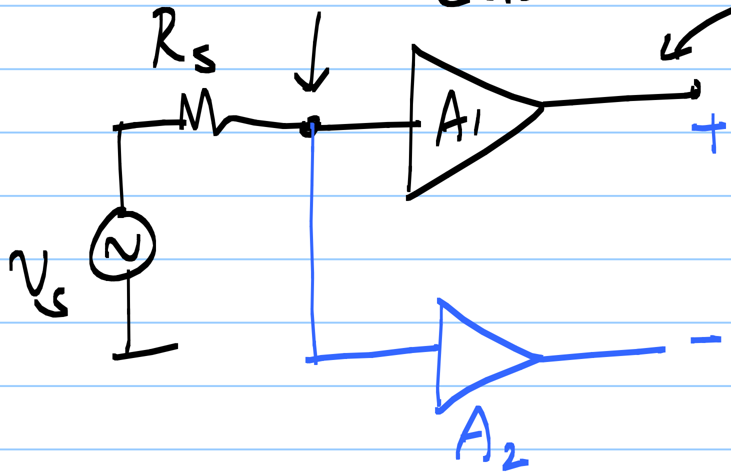
21/2/20

Lec 17

CGLNA

$\overline{v_{n,in}} = \frac{\overline{i_{n,1}} R_s}{2}$

$\overline{v_{nout}} = -\frac{\overline{i_{n,1}} R_d}{2}$



$v_{od} = v_+ - v_-$

$-\overline{v_{no_2}}$ (desired) $= -\frac{\overline{i_{n,1}} R_d}{2}$

We want $\overline{v_{odn}} = 0$

$A_2 = \frac{-R_d}{R_s}$

CG ← X because Z_{in} is low

CD ← X because no gain

CS ✓

* $Z_{in} \rightarrow \infty \Rightarrow$ small C_{gs}, small $\left(\frac{W}{L}\right)$
* gain $= -g_m R_L$ (correct sign)

Set $g_m R_L = \frac{R_d}{R_s}$

* low noise : $\overline{e_n^2} = \dfrac{4kT\gamma g_m + \frac{4kT}{R_L}}{g_m^2}$

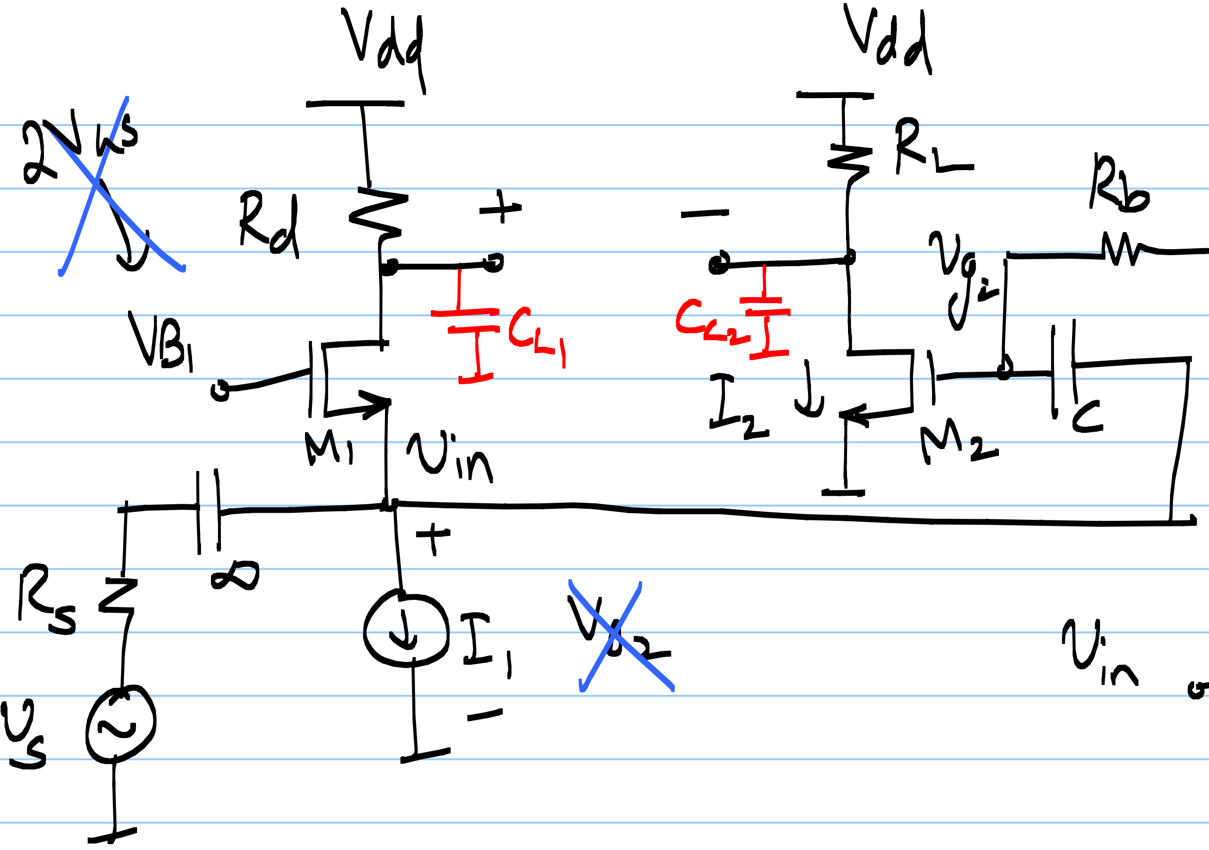
$$\frac{\overline{e_n^2}}{\Delta f} = \frac{4kT\gamma}{g_m} + \frac{4kT}{g_m^2 R_L}$$

