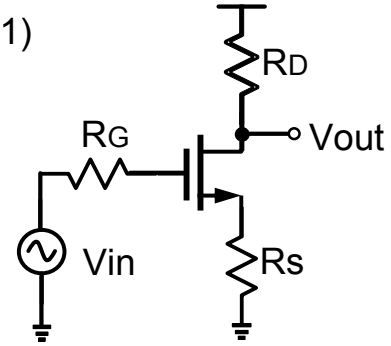
ECE323

Homework 2

Find expression for Rin, Rout and small signal voltage gain for the circuit shown below.

Assume: 1) $r_O=\infty$, 2) All transistor are biased in saturation.

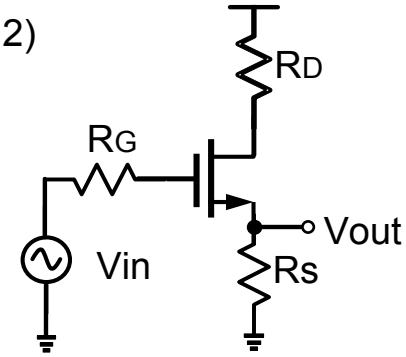
1)



$R_{in}=\infty \quad R_{out}=R_D$

$Gain=\dfrac{-g_mR_D}{1+g_mR_S}$

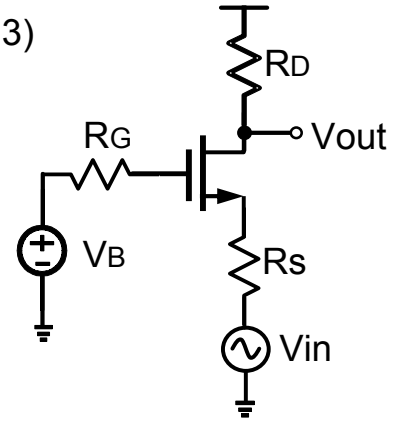
2)



$R_{in}=\infty \quad R_{out}=R_S \| \frac{1}{g_m}$

$Gain=\dfrac{g_mR_S}{1+g_mR_S}$

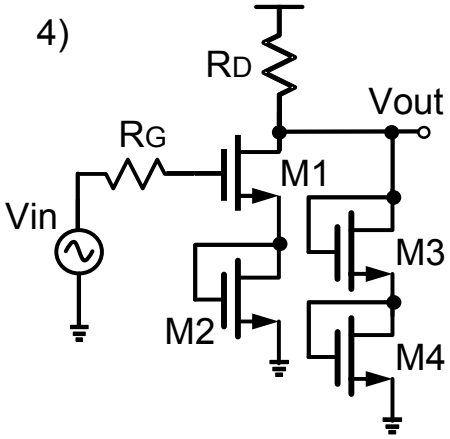
3)



$R_{in}=R_S+\frac{1}{g_m} \quad R_{out}=R_D$

$Gain=\dfrac{g_mR_D}{1+g_mR_S}$

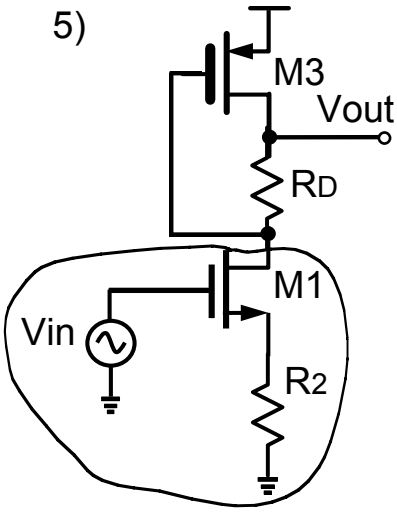
4)



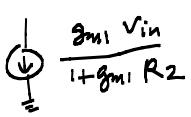
$R_{in}=\infty \quad R_{out}=R_D \| \left(\frac{1}{g_{m3}}+\frac{1}{g_{m4}}\right)$

$Gain=\dfrac{-g_{m1}R_{out}}{1+g_{m1}\frac{1}{g_{m2}}}$

5)



