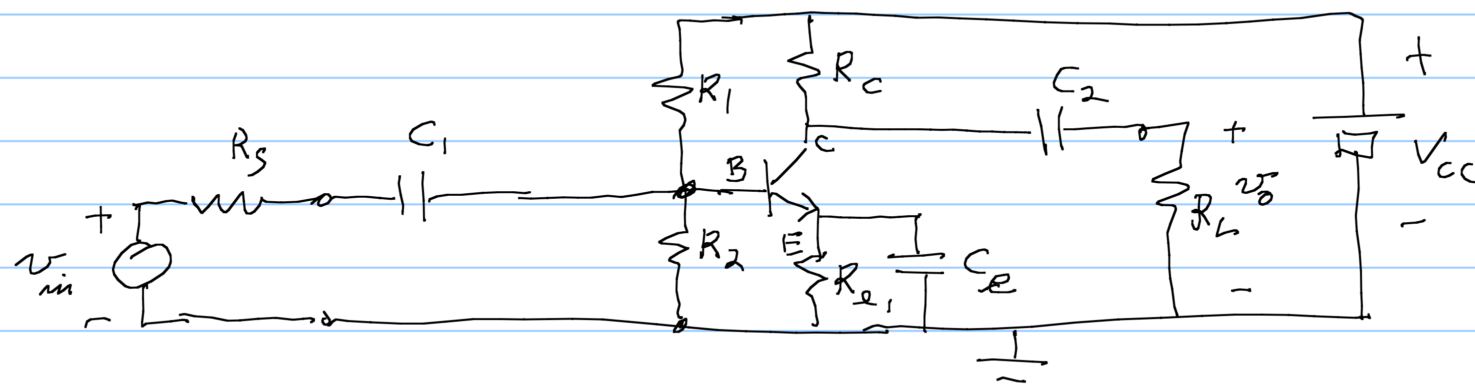
Note Title 3/9/2016

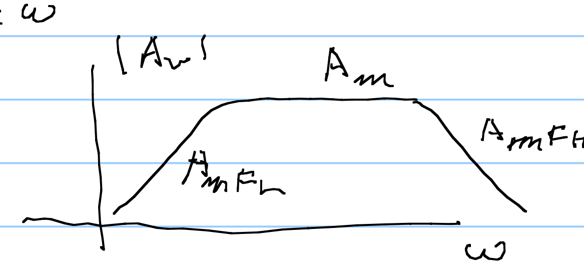
EE307
03/09/16

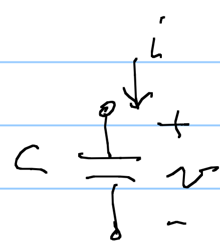
Frequency response   AC analysis in Spice



$$A_v = \frac{v_o}{v_{in}}(s) \Rightarrow s = j\omega \;,\; 2\pi f = \omega$$

$$|A_v(j\omega)|$$





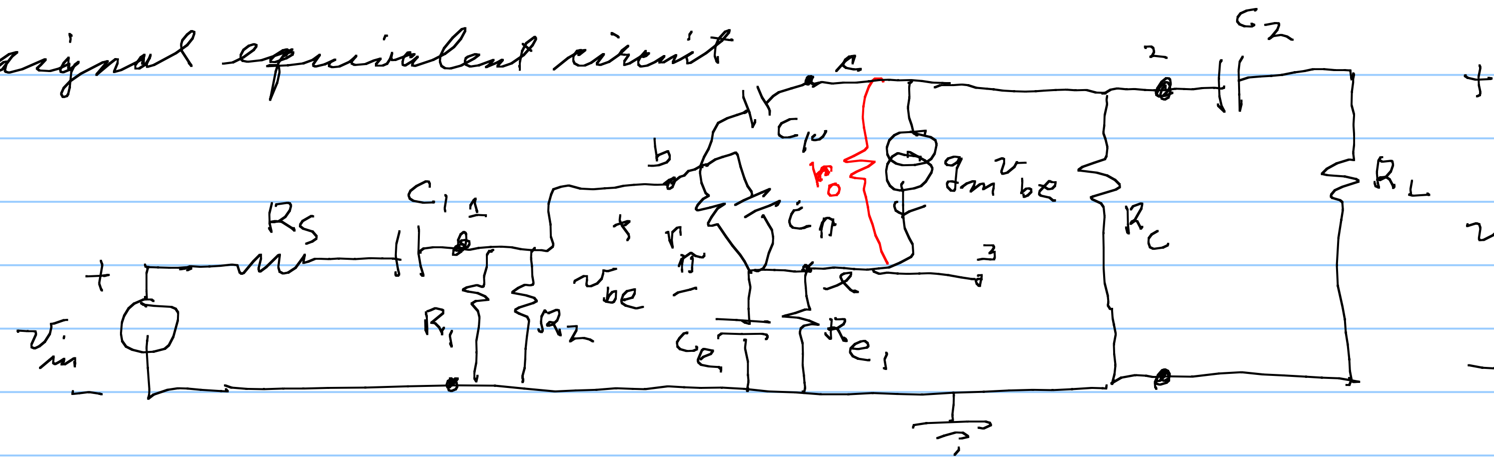
$$C \quad v \;;\; i = \frac{dq}{dt} = \frac{d\,Cv}{dt} = C\frac{dv}{dt}$$

