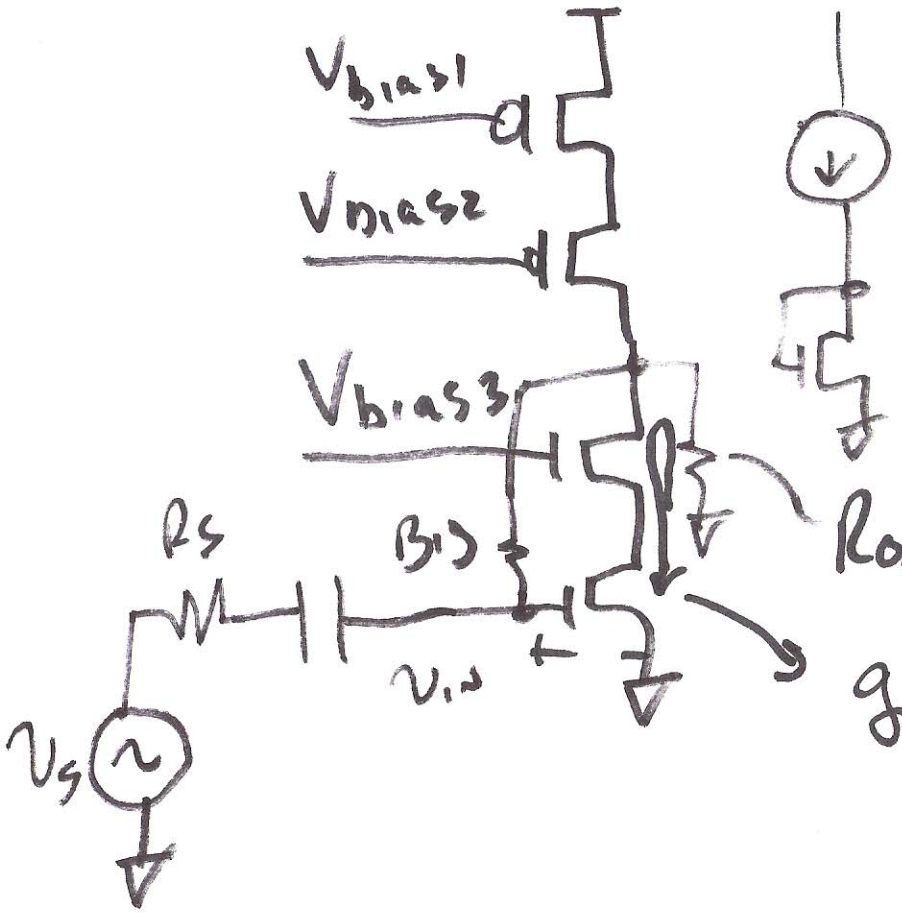
21.2.2 Cascode Amplifier



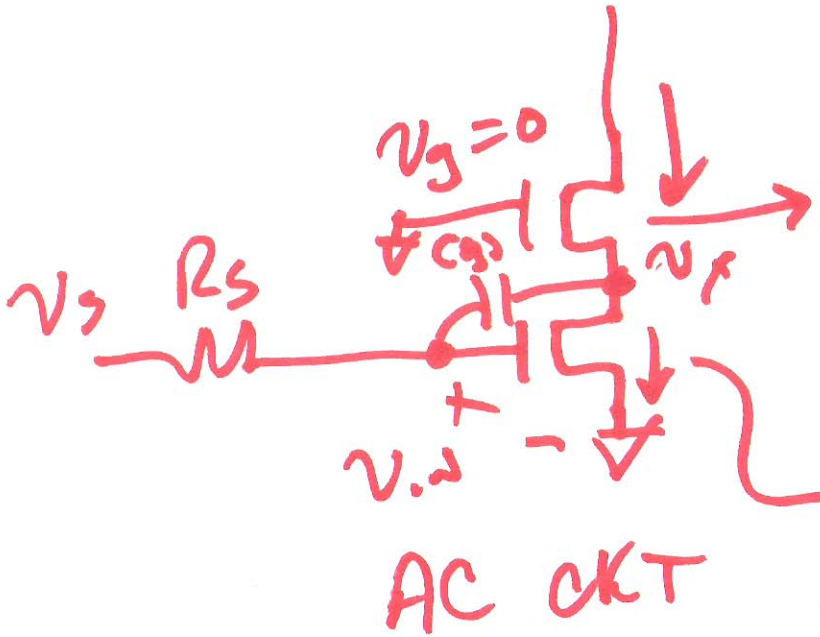
$$V_{OUT} = -g_m V_{IN} \cdot R_{OCASN} \| R_{OCASP}$$

