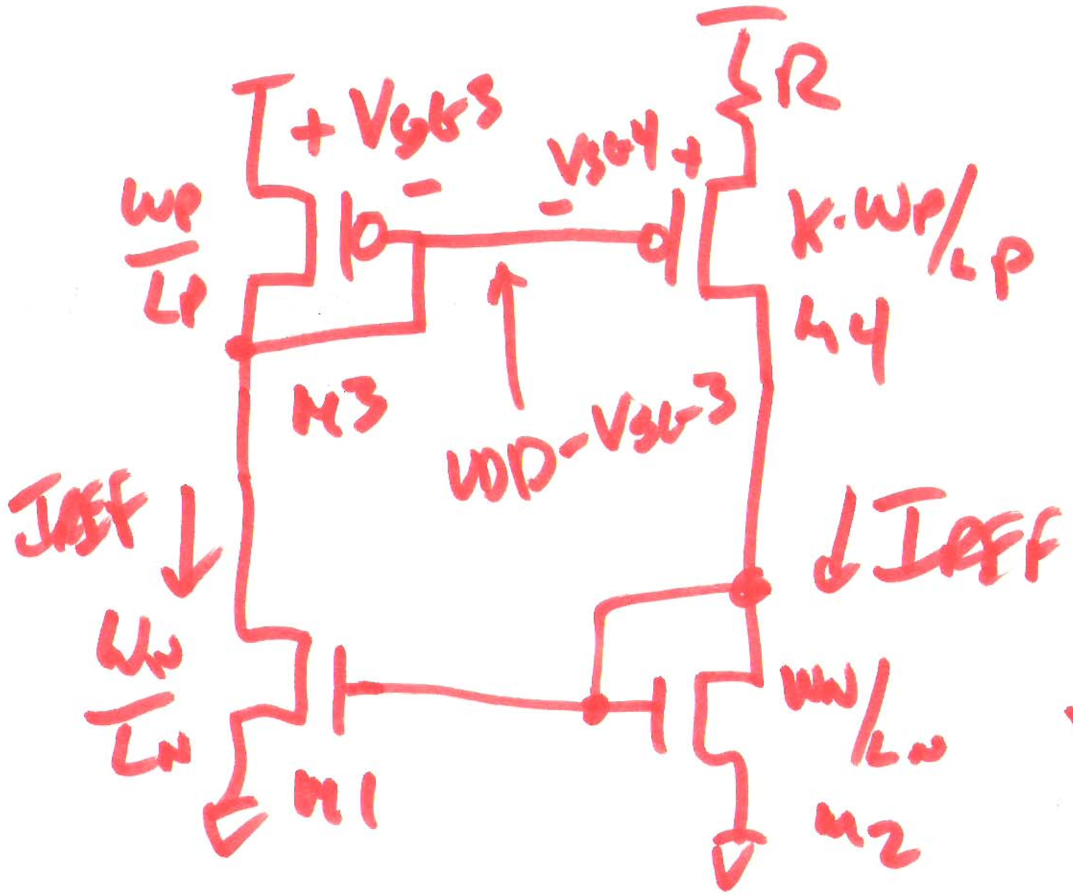
EE 422/ECG 622

Analog IC Design

Lecture 16 3/20/13



$$VDD - V_{SG3} =$$

$$VDD - I_{REF} \cdot R - V_{SG4}$$

$$V_{SG3} = V_{SG4} + I_{REF} R$$

$$\sqrt{\frac{2I_{REF}}{\beta_P}} + \cancel{V_{THP}} =$$

$$\sqrt{\frac{2I_{REF}}{K \cdot \beta_P}} + \cancel{V_{THP}} + I_{REF} R$$

$$I_{REF} \cdot R = \sqrt{\frac{2I_{REF}}{\beta_P}} \left(1 - \frac{1}{\sqrt{K}}\right)$$

