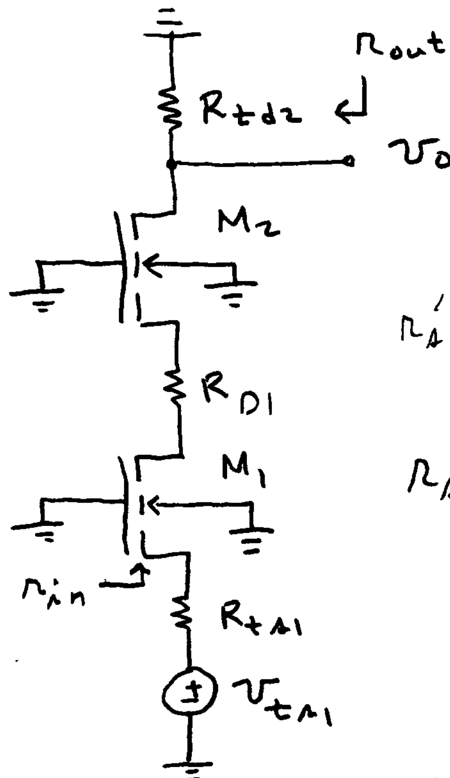
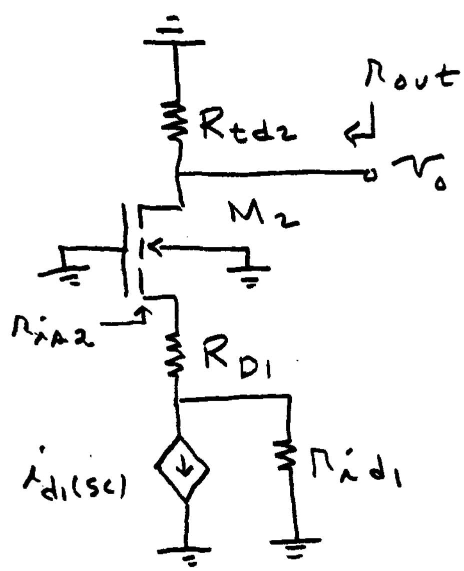
A Two Stage CG Amplifier with Body Effect



$$r_{s1}' = \frac{r_{s1}}{1+\chi_1} = \frac{1}{g_{m1}(1+\chi_1)}$$

$$r_{s2}' = \frac{r_{s2}}{1+\chi_2} = \frac{1}{g_{m2}(1+\chi_2)}$$

Replace M_1 with its Norton Drain Circuit



where

$$i'_{d1(sc)} = -G_{ms1} v_{ts1}$$

$$G_{ms1} = \frac{1}{R_{ts1} + r'_{s1} \| r_{01}}$$

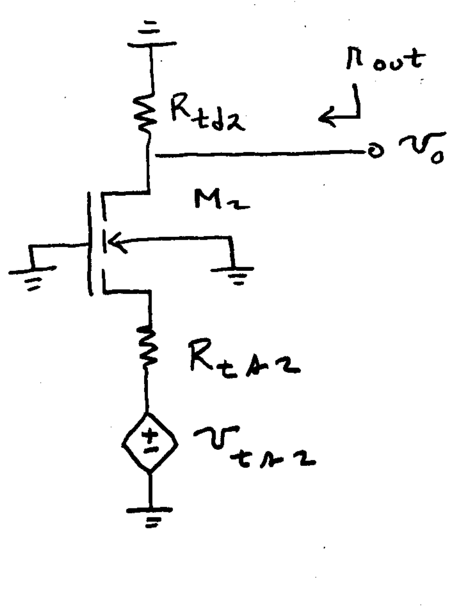
$$r'_{s1} = \frac{r_{s1}}{1+\chi_1} = \frac{1}{g_{m1}(1+\chi_1)}$$

$$r_{id1} = r_{01}\left(1 + \frac{R_{ts1}}{r_{s1}}\right) + R_{ts1}$$

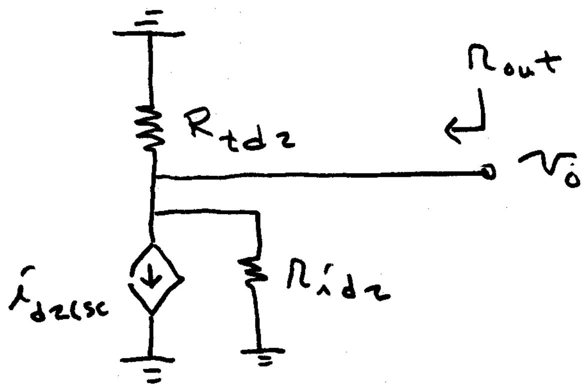
Make a Thévenin equivalent circuit looking out of the source of M_2.

$$v_{ts2} = -i_{d1(sc)} r_{id1}$$

$$R_{ts2} = R_{D1} + r_{id1}$$



Replace M_2 with its Norton drain circuit



$$v_o = -i_{d2(sc)}\, r_{id2} \| R_{td2}$$

$$= +G_{mA2} v_{tA2}\, r_{id2} \| R_{td2}$$

where

$$G_{mA2} = \frac{1}{R_{tA2} + r'_{A2} \| r_{o2}}$$

$$r_{id2} = r_{o2}\left(1 + \frac{R_{ts2}}{r'_{A2}}\right) + R_{tA2}$$

Combine results to obtain

$$v_o = +G_{mA2}\left[-\left(-G_{mA1} v_{tA1}\right) r_{id1}\right] r_{id2} \| R_{td2}$$

Thus the voltage gain is

$$A_v = \frac{v_o}{v_{tA1}} = G_{mA1}\, r_{id1}\, G_{mA2}\, r_{id2} \| R_{td2}$$

The output resistance is

$$r_{out} = r_{id2} \parallel R_{td2}$$

To solve for the input resistance, we must solve for R_{td1}. This is given by

$$R_{td1} = R_{D1} + r_{iA2}$$

where

$$r_{iA2} = r'_{A2} \frac{r_{o2} + R_{td2}}{r'_{A2} + r_{o2}}$$

The input resistance is given by

$$r_{in} = r_{iA1} = r'_{A1} \frac{r_{o1} + R_{td1}}{r'_{A1} + r_{o1}}$$