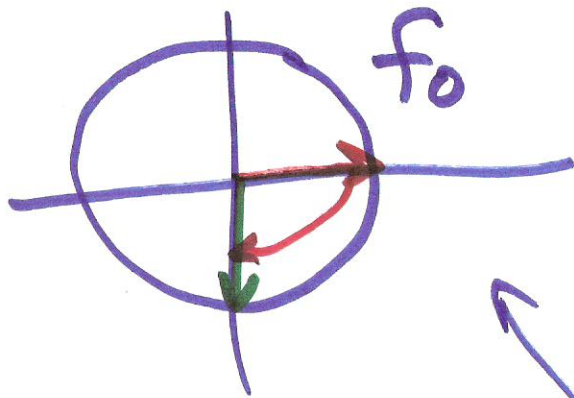
Fig. 1.6





$$\angle \frac{v_{out}}{v_{in}} = 1 \angle 2\pi \frac{t_d}{T}$$

$$= 1 \angle 2\pi t_d \cdot f$$

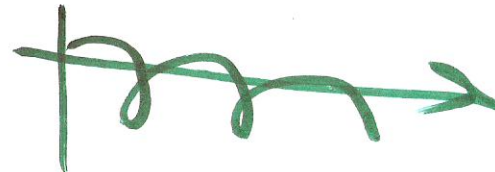


$$\rightarrow \cos 2\pi t_d \cdot f +$$

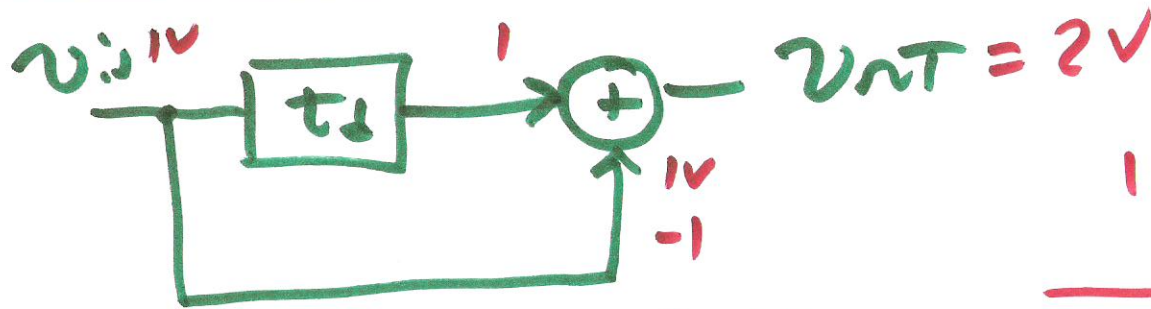
$$-j \sin 2\pi t_d \cdot f$$

$$e^{-j 2\pi t_d \cdot f}$$

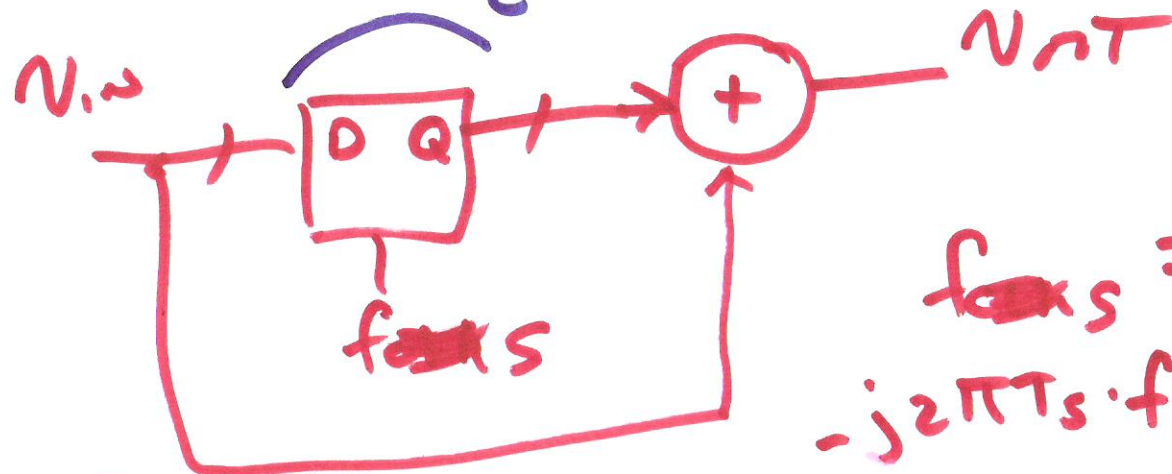
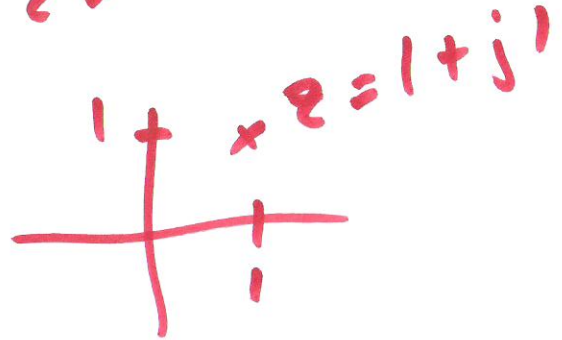
$$\frac{T}{4}$$



