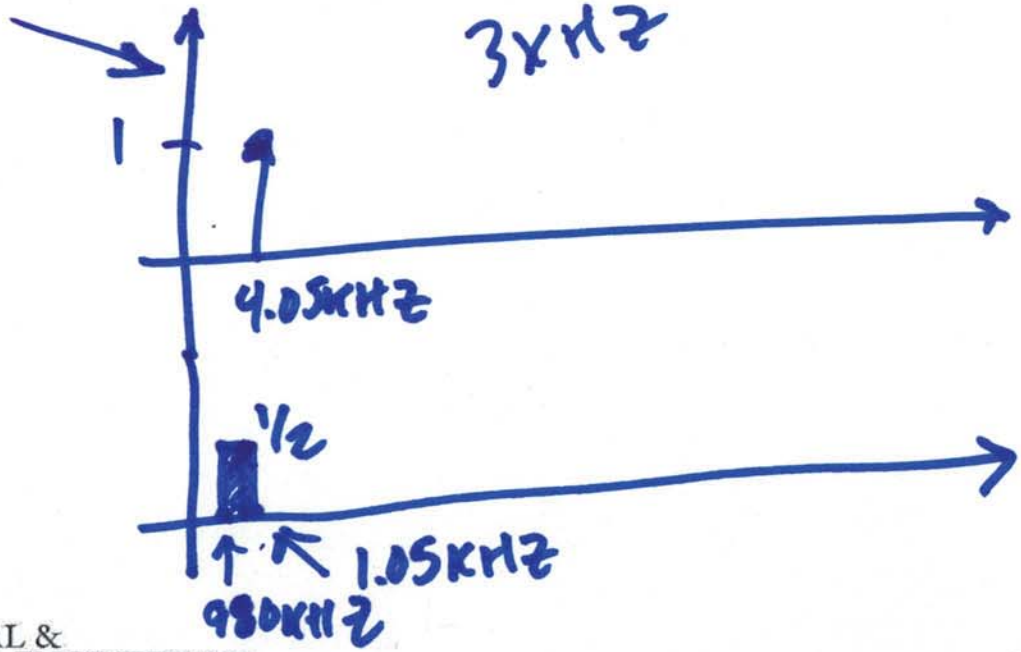
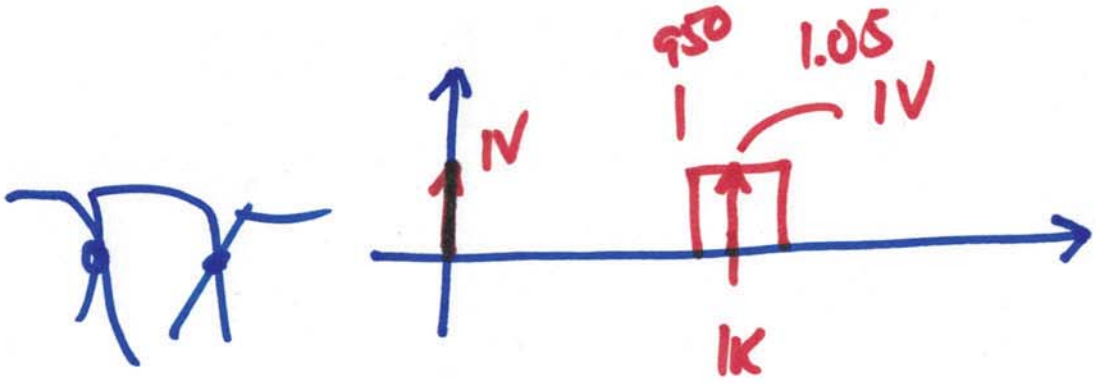
Lecture 7

