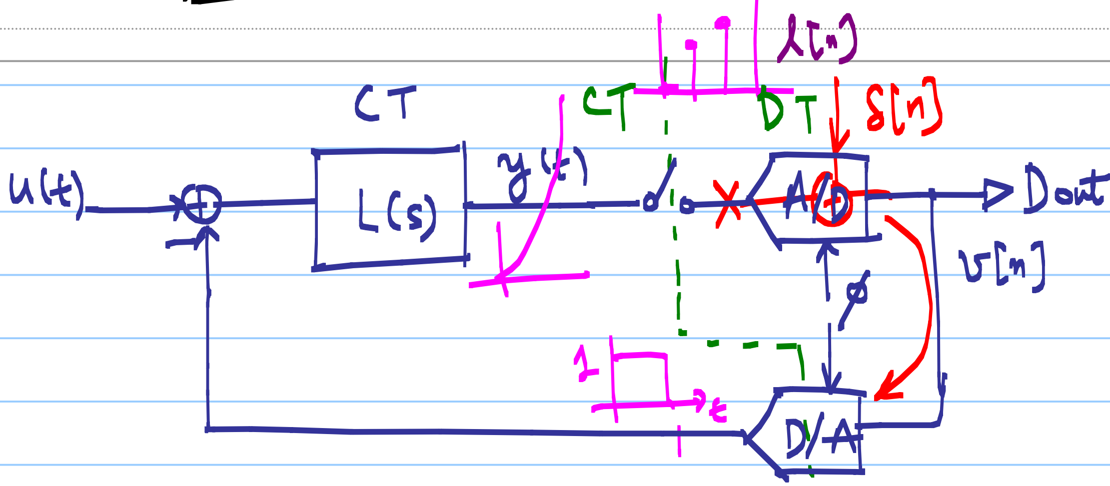
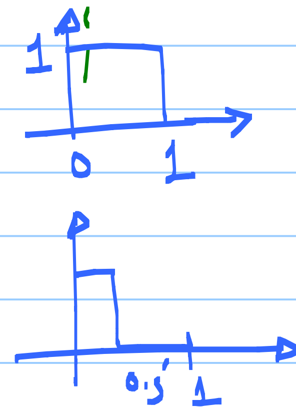
ECE 615 - Lecture 19

