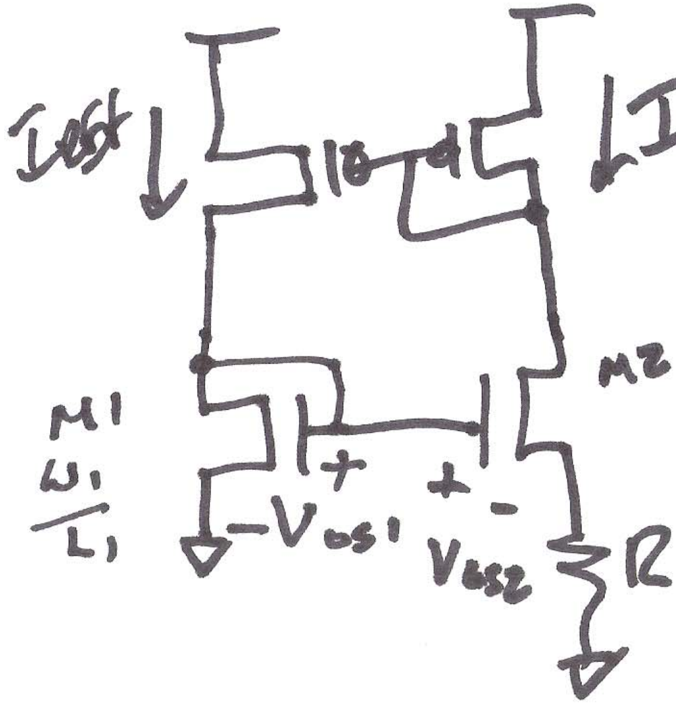


$$V_{GS1} = V_{GS2} + I_{REF}\cdot R$$

$$V_{GS} = \sqrt{\frac{2I_{REF}}{KP_N\cdot\frac{W}{L}}} + V_{THN}$$

$$\frac{W2}{L2} = K\cdot\frac{W_1}{L_1}$$

$$\sqrt{\frac{2I_{REF}}{\underbrace{KP_N\cdot\frac{W_1}{L_1}}_{\beta_1}}} + \cancel{V_{THN}} =$$

$$V_{GS1} > V_{GS2}$$

$$\sqrt{\frac{2I_{REF}}{K\cdot KP_N\cdot\frac{W_1}{L_1}}} + \cancel{V_{THN}} + I_{REF}\cdot R$$

$$\sqrt{\frac{2I_{REF}}{\beta_1}} - \sqrt{\frac{2I_{REF}}{K\cdot\beta_1}} = I_{REF}\cdot R$$

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$$\sqrt{\frac{2I_{REF}}{\beta_1}}\left(1-\frac{1}{\sqrt{K}}\right) = I_{REF}\cdot R$$

$$\frac{2\cancel{I_{REF}}}{\beta_1}\left(1-\frac{1}{\sqrt{K}}\right)^2 = I_{REF}^{\cancel{2}}\cdot R^2$$

$$I_{REF} = \frac{2}{\beta_1\cdot R^2}\left(1-\frac{1}{\sqrt{K}}\right)^2$$

If $K=4$ (CONSTANT-$g_m$ BMR)

