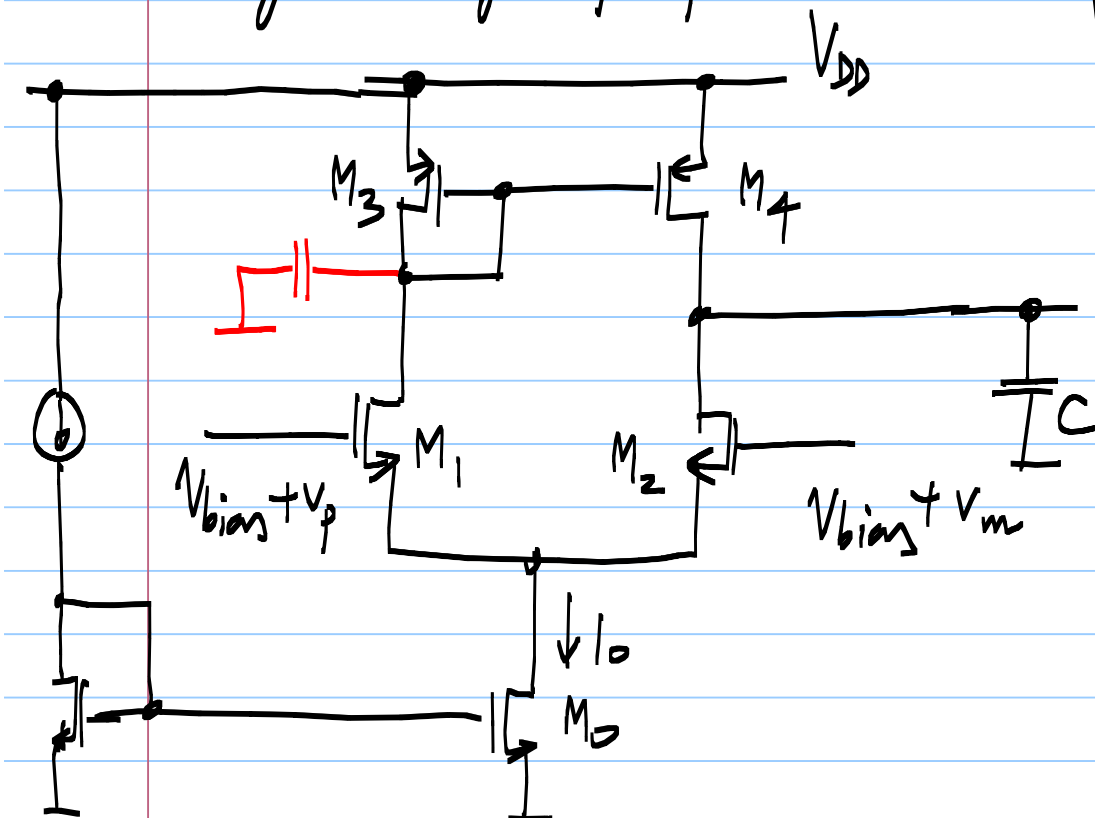
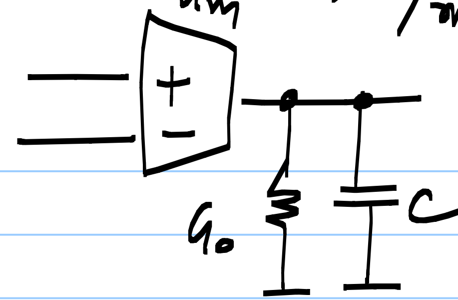
Lecture 32

Single stage opamp.



