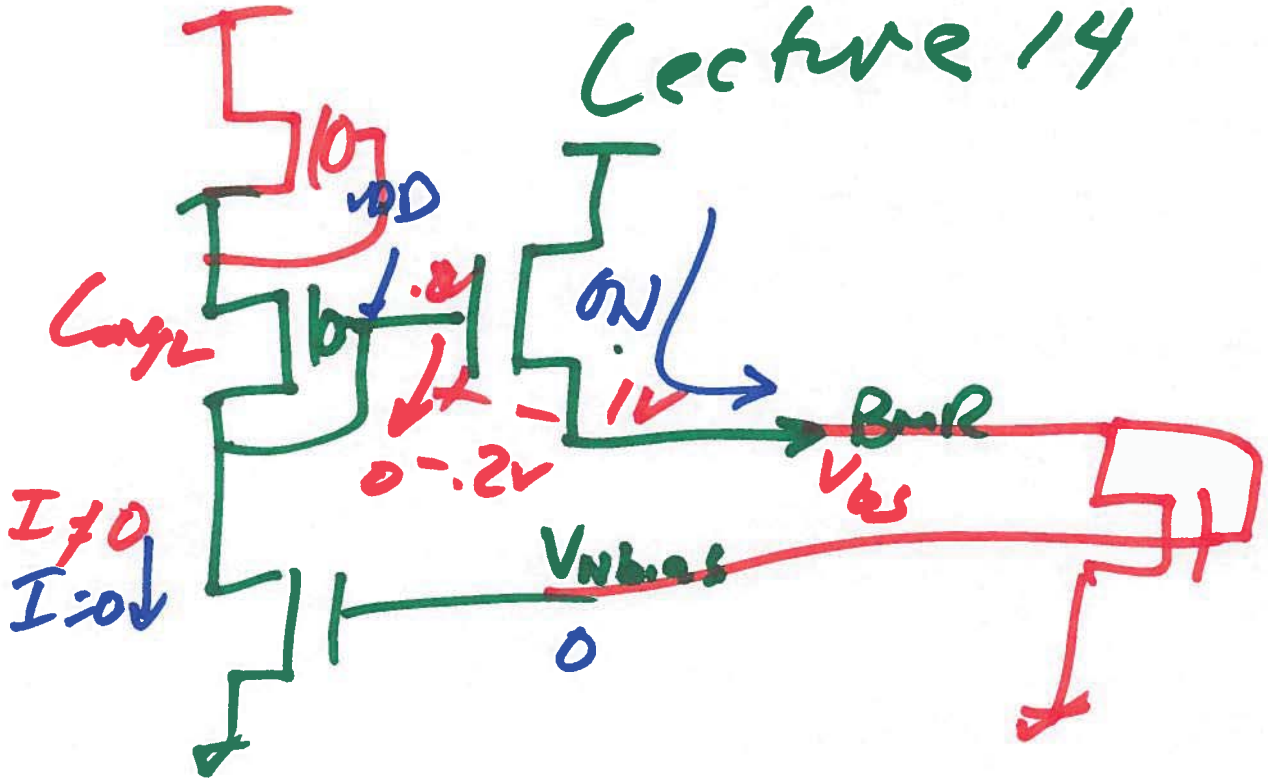
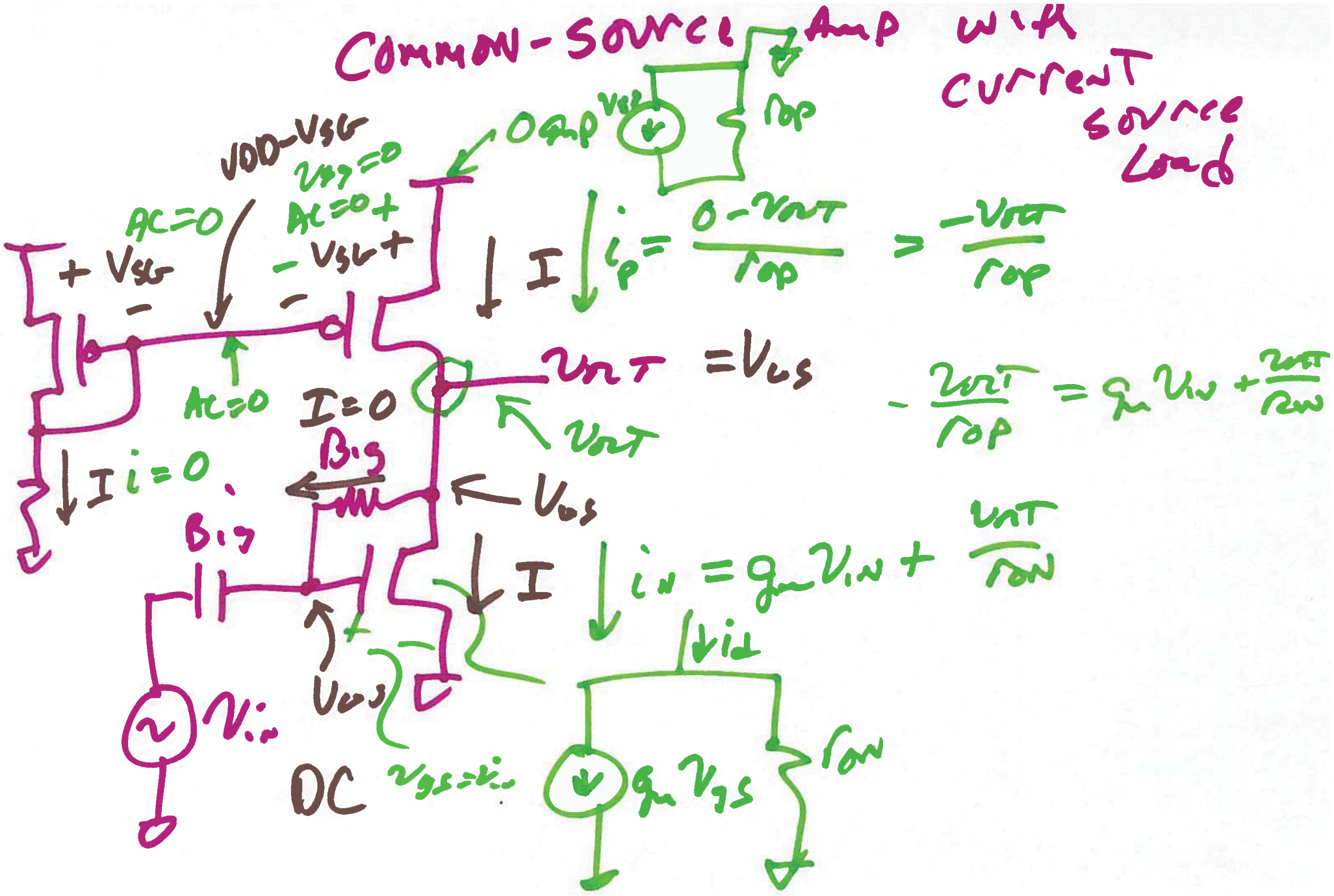
# EE 420/ECE 620
# Analog IC Design
## MARCH 25, 2019
## Lecture 14

