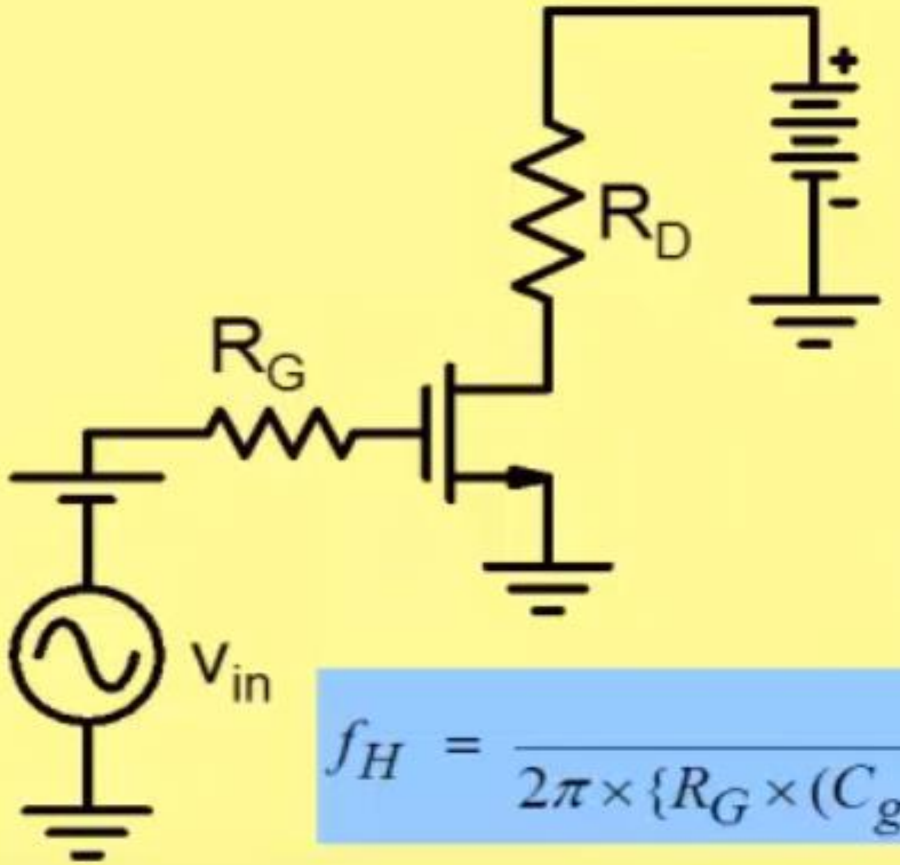
Common Gate Amplifier

Why do we want another amplifier configuration?

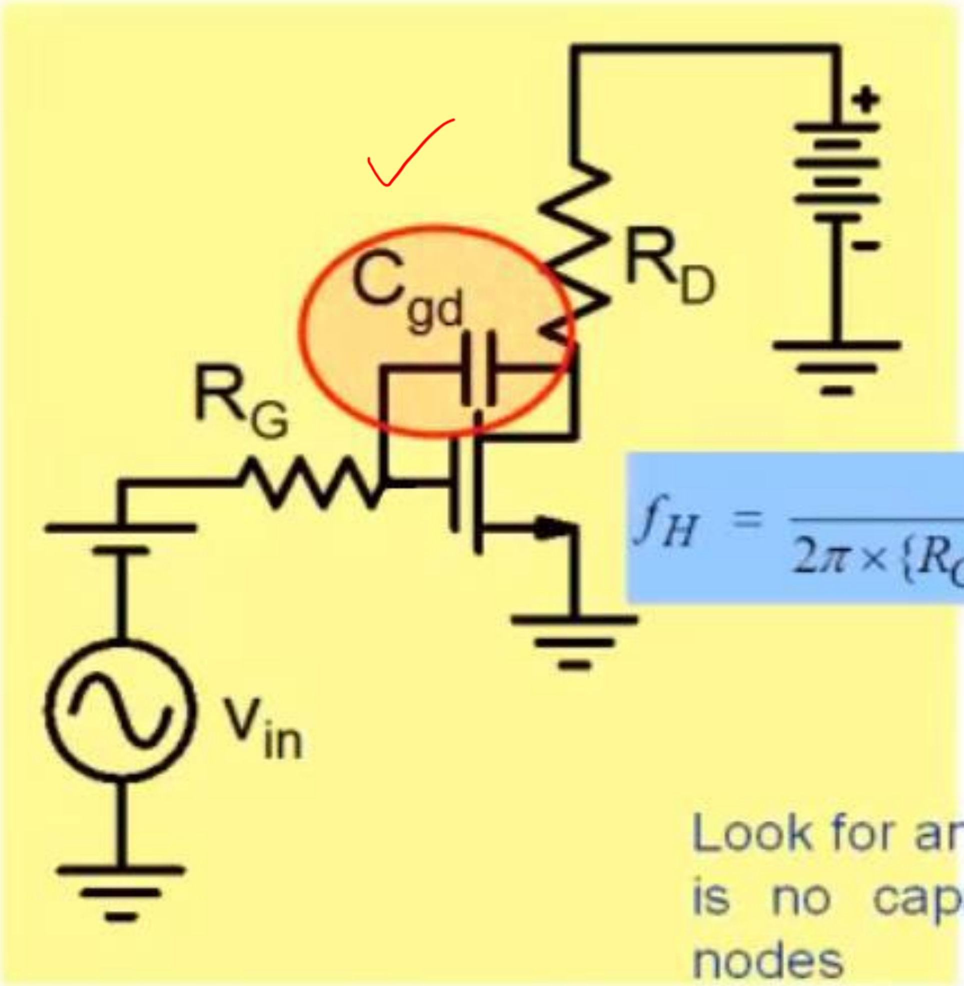
Problem with CS amplifier:



$$f_H = \frac{1}{2\pi \times \{R_G \times (C_{gs} + C_{gd}(1 - A_V)) + R_D \times (C_{gd} + C_{db})\}}$$

