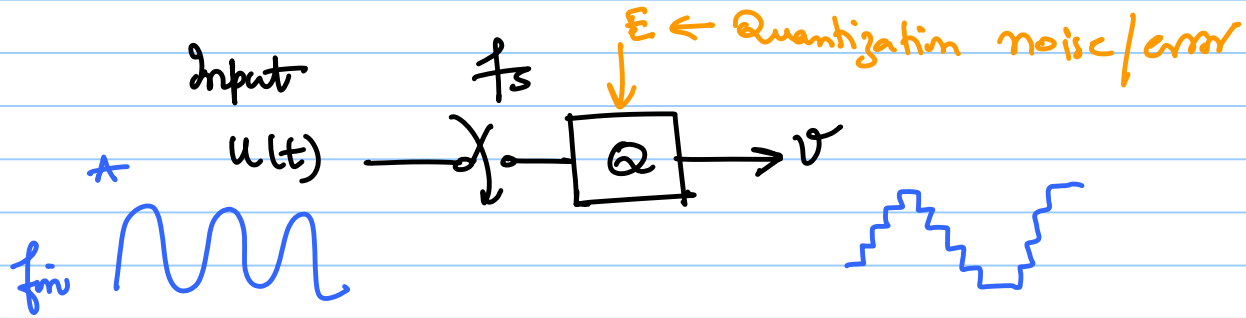
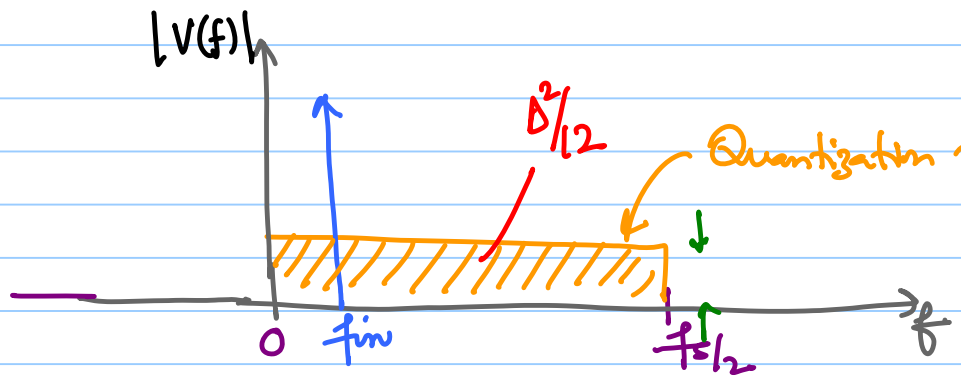
ECE 517- Lecture 26

