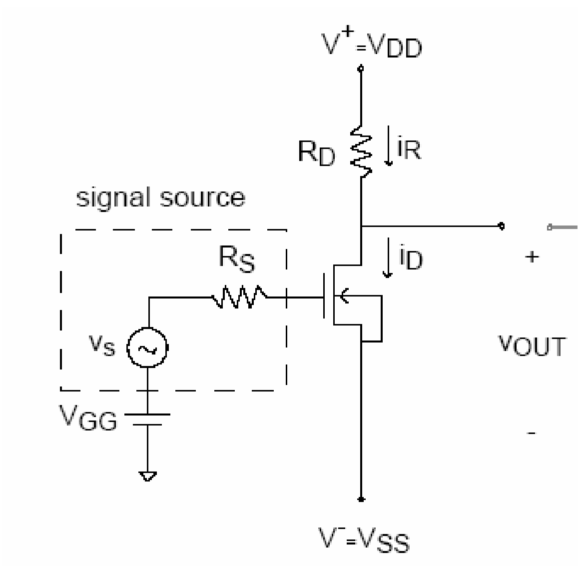
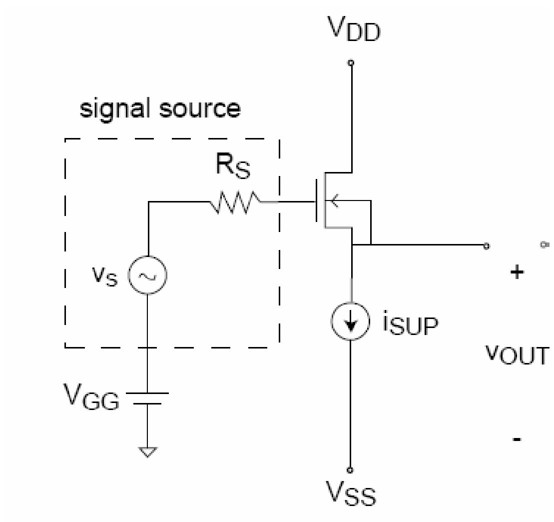
Lect. 6: Amplifiers (2)

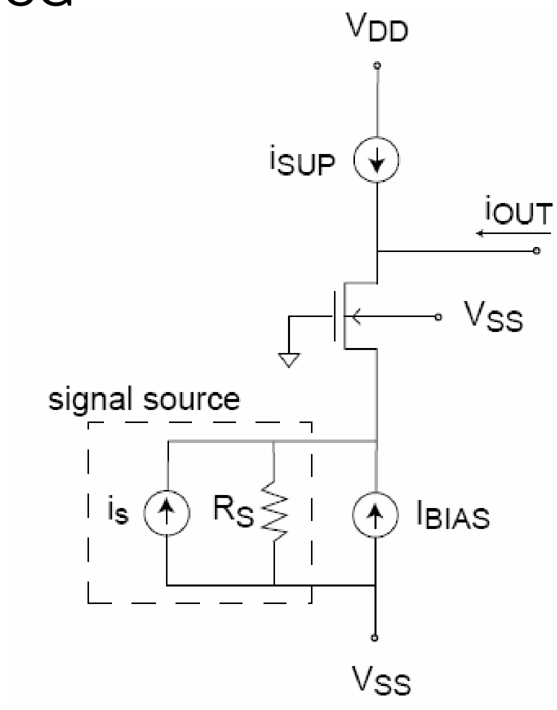
Three basic configurations: CS, CD, CG



Common Source



Common Drain
(Source Follwer)



