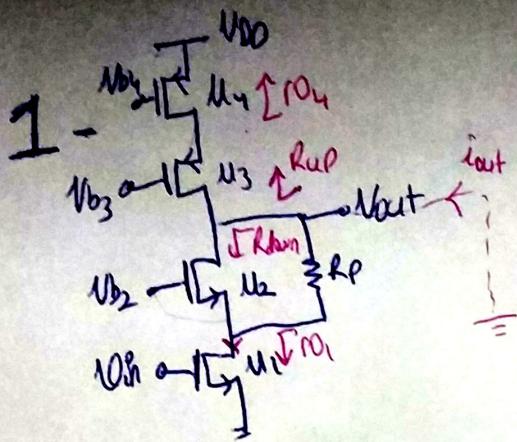


Homework



$$6m = \frac{i_{out}}{i_{in}}$$

$$6m = \frac{i_{out}}{i_{in}} \Big|_{i_{out}=0} = gm_1$$

Ruf

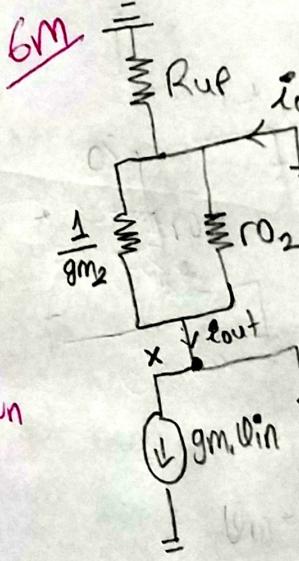
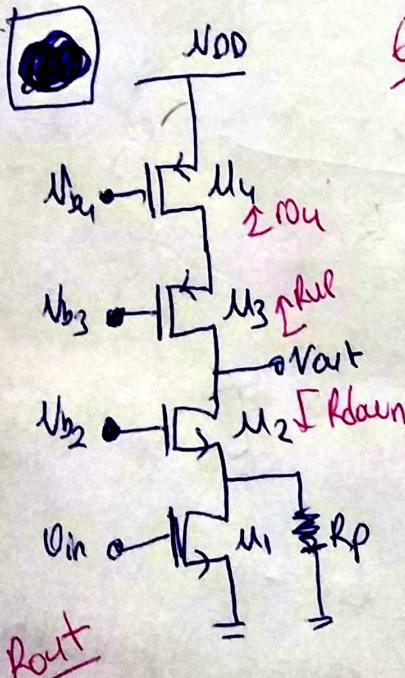
$$R_{up} = r_{O_4} + r_{O_3} + gm_3 r_{O_3} r_{O_4}$$

$$R_{down} = r_{O_1} + (r_{O_2} || R_p) + gm_2 (r_{O_2} || R_p) r_{O_1}$$

$$R_{out} = R_{up} || R_{down}$$

$$A_v = -6m R_{out} = -gm_1 \left[(r_{O_4} + r_{O_3} + gm_3 r_{O_3} r_{O_4}) || (r_{O_1} + (r_{O_2} || R_p) + gm_2 (r_{O_2} || R_p) r_{O_1}) \right]$$

$$A_v \approx -gm_1 \left[gm_3 r_{O_3} r_{O_4} || gm_2 (r_{O_2} || R_p) r_{O_1} \right]$$



∂X :

$$0 - V_x = i_{out} \left(\frac{1}{gm_2} || r_{O_2} \right)$$

$$V_x = (R_p || r_{O_1}) (i_{out} - gm_1 V_{in})$$

$$-i_{out} \left(\frac{1}{gm_2} || r_{O_2} \right) = (R_p || r_{O_1}) (i_{out} - gm_1 V_{in})$$

$$6m = \frac{i_{out}}{V_{in}} \Big|_{i_{out}=0} = \frac{(R_p || r_{O_1}) gm_1}{(R_p || r_{O_1}) + \left(\frac{1}{gm_2} || r_{O_2} \right)}$$

