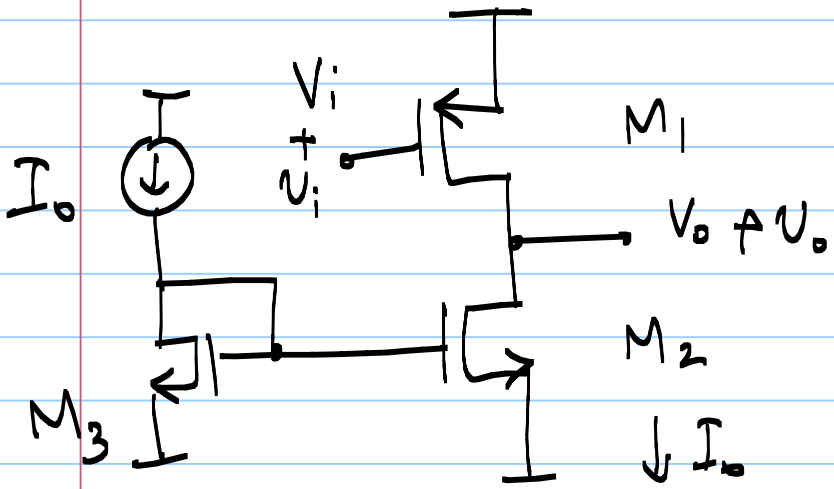
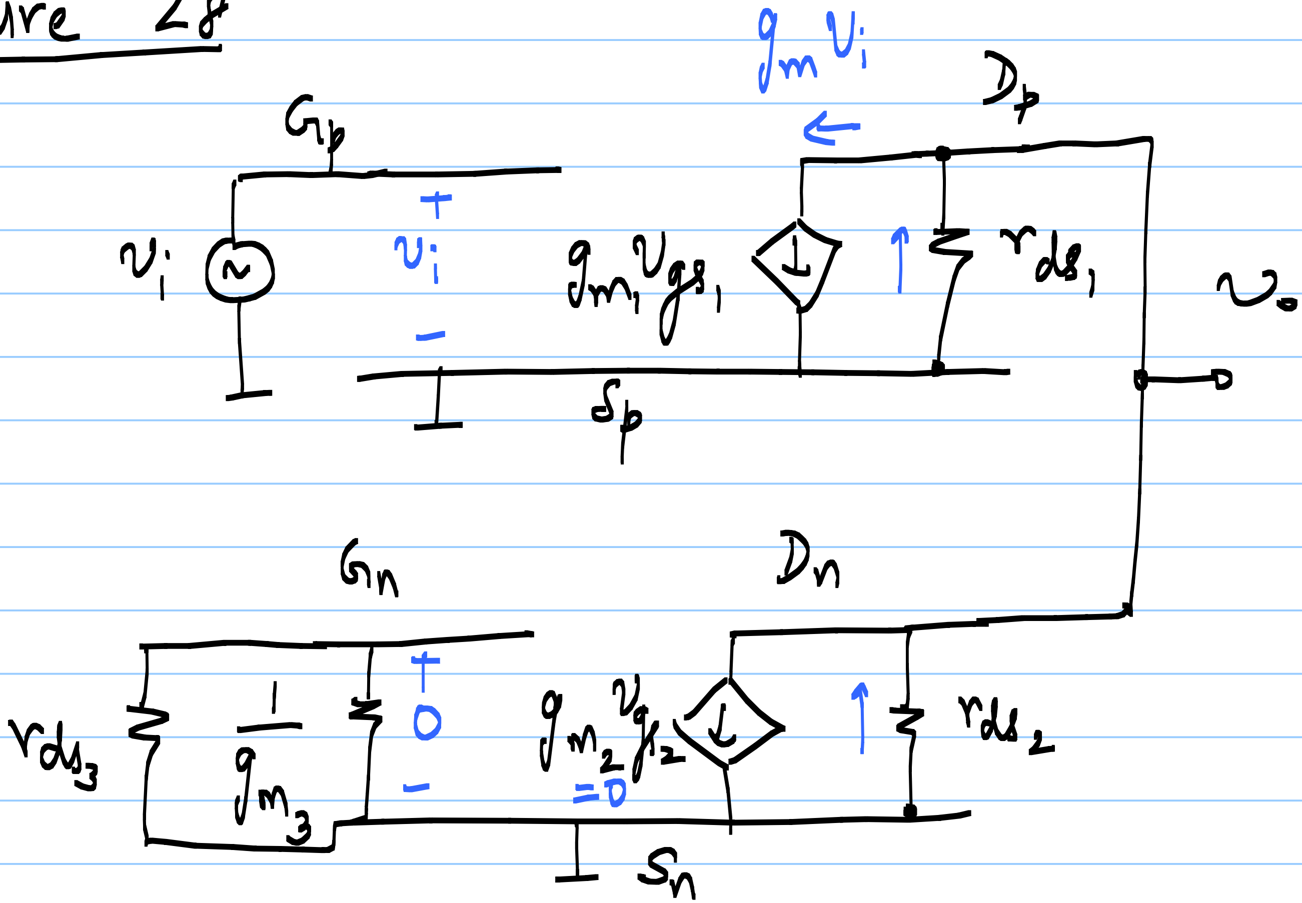
22|9|2020