$$= \frac{4kT}{g_m}\left[\gamma + \frac{R_s}{R_d}\right]$$

$\Rightarrow$ maximize g_m of CS stage

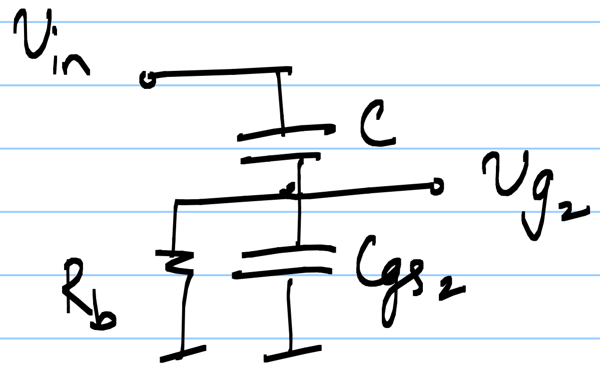
$\Rightarrow$ burn more current

*



$C \approx 10\, C_{gs_2}$

V_{B_2} is normally very large



$$\frac{v_{g_2}}{v_{in}}(s) = \frac{R_b \,\|\, \frac{1}{sC_{gs_2}}}{R_b \,\|\, \frac{1}{sC_{gs_2}} + \frac{1}{sC}}$$

@ RF e.g. $|R_b| \gg \left|\frac{1}{\omega C_{gs_2}}\right|$

$$\left| \frac{v_{g_2}}{v_{in}} (\infty) \right| = \frac{C}{C + C_{gs_2}}$$

close to DC : $|R_b| << \left| \frac{1}{\omega C_{gs_2}} \right| , \left| \frac{1}{\omega C} \right|$

$$\left| \frac{v_{g_2}}{v_{in}} (\omega) \right| = \left| \frac{R_b}{R_b + \frac{1}{j\omega C}} \right| \quad \text{small}$$

* DC @ ⊕ node = $V_{dd} - I_1 R_d$

DC @ ⊖ node = $V_{dd} - I_2 R_L$

$$BW \text{ @ } \oplus \text{ node output} = \frac{1}{2\pi R_d (C_{db_1} + C_{L_1})}$$

$$BW \text{ @ } \ominus \text{ output node} = \frac{1}{2\pi R_L (C_{db_2} + C_{L_2})}$$

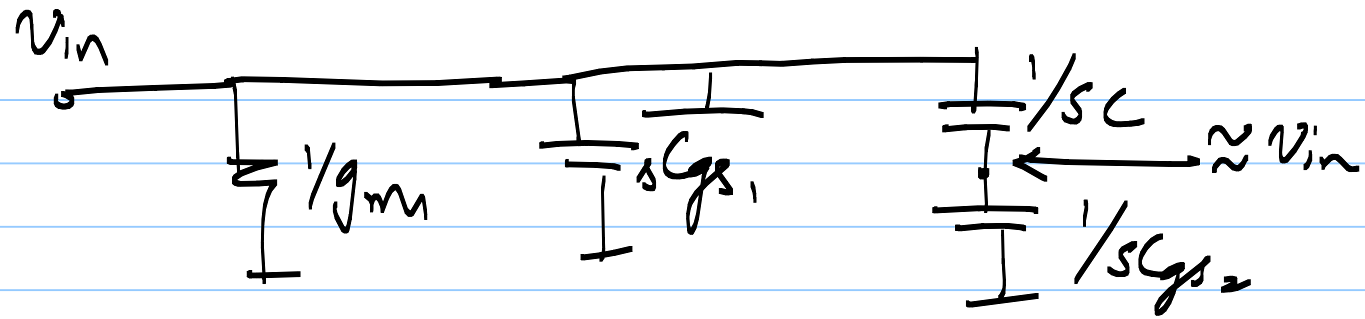
$$R_d \neq R_L \quad ; \quad C_{db_1} \neq C_{db_2}$$

