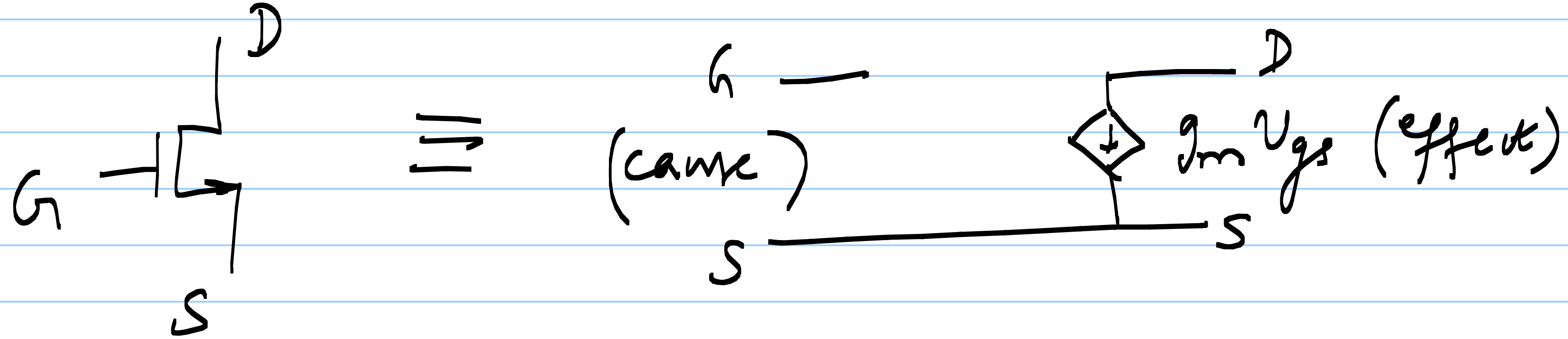
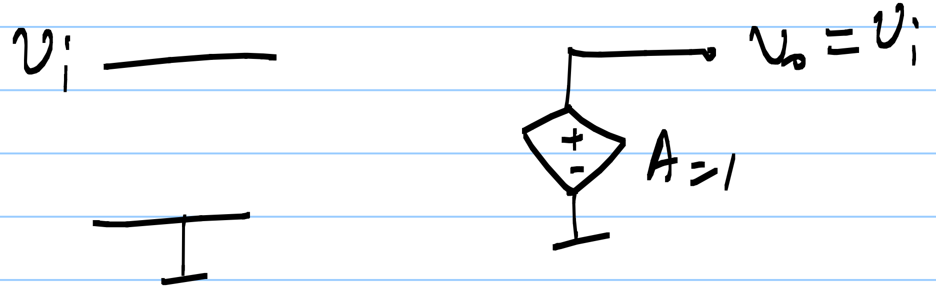
9/9/20

Lecture 21

MOSFET VCVS, gain = 1, $v_o = v_i$

using negative f.b.





$v_o = v_i$

$\Rightarrow \underbrace{v_i - v_o}_{\text{comparison action}} = 0$

use this $(v_i - v_o)$ to change v_o

Sense i_d or i_s (relate to v_o)

drive back to v_{gs} (relate to $v_i - v_o$)

i_d, i_s, v_g, v_s etc. are small signal quantities

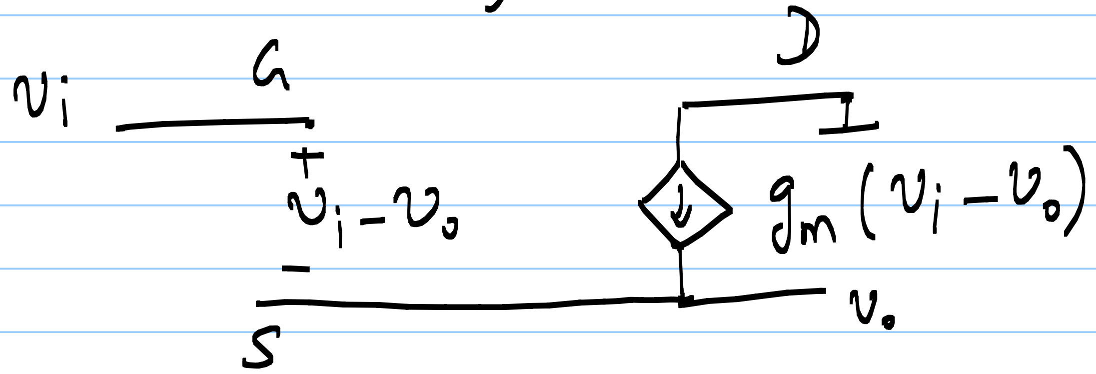
v_i, v_o $\longleftrightarrow$ v_g, v_s (cause)

v_o $\longleftrightarrow$ v_d, v_s (effect i_d or i_s)