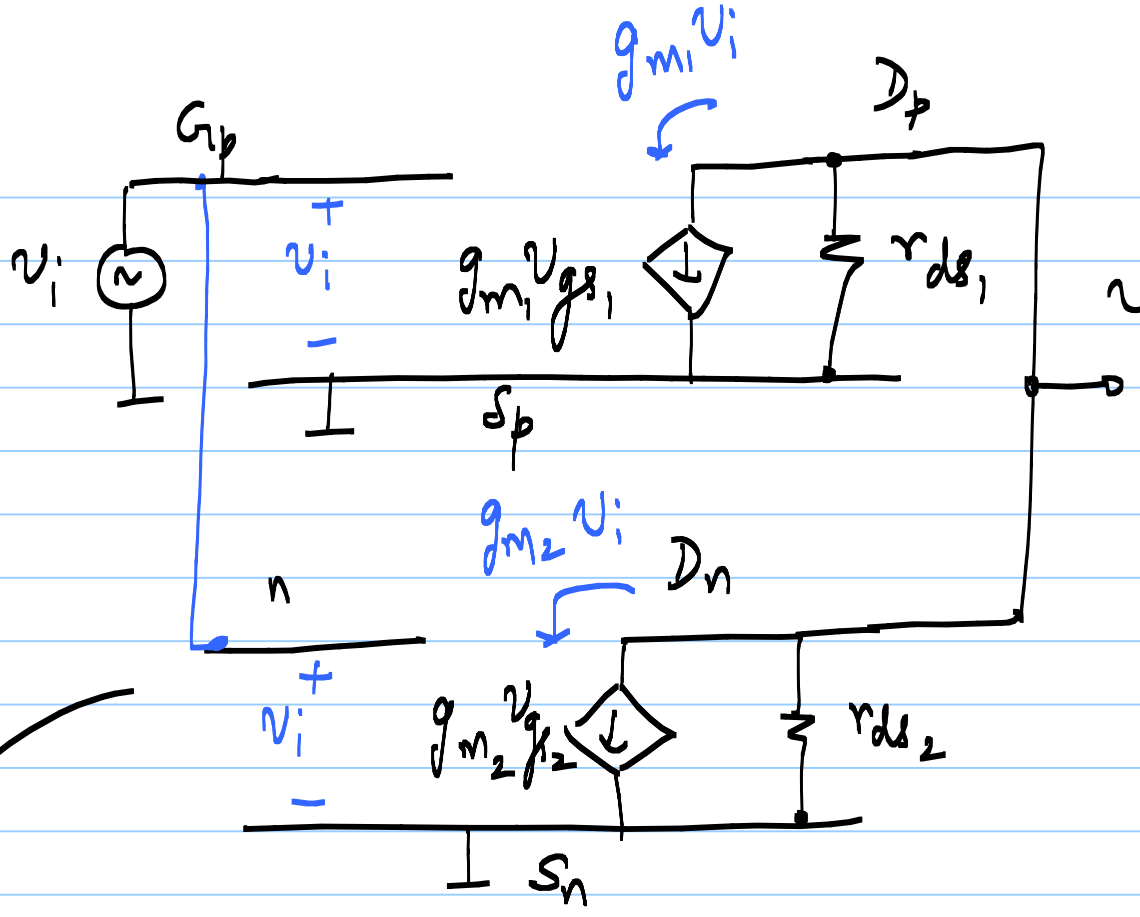
Lecture 28





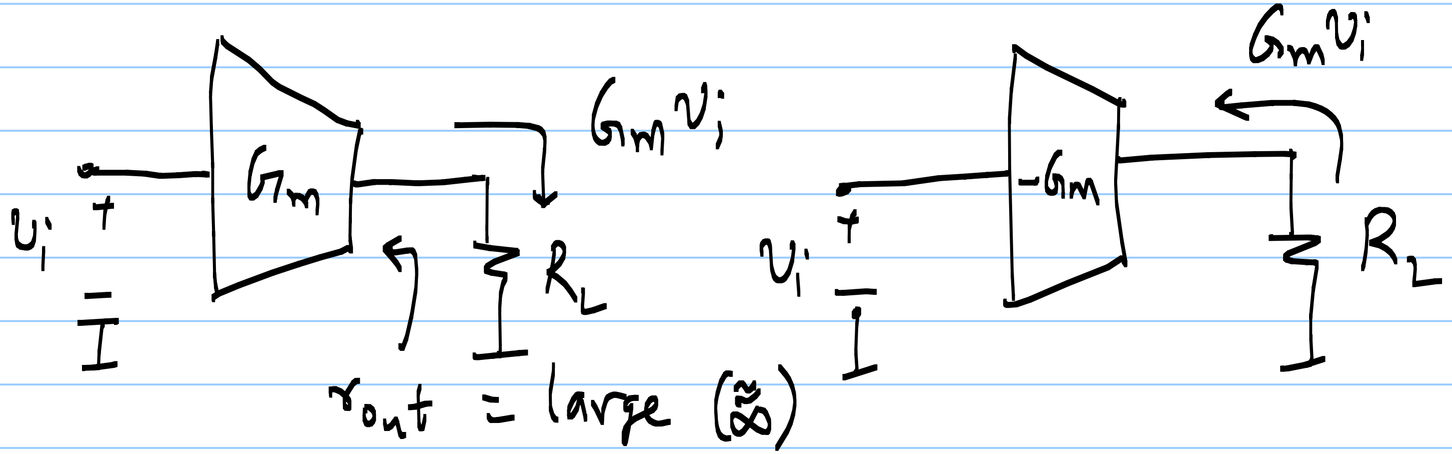
$$\frac{v_o}{v_i} = -g_{m1} \left(r_{ds1} \,\|\, r_{ds2} \right)$$

