

Lecture 19

OUTLINE

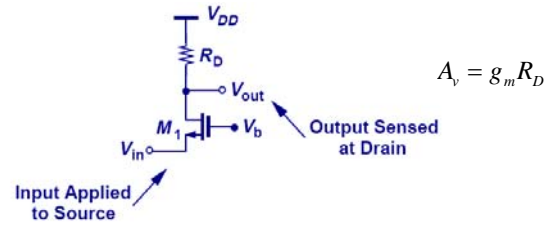
- Common-gate stage
- Source follower
- Reading: Chap. 7.3-7.4

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Common-Gate Stage



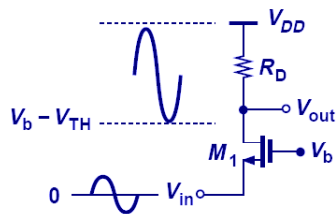
- Common-gate stage is similar to common-base stage: a rise in input causes a rise in output. So the gain is positive.

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Signal Levels in CG Stage



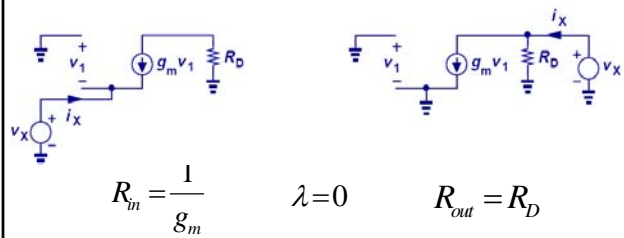
- In order to maintain M1 in saturation, the signal swing at V_{out} cannot fall below $V_b - V_{TH}$

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I/O Impedances of CG Stage



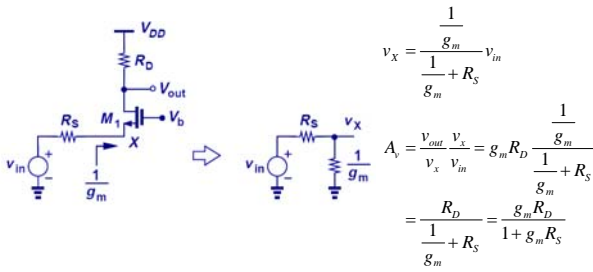
- The input and output impedances of CG stage are similar to those of CB stage.

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CG Stage with Source Resistance



$$v_x = \frac{1}{\frac{1}{g_m} + R_S} v_{in}$$

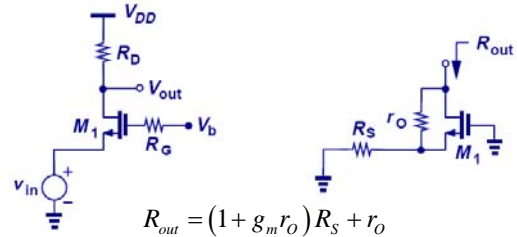
$$A_v = \frac{v_{out}}{v_x} \frac{v_x}{v_{in}} = g_m R_D \frac{1}{1 + R_S/g_m}$$

$$= \frac{R_D}{\frac{1}{g_m} + R_S} = \frac{g_m R_D}{1 + g_m R_S}$$

- When a source resistance is present, the voltage gain is equal to that of a CS stage with degeneration, only positive.

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Generalized CG Behavior

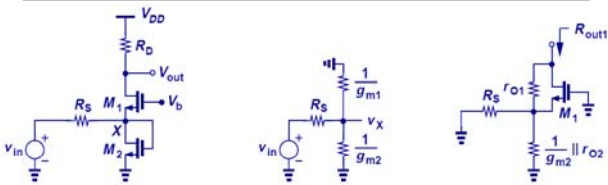


$$R_{out} = (1 + g_m r_o) R_S + r_o$$

- When a gate resistance is present it does not affect the gain and I/O impedances since there is no potential drop across it (at low frequencies).
- The output impedance of a CG stage with source resistance is identical to that of CS stage with degeneration.