Increase in voltage gain reduces Bandwidth

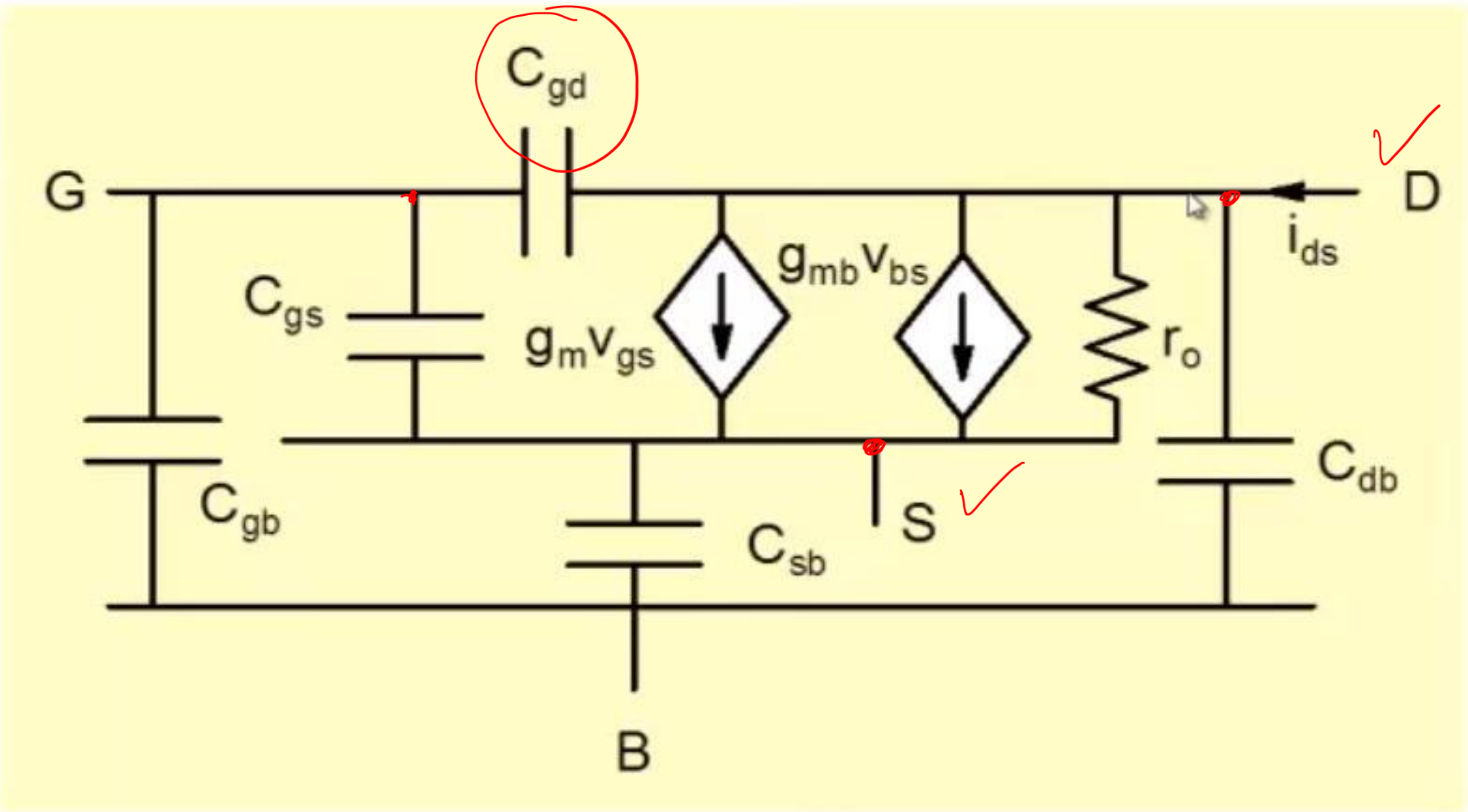
How do we eliminate the Miller Capacitance?



$$f_H = \frac{1}{2\pi \times \{R_G \times (C_{gs} + C_{gd}(1 - A_V)) + R_D \times (C_{gd} + C_{db})\}}$$