Note Title 4/20/2017



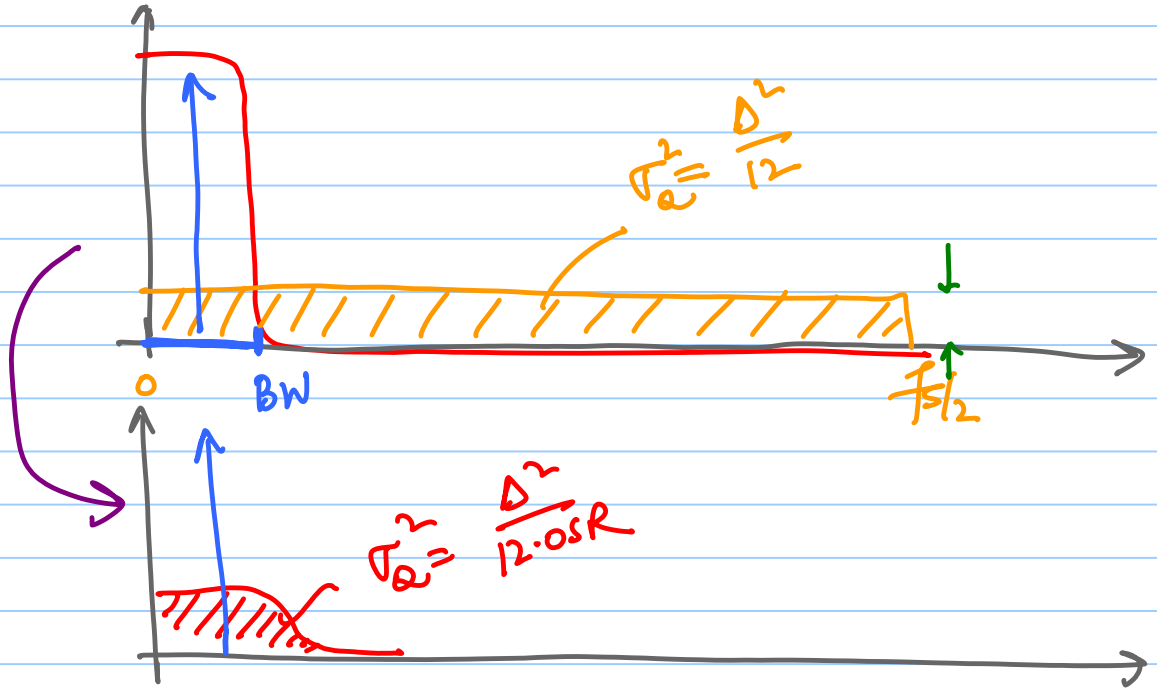
$$SQNR = \frac{P_{signal}}{P_{noise}}$$

$$ENOB = \frac{SQNR - 1.76}{6.02}$$



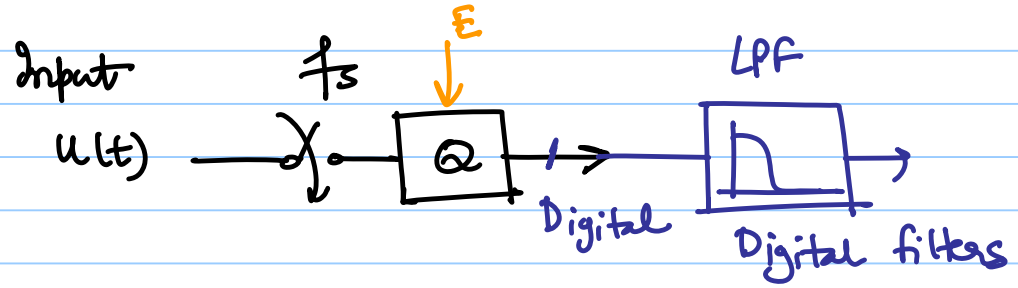
Oversampling : $OSR = \frac{f_s/2}{BW}$ ← $f_s/2$: Nyquist rate of sampling; ← BW: Bandwidth

$OSR > 1$



↳ Leverage Digital Signal Processing

↳ Oversampling Converters



$$SQNR = 10\log_{10}\left(\frac{A^2/2}{\frac{\Delta^2}{12 \cdot OSR}}\right) = 10\log_{10}\left(\frac{\frac{(2^{N-1}\Delta)^2}{2}}{\frac{\Delta^2}{12 \cdot OSR}}\right)$$

$$= 6.02N + 1.76 + 10\log_{10}(OSR)$$ ← Extra term

Increase in ENOB $= \dfrac{10\log_{10}(OSR)}{6.02} = \dfrac{1}{2} \times \log_2(OSR)$

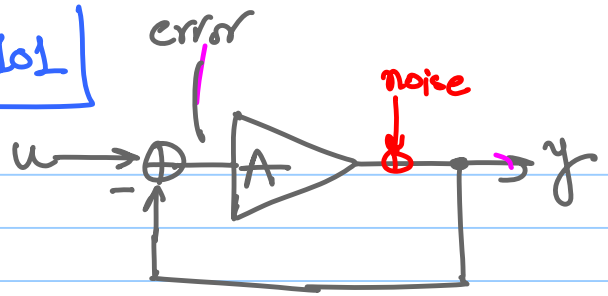
$OSR = 2 \rightarrow \dfrac{10\log_{10}(2)}{6} = 0.5$

* ½ bit extra resolution per doubling in OSR!