Note Title 11/7/2013



$f_s = 1$ Hz



DAC pulse shape

overall, the system is discrete-time

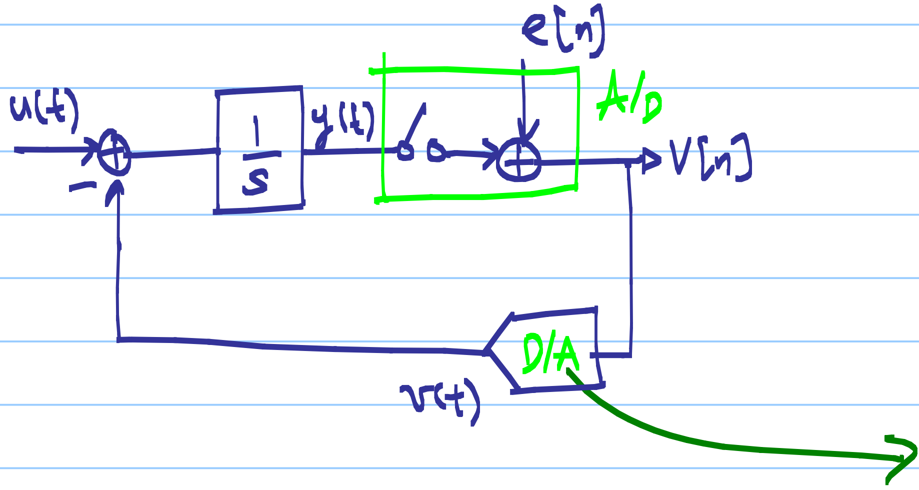
$$NTF(z) = \frac{1}{1+L(z)}$$

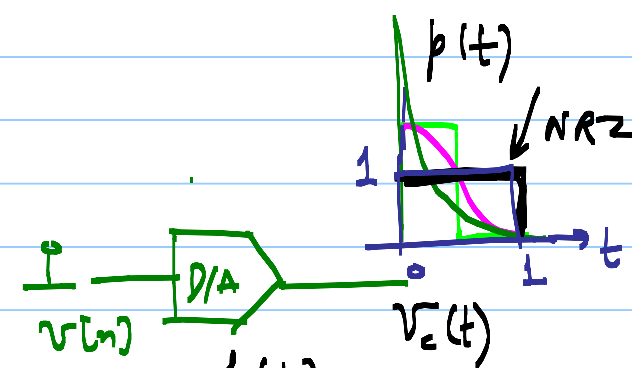
$\cancel{NTF(s)}$

1st-order CT ΔΣ Modulator

Normalized to

$f_s = 1$ Hz



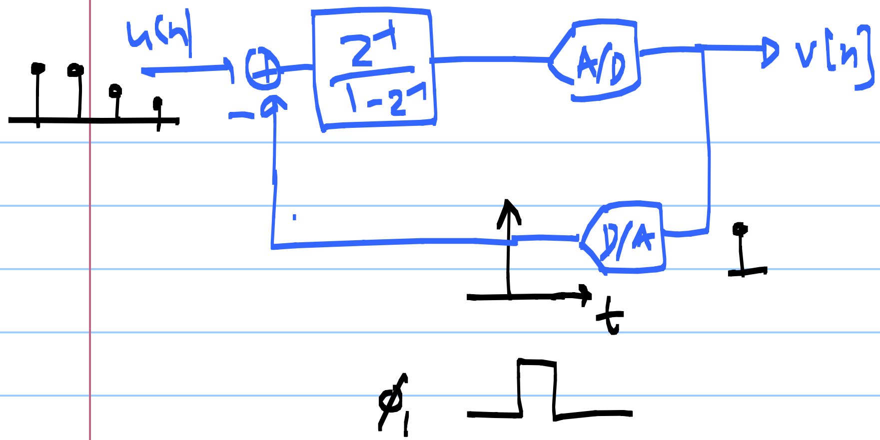


p(t)
↑ DAC pulse shape

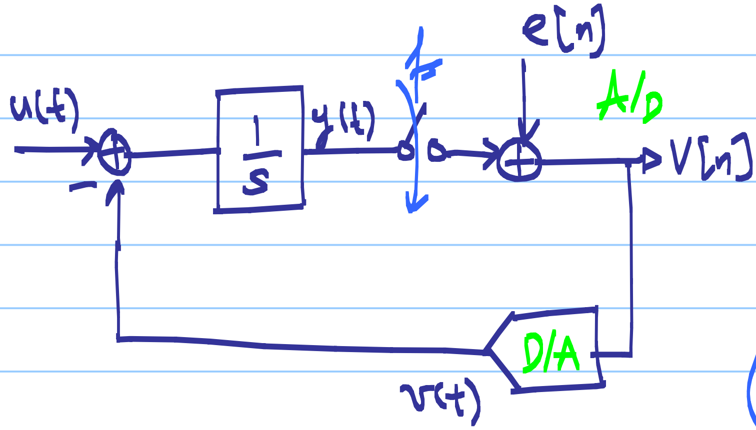
* DAC is converting a DT signal
to a CT signal

↳ p(t) ← pulse shape

NTF ??

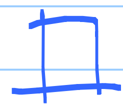


ASIDE



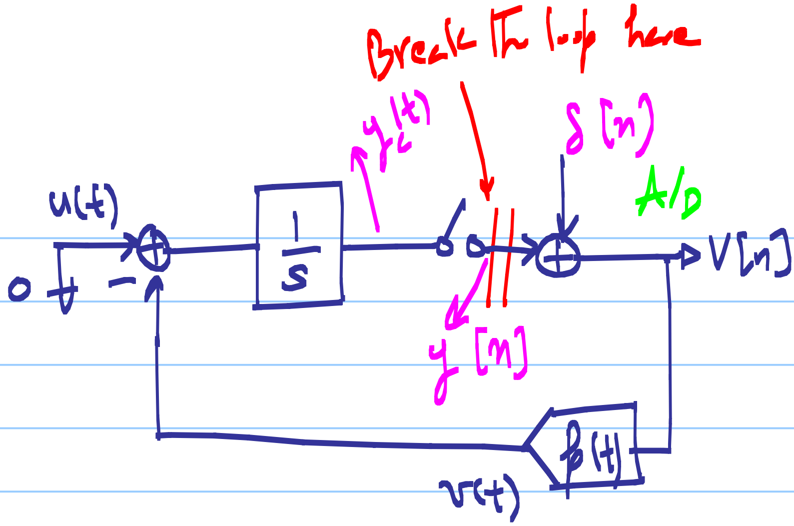
$$\cancel{\left(U(s) - V(s)\right)\frac{1}{S} + E(s) = V(s)}$$