$G_m \rightarrow Y_m$



$$A_0 = g_{m1} / g_{ds1} + g_{ds3}$$

$$Z_1 = 2 g_{m3} / C_{d3}$$

$$p_2 = g_{m3} / C_{d3}$$

$$\sigma_{V_{os}}^2 = \sigma_{V_{T1/2}}^2 + \sigma_{V_{T3/4}}^2 \cdot \left(\frac{g_{m3}}{g_{m1}}\right)^2$$

$$S_{v_{in}} = \frac{16}{3} \frac{kT}{g_{m1}} \left(1 + \frac{g_{m3}}{g_{m1}}\right)$$

$$V_{bias} - V_{T_1} < V_{out} < V_{DD} - V_{DSAT_3}$$

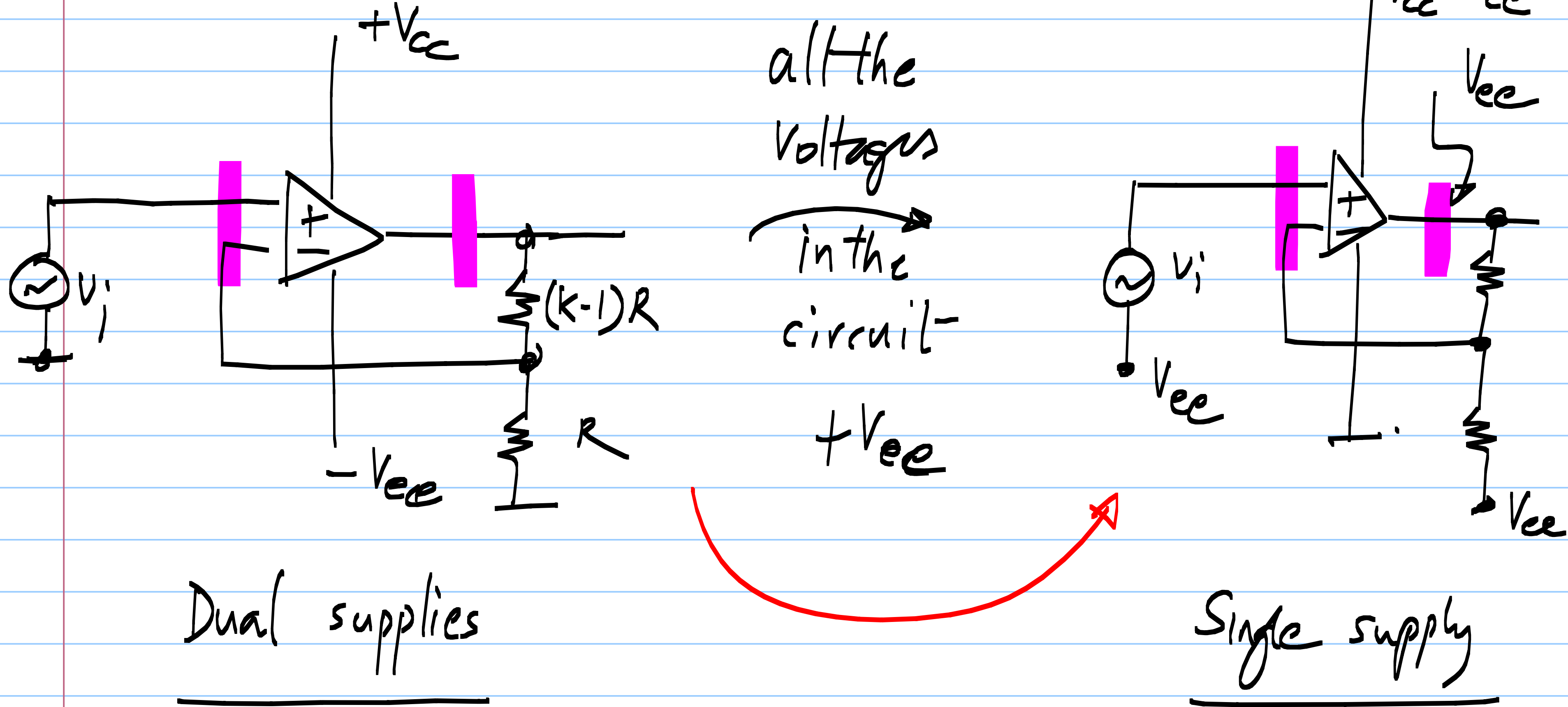
$$V_{DSAT_0} + V_{DSAT_1} + V_{T_1} < V_{bias} < V_{DD} - V_{T_3} + V_{T_1} - V_{DSAT_3}$$