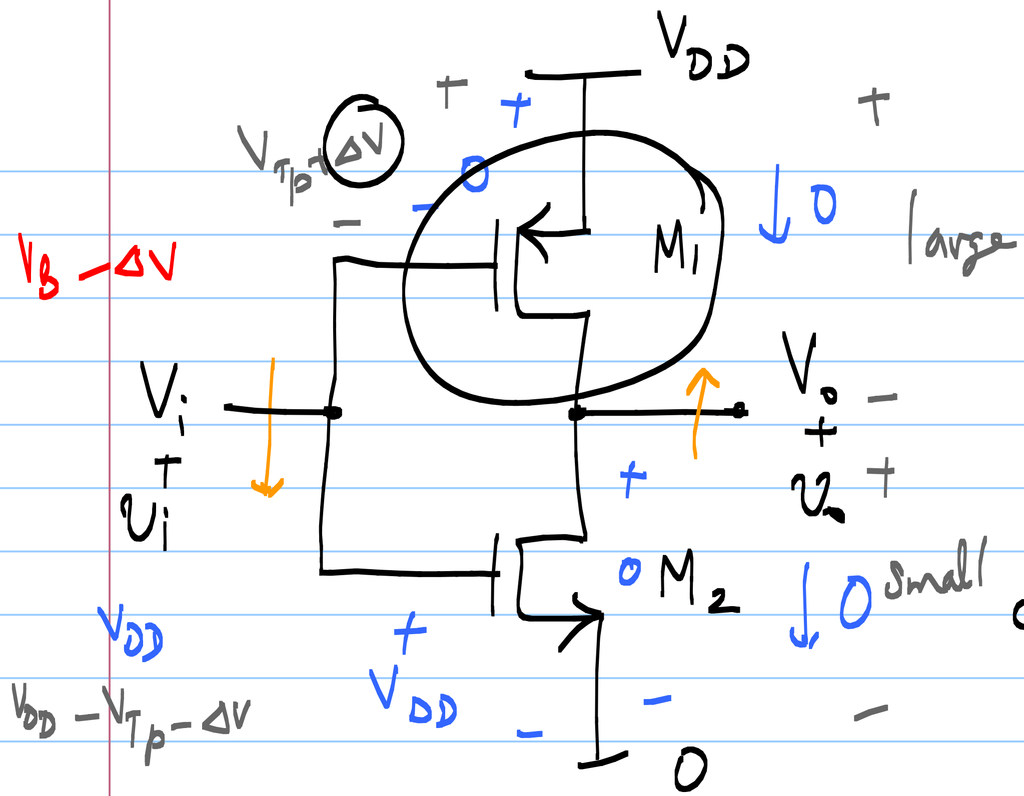
$$= \frac{-g_{m1}}{g_{ds1} + g_{ds2}}$$

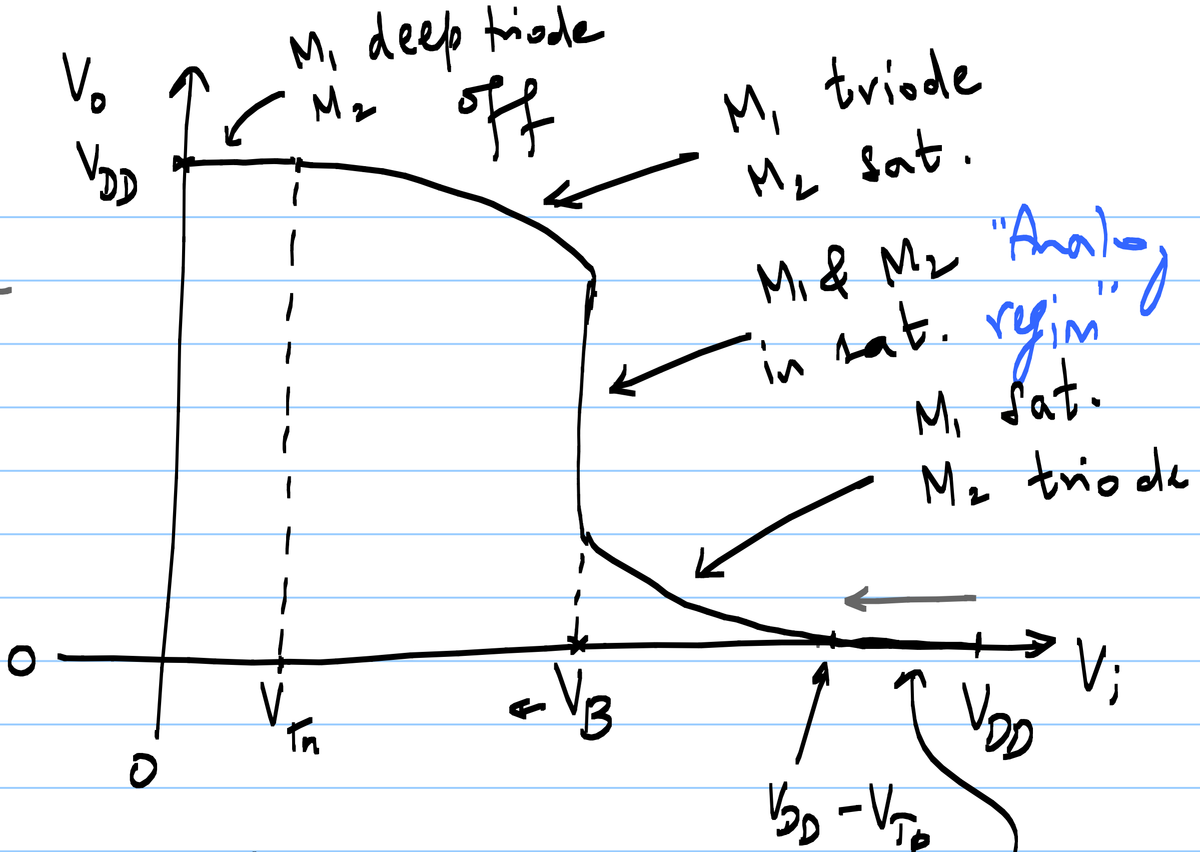


$$v_o = \frac{-(g_{m1} + g_{m2})}{g_{ds1} + g_{ds2}} v_i$$