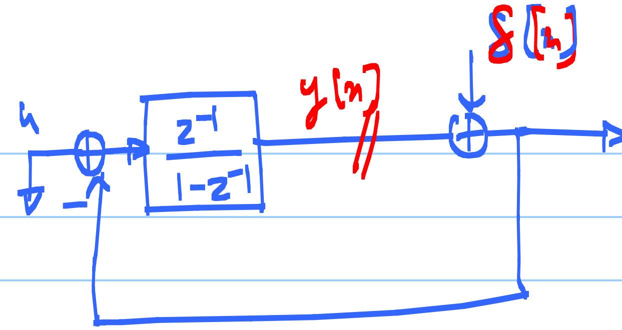
$$\cancel{\times \frac{1}{S}\left(1 - e^{-sT}\right)}$$

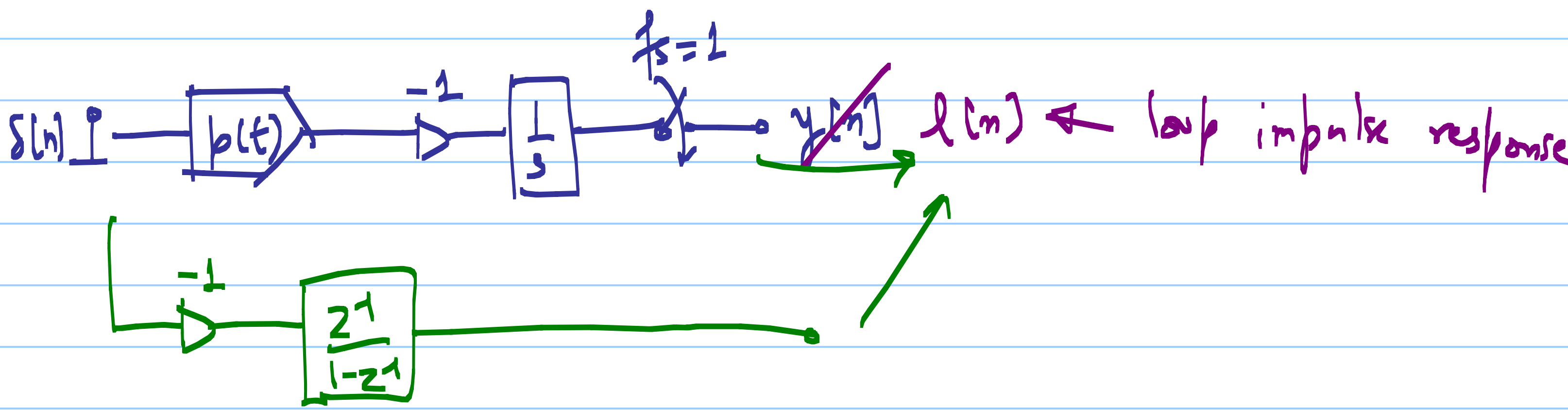


ZOH

$u(t) - u(t-T)$

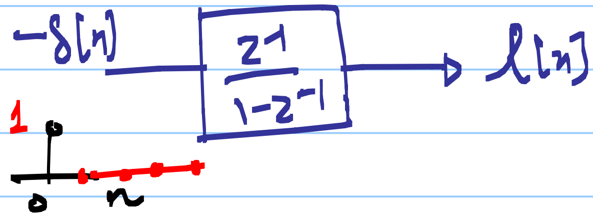


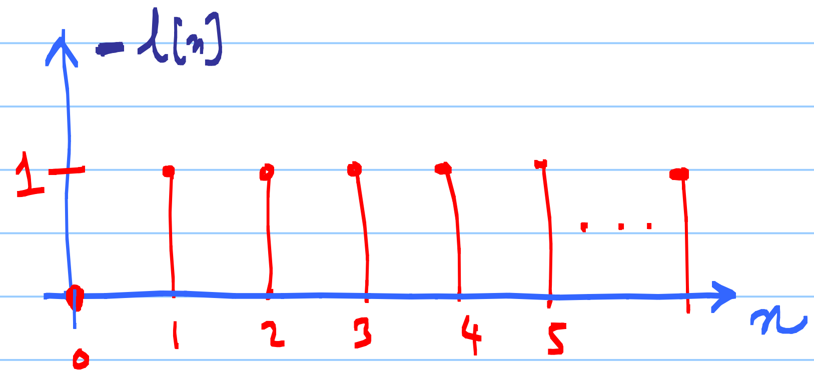




$l[n] \overset{\mathcal{Z}}{\longleftrightarrow} L(z)$ should be the same for the CT & DT loops