ECE 720

Advanced Analog IC Design

2/9/2016

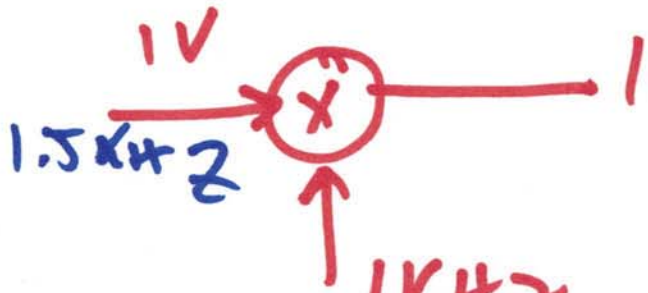




$1.5KHz - 0.5KHz$

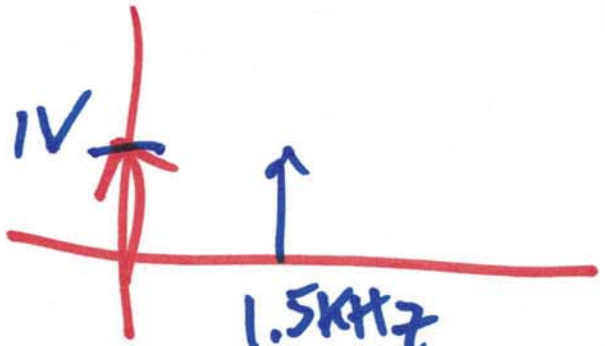
$f_{in} + f_{LO} = 1KHz$

$\cos 2\pi t - 0.5KHz) \cdot t \quad f_{LO} = 1KHz$



$1KHz \rightarrow \frac{1}{2}\cos 1KHz \cdot t$

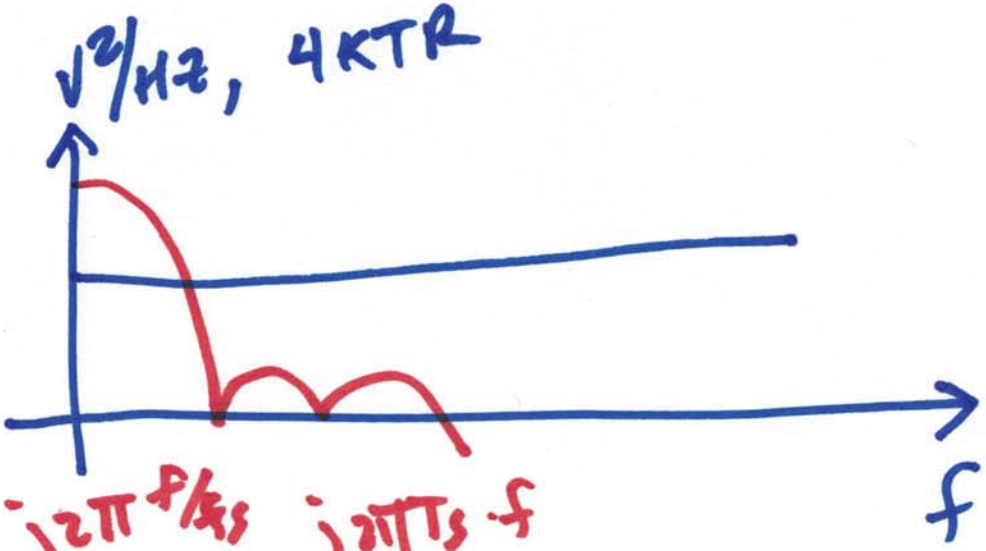
$\frac{1}{2}\cos 2\pi\, 2KHz\, t$



$1KHz$