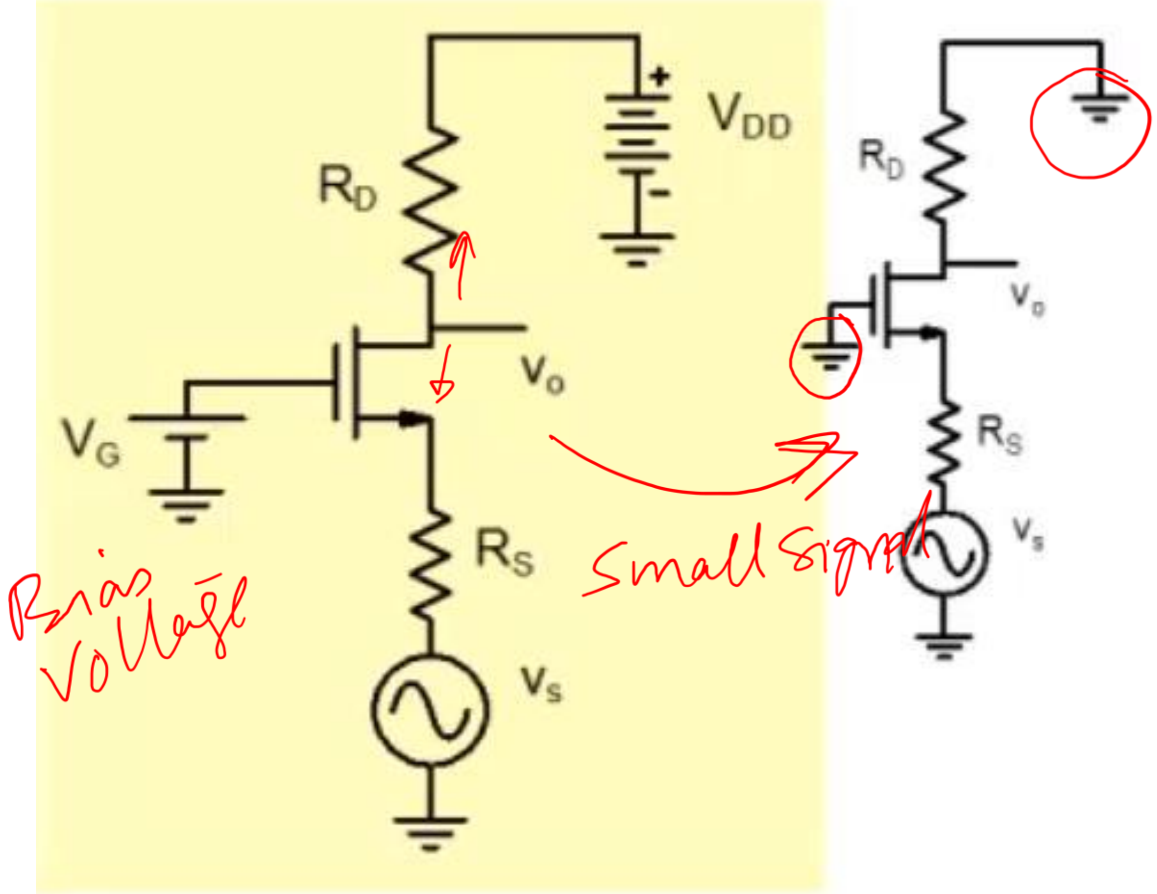
Look for an amplifier configuration in which there is no capacitance between input and output nodes

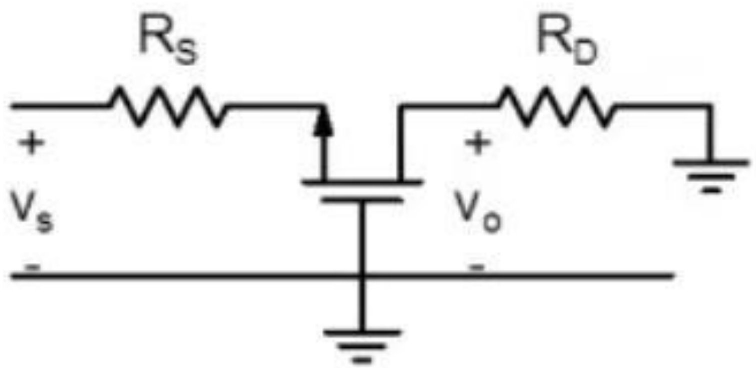
Let's understand from MOS high frequency small signal model



Apply input at source and take output at drain

CG amplifier



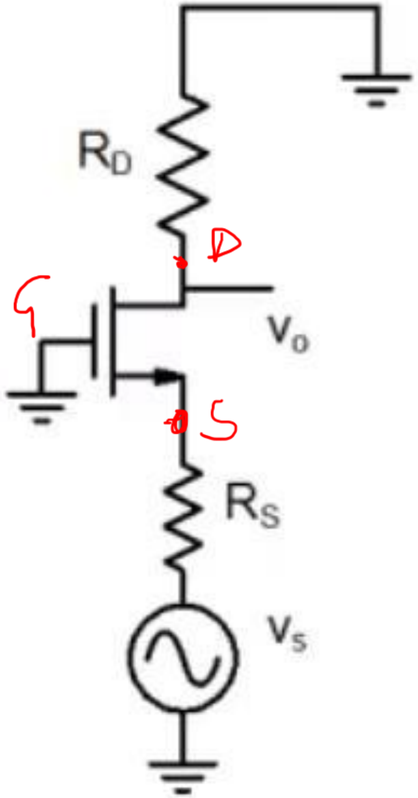


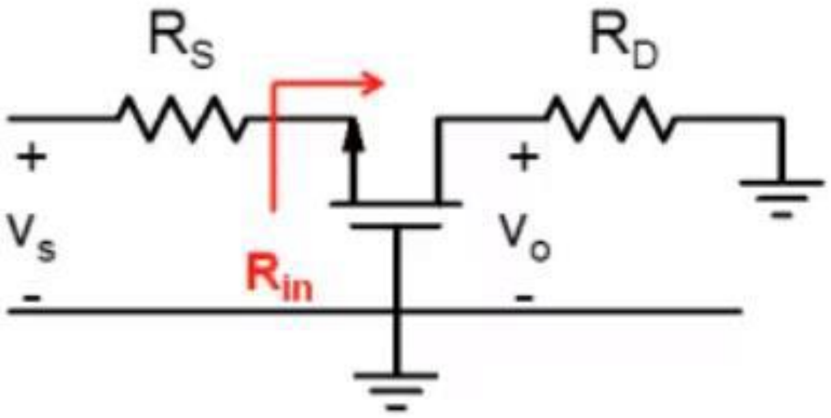
Gate is common to both input and output ports and hence the name Common Gate Amplifier

