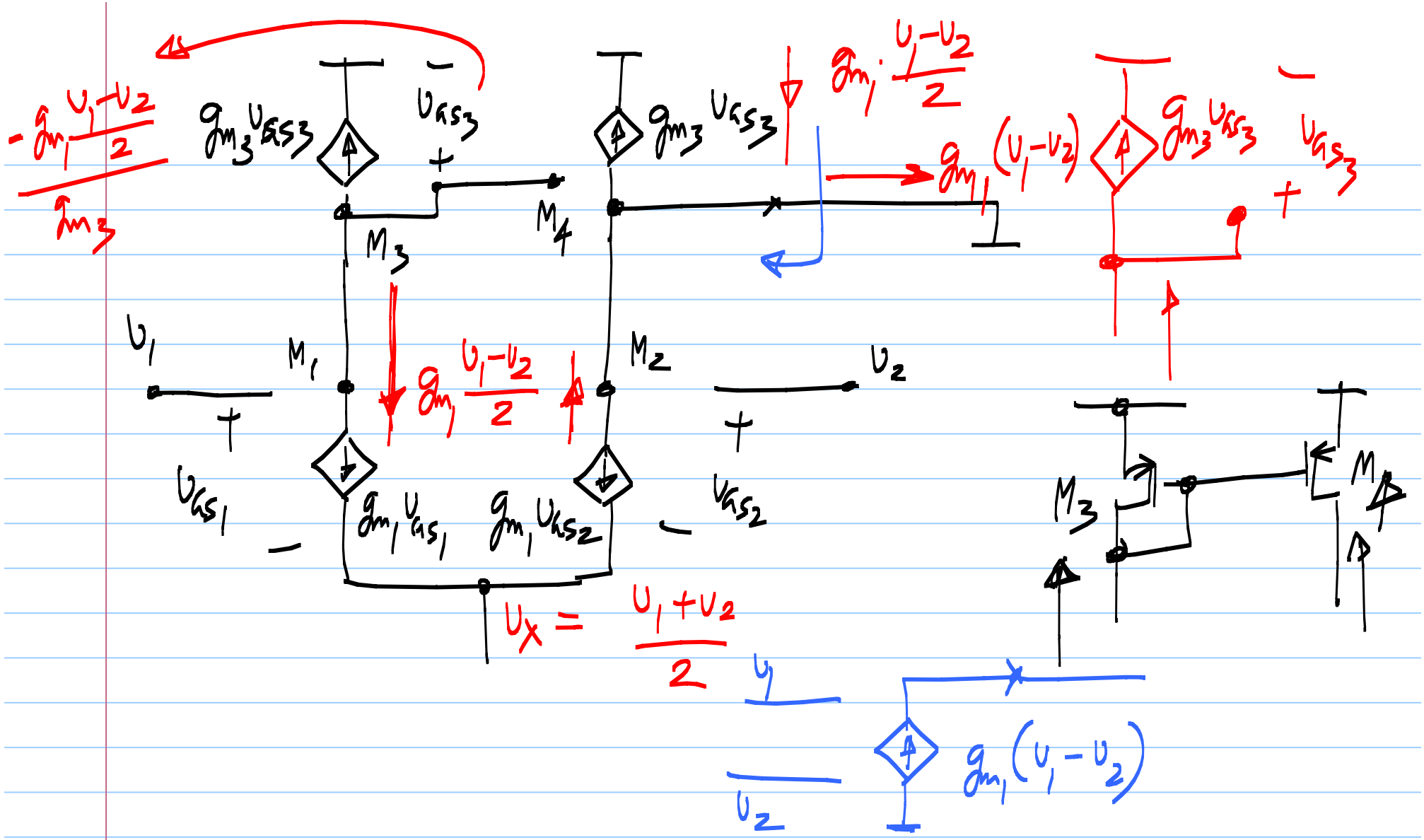