2)



digital comb filter



$$z = e^{j2\pi f/f_s}$$

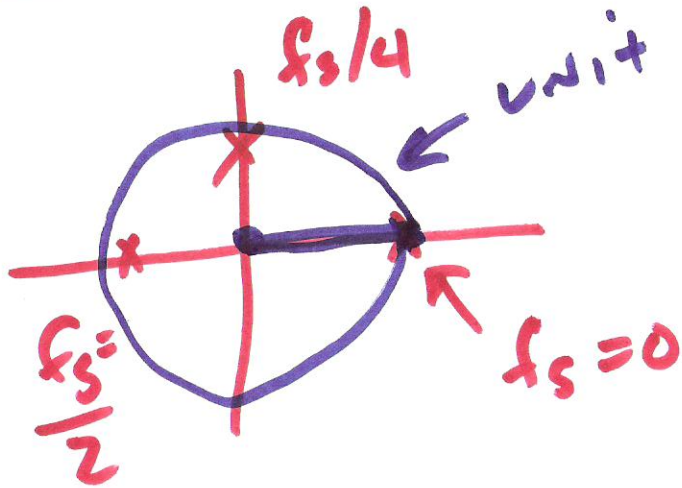
$$z^{-1} = e^{-j2\pi f/f_s}$$

$$f_s = \frac{1}{T_s}$$

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

$$e^{-j2\pi \frac{f}{f_s}}$$

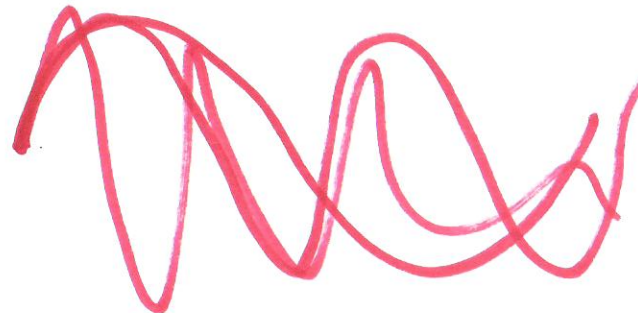
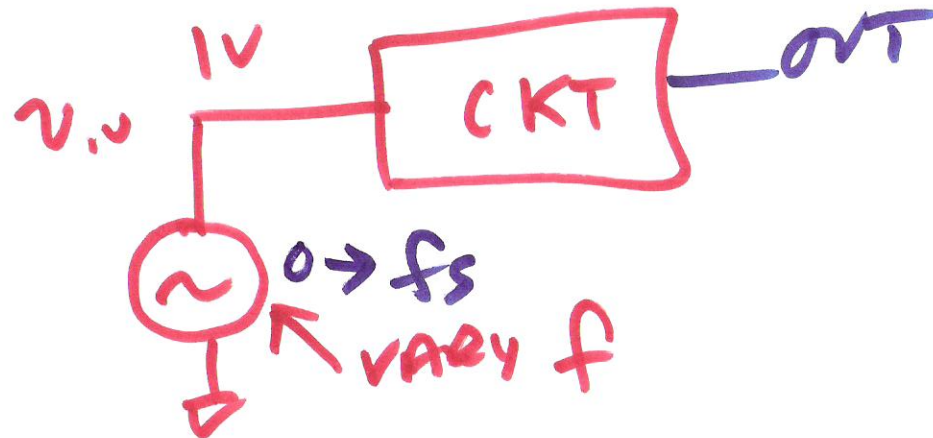
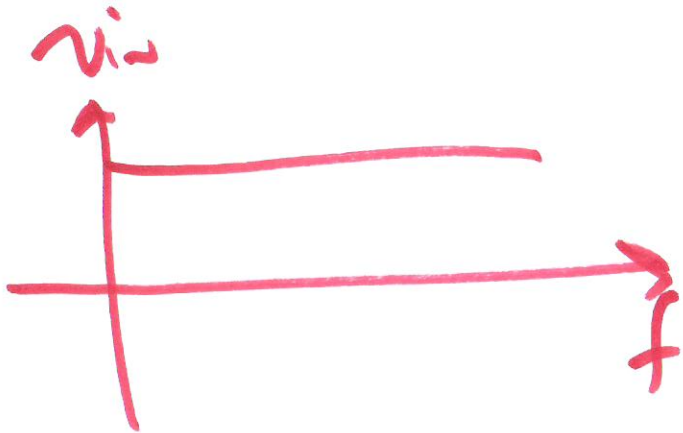
3)



