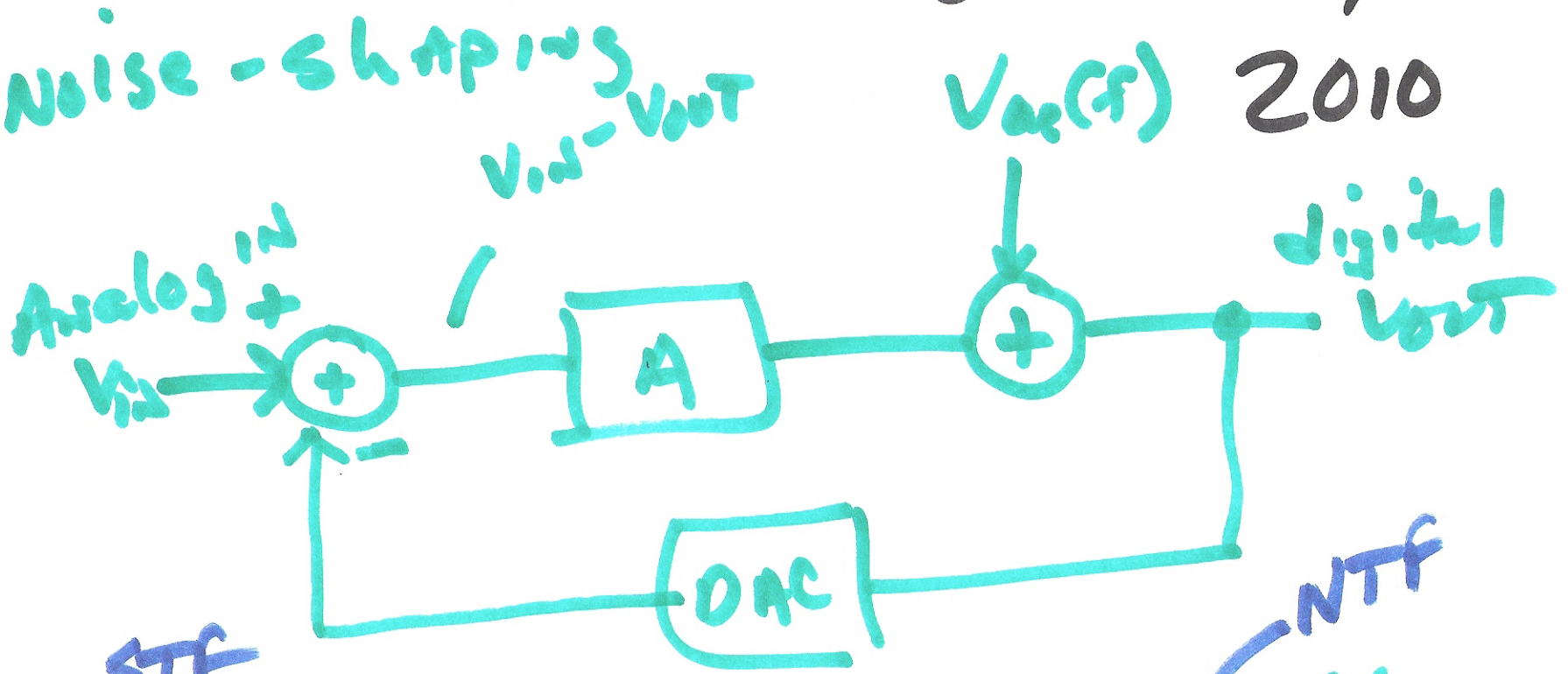
ECE 615 CMOS Mixed-Signal

BOISE STATE UNIVERSITY

Lecture 19

OCT. 27, 2010

Noise-shaping



STF

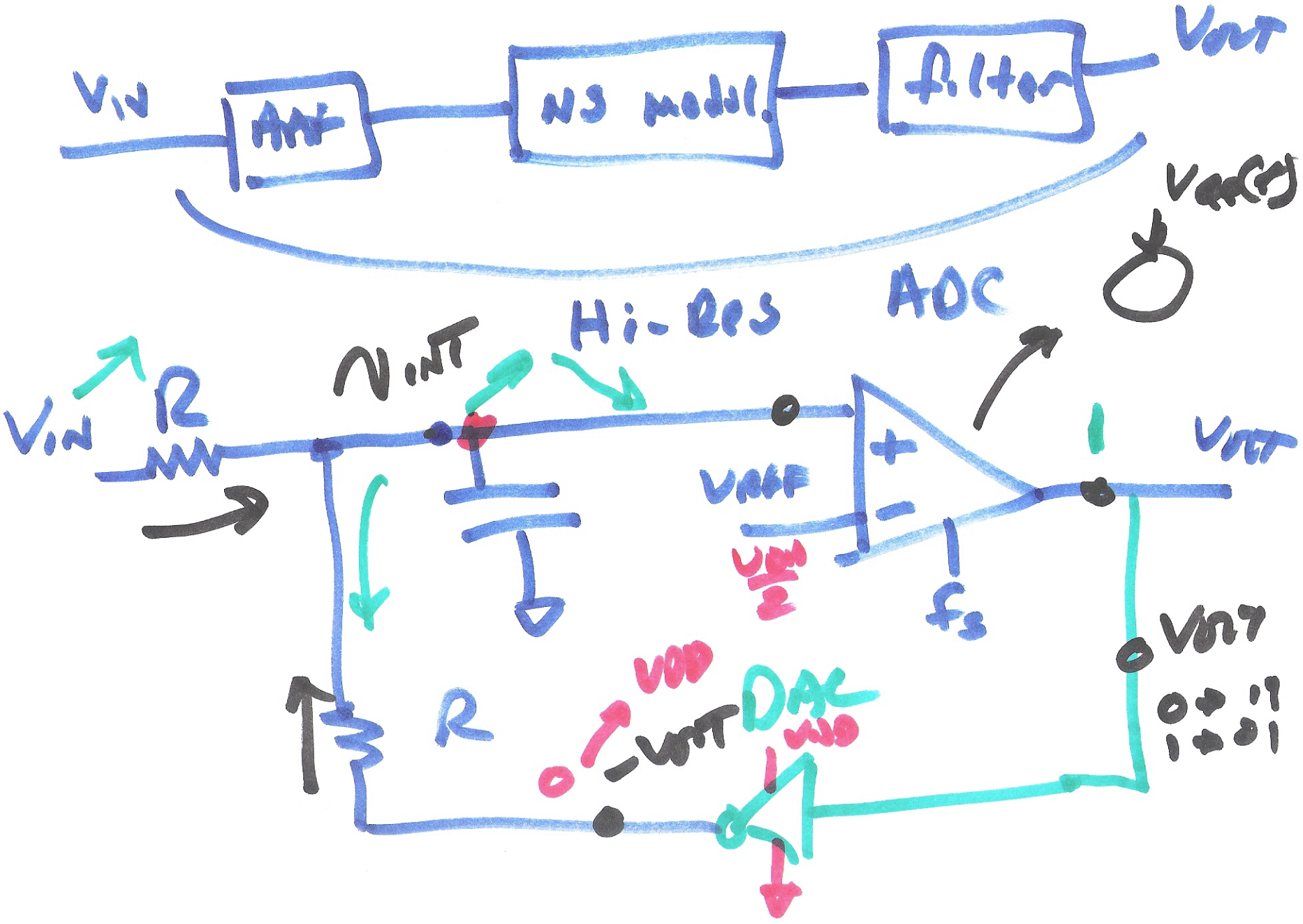
NTF

$A(V_{IN}-V_{OUT}) + V_{QE}(z) = V_{OUT}$

$V_{IN}\cdot\left(\frac{A}{1+A}\right)$

$V_{QE}\cdot\left(\frac{1}{1+A}\right) = V_{OUT}$

1)


VIN
AAF
NS modul.
filter
VOUT
VADC(z)
AOC
Hi-Res
VINT
VIN
R
VREF
VDD/2
fs
VOUT
0 → 11
1 → 01
R
VDD
VOUT
DAC
VDD
0
1

2)