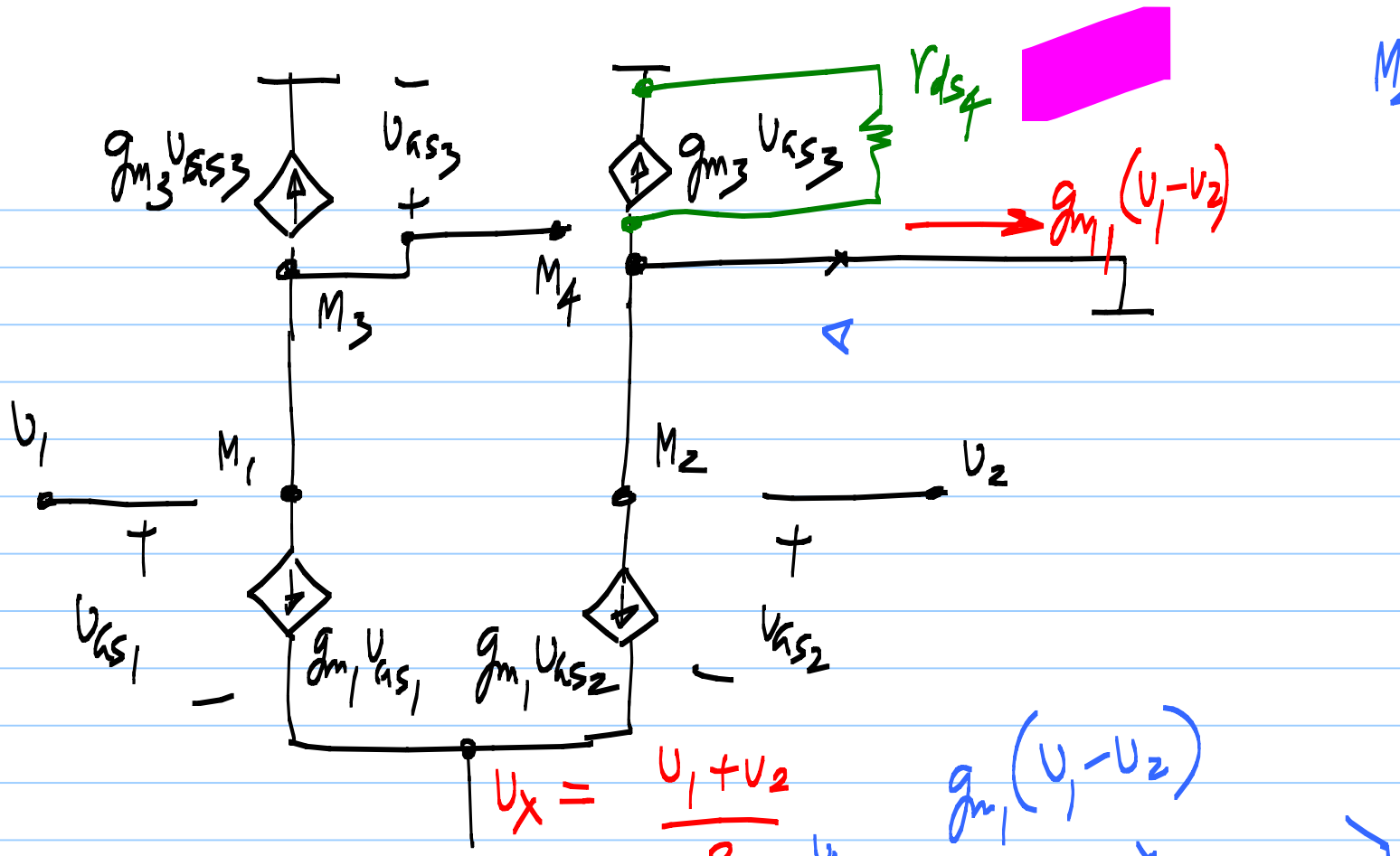
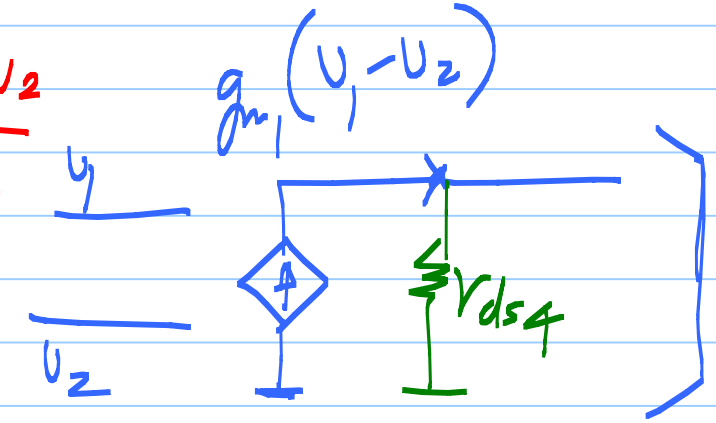