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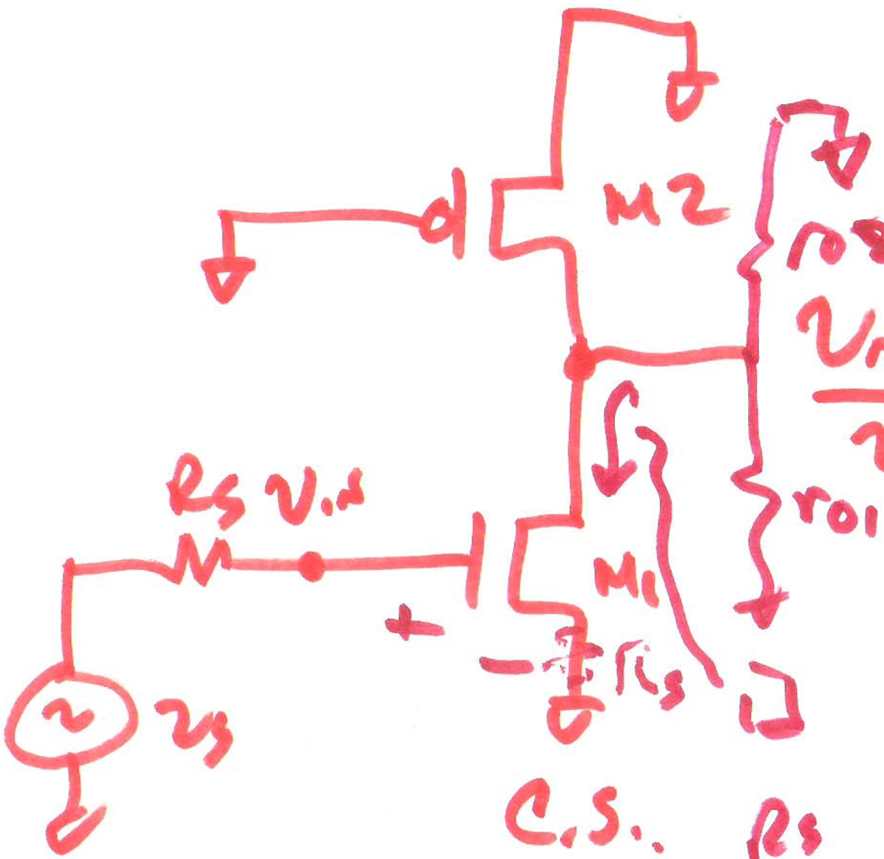
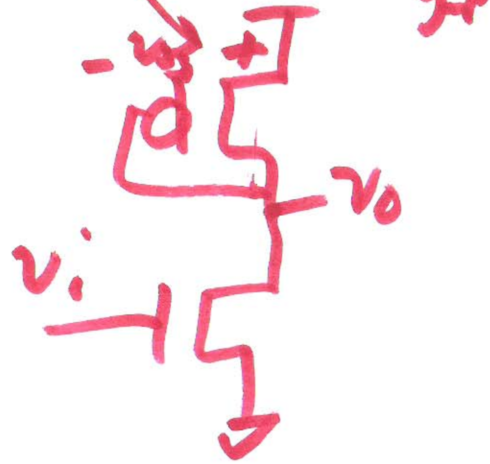


