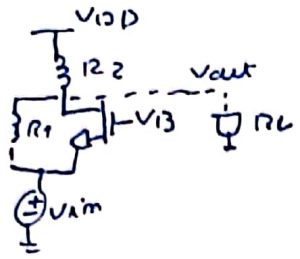
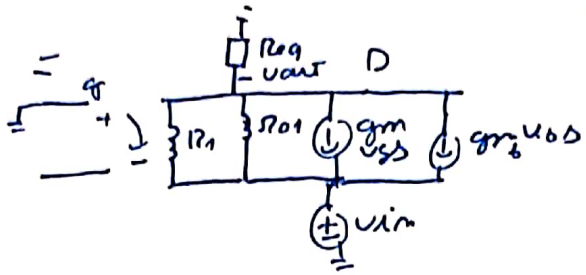
amplifier 13



$R_{eq} = R_2 \| R_L$

$V_{gs} = -v_{in}$
$V_{bs} = -v_{in}$



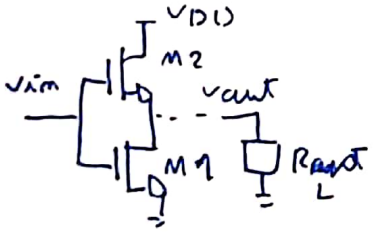
$$\frac{-v_{out}}{R_{eq}} - \frac{v_{out} - v_{in}}{R_1 \| r_{o1}} - g_{m1} v_{gs} - g_{mb1} v_{bs} = 0$$

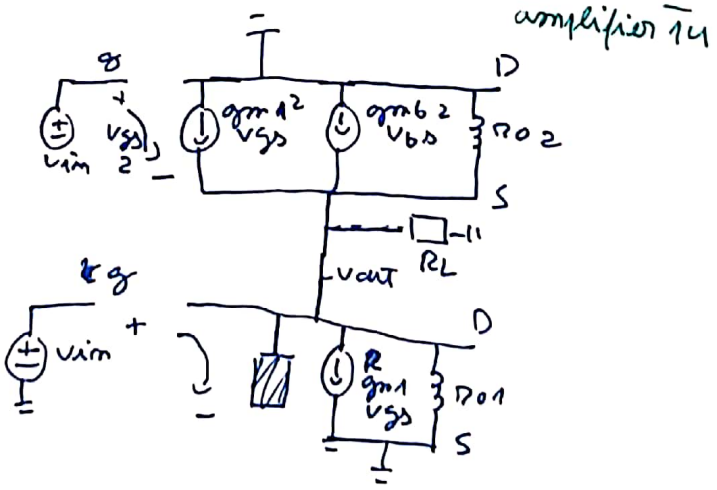
$$-v_{out}\left(\frac{1}{R_{eq}} + \frac{1}{R_1 \| r_{o1}}\right) + v_{in}\left(\frac{1}{R_1 \| r_{o1}} + g_m + g_{mb1}\right)$$

$$\frac{v_{out}}{v_{in}} = \frac{\left(\frac{1}{R_1 \| r_{o1}} + g_m + g_{mb1}\right)}{\left(\frac{1}{R_2} + \frac{1}{R_L} + \frac{1}{R_1} + \frac{1}{r_{o1}}\right)}$$

$$\frac{v_{out}}{v_{in}} = \frac{\frac{1}{R_1} + \frac{1}{r_{o1}} + g_m + g_{mb1}}{\frac{1}{R_2} + \frac{1}{R_L} + \frac{1}{R_1} + \frac{1}{r_{o1}}}$$

amplifier 14





Sum of currents In vout

$V_{gs2} = V_{in} - V_{out}$

$V_{bs2} = -V_{out}$

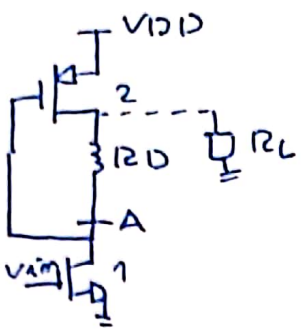
$V_{gs1} = V_{in}$

$$-\frac{V_{out}}{R_L} - g_{m1} V_{in} - \frac{V_{out}}{R_{o1}} - \frac{V_{out}}{R_{o2}} + g_{m2} (V_{in} - V_{out}) + g_{m2} (-V_{out}) = 0$$