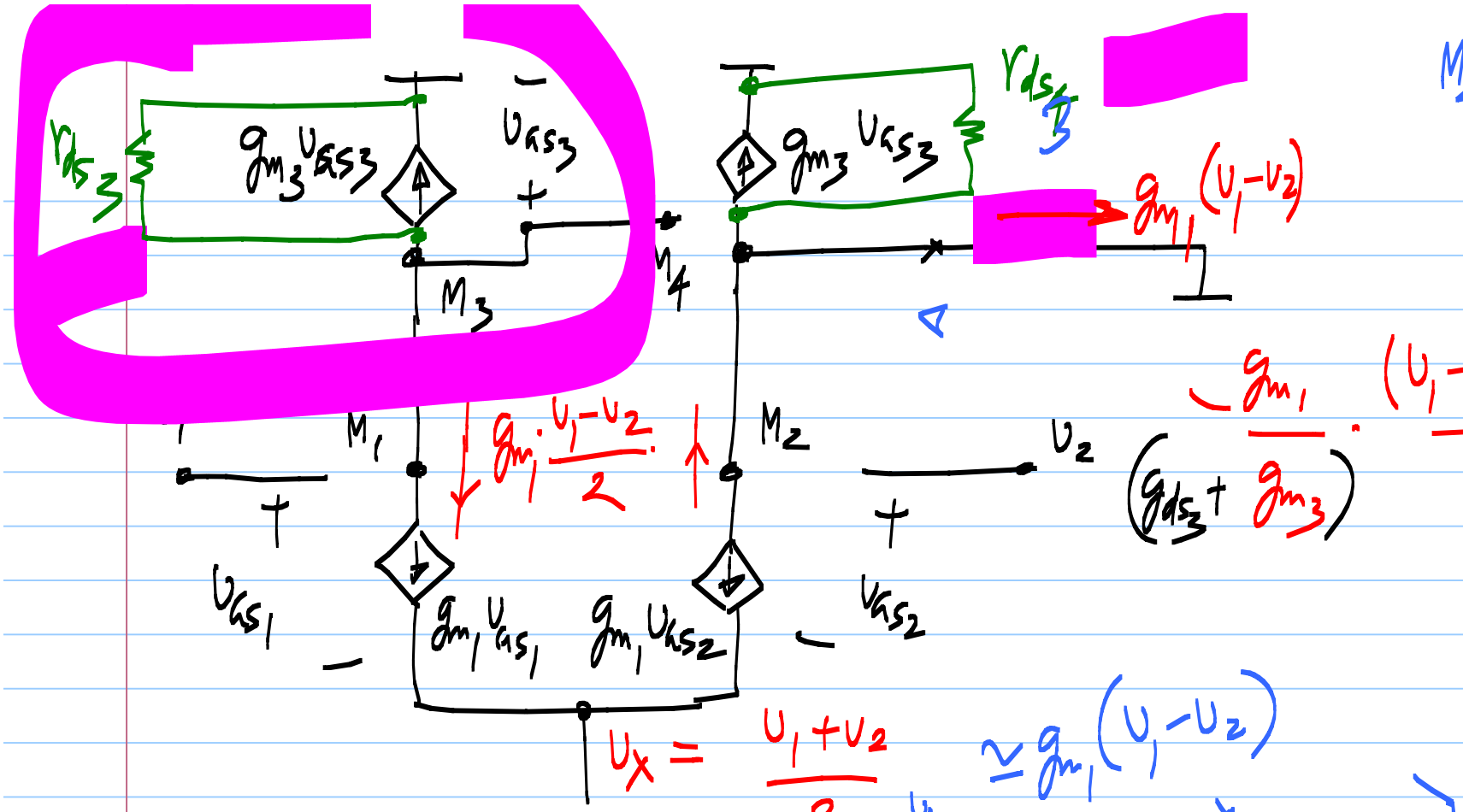