$$\frac{V_{OUT}}{V_{in}} = -g_m R_{OCASN} \| R_{OCASP}$$

Miller effect

↖ Miller killer

$$\frac{v_x}{v_{in}} = \frac{-1/g_{mN}}{1/g_{mN}} = -1$$



$$v_{gs} = 0 - v_x = -v_x$$

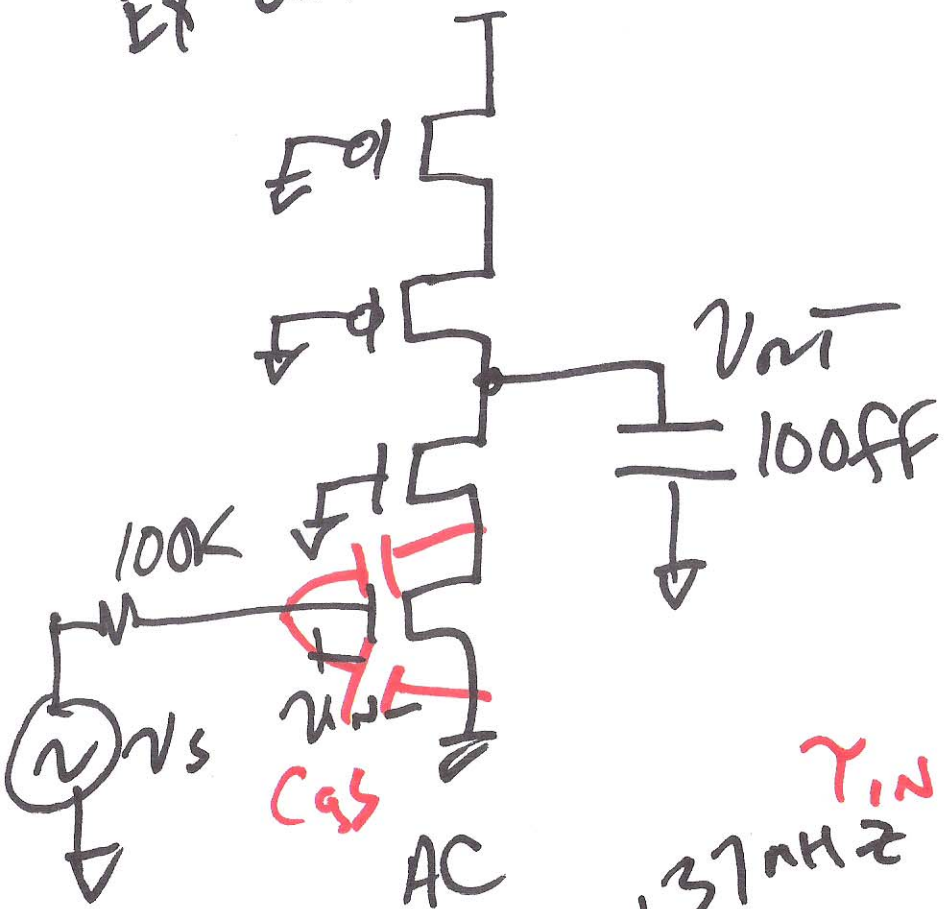
$$C_{miN} = C_{gd}(1 + |-1|)$$

$$g_{mN} \cdot v_{in} = g_{mN} \cdot (-v_x)$$

$$\boxed{\frac{v_x}{v_{in}} = -1}$$

INCORRECT SER is 21.78

Ex 21.12



$$\frac{V_o}{V_{in}} = -g_{mN} R_{ocmsN} \| R_{contsp}$$

$$= 150\frac{\mu}{V} \cdot 16.6 \| 4.2\,M$$