$.5KHz$

$f_{LO} = 0.5\,KHz$



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

$x_1 + x_2 + x_3 + x_4 = y$

$$\frac{KTTR}{K}$$ ← # of Averages

$$z = e^{j2\pi f/f_s} = e^{j\omega T_s \cdot f}$$

$$y = x[nT_s] + x[(n-1)T_s] + x[(n-2)T_s) \cdots + x\left((n-k)T_z\right)$$

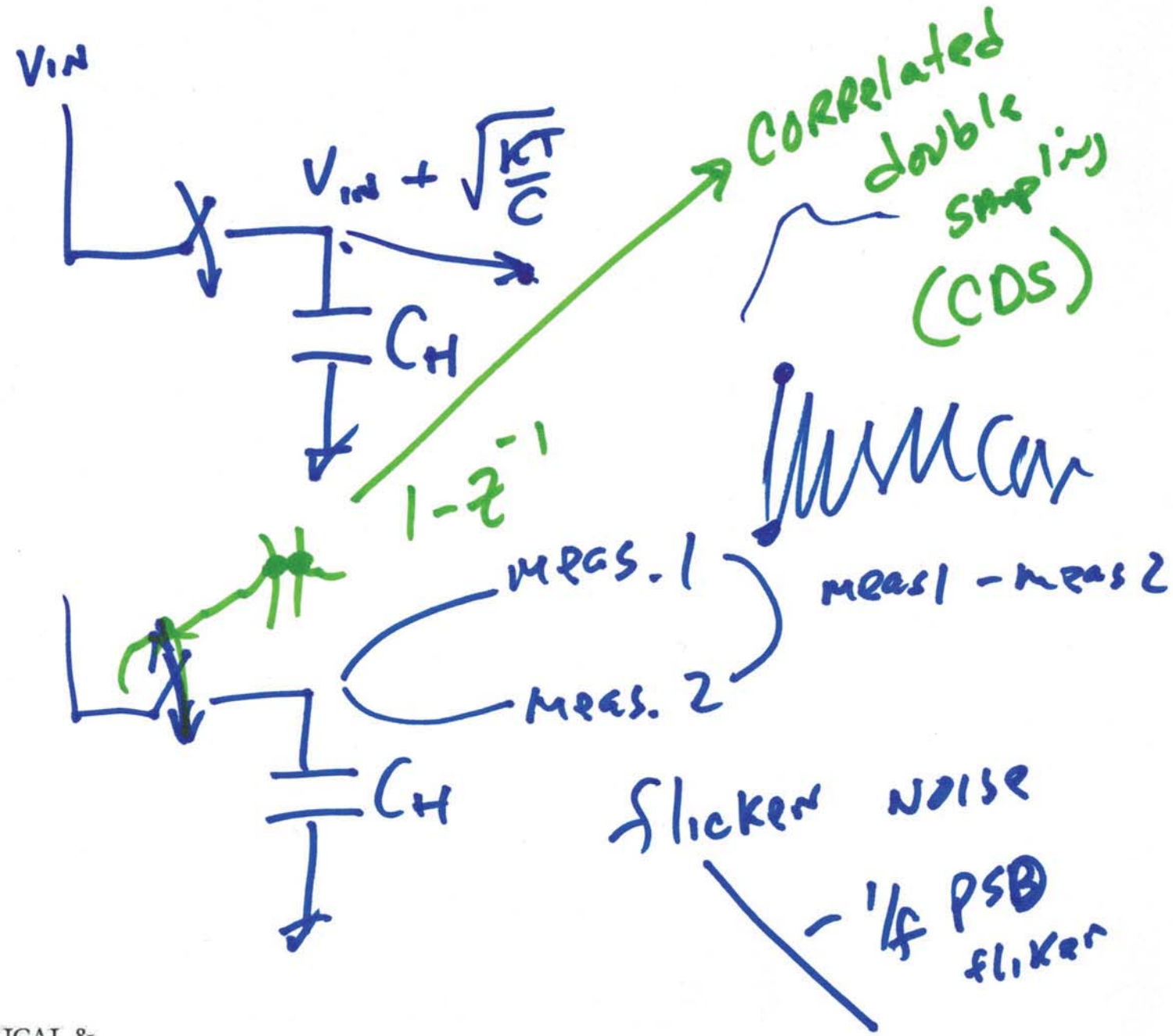
$$= \cos 2\pi \frac{f}{f_s} + j \sin 2\pi f/f_s$$

