EE 422 & EGG 622

Analog IC Design 2/11/13

Lecture 6

Ex. 9.5 KP, $\frac{\mu A}{V^2}$

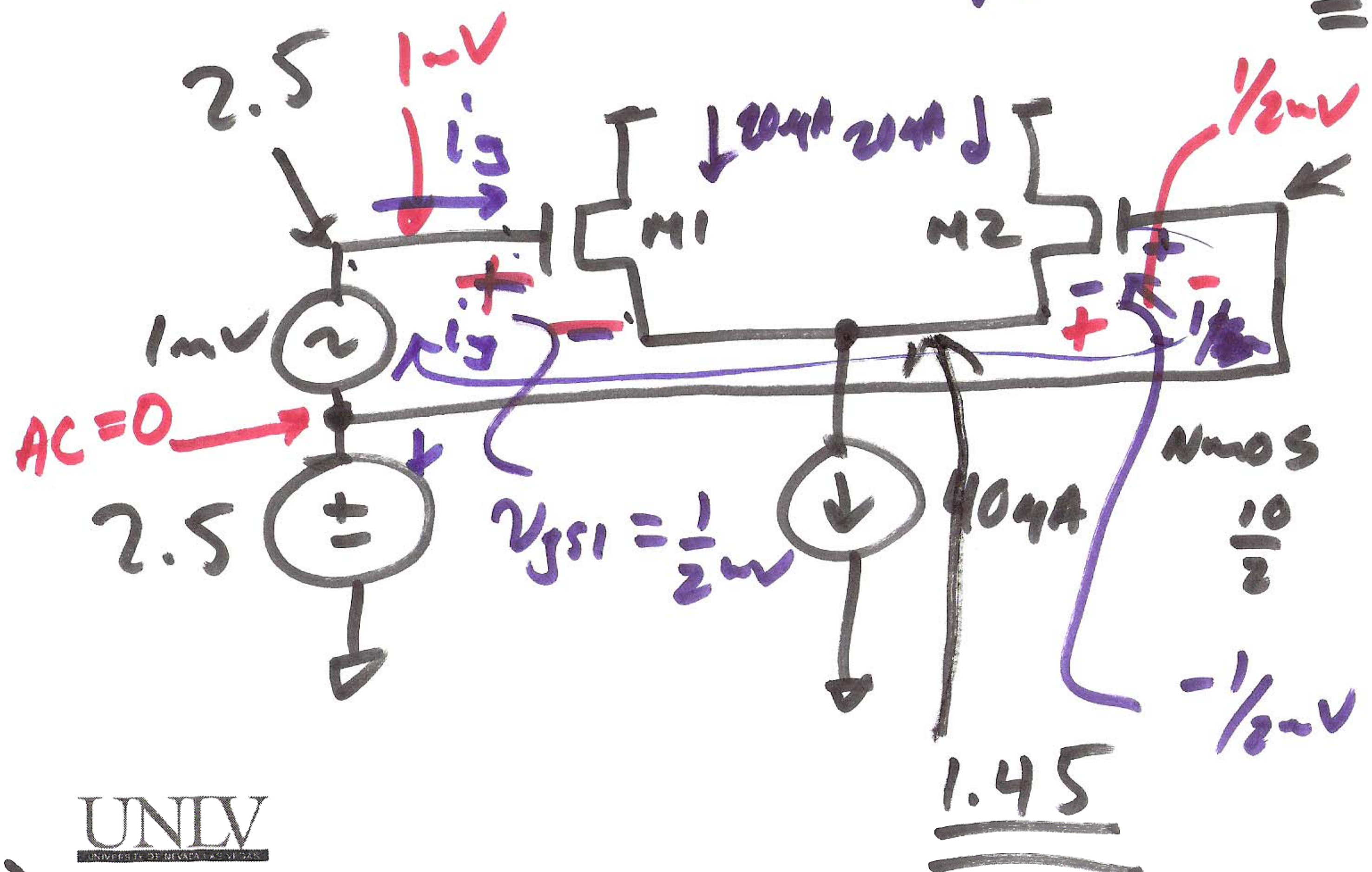
$$V_{GS} = \sqrt{\frac{2I_D}{\beta_N}} + V_{THN}$$