$V_{int} + V_{dac} = V_{out}$

$V_{int} + V_{dac}(z) = V_{out}$

$$\frac{V_{in} - V_{int}}{R} + \frac{-V_{out} - V_{int}}{R} = \frac{V_{int}}{\frac{1}{j\omega C}}$$

$$j\omega RC\, V_{out} = V_{in} - V_{int} - V_{out}$$

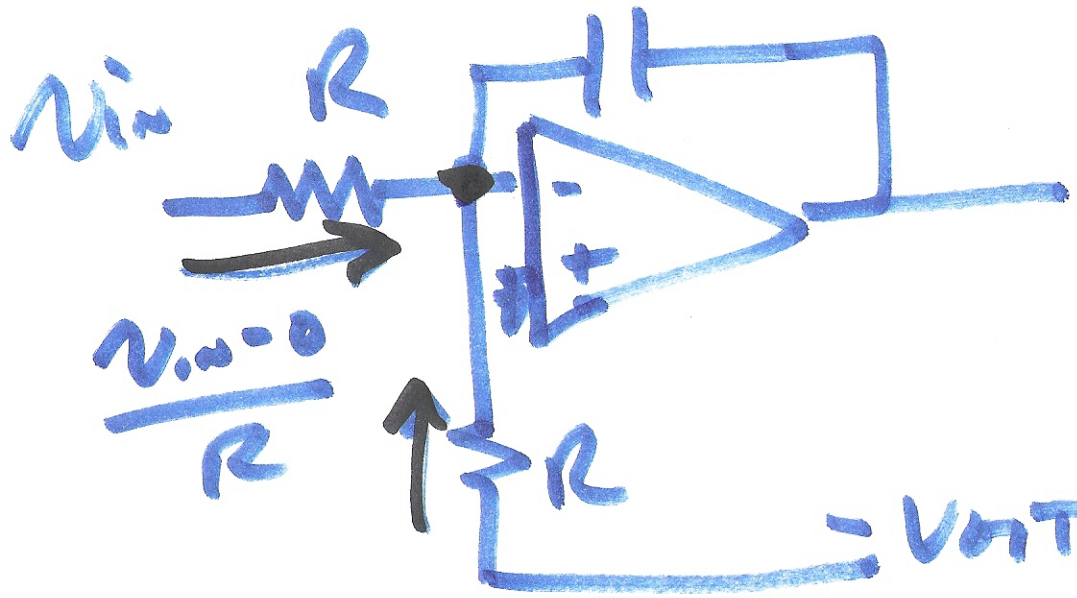
$$V_{in} - 2V_{out} + V_{dac} \cdot j\omega RC =$$

$$V_{out}(1 + j\omega RC) \quad \text{NTF}$$

$$V_{out} = \underbrace{\frac{1}{1 + j\omega RC}}_{\text{STF}} \cdot V_{in} + \underbrace{\frac{j\omega RC}{1 + j\omega RC} \cdot V_{dac}}_{\text{quantization}} + \frac{-2V_{int}}{1 + j\omega RC}$$

3)