Common Gate

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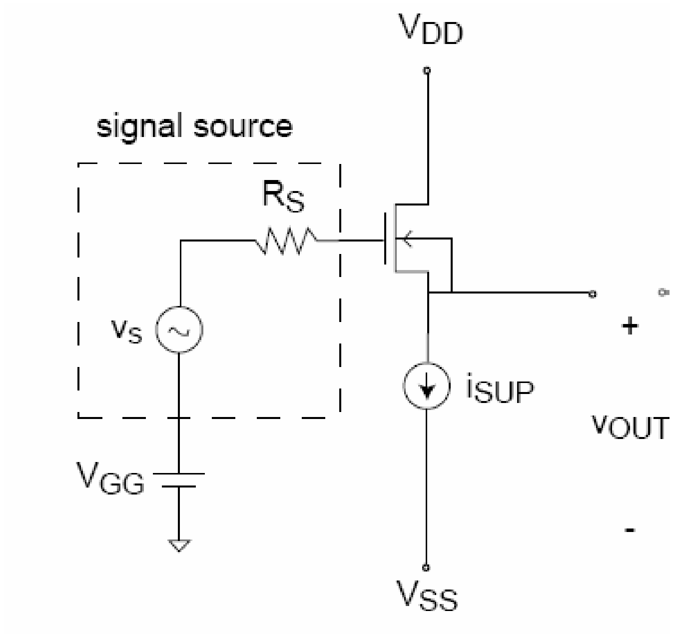
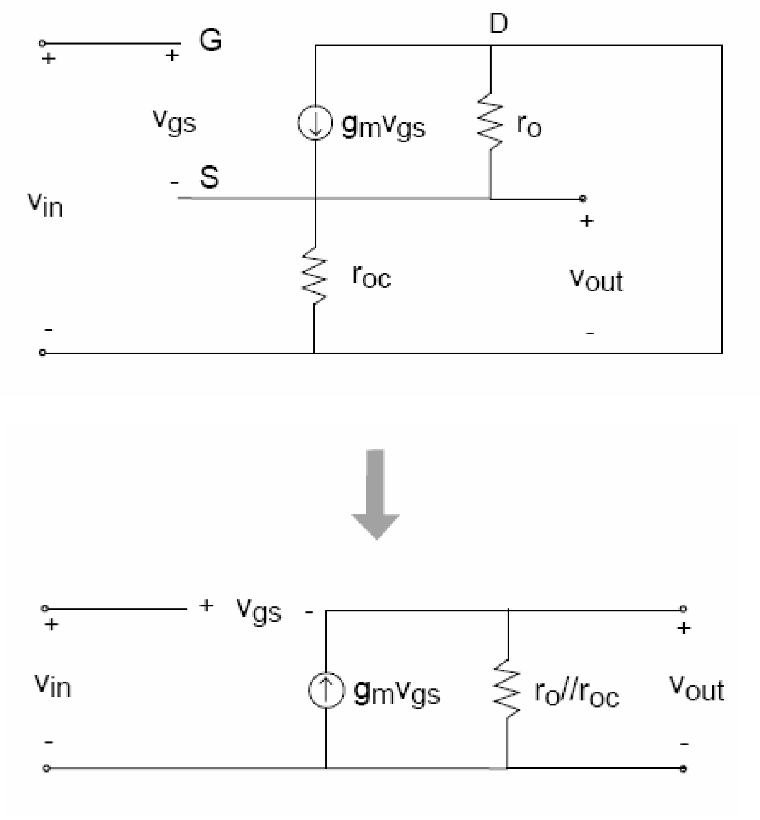
Common-Drain Amplifier
(Source Follower)



How does it work?

$$v_G \uparrow \Rightarrow \; i_D \text{ can't change} \Rightarrow \; v_{OUT} \uparrow$$
$$(source\ follower)$$

Small signal circuit
(No Body Effect)



