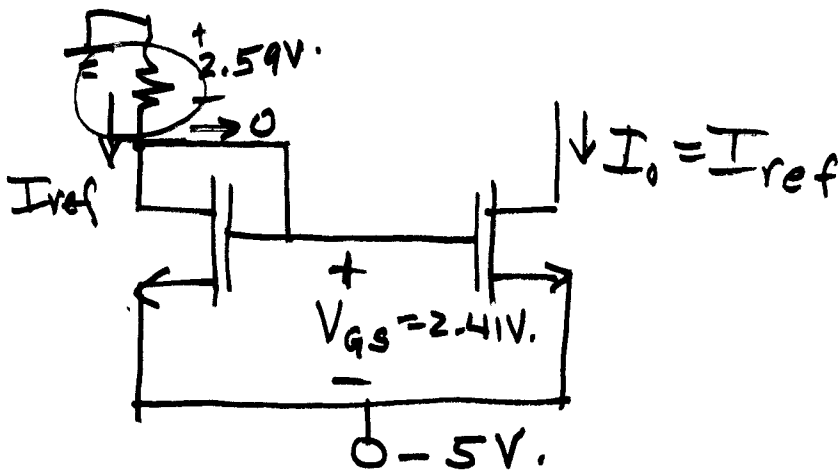


# MOSFET CURRENT MIRROR



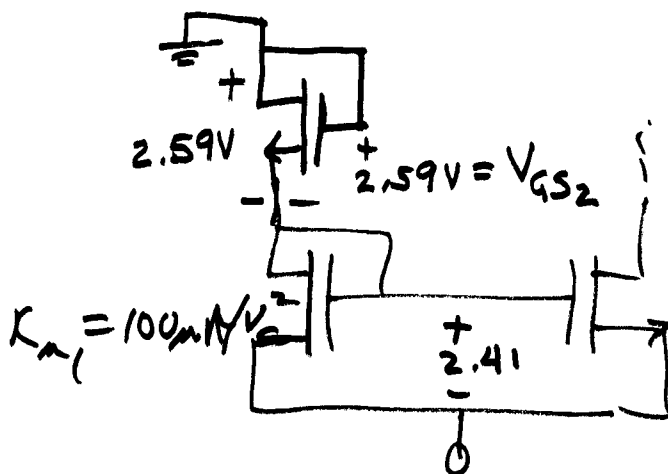
$$V_{GS} = \sqrt{\frac{I_D}{K_m}} + V_{TN}$$

