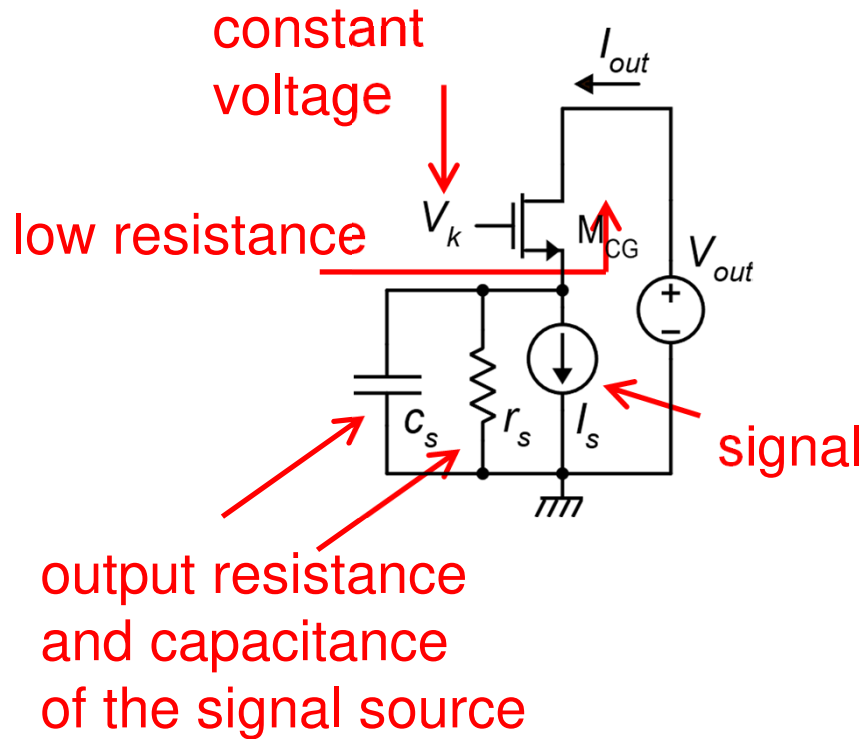
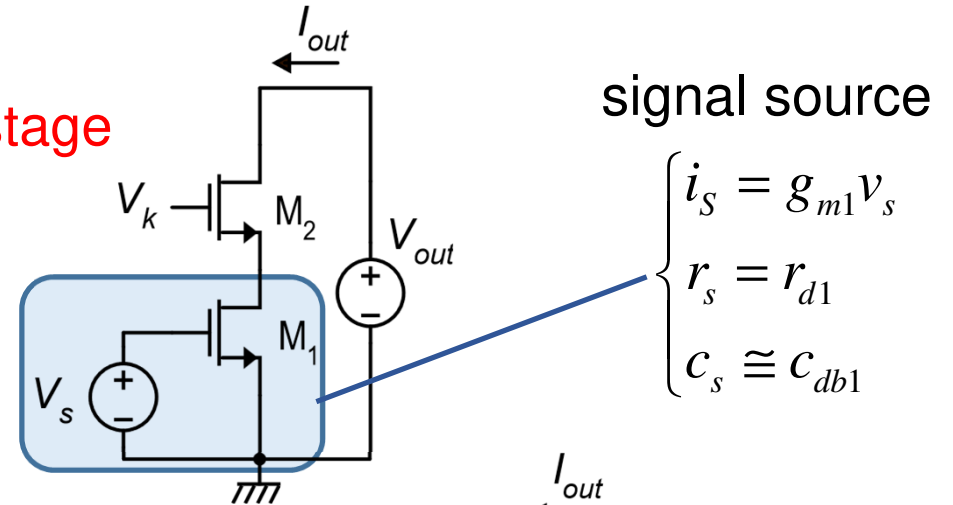