$$\frac{v_{out}}{v_{in}} = -\frac{r_{o1}||r_{o2}}{1/g_{m1} + R_s}$$

$$= -g_{m1}(r_{o1}||r_{o2})$$

C.S. .. R_s

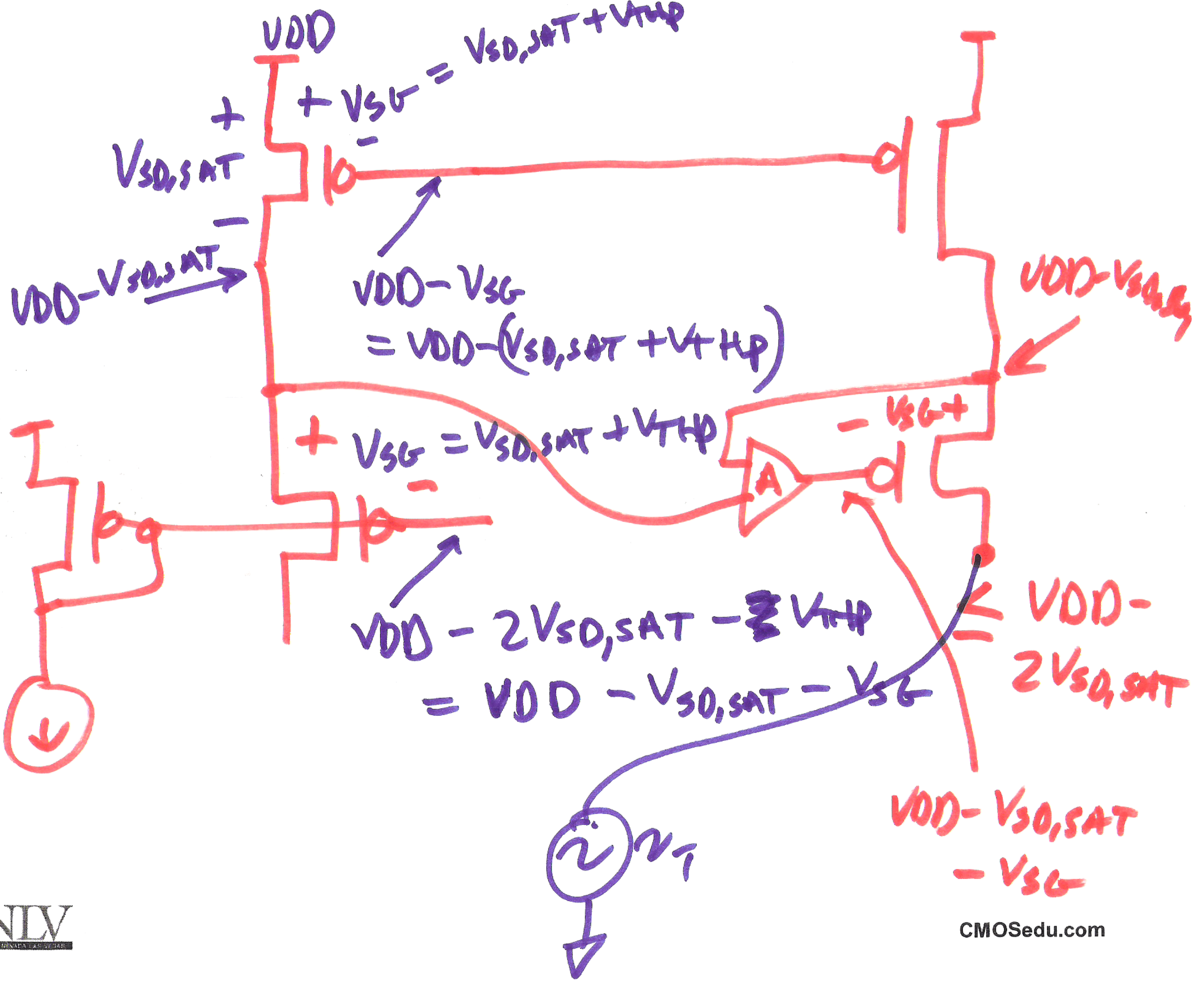
$v_o = -v_{sg} = -\frac{i_d}{g_m}$

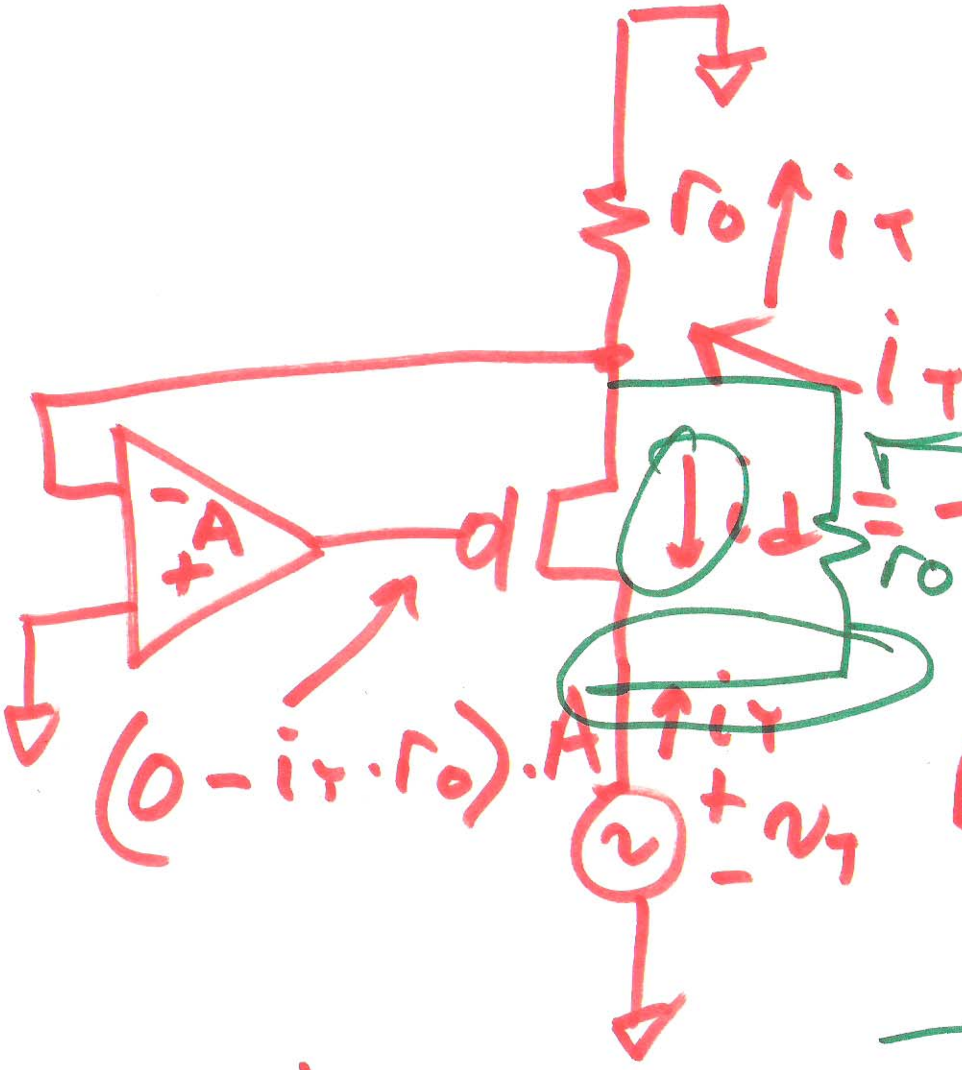


$+ i_d \cdot R_s$

$$v_{in} = v_{gs} = \frac{i_d}{g} + i_d \cdot R_s$$

$$v_{out} = -i_d(r_{o1}||r_{o2})$$


VDD
+ VSG = VSD,SAT + VTHP
+ VSD,SAT −
VDD−VSD,SAT
VDD − VSG
= VDD−(VSD,SAT + VTHP)
VDD-VSD,SA
− VSG +
+ VSG = VSD,SAT + VTHP
−
A
VDD − 2VSD,SAT − VTHP
= VDD − VSD,SAT − VSG