$f \rightarrow \text{VARY} = j$

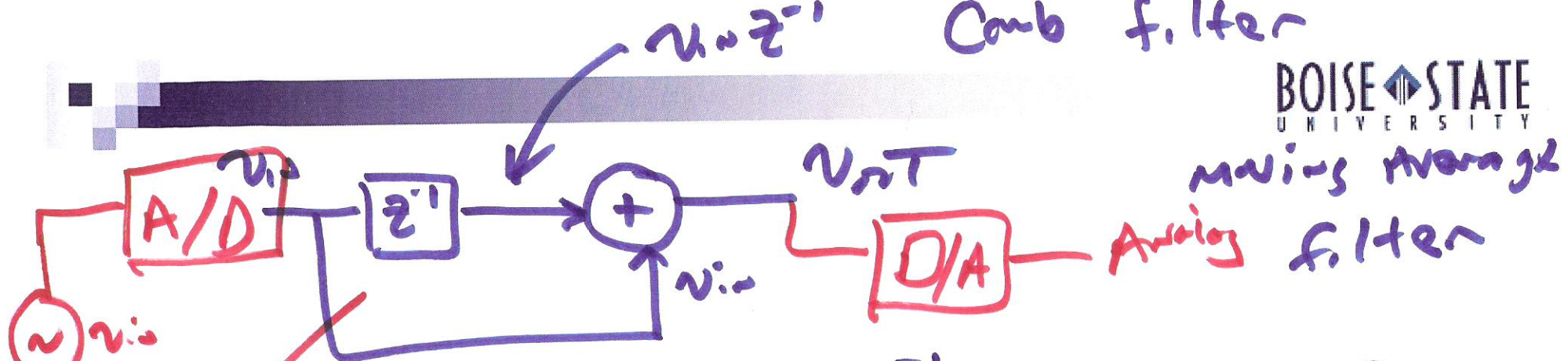
$$e^{-j2\pi T_s f}$$

$$\frac{2\pi T_s}{2\pi} = 2\pi$$



4)





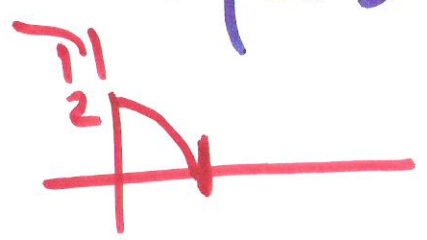
$$v_{nT} = v_n + v_n z^{-1}$$

$$\frac{v_{nT}}{v_n} = 1 + z^{-1} = 1 + e^{-j2\pi \frac{f}{f_s}}$$

$$= \underbrace{1 + \cos 2\pi \frac{f}{f_s}}_{\text{Re}} + j \underbrace{\sin(-2\pi \frac{f}{f_s})}_{\text{Im}}$$

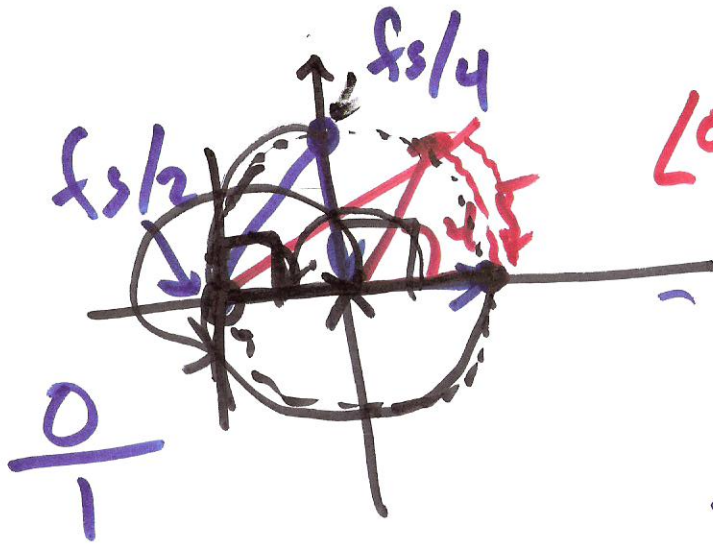
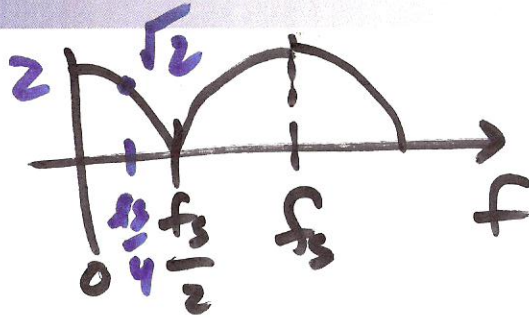
$1 + z^{-1}$

$$\left| \frac{v_{nT}}{v_n} \right| = 2 \left| \cos \pi \frac{f}{f_s} \right| \quad \angle \frac{v_{nT}}{v_n} = -\pi \frac{f}{f_s}$$



5)

