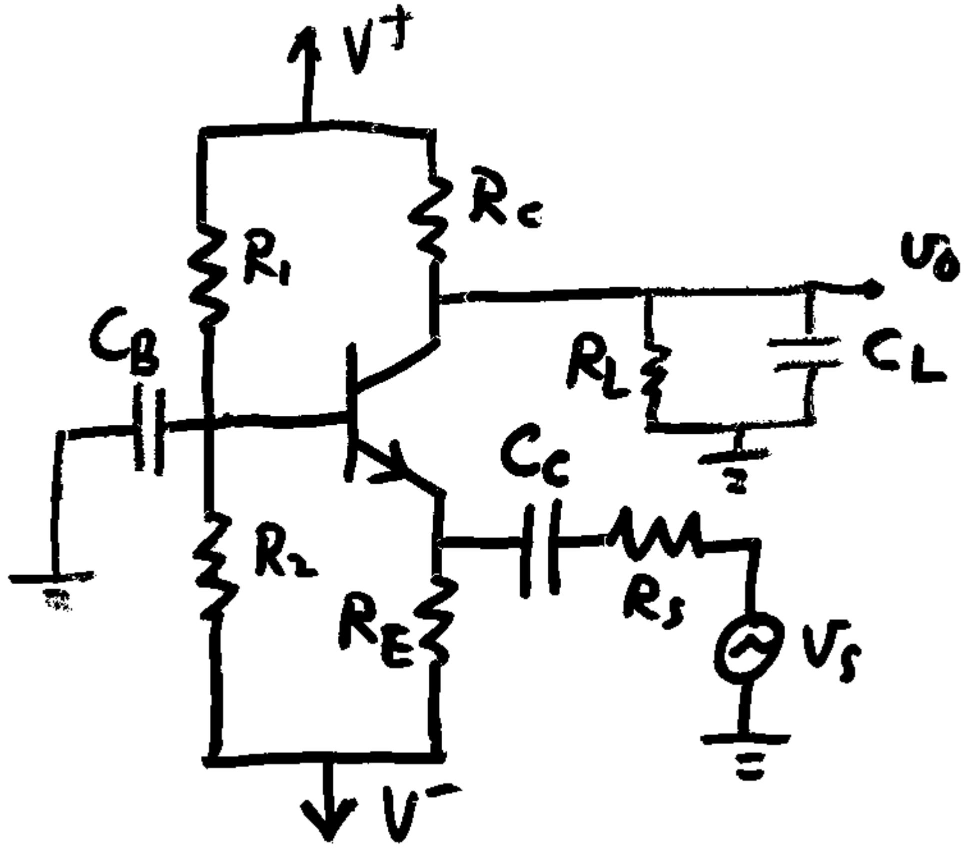
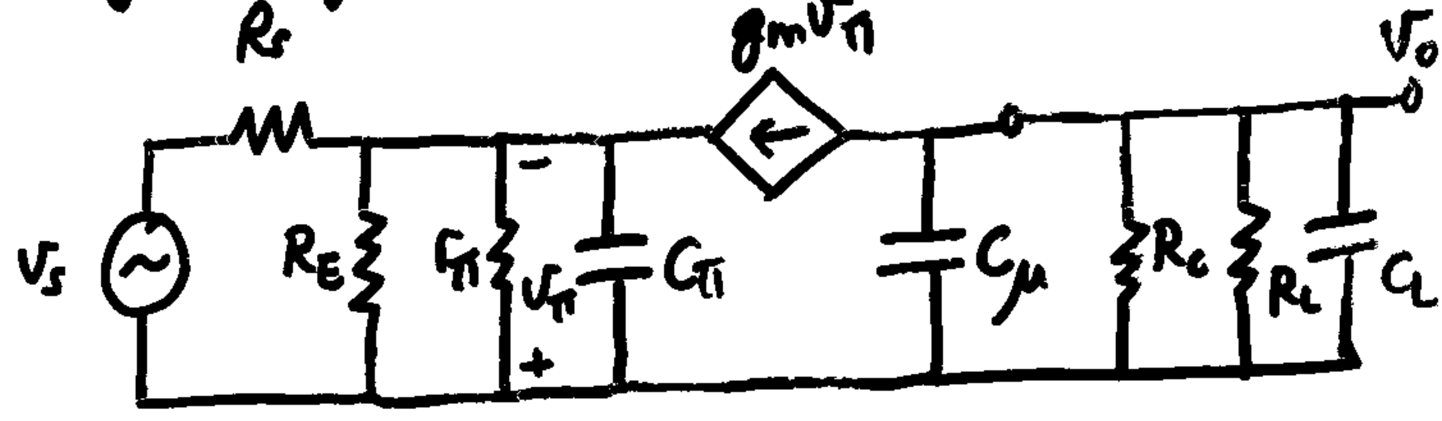
Common Base Amplifier