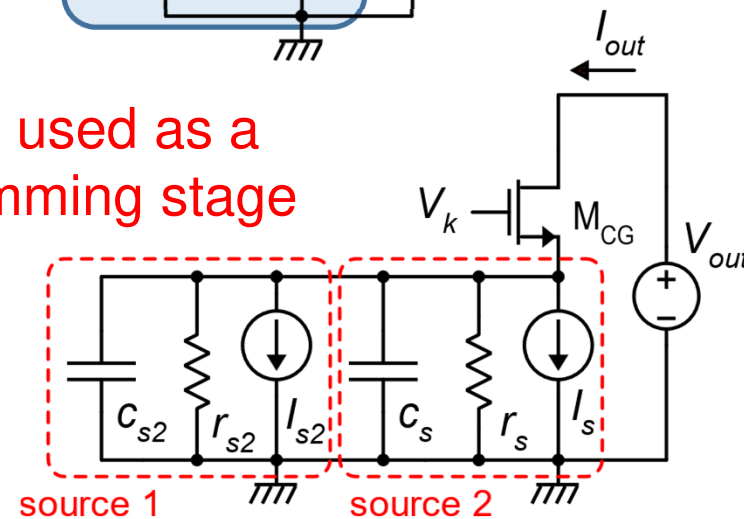
The common gate (CG) stage



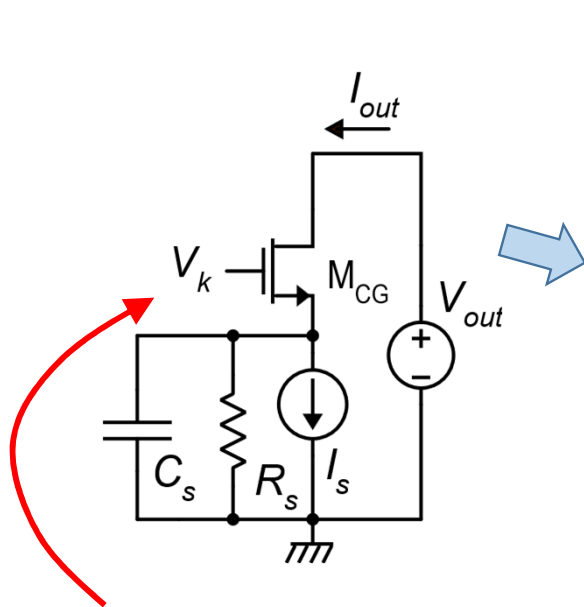
Example:
cascode stage



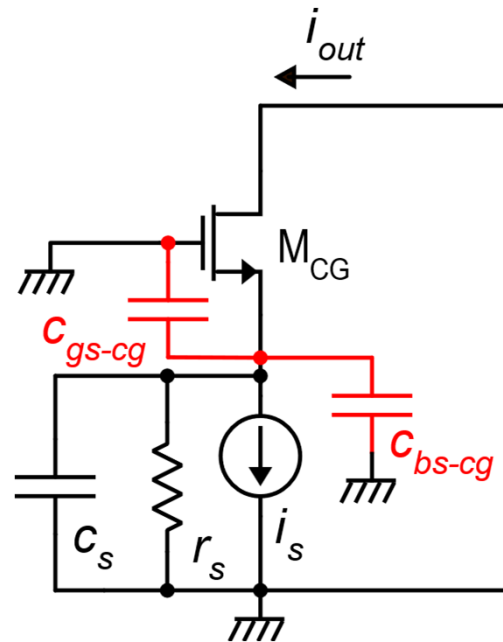
CG used as a
summing stage



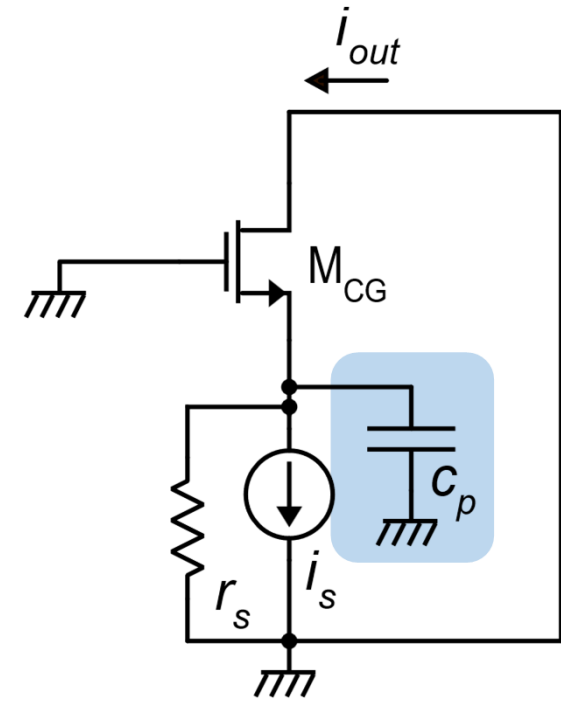
Frequency response of the common gate stage