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



$$\angle 0^\circ - \angle 0^\circ$$

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

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

$$\frac{z}{1}$$

$$\textcircled{0} | | = 2$$

$$fs/2$$

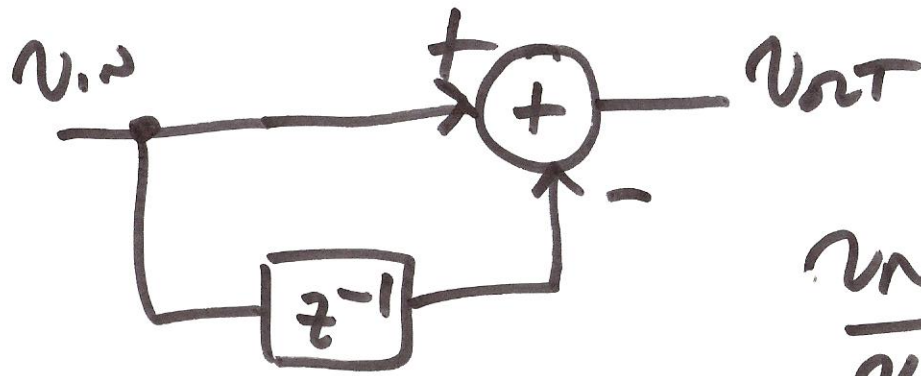
$$\sqrt{2}$$

$$\angle 90^\circ - \angle 180^\circ = -\angle 90^\circ$$

$$b) \angle -90^\circ - \angle 180^\circ = \angle -270^\circ \angle 45^\circ - \angle 90^\circ = -\angle 45^\circ \textcircled{\frac{fs}{4}}$$