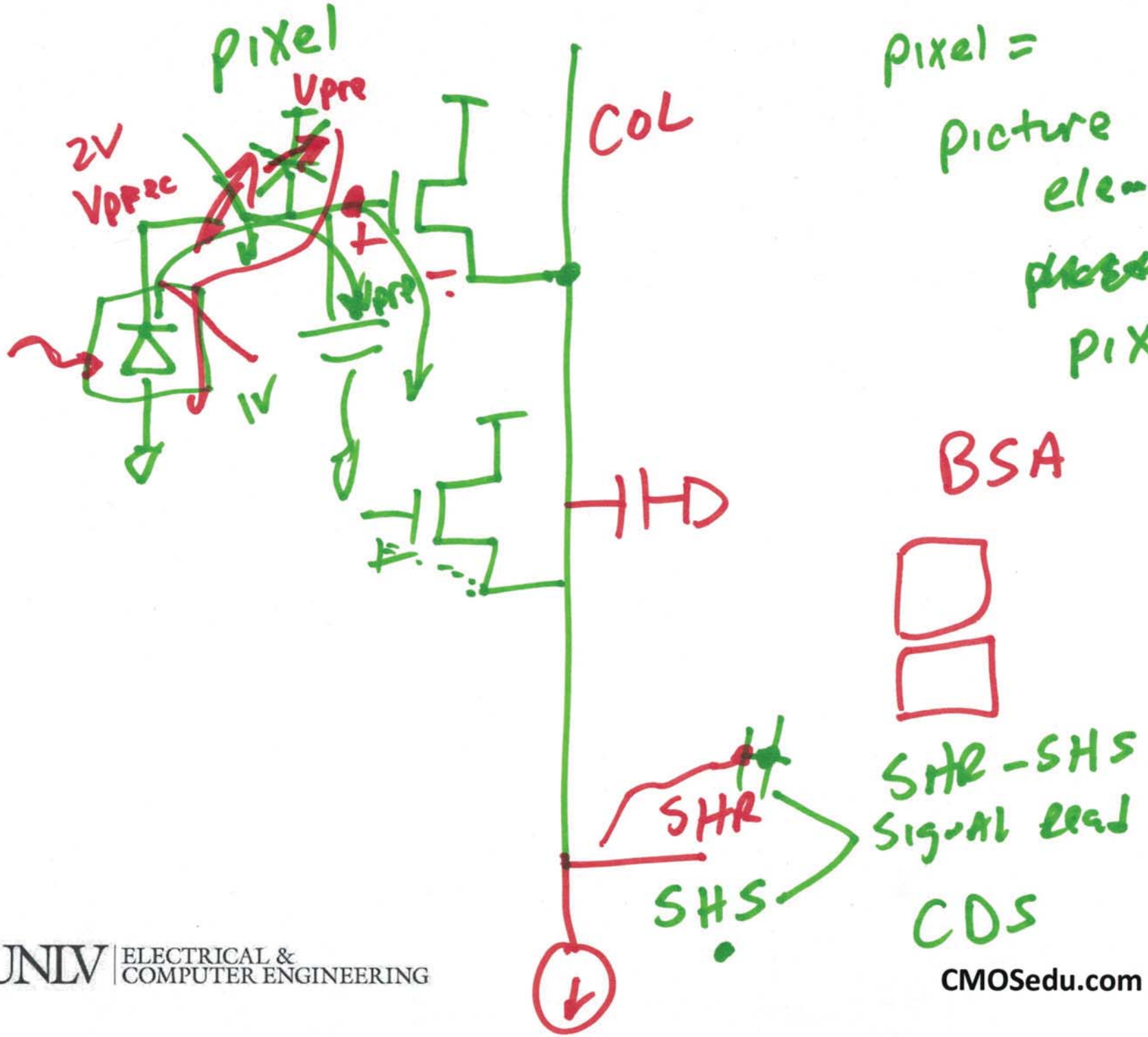
$$\downarrow \quad \frac{1-z^{-K-1}}{1-z^{-1}}$$

$$Y(z) = X(z) + z^{-1}X(z) + z^{-2}X(z) + \cdots + z^{-K}X(z)$$

$$\Rightarrow \text{SINC} \Rightarrow \frac{\sin x}{x}$$

$$H(z) = \frac{Y(z)}{X(z)} = 1 + z^{-1} + z^{-2} + \cdots z^{-k}\frac{1-z^{-1}}{1-z^{-1}}$$