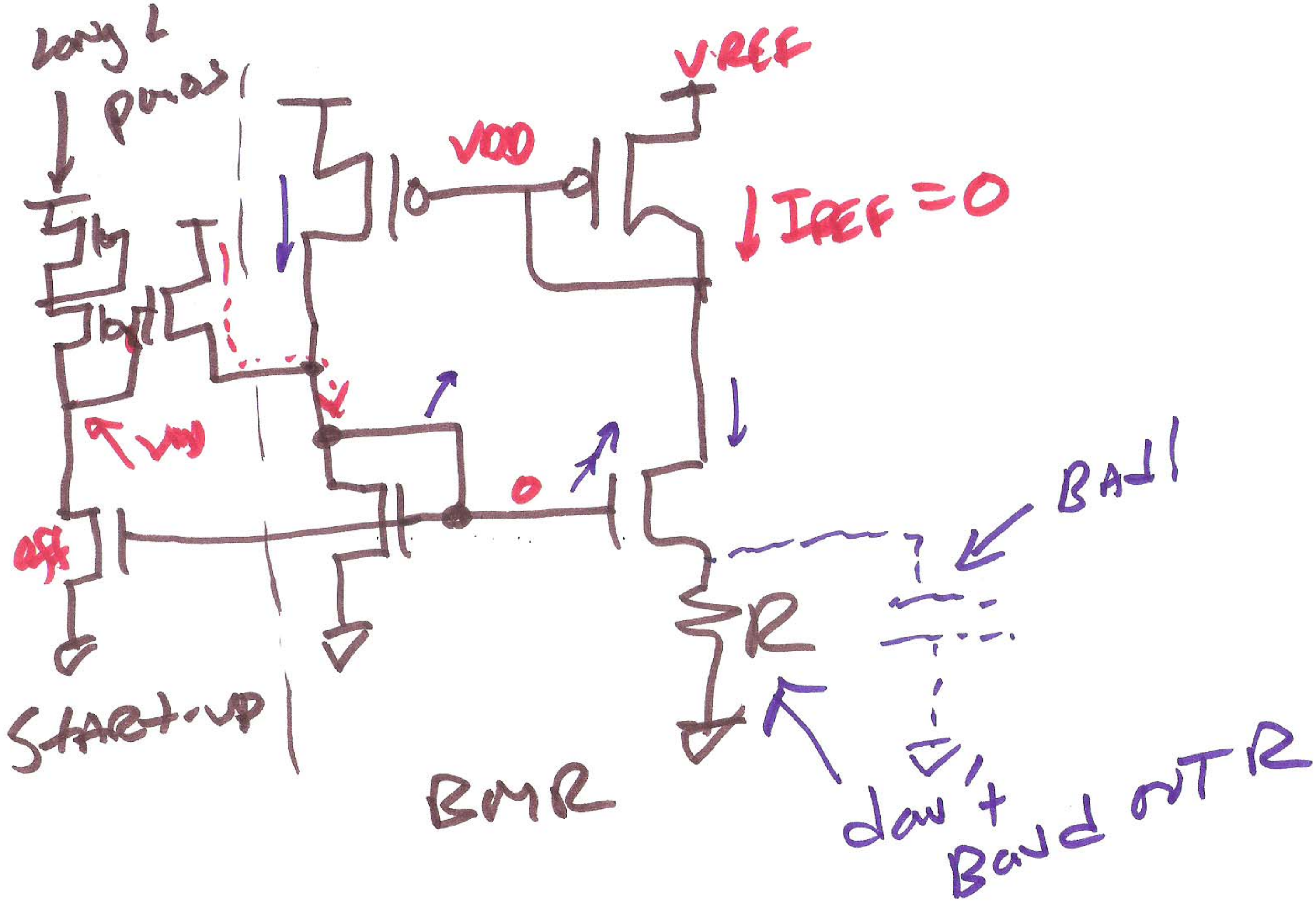
$$I_{REF} = \frac{1}{2R^2\beta_1}$$

$$g_m = \sqrt{2I_{REF}\cdot\beta_1} = \sqrt{2\cdot\frac{1}{2R^2\beta_1}\cdot\beta_1}$$

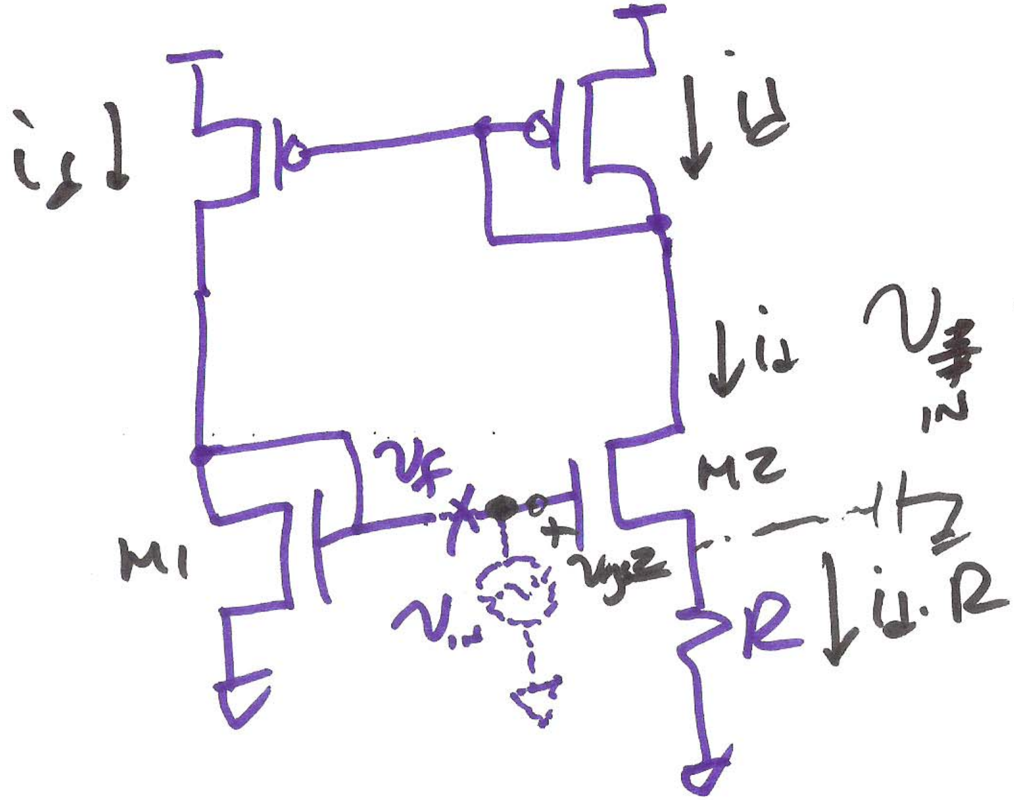
$$\boxed{g_m = \frac{1}{R}}$$



2)