$$\simeq 500 \frac{V}{V}$$

$$f_{in} = 137\,MHz$$

$$\tau_{in} = 100K(4.17fF + 1.56fF$$

$$C_{gs}\ (1 + 3\ldots)$$

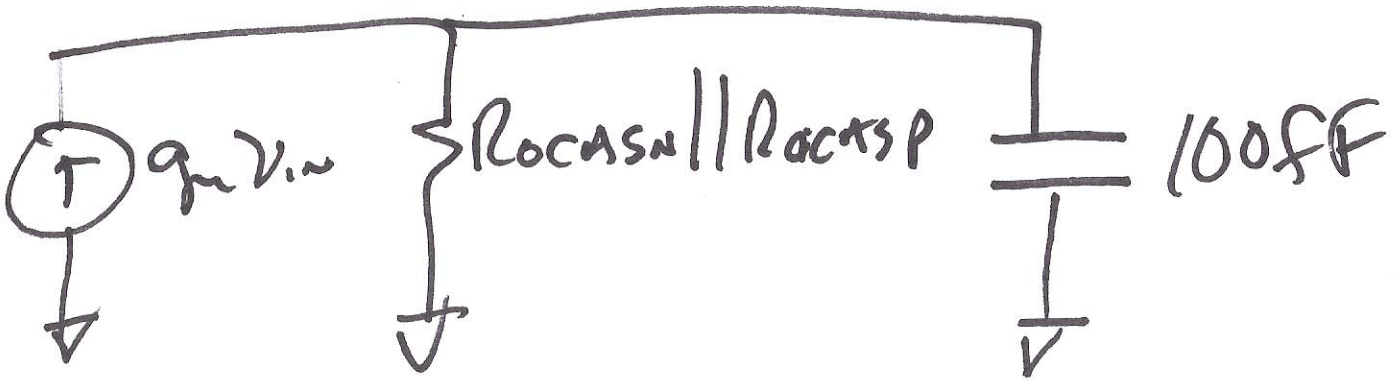
$$C_m$$

$$= 100K\ (7.29fF)$$

see Ex. 21.12 $= 729$ PS

$$\tau_{in} = 1.16\,ns$$

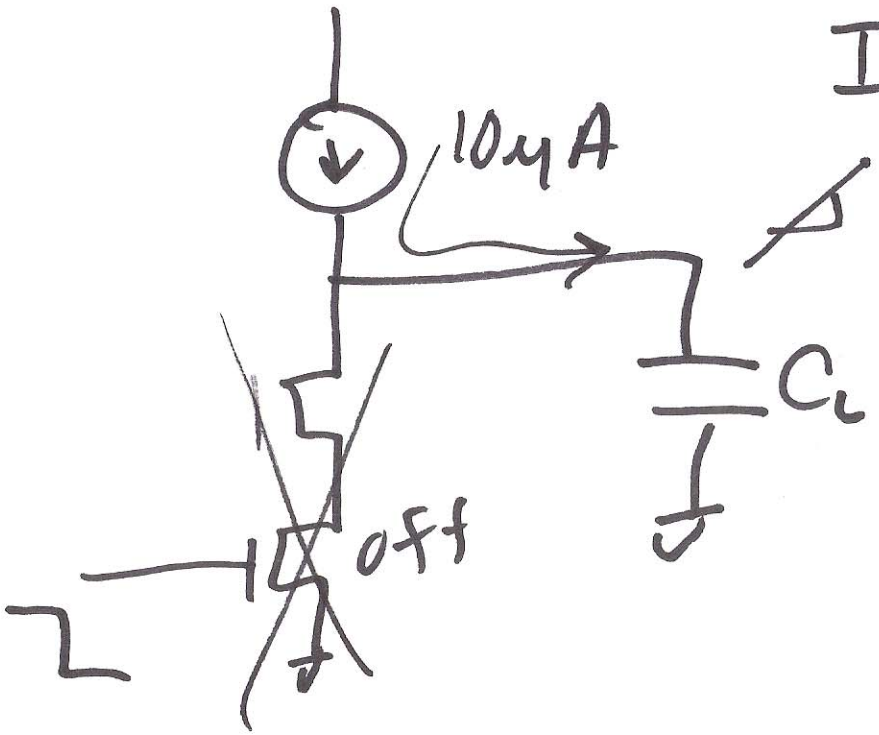
3)



$$\tau_{OT} = 335\,ns \rightarrow f_{OT} = 475\,KHz$$

$$\frac{v_o}{v_i} = \frac{500}{\left(1 + j\frac{f}{137\,MHz}\right)\left(1 + j\frac{f}{475\,KHz}\right)}$$