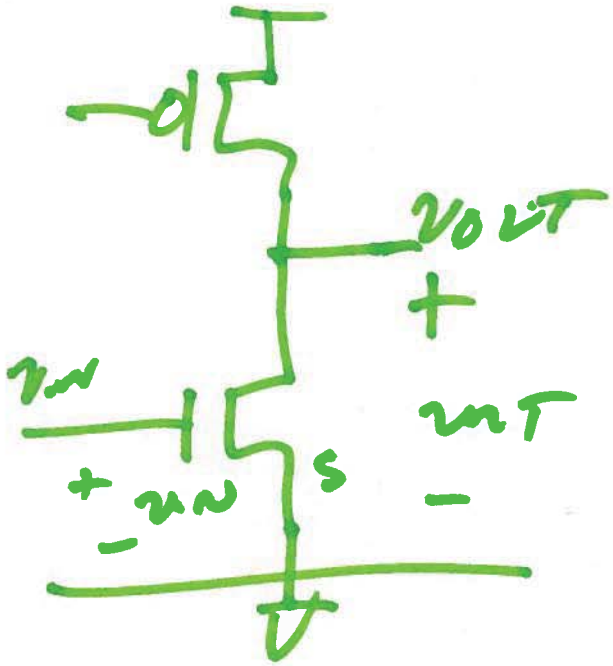



COMMON-SOURCE Amp with current source Load
Oamp
VBP
rop
VDD-VSG
VSG=0
AC=0
AC=0+
+ VSG -
- VSG +
I
ip = (0 - vout)/rop = -vout/rop
AC=0
I=0
vout = vds
vout
- vout/rop = gm vin + vout/ron
I i=0
Big
vds
Big
I
iin = gm vin + vout/ron
vin
vgs
vid
DC vgs=vin
gm vgs
ron

$$-\frac{v_{out}}{r_{op}} = g_m v_{in} + \frac{v_{out}}{r_{ON}}$$

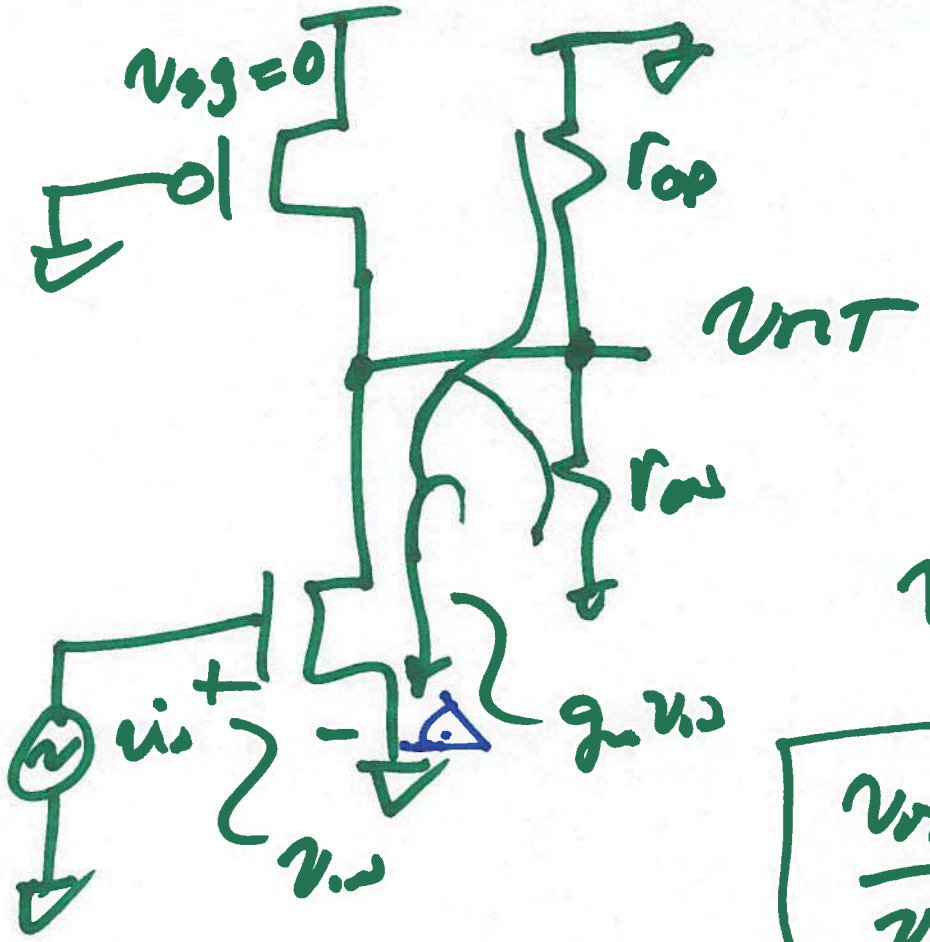
$$-v_{out}\left(\frac{1}{r_{op}} + \frac{1}{r_{ON}}\right) = g_m v_{in}$$