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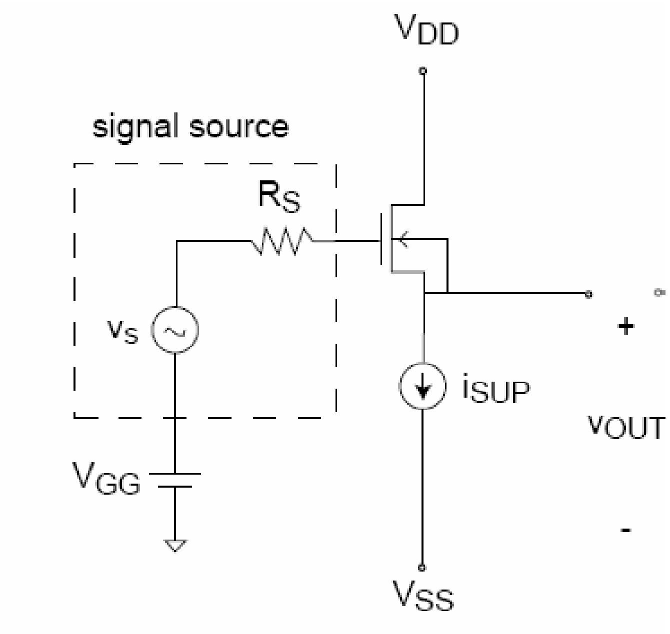
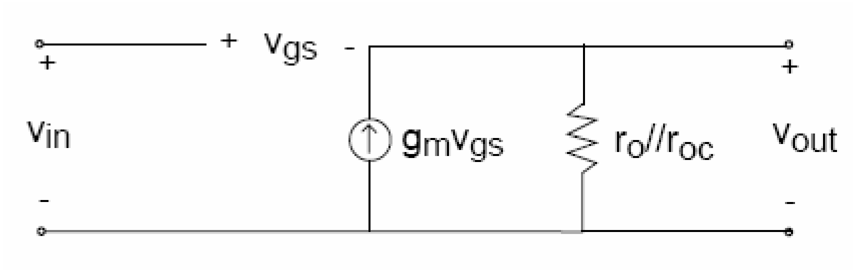
Lect. 6: Amplifiers (2)

Common-Drain Amplifier
(Source Follower)





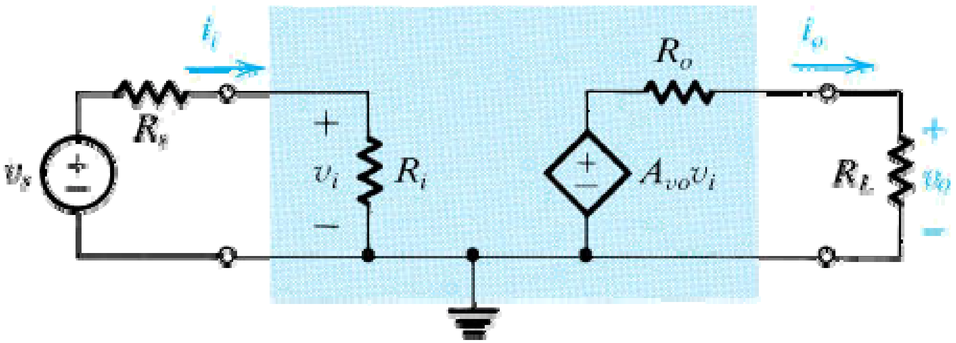
$$v_{in} = v_{gs} + v_{out}$$
$$v_{out} = g_m v_{gs}(r_o//r_{oc})$$
$$A_{vo} = \frac{g_m}{g_m + \frac{1}{r_o//r_{oc}}} \simeq 1$$

$$R_{in} = \infty$$
$$R_{out} = \frac{1}{g_m + \frac{1}{r_o//r_{oc}}} \simeq \frac{1}{g_m}$$

Large R_{in}, Small R_{out}

➔ Voltage amplifier   But (almost) unit voltage gain   ➔ Voltage buffer

Lect. 6: Amplifiers (2)



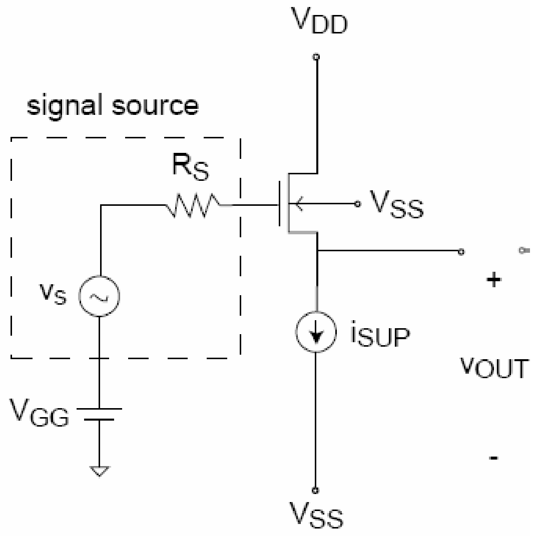
$$v_o = \frac{R_L}{R_L + R_o} A_{vo} v_i = \frac{R_L}{R_L + R_o} A_{vo} \frac{R_i}{R_i + R_s} v_s \simeq v_s$$