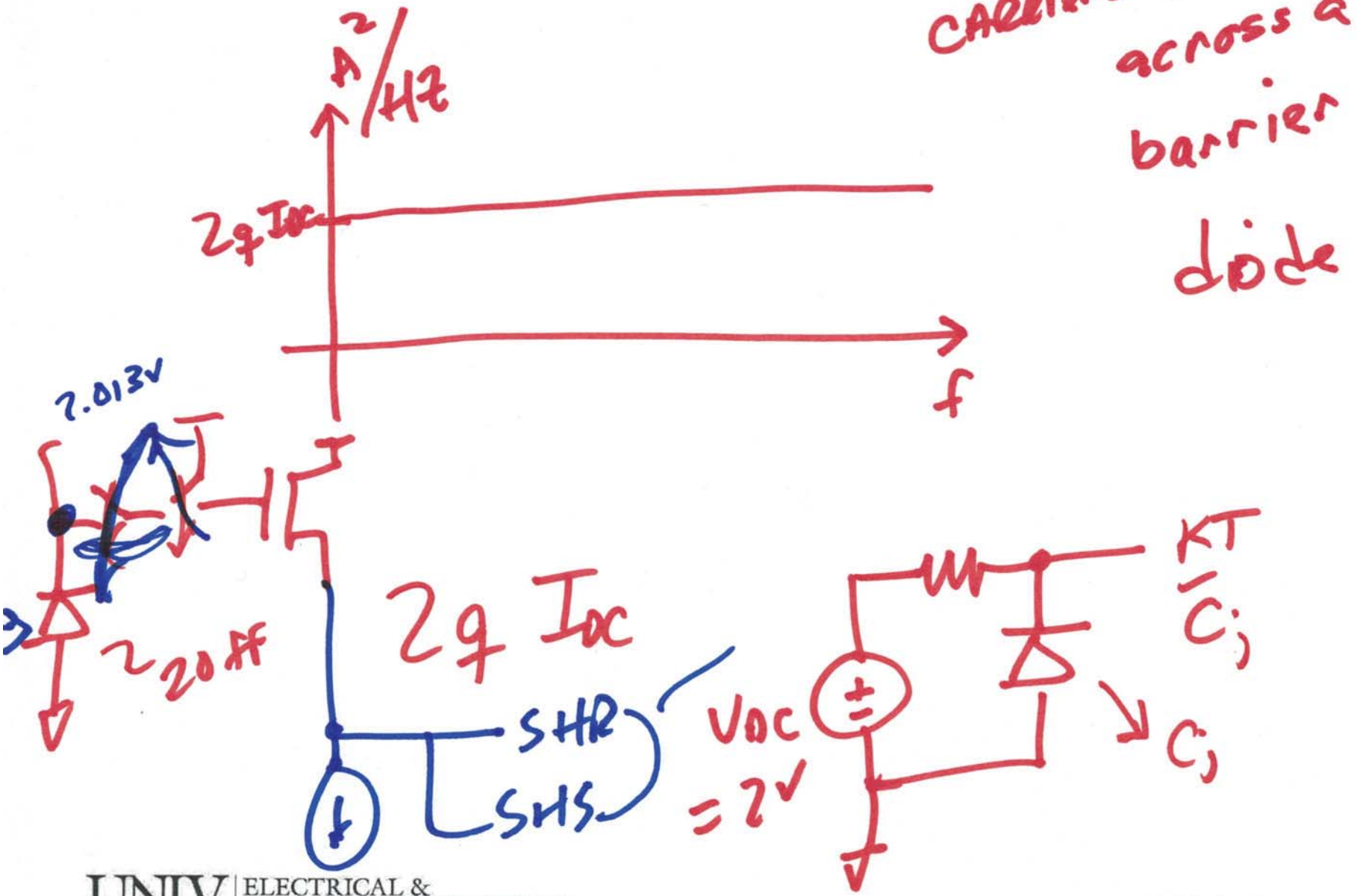

VIN
$V_{in} + \sqrt{\frac{kT}{C}}$
C_H
$1 - z^{-1}$
Correlated double sampling (CDS)
meas. 1
meas. 2
meas1 - meas2
C_H
flicker noise
- 1/f PSD
flicker