$-\frac{g_{m_1}\frac{v_1-v_2}{2}}{g_{m_3}}$
$g_{m_3}v_{GS_3}$
v_{GS_3}
M_3
M_4
v_1
M_1
M_2
v_2
v_{GS_1}
$g_{m_1}\frac{v_1-v_2}{2}$
v_{GS_2}
$g_{m_1}v_{GS_1}$
$g_{m_1}v_{GS_2}$
$v_X = \frac{v_1+v_2}{2}$
$g_{m_1}\cdot\frac{v_1-v_2}{2}$
$g_{m_1}(v_1-v_2)$
M_3
M_4
v_1
v_2
$g_{m_1}(v_1-v_2)$



M_4: finite r_{ds}

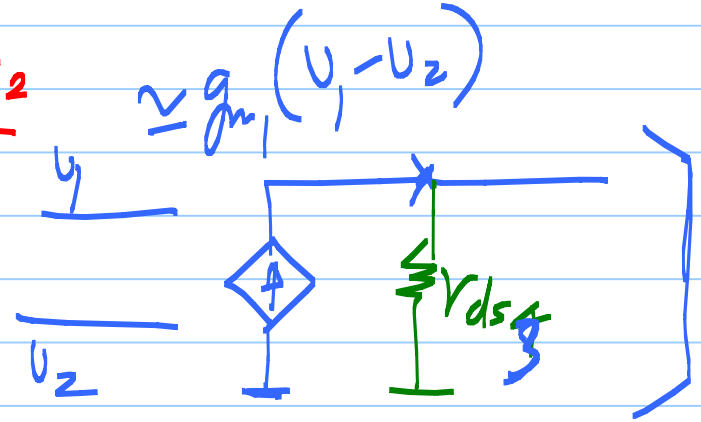


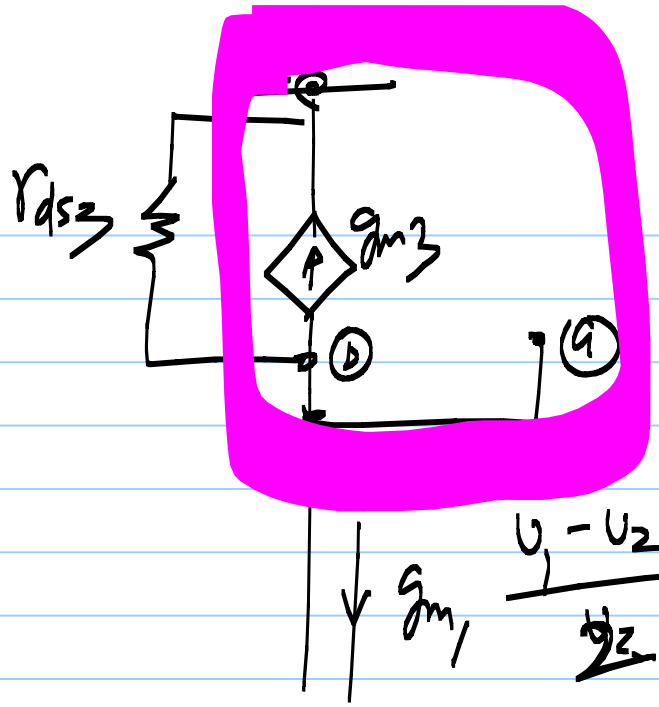


M_4: finite r_{ds}

$$-\frac{g_{m1}}{(g_{ds3}+g_{m3})}\cdot\frac{(v_1-v_2)}{2}$$