$$= \angle 90^\circ$$

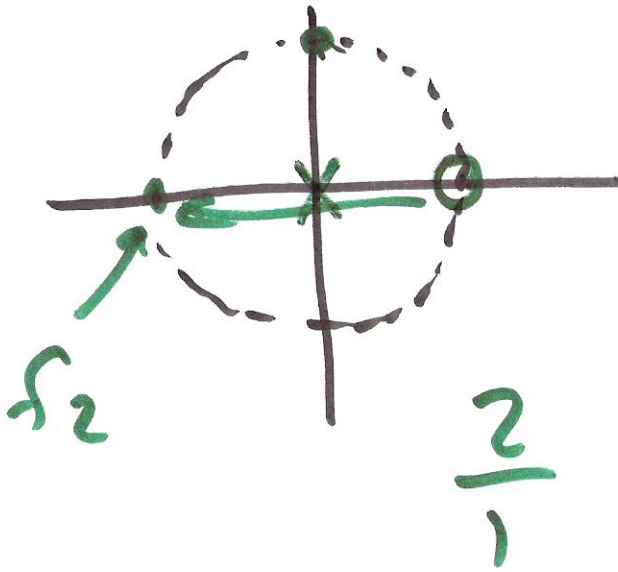
# Digital Differentiator



$$v_{out} = v_{in} - v_{in} z^{-1}$$

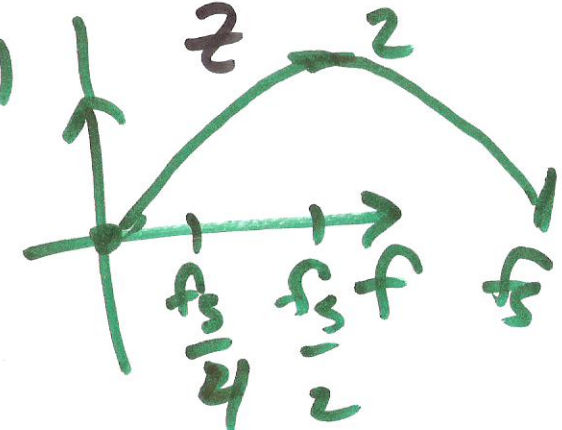
$$\frac{v_{out}}{v_{in}} = 1 - z^{-1}$$

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



@ DC

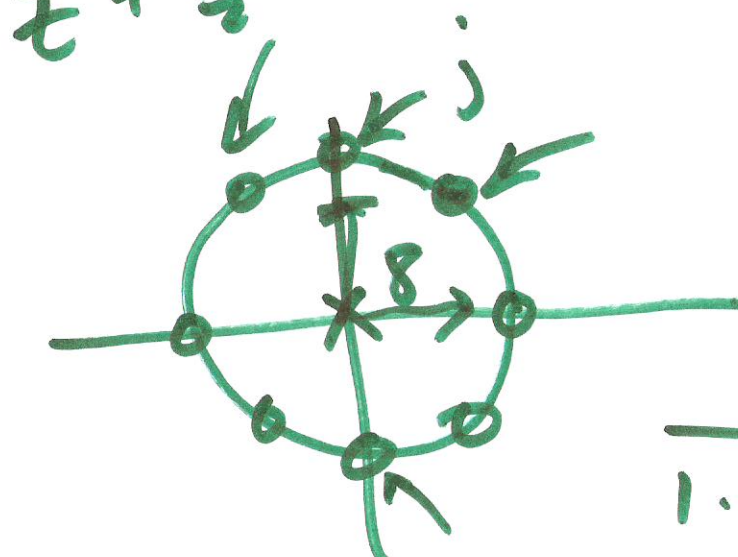
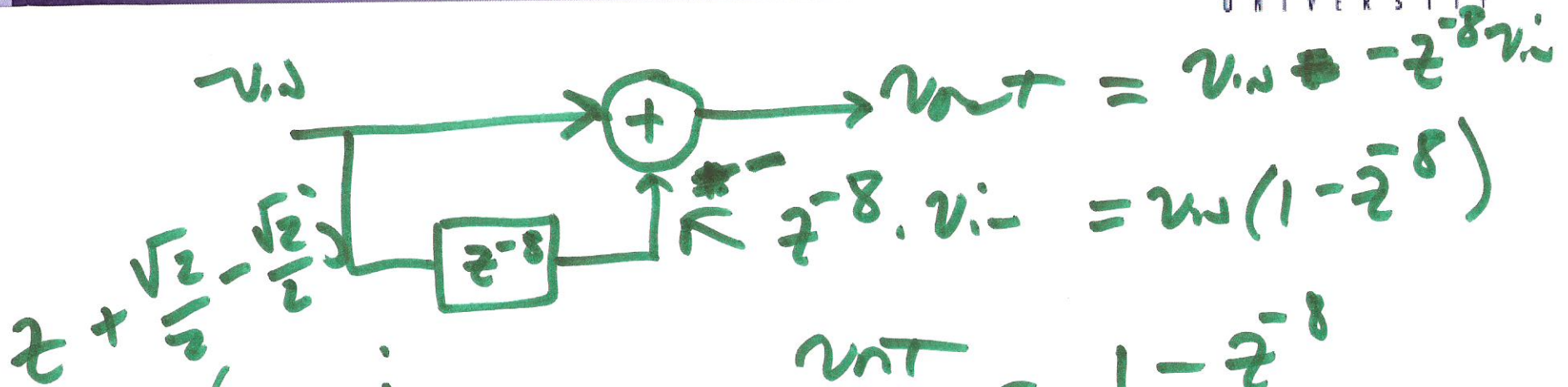
$$\approx \frac{\sqrt{2}}{1} \approx 1.414$$



7)



# Comb filters



$$\frac{v_{out}}{v_{in}} = 1 - z^{-8}$$

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

$$1 \cdot 1 \cdot 1 \cdot 1$$

$$= (z-1)(z+1) \cdot (z-j)(z+j)$$

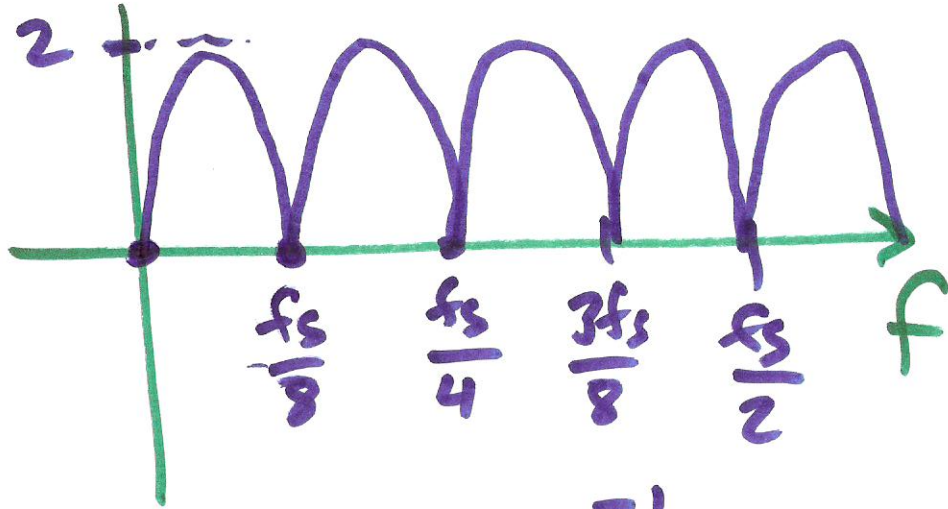
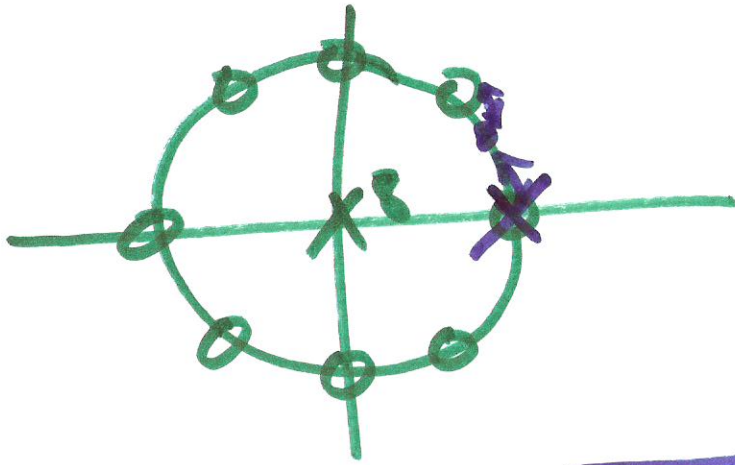
$$\left(\frac{\sqrt{2}}{2}\right)^2 + \left(\frac{\sqrt{2}}{2}\right)^2 = 1$$

$$\left(z - \frac{\sqrt{2}}{2} - \frac{j\sqrt{2}}{2}\right)$$

8)



