Reference:C:\Users\Bernhard Boser\Documents\Files\Lib\MathCAD\Default\defaults.mcd

L20: Source Follower

Given

$$\frac{v_g - v_i}{R_s} + (v_g - v_o)\cdot s\cdot C_{gs} = 0$$

$$\frac{v_o}{R_L} + (v_o - v_g)\cdot s\cdot C_{gs} - g_m\cdot(v_g - v_o) = 0$$

$$a_v = \frac{v_o}{v_i} \qquad Z_i = \frac{v_i}{v_i - v_g}\cdot R_s$$

$$\text{Find}(v_g, v_o, a_v, Z_i)\ \text{collect}, s \rightarrow \begin{bmatrix} v_i\cdot\dfrac{(1 + s\cdot C_{gs}\cdot R_L + g_m\cdot R_L)}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]} \\ R_L\cdot\dfrac{(s\cdot C_{gs} + g_m)}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]}\cdot v_i \\ R_L\cdot\dfrac{(s\cdot C_{gs} + g_m)}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]} \\ \dfrac{(C_{gs}\cdot R_s + C_{gs}\cdot R_L)}{C_{gs}} + \dfrac{(1 + g_m\cdot R_L)}{C_{gs}\cdot s} \end{bmatrix}$$

$$z = \frac{g_m}{C_{gs}} = \omega_T$$

$$p = -\frac{1 + g_m\cdot R_L}{C_{gs}\cdot(R_s + R_L)} = -\frac{1}{C_{gs}\cdot\dfrac{R_s + R_L}{1 + g_m\cdot R_L}} \qquad \text{approx} \quad R_L < R_s \qquad p = \frac{g_m}{C_{gs}}\cdot\frac{R_L}{R_s} = \omega_T\cdot\frac{R_L}{R_s}$$

Given

$$\frac{v_g}{R_s} + (v_g - v_o)\cdot s\cdot C_{gs} = 0$$

$$\frac{v_o}{R_L} + (v_o - v_g)\cdot s\cdot C_{gs} - g_m\cdot(v_g - v_o) - i_t = 0$$

$$Z_o = \frac{v_o}{i_t}$$

$$\text{Find}(v_g, v_o, Z_o)\ \text{collect}, s \rightarrow \begin{bmatrix} i_t\cdot R_L\cdot s\cdot C_{gs}\cdot\dfrac{R_s}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]} \\ \dfrac{R_L}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]}\cdot(1 + s\cdot C_{gs}\cdot R_s)\cdot i_t \\ \dfrac{R_L}{\left[(C_{gs}\cdot R_s + C_{gs}\cdot R_L)\cdot s + 1 + g_m\cdot R_L\right]}\cdot(1 + s\cdot C_{gs}\cdot R_s) \end{bmatrix}$$

Derive by Inspection

Gain

dc gain

$$a_{vo} = \frac{\frac{1}{g_m}}{R_L + \frac{1}{g_m}} = \frac{1}{1 + \frac{1}{g_m \cdot R_L}}$$ divider

very HF gain

$$a_{v\_inf} = \frac{R_L}{R_s + R_L}$$

zero

$$v_{gs} \cdot z \cdot C_{gs} = g_m \cdot v_{gs} \qquad z = \frac{g_m}{C_{gs}}$$ Bode Plot

pole

$$p = -z \cdot \frac{a_{v\_inf}}{a_{vo}} = -\omega_T \cdot \frac{R_L}{R_L + R_s} \cdot \frac{1 + g_m \cdot R_L}{g_m \cdot R_L} = -\omega_T \cdot \frac{R_L}{R_s}$$

Input impedance

$$Z_{in} = \frac{V_{in}}{I_{in}}$$

low frequency

$$I_{in} = s \cdot C_{gs} \cdot V_{gs} = s \cdot C_{gs} \cdot \left(V_{in} - a_{vo} \cdot V_{in}\right)$$

$$I_{in} = \frac{s \cdot C_{gs} \cdot V_{in}}{1 + g_m \cdot R_L}$$

$$Z_{in\_o} = \frac{1 + g_m \cdot R_L}{s \cdot C_{gs}}$$

very HF

$$Z_{in\_inf} = R_s + R_L$$

Output impedance

low frequency

$$Z_{o\_o} = \mathrm{par}\left(R_L, \frac{1}{g_m}\right) = \frac{R_L}{1 + g_m \cdot R_L}$$

very HF

$$Z_{o\_inf} = \mathrm{par}\left(R_s, R_L\right) = \frac{R_s \cdot R_L}{R_s + R_L}$$

$$\frac{Z_{o\_o}}{Z_{o\_inf}} = \frac{1}{1 + g_m \cdot R_L} \cdot \frac{R_s + R_L}{R_s}$$ usually < 1

Bode plot --> inductor