$$K_m = 100 \mu A/V^2 \quad V_{TN} = 1V$$

$$I_D = 200 \mu A$$

$$V_{GS} = \sqrt{\frac{200 \mu}{100 \mu}} + 1 = 2.41V$$

$$R = \frac{5 - 2.41}{200 \mu} = \frac{2.59}{200 \mu A} = 12.95 K$$



$$K_{m1} = \frac{K'_m}{2} \frac{W}{L} = 100 \mu A/V^2$$

$$K_{m2} = 79.1 \mu A/V^2$$

$$I_D = K_m (V_{GS} - V_{TN})^2$$

$$200 \mu A = K_m (2.59 - 1)^2$$

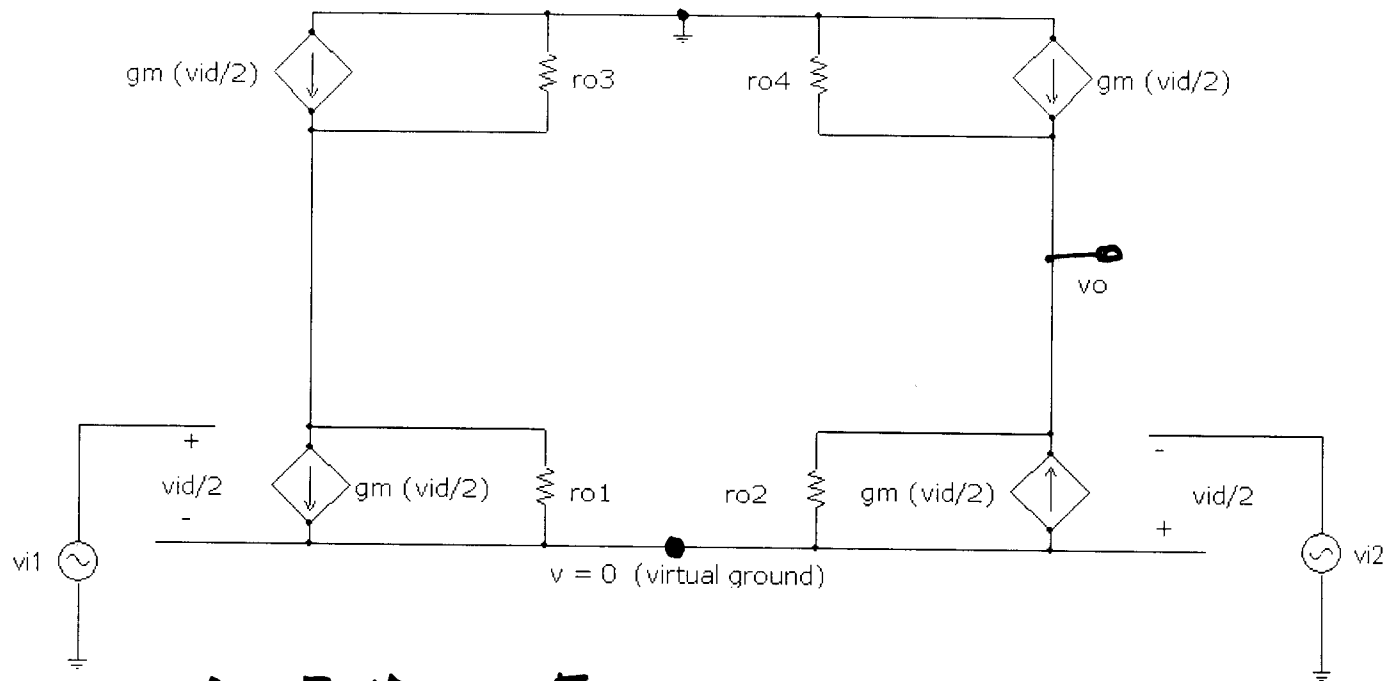
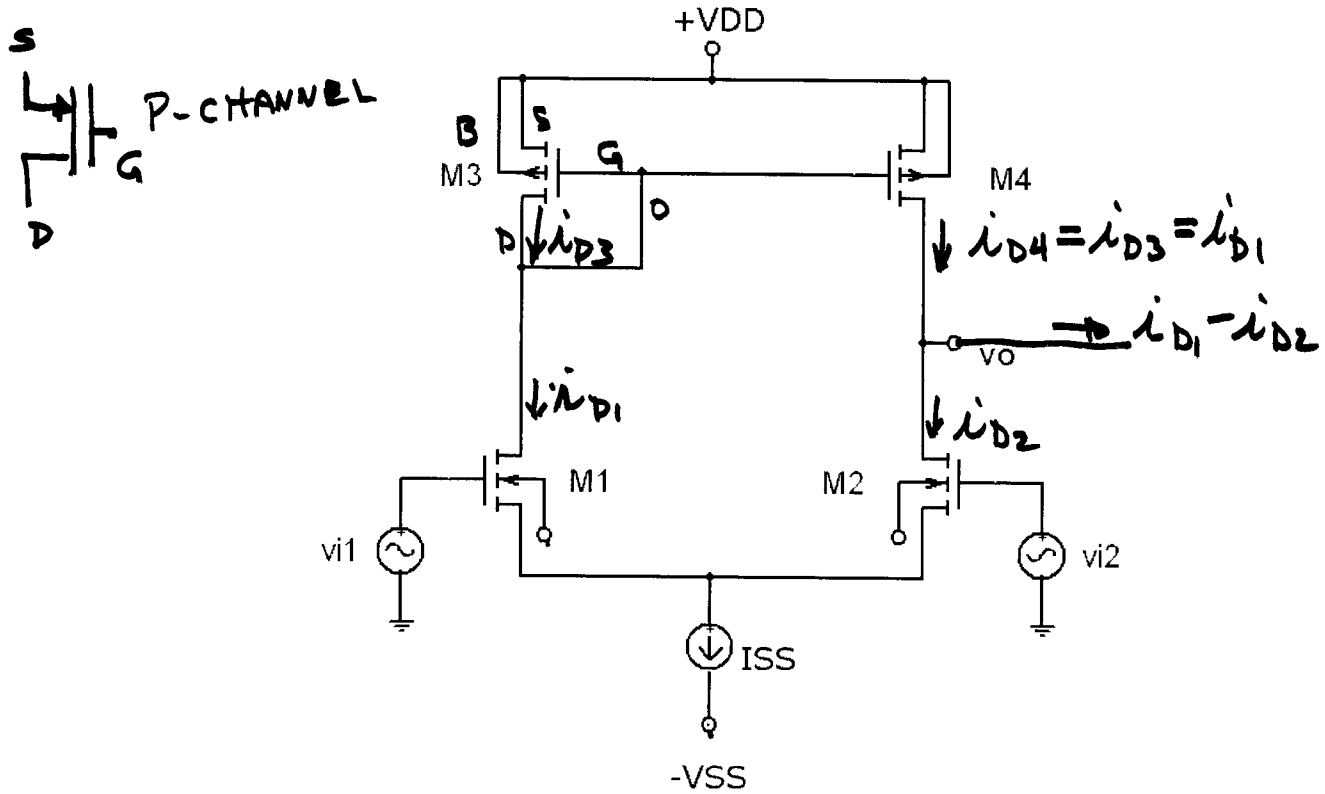
$$\frac{K_{m2}}{K_{m1}} = 0.791 = \frac{(W/L)_2}{(W/L)_1}$$