N_0 = 3-bit Quantizer
OSR > 64

$N = 3 + \frac{1}{2} \cdot \log_2(64) = 6$ bits

feedback control 101

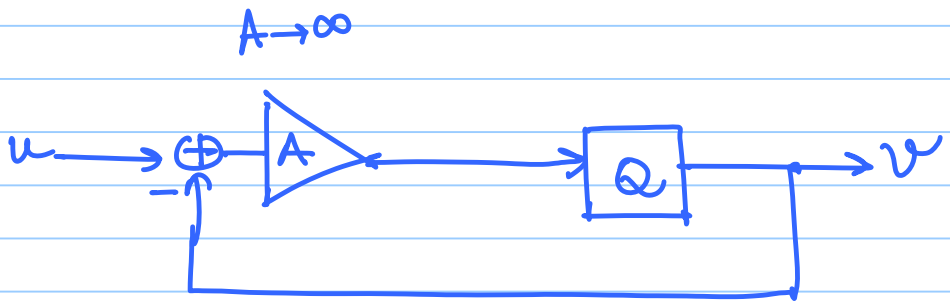


$A \to \infty$

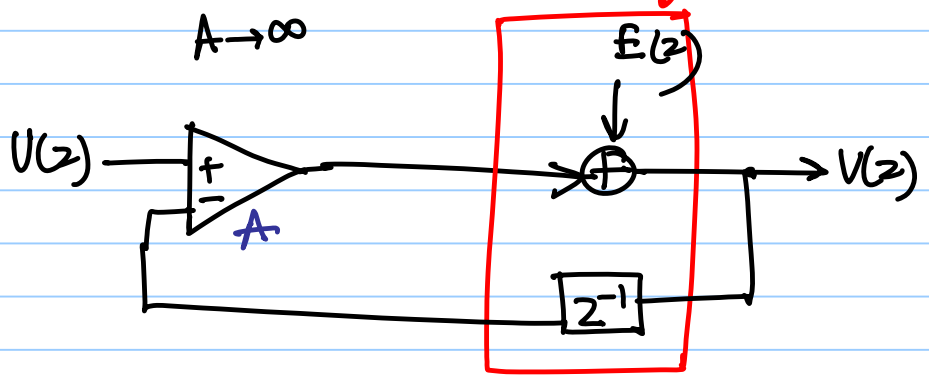
error $\to 0$

$y \simeq u$

$y \to$ tracks u



Quantizer linearized model with delay



Will this scheme work?

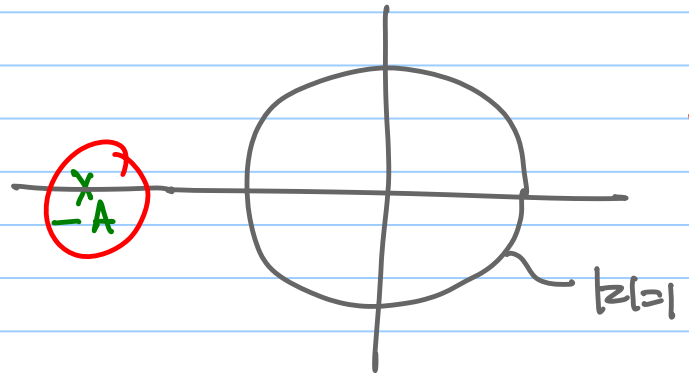
$z^{-1} \Rightarrow$ delay of T_s

$$\left(U(z) - z^{-1}V(z)\right)A + E(z) = V(z)$$

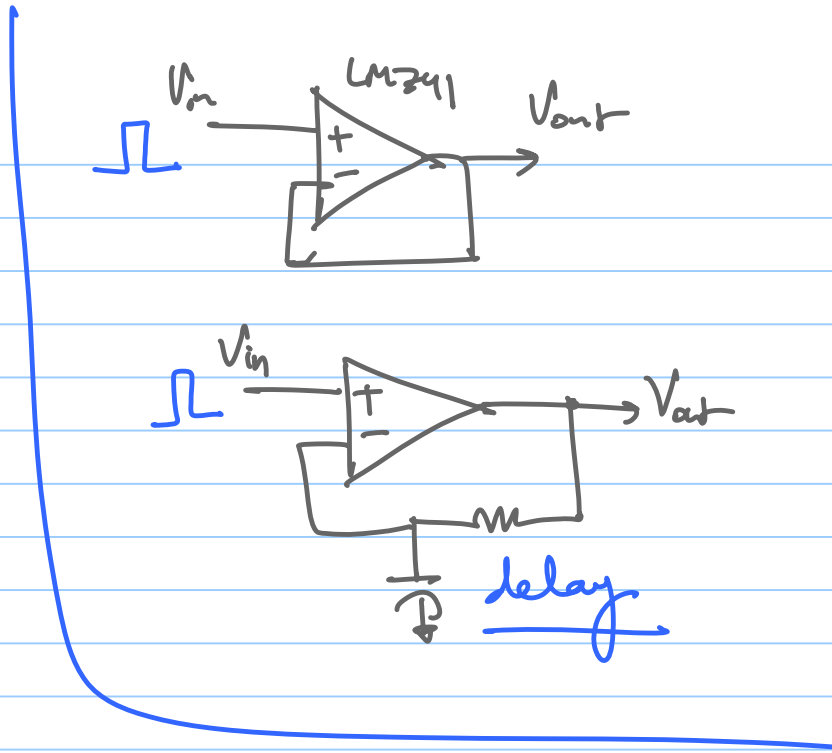
$$\Rightarrow \quad V(z) = \left(\frac{A}{1+Az^{-1}}\right) U(z) + \underbrace{\left(\frac{1}{1+Az^{-1}}\right) E(z)}$$