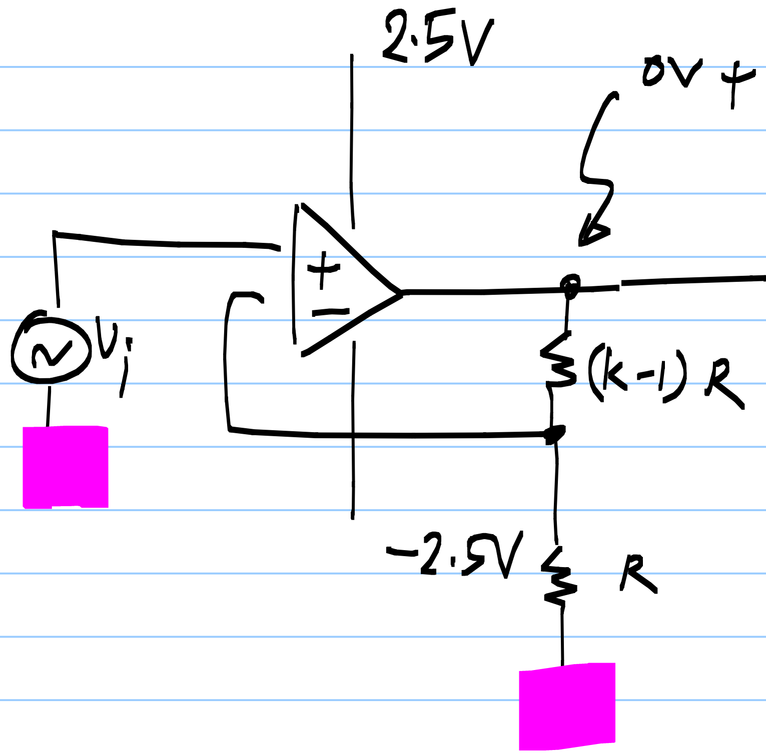
$$SR_+ = I_0/C \; ; \; SR_- = I_0/C$$

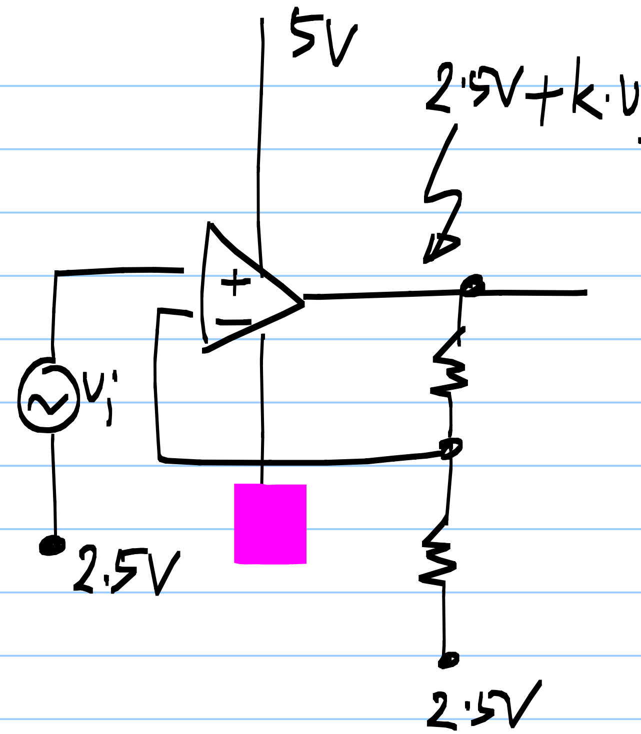
To increase SR, increase I_0 (& reduce $\frac{W_1}{L_1}$ so that g_{m_1} doesn't change)