$$= \sqrt{\frac{2 \cdot 20\mu}{120\mu \cdot \frac{10}{2}}} + V_{THN} \quad (V_{THN} = .8)$$

$$= \underline{1.05\,V}$$

$$g_m = \beta_N (V_{GS} - V_{THN})$$

$$= 150 \frac{\mu A}{V}$$



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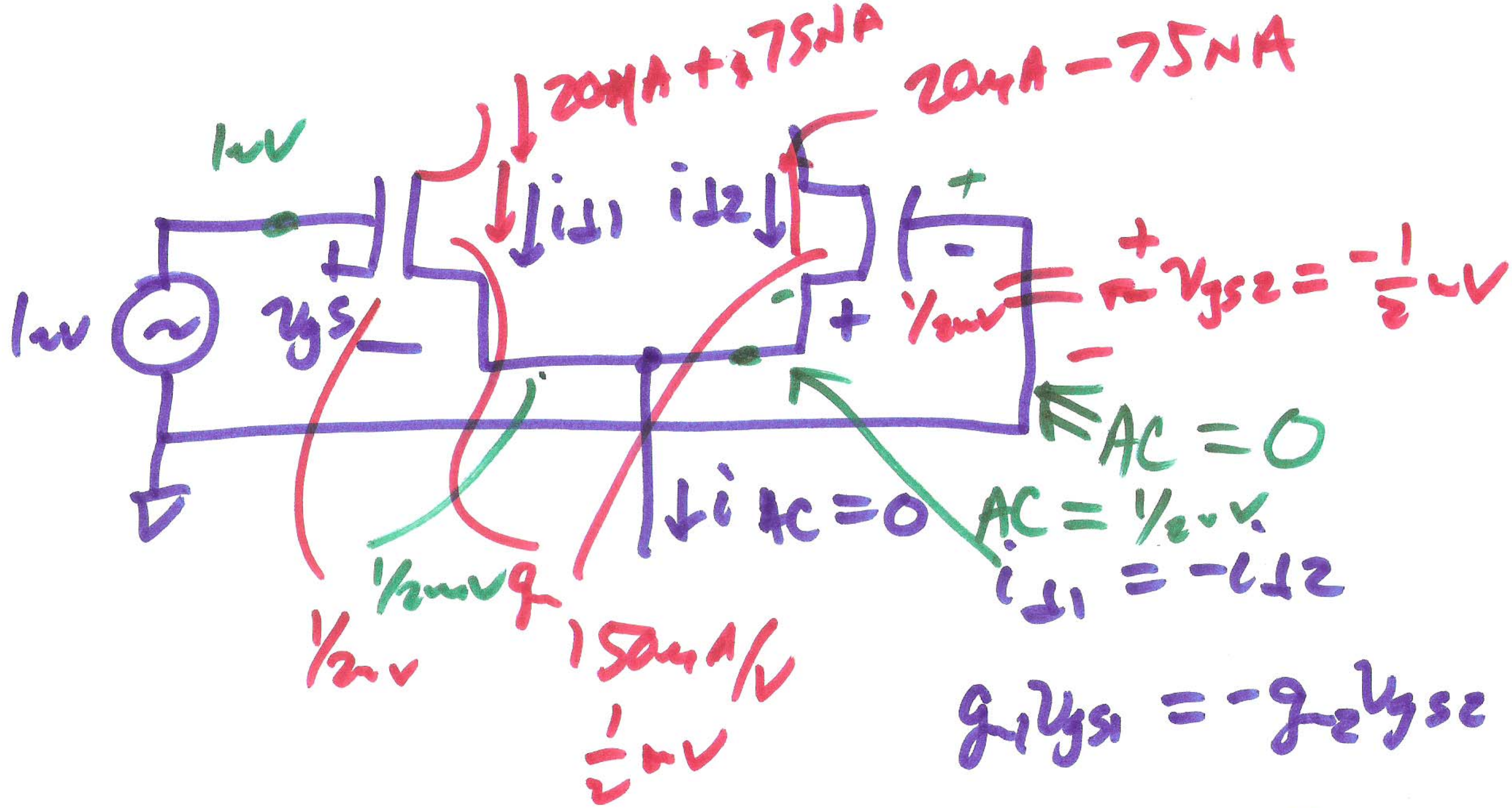