$$\simeq g_{m1}(v_1-v_2)$$



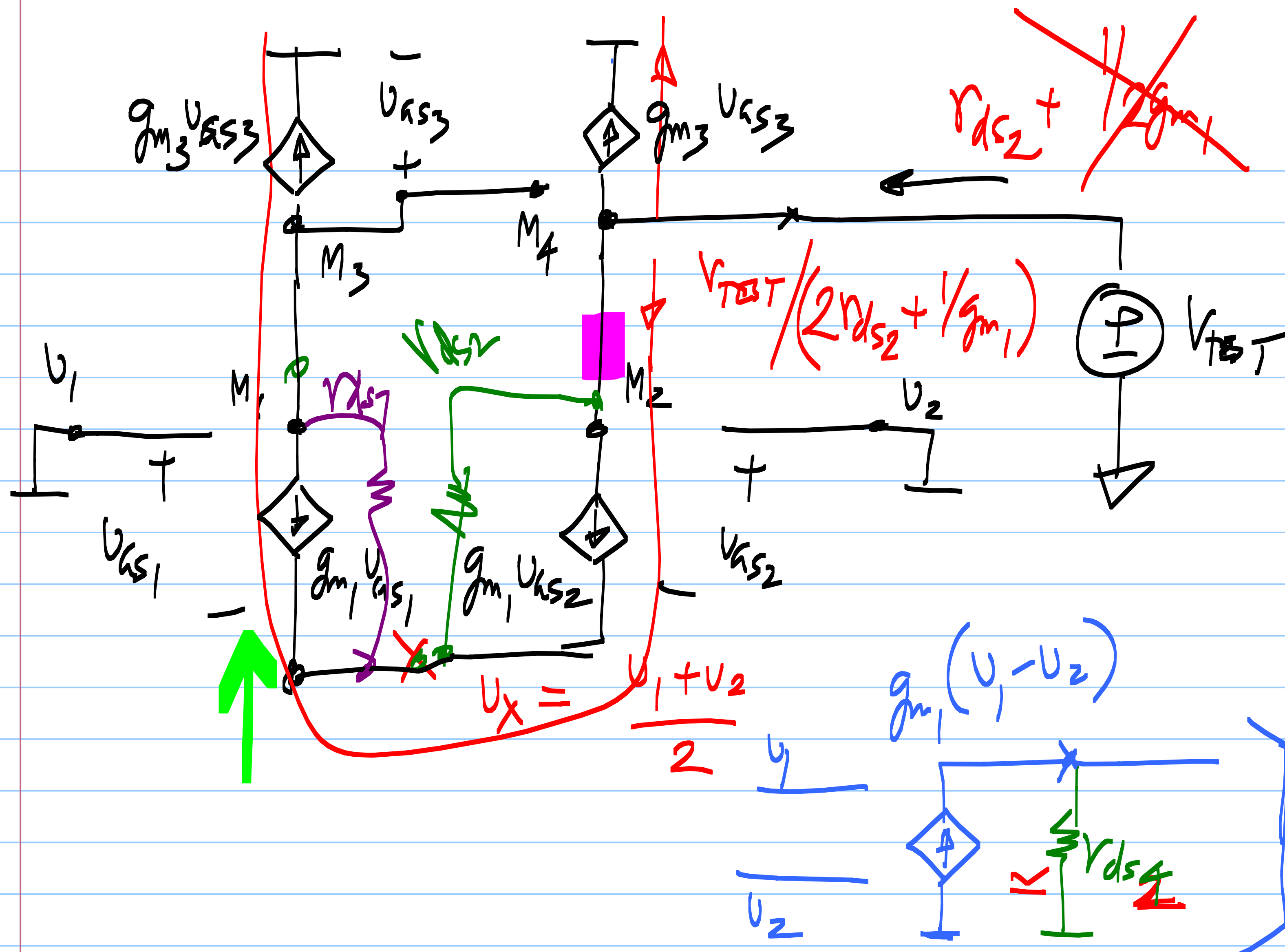


$$g_{m1}(v_1 - v_2)\left[\frac{1 + g_{ds3}/2g_{m3}}{1 + g_{ds3}/g_{m3}}\right]$$

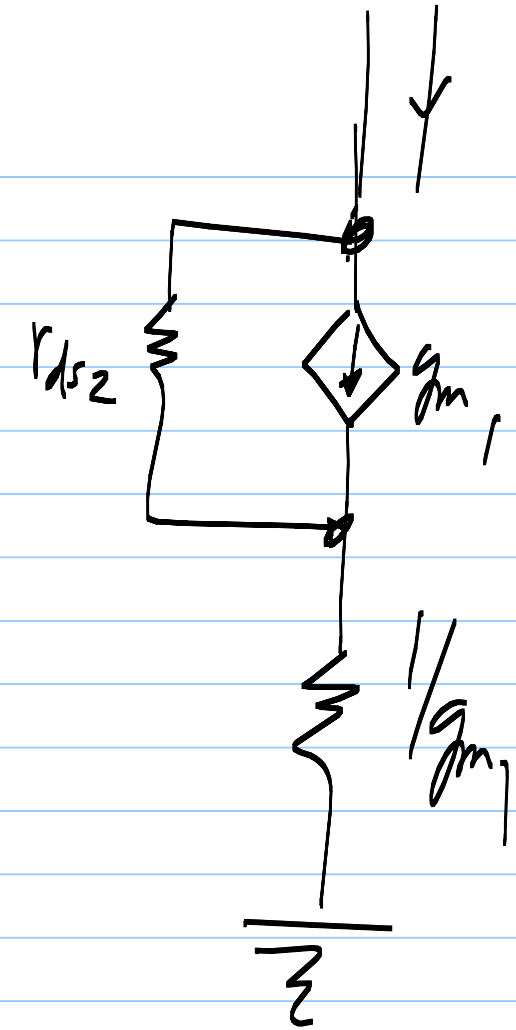
$$\sim g_{m1}(v_1 - v_2)$$

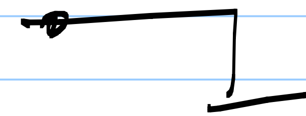
$$\frac{g_{m3}}{g_{m3} + g_{ds3}} \cdot \frac{g_{m1}}{2}(v_1 - v_2) + \frac{g_{m1}}{2}(v_1 - v_2)$$

$$\left(\frac{2g_{m3} + g_{ds3}}{g_{m3} + g_{ds3}}\right) \cdot \frac{g_{m1}}{2}(v_1 - v_2)$$