The DT impulse response

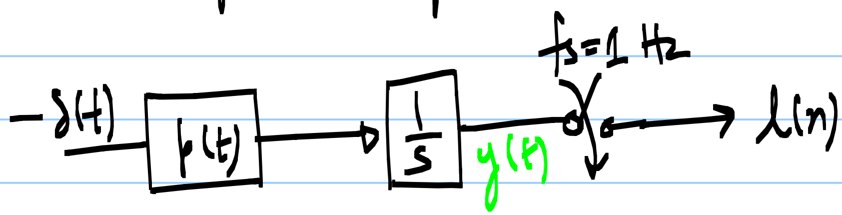




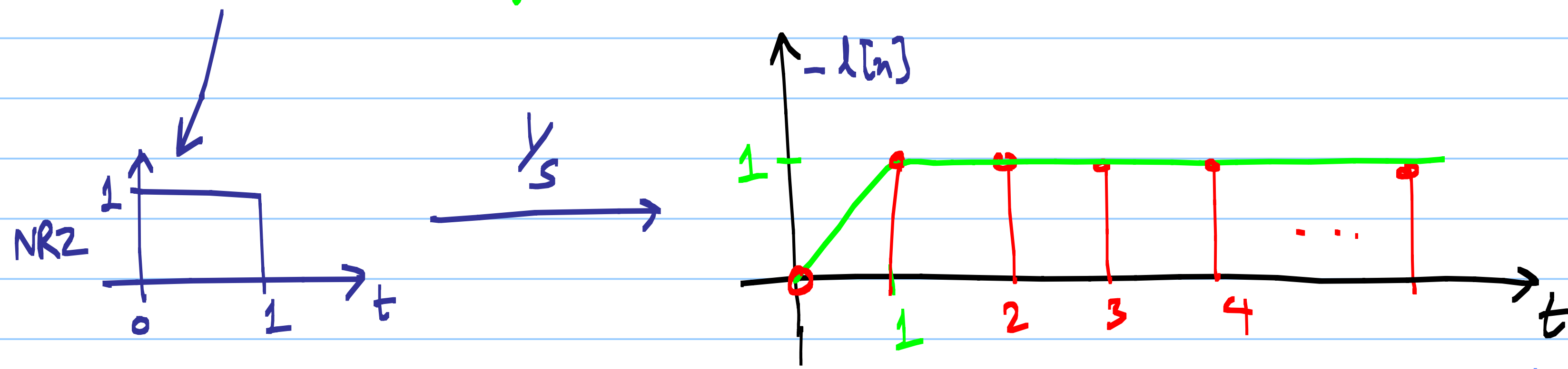
$\{0, 1, 1, 1 \ldots\}$

The CT impulse response

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



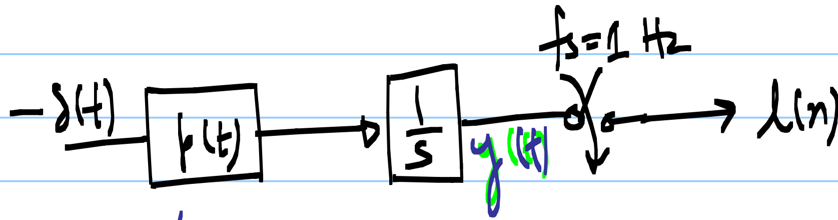
$$\{0, 1, 1, 1, \dots\}$$



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

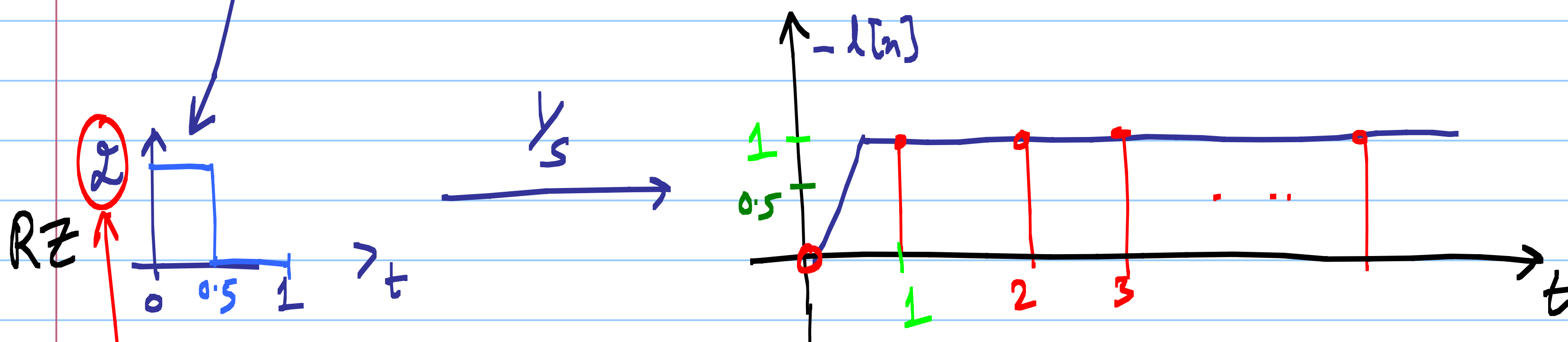
$$\left(\sum_{n=0}^{\infty} x^n = \frac{1}{1-x} \qquad |x| < 1\right)$$