Class A Amplifier



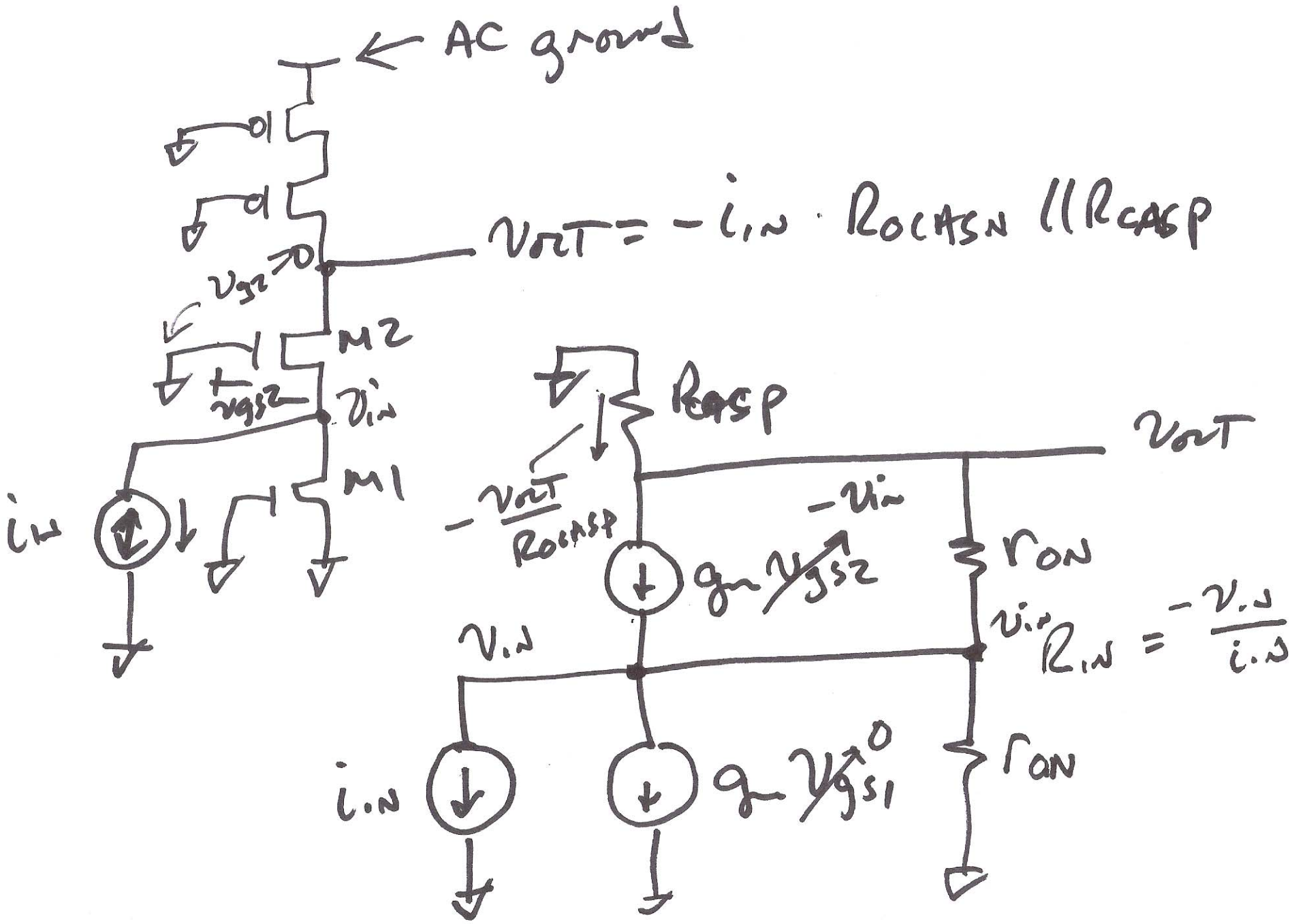
$$I = C\frac{dv}{dT}$$

$$\frac{dv}{dT} = \frac{10\mu}{100fF}$$

$C_L = 100fF$

$$= 100\frac{mV}{ns}$$

Slew rate


AC ground
$v_{OUT} = -i_{in} \cdot R_{OCASN} \| R_{CASP}$
v_{gs2}
M2
v_{in}
M1
i_{in}
R_{CASP}
v_{OUT}
$-\frac{v_{OUT}}{R_{OCASP}}$
$-v_{in}$
$g_m v_{gs2}$
r_{ON}
v_{in}
$R_{in} = \frac{-v_{in}}{i_{in}}$
v_{in}
i_{in}
$g_m v_{gs1} = 0$
r_{ON}

$$-\frac{v_{out}}{R_{OCASP}} = g_m(-v_{in}) + \frac{v_{out} - v_{in}}{r_{on}}$$

$$v_{in}\left(g_{mn} + \frac{1}{r_{on}}\right) = v_{out}\left(\frac{1}{r_{on}} + \frac{1}{R_{OCASP}}\right)$$

$$v_{out} = v_{in}\,\frac{g_{mn} + \frac{1}{r_{on}}}{\frac{1}{r_{on}} + \frac{1}{R_{OCASP}}}$$

$$= v_{in}\,\frac{1 + g_{mn} r_{on}}{1 + \frac{r_{on}}{R_{OCASP}}}$$

$$-\frac{v_{out}}{R_{OCMSP}} = i_{IN} + \frac{v_{IN}}{r_{ON}}$$

$$R_{IN} = \frac{-v_{IN}}{i_{IN}} \qquad v_{out} \cdot \frac{-1}{R_{OCMSP}} \left(v_{IN} \cdot \frac{1 + g_m r_{ON}}{1 + \frac{r_{ON}}{R_{OCMSP}}} \right) =$$