$V_{DSAT1} \uparrow$ $\quad g_{m_1} = \frac{2I_0}{V_{DSAT_1}}$

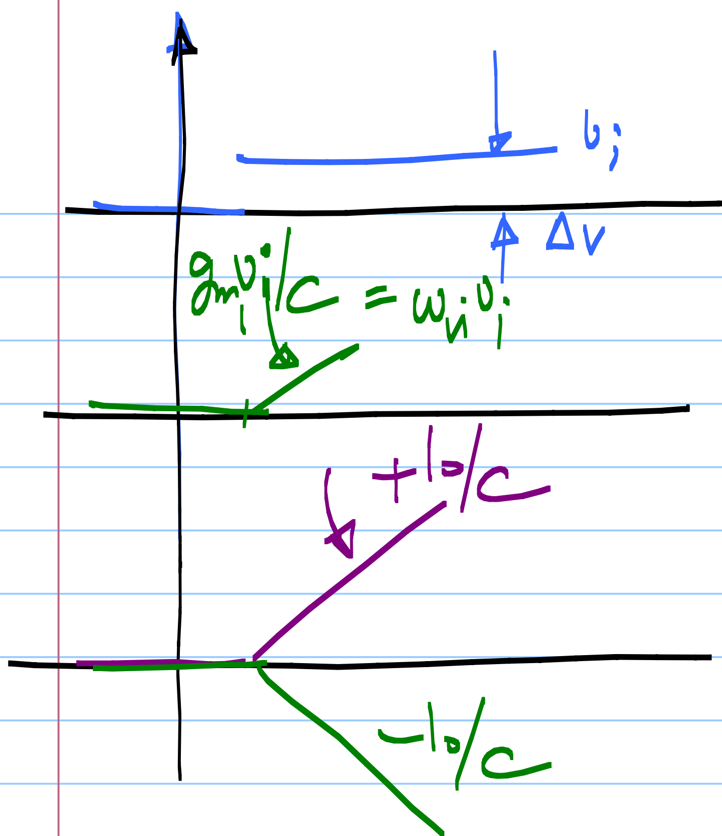
Opamp with dual supply & single supply

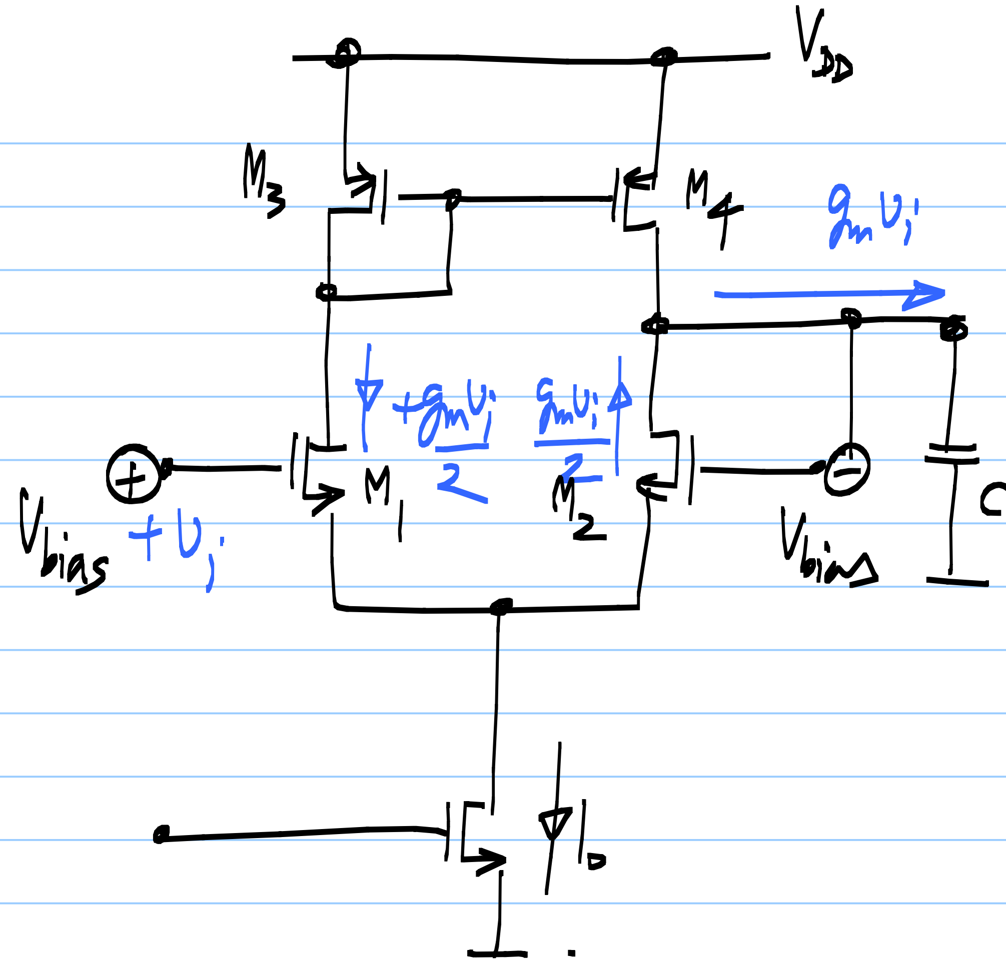



2.5V
0V + k·v_i
+
−
v_i
(k-1) R
−2.5V
R