N.D.  $1 - z^{-8}$   $\frac{z^{-8}}{1 - z^{-8}}$



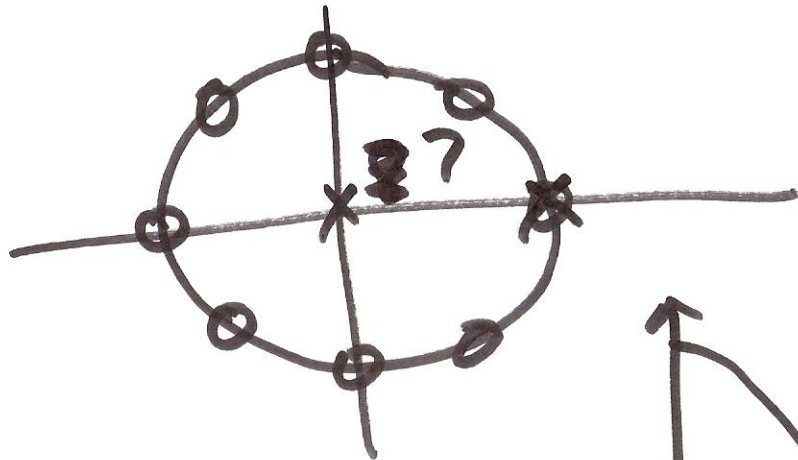
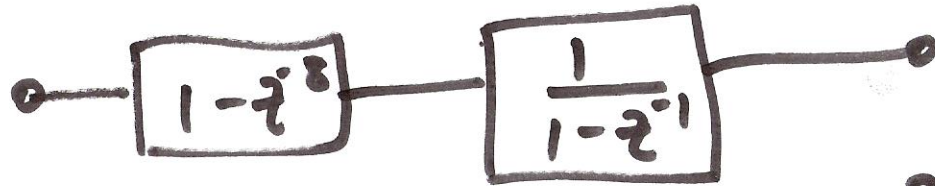
$$\frac{1}{1 - z^{-1}}$$

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

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

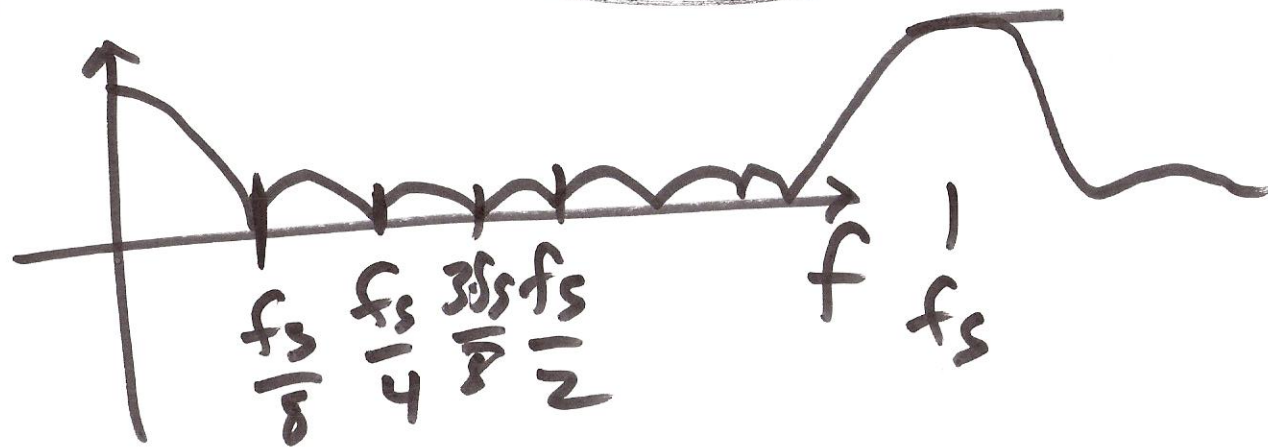
9)

# Sinc filter



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

~~(1+z)~~  
~~(1+z^{-1})~~



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

10)

$$\frac{v_{out}}{v_{in}} = 1 + z^{-1} + z^{-2} + z^{-3} + z^{-4} + z^{-5} + z^{-6} + z^{-7}$$