High Freq Equiv. Ckt



All capacitances are grounded, no Miller effect

Define $R_L' = R_C \| R_L$, $C_L' = C_\mu + C_L$

$$R_E' = R_E \| \frac{r_\pi}{\beta+1}$$

$$v_o = -g_m \left(R_L' \| \frac{1}{j\omega C_L'} \right)$$

$$v_\pi = -\left(\frac{R_E' \| \frac{1}{j\omega C_\pi}}{R_E' \| \frac{1}{j\omega C_\pi} + R_s} \right) V_s$$

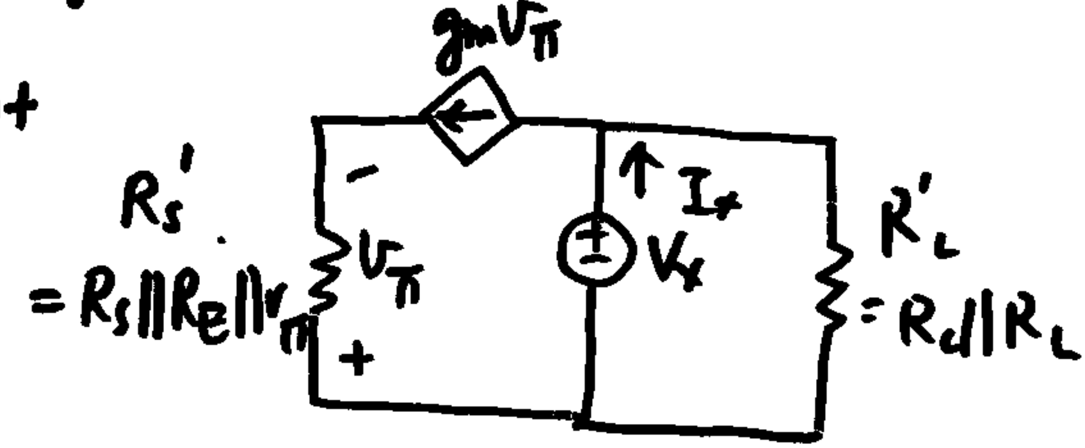
$$A_{vs} = g_m \left(R_L' \| \frac{1}{j\omega C_L'} \right) \left(\frac{R_E' \| \frac{1}{j\omega C_\pi}}{R_E' \| \frac{1}{j\omega C_\pi} + R_s} \right)$$

$$= g_m R_L' \frac{R_E'}{R_E' + R_s} \left(\frac{1}{1 + j\omega R_L' C_L'} \right) \times$$