$$A_V \cong \frac{(g_m + g_{mb})}{1+(g_m+g_{mb})R_S} \times R_D$$

$$R_O \cong R_D$$

Non-inverting amplifier





$$R_{in} \cong \frac{1 + R_D / r_o}{g_m + g_{mb}}$$

$$r_o \gg R_D$$

$$\boxed{R_{in} \cong \frac{1}{g_m + g_{mb}}}$$

$r_o \cong 4M\Omega$

$R_D \cong 80k\Omega$

$10k\Omega$

If we take; $g_m = 100\mu A/V; g_{mb} = 42\ \mu A/V$ for $I_{DSQ} = 25\mu A$

R_{in} is around 7K

Compare CS and CG (A_v, R_{in}, R_o)

CG

$$A_V \cong \frac{(g_m + g_{mb})}{1+(g_m + g_{mb})R_S} \times R_D$$

if R_S is small $\Rightarrow A_v \cong (g_m + g_{mb}) \cdot R_D$

$$R_O \cong R_D$$

$$R_{in} \cong \frac{1+R_D/r_o}{g_m + g_{mb}}$$

→ CG is a inferior voltage Amp

CS

$$A_V \cong -g_m R_D$$

$$R_O \cong R_D$$

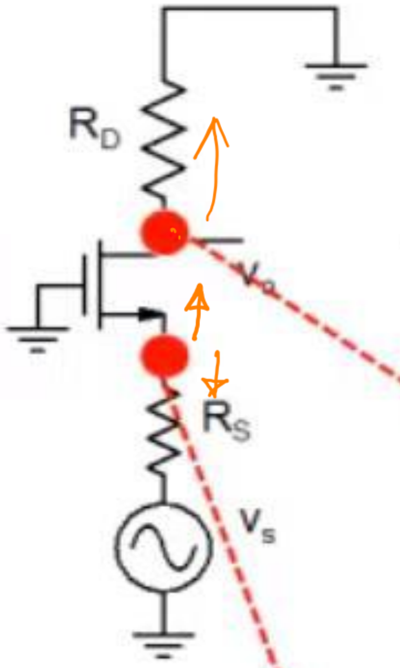
$$R_{in} \to \infty$$

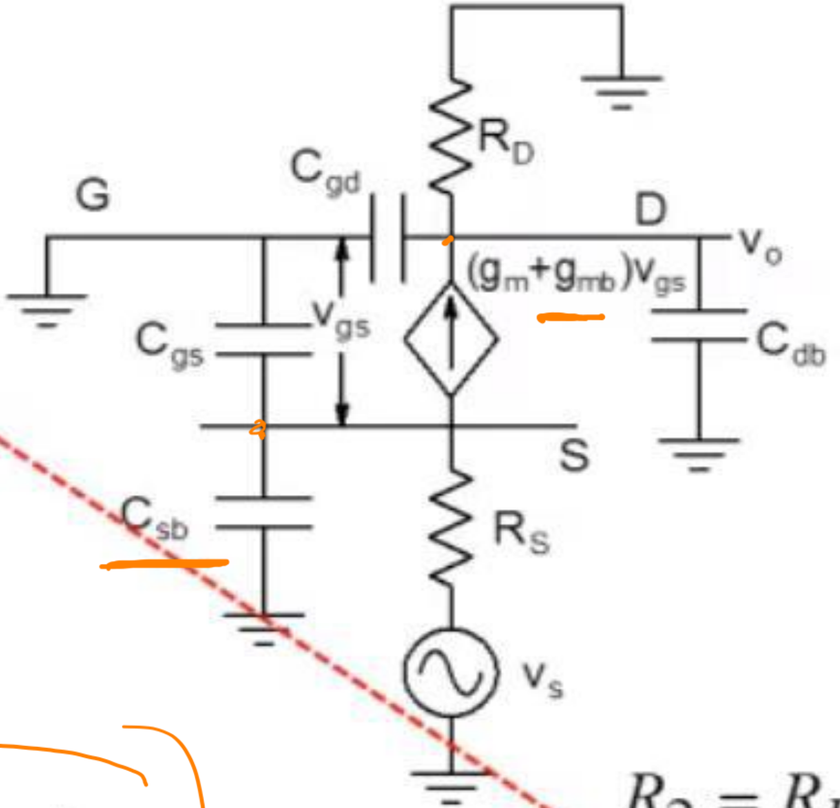
- A CG amplifier thus has similar voltage gain and output resistance as a CS amplifier but has a very low input impedance