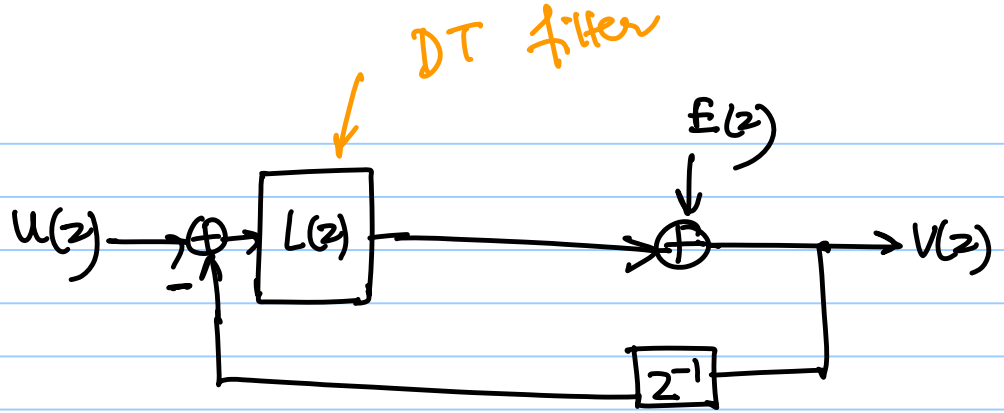
$$\frac{1}{1+Az^{-1}} \Rightarrow \text{pole: } D^r = 0 \Rightarrow 1 + Az^{-1} = 0$$

$$\Rightarrow z = -A$$



unstable system!


V_{in}
LM741
V_{out}
+
−
V_{in}
+
−
V_{out}
delay



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

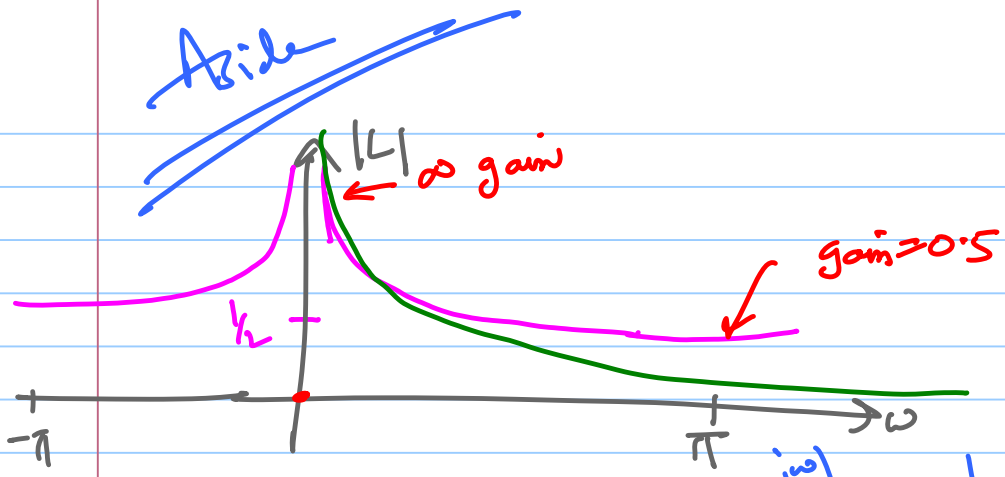
$$\left(U(z) - V(z)\right) L(z) + E(z) = V(z)$$

$$\Rightarrow \quad V(z) = \frac{L(z)}{1+z^{-1}L(z)} U(z) + \frac{1}{1+z^{-1}L(z)} E(z)$$