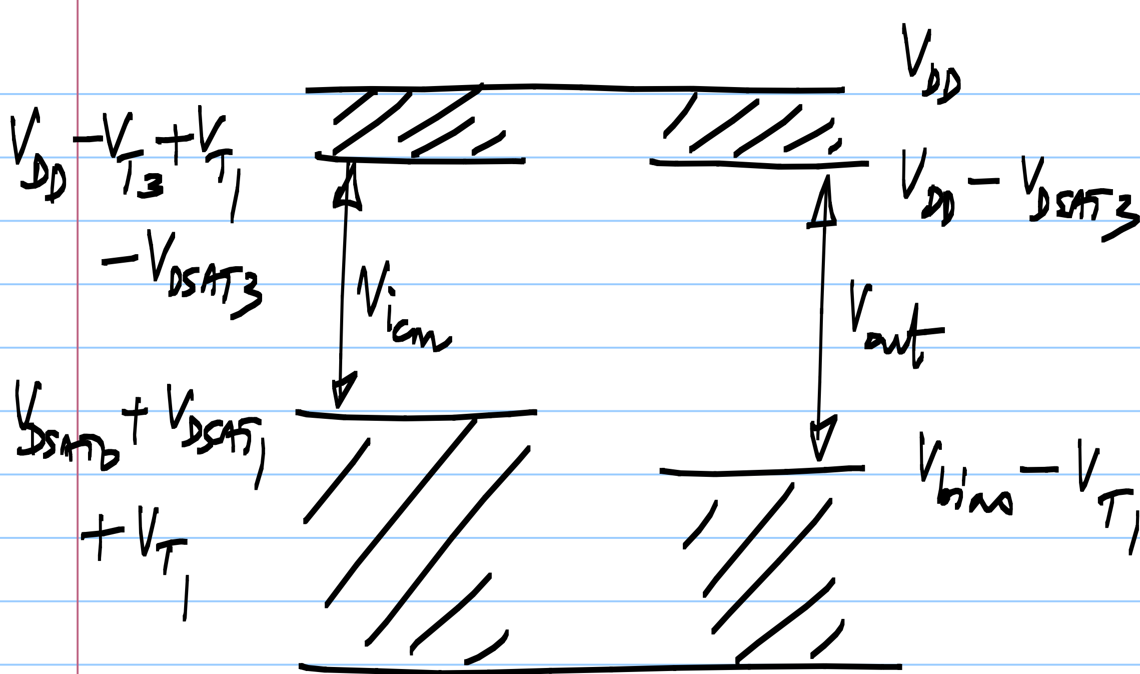

5V
2.5V + k·v_i
+
−
v_i
2.5V
2.5V

* Opamps can be operated from single or dual supplies ⟷ just a voltage shift
* Input common mode voltage & the output voltage within the respective limits.