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

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

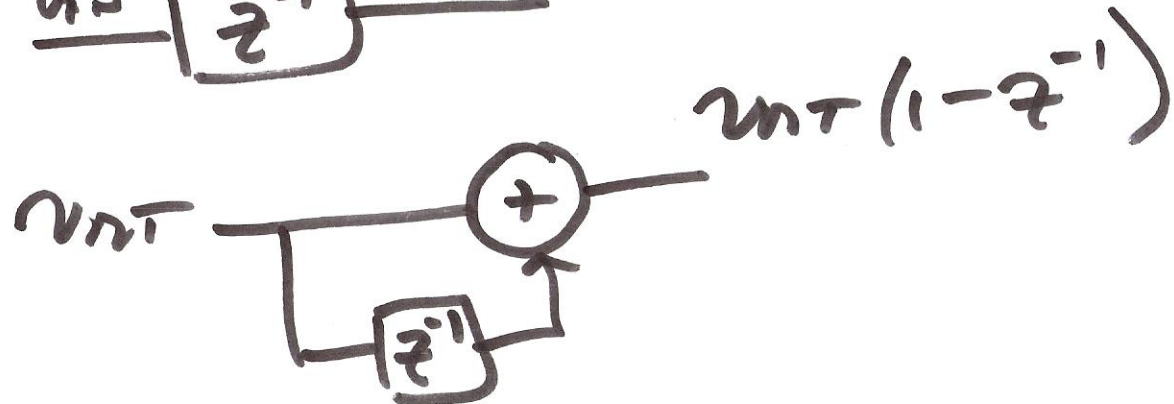
11)



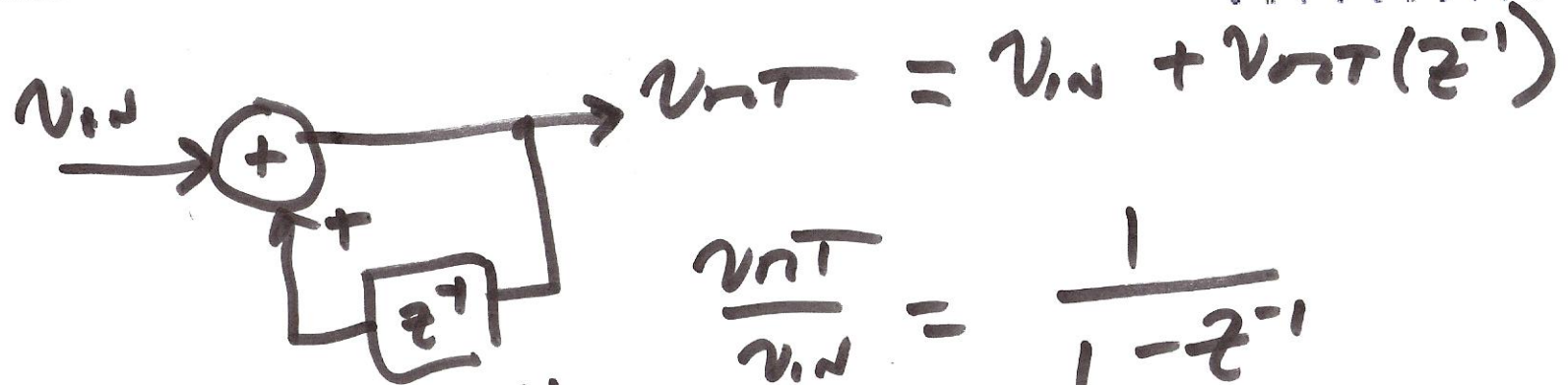
$\frac{z^{-1}}{1-z^{-1}}$  delay integrator

