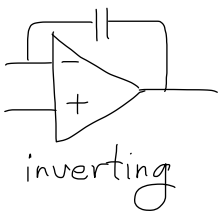
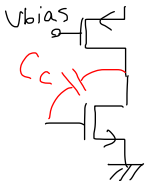
* opamp design:

Compensation capacitor





$C_c \gg 100 \times C_{gs}$

$C_{gs} = 15\,fF$

$C_c = 1.5\,pF$

$\frac{1}{rC_c} < \omega_{p1}$

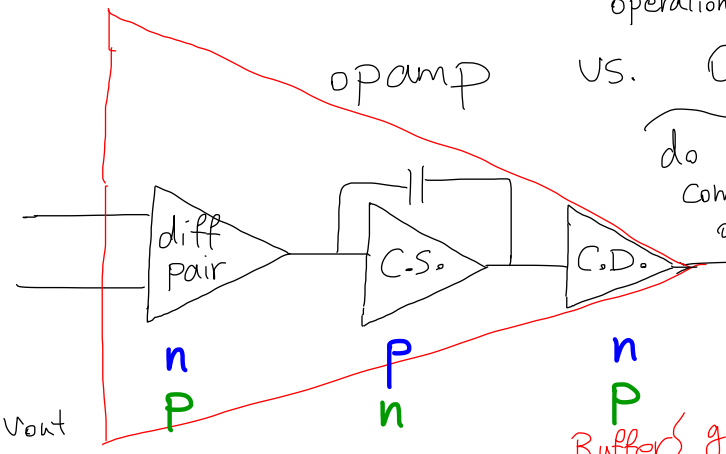
resistance of previous stage

first pole of common source amplifier

operational transconductance amplifier

opamp vs. OTA

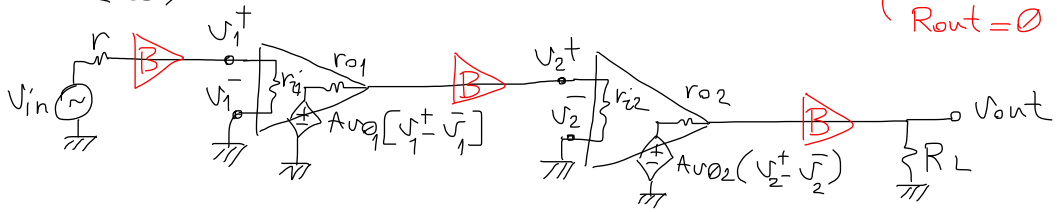
do not have common drain output stage



unity gain

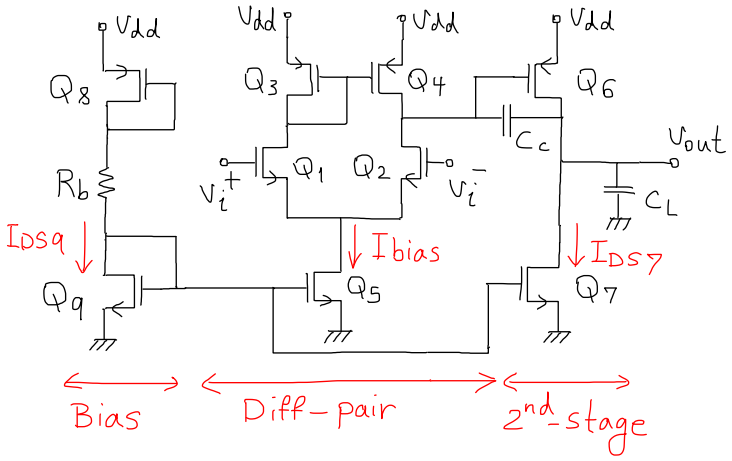
$V_{out} = \left(1 + \frac{\emptyset}{\infty}\right) V_{in}$