VDD−
2VSD,SAT
VDD− VSD,SAT
− VSG
v1



$i_T\cdot r_o = v_s$

$i_d = -i_T$

$$\frac{-r_o\cdot i_T - v_T}{r_o}$$

$$R_o = \frac{v_T}{i_T}$$

$$\cancel{i_d = g_m v_{gs}} = g_m\overbrace{\left(\underbrace{i_T\cdot r_o}_{v_s} - \underbrace{(0-i_T\cdot r_o)A}_{v_g}\right)}^{i_d}$$

$$\cancel{-i_T = g_m(+i_T)(r_o + A r_o)}$$

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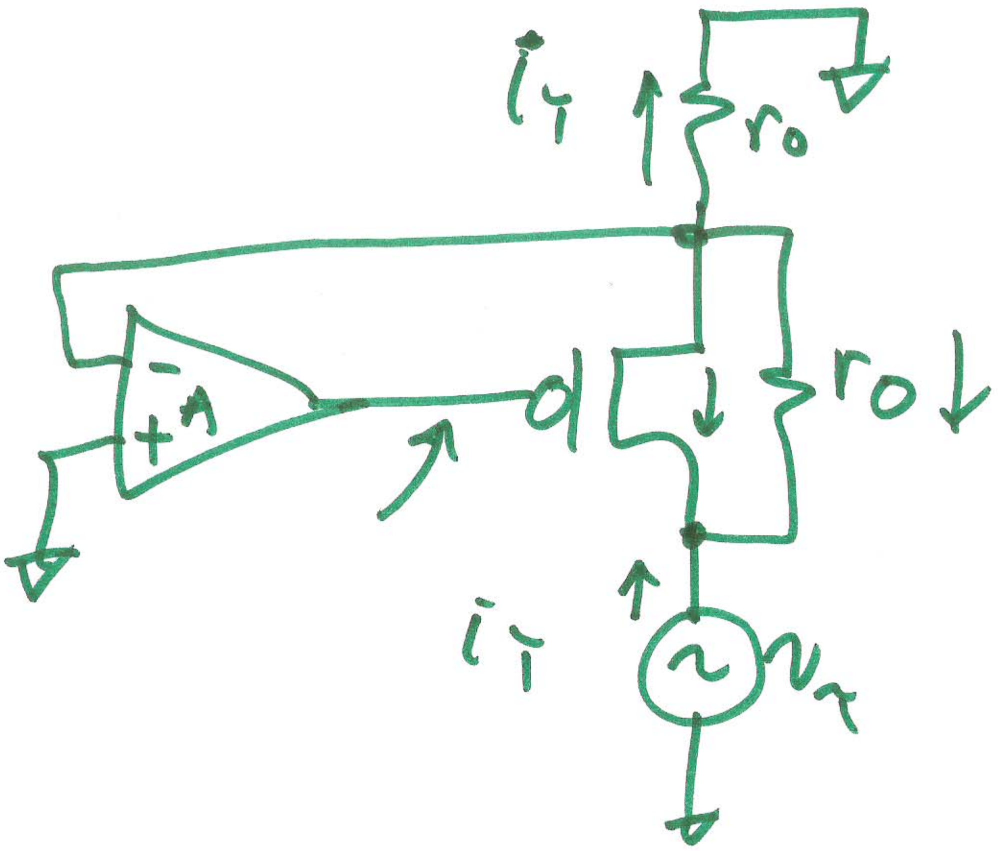
$$\frac{-i_T\cdot r_o - v_T}{r_o} = -i_T\cdot g_m\left(r_o + r_o\cdot A\right) + i_T$$



