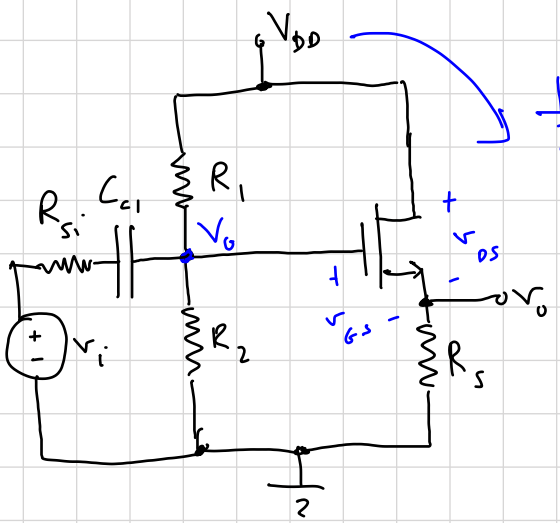
Lecture #20 — Common-Drain and Common-Gate Amplifiers

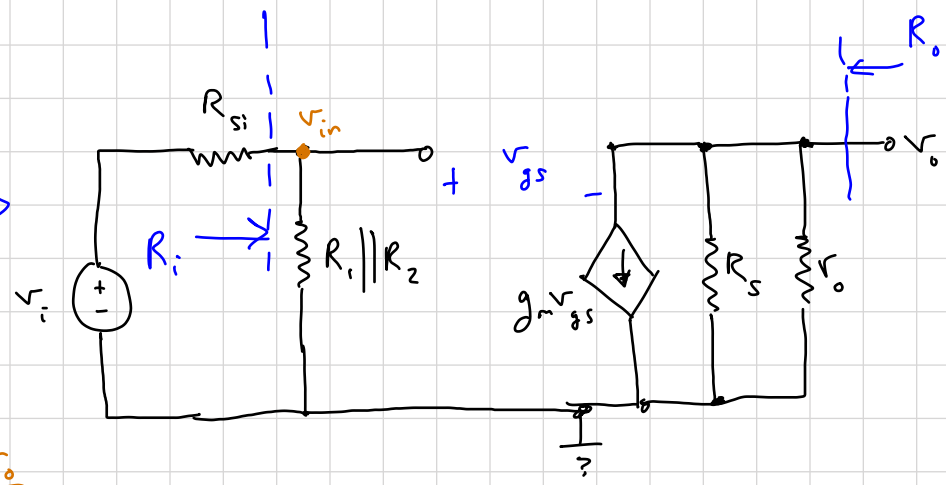
Common-Drain Amplifier (AKA Source-Follower)

→ output signal moved to source-end

→ Drain connected directly to V_{DD}



$\frac{1}{i\omega}$ for ac equiv. circuit $\Rightarrow$



we want $A_v = \frac{v_o}{v_i}$

→ A_v will always be < 1 (no "gain")

→ output will be in-phase and nearly = to input

hence: "source-follower"

Why ever use it??

→ output resistance is smaller than input, can be very useful for a voltage source to drive a load circuit.

$$v_o = (g_m v_{gs})(R_s \| r_o)$$

like a voltage divider

KVL gives:

$$v_{in} = v_{gs} + v_o = v_{gs} + g_m v_{gs}(R_s \| r_o)$$

$$\Rightarrow v_{gs} = \frac{v_{in}}{1 + g_m(R_s \| r_o)} = \left[\frac{1/g_m}{1/g_m + (R_s \| r_o)}\right] v_{in}$$

$$v_{in} = \left(\frac{R_i}{R_i + R_{si}}\right) v_i$$

$$A_v = \frac{v_o}{v_i} = \frac{g_m(R_s \| r_o)}{1 + g_m(R_s \| r_o)} \left(\frac{R_i}{R_i + R_{si}}\right) = \frac{R_s \| r_o}{1/g_m + R_s \| r_o} \left(\frac{R_i}{R_i + R_{si}}\right)$$