$i_{d1} = -i_{d2}$

$g_1 v_{gs1} = -g_2 v_{gs2}$

$g_1 = g_2$

$v_{gs1} = -v_{gs2}$

$i_{d1} = -i_{d2} =$

$\frac{1}{2}\,mV \cdot 150\,uA$

$v_{gs} \cdot g_m = \underline{75\,nA}$

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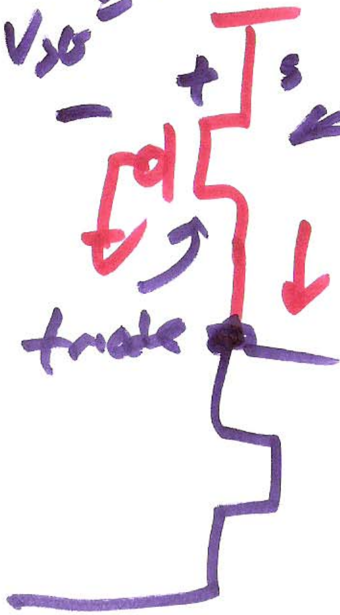
2)

$5 - 1.15$

3.85



for saturation

$V_{SD} \overset{?}{\geq} V_{SG} - V_{THP}$

$5 - .9 = 4.1$

$V_{SD} \overset{?}{\geq} 4.1$

$V_S - V_D \overset{?}{\geq} 4.1$

$5 - 1.45 \overset{?}{\geq} 4.1$

NO

$$V_{SG} = \underbrace{\sqrt{\frac{2I_D}{\beta_p}}}_{.25} + \underbrace{V_{THP}}_{.9}$$