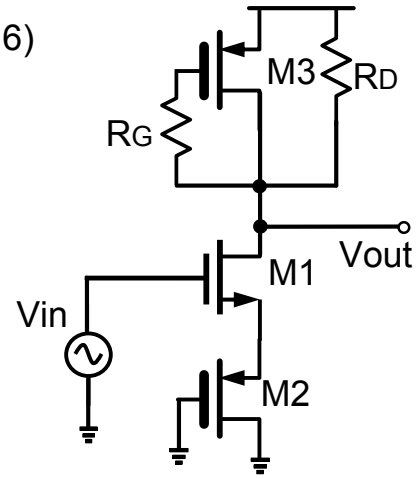
$\Downarrow$



$R_{in}=\infty \quad R_{out}=\frac{1}{g_{m3}}$

$Gain=\dfrac{g_{m1}}{1+g_{m1}R_2}(R_D g_{m3}-1)\dfrac{1}{g_{m3}}$

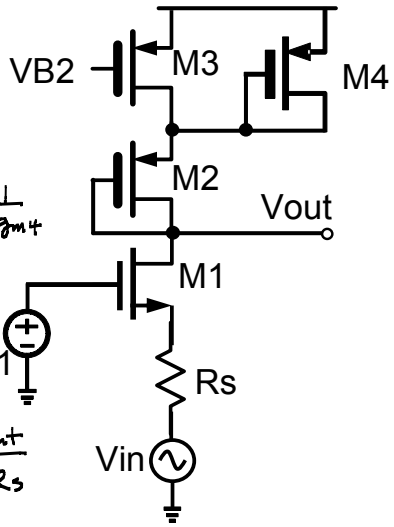
6)



$R_{in}=\infty \quad R_{out}=R_D \| \frac{1}{g_{m3}}$

$Gain=\dfrac{-g_{m1}}{1+g_{m1}\frac{1}{g_{m2}}}R_{out}$

7)

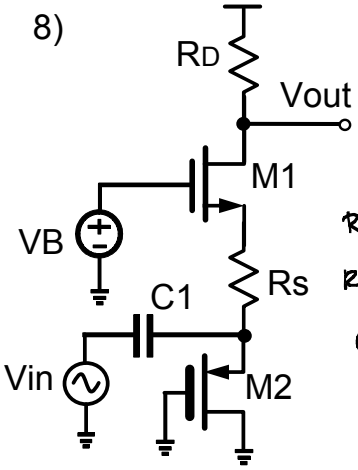


$R_{out} = \frac{1}{g_{m2}} + \frac{1}{g_{m4}}$

$R_{in} = R_s + \frac{1}{g_{m1}}$

$Gain = \frac{g_{m1} R_{out}}{1 + g_{m1} R_s}$

8)

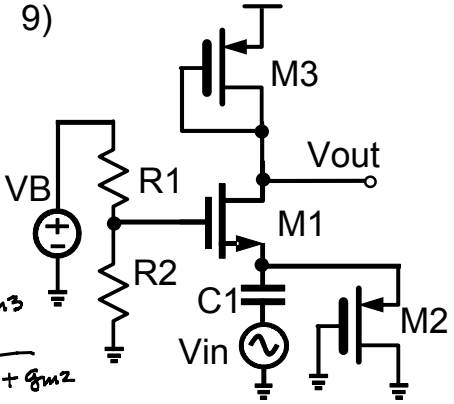


$R_{out} = R_D$

$R_{in} = \frac{1}{g_{m2}} \parallel \left(R_s + \frac{1}{g_{m1}}\right)$

$Gain = \frac{g_{m1} R_D}{1 + g_{m1} R_s}$

9)