$$K_m = \frac{200 \mu}{(2.59 - 1)^2} = 79.1 \mu A/V^2$$

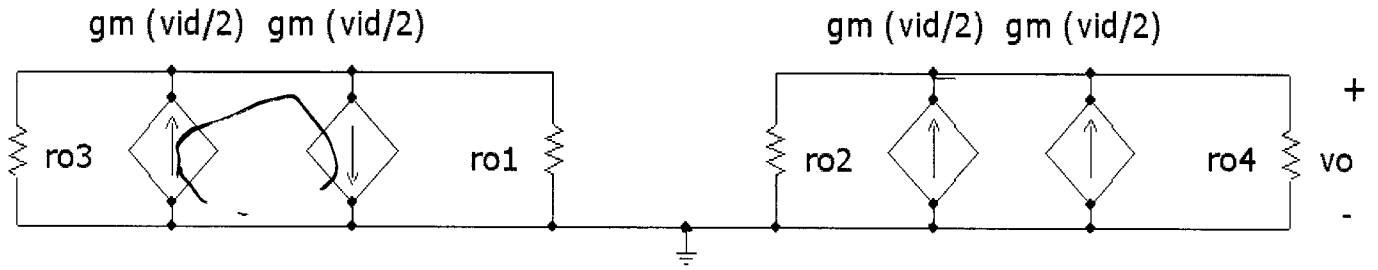
$$L_2 = L_1$$

$$W_2 = 0.791 W_1$$

# A CMOS DIFFERENTIAL AMPLIFIER



$$i_{id} = i_{i1} - i_{i2}$$



The equivalent circuit consists of a current source with value  $g_m(vid)$  in parallel with a resistor labeled  $r_{o4} // r_{o2}$ . This combination is connected to an output terminal  $v_o$ .

