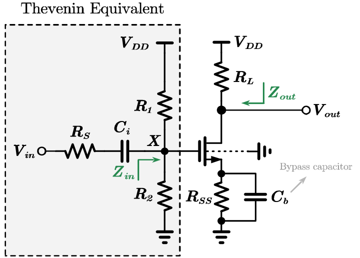
1. CS/CE

Low Frequency Analysis

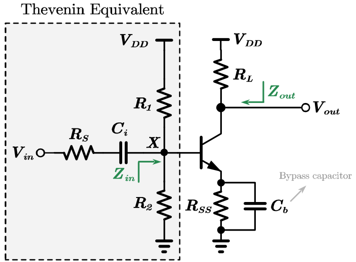
(assuming other caps open-circuit)

neglecting r_O unless otherwise specified

Thevenin Equivalent



Thevenin Equivalent



Z_{in} and Z_{out}: trivial

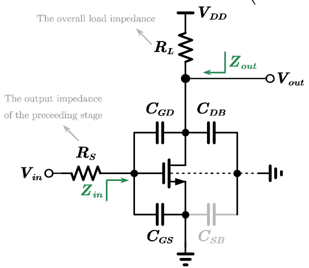
$$R_{Thev} = \left(R_S + \frac{1}{sC_i}\right) \parallel R_1 \parallel R_2, \quad A_{v1} = \frac{V_{Thev}}{V_{in}} = \frac{R_1 \parallel R_2}{R_1 \parallel R_2 + R_S + \frac{1}{sC_i}} = \frac{s(R_1 \parallel R_2)C_i}{1 + s(R_1 \parallel R_2 + R_S)C_i} \quad \begin{cases} z = 0 \\ p = -\dfrac{1}{(R_1 \parallel R_2 + R_S)C_i} \end{cases}$$

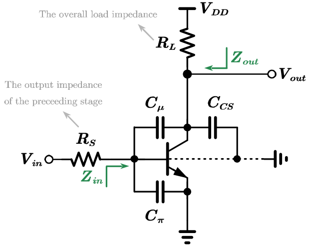
MOS: $$\frac{-R_L}{(1+\eta)R_{SS} + \frac{1}{g_m}} \longrightarrow A_{v2} = \frac{-R_L}{(1+\eta)\left(R_{SS} \parallel \frac{1}{sC_b}\right) + \frac{1}{g_m}} = \frac{-g_m R_L}{1 + (g_m + g_{mb})R_{SS}} \cdot \frac{1 + sR_{SS}C_b}{1 + s\frac{R_{SS}C_b}{1 + (g_m + g_{mb})R_{SS}}} \quad \begin{cases} z = -\dfrac{1}{R_{SS}C_b} \\ p = -\dfrac{1 + (g_m + g_{mb})R_{SS}}{R_{SS}C_b} \end{cases}$$

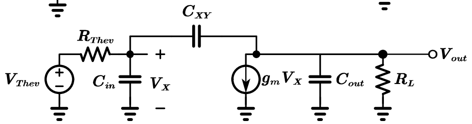
BJT: $$\frac{-R_L}{R_{SS} + \frac{1}{g_m} + \frac{R_B}{\beta+1}} \longrightarrow A_{v2} = \frac{V_{out}}{V_{Thev}} = \frac{-R_L}{R_{SS} \parallel \frac{1}{sC_b} + \frac{1}{g_m} + \frac{R_B}{\beta+1}} \approx \frac{-g_m R_L}{1 + g_m R_{SS}} \cdot \frac{1 + sR_{SS}C_b}{1 + s\frac{R_{SS}C_b}{1 + g_m R_{SS}}} \quad \begin{cases} z = -\dfrac{1}{R_{SS}C_b} \\ p = -\dfrac{1 + g_m R_{SS}}{R_{SS}C_b} \end{cases}$$

High Frequency Analysis

$\left(\text{assuming } \frac{1}{sC_b} \parallel R_{SS} \to 0\right)$ hence source shorted to ac ground and no body effect







MOS: $V_{Thev} = V_{in}$, $\quad R_{Thev} = R_S$

BJT: $V_{Thev} = V_{in} \cdot \frac{r_\pi}{r_\pi + R_S}$, $\quad R_{Thev} = R_S \parallel r_\pi$

$$\begin{cases} \dfrac{V_{out}}{V_{Thev}} = -g_m R_L \cdot \dfrac{1 - s \cdot \frac{C_{XY}}{g_m}}{as^2 + bs + 1} \\ a = R_{Thev} R_L (C_{in} C_{XY} + C_{in} C_{out} + C_{XY} C_{out}) \\ b = g_m R_{Thev} R_L C_{XY} + R_{Thev}(C_{XY} + C_{in}) + R_L(C_{XY} + C_{out}) \end{cases} \longrightarrow \begin{cases} z = +\dfrac{g_m}{C_{XY}} \\ p_1 = \dfrac{-b + \sqrt{b^2 - 4a}}{2a} \approx -\dfrac{1}{b} \\ p_2 = \dfrac{-b - \sqrt{b^2 - 4a}}{2a} \approx -\dfrac{b}{a} \end{cases}$$

dominant pole approximation

(holds only if $|p_1| \ll |p_2|$)

$$as^2 + bs + 1 \Longrightarrow \begin{cases} s_1 = \dfrac{-b + \sqrt{b^2 - 4a}}{2a} \approx -\dfrac{1}{b} \\ s_2 = \dfrac{-b - \sqrt{b^2 - 4a}}{2a} \approx -\dfrac{b}{a} \end{cases}$$

High Frequency Analysis using Miller Approximation:

$$\begin{cases} \dfrac{V_{out}}{V_{Thev}} = -g_m R_L \cdot \dfrac{1}{1 + s\tau_1} \cdot \dfrac{1}{1 + s\tau_2} \\ \tau_1 = R_{Thev}\left[C_{in} + (1 + g_m R_L)C_{GD}\right] \\ \tau_2 = R_L\left[C_{out} + \left(1 + \dfrac{1}{g_m R_L}\right)C_{GD}\right] \end{cases}$$

Z_{in} and Z_{out}: trivial

$$\text{MOS} \begin{cases} Z_{in} = \dfrac{1}{sC_{GS}} \parallel \dfrac{1 + sR_L(C_{GD} + C_{DB})}{sC_{GD}(1 + g_m R_L + sR_L C_{DB})} \\ Z_{out} = R_L \parallel \dfrac{1}{sC_{DB}} \parallel \dfrac{1 + sR_S(C_{GS} + C_{GD})}{sC_{GD}(1 + g_m R_S + sR_S C_{GS})} \end{cases}$$

$$\text{BJT} \begin{cases} Z_{in} = r_\pi \parallel \dfrac{1}{sC_\pi} \parallel \dfrac{1 + sR_L(C_\mu + C_{CS})}{sC_\mu(1 + g_m R_L + sR_L C_{CS})} \\ Z_{out} = R_L \parallel \dfrac{1}{sC_{CS}} \parallel \dfrac{1 + s(R_S \parallel r_\pi)(C_\pi + C_\mu)}{sC_\mu\left[1 + g_m(R_S \parallel r_\pi) + s(R_S \parallel r_\pi)C_\pi\right]} \end{cases}$$