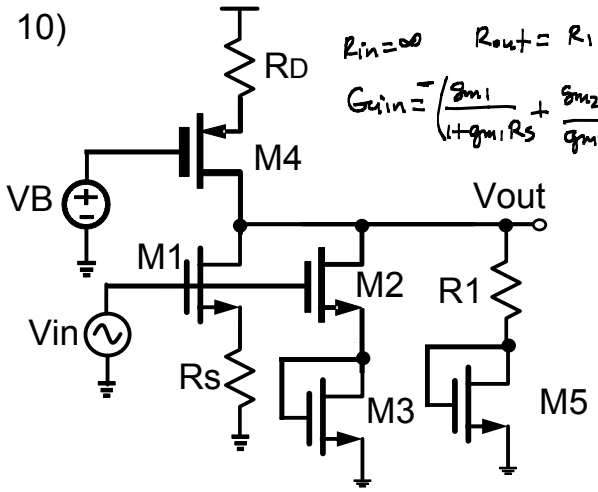


$R_{out} = \frac{1}{g_{m3}}$

$R_{in} = \frac{1}{g_{m1} + g_{m2}}$

$Gain = \frac{g_{m1}}{g_{m3}}$

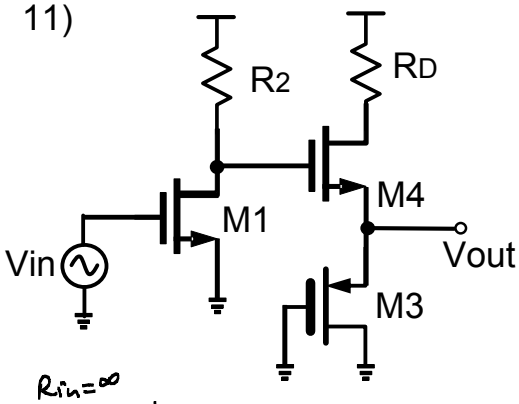
10)



$R_{in} = \infty \qquad R_{out} = R_1 + \frac{1}{g_{m5}}$

$Gain = -\left(\frac{g_{m1}}{1 + g_{m1} R_s} + \frac{g_{m2} g_{m3}}{g_{m2} + g_{m3}}\right) R_{out}$

11)

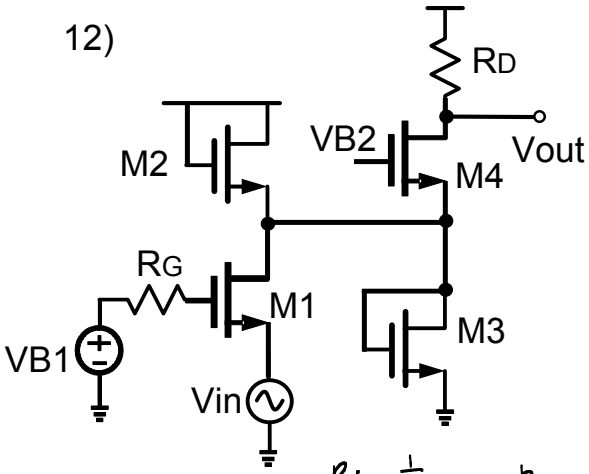


$R_{in} = \infty$

$R_{out} = \frac{1}{g_{m3} + g_{m4}}$

$Gain = -g_{m1} R_2 \frac{g_{m4}}{g_{m3} + g_{m4}}$

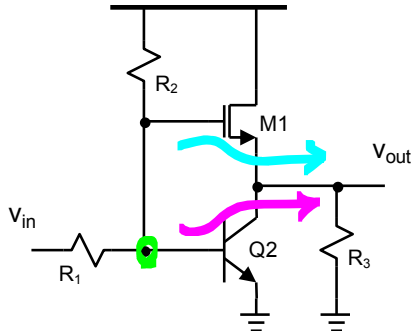
12)



$R_{in} = \frac{1}{g_{m1}} \qquad R_{out} = R_D$

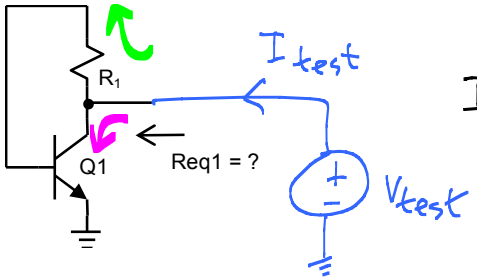
$Gain = g_{m1} \frac{g_{m4}}{g_{m2} + g_{m3} + g_{m4}} R_D$

13) Find the small-signal gain from v_{in} to v_{out}.



$$Gain = \frac{R_2 \| r_{\pi 2}}{R_1 + (R_2 \| r_{\pi 2})} \left(\frac{R_3}{\frac{1}{g_{m1}} + R_3} - g_{m2} \left[R_3 \| \frac{1}{g_{m1}} \right] \right)$$

14) Find the small-signal Req1.



$$I_{test} = \frac{V_{test}}{R_1 + r_{\pi 1}} + V_{test} \frac{r_{\pi 1}}{R_1 + r_{\pi 1}} g_{m1}$$

$$Req1 = \frac{V_{test}}{I_{test}} = (R_1 + r_{\pi 1}) \left\| \left(\frac{r_{\pi 1} g_{m1}}{R_1 + r_{\pi 1}} \right)^{-1} \right. = \frac{R_1 + r_{\pi 1}}{1 + \beta_1}$$