Rout

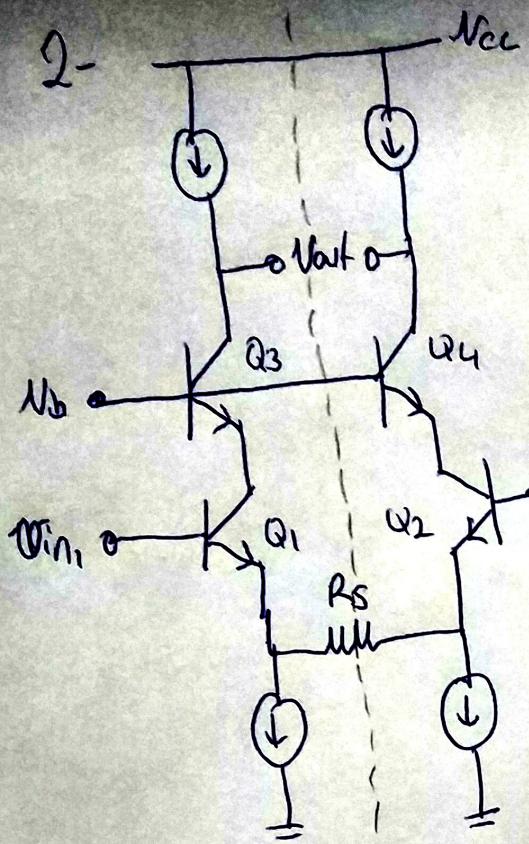
$$R_{up} = r_{O_4} + r_{O_3} + gm_3 r_{O_3} r_{O_4}; R_{down} = r_{O_2} + (r_{O_1} || R_p) + gm_2 r_{O_2} (r_{O_1} || R_p)$$

$$R_{out} = R_{up} || R_{down} = \left[r_{O_4} + r_{O_3} + gm_3 r_{O_3} r_{O_4} \right] || \left[r_{O_2} + (r_{O_1} || R_p) + gm_2 r_{O_2} (r_{O_1} || R_p) \right]$$

$$A_v = -6m R_{out} = -\frac{(R_p || r_{O_1}) gm_1}{(R_p || r_{O_1}) + \left(\frac{1}{gm_2} || r_{O_2} \right)} \left\{ \left[r_{O_3} + (1 + gm_3 r_{O_3}) r_{O_4} \right] || \left[r_{O_2} + (1 + gm_2 r_{O_2}) (r_{O_1} || R_p) \right] \right\}$$

$$A_v \approx -\frac{gm_1 (R_p || r_{O_1})}{(R_p || r_{O_1}) + \frac{1}{gm_2}} \left[(gm_3 r_{O_3} r_{O_4}) || (gm_2 r_{O_2} (r_{O_1} || R_p)) \right]$$

J.-L. Gossel
Les bonnes façons



Let's assume $Q_3 = Q_u$ and $Q_1 = Q_2$
 Then if the input voltages are differential
 Then the line of symmetry is the virtual
 ground. (ac ground)

Half-Circuit

Diagram illustrating the circuit for problem 112. The circuit consists of three resistors (R_1 , R_2 , R_3) connected in series. A dependent current source K is connected between the node before R_3 and the node after R_3 . The output voltage V_{out} is measured across R_3 . The input voltage V_{in} is applied across the entire series combination of R_1 , R_2 , and R_3 .

$$V_{out} = R_3 \cdot I_{out}$$

$$I_{out} = \frac{V_{in}}{R_1 + R_2 + R_3}$$

$$V_{out} = R_3 \cdot \frac{V_{in}}{R_1 + R_2 + R_3}$$

$$V_{out} = R_3 \cdot \frac{V_{in}}{1 + \frac{R_1 + R_2}{R_3}}$$

$$V_{out} = R_3 \cdot \frac{V_{in}}{1 + g m_1}$$

$$R_{out} = R_3 + \left(1 + g m_1 \right) R_{S1/2}$$

$$R_{down} = R_1 + \left(1 + g m_1 \right) R_{S1/2}$$

$$R_{\text{down}} = r_0 + (1 + g m_1 r_0) \left(\frac{r_s}{2} \| \pi_1 \right)$$

$$R_{out} = r_{O_3} + (1 + g m_3 r_{O_3}) (R_{down} \parallel R_B)$$

Line of Symmetry

$$A_{\text{out}} = -b m R_{\text{out}}$$

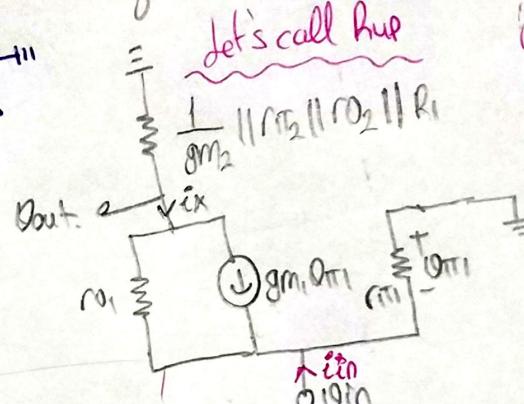
$$A_{DU} = -\frac{g m_1}{1 + g m_1 \frac{R_S}{2}} \left[m_3 + \left(1 + g m_3 m_3 \right) \underbrace{\left(r_{01} + (1 + g m_1 r_{01}) \left(\frac{R_S}{2} || r_{01} \right) \right)}_{R_{down}} \right] \left(\frac{r_{01}}{r_{01} + R_{down}} \right)^{\frac{3}{2}}$$