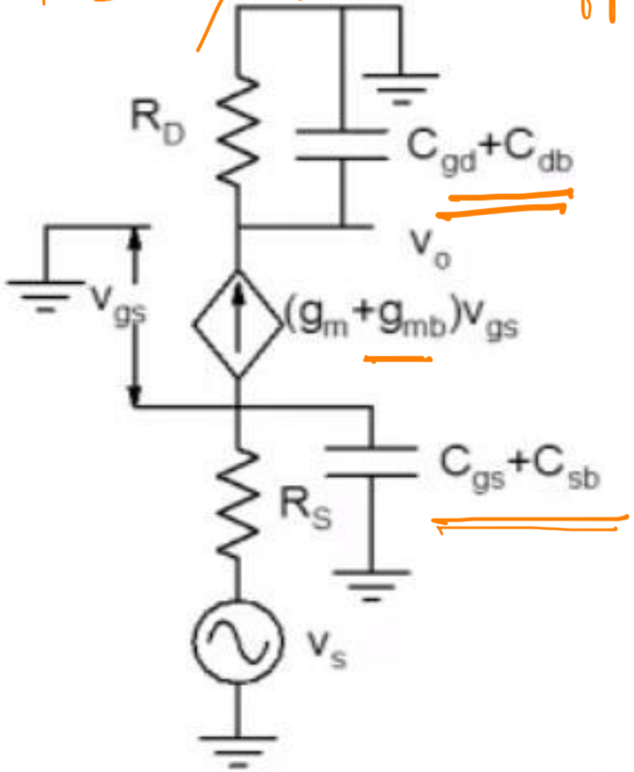
$$\frac{A_V \times R_{in}}{R_o} = 1 \text{ for negligible } R_S$$

Frequency Response

C_{sb} → Have to include for C-G configuration.
→ Source and Body are at different potential







$$R_1 = \frac{1}{g_m + g_{mb}} \| R_S$$

$$C_1 = C_{gs} + C_{sb}$$

$\tau_{in} =$

$\tau_1 = R_1 C_1$

$$R_2 = R_D \| r_{o1} \simeq R_D$$

$$C_2 = C_{gd} + C_{db}$$

$\tau_2 = R_2 C_2$

or

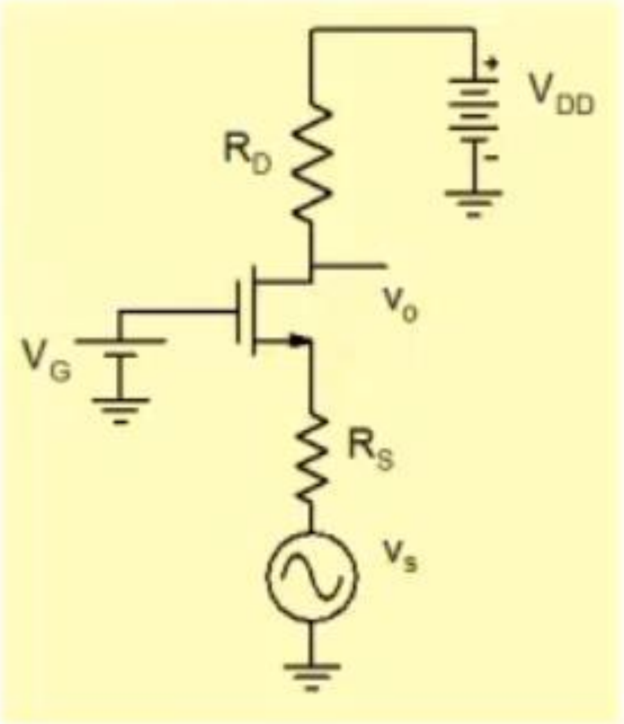
τ_{out}

$$f_{3dB} \cong \frac{1}{2\pi R_D (C_{gd} + C_{db})}$$

$\boxed{R_2 C_2 >> R_1 C_1}$

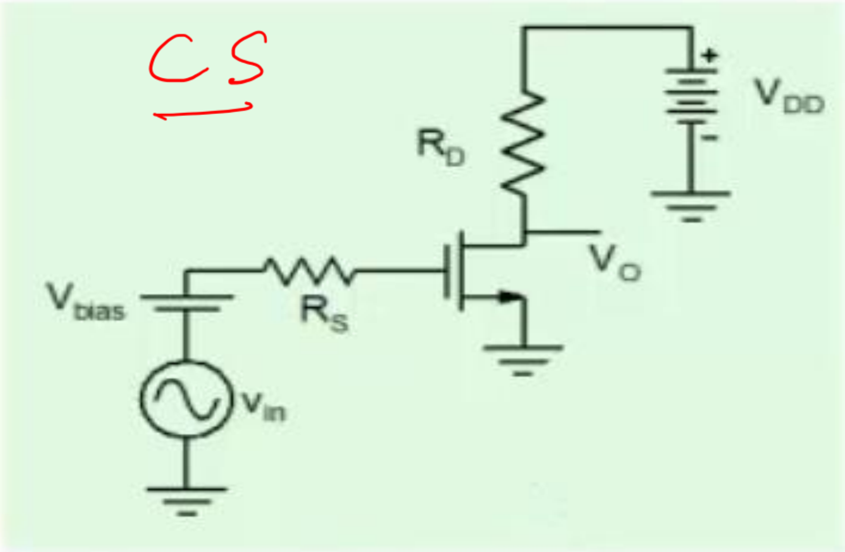
→ $\boxed{f_{3dB} \text{ can be approximated by } \tau_2}$