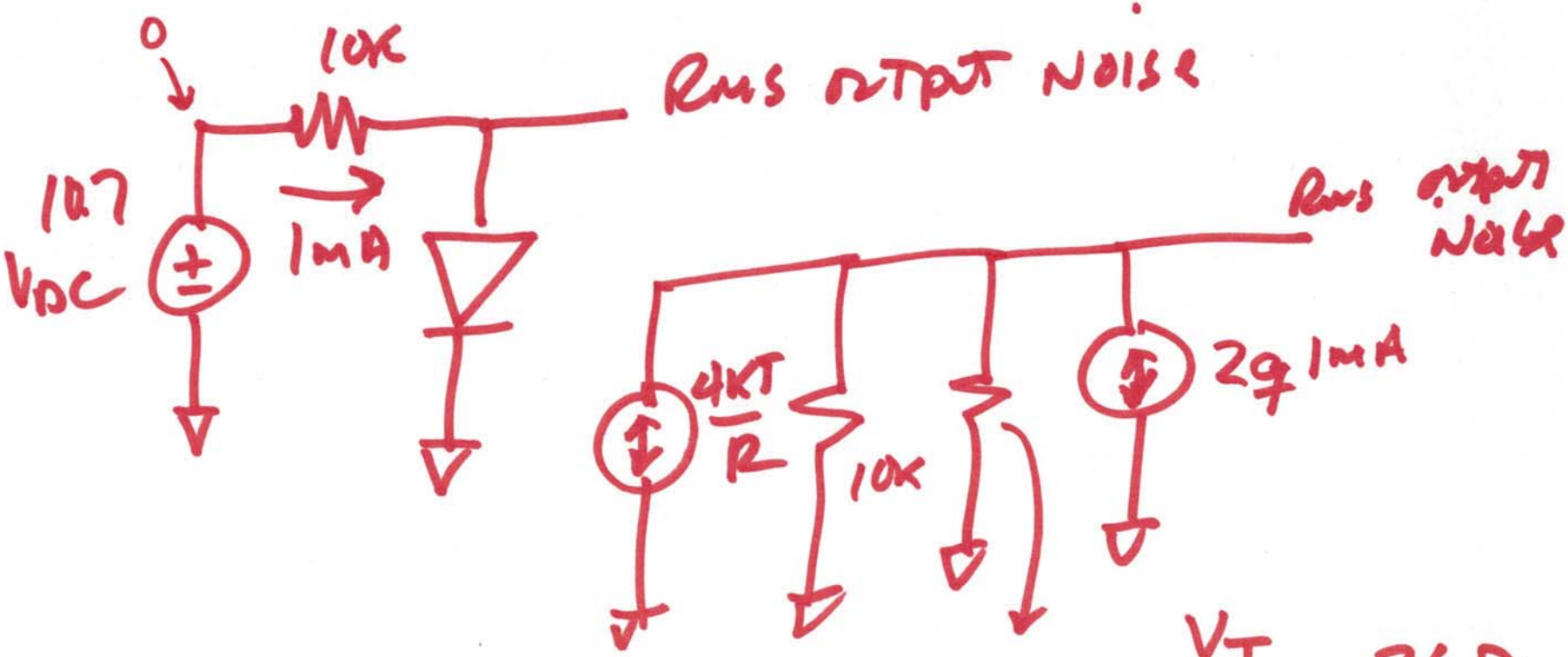

pixel
VPRE
2V
VPRE
COL
1V
VPRE
HD
SHR
SHS
pixel =
picture
element
pix = pics
BSA
SHR - SHS
signal lead
CDS