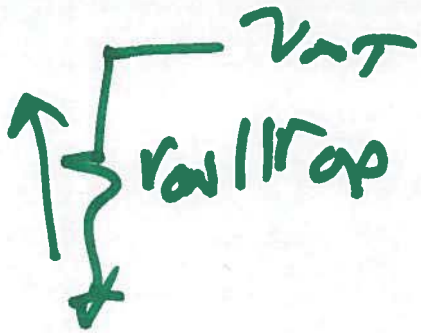
$$\frac{v_{out}}{v_{in}} = -g_m \frac{1}{\frac{1}{r_{ON}} + \frac{1}{r_{op}}}$$




$$\boxed{\frac{v_{out}}{v_{in}} = -g_m r_{ON} \| r_{op}}$$

C.S. Amp Gain




$$v_{out} = r_{on} \| r_{op} \cdot (-g_m v_{in})$$

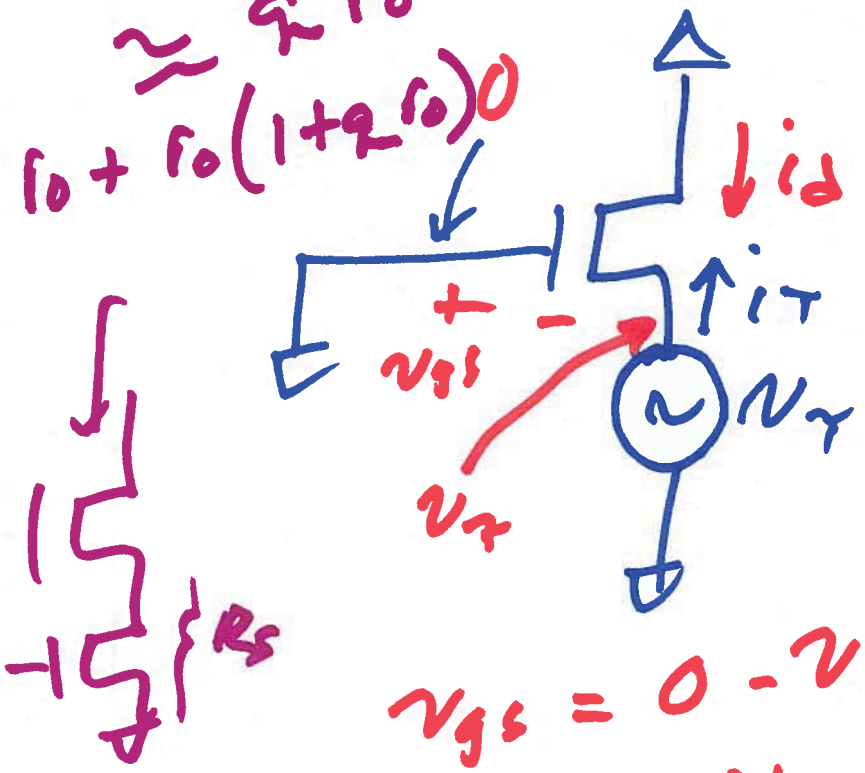
$$\frac{v_{out}}{v_{in}} = -g_m \cdot r_{on} \| r_{op}$$

C.S.

$$\frac{-\text{res. in drain}}{\text{res in source}} = \frac{-r_{on} \| r_{op}}{1/g_m}$$