Source Follower: Large R_i, Small R_o, A_{vo} close to one

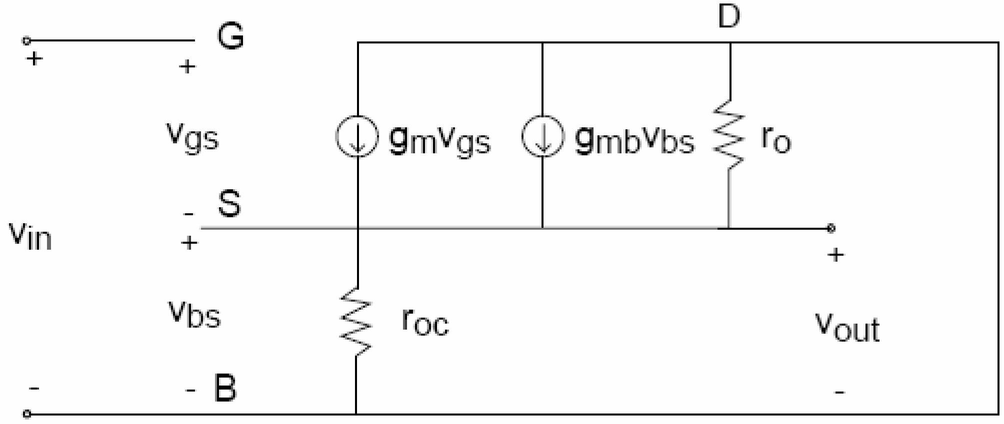
➔ Voltage buffer

Lect. 6: Amplifiers (2)

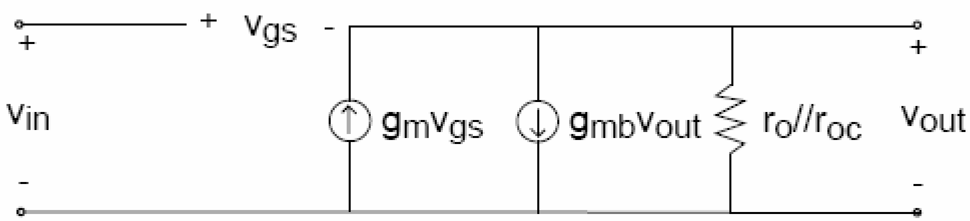
With Body Effect



$g_{mb} = \chi g_m$ (χ: 0.1-0.3)



$v_{bs} = -v_{out}$



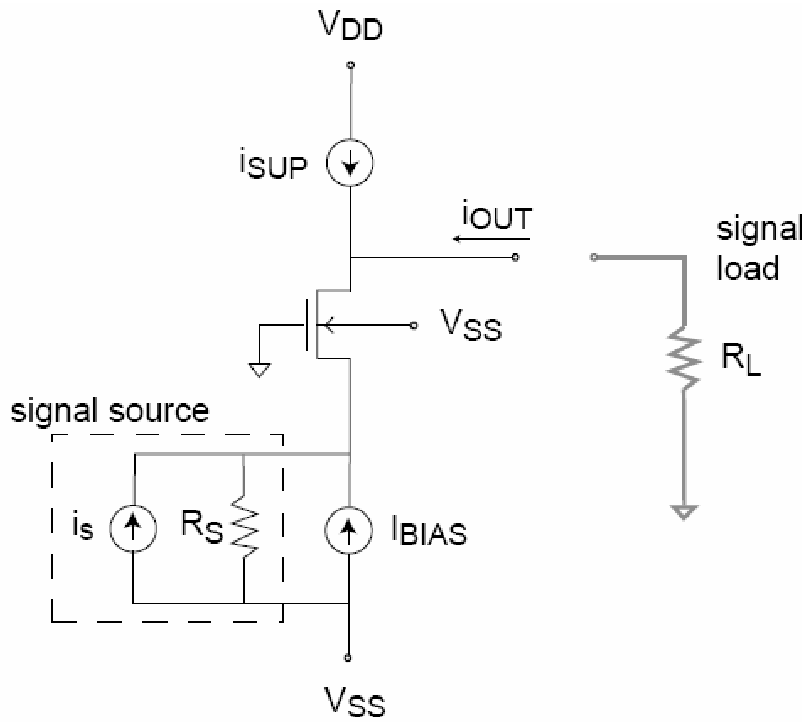
$$A_{vo} = \frac{g_m}{g_m + g_{mb} + \frac{1}{r_o//r_{oc}}} \simeq \frac{g_m}{g_m + g_{mb}}$$