Voltage follower using the single stage opamp.



$$V_{icm,min} < V_{bias} + v_i < V_{icm,max}$$

$$V_{o,min} < V_{bias} + v_i < V_{o,max}$$

[$\underline{\underline{V_{bias}}}$ for maximum signal swing (v_i)

$V_{DD} = 5V$; $V_{T1} = V_{T3} = V_{T0} = 0.7V$

$V_{DSAT\,0,1,2,3,4} = 0.2V$ [signal swing

Offset :

$$\sigma_{V_{OS}}^2 = \sigma_{V_{T12}}^2 + \sigma_{V_{T34}}^2 \cdot \left(\frac{g_{m3}}{g_{m1}}\right)^2$$

* M_4 mismatch contribution reduced by reducing $g_{m3} \rightarrow$ increase V_{DSAT3}

$$g_{m3} = \frac{2 I_0/2}{V_{DSAT3}}$$

* Increase the size of all transistors:

To reduce the offset by 2x Area ↑ 4x

→ C_{gs}, C_{db} .. ↑

Noise:

$$S_{v_{in}} = \frac{16}{3}\frac{kT}{g_{m_1}}\left(1 + \frac{g_{m_3}}{g_{m_1}}\right)$$

* M_{34} contribution reduced by reducing g_{m_3}

$\Rightarrow V_{DSAT3} \uparrow \Rightarrow$ reduced swing

* Increase g_{m_1}, g_{m_3} (Noise scaling)

Increases power dissipation.

Offset, Noise reduction

- Reduce the swing
- Reduce the speed.
- Increase the power dissipation

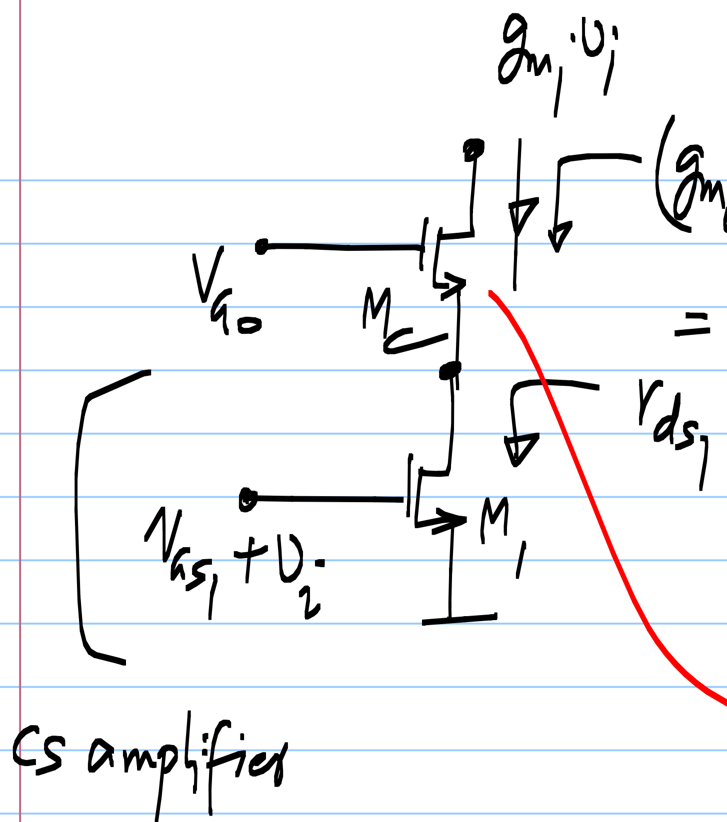
$$A_o = \frac{g_{m1}}{g_{ds1} + g_{ds3}} = \frac{g_{m1}}{\frac{k_\lambda}{L_1} \cdot \frac{I_o}{2} + \frac{k'_\lambda}{L_3} \cdot \frac{I_o}{2}}$$

Increasing the dc gain:

Transconductance: g_{m_1} o/p conductance: $g_{ds_1} + g_{ds_3}$

Reduce the o/p conductance:

Use a current buffer / common gate amplifier



$$(g_{mc} r_{dsc} + 1) \cdot r_{ds1} + r_{dsc}$$

$$= g_{mc} r_{dsc} r_{ds1} + r_{dsc} + r_{ds1}$$

Cascode device

Cascode arrangement