If r_{ds1} & r_{ds2} were ∞, gain $= \infty$

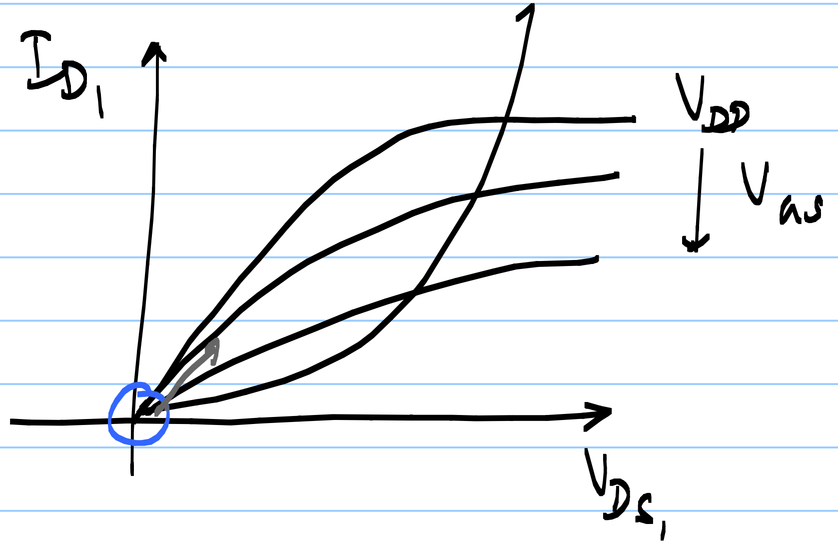






assume $r_{ds} = \infty$

"CMOS Inverter"