Long L
pmos
VREF
VDD
IREF = 0
0
Bad!
R
don't
Band on R
START-UP
BMR




$$v_{IN} = v_{gs2} + i_d \cdot R$$

$$= \frac{i_d}{g_{m2}} + i_d \cdot R$$

$$K \cdot g_{m1}$$

$$v_{IN} = i_d\left(1/g_{m2} + R\right)$$

$$v_f = v_{gs1} = \frac{i_d}{g_{m1}}$$

$$i_d = g_{m1} \cdot v_f$$

$$\frac{v_{in}}{v_f} = \left(1/g_{m2} + R\right) g_{m1}$$

$$= \cancel{\frac{g_{m1}}{g_{m2}}}^{\,\frac{1}{K}} + R$$



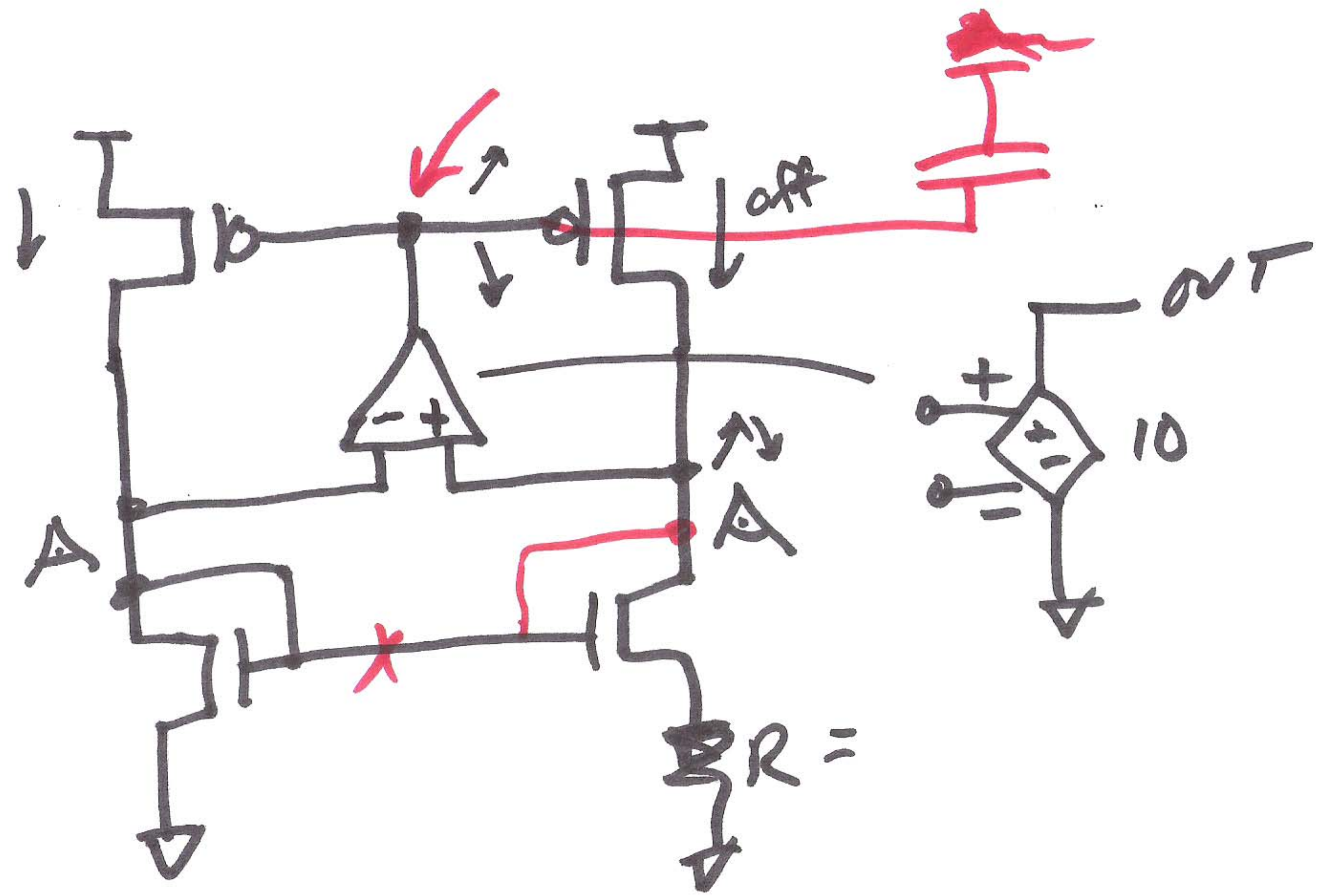
4)

