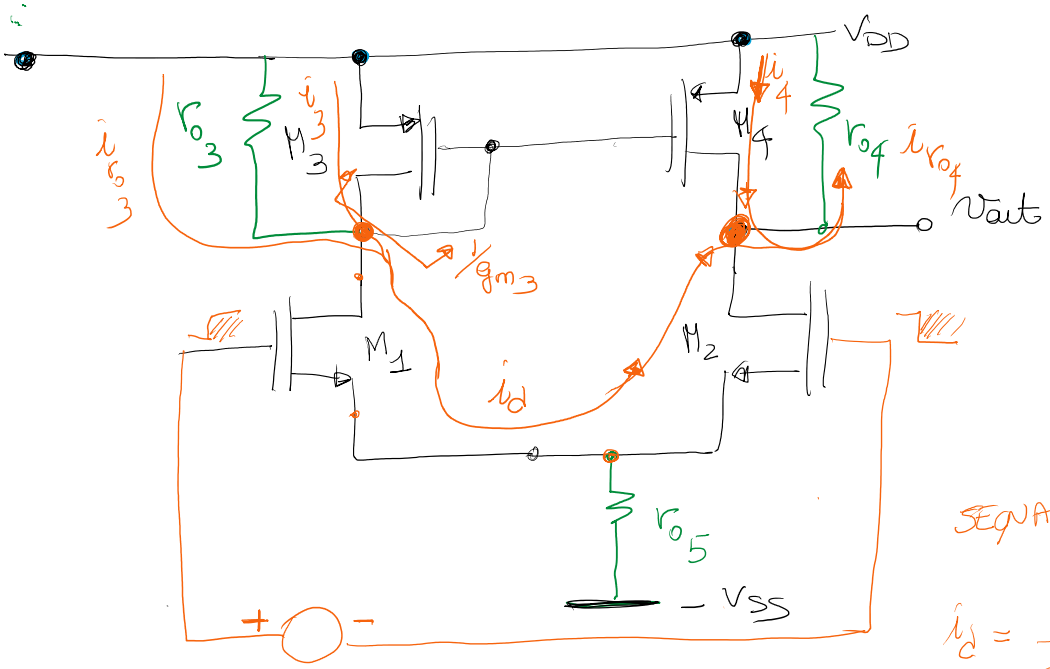


$v_d = v_1 - v_2$

SEGNALE DIFFERENZIALE

$g_{m1} = g_{m2} = g_m$

$$i_d = \frac{v_d}{1/g_{m1} + 1/g_{m2}} = \frac{v_d}{2/g_m} = g_m \frac{v_d}{2}$$

$$i_3 = i_d \cdot \frac{r_{o3}}{r_{o3} + 1/g_{m3}} \qquad i_4 = i_3$$

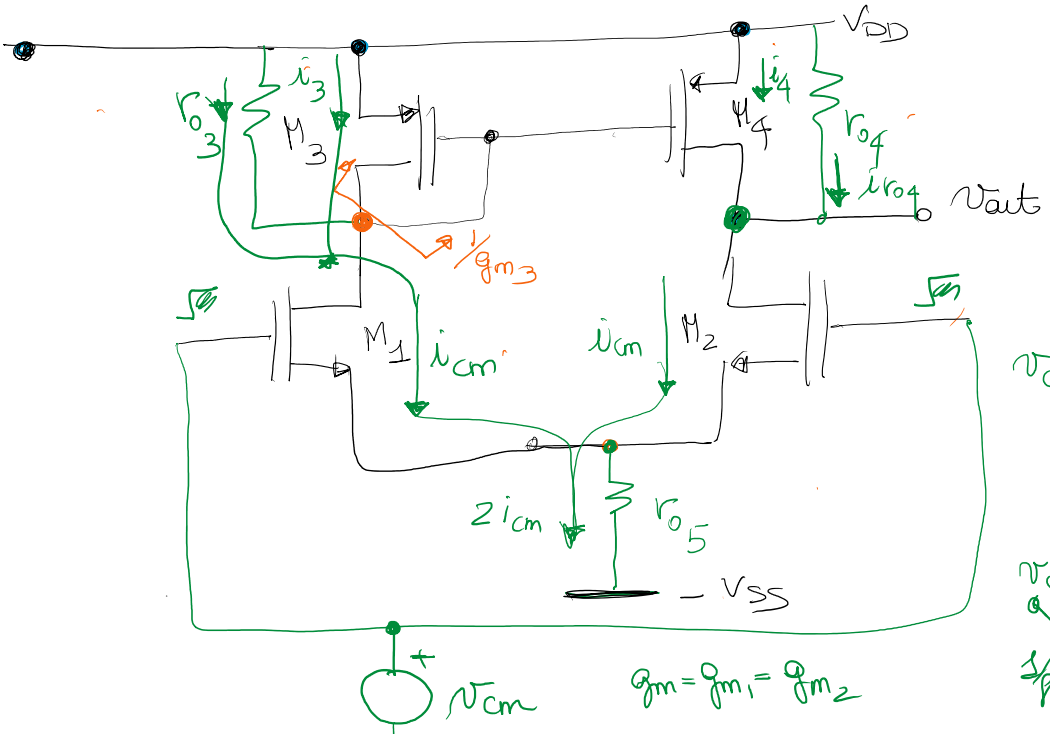
$$v_{out} = i_{r_{o4}} * r_{o4} = (i_4 + i_d)\, r_{o4} = i_d\, r_{o4} \left[1 + \frac{r_{o3}}{r_{o3} + 1/g_{m3}} \right] =$$

$$= g_m \frac{v_d}{2} r_{o4} \left[\frac{r_{o3} + r_{o3} + 1/g_{m3}}{r_{o3} + 1/g_{m3}} \right]$$