$v_o \rightarrow v_s$

$v_i \rightarrow v_g$

$v_i - v_o = v_{gs}$



$\downarrow g_m(v_i - v_o)$

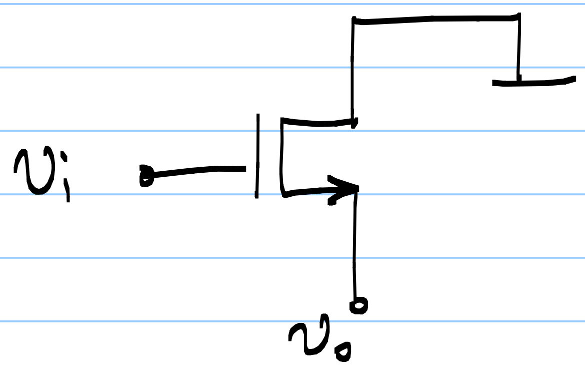
$\uparrow g_m(v_o - v_i)$

Check for -ve f.b.:

If $v_o > v_i \Rightarrow g_m(v_o - v_i)$ will flow out of (S) node $\Rightarrow v_o \downarrow$

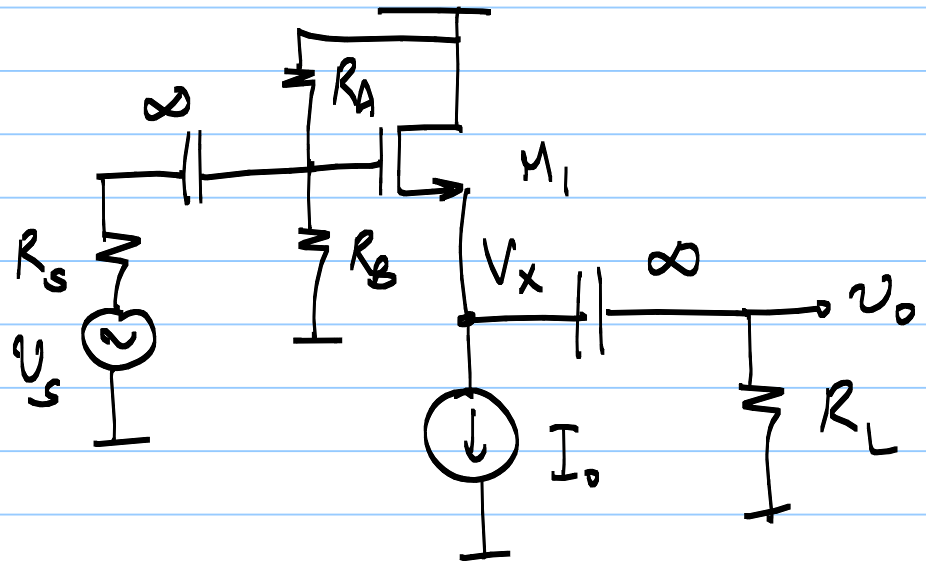
If $v_o < v_i \Rightarrow g_m(v_i - v_o)$ will flow into (S) node $\Rightarrow \uparrow v_o$

$v_o = v_i \Rightarrow i_d = 0$



Common Drain Amplifier

Common Drain Amplifier
(or)
Source follower



$$V_x = \frac{R_B}{R_A + R_B} V_{DD} - V_T - \sqrt{\frac{2 I_o}{\mu_n C_{ox} \left(\frac{W}{L}\right)}}$$

1) Choose large R_A, R_B (large Z_{in})
2) As $g_m \to \infty$, gain $\to 1$ (gain < 1 if r_{ds} is significant)
3) As $g_m \to \infty$ $Z_{out} \to 0$

$$\frac{v_o}{v_s} = \frac{g_m}{g_m + g_{ds} + G_L}$$

$g_m \gg G_L$

$g_m \gg g_{ds}$

Swing limits

$$v_s = V_A \sin\omega t$$

1) Cutoff limit

$$I_D = I_Q + i_d$$

$$= I_0 + i_d$$

assume g_{ds} is very small

$$i_d = \frac{v_o}{R_L} = \frac{1}{R_L} \cdot \frac{g_m R_L}{1+g_m R_L} \cdot v_s$$

$$I_D = I_0 + \frac{g_m R_L}{1+g_m R_L} \cdot \frac{V_{A_1} \sin\omega t}{R_L}$$

Set $I_D = 0 \Rightarrow V_{A_1} = I_o \cdot R_L \left[1 + \frac{1}{g_m R_L} \right]$