$\simeq g_m r_o^2$

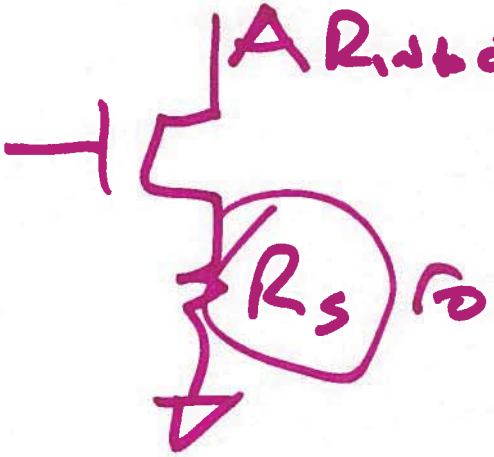
$r_o + r_o(1+g_m r_o)\Theta$




$$R_{\text{to,source}} = \frac{v_T}{i_T}$$

$$A R_{\text{to,drain}} = r_o + g_m r_o R_S$$

$$= g_m r_o R_S$$



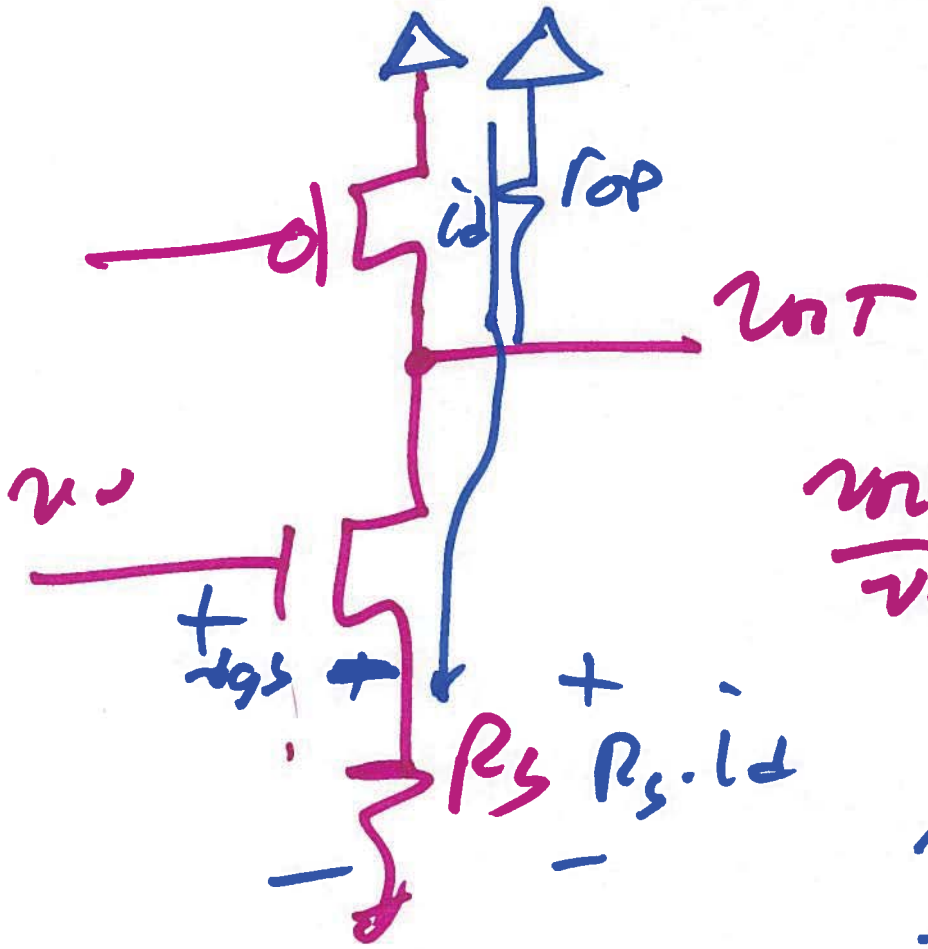

$$v_{gs} = 0 - v_T$$

$$= -v_T$$

$$g_m v_{gs} = i_d = -i_T = g_m(-v_T)$$