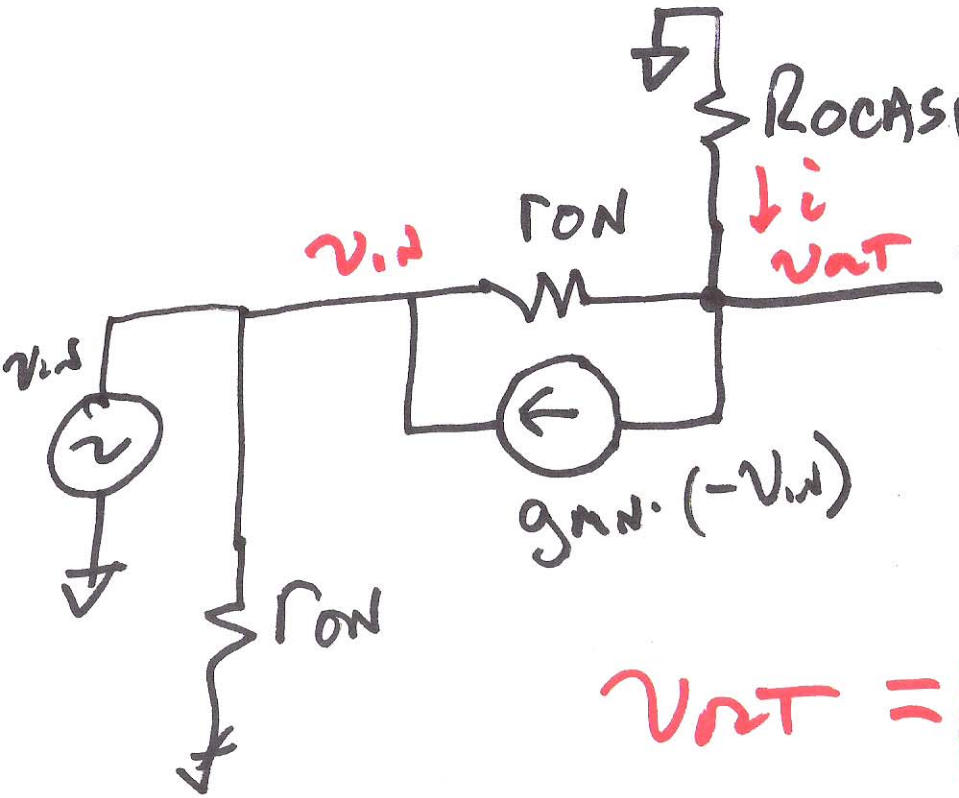
$$= v_{IN} \left(\frac{1 + g_m r_{ON}}{R_{OCMSP} + r_{ON}} \right) = i_{IN} + \frac{v_{IN}}{r_{ON}}$$

$$-i_{IN} = v_{IN} \left(\frac{1}{r_{ON}} + \frac{1 + g_m r_{ON}}{R_{OCMSP} + r_{ON}} \right)$$

$$\simeq v_{IN} \left(\frac{1}{r_{ON}} + \frac{1 + g_m r_{ON}}{R_{OCMSP}} \right)^{-1}$$

$$\boxed{\frac{v_{IN}}{i_{IN}} = \frac{r_{ON}}{2}}$$

$g_m r_o^2$



$$v_{OUT} = -i \cdot R_{OCHSP}$$

$$i = \frac{v_{OUT} - v_{in}}{r_{ON}} + g_{mN}(-v_{in})$$

$$v_{OUT} = \left(-\frac{v_{OUT}}{r_{ON}} + \frac{v_{in}}{r_{ON}} + g_{mN} v_{in}\right)$$

$$v_{OUT}\left(1 + \frac{R_{OCHSP}}{r_{ON}}\right) = v_{in}\left(\frac{R_{OCHSP}}{r_{ON}} + g_{mN} R_{OCHSP}\right)$$