$$i_T + \frac{i_T\cdot r_o - v_T}{r_o} + g_m\left(v_{sg}\right) = 0$$

$$\swarrow$$

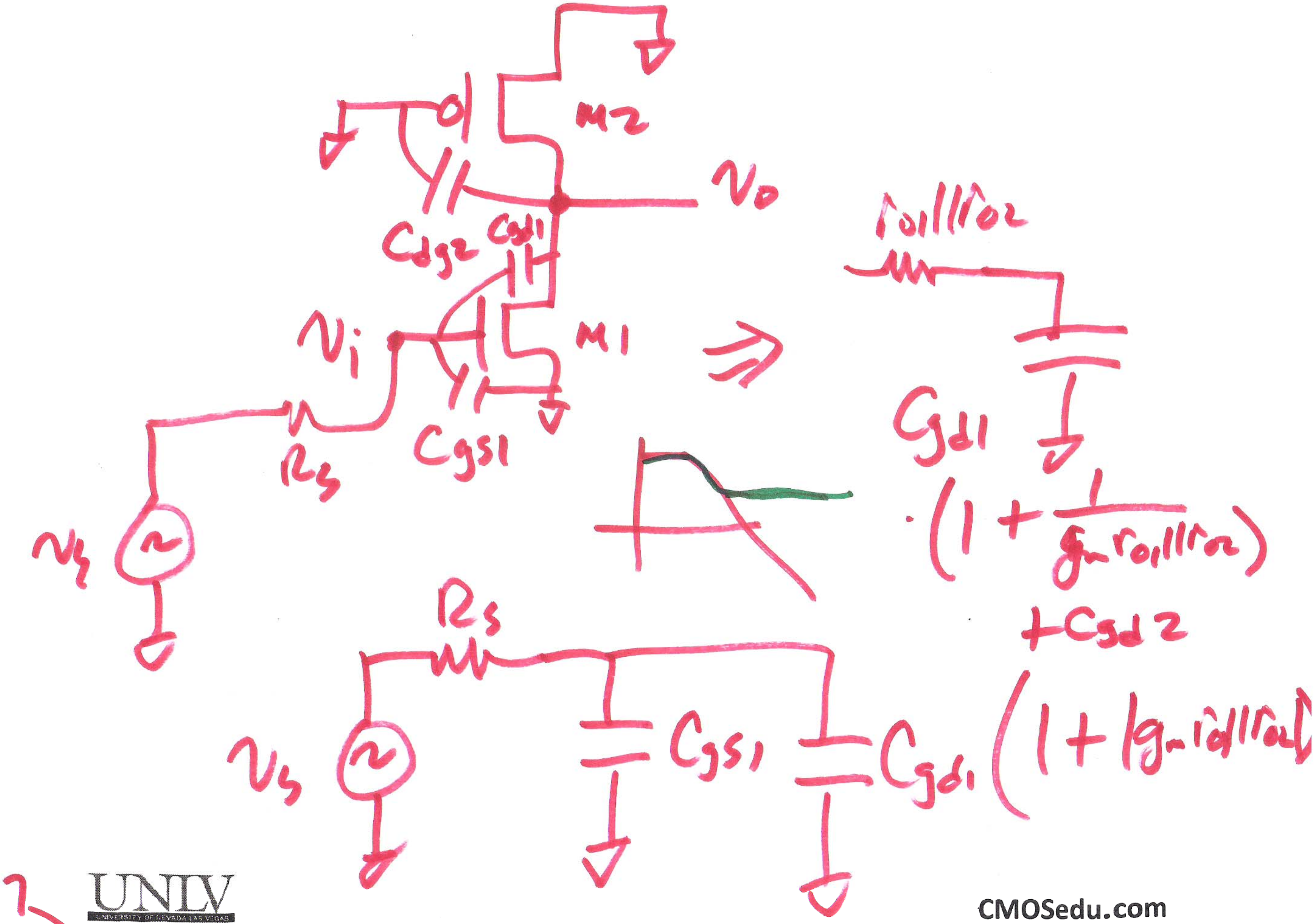
$$r_o\cdot i_T - A\left(-i_T r_o\right)$$