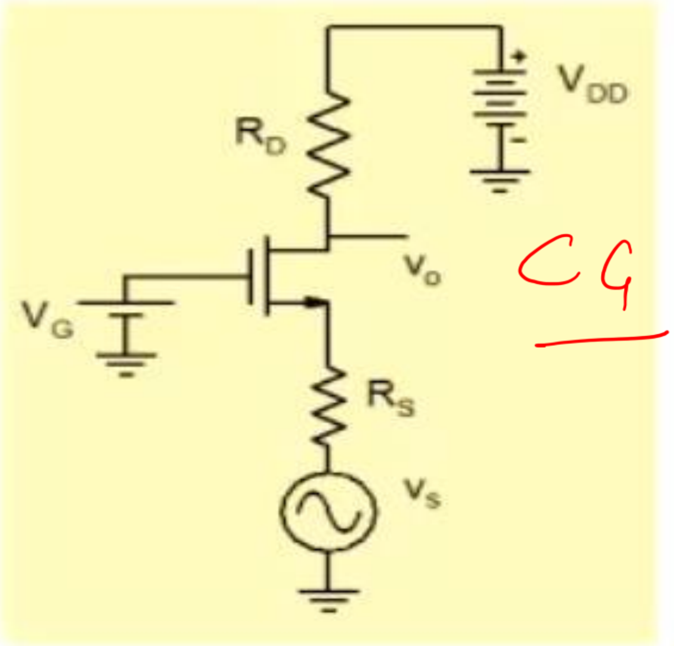
Output Swing



Output swing is similar to CS amplifier determined by transistor entering linear region and harmonic distortion

CS-CG Comparison





$$A_V \cong -g_m R_D$$

$$R_O \cong R_D$$

$$R_{in} \cong \text{very high}$$

$$f_{3dB} = \frac{1}{2\pi R_S(C_{gs} + C_{gd}(1 - A_V)) + R_D(C_{gd} + C_{db})}$$