2) Triode limit

$$V_D - \cancel{V_S} = V_G - \cancel{V_S} - V_T$$

$$V_D = V_G - V_T$$

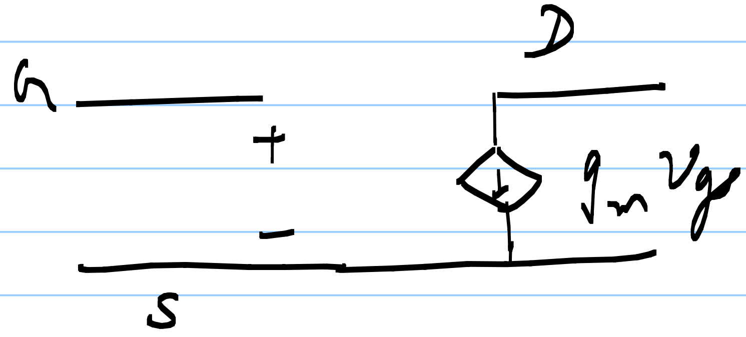
$$V_{DD} = \frac{V_{DD} \cdot R_B}{R_A + R_B} + V_{A_2} \sin \omega t - V_T$$

$$V_{A_2} = \frac{R_A}{R_A + R_B} \cdot V_{DD} + V_T$$

$$V_{A_{max}} = \min. \{ V_{A_1}, V_{A_2} \}$$

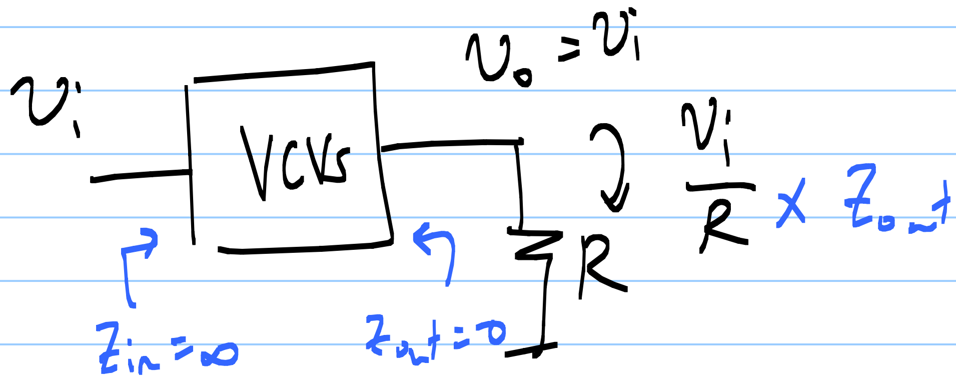
MOSFET VCCS

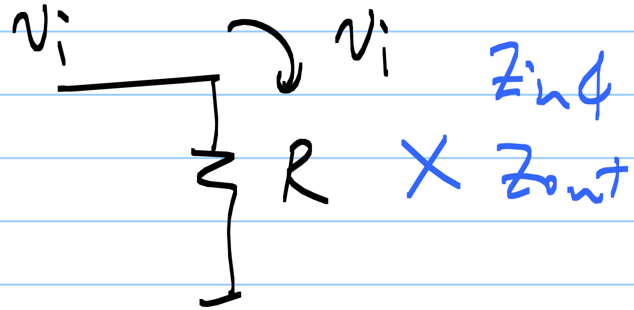
$$i_o = G \cdot v_i = \frac{v_i}{R}, \quad Z_{in} = \infty, \quad Z_{out} = \infty$$