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



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

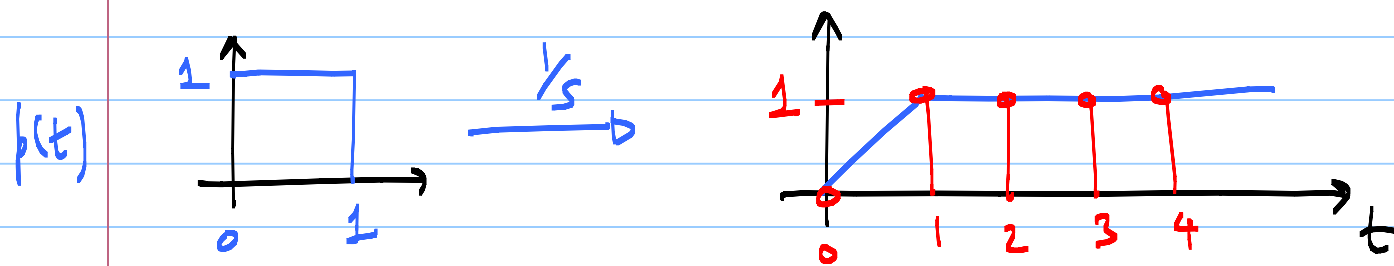
$$\{0, 1, 2, \ldots\}$$

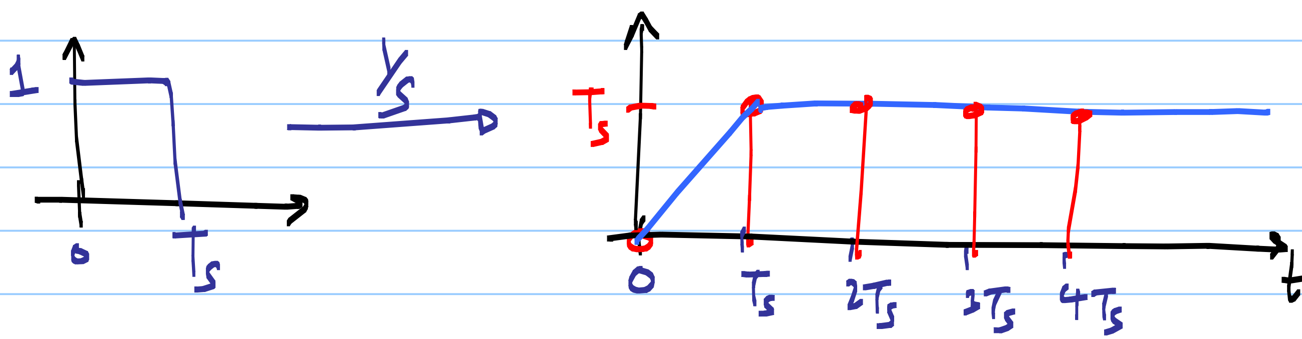


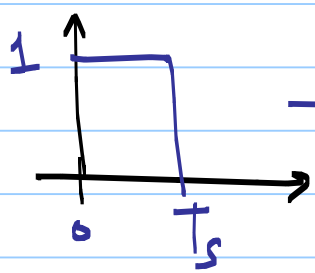
scale the DAC pulse amplitude by x2 to get the same impulse response

Many possibilities for $\{p(t), L(s)\}$ for the same $NTF(z)$

Time-scaling (change the sampling rate)