signal transfer function — STF

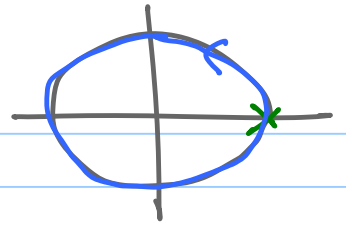
NTF — noise transfer function

Aside



Aside

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



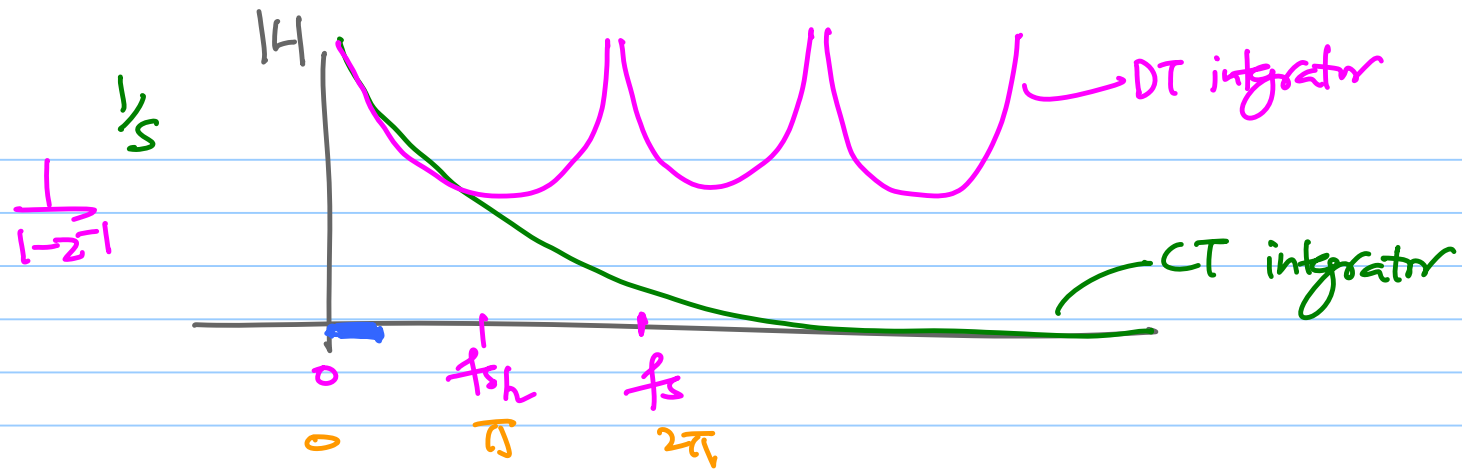
$z \to e^{j\omega}$ DTFT

$$L(e^{j\omega}) = \frac{1}{1-e^{-j\omega}} = \frac{1}{e^{-j\omega/2}\left(e^{j\omega/2} - e^{-j\omega/2}\right)}$$