Hypothesis: V_k is at *gnd* in the small signal circuit. For example, it is provided by an ideal voltage source

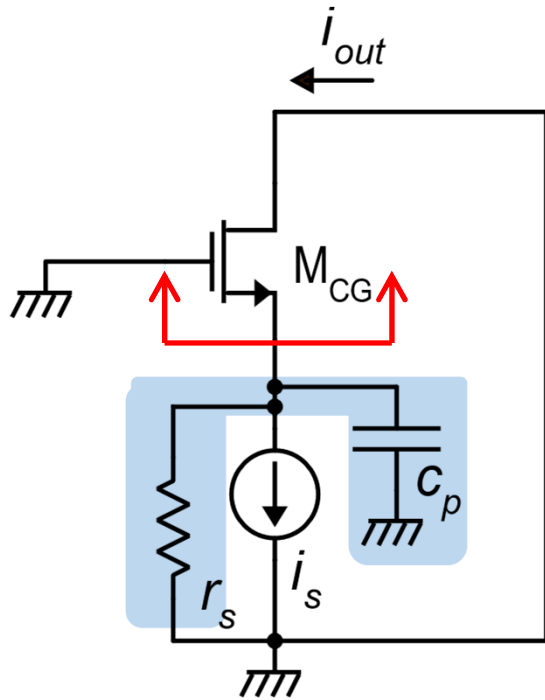


small-signal circuit with parasitic capacitances



$$C_p = C_{gs-cg} + C_{bs-cg} + C_s$$

Frequency response of the common gate stage



current division
between R_{in} and z_s

$$i_{out} = i_s \frac{z_s}{z_s + \frac{1}{g_{m-cg}}} = i_s \frac{1}{1 + \frac{1}{g_{m-cg} z_s}}$$

$$\frac{1}{z_s} = \frac{1}{r_s} + sC_p$$

$$i_{out} = i_s \frac{1}{1 + \frac{1}{g_{m-cg}} \left(\frac{1}{r_s} + sC_p \right)}$$