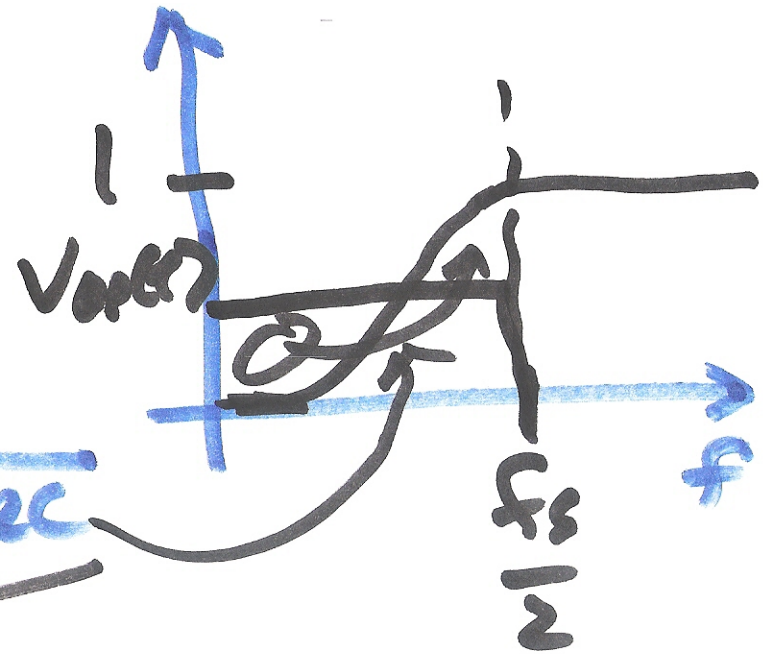
$V_{out} \to 0$



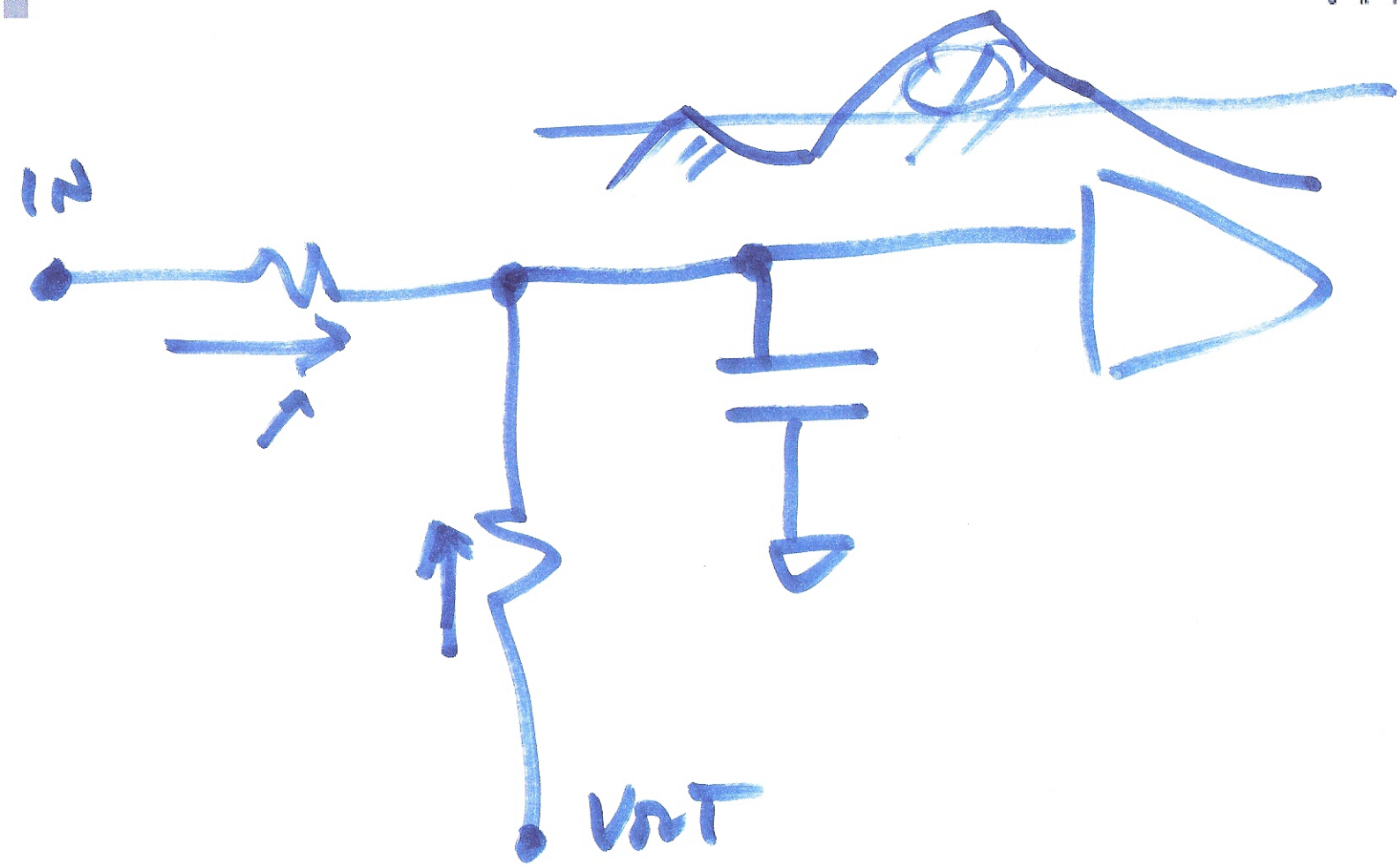
$$-\frac{V_{out}-0}{R}$$

NTF

$$V_{QE} \cdot \frac{j\omega RC}{1+j\omega RC}$$

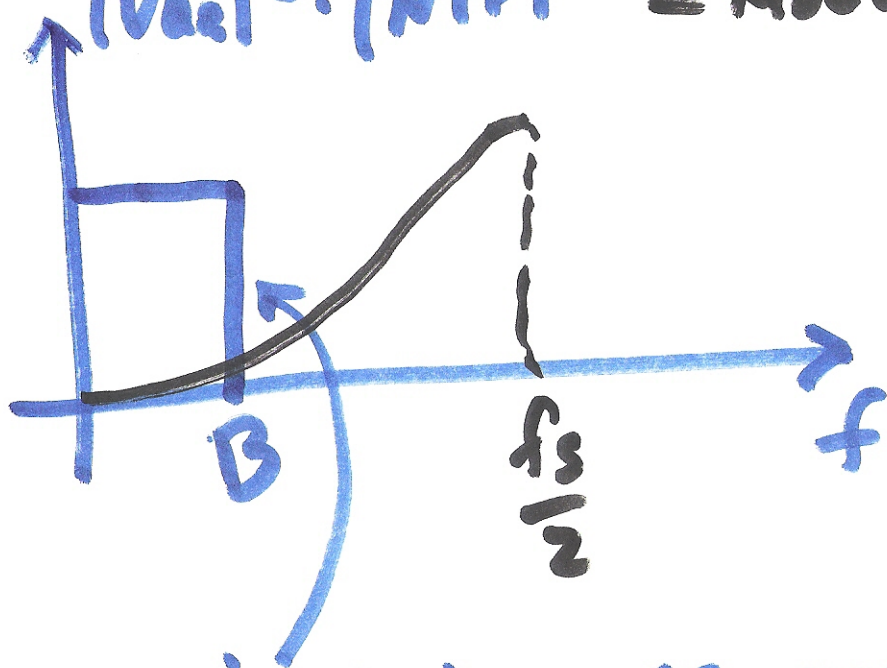


4)



5)

$|V_{noise}|^2 \cdot |NTF|^2$ = modulation noise



ideal lowpass response

low freq

$$\frac{j\omega RC}{1+j\omega RC} \approx j\omega RC$$

$$|j\omega RC|^2 = \omega^2 R^2 C^2$$

$$V^2_{noise,rms} = \int_0^B \frac{V^2_{LSB}}{12 f_s} \cdot (\omega RC)^2 \cdot df = 2 \cdot \frac{V^2_{LSB}}{12 f_s} \cdot (2\pi RC)^2 \cdot \frac{B^3}{3}$$

6)

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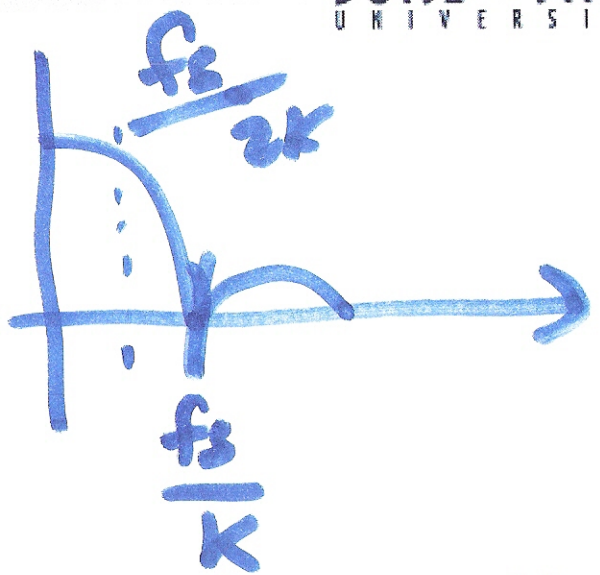
$$B = \frac{f_s}{2K}$$



$$V^2_{NOISE,rms} = \frac{V^2_{LSB}}{12}(2\pi RC)^2 \cdot \frac{f_s^3}{12K^3}$$

0.5 bits
1.5 b.t.

$$SNR = 20\log\frac{V_p/\sqrt{2}}{V_{NOISE,rms}} = 6.02N + 1.76 + \underbrace{-20\log\frac{2\pi RC \cdot f_s}{\sqrt{12}}}_{18.0b\ 36.t_3} + \underbrace{20\log K^{3/2}}_{30\log K}$$