Buffer { gain = 1, $R_{in} \to \infty$, $R_{out} = \emptyset$



$$V_{out} = A_{v02} \frac{R_L}{r_{o2} + R_L} \times A_{v01} \frac{r_{i2}}{r_{o1} + r_{i2}} \times V_{in} \frac{r_{i1}}{r + r_{i1}}$$

if all resistors are equal: $\frac{V_{out}}{V_{in}} = \frac{A_{v01} \cdot A_{v02}}{8}$



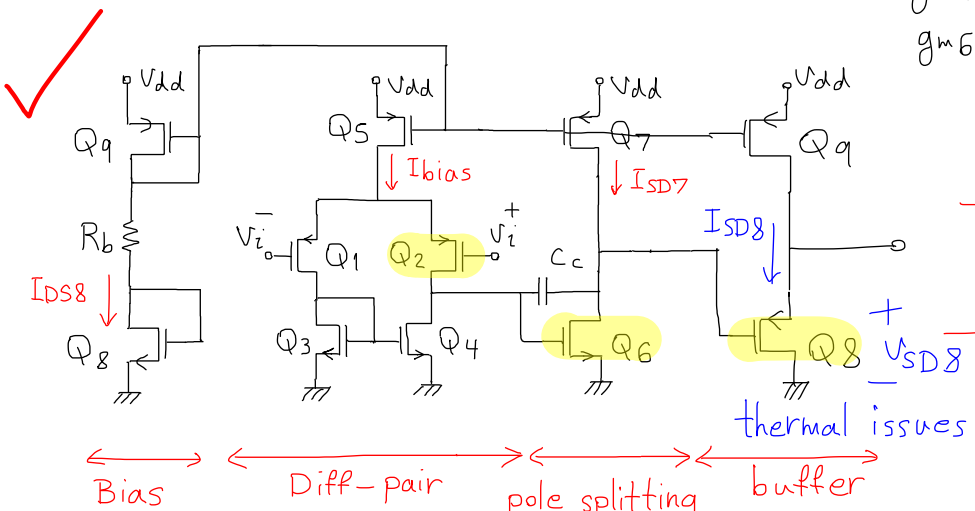
$$A_{v02} = -g_{m2}(r_{ds2} \| r_{d4})$$

$$A_{v06} = -g_{m6}(r_{ds6} \| r_{ds7})$$

$$A_{v02} \cdot A_{v06}$$

$$g_{m2} = \mu_n C_{ox} \frac{W}{L} V_{eff}$$

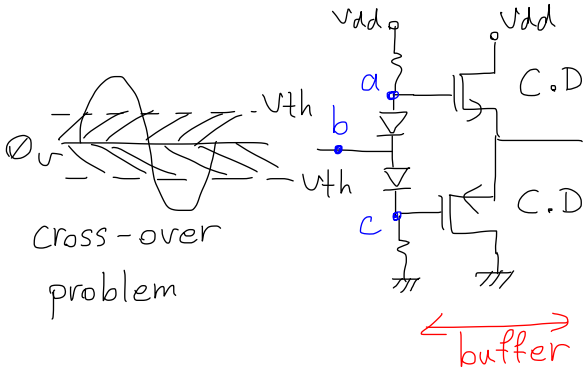
$$g_{m6} = \mu_p C_{ox} \frac{W}{L} V_{eff}$$