$$A_{DU} \approx -\frac{g_m}{1+g_m \frac{R_s}{2}} \left[g_m r_0 \left(g_m r_0 \left(\frac{R_s}{2} \ln \frac{r_0}{R_s} \right) + \Gamma T_3 \right) \right]$$

3-

V_{in}

Assume we are operating in the midband frequency and C_B is very large. Then in the small-signal analysis C_B is short circuit.



2nd way

$$V_{out} = -i_x R_{up} \Rightarrow i_x = -\frac{V_{out}}{R_{up}}$$

$$(V_{out} - V_{in}) = r_{o1} (i_x - g_{m1} (\theta_{T1})) ; \theta_{T1} = -V_{in}$$

$$(V_{out} - V_{in}) = r_{o1} \left(-\frac{V_{out}}{R_{up}} + g_{m1} V_{in} \right)$$

$$(V_{out} \left(1 + \frac{r_{o1}}{R_{up}} \right)) = \left(1 + g_{m1} r_{o1} \right) V_{in} \Rightarrow \frac{V_{out}}{V_{in}} = A_{v0} = \frac{1 + g_{m1} r_{o1}}{1 + \frac{r_{o1}}{R_{up}}} = \frac{1 + g_{m1} r_{o1}}{1 + r_{o1} + \frac{1}{R_{up}}}$$

$$\Rightarrow A_{v0} \approx \frac{g_{m1}}{\frac{1}{r_{o1}} + \frac{1}{R_{up}}} \Rightarrow A_{v0} = g_{m1} (R_{up} \| r_{o1}) = g_{m1} \left(\frac{1}{g_{m2}} \| r_{T2} \| r_{o2} \| R_1 \| r_{o1} \right)$$

R_{in} Calculation

$$\text{We found that : } V_{out} = g_{m1} (R_{up} \| r_{o1}) V_{in} ; \theta_{T1} = -V_{in}$$

$$\Rightarrow i_{in} = -\left(i_x + \frac{V_{in}}{\theta_{T1}}\right) = \frac{V_{out}}{R_{up}} + \frac{V_{in}}{\theta_{T1}} = \frac{1}{R_{up}} \left(g_{m1} (R_{up} \| r_{o1}) V_{in} \right) + \frac{V_{in}}{\theta_{T1}}$$

$$\Rightarrow i_{in} = V_{in} \left(\frac{g_{m1} (R_{up} \| r_{o1})}{R_{up}} + \frac{1}{\theta_{T1}} \right)$$

$$\Rightarrow R_{in} = \frac{V_{in}}{i_{in}} = \frac{1}{\frac{g_{m1} (R_{up} \| r_{o1})}{R_{up}} + \frac{1}{\theta_{T1}}} , \text{ where } R_{up} = \frac{1}{g_{m2}} \| r_{T2} \| r_{o2} \| R_1$$

$$R_{in} \text{ if } N_A \rightarrow \infty , R_{in} = \frac{1}{g_{m1} + \frac{1}{\theta_{T1}}} = \left(\theta_{T1} \| \frac{1}{g_{m1}} \right) \approx \frac{1}{g_{m1}}$$

Gain Calculation

1st way

$$V_{out} = 0 \Rightarrow V_{R_{up}} = 0$$

$$i_{out} \approx g_{m1} (\theta_{T1}) ; \theta_{T1} = -V_{in}$$

$$b_m = \frac{i_{out}}{V_{in}} \Big|_{V_{out}=0} = -g_{m1}$$

$$A_{v0} = R_{up} \| r_{o1} \quad (V_{in} = 0)$$

$$A_{v0} = -b_m R_{out}$$

$$A_{v0} = g_{m1} (R_{up} \| r_{o1})$$

$$A_{v0} = g_{m1} \left(\frac{1}{g_{m2}} \| r_{T2} \| r_{o2} \| R_1 \| r_{o1} \right)$$

$$A_{v0} = \frac{1 + g_{m1} r_{o1}}{1 + r_{o1} + \frac{1}{R_{up}}}$$

③