$$i_{out} = i_s \frac{1}{1 + \frac{1}{g_{m-cg} r_s} + \frac{sC_p}{g_{m-cg}}}$$

$$R_{in} = \frac{1}{g_{mb-cg} + g_{m-cg}} \cong \frac{1}{g_{m-cg}}$$

Frequency response of the common gate stage

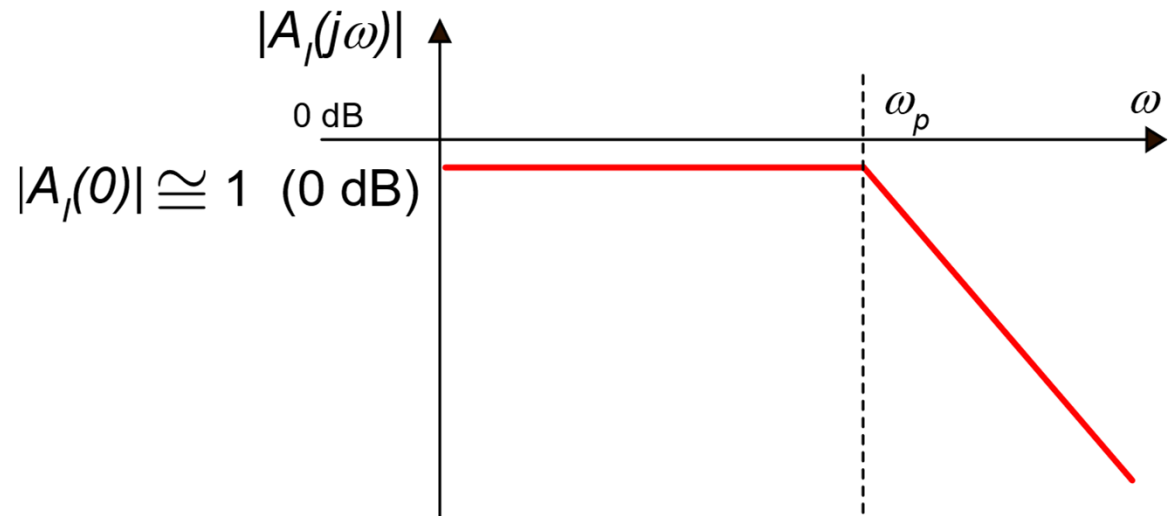
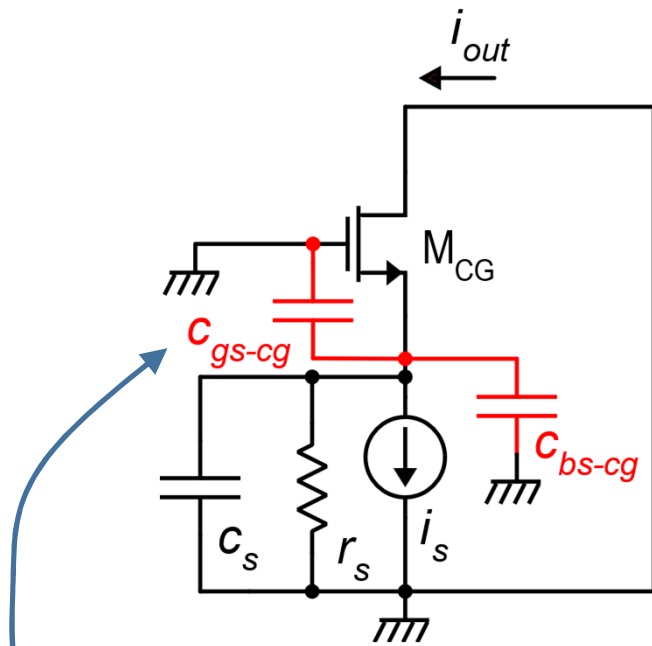
$$i_{out} = i_s \frac{1}{1 + \frac{1}{g_{m-cg} r_s} + \frac{sC_p}{g_{m-cg}}} \quad \frac{i_{out}}{i_s} = A_I(s) = \frac{1}{1 + \frac{1}{g_{m-cg} r_s}} \cdot \frac{1}{1 + s \frac{C_p}{g_{m-cg}} \left(1 + \frac{1}{g_{m-cg} r_s}\right)^{-1}}$$

$A_{I-CG}(0)$

$$A_{I-CG}(s) = A_{I-CG}(0) \frac{1}{1 + \frac{s}{\omega_p}} \quad \text{Typical case: } r_s \gg \frac{1}{g_{m-cg}} \Rightarrow g_{m-cg} r_s \gg 1$$

$$A_{I-CG}(0) = \frac{1}{1 + \frac{1}{g_{m-cg} r_s}} \cong 1 \quad \omega_p \cong \frac{g_{m-cg}}{C_p}$$