$$V_i = V_{DD} - V_{Tp} - \Delta V : I_{D_1}(\text{sat.}) = I_{D_2}(\text{triode})$$

Determine V_B:

$$I_{D_1}(\text{sat}) = I_{D_2}(\text{sat.})$$

$$\frac{1}{2}\mu_p C_{ox}\left(\frac{W}{L}\right)_p\left[V_{DD}-V_B-V_{Tp}\right]^2 = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_n\left[V_B-V_{Tn}\right]^2$$

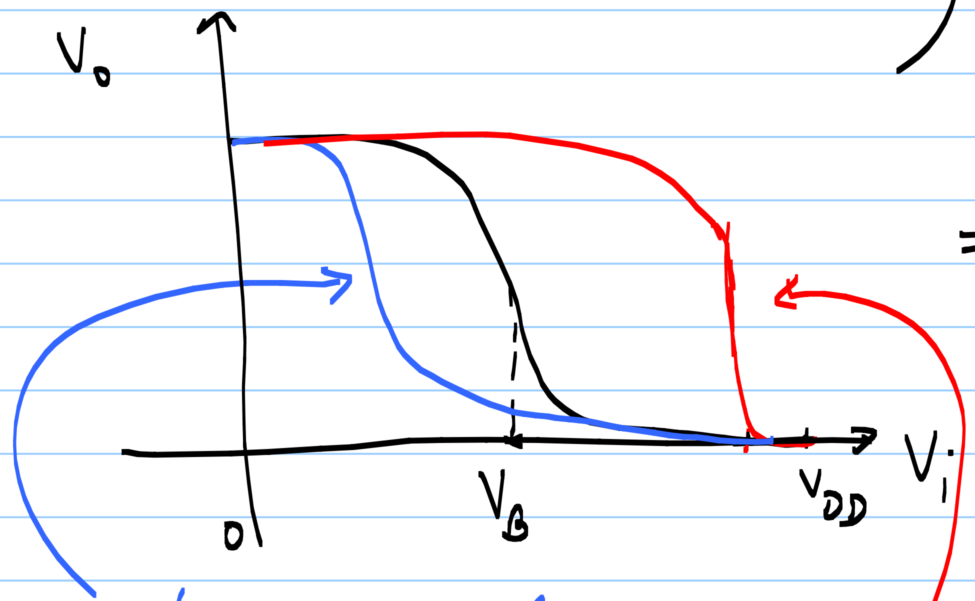
$$k_n = \mu_n\left(\frac{W}{L}\right)_n \quad ; \quad k_p = \mu_p\left(\frac{W}{L}\right)_p$$

$$V_B - V_{Tn} = \sqrt{\frac{k_p}{k_n}}\cdot\left(V_{DD}-V_B-V_{Tp}\right)$$

$$V_B\left[1+\sqrt{\frac{k_p}{k_n}}\right] = V_{Tn} + \left(V_{DD}-V_{Tp}\right)\left[\sqrt{\frac{k_p}{k_n}}\right]$$

$$V_B = \frac{V_{T_n} + (V_{DD} - V_{T_p})\left[\sqrt{\frac{k_p}{k_n}}\right]}{1 + \sqrt{\frac{k_p}{k_n}}}$$

* $\mu_n \approx 3\,\mu_p$



1) $V_{T_n} = V_{T_p} = V_T$

We want $V_B = V_{DD}/2$

$\Rightarrow k_p = k_n \Rightarrow \left(\frac{W}{L}\right)_p = 3\left(\frac{W}{L}\right)_n$

$$\left(\frac{W}{L}\right)_p = \left(\frac{\mu_n}{\mu_p}\right)\left(\frac{W}{L}\right)_n$$

2) If $\left(\frac{W}{L}\right)_n \gg \left(\frac{W}{L}\right)_p$ $\quad V_B \approx V_{T_n}$

3) If $\left(\frac{W}{L}\right)_p \gg \left(\frac{W}{L}\right)_n$ $\quad V_B \approx V_{DD} - V_{T_p}$