$$\left(\frac{1}{1 + j\omega (R_E' \| R_s) C_\pi} \right)$$

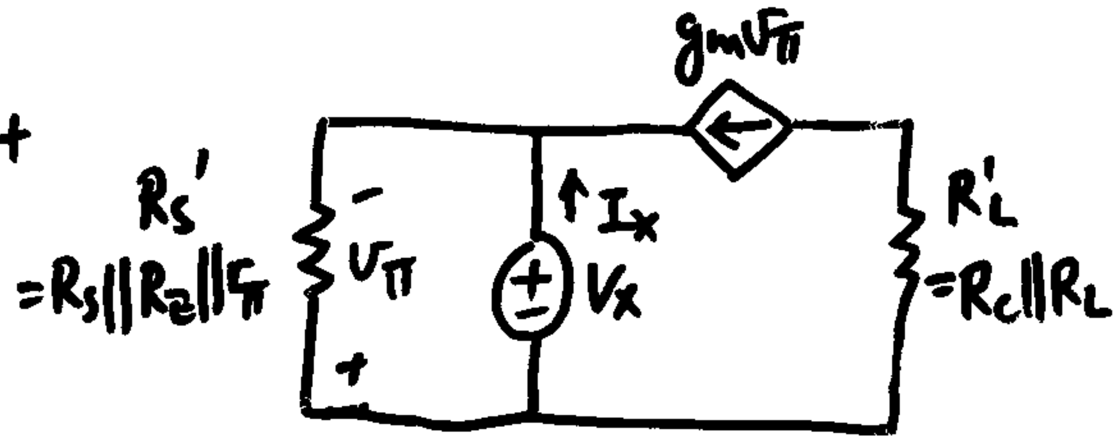
Thevenin Equiv. Resistance

R_μ circuit



$$R_\mu = R_C \| R_L$$

R_π circuit



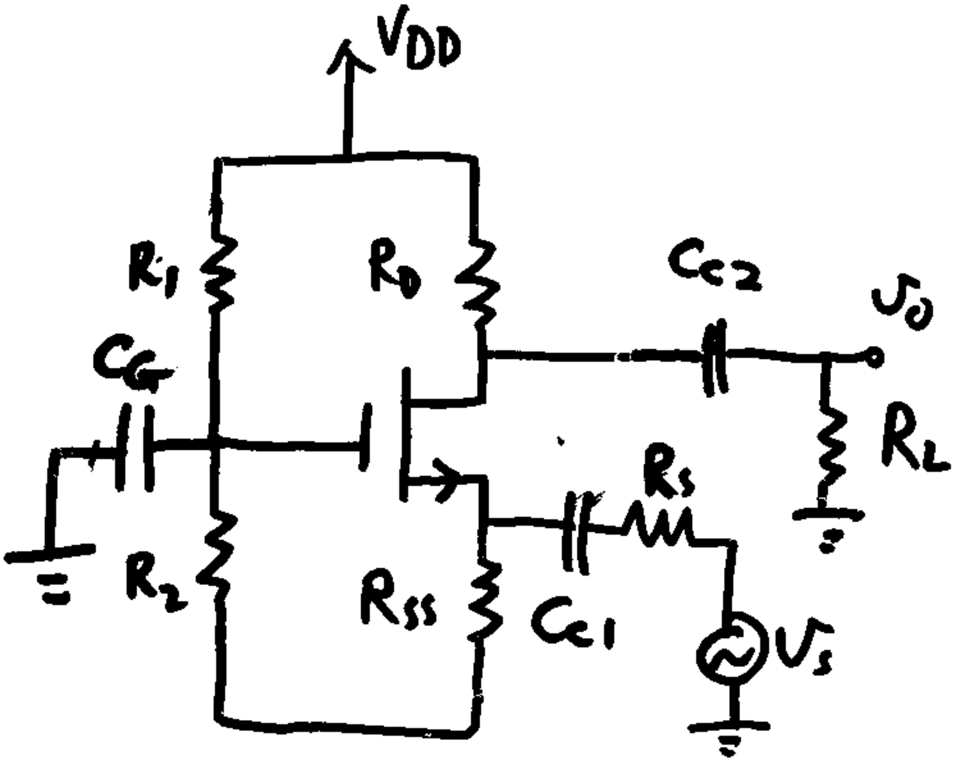
$$I_x = \frac{V_x}{R_s'} + g_m V_x$$

$$R_\pi = R_s \| R_E \| r_\pi \| \frac{1}{g_m} = R_s \| R_E \| \frac{r_\pi}{\beta+1}$$