Frequency response of the common gate stage

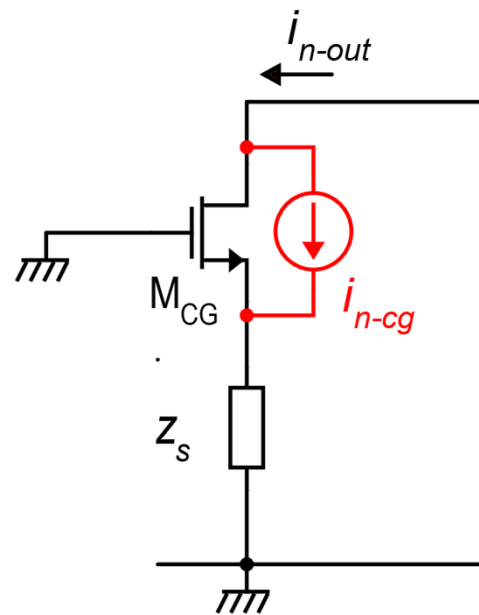


In many cases, the main contribution to C_p is the C_{gs} of the CG MOSFET

$$\omega_p \cong \frac{g_{m-cg}}{C_p}$$

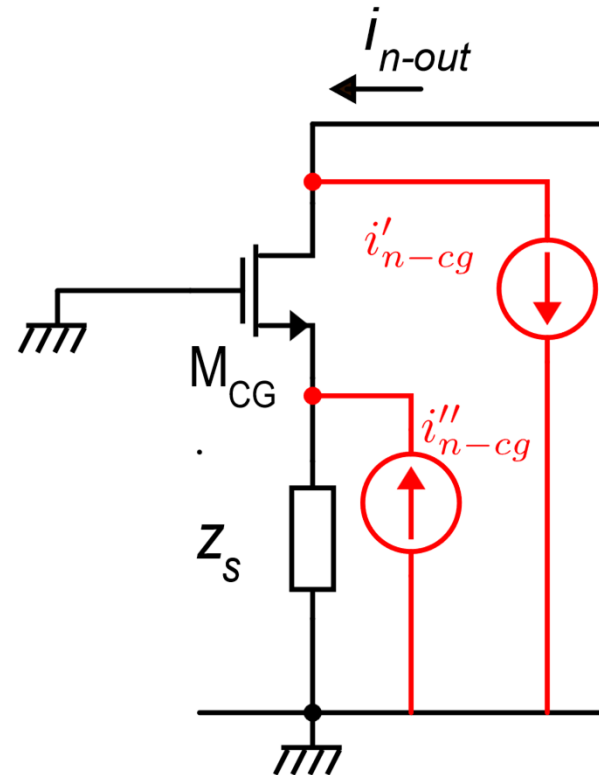
$$f_p \cong \frac{1}{2\pi} \frac{g_{m-cg}}{C_{gs-cg}} \cong f_{T-CG}$$

Noise contribution of a CG stage



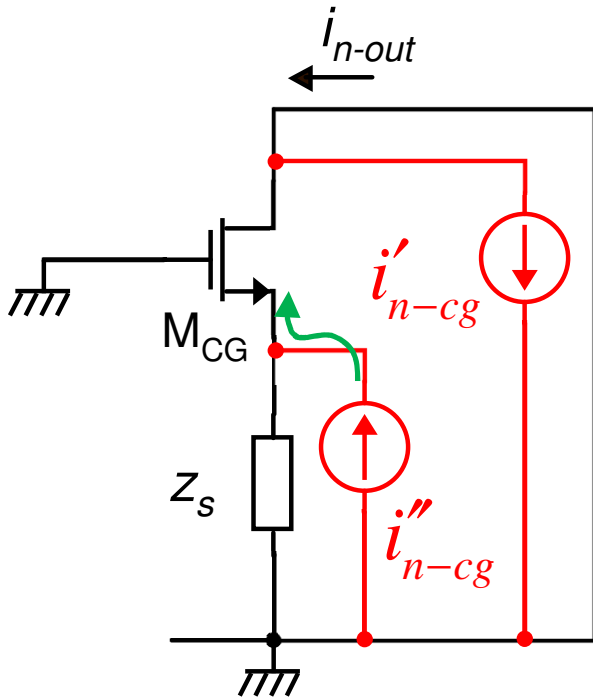
$$Z_s = C_p // r_s$$

Every time we have a floating current source, we can split it into two sources with one terminal at ground



$$i'_{n-cg} = i''_{n-cg} = i_{n-cg}$$

Noise contribution of a CG stage



$$i_{n-out} = i'_{n-cg} - i''_{n-cg} A_I(s) = i_{n-cg} [1 - A_I(s)]$$

$$i'_{n-cg} = i''_{n-cg} = i_{n-cg}$$

$$\text{In DC: } A_I = A_{I-CG}(0) = \frac{1}{1 + \frac{1}{g_{m-cg} r_s}} = \frac{g_{m-cg} r_s}{1 + g_{m-cg} r_s}$$

$$1 - A(0) = 1 - \frac{g_{m-cg} r_s}{1 + g_{m-cg} r_s} = \frac{1}{1 + g_{m-cg} r_s}$$

$$\frac{i_{n-out}}{i_{n-cg}} \cong \frac{1}{1 + g_{m-cg} r_s}$$

Summary of properties of a CG stage in typical cases

$$r_s \gg \frac{1}{g_{m-cg}} \Rightarrow g_{m-cg} r_s \gg 1$$

$$1. \quad A_{I-CG}(0) = \frac{g_{m-cg} r_s}{1 + g_{m-cg} r_s} \cong 1$$

$$2. \quad \omega_p \cong \frac{g_{m-cg}}{C_p} \quad C_p \cong C_{gs-cg}$$

$$3. \quad \frac{i_{n-out}}{i_{n-cg}} = |1 - A(j\omega)| \leftarrow \text{Usually, this factor is } \ll 1 \text{ for } f \ll f_p = \frac{\omega_p}{2\pi}$$

$$\text{In DC: } \frac{i_{n-out}}{i_{n-cg}} = \frac{1}{1 + g_{m-cg} r_s} \cong \frac{1}{g_{m-cg} r_s} \ll 1$$