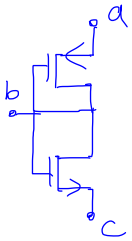


→ better stable frequency range

→ better noise performance

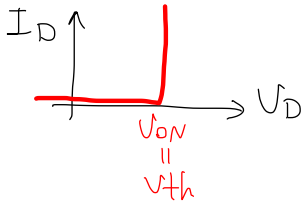
p-type C.S n-type C.D p-type

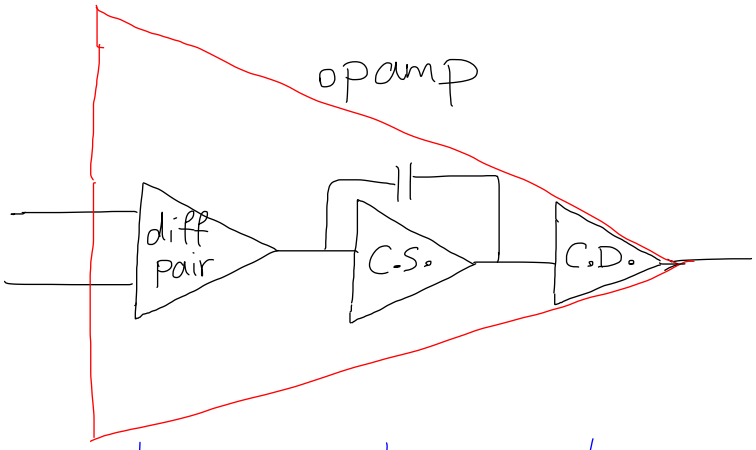




$V_{dd} \gg 2V_{ON}$

push-pull amplifier



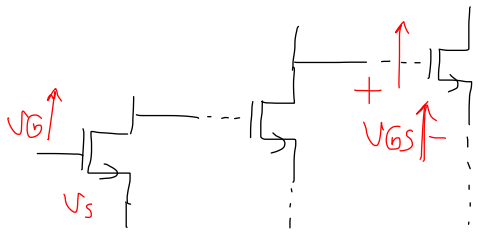


① ⟹ n-type p-type n-type

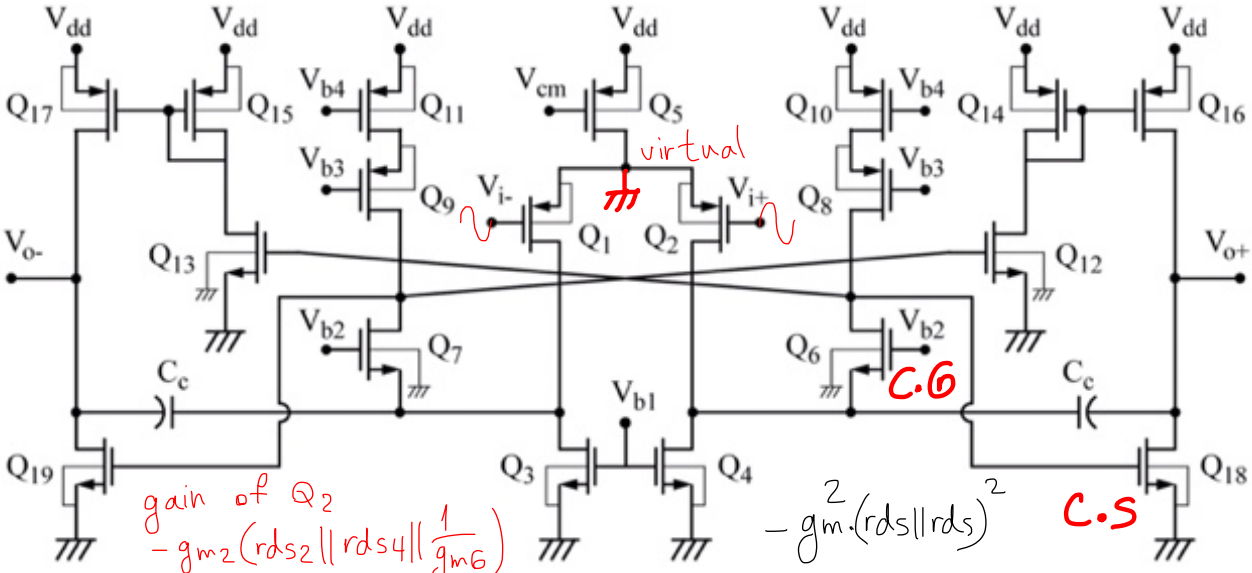
② ⟹ p-type n-type p-type

} Both have the same gain

2nd approad is better because it provides more pole splitting



$V_{DS} > V_{GS} - V_{th}$ (large)



gain of Q_2

$-g_{m2}(r_{ds2} \| r_{ds4} \| \frac{1}{g_{m6}})$

$= \frac{-g_{m2}}{g_{m6}} \approx 1$

$-g_m^2 \cdot (r_{ds} \| r_{ds})^2$