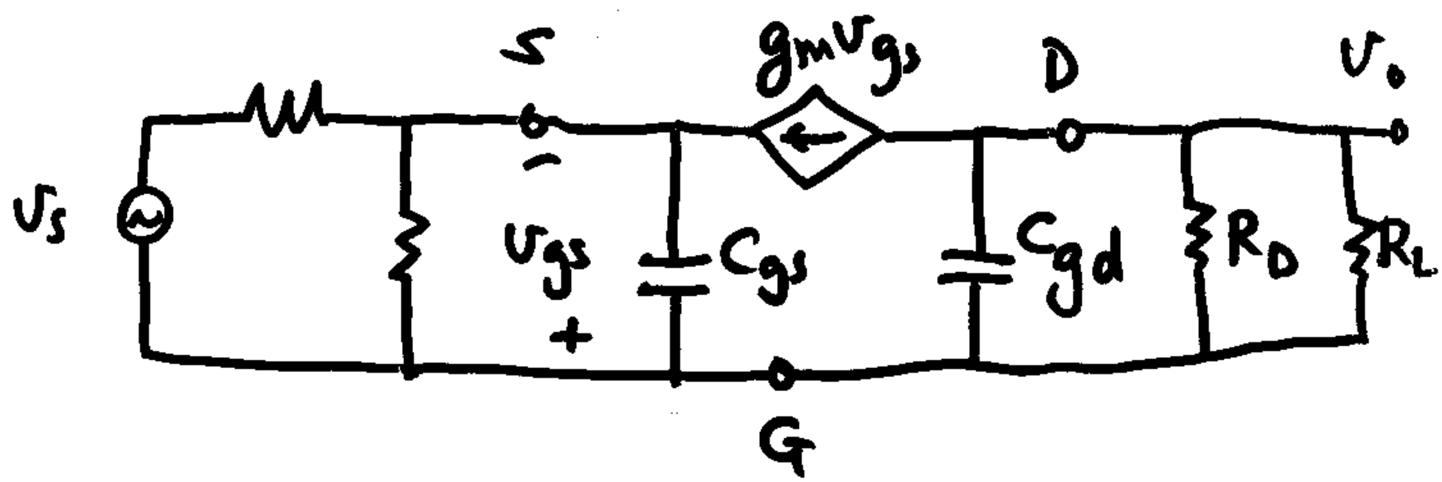
R_{CL} circuit $\equiv$ R_μ circuit

$$R_{CL} = R_C \| R_L$$

Common gate Amplifier



High freq. equiv. ckt



$$R_{gs} = R_S \| R_{SS} \| \frac{1}{g_m}$$

$$\tau_{gs} = \left(R_s \| R_{SS} \| \frac{1}{g_m}\right) C_{gs}$$

With C_L

$$R_{gd} = R_D \| R_L$$

$$\tau_{gd} = (R_D \| R_L)\, C_{gd}$$

$$R_{CL} = R_D \| R_L$$

$$\tau_{CL} = (R_D \| R_L) C_L$$

$$\omega_H \cong \frac{1}{\tau_{gd} + \tau_{gs}}$$

$$\omega_H \cong \frac{1}{\tau_{gd} + \tau_{gs} + \tau_{CL}}$$

Typically, $(\tau_{gd} + \tau_{CL})$ dominates

$$\omega_H \cong \frac{1}{(R_D \| R_L)(C_{gd} + C_L)}$$

$$\omega_H \cdot |A_{v_o}| = \frac{g_m}{C_{gd} + C_L}$$

NOT CONSTANT

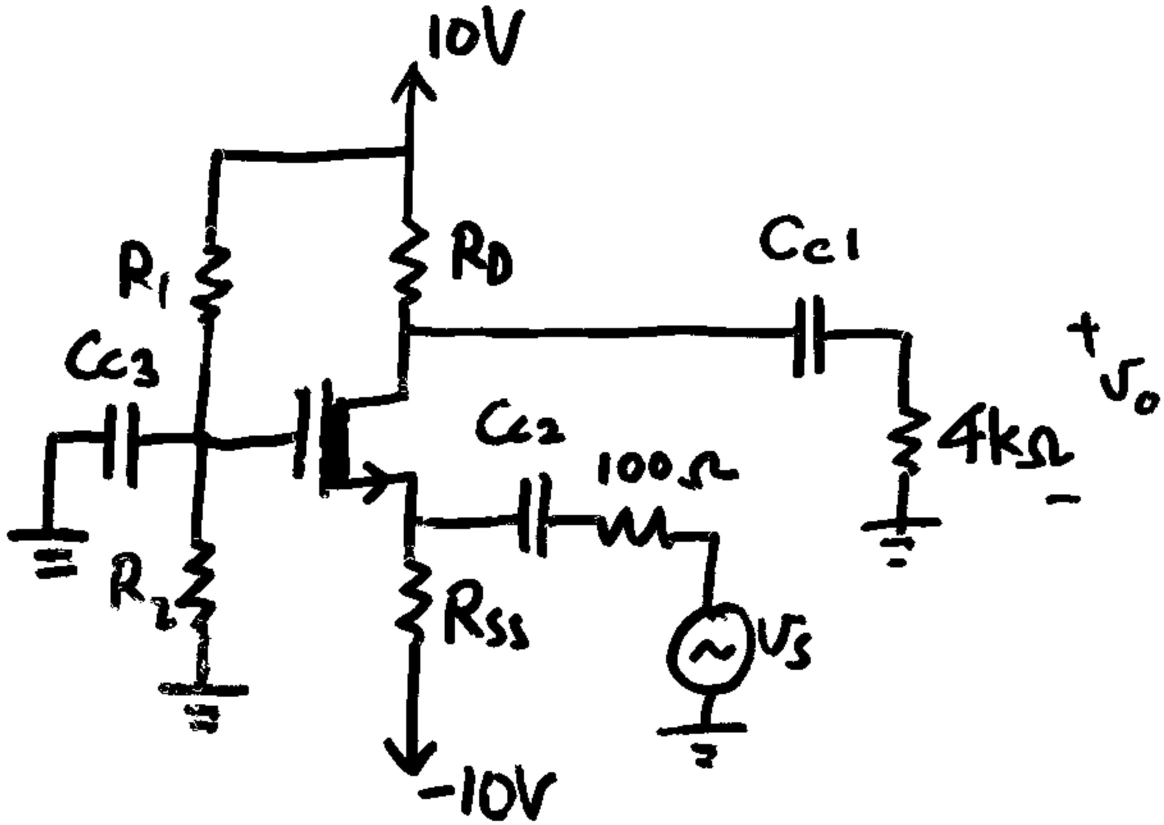
Depends on I_D

Common-Gate Amplifier Design

$f_L \leq 200Hz$ $f_H \geq 25MHz$

Given $V_{DD} = 10V$, $I_D = 1mA$, $K_N = 0.25 \frac{mA}{V^2}$

$V_{TH} = -2V$



$C_{gs} = 5pF$

$C_{gd} = 2pF$

Solve around the transistor:

$$1\,mA = \frac{1}{4}(V_{GS}+2)^2, \quad g_m = 2K_N(V_{GS}-V_{TH}) = 1\,mA/V$$

$$V_{GS} = -4 \text{ or } \underline{0\,V}$$

Pick $V_G = 2V$