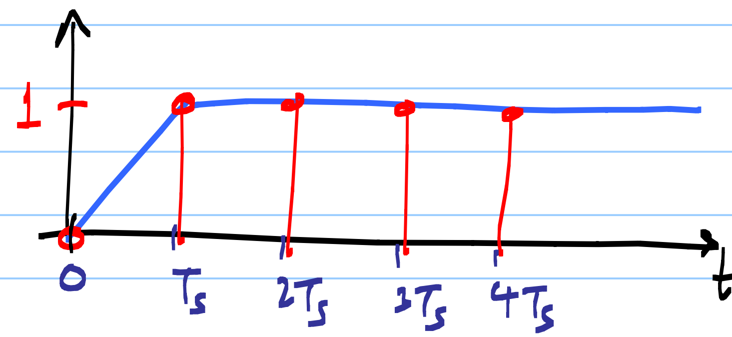




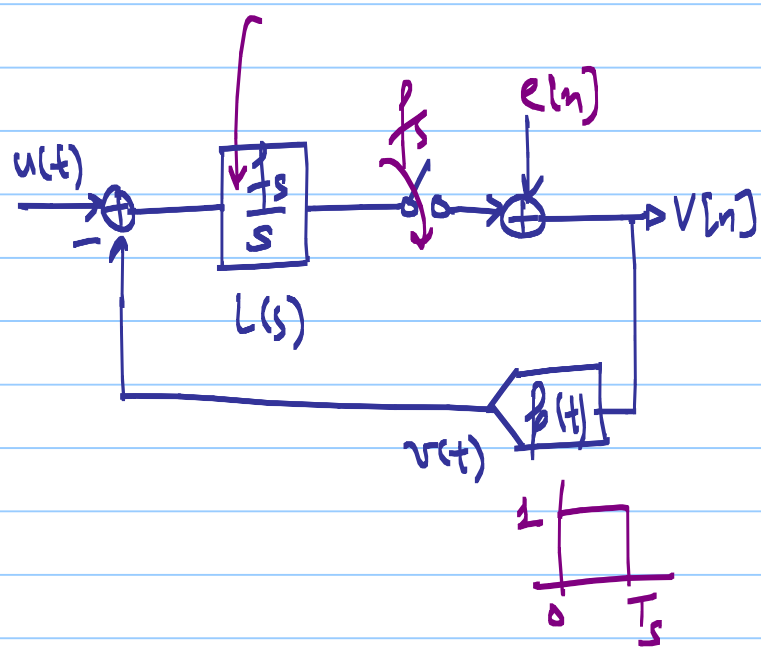


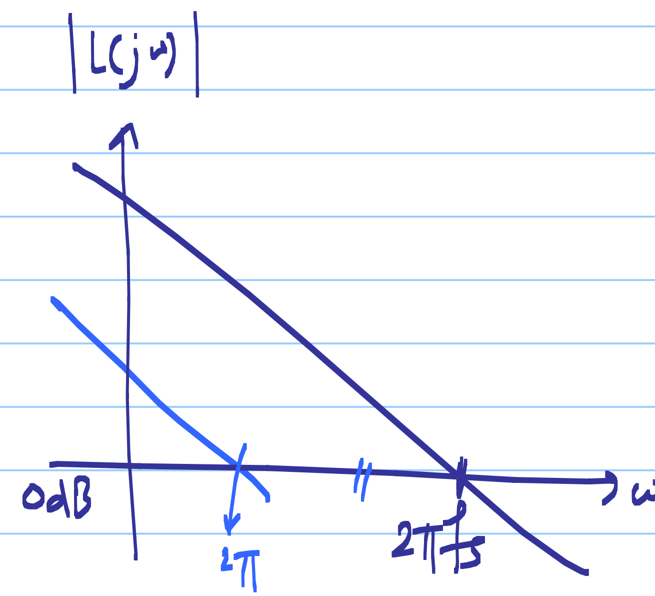
$$\xrightarrow{\cancel{1/s}}$$

$$\frac{1}{sT_s} = \frac{1/T_s}{s}$$



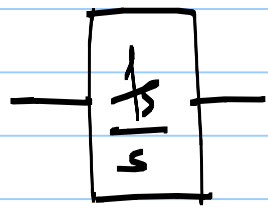
time scaling
of the loop filter

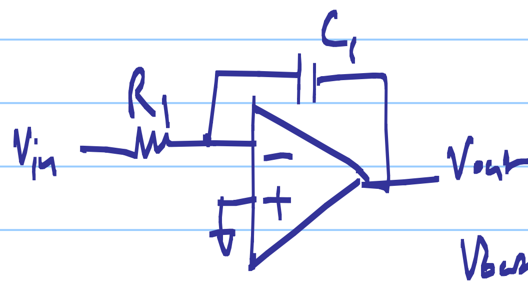




" we have scaled f_{un} of the Integrator "

→ not the opamp





$\boxed{\text{Ortmanns CT } \Delta\Sigma \text{ Book}}$

$$\frac{V_{out}}{V_{in}} = -\frac{1}{R_1C_1} \cdot \frac{1}{s}$$

Why $\boxed{\frac{f_s}{s}}$ and not $\cancel{\frac{\omega_s}{s}}$

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

$$\Rightarrow RC = \frac{1}{f_s}$$

for $f_s = 1\,Hz \Rightarrow RC = 1\,s \Rightarrow 1\,\mu F \times 1\,M\Omega$