7)

$$\log_2 k \geq \frac{30\log k - 18.06}{6.02}$$

Nine

1-Sine

$N + \log_2 k$

$$\left(\frac{1-2^{-K}}{1-2^{-1}}\right)^L$$

$\log 2^3 = .9$

$K = 8$

$$\log_2 2^3 \geq \frac{27 - 18.06}{6.02} \times 1.5$$

$3 \geq 1.5$

$K \leq 256 \quad L = 1$

8)

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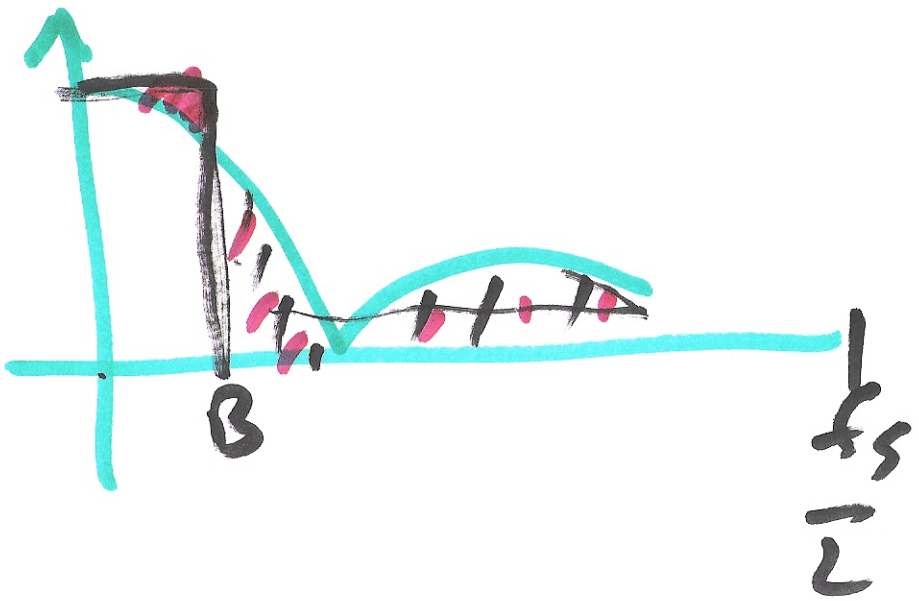
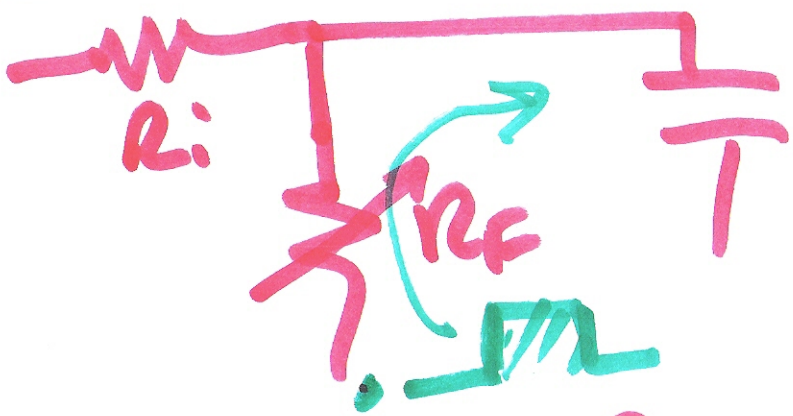
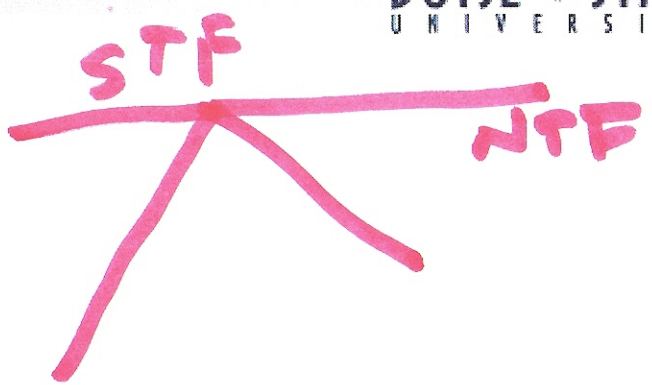
Using a Sinc filter

$$V_{BE,rms}^2 = \frac{V_{LSB}^2}{12}(2\pi RC)^2 \cdot \frac{f_s^2}{2\pi^2 k^3}$$