$$V_{R_{SS}} = 12V \Rightarrow \boxed{R_{SS} = 12k\Omega}$$

$$V_{DS} \geq V_{GS} - V_{TH} = 2V \text{ for SAT}$$

$$\Rightarrow R_D \leq 6k\Omega$$

Pick $\boxed{R_D = 4k\Omega} \Rightarrow V_{DS} = 4V$

$$\hookrightarrow A_{v_i} = +g_m(2000) = 2V/V$$

$V_{R2} = 2V, \quad V_{R1} = 8V$

Pick $\boxed{R_1 = 400k\Omega, \quad R_2 = 100k\Omega}$

Check for $f_L \leq 200\,Hz$

$$\tau_{cc1} = (R_L + R_D)C_{c1} = 8000\,C_{c1}$$

$$\tau_{cc2} = \left(R_S + R_{SS} \parallel \frac{1}{g_m}\right)C_{c2}$$

$$= 1023\,C_{c2}$$

$$\tau_{cc3} = (R_1 \parallel R_2)C_{c3}$$

$$= 80000\,C_{c3}$$

Pick $\omega_{cc2} = 150\,Hz \Rightarrow C_{c2} = \frac{1}{2\pi(150)(1023)}$

$$= 1.0\,\mu F$$

$$\omega_{cc1} = 40\,Hz \Rightarrow C_{c1} = 0.5\,\mu F$$

$$\omega_{cc3} = 1\,Hz \Rightarrow C_{c1} = 2\,\mu F$$

$$\boxed{\omega_L \leq 191\,Hz}$$

Check for $\omega_H \geq 25\,MHz$

$$\tau_{gd} = (R_D \| R_L)\, C_{gd}$$

$$= 4\,ns$$

$$\tau_{gs} = \left(R_s \| R_{ss} \| \frac{1}{g_m}\right) C_{gs}$$

$$= 0.45\,ns$$

$$\omega_H = \frac{1}{\tau_{gd} + \tau_{gs}} = 225\ M\,rad/s$$

$$\cong \underline{36\,MHz}$$