$$i_T + \frac{i_T r_o - v_T}{r_o} + g_m r_o i_T + g_m A r_o i_T = 0$$

$$\frac{v_T}{r_o} = i_T\left(1 + 1 + g_m r_o + g_m r_o \cdot A\right)$$

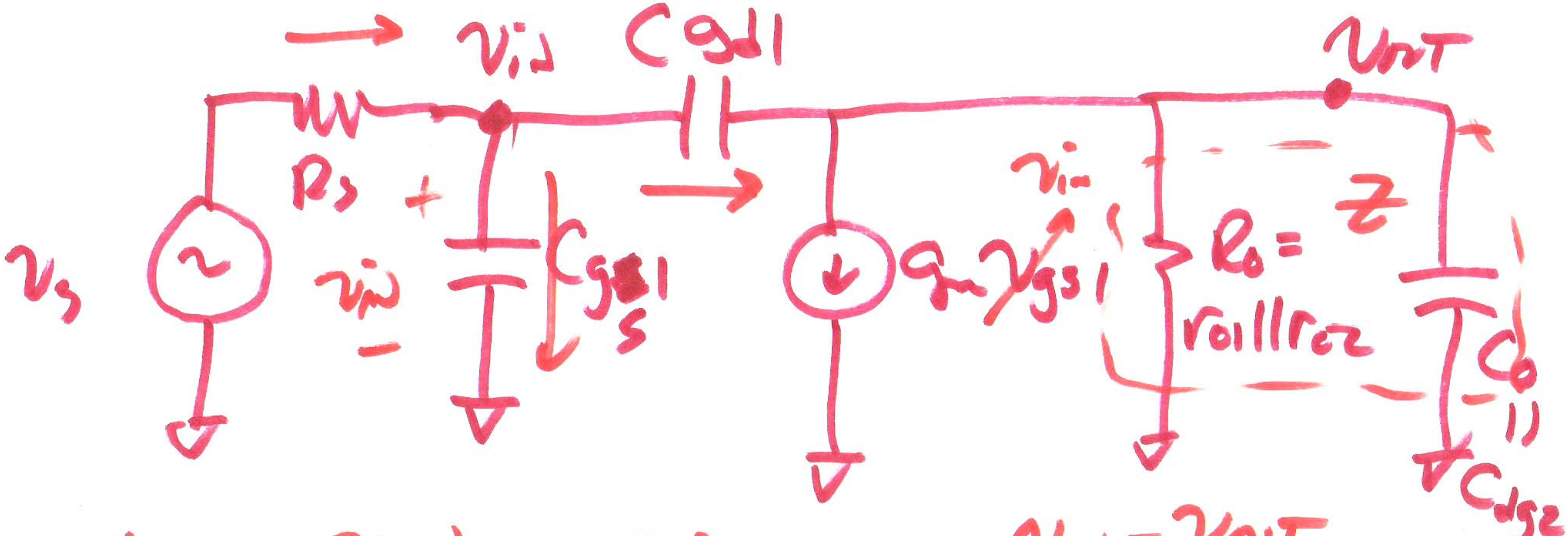
$$\frac{v_T}{i_T} = r_o\left(2 + g_m r_o + g_m r_o \cdot A\right)$$

$$\simeq \underline{\underline{g_m r_o^2 \cdot A}}$$



$$C_{gd1}\left(1+\frac{1}{g_m r_{o1}||r_{o2}}\right)+C_{gd2}$$

$$C_{gd1}\left(1+|g_m r_{o1}||r_{o2}|\right)$$



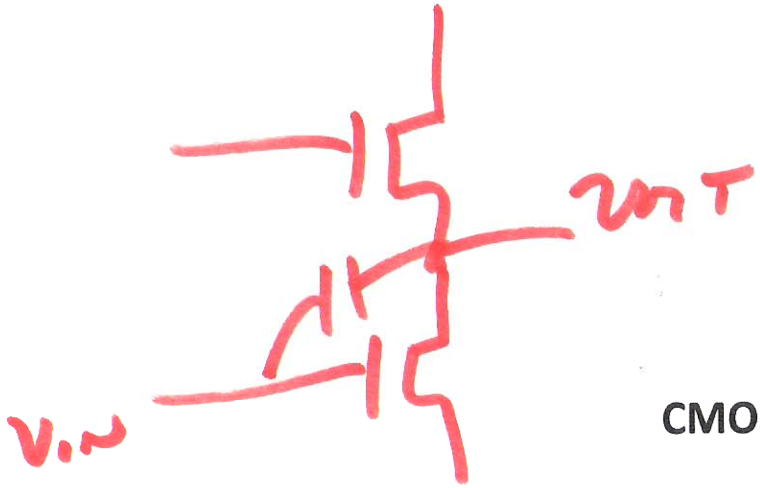
$$-\left(\frac{v_s - v_{in}}{R_s}\right) + \frac{v_{in}}{1/j\omega C_{gs1}} + \frac{v_{in} - v_{out}}{1/j\omega C_{gd1}} = 0$$