$$V_{SG} = 1.15V$$

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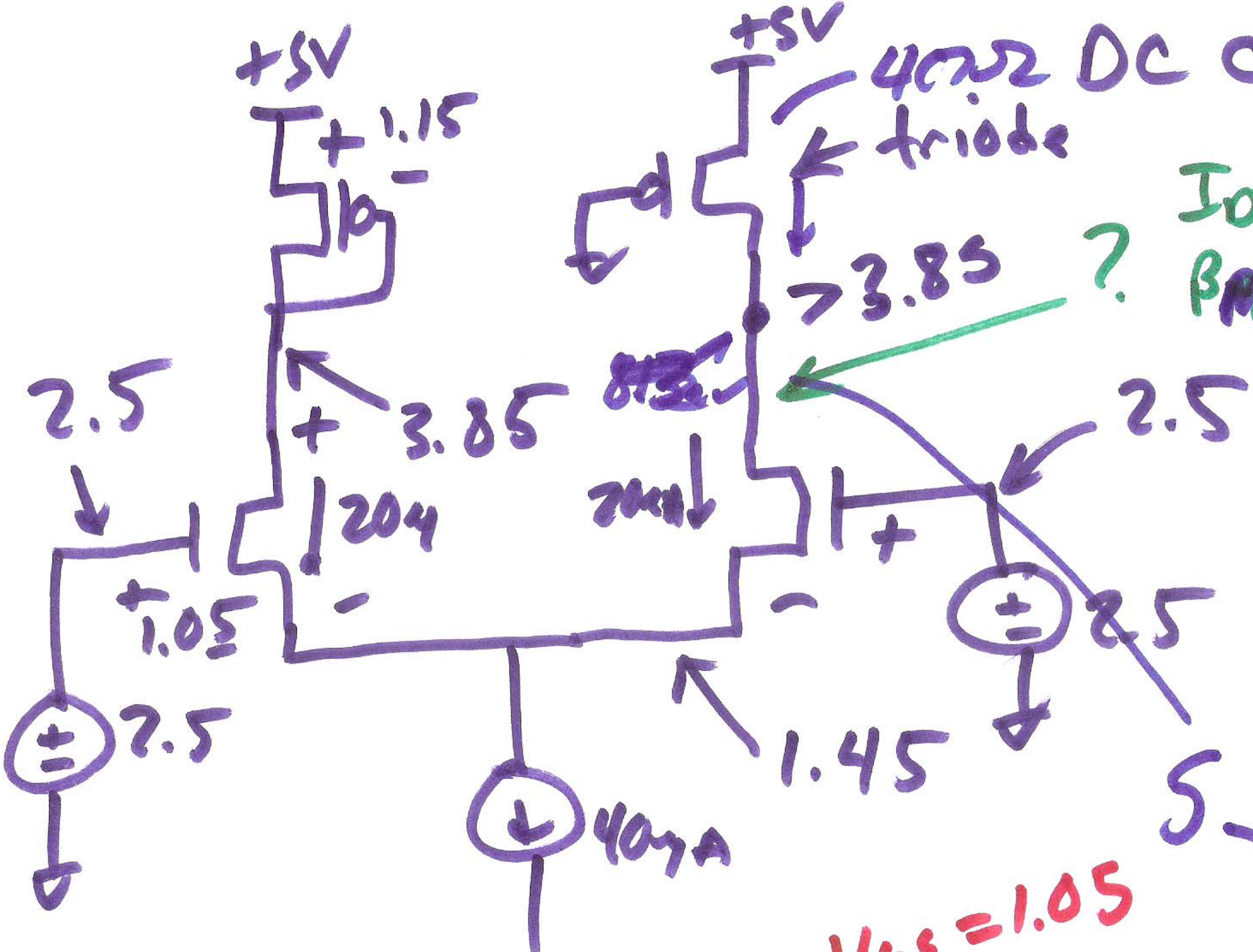
40kΩ DC CKT



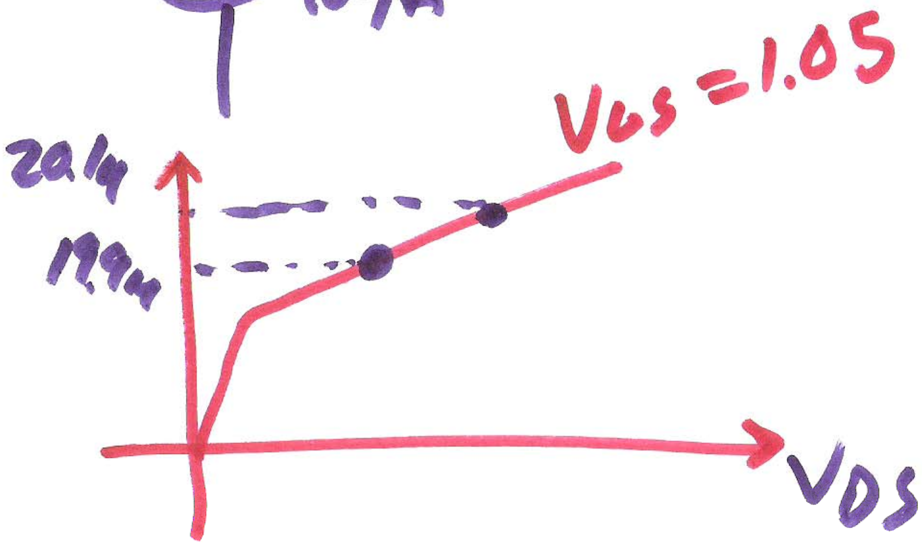
$I_D = \beta_n \left[(V_{GS} - V_{THN}) V_{DS} - \frac{V_{DS}^2}{2} \right]$?