$$= \frac{e^{j\omega/2}}{2j\sin(\omega/2)}$$

$e^{j\theta} - e^{-j\theta} = 2j\sin\theta$

$$|L(e^{j\omega})| = \frac{1}{2|\sin(\omega/2)|}$$


|H|
1/s
1/(1−z⁻¹)
DT integrator
CT integrator
0
fs/2
fs
0
π
2π

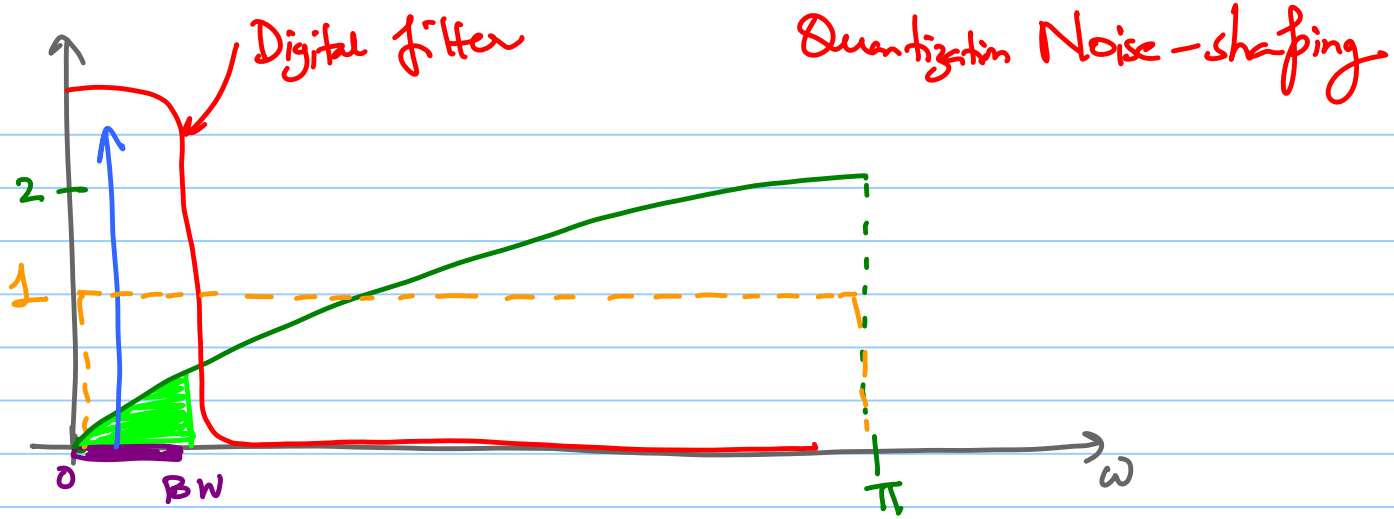
$$NTF(z) = \frac{1}{1+z^{-1}L(z)} = \frac{1}{1+\frac{z^{-1}}{1-z^{-1}}} = \frac{(1-z^{-1})}{1+z^{-1}-z^{-1}} = (1-z^{-1})$$

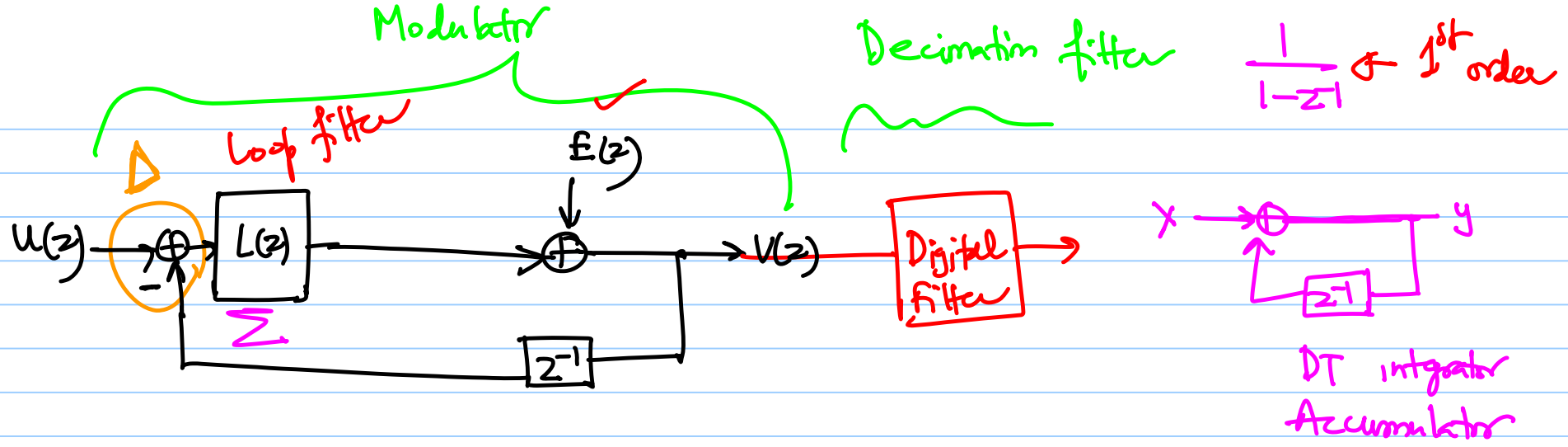
$$STF(z) = \frac{L(z)}{1+z^{-1}L(z)} = 1$$

$NTF = 1-z^{-1} \Rightarrow$

$$NTF(e^{j\omega}) = 1-e^{-j\omega} = e^{-j\omega/2}\left[e^{j\omega/2} - e^{-j\omega/2}\right] = 2je^{-j\omega/2}\cdot \sin(\omega/2)$$

$$|NTF| = 2\left|\sin(\omega/2)\right|$$


Digital filter
Quantization Noise-shaping
2
1
0
BW
π
ω



ΔΣ ADC

ΣΔ ADC

order ⇒ M

(M+½) bits per 2x in OSR