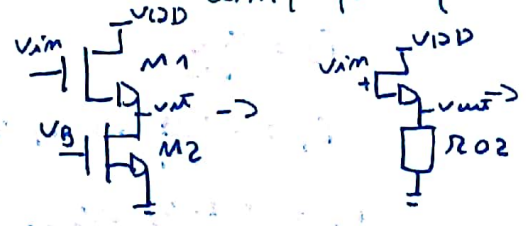
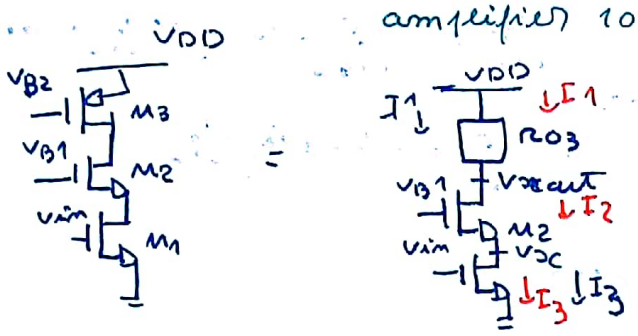
amplifier 9



$$Av = \frac{g_{m1}}{\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m1} + g_{mb1}}$$

amplifier 10



$$I_1 = -\frac{V_{out}}{r_{o3}}$$

$$I_3 = \frac{V_{dc}}{r_{o1}} + g_{m1} V_{in}$$

$$I_2 = \frac{V_{out} - V_{dc}}{r_{o2}} - g_{m2} V_{dc} - g_{mb} V_{dc}$$

$$I_3 = I_2$$

$$\frac{V_{dc}}{r_{o1}} + g_{m1} V_{in} = \frac{V_{out}}{r_{o2}} - V_{dc}\left(\frac{1}{r_{o2}} + g_{m2} + g_{mb}\right)$$

$$r_{o2} g_{m1} V_{in} - \frac{V_{out}}{r_{o2}} = -V_{dc}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)$$

$$V_{dc} = \frac{\left(-r_{o2} g_{m1} V_{in} + V_{out}\right)}{r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}$$

$$I_3 = I_1$$

$$-\frac{V_{out}}{r_{o3}} = \frac{V_{dc}}{r_{o1}} + g_{m1} V_{in}$$

$$-\frac{V_{out}}{r_{o3}} - \frac{1}{r_{o1}} \times \frac{+V_{out}}{r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)} = g_{m1} V_{in} - \frac{r_{o2} g_{m1} V_{in}}{r_{o1} r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}$$

$$\frac{V_{out}}{V_{in}} = \frac{-g_{m1} + \frac{r_{o2} g_{m1}}{r_{o1} r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}}{\frac{1}{r_{o3}} + \frac{1}{r_{o1} r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}}$$

$$\frac{V_{out}}{V_{in}} = \frac{r_{o2} g_{m1} - g_{m1} r_{o1} r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}{\frac{r_{o1} r_{o2}\left(\frac{1}{r_{o2}} + \frac{1}{r_{o1}} + g_{m2} + g_{mb}\right)}{r_{o3}} + 1}$$

"very little gain"

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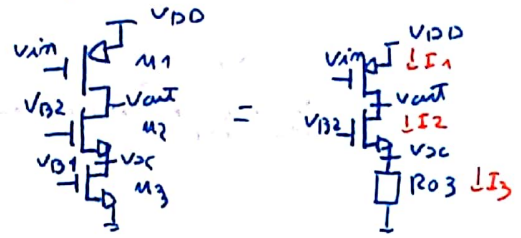
amplifier 11



$I_3 = \frac{V_{sc}}{R_{o3}}$

$I_1 = -\frac{V_{out}}{R_{o1}} - g_{m1} V_{sc} v_{in}$

$I_2 = \frac{V_{out} - V_{sc}}{R_{o2}} - V_{sc}(g_{m2} + g_{mb6})$

$I_3 = I_2$

$\frac{V_{sc}}{R_{o3}} = \frac{V_{out}}{R_{o2}} - V_{sc}\left(\frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)$