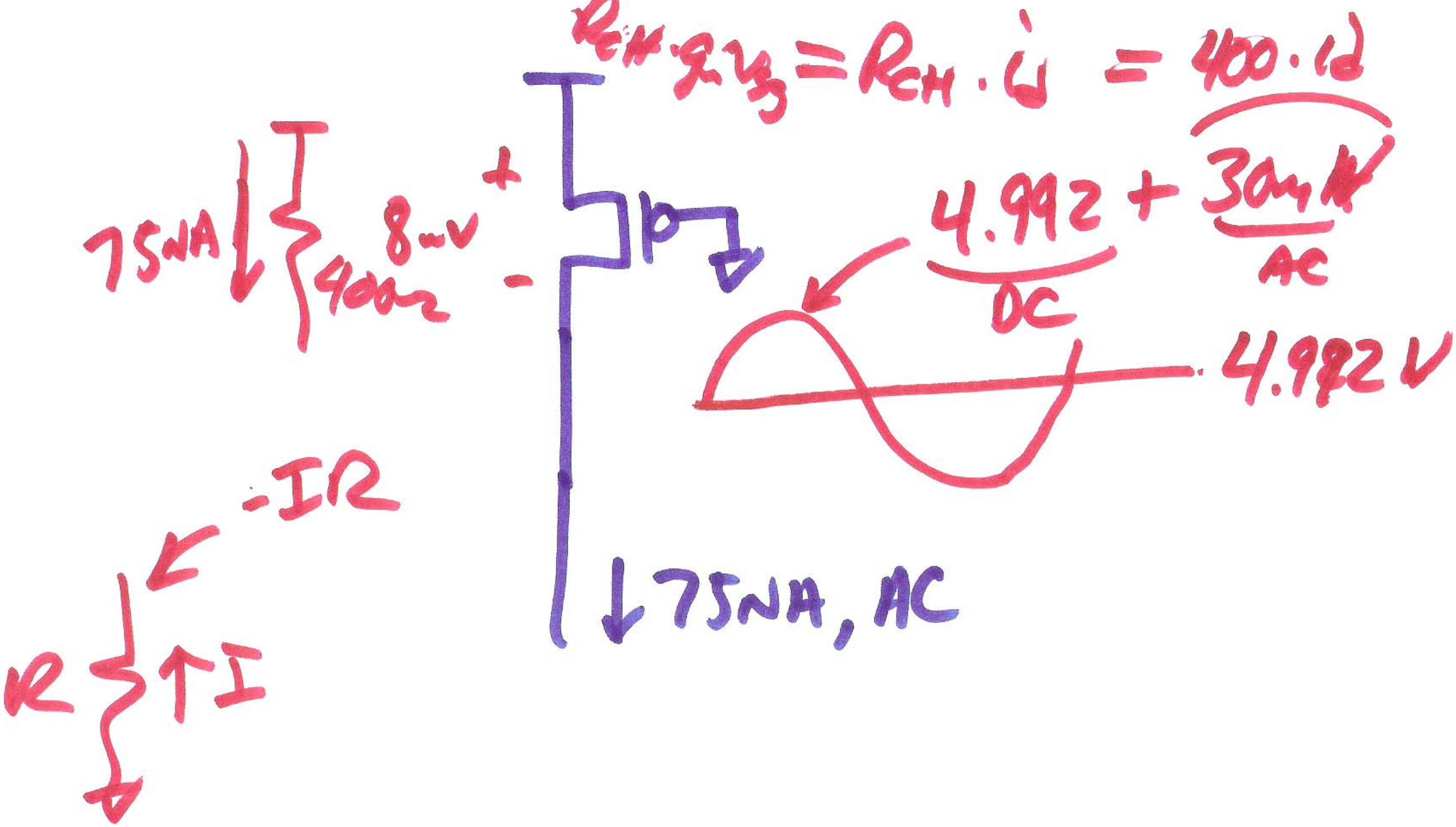
$V_{DS} = \frac{20uA}{\beta_n (V_{GS} - V_{THN})}$