$$\frac{v_f}{v_{in}} = \frac{1}{\frac{1}{K} + R} = \frac{K}{K + R}$$

$$\frac{v_f}{v_{in}} < 1$$

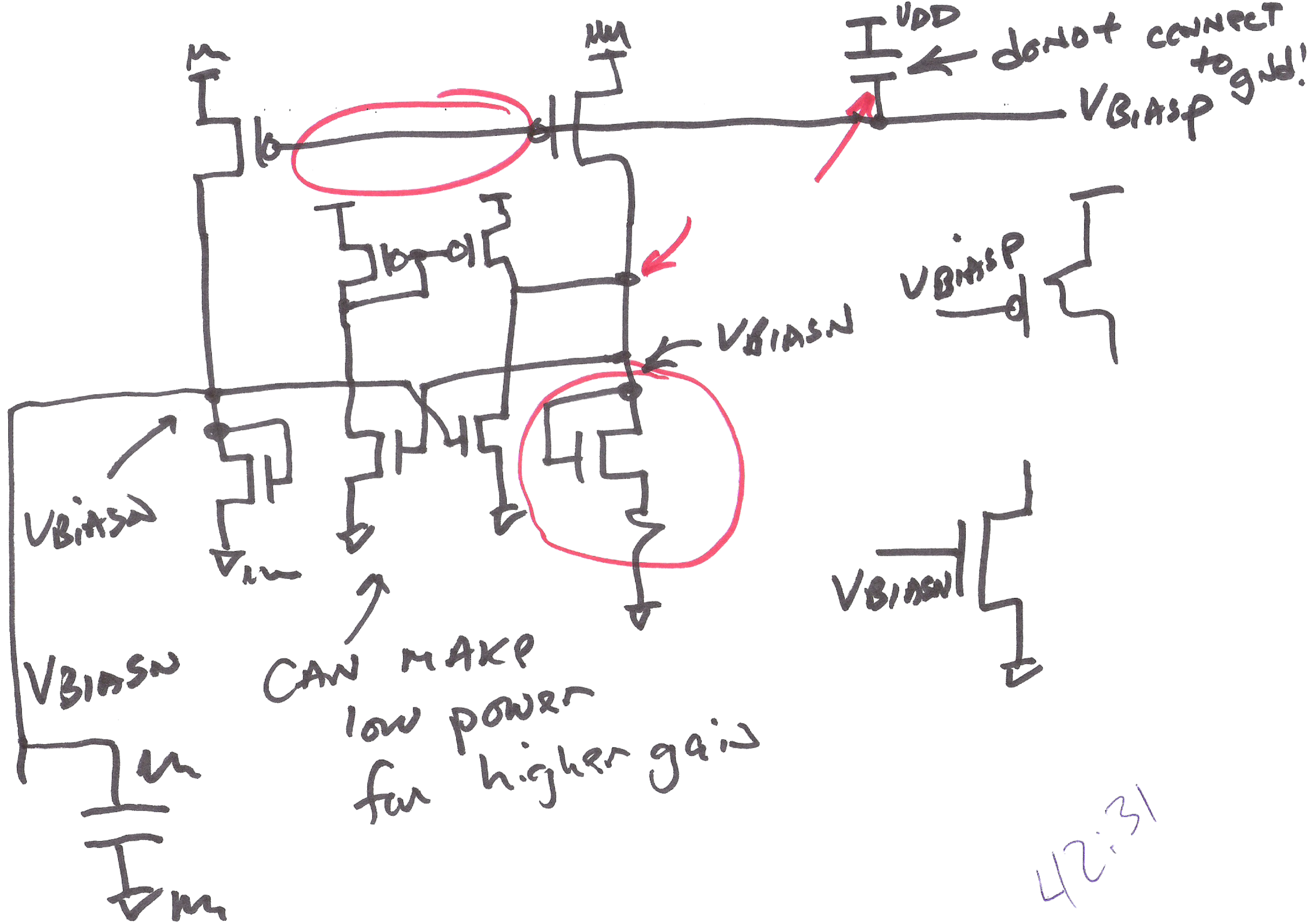
don't WANT capacitance ACROSS R!

Concern for all self-biased references!






c)


VDD
do not connect to gnd!
VBIASP
VBIASN
VBIASP
VBIASN
VBIASN
VBIASN
CAN MAKE low power for higher gain

42:31