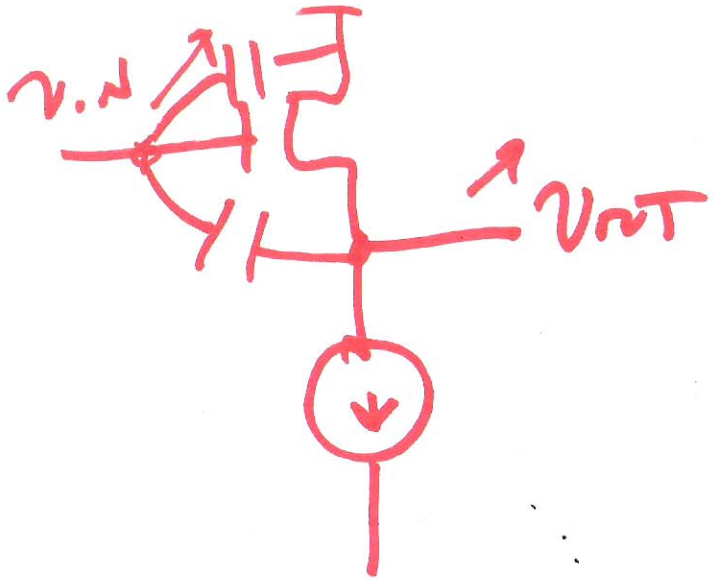
$$v_{OUT}\left(\frac{1}{R_{OCHSP}} + \frac{1}{r_{ON}}\right) = v_{in}\left(\frac{1}{r_{ON}} + g_{mN}\right)$$

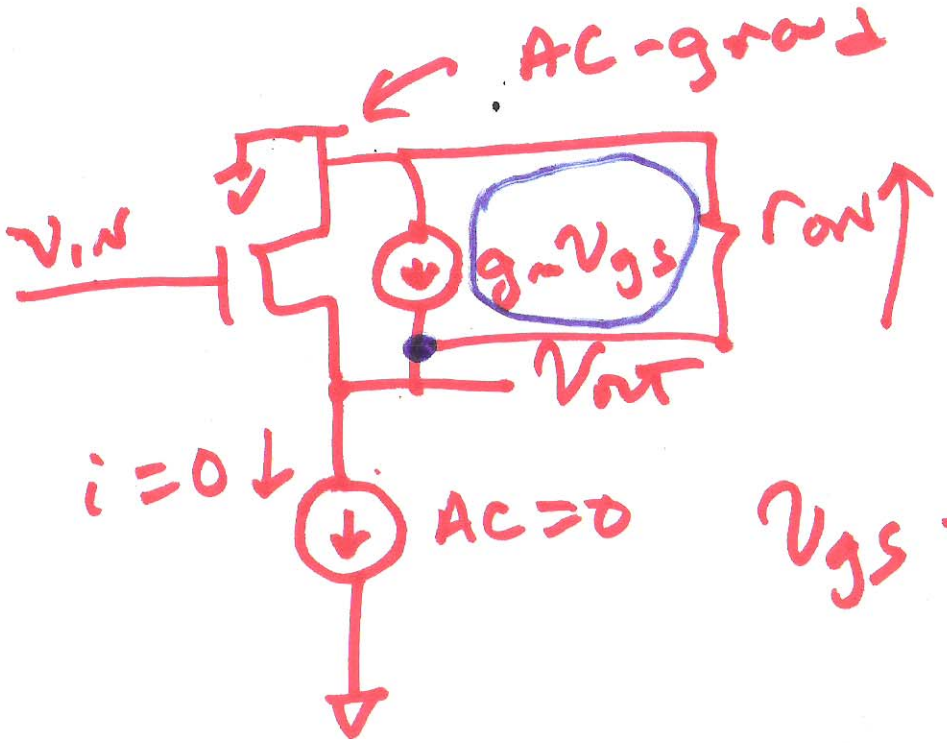
$$\simeq \frac{1}{r_{ON}}$$

$$\frac{V_{out}}{V_{in}} \simeq 1 + g_m r_{ON} \approx \frac{r_{ON}}{1/g_m}$$

Source follower (common-drain)