$$v_{in} = \frac{v_s/R + v_{out} \cdot j\omega C_{gd1}}{\frac{1}{R_s} + j\omega C_{gs1} + j\omega C_{gd2}}$$

$$\frac{v_{out}}{Z} + g_m v_{in} = \frac{v_{in} - v_{out}}{1/j\omega C_{gd1}}$$

$$\frac{v_{out}}{v_{in}} = -g_{m1} \cdot R_o \cdot \frac{1 - j\omega \frac{C_{gd1}}{g_{m1}}}{1 + j\omega (C_{gd1} + C_o) \cdot R_o}$$

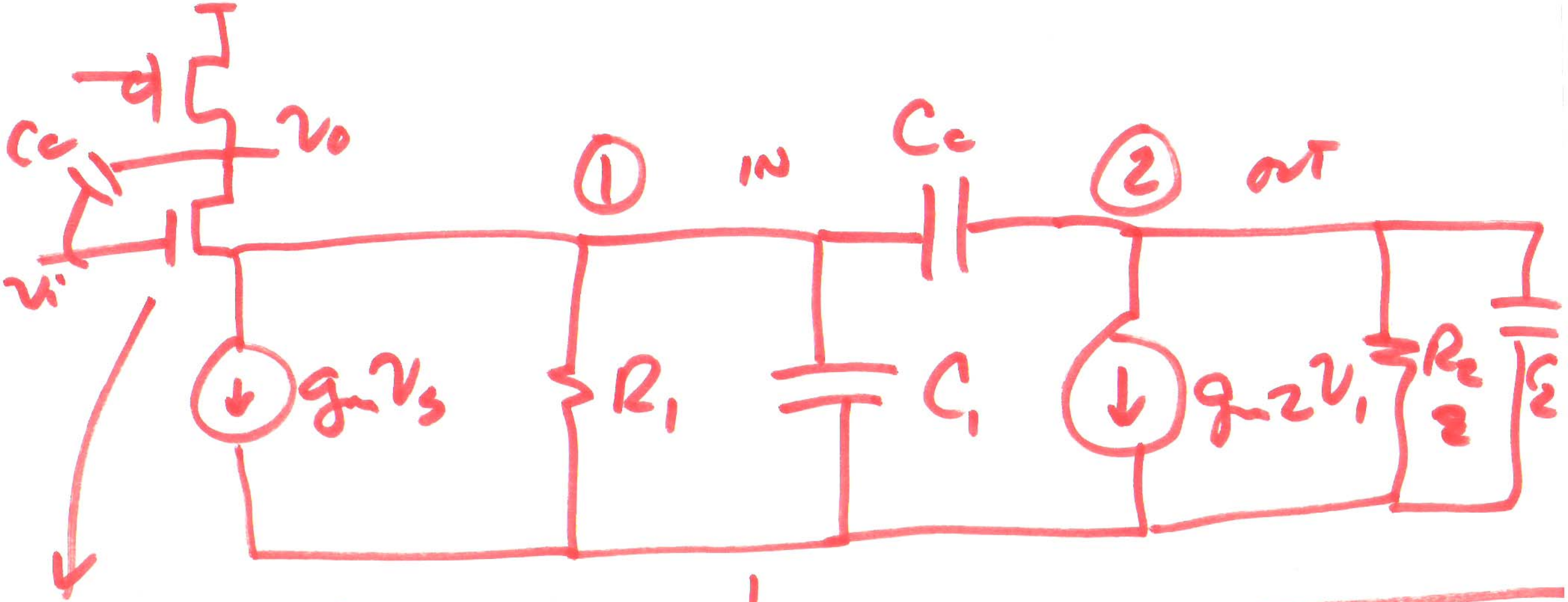
$$\boxed{f_z = \frac{+g_{m1}}{2\pi C_{gd1}}}$$ RHP Zero



$$\frac{1 + \frac{f}{f_z}\cdot j}{1 + j\frac{f}{f_p}} = \frac{1 + j\left(-f\cdot\frac{2\pi C_{gd1}}{g_{m1}}\right)}{\underbrace{1 + jf\cdot 2\pi RC}_{j\omega RC}}$$