$$R_{out} = \frac{1}{g_m + g_{mb} + \frac{1}{r_o//r_{oc}}} \simeq \frac{1}{g_m + g_{mb}}$$

$$R_{in} = \infty$$

Lect. 6: Amplifiers (2)

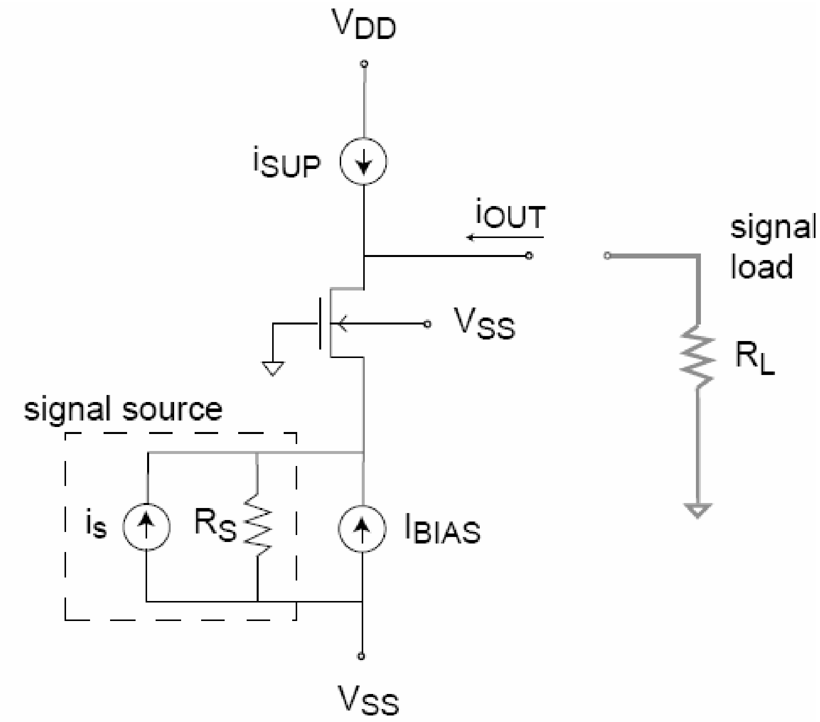
Common-Gate Amplifier (Current Buffer: Unit Current Gain, Low R_{in}, High R_{out})