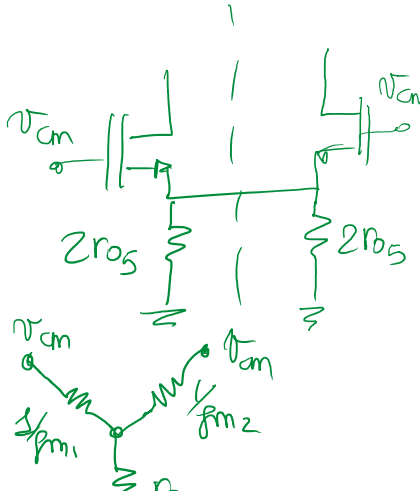
$$\Downarrow$$

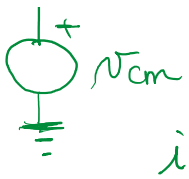
$$A_d \triangleq \frac{v_{out}}{v_d} = g_m \frac{r_{o4}}{2} \left[\frac{2r_{o3} + 1/g_{m3}}{r_{o3} + 1/g_{m3}} \right]$$

COMPORTAMENTO SU SEGNALE DI MODO COMUNE



$g_m = g_{m1} = g_{m2}$





v_{cm}

$g_m = g_{m_1} = g_{m_2}$

$$i_{cm} = \frac{v_{cm}}{1/g_m + 2r_{o_5}}$$

$$i_3 = \frac{r_{o_3}}{r_{o_3} + 1/g_{m_3}}\, i_{cm}$$

$i_4 = i_3$

$$i_4 + i r_{o_4} = i_{cm}$$

$$i_{cm} = \frac{r_{o_3}\, i_{cm}}{r_{o_3} + 1/g_{m_3}} - \frac{v_{out}}{r_{o_4}}$$

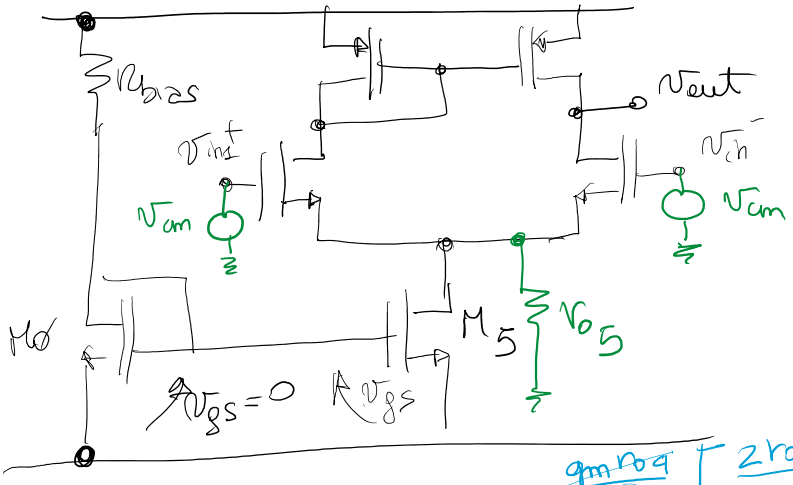
$$v_{out} = r_{o_4}\left[\frac{r_{o_3}}{r_{o_3} + 1/g_{m_3}} - 1\right] i_{cm} =$$

$$= r_{o_4}\left[\frac{\cancel{r_{o_3}} - \cancel{r_{o_3}} - 1/g_{m_3}}{r_{o_3} + 1/g_{m_3}}\right] \frac{v_{cm}}{1/g_m + 2r_{o_5}} =$$

$$= -\, r_{o_4}\, \frac{1/g_{m_3}}{r_{o_3} + 1/g_{m_3}}\, \frac{v_{cm}}{1/g_m + 2r_{o_5}}$$

$$A_{cm} \triangleq \frac{v_{out}}{v_{cm}} = -\, \frac{r_{o_4}\, 1/g_{m_3}}{r_{o_3} + 1/g_{m_3}}\, \frac{1}{1/g_m + 2r_{o_5}} =$$

$$= -\, \frac{r_{o_4}}{(1 + g_m r_{o_3})}\, \frac{g_m}{(1 + 2 g_m r_{o_5})}$$



$$CMRR \triangleq \left|\frac{A_d}{A_{cm}}\right| = \frac{\frac{g_m r_{o_4}}{2}\left[\frac{2r_{o_3} + 1/g_{m_3}}{r_{o_3} + 1/g_{m_3}}\right]}{\frac{g_m r_{o_4}}{(1 + g_m r_{o_3})(1 + 2 g_m r_{o_5})}} =$$

$$A_d \triangleq \frac{v_{out}}{v_d} = \frac{g_m r_{o_4}}{2}\left[\frac{2r_{o_3} + 1/g_{m_3}}{r_{o_3} + 1/g_{m_3}}\right]$$

$$= \cancel{(1+g_m r_{o_3})}\,(1+2g_m r_{o_5})\frac{1}{2}\left[\frac{2g_m r_{o_3}+1}{\cancel{1+g_m r_{o_3}}}\right] =$$

$$= \frac{1}{2}(1+2g_m r_{o_3})(1+2g_m r_{o_5})$$