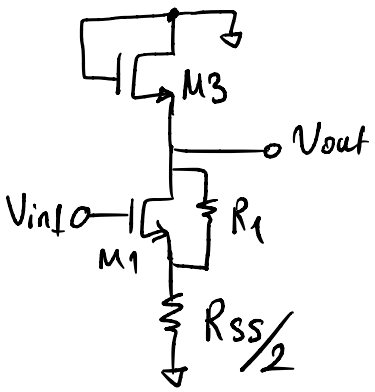
EHB 262E - Electronics II

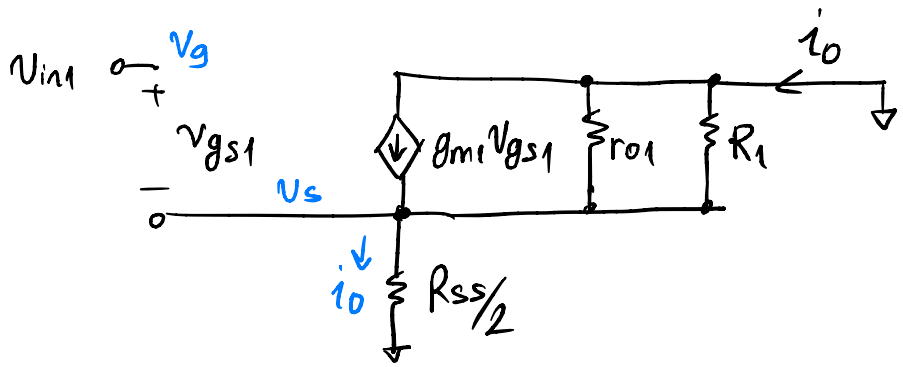
Homework-3 Solutions

a) Half circuit



$$R_{out} = \left(r_{o3} \,//\, \frac{1}{g_{m3}}\right) // \left(g_{m1}\,(R_1 // r_{o1})\,\frac{R_{ss}}{2} + \frac{R_{ss}}{2} + R_1 // r_{o1}\right)$$

Gm calculation:



$$v_{gs1} = v_{in1} - v_s$$

$$\frac{v_s}{\frac{R_{ss}}{2} // R_1 // r_{o1}} = g_{m1} v_{gs1} \Rightarrow \frac{v_s}{\frac{R_{ss}}{2} // R_1 // r_{o1}} + g_{m1} v_s = g_{m1} v_{in1}$$

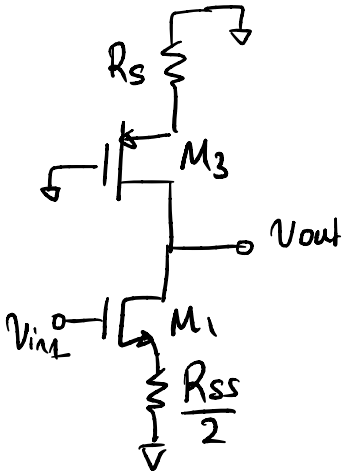
$$\Rightarrow v_s = \frac{g_{m1} v_{in1}}{g_{m1} + \frac{1}{\frac{R_{ss}}{2} // R_1 // r_{o1}}}$$

$$i_o = \frac{v_s}{\frac{R_{ss}}{2}} = \frac{1}{\frac{R_{ss}}{2}} \cdot \frac{g_{m1} v_{in1}}{g_{m1} + \frac{1}{\frac{R_{ss}}{2} // R_1 // r_{o1}}}$$

$$G_m = \frac{i_o}{v_{in1}} = \frac{2g_{m1}}{R_{ss}} \cdot \frac{1}{g_{m1} + \frac{1}{\frac{R_{ss}}{2} // R_1 // r_{o1}}}$$

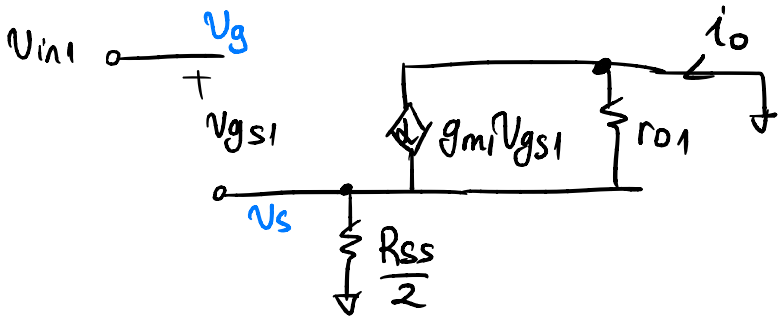
$$A_v = -G_m \cdot R_{out}$$

(b) Half circuit



$$R_{out} = (g_{m3} r_{o3} R_S + r_{o3} + R_S) \,//\, (g_{m1} r_{o1} \frac{R_{ss}}{2} + r_{o1} + \frac{R_{ss}}{2})$$

Gm calculation:



Similar to the previous solution:

$$\frac{V_s}{r_{o1} \,//\, \frac{R_{ss}}{2}} + g_{m1} V_s = g_{m1} V_{in1} \Rightarrow V_s = \frac{g_{m1} V_{in1}}{g_{m1} + \frac{1}{\frac{R_{ss}}{2} \,//\, r_{o1}}}$$

$$G_m = \frac{i_o}{V_{in1}} = \frac{V_s}{\frac{R_{ss}}{2}} \cdot \frac{1}{V_{in1}} = \frac{2 g_{m1}}{R_{ss}} \frac{1}{g_{m1} + \frac{1}{\frac{R_{ss}}{2} \,//\, r_{o1}}}$$

$$A_v = -G_m R_{out}$$