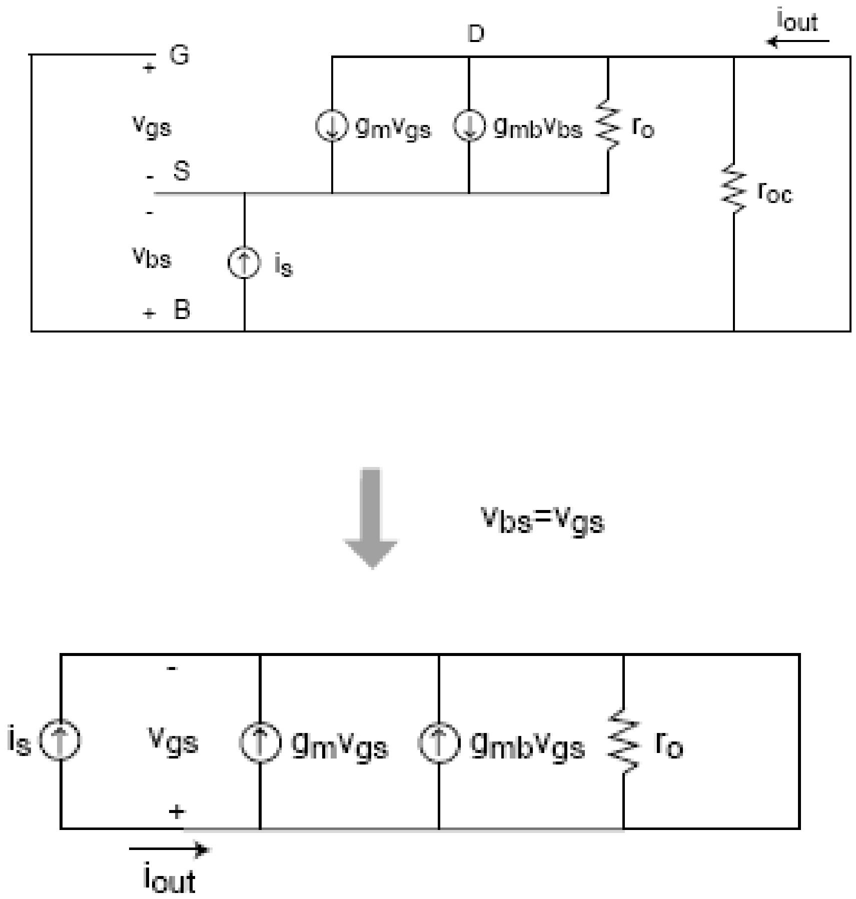


How does it work?

$$i_s \simeq -i_{out}$$

Common-Gate Amplifier





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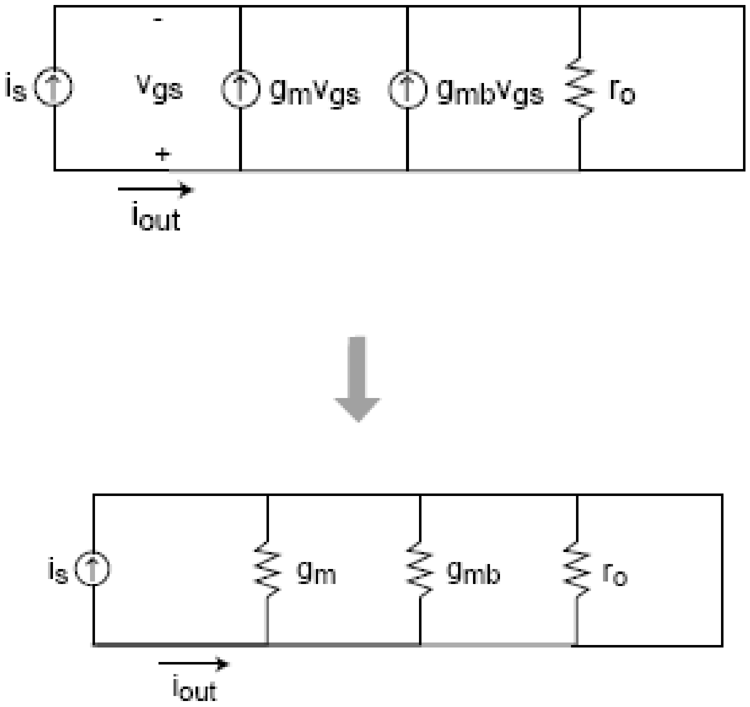
Lect. 6: Amplifiers (2)