SHOT NOISE

→ Carriers flowing across a barrier

diode



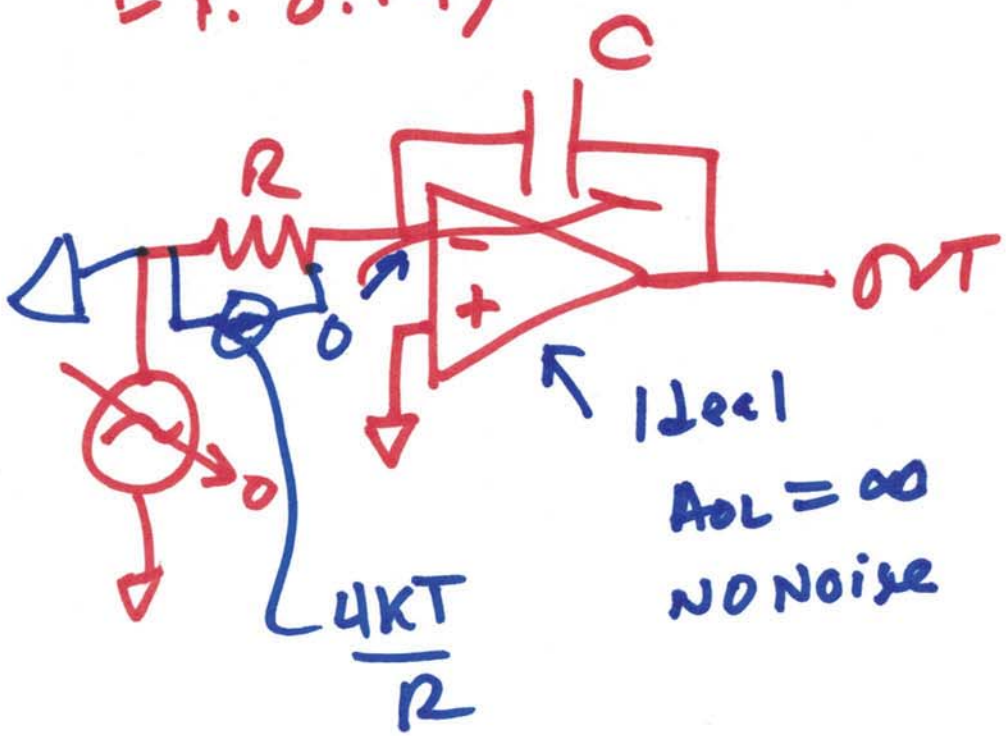


$$r_d = \frac{V_T}{1mA} = 26\Omega$$

$$\text{Rms output noise} = \sqrt{(26 \| 10K)^2 \cdot \left(\frac{4KT}{10K} + 2q\,1mA\right) \cdot \frac{1}{r_d}}$$

$$\| \approx 26$$

EY. 8.14)



$$\int f^{-2} \cdot df$$

$$V_{OUT} = \left|\frac{1}{j\omega C}\right|^2 \cdot \frac{4kT}{R} = \overbrace{\frac{4kT}{R} \cdot \frac{1}{(2\pi C)^2} \cdot \frac{1}{f^2}}^{K}$$

$$V_{OUTrms}^2 = K\int_{f_L}^{f_H} \frac{df}{f^2} = K\frac{-1}{f}\Big|_{f_L}^{f_H} = -K\left(\frac{1}{f_H} - \frac{1}{f_L}\right)$$

$$V_{OUT,rms}^2 = -K\left(\frac{1}{f_H} - \frac{1}{f_L}\right)$$

Let $f_H \to \infty$

$$V_{OUT,rms}^2 = \frac{K}{f_L}$$

$$V_{OUT,rms} = \sqrt{\frac{K}{f_L}} = \sqrt{K T_{meas}}$$

Rms noise

$$T_{meas} \Rightarrow \frac{1}{f_L}$$

$$SNR = \frac{T_{meas}}{\sqrt{T_{meas}}} = \sqrt{T_{meas}}$$