for $f_s = 1\,GHz \Rightarrow RC = 1\,ns \Rightarrow 1\,pF \times 1\,k\Omega$

In MATLAB,

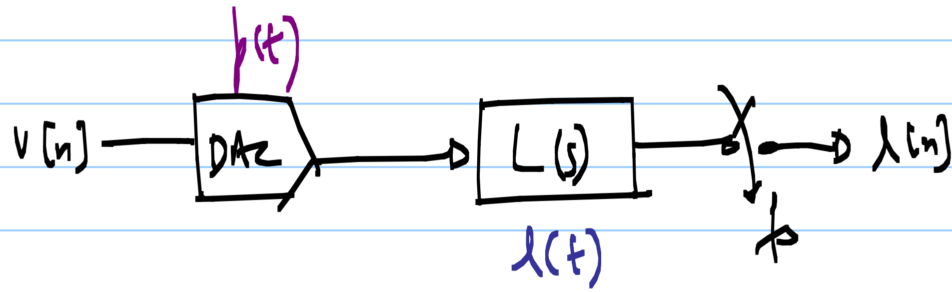
Design CT filters with $f_s = 1$ Hz

↓ Time-scaling → Scale all the coefficients

Circuit Schematics

Impulse Invariant Transformation

CT



DT

$$p(t) \circledast l(t)\Big|_{t=nT_s} = l[n]$$

$$\boxed{\mathcal{L}^{-1}\{P(s)\cdot L(s)\}\Big|_{t=nT_s} = \mathcal{Z}^{-1}\{L(z)\}}$$

I.T.T.

Synthesis of Higher-Order CT ΔΣ Modulators

$$\ell[n] = \mathcal{Z}^{-1}\{L(z)\} = \mathcal{L}^{-1}\{R_D(s)\cdot L(s)\}\Big|_{t=nT_s}$$

NTF(z) $\longrightarrow$ $L(z)$ $\longrightarrow$ How do we get $L(s)$ for any $R_D(s)$

3rd order

Using LT Table

"Symbolic Math"

Impulse Response Fitting

(Numerical)

J.A. Cherry, Books

ΔΣ Toolbox

realizeNTF_ct