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Example of CG Stage



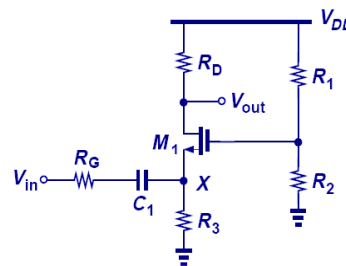
$$\frac{v_{out}}{v_{in}} = \frac{g_{m1} R_D}{1 + (g_{m1} + g_{m2}) R_S}$$

$$R_{out} \approx \left[g_{m1} r_{o1} \left(\frac{1}{g_{m2}} \parallel R_S \right) + r_{o1} \right] \parallel R_D$$

- Diode-connected M2 acts as a resistor to provide the bias current.

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CG Stage with Biasing

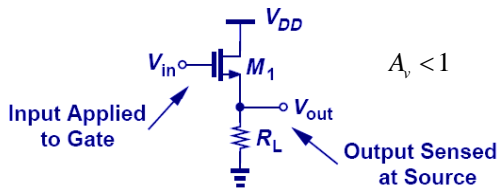


$$\frac{v_{out}}{v_{in}} = \frac{R_3 \parallel (1/g_m)}{R_3 \parallel (1/g_m) + R_G} \cdot g_m R_D$$

- R₁ and R₂ provide gate bias voltage, and R₃ provides a path for DC bias current of M₁ to flow to ground.

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Source Follower Stage

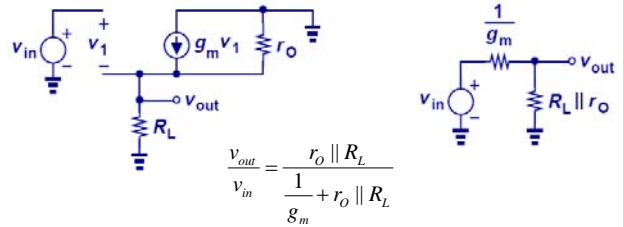


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Source Follower Core



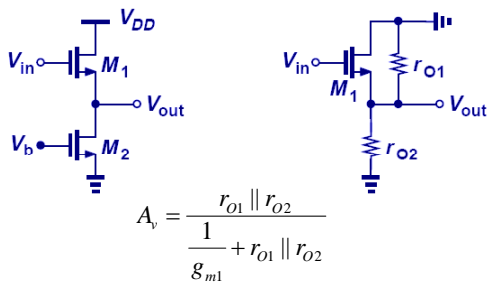
- Similar to the emitter follower, the source follower can be analyzed as a resistor divider.

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Source Follower Example



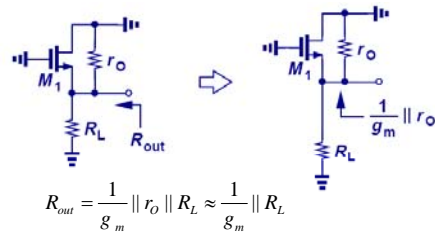
- In this example, M_2 acts as a current source.

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Output Resistance of Source Follower



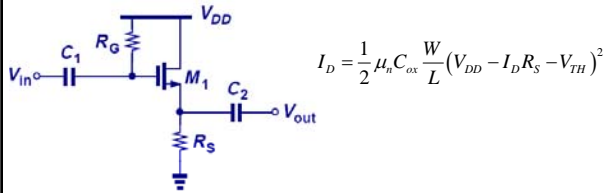
- The output impedance of a source follower is relatively low, whereas the input impedance is infinite (at low frequencies); thus, a good candidate as a buffer.

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Source Follower with Biasing



$$I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{DD} - I_D R_S - V_{TH})^2$$

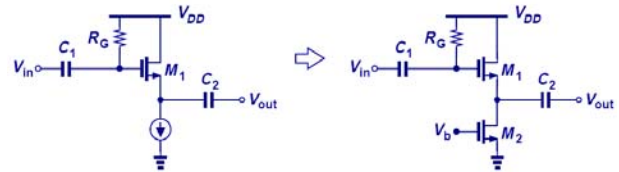
- R_G sets the gate voltage to V_{DD} , whereas R_S sets the drain current
- The quadratic equation above can be solved for I_D

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Supply-Independent Biasing



- If R_S is replaced by a current source, drain current I_D becomes independent of supply voltage.

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