Common-Gate Amplifier

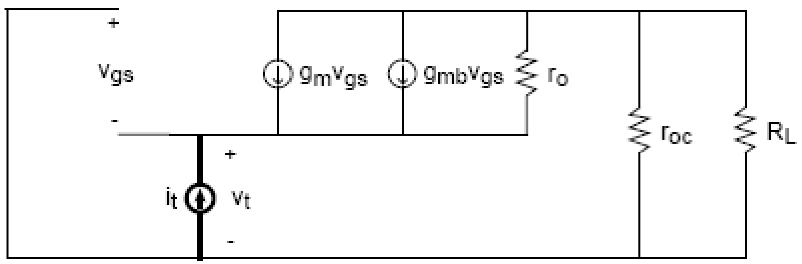


$$i_s = -i_{out}$$

Lect. 6: Amplifiers (2)

Common-Gate Amplifier

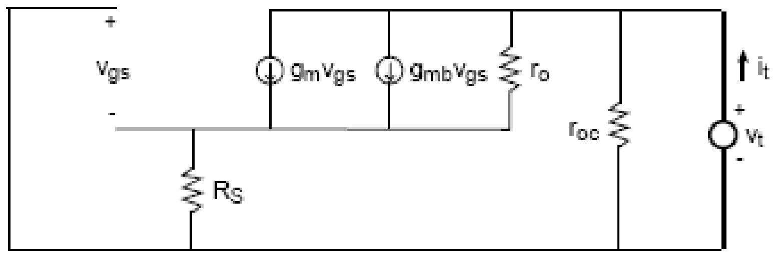
Input Resistance



$$R_{in} = \frac{1 + \frac{r_{oc}//R_L}{r_o}}{g_m + g_{mb} + \frac{1}{r_o}}$$

$$\simeq \frac{1}{g_m + g_{mb}}$$

Output Resistance



$$R_{out} = r_{oc}//\{r_o[1+R_S(g_m+g_{mb}+\frac{1}{r_o})]\}$$

$$\simeq r_{oc}//[r_o(1+g_m R_S)]$$

Lect. 6: Amplifiers (2)

stage	$A_{vo},\ G_{mo},\ A_{io}$	R_{in}	R_{out}	key function
common source	$G_{mo} = g_m$	∞	$r_o // r_{oc}$	transconductance amp.
common drain	$A_{vo} \simeq \frac{g_m}{g_m + g_{mb}}$	∞	$\frac{1}{g_m + g_{mb}}$	voltage buffer
common gate	$A_{io} \simeq -1$	$\frac{1}{g_m + g_{mb}}$	$r_{oc} // [r_o(1 + g_m R_S)]$	current buffer

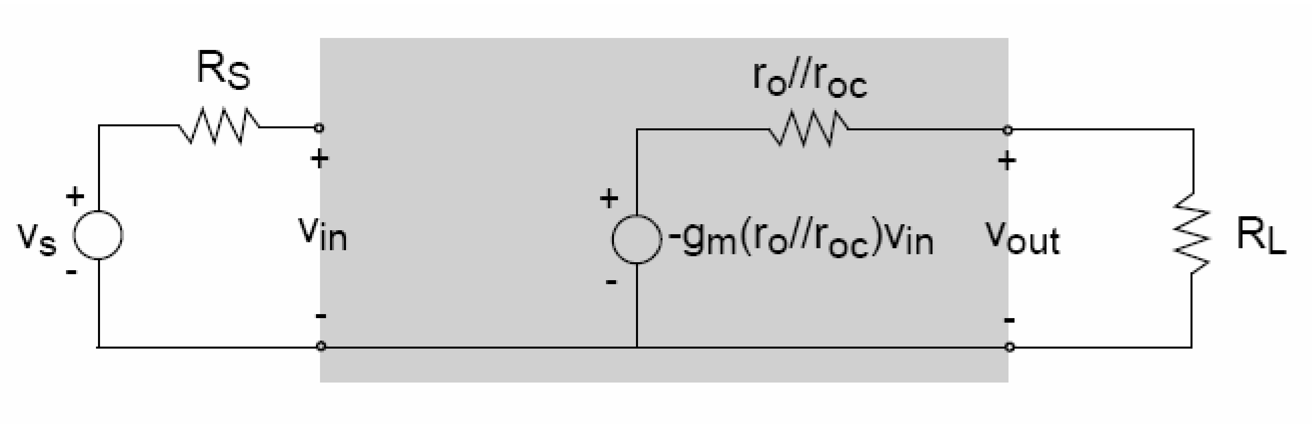
Amplifiers with other characteristics?