$$f_p = \frac{1}{2\pi RC}$$

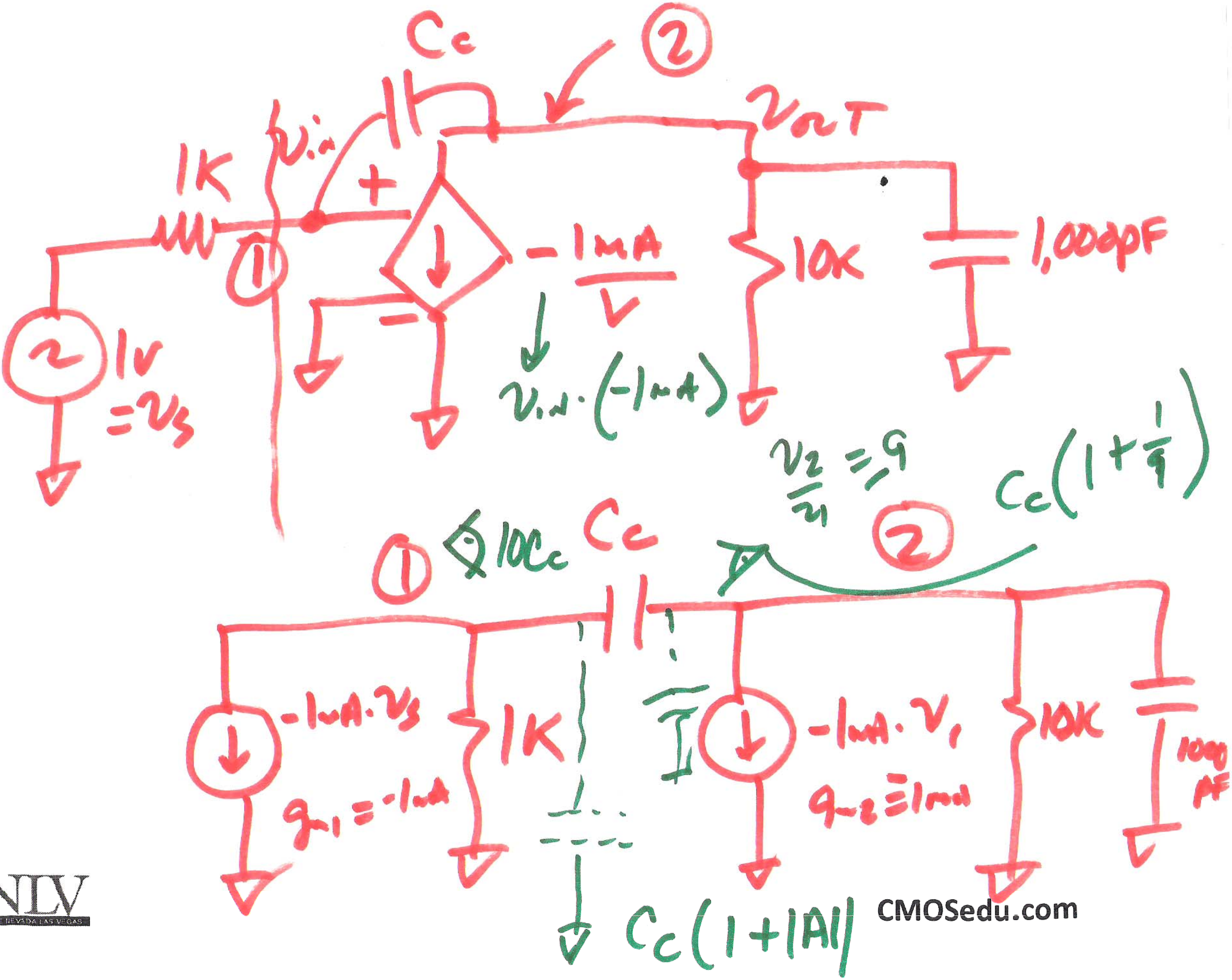
$$f_z = \frac{-g_{m1}}{2\pi C_{gd1}}$$



$$\frac{1}{2\pi \frac{1}{g_m} \cdot C}$$

$$f_1 \approx \frac{1}{2\pi R_1 \left(C_1 + \underbrace{C_c \left(1 + g_{m2} \cdot R_2\right)}_{\text{Miller } C}\right)}$$

$$\approx \frac{1}{2\pi R_1 R_2 C_c \cdot g_{m2}}$$



C_c
②
v_{OUT}
v_{in}
1K
+
−
①
$-\frac{1mA}{V}$
$v_{in} \cdot (-1mA)$
10K
1,000pF
1V
$= v_s$
$\frac{v_2}{v_1} = -9$
$C_c(1 + \frac{1}{9})$
①
$\approx 10C_c$
C_c
②
$-1mA \cdot v_s$
1K
$g_{m1} = -1mA$
$-1mA \cdot v_1$
$g_{m2} = 1mA$
10K
1000 pF
$C_c(1+|A|)$