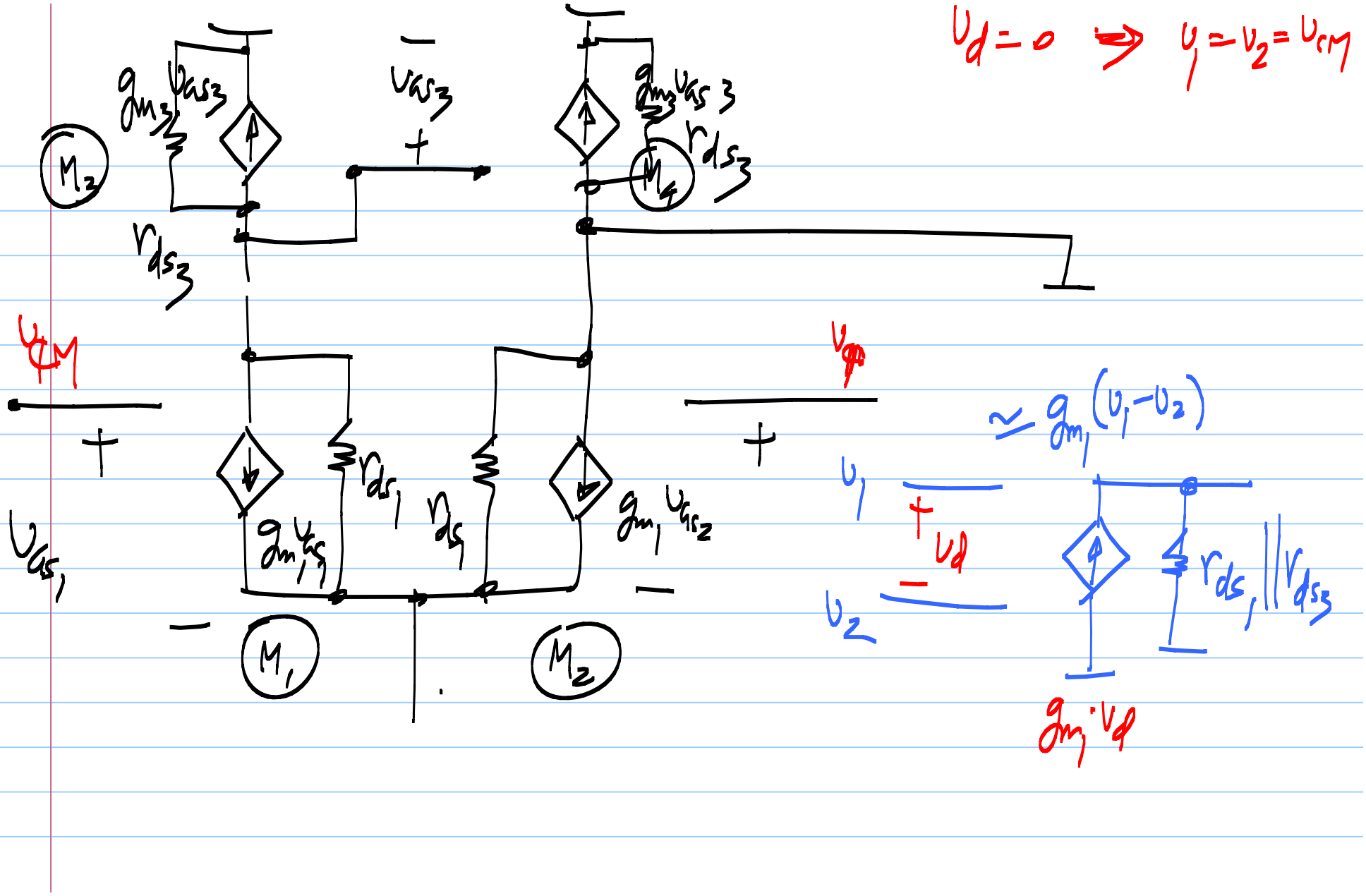
$g_{m_3} v_{GS3}$
v_{GS3}
M_3
M_4
$g_{m_3} v_{GS3}$
$r_{ds_2} + 1/2g_{m_1}$
$v_{TEST}/(2r_{ds_2} + 1/g_{m_1})$
V_{TEST}
v_1
M_1
r_{ds1}
r_{ds2}
M_2
v_2
v_{GS1}
$g_{m_1} v_{GS1}$
$g_{m_1} v_{GS2}$
v_{GS2}
$v_x = \frac{v_1 + v_2}{2}$
$g_{m_1}(v_1 - v_2)$
v_1
v_2
r_{ds4}

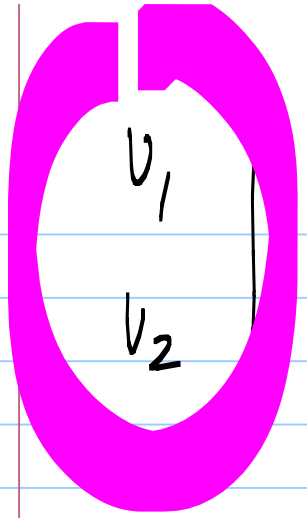




r_{ds_2}

$$\frac{\overbrace{g_{m_2} r_{ds_2} R_x} + R_x + r_{ds_2}}{2 \cdot r_{ds_2} + 1/g_{m_1}}$$


$v_d = 0 \Rightarrow v_1 = v_2 = v_{CM}$
$g_{m3} v_{gs3}$
v_{gs3}
M_3
r_{ds3}
$g_{m3} v_{gs3}$
M_4
r_{ds3}
v_{CM}
v_{gs1}
$g_{m1} v_{gs1}$
r_{ds1}
r_{ds1}
$g_{m1} v_{gs2}$
M_1
M_2
v_{CM}
$\simeq g_{m1}(v_1 - v_2)$
v_1
v_d
v_2
$r_{ds1} \| r_{ds3}$
$g_{m1} \cdot v_d$



$\equiv$

$v_d = v_1 - v_2$ ✓

$v_{CM} = \frac{v_1 + v_2}{2}$ ✗

$v_1 = v_{CM} + v_d/2$

$v_2 = v_{CM} - v_d/2$

differential voltage

Common mode voltage

$V_{GS} - V_T = 2V$; $g_m = 200\mu S$; $g_{DS} = 4\mu S$

$I_D = 200\mu A$; $\lambda = 0.02$

$\frac{g_m}{g_{DS}} = 50$