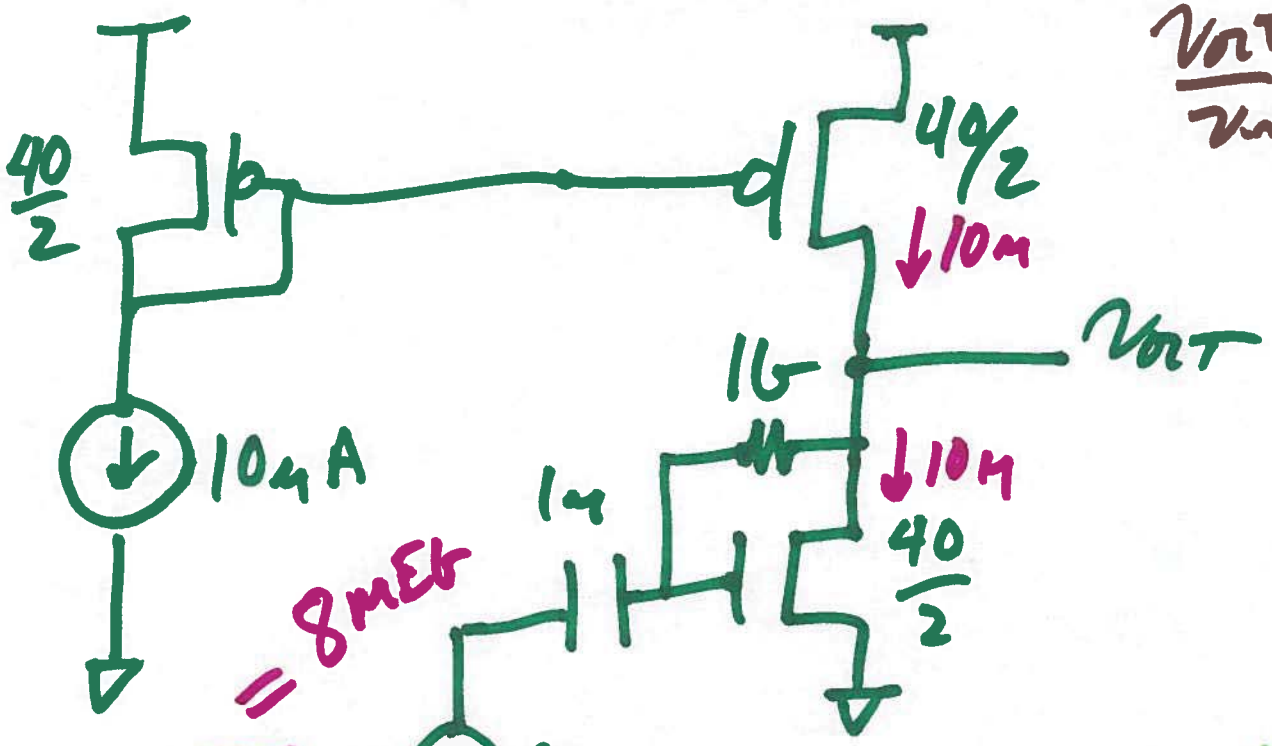
$$\frac{v_T}{i_T} = \frac{1}{g_m} = R_{\text{to,source}}$$

5)




$$\frac{v_{out}}{v_{in}} \simeq -\frac{r_{op} \| g_m r_o R_s}{1/g_m + R_s}$$

$$\frac{v_{out}}{v_{in}} = \frac{-i_d \cdot r_{op}}{v_{gs} + i_d \cdot R_s} \quad \| \quad \frac{i_d}{g_m}$$