5 = 8.13mV

8.13mV

4.99 1/V




$R_{CH} \cdot g_m v_{gs} = R_{CH} \cdot i_d = 400 \cdot i_d$
4.992 + 30mV
DC
AC
4.982 V
75nA
8mV
400Ω
+
-
75nA, AC
-IR
R
I

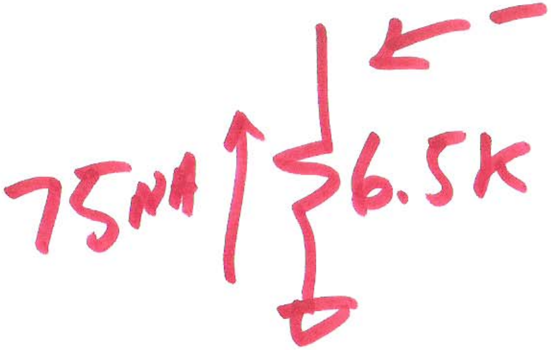
$V_D = V_G$

$$\Rightarrow \quad \frac{v_{sg}}{i_d} = \frac{1}{g_{mp}}$$

$$\frac{1}{150\mu} = 6.5K$$

AC CKT

$-75nA \cdot 6.5K$



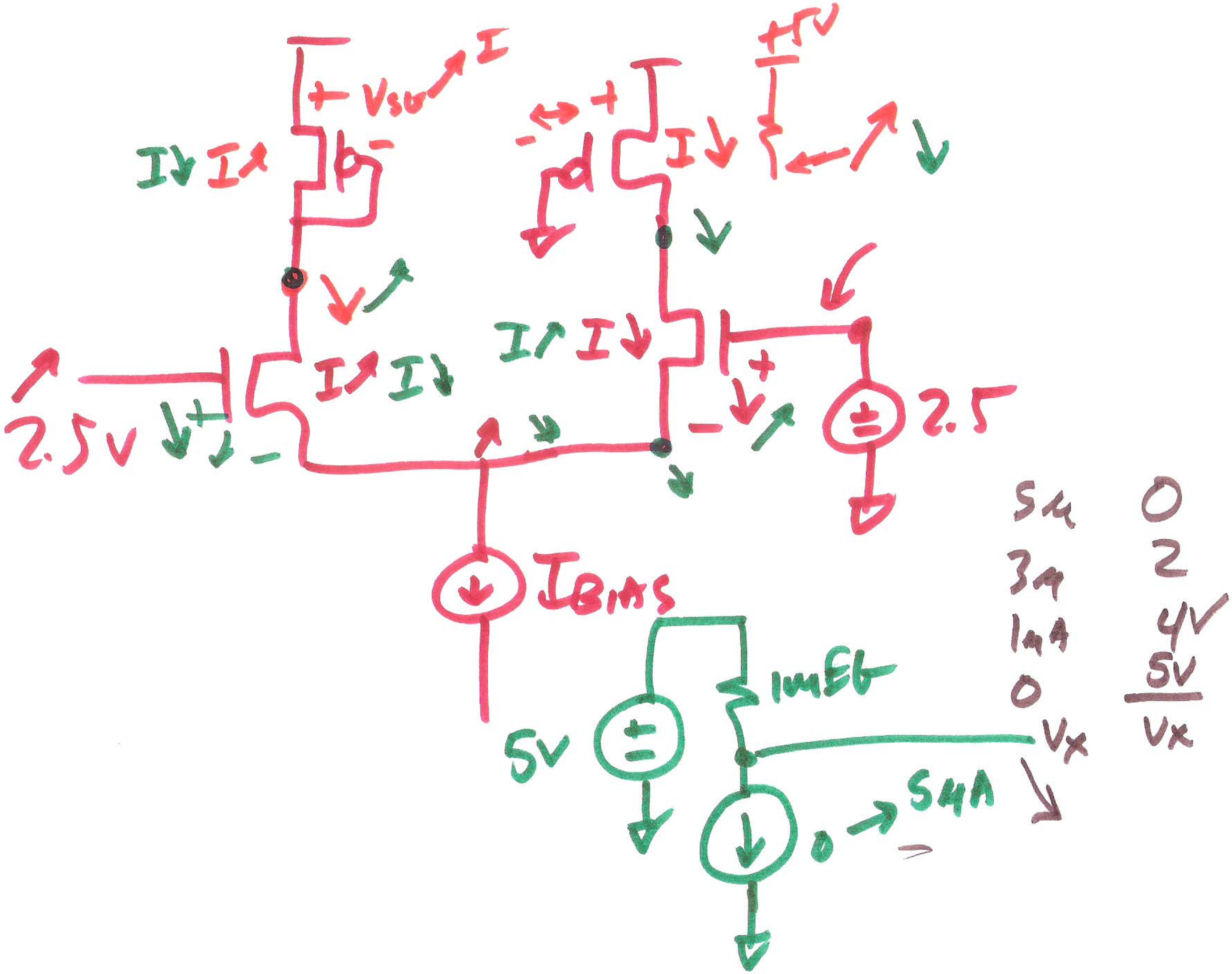
$$V_{SD} \geq V_{SG} - V_{THP}$$

$$\cancel{V_S} - V_D \geq \cancel{V_S} - V_G - V_{THP}$$

$$V_D \leq V_G + V_{THP}$$

$$0 \leq V_{THP}$$

yes!



7)

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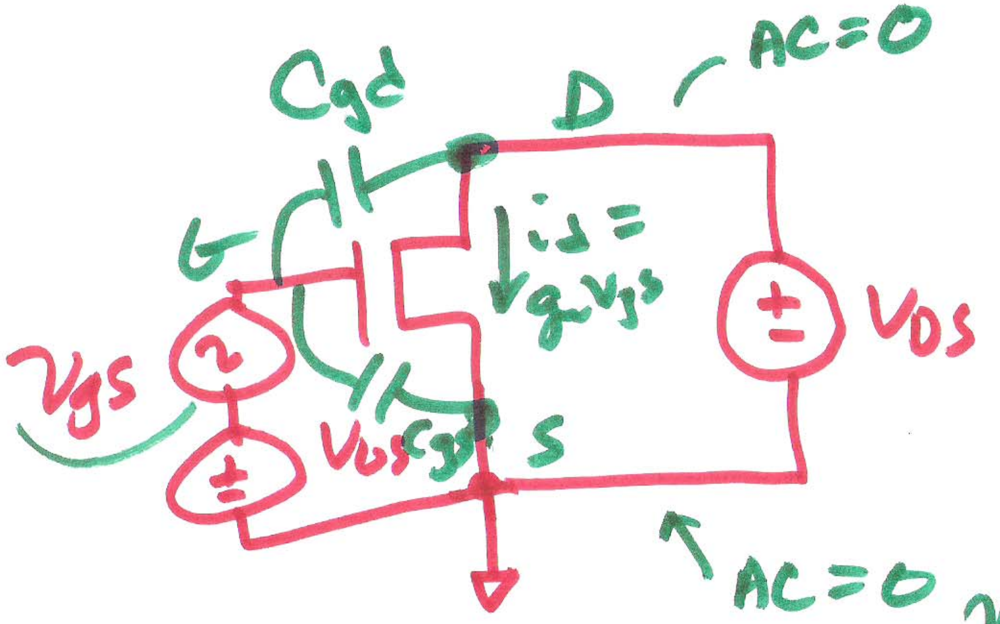
$f_T \rightarrow$ Figure of merit (FOM)