For example, a voltage amplifier with very high gain.

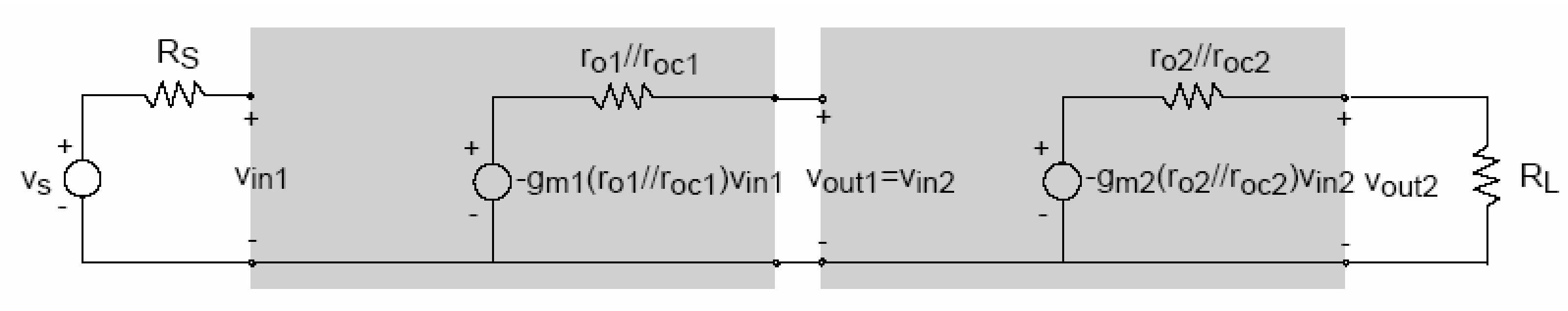
➔ Multistage amplifier

Lect. 6: Amplifiers (2)

- Start with CS

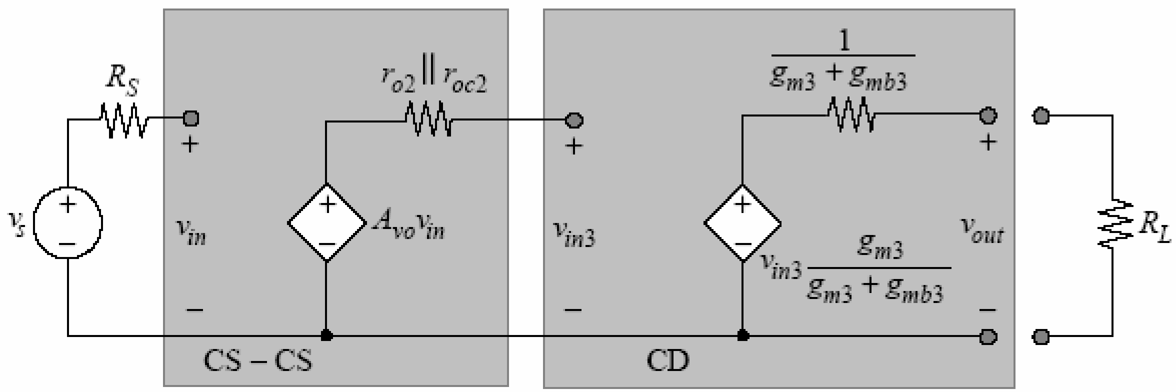


- More gain with another CS



$R_{in} = \infty \qquad A_{vo} = g_{m1}(r_{o1}//r_{oc1})g_{m2}(r_{o2}//r_{oc2}) \qquad R_{out} = r_{o2}//r_{oc2},$

- Add CD at output



$$R_{in} = \infty$$

$$A_{vo} = g_{m1}(r_{o1}//r_{oc1})g_{m2}(r_{o2}//r_{oc2})\frac{g_{m3}}{g_{m3}+g_{mb3}}$$

$$R_{out} = \frac{1}{g_{m3}+g_{mb3}}$$