low input capacitance





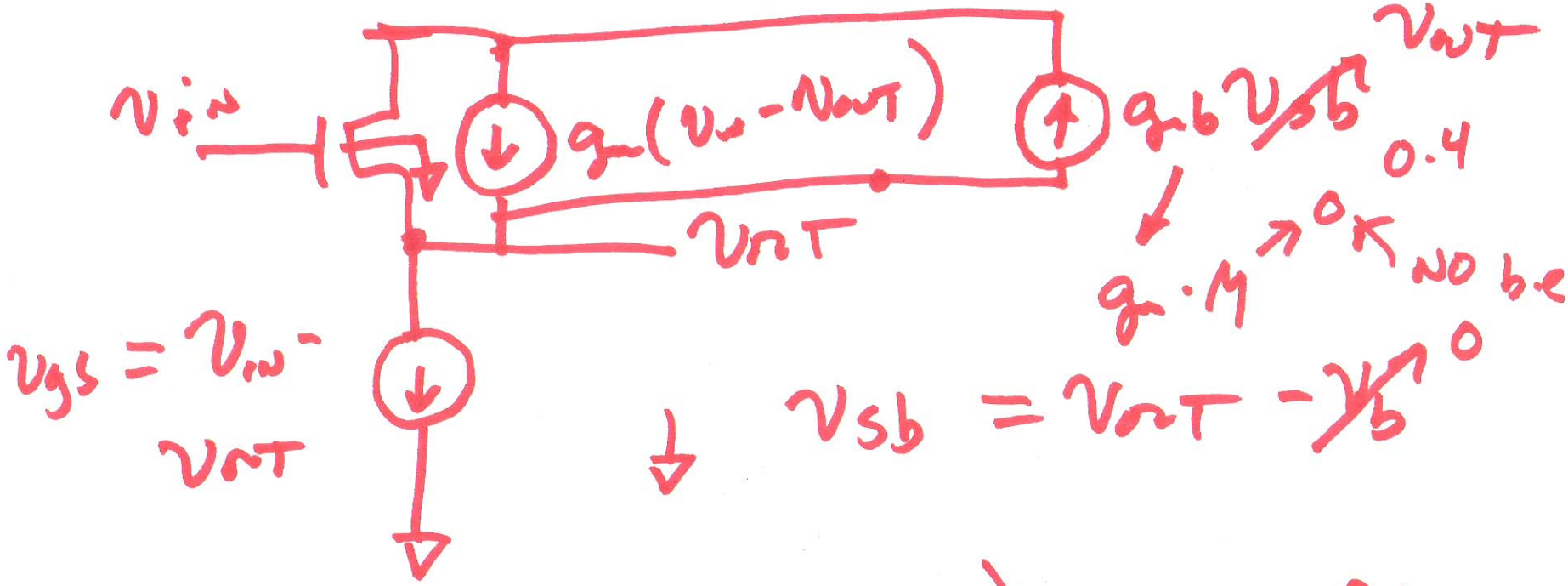
$$v_{gs} = v_{in} - v_{out}$$

$$g_m(v_{in} - v_{out}) = g_m v_{gs} = \frac{v_{out}}{r_{on}}$$

$$g_m v_{in} = v_{out}\left(\frac{1}{r_{on}} + g_m\right)$$

$$\frac{v_{out}}{v_{in}} = \frac{1}{1 + \frac{1}{g_m r_{on}}} \simeq 1$$

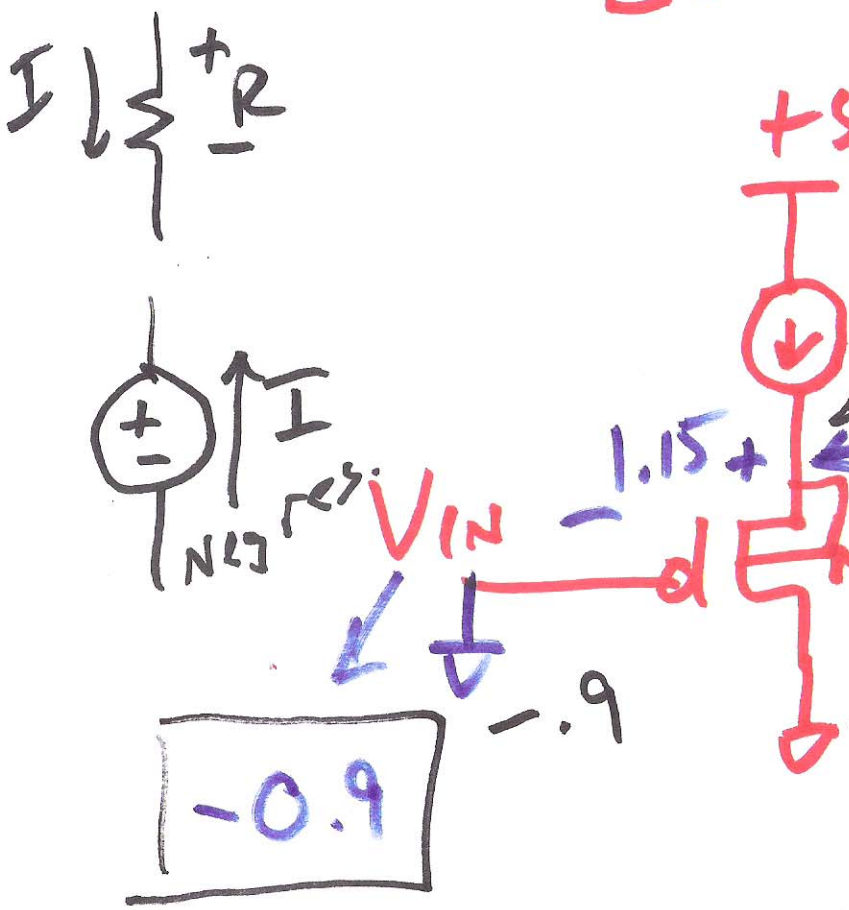
S.F. Gain with Body effect