In general, R_d is larger than R_L

The two outputs are asymmetric

What about $\frac{v_{od}}{v_s}$?

$$Z_{in} = 50\Omega \Rightarrow g_{m_1} = 20mS \to \left(\frac{W}{L}\right)_1, \; I_1$$



$$v_{in} = \frac{v_s}{2}$$

$$v_{o+} = + \frac{R_d}{2R_s} \cdot v_s$$

$$v_{o-} = -i_{d2} \cdot R_L$$

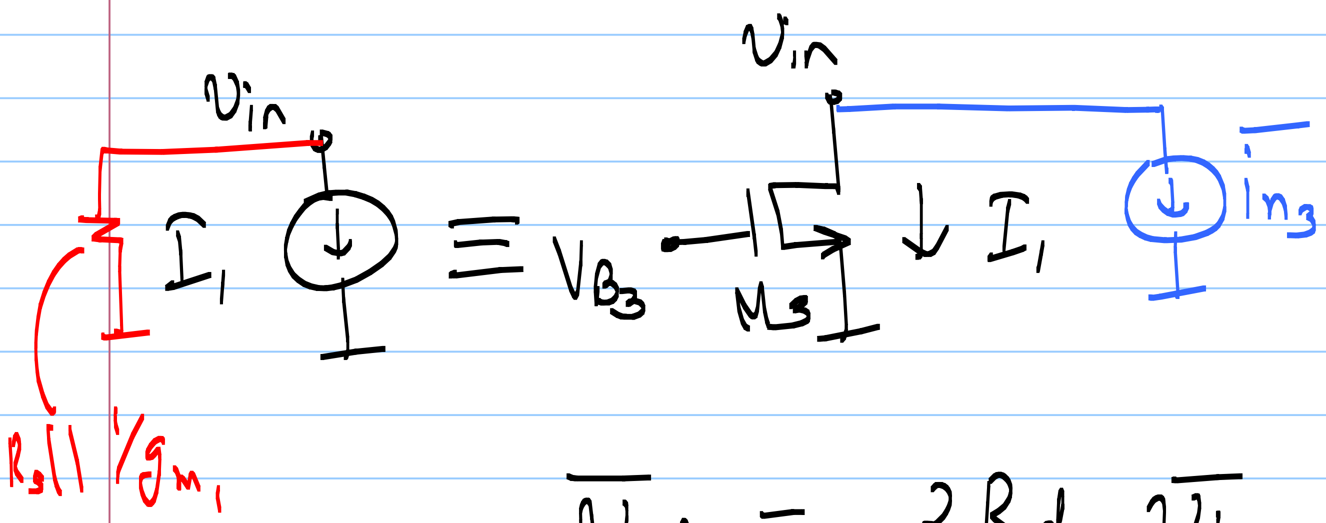
$$\approx -g_{m2} \cdot v_{in} \cdot R_L = -\frac{g_{m2} R_L}{2} \cdot v_s$$

$$v_{od} = \left[\frac{R_d}{2R_s} + \frac{g_{m2} R_L}{2}\right] v_s$$

condition for noise cancellation: $\dfrac{R_d}{R_s} = g_{m2} R_L$

$$\Rightarrow \quad \frac{v_{od}}{v_s} = \frac{R_d}{R_s} = g_{m_2} R_L$$

* Noise of current source I_1 ?



$R_s || 1/g_{m_1}$

$||$

$$\overline{v_{in_{M_3}}} = -\overline{i_{n_3}} \cdot \frac{R_s}{2}$$

$$\overline{v_{o_+}} = \frac{R_d}{R_s} \cdot \overline{v_{in_{M_3}}}$$

$$\overline{v_{o_-}} = -g_{m_2} R_L \, \overline{v_{in_{M_3}}}$$

$$\overline{v_{od_n}} = \frac{2R_d}{R_s} \cdot \overline{v_{in_{M_3}}}$$

$$\overline{v_{od_n}^2} = \frac{4R_d^2}{R_s^2} \cdot \overline{v_{in_{M_3}}^2} = \frac{4R_d^2}{R_s^2} \cdot \overline{i_{n_3}^2} \, \frac{R_s^2}{4}$$

$$= 4kT\gamma g_{m_3} \cdot R_d^2$$