$\frac{v_{out}}{v_{in}} = ?$

$= 8\,M\Omega$

$r_{op} = \frac{1}{10\mu \cdot 0.0125}$

$r_{on} = \frac{1}{10\mu \cdot 0.01} = 10\,M\Omega$

$g_m = \sqrt{2 \cdot 120\mu \cdot 10\mu \cdot \frac{40}{2}} = 219\mu$

$\frac{v_{out}}{v_{in}} = -g_m (r_{on} \| r_{op})$

$= 219\mu \cdot 8\,M\Omega \| 10M\Omega$

$= 219 \cdot 4.4$

$= 964 \frac{V}{V}$

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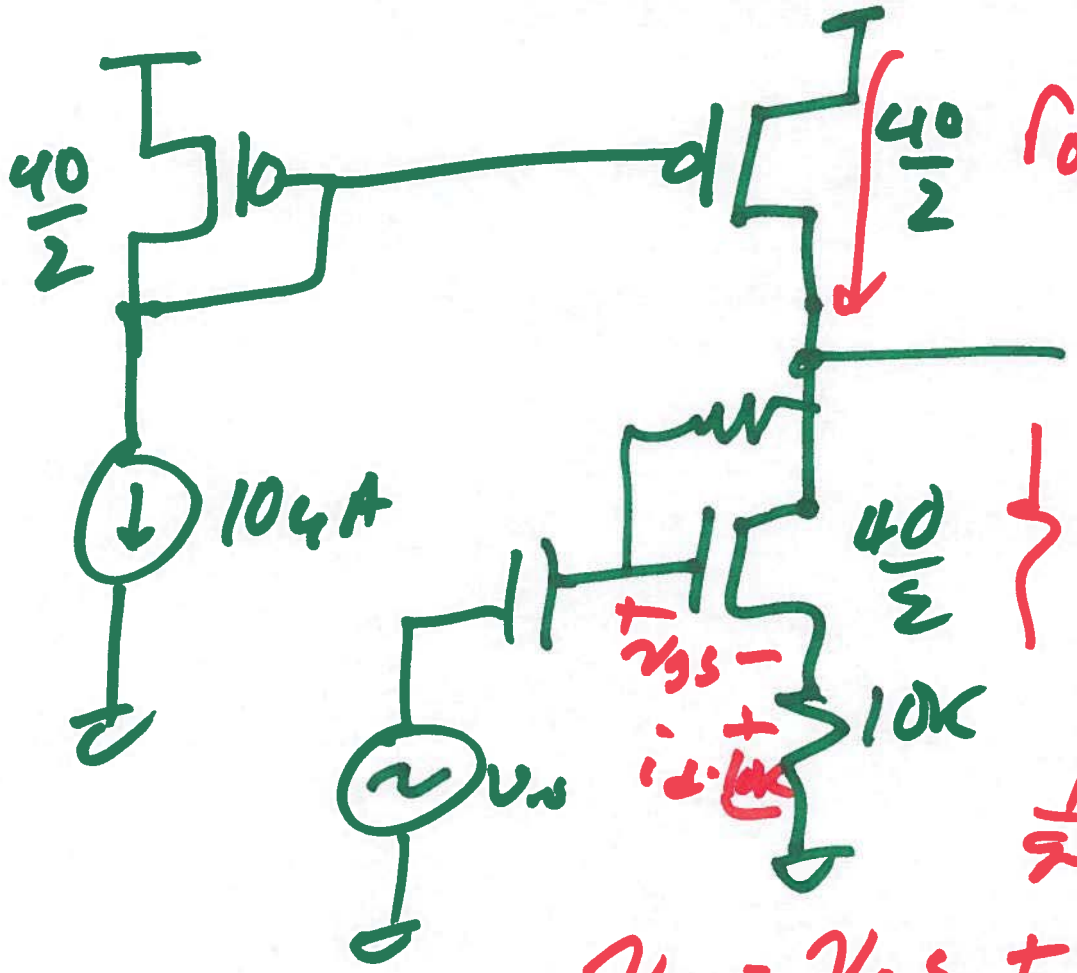
7)




$r_{op} = 8\,M\Omega$

$v_{out} = -i_d \cdot r_{op}$

$r_{on} = 10\,M\Omega$

$g_m = 219\,\frac{\mu A}{V}$

$\frac{1}{g_m} \simeq 5K$

$v_{in} = v_{gs} + i_d \cdot 10K = \frac{i_d}{g_m} + i_d \cdot 10K$

$$\frac{v_{out}}{v_{in}} = \frac{-i_d \cdot r_{op}}{i_d\left(\frac{1}{g_m} + 10K\right)} = -\frac{8\,M\Omega}{15K}$$