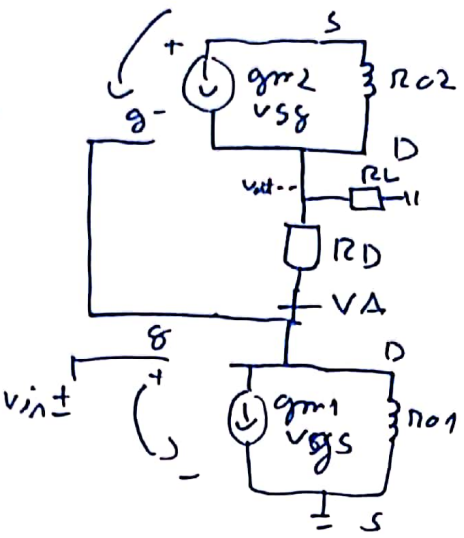
$$+ V_{in}(-g_{m1} + g_{m2}) - V_{out}\left(\frac{1}{R_L} + \frac{1}{R_{o1}} + \frac{1}{R_{o2}} + g_{m2} + g_{m2bs}\right) = 0$$

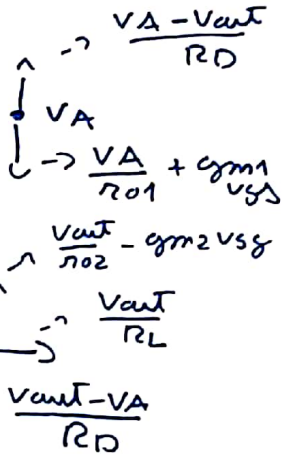
$$\frac{V_{out}}{V_{in}} = \frac{g_{m2} - g_{m1}}{\frac{1}{R_L} + \frac{1}{R_{o1}} + \frac{1}{R_{o2}} + g_{m2} + g_{m2b}}$$

$A_V < 1$ -> Buffer stage. like a Push Pull Baid



Amplifier 1S





currents at VA

$$-\frac{(VA-Vout)}{RD}$$

$$-\frac{VA}{RD}+\frac{Vout}{RD}-gm\,vin-\frac{VA}{ro1}=0$$

$$VA\left(\frac{1}{RD}+\frac{1}{ro1}\right)=-gm\,vin+\frac{Vout}{RD}$$

$$VA\left(\frac{ro1+RD}{RD\,ro1}\right)=\frac{Vout-gm_1 vin\,RD}{RD}$$

$$VA=\frac{Vout\,ro1-gm_1 vin\,RD\,ro1}{ro1+RD}$$

$-VA$

$gm\,Vsg$

currents at node Vxcout

$$-\frac{Vout}{RL}-\frac{Vout}{ro2}-\frac{(Vout-VA)}{RD}-gm_2 VA=0$$

$$-Vout\left(\frac{1}{RL}+\frac{1}{ro2}+\frac{1}{RD}\right)-VA\,gm_2+\frac{VA}{RD}$$

$$-Vout\left(\frac{1}{RD}+\frac{1}{RL}+\frac{1}{ro2}-\frac{ro1}{RD(ro1+RD)}+\frac{gm_2\,ro1}{ro1+RD}\right)$$

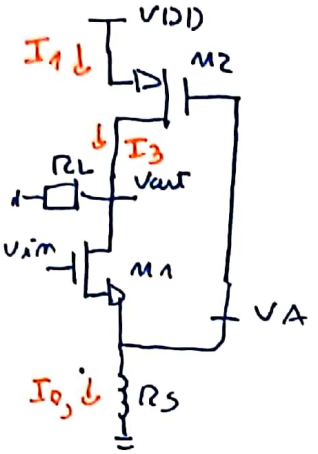
$$-vin\left(\frac{gm_1\,ro1}{ro1+RD}-\frac{gm_1\,RD\,ro1\,gm_2}{ro1+RD}\right)=0$$