$\frac{V_{sc}}{R_{o3}} + \frac{V_{out}}{R_{o2}} - V_{sc}\left(\frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)$

$-\frac{V_{out}}{R_{o2}} = -V_{sc}\left(\frac{1}{R_{o2}}\right)$

$-V_{out} = -V_{sc} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)$

$V_{sc} = \frac{V_{out}}{R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)}$

$I_1 = I_3$

$\frac{V_{out}}{R_{o3} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)} = \frac{V_{out}}{R_{o1}} - g_{m1} v_{in}$

$V_{out} = \left(\frac{V_{out}}{R_{o1}} - g_{m1} v_{in}\right)\left(R_{o3} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)\right)$

$\frac{V_{out}}{V_{in}} = A_V = \frac{(-g_{m1})\left(R_{o3} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)\right)}{1 - \frac{1}{R_{o1}}\left(R_{o3} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} + g_{m2} + g_{mb6}\right)\right)}$

$R_{o31} \rightarrow L_1$ should be Decreased Increased

By a little to maximise the gain

↓

The smaller R_{o1} The Bigger the gain

↓

when $1 > \frac{1}{R_{o1}}\left(R_{o3} R_{o2}\left(\frac{1}{R_{o3}} + \frac{1}{R_{o2}} \ldots\right)\right)$

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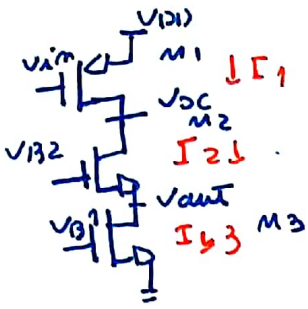
amplifier 12



$$I_1 = \frac{-V_x}{r_{o1}} - g_{m1} v_{in}$$

$$I_2 = \frac{V_x - V_{out}}{r_{o2}} - V_x (g_{m2} + g_{mb2})$$

$$I_3 = \frac{V_{out}}{r_{o3}}$$

$$I_1 = I_2$$

$$\frac{-V_x}{r_{o1}} - g_{m1} v_{in} = \frac{V_x}{r_{o2}} - V_{out}\left(g_{m2} + g_{mb2} + \frac{1}{r_{o2}}\right)$$

$$-V_x\left(\frac{1}{r_{o1}} + \frac{1}{r_{o2}}\right) = g_{m1} v_{in} - V_{out}\left(g_{m2} + g_{mb2} + \frac{1}{r_{o2}}\right)$$

$$V_x = \frac{V_{out}\left(g_{m2} + g_{mb2} + \frac{1}{r_{o2}}\right) - g_{m1} v_{in}}{\frac{1}{r_{o1}} + \frac{1}{r_{o2}}}$$

$$I_1 = I_3$$

$$+ v_{in}\left(+\frac{g_{m1}}{\left(\frac{1}{r_{o1}} + \frac{1}{r_{o2}}\right) r_{o1}} - g_{m1}\right) - V_x\left(+\frac{V_{out}\left(g_{m2} + g_{mb2} + \frac{1}{r_{o2}}\right)}{r_{o1}\left(\frac{1}{r_{o1}} + \frac{1}{r_{o2}}\right)}\right) = \frac{V_{out}}{r_{o3}}$$

$$\frac{V_{out}}{V_{in}} = \frac{-g_{m1}\left(\frac{1}{r_{o1}} + \frac{1}{r_{o2}}\right) r_{o1} + g_{m1}}{\frac{1}{r_{o3}}\left(r_{o1}\left(\frac{1}{r_{o1}} + \frac{1}{r_{o2}}\right)\right) + \left(g_{m2} + g_{mb2} + \frac{1}{r_{o2}}\right)}$$

↓ gain always negative Keep r_{o3} → high and g_{m1} To maximize gain

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