$$A_V \cong \frac{(g_m + g_{mb})}{1 + (g_m + g_{mb})R_S} \times R_D$$

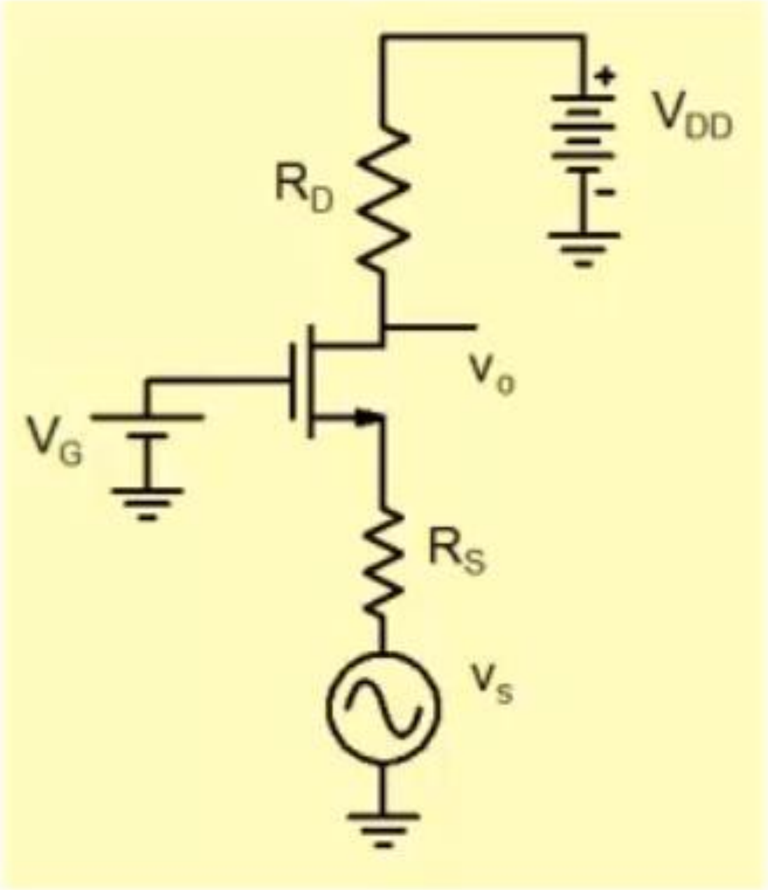
$$R_O \cong R_D$$

$$R_{in} \cong \frac{1 + R_D / r_o}{g_m + g_{mb}}$$

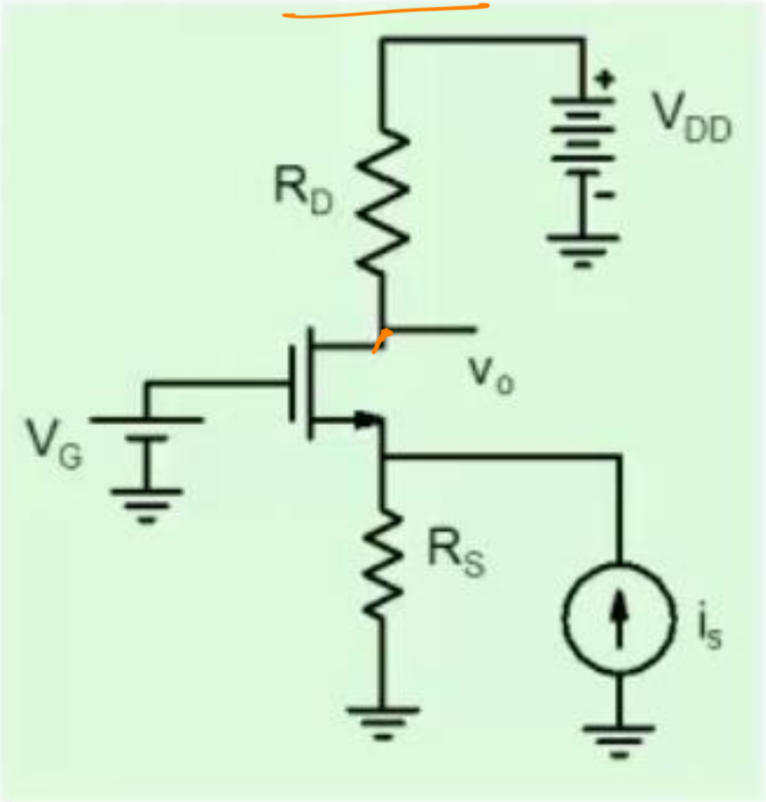
$$f_{3dB} \cong \frac{1}{2\pi R_D(C_{gd} + C_{db})}$$

⇒ CS is a good voltage to current converter.

⇒ CG is a good current to voltage converter.

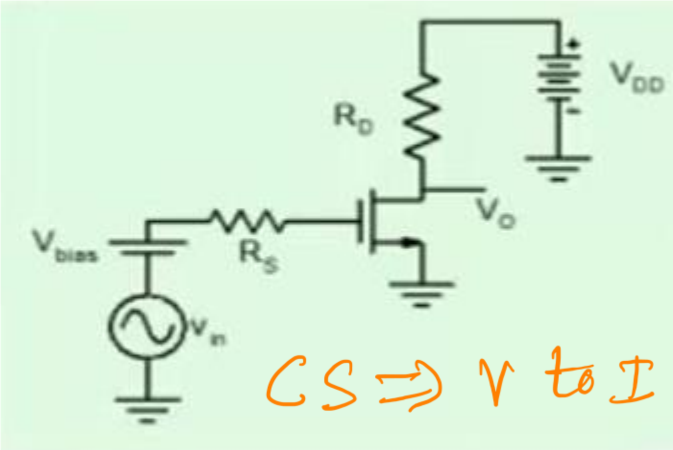


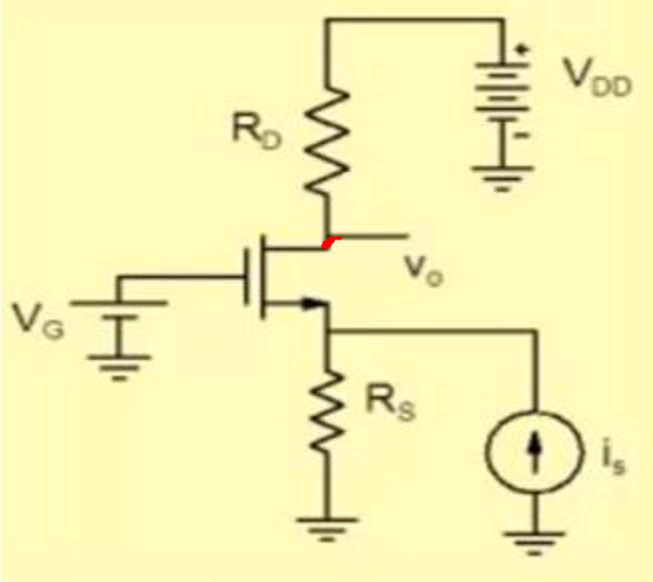
CG



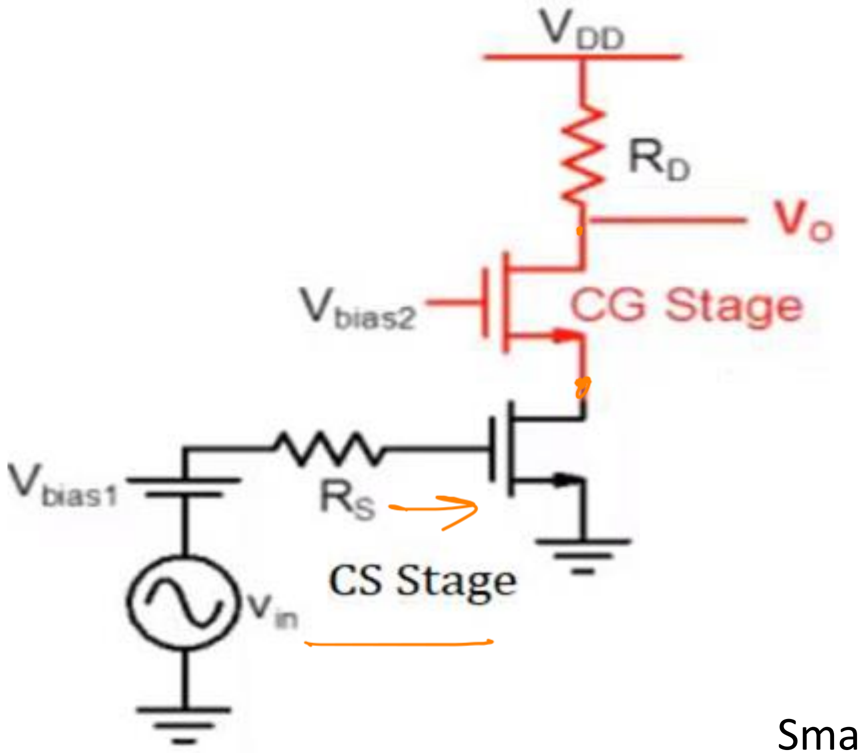
Transresistance Amplifier

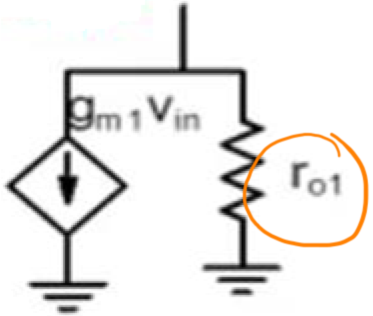
Let's combine the advantages of both the configurations