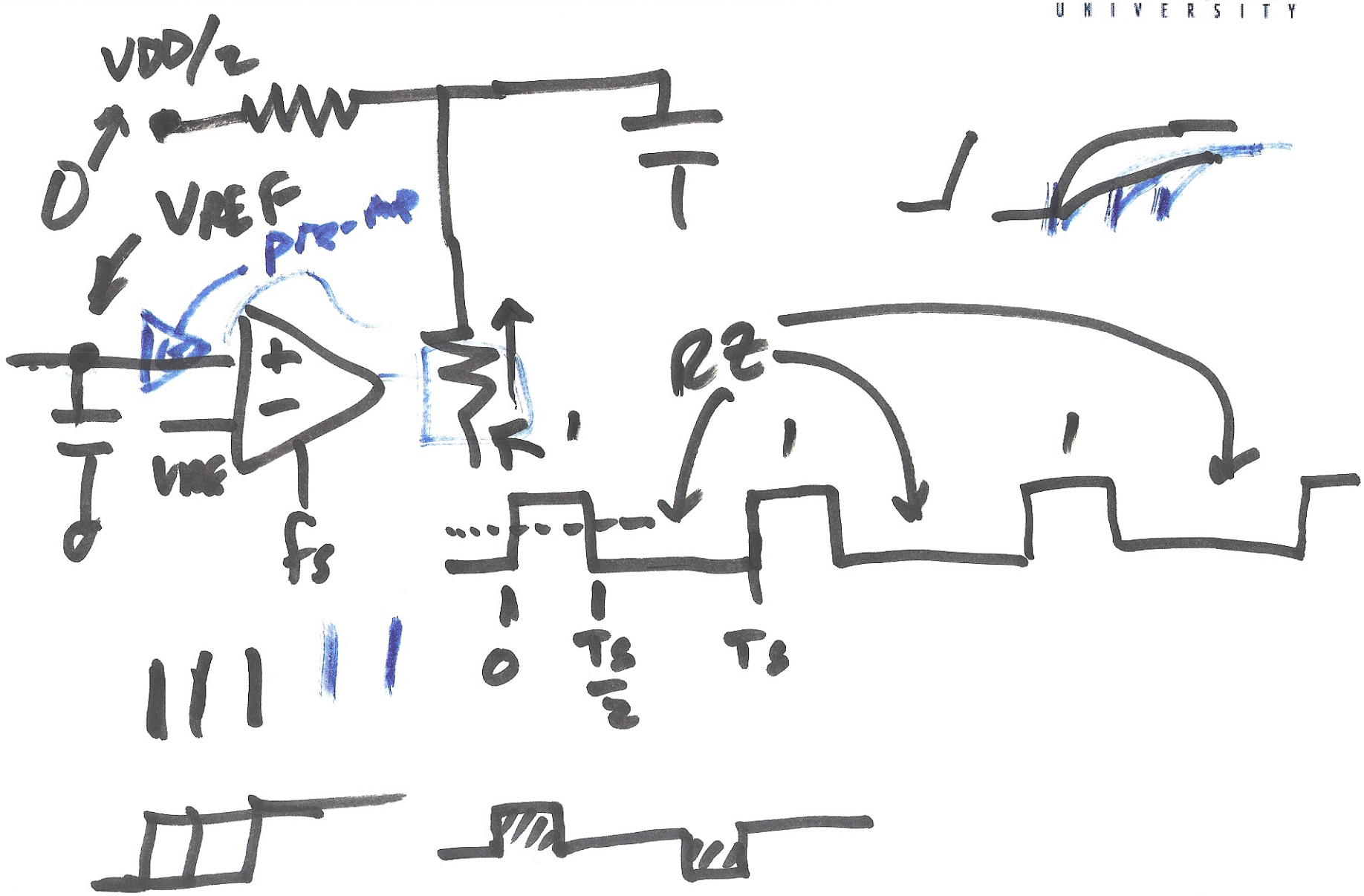


9)





$$\underbrace{\frac{\frac{R_F}{R_I}}{1+j\omega C R_F}}_{STF} \cdot V_{IN} + \underbrace{\frac{j\omega R_F}{1+j\omega R_F}}_{NTF} \cdot V_{ap}$$



11)