$\frac{1}{1-z^{-1}}$  non-delaying integrator

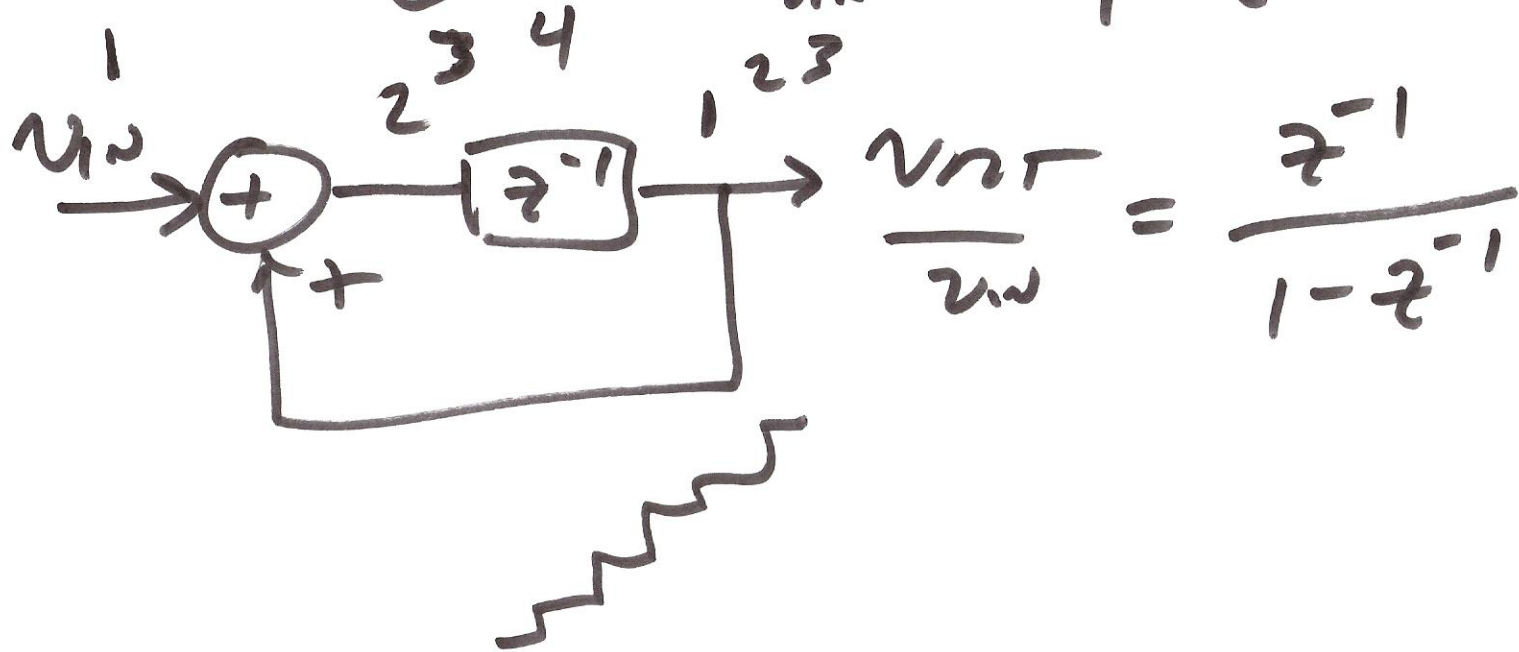
$$\frac{v_{nT}}{v_{i-1}} = \frac{z^{-1}}{1-z^{-1}} \rightarrow v_{nT}(1-z^{-1}) = v_{i-1} \cdot z^{-1}$$



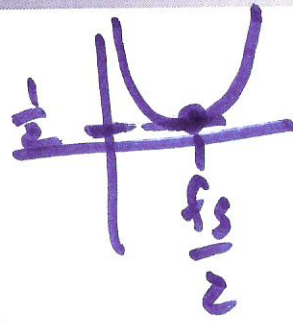
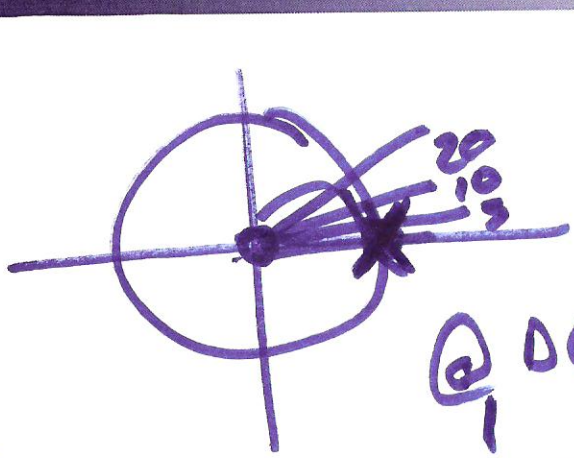
12)



$$\frac{v_{out}}{v_{in}} = \frac{1}{1-z^{-1}}$$



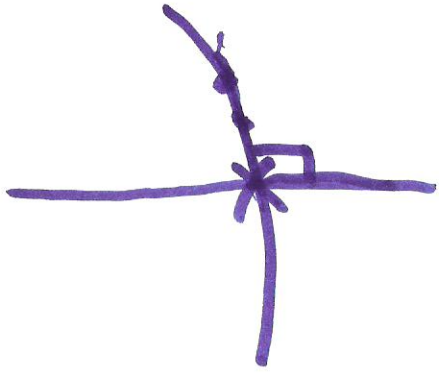
# Integrators



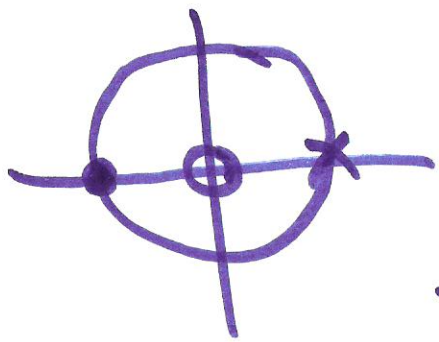
$$\frac{1}{1-z^{-1}} = \frac{z}{z-1}$$

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

@ DC  
 $\frac{1}{0} \rightarrow \infty$



$0 - 90^\circ$   
 $-90^\circ$



$\frac{1}{2}$

$1-z^{-1} \frac{z^{-1}}{z}$   
 differentiator!