→ output resistance / impedance

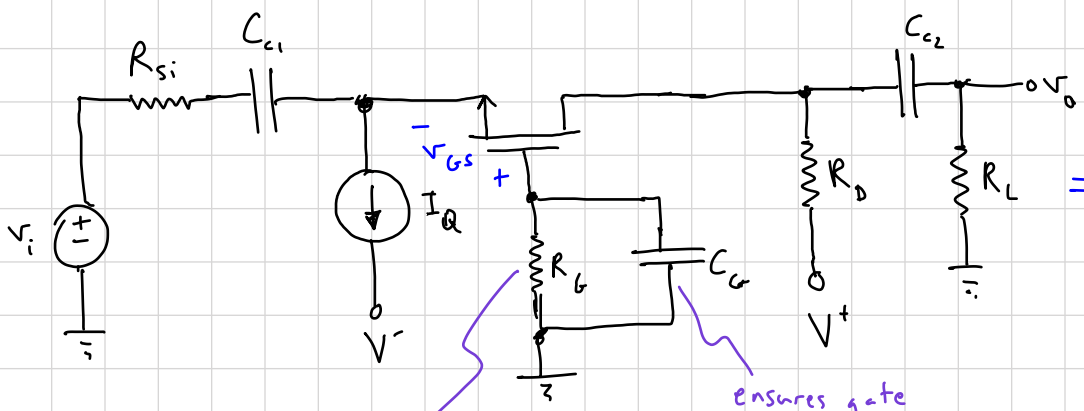
→ input and output impedances are important as they provide a "loading" effect

$$R_o = \frac{1}{g_m} \| R_s \| r_o$$

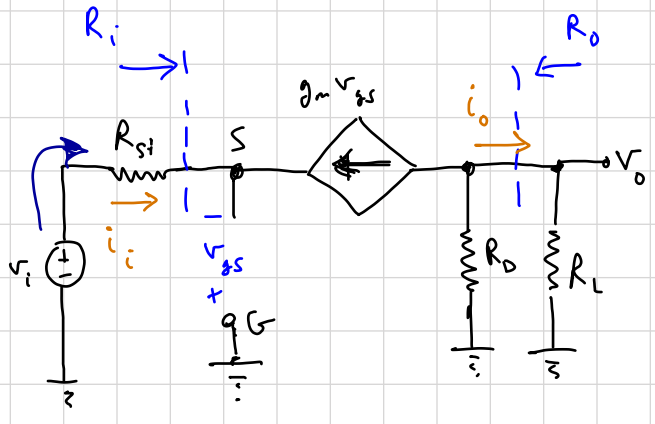
• Common-Gate Amplifier

→ gate at signal ground, input at source

→ Biased with constant current source for DC



small-signal ac equiv. circuit $\Rightarrow$



★ r_o assumed to be ∞

$$A_v = \frac{v_o}{v_i}$$

$$v_o = -(g_m v_{gs})(R_D \| R_L)$$

$$v_i = i_i R_{si} - v_{gs} \qquad i_i = -g_m v_{gs}$$

$$v_{gs} = \frac{-v_i}{1 + g_m R_{si}}$$

$$A_v = \frac{v_o}{v_i} = \frac{g_m (R_D \| R_L)}{1 + g_m R_{si}}$$

output & input are in-phase since A_v is positive

If input signal is a current (common for this config) then small-signal current gain:

$$A_i = \frac{i_o}{i_i} = \left(\frac{R_D}{R_D + R_L}\right)\left(\frac{g_m R_{si}}{1 + g_m R_{si}}\right)$$

Summary & Comparison: (pg. 620 of E-Book)

Table 4.2 Characteristics of the three MOSFET amplifier configurations

Configuration	Voltage gain	Current gain	Input resistance	Output resistance
Common source	$A_v > 1$	—	R_{TH}	Moderate to high
Source follower	$A_v \cong 1$	—	R_{TH}	Low
Common gate	$A_v > 1$	$A_i \cong 1$	Low	Moderate to high