CG ⇒ I to V



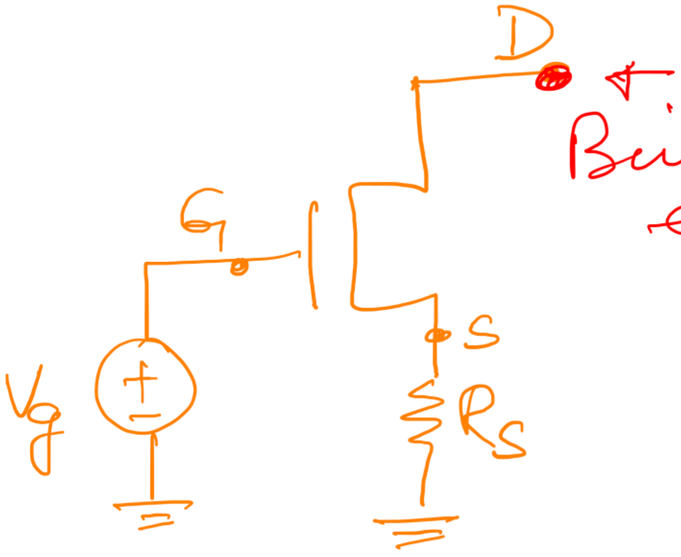


Small signal equivalent of CS stage

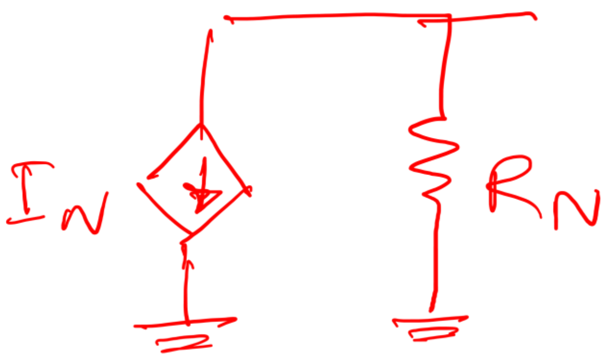
This CS-CG combination is called **CASCODE** Amplifier

When drain of one Tr. Is connected to source of next Tr., the connection is called a **CASCODE**

Useful Results (Small-Signal) for MOS Amplifier.



Built a norton equivalent at this node (I_N, R_N)

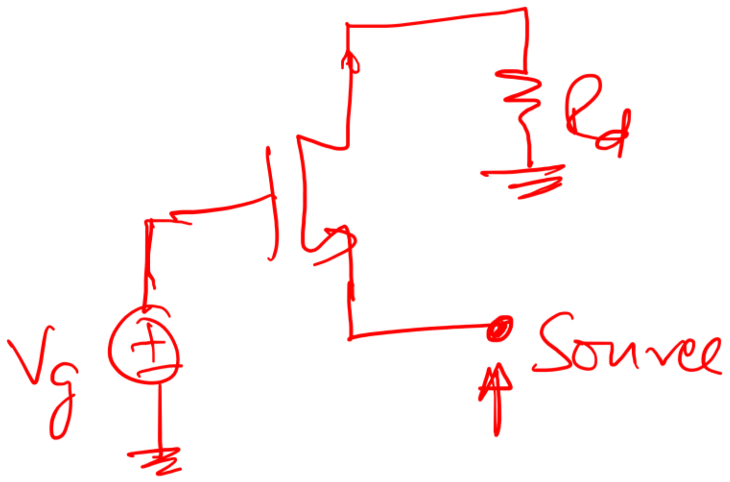


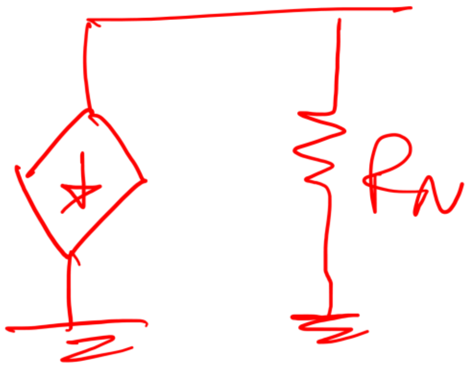
✓

$$\boxed{\begin{aligned} i_n &\simeq \frac{g_m v_g}{1+(g_m+g_{mb})R_s} \\ R_n &\simeq r_o \times \{1+(g_m+g_{mb})R_s\} \end{aligned}}$$

if $R_s = 0$

$i_n \simeq g_m v_g$





$$i_n = \frac{-g_m v_g}{1 + R_d/r_o}$$

$$R_n \simeq \frac{1 + R_d/r_o}{g_m + g_{mb}}$$

[If R_d is small

$i_n = g_m V_d$

$R_d << r_o$

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