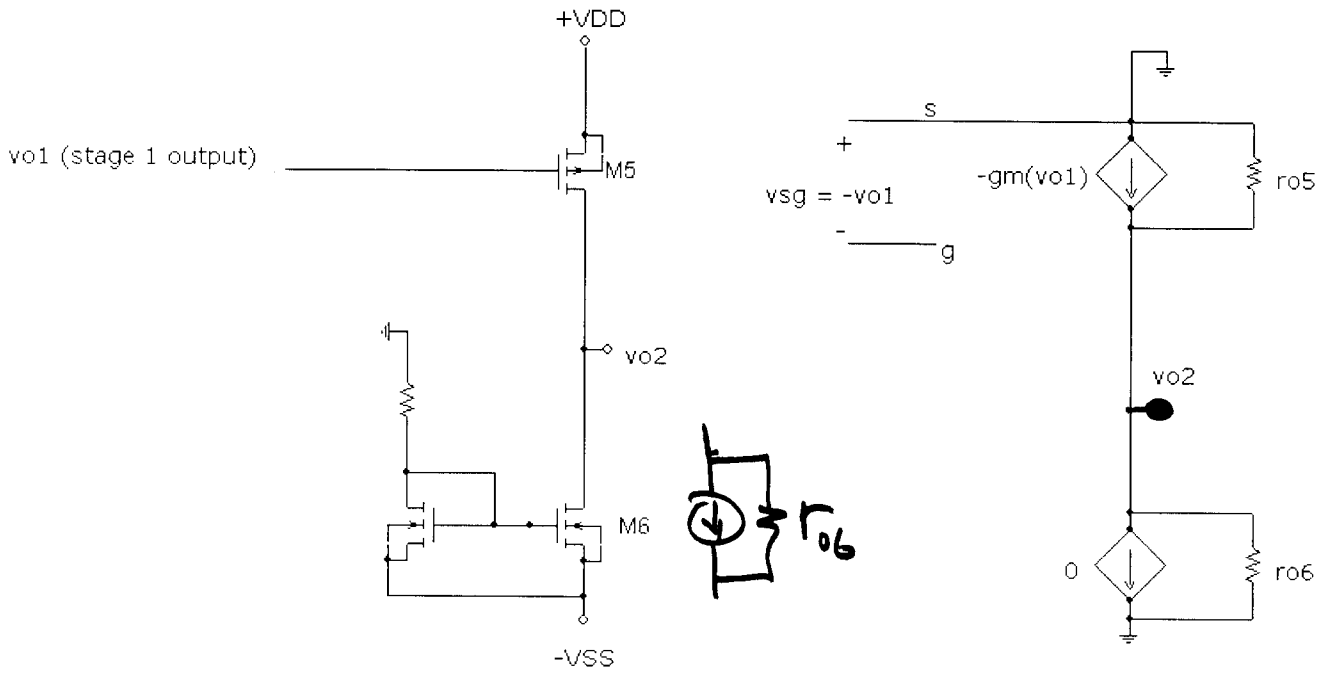
$$v_o = g_m v_{id} (r_{o4} // r_{o2})$$

$$A_{v_d} = \frac{v_o}{v_{id}} = g_m (r_{o4} // r_{o2})$$

$$g_m = 2 \sqrt{K_m I_{DQ}}$$

$$r_o = \frac{V_A}{I_{DQ}} = \frac{1}{\lambda I_{DQ}}$$

## STAGE 2



The small-signal equivalent circuit for the common source node is shown. It consists of a dependent current source  $-g_m(v_{o1})$  in parallel with the output resistances  $r_{o5}$  and  $r_{o6}$ . The output voltage  $v_{o2}$  is measured across the parallel combination of  $r_{o5}$  and  $r_{o6}$ .

$$v_{o2} = -g_m v_{o1} (r_{o5} // r_{o6})$$

$$\frac{v_{o2}}{v_{o1}} = -g_m (r_{o5} // r_{o6})$$

## STAGES 1 AND 2 TOGETHER