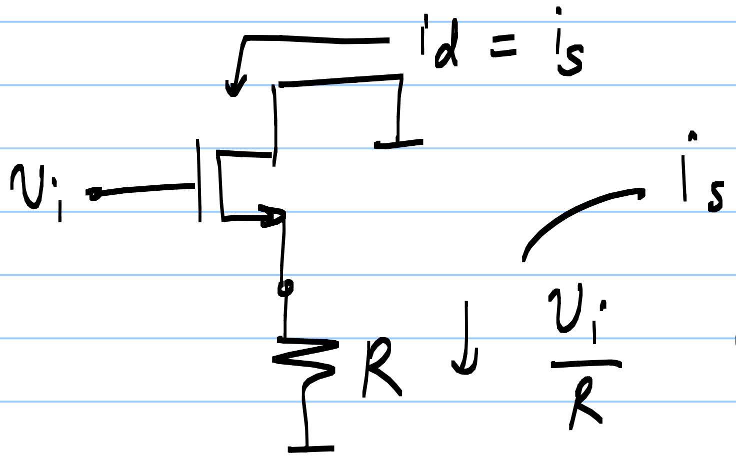


controlling − v_{gs}

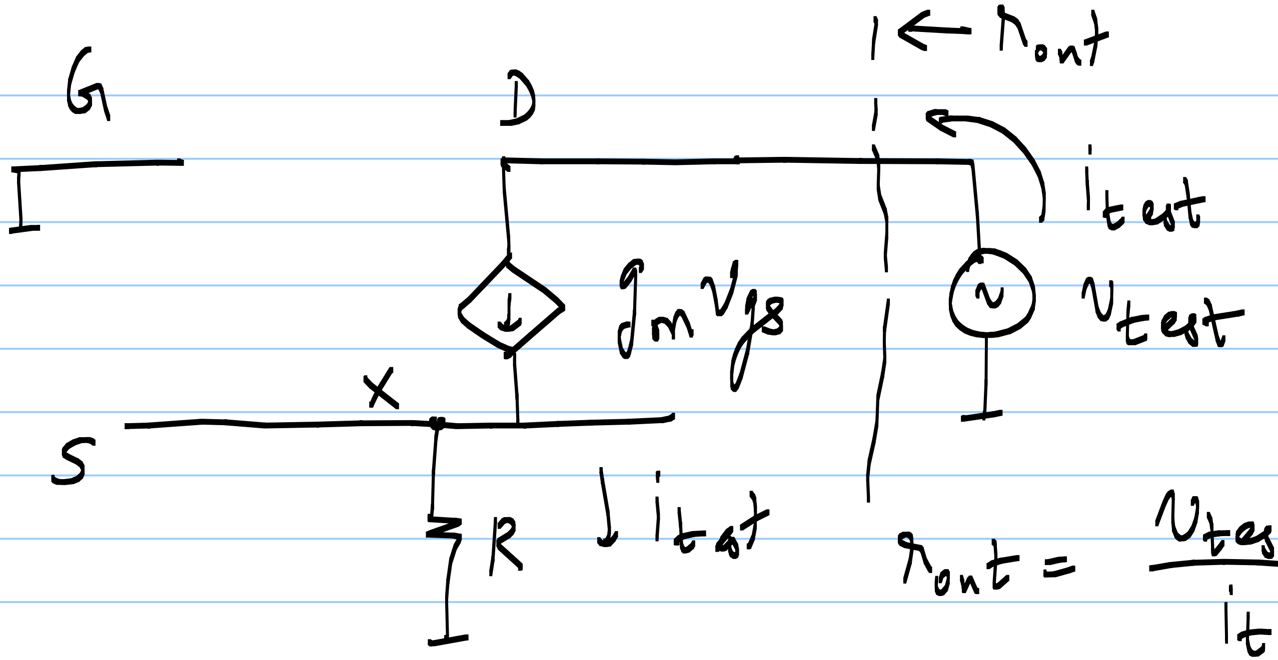
controlled − i_d







if $g_m R \gg 1$



$$r_{out} = \frac{v_{test}}{i_{test}}$$

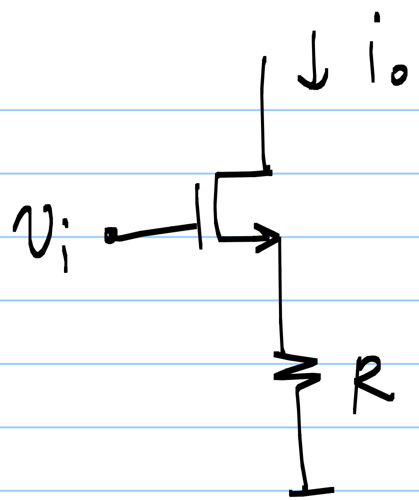
$$v_x = i_{test} \cdot R$$

$$g_m v_{gs} = -g_m v_x = -g_m R \cdot i_{test} = i_{test}$$

$$i_{test} = 0 \Rightarrow Z_{out} = \infty$$

HW #6 Calculate Z_{out} if r_{ds} is finite

$$Z_{out} = r_{ds} + g_m R r_{ds} + R$$



Trans admittance amplifier