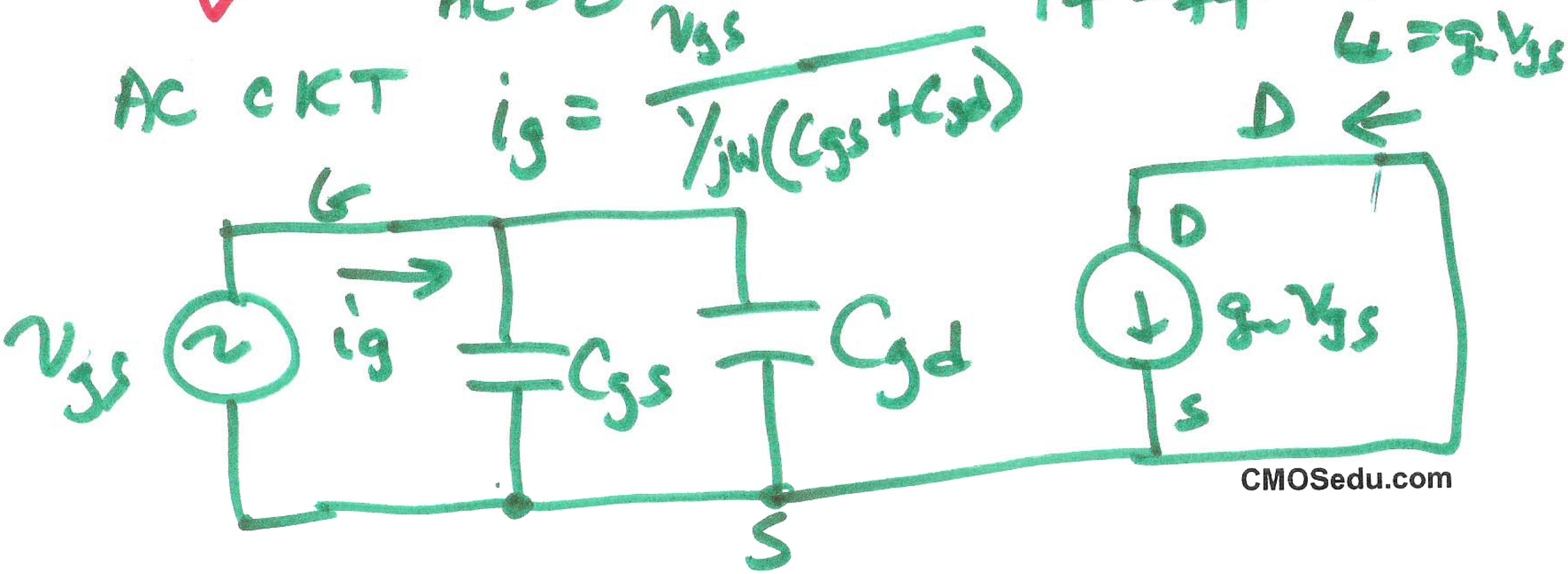
$\nwarrow$ transition of MOSFET from an Amplifier to Attenuator



$$\left| \frac{i_d}{i_g} \right| = 1 \quad f = f_T$$

AC CKT

$$i_g = \frac{v_{gs}}{1/j\omega(C_{gs}+C_{gd})}$$



$$\left|\frac{i_d}{i_g}\right| = \left|\frac{g_m v_{gs}}{v_{gs} \cdot j\omega(C_{gs}+C_{gd})}\right|$$

$$\left|\frac{i_d}{i_g}\right|_{f=f_T} = 1 \qquad 1 = (g_m)^{-1}\, 2\pi f_T \cdot (C_{gs}+C_{gd})$$

$$f_T = \frac{g_m}{2\pi (C_{gs}+C_{gd})}$$

$$= \frac{KP \cdot \frac{W}{L}(V_{GS}-V_{THN})}{2\pi (C_{gs}+C_{gd})}$$

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