$$\frac{Vout}{Vin}=\frac{\dfrac{gm_1\,RD\,ro1\,gm_2-gm_1\,ro1}{ro1+RD}}{\dfrac{1}{RD}+\dfrac{1}{RL}+\dfrac{1}{ro2}+\dfrac{gm_2\,ro1}{ro1+RD}-\dfrac{ro1}{RD(ro1+RD)}}$$

$$\Delta V = \frac{g_{m1}\left(R_D g_{m2} - 1\right)}{\frac{R_{O1}+R_D}{r_{O1}}\left(\frac{1}{R_D}+\frac{1}{R_L}+\frac{1}{r_{O2}}\right)+g_{m1}-\frac{g_{m1}}{R_D}}$$

$$\Delta V = \frac{g_{m1}\left(R_D g_{m2} - 1\right)}{\left(1+\frac{R_D}{r_{O1}}\right)\left(\frac{1}{R_L}+\frac{1}{r_{O2}}\right)+g_{m1}+\frac{1}{r_{O01}}-\frac{1}{R_D}+\frac{1}{R_D}}$$

amplifier 16



In small signals

$$\frac{V_A}{R_S} = I_1 := -\frac{V_{out}}{R_{O2}} + g_{m_2} V_S \quad (V_S = -V_A)$$

$$\frac{V_A}{R_S} + g_{m_2} V_A = -\frac{V_{out}}{R_{O2}}$$

$$V_A = \frac{-V_{out} R_S}{(1 + g_{m_2} R_S) R_{O2}}$$

$$V_A = \frac{-V_{out}}{\left(\frac{1}{R_S} + g_{m_2}\right) R_{O2}}$$

$I_3 = I_2$

$$I_3 = \frac{V_{out}}{R_L} + \frac{V_{out} - V_A}{R_{O1}} + g_{m_1}(V_{in} - V_A) - g_{mb_1} V_A$$

$$I_3 = V_{out}\left(\frac{1}{R_L} + \frac{1}{R_{O1}}\right) + g_m V_{in} - V_A\left(\frac{1}{R_{O1}} + g_{m1} + g_{mb1}\right)$$

$I_3 = I_2 \rightsquigarrow$

$$0 = V_{out}\left(\frac{1}{R_L} + \frac{1}{R_{O1}}\right) + g_m V_{in} + \frac{V_{out}}{\left(\frac{1}{R_S} + g_m\right) R_{O2}}\left(\frac{1}{R_S} + \frac{1}{R_{O1}} + g_{m1} + g_{mb}\right)$$

$$\frac{-V_{out}}{(1 + g_m R_S) R_{O2}}$$

$$V_{out}\left(\frac{1}{R_L} + \frac{1}{R_{O1}}\right) + g_{m_1} V_{in} = \frac{-V_{out}}{\left(\frac{1}{R_S} + g_{m_2}\right) R_{O2}}\left(\frac{1}{R_S} + \frac{1}{R_{O1}} + g_{m1} + g_{mb}\right)$$

$$V_{out}\left(\frac{1}{R_L} + \frac{1}{R_{O1}}\right)\left(\frac{1}{R_S} + g_{m2}\right) R_{O2} + g_{m1} V_{in}\left(\frac{1}{R_S} + g_{m2}\right)(R_{O2}) = -V_{out}\left(\frac{1}{R_S} + \frac{1}{R_{O1}} + g_{m1} + g_{mb}\right)$$

$$\frac{V_{out}}{V_{in}} = \frac{g_{m1}\left(g_{m2} + \frac{1}{R_S}\right) R_{O2}}{\left(\frac{1}{R_L} + \frac{1}{R_{O1}}\right)\left(\frac{1}{R_S} + g_{m2}\right) R_{O2} + g_{m1}\left(\frac{1}{R_S} + \frac{1}{R_{O1}} + g_{m1} + g_{mb}\right)}$$

$R_{O1} \rightarrow$ low
$R_{O2} \rightarrow$ low
$R_S \rightarrow$ high
$g_{m1} \rightarrow$ high
$g_{m2} \rightarrow$ high

} for gain
→ Depends
gain is complex