$$g_m(v_{in} - v_{out}) = g_{mb} \cdot v_{out}$$

$$\frac{v_{out}}{v_{in}} = \frac{g_m}{g_m + g_{mb}} = \frac{1}{1+\eta}$$

Level-shifting



$.25 \geq 1.15 - .9$

yes!

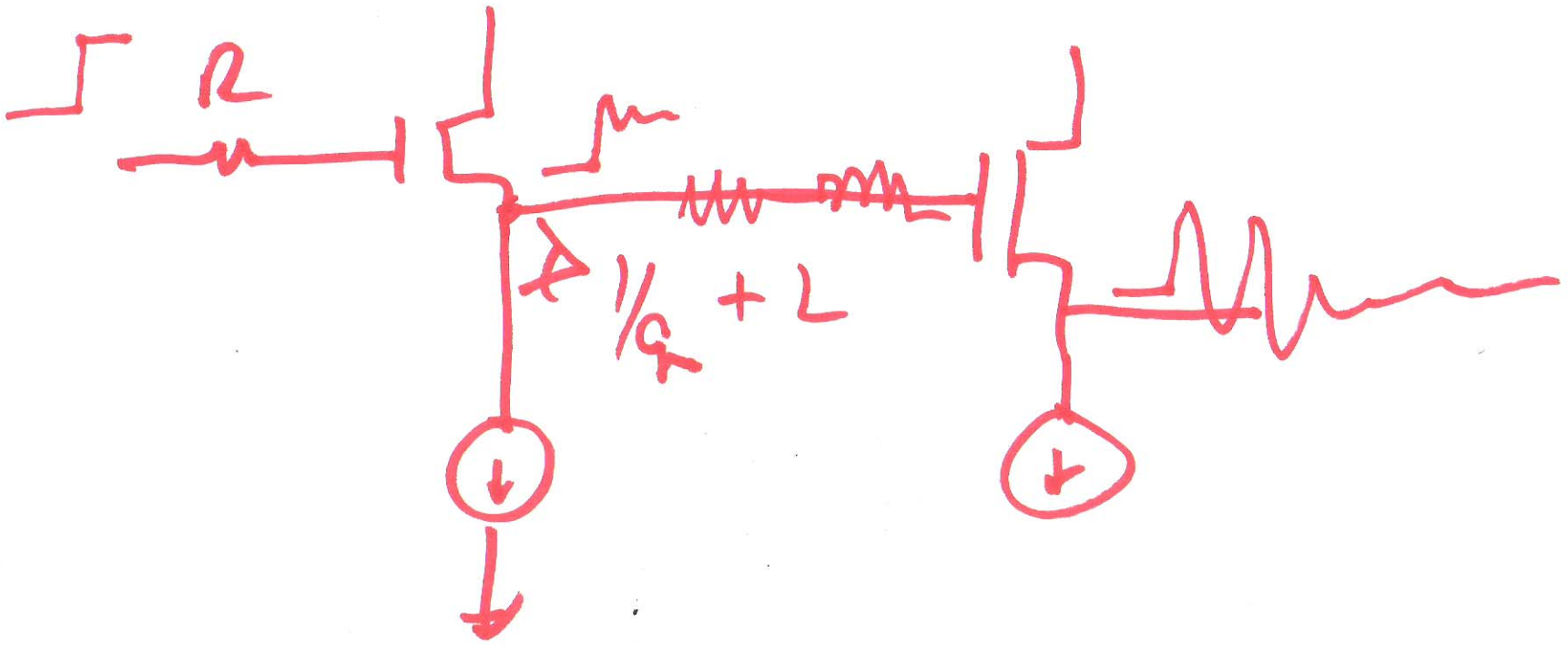
$1.15 = V_{SG} + V_{SD} = 1.15, .25$

$V_{SD} \geq V_{SG} - V_{THP}$

$0 \geq -V_{THP}$

TABLE 9.1

How low can V_{IN} go and the M1 stays in saturation?


R
1/gm + L