C = const in time

$$\Rightarrow i(s) = I(s) = C\,s\,V(s)$$

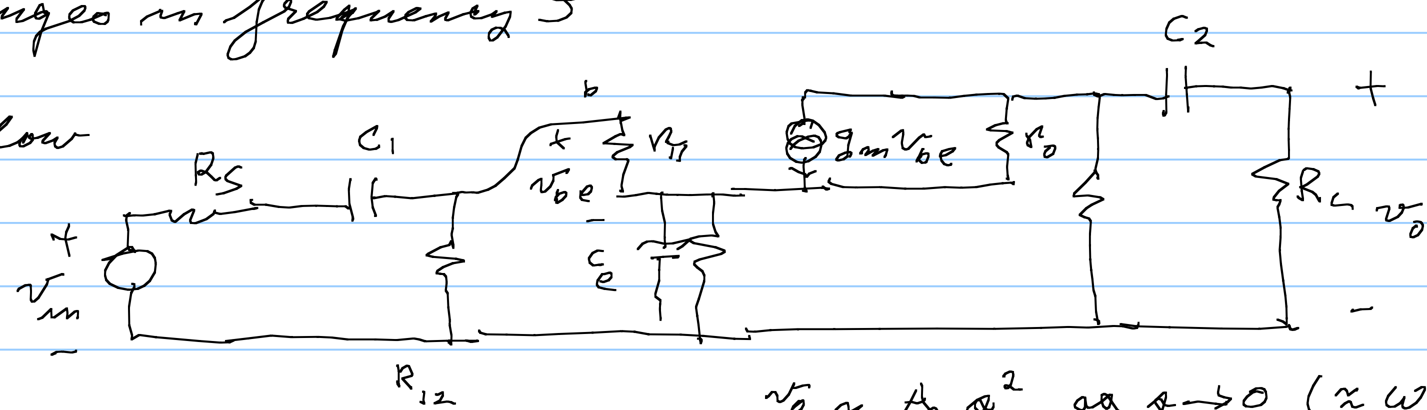
$$y(s) = \frac{I}{V}(s) = sC \;;\; z(s) = 1/y(s) = \frac{1}{sC} \Rightarrow z(j\omega) = \frac{1}{j\omega}\cdot\frac{1}{C}$$

signal equivalent circuit

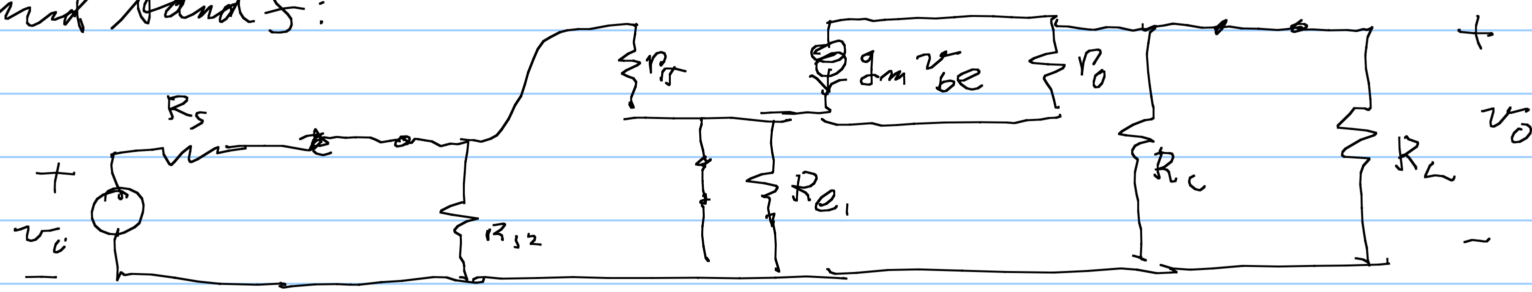


3 ranges in frequency f

f low



$\frac{v_o}{v_{in}} \approx A_0 s^2$ as $s \to 0$ ($\approx \omega \to 0$ near DC) mid band f:

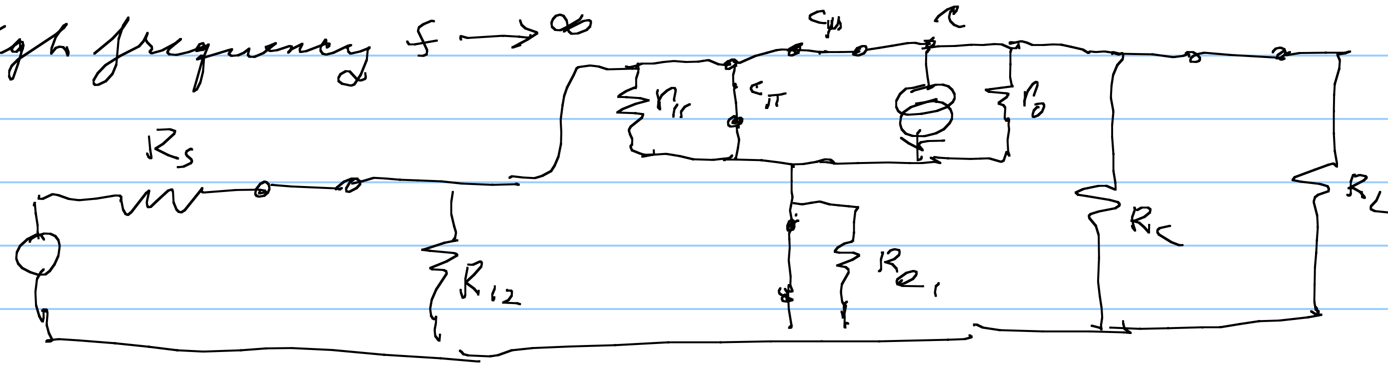


effective $R_L = R_L'$

ideally $\frac{v_o}{v_i} \approx -g_m R_L'$

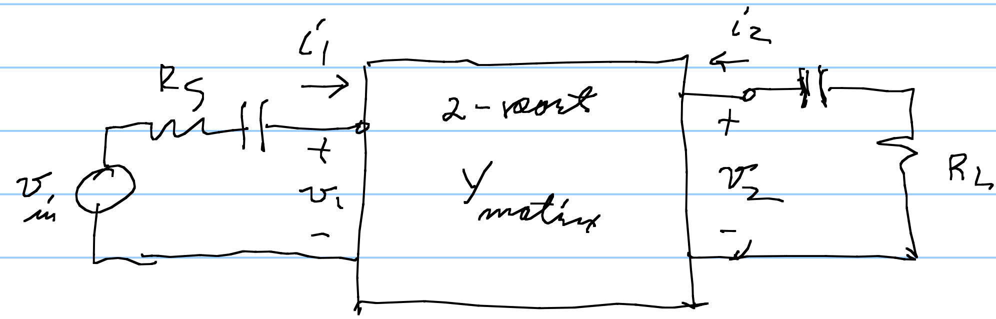
$g_m = I_C / V_T$

high frequency $f \to \infty$



$$A_{v}\Big|_{\omega \to \infty} \approx \frac{1}{\omega^2} A_o$$

analysis (SSSSS)
small signal sinusoidal steady state



$$Y = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \qquad \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = Y \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

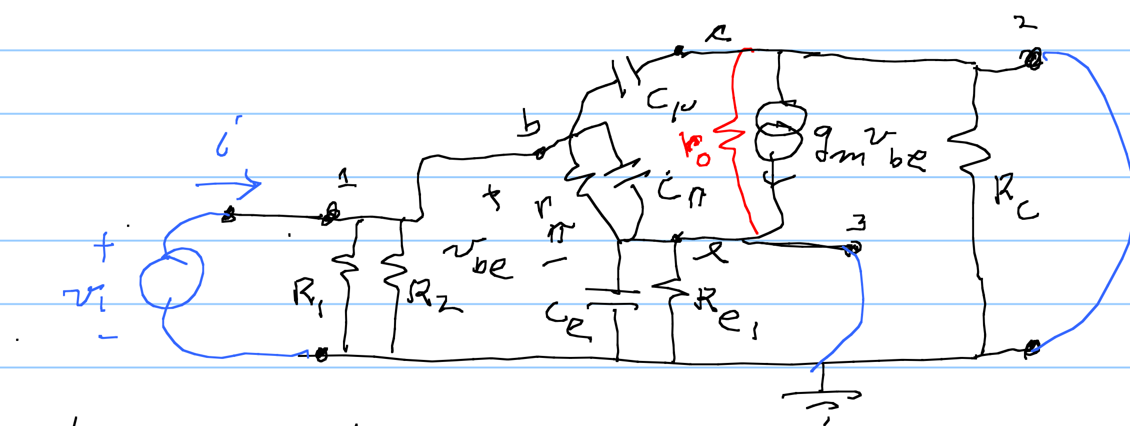
$$Y_3 \Rightarrow \begin{bmatrix} i_1 \\ i_2 \\ \hline i_3 \end{bmatrix} = \left[\begin{array}{c|c} Y_{11} & Y_{12} \\ \hline Y_{21} & y_{33} \end{array}\right] \begin{bmatrix} v_1 \\ v_2 \\ \hline v_3 \end{bmatrix}$$

with $0 = i_3$

set $i_3 = 0$ to eliminate node 3

$$0 = Y_{21} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + y_{33} \times v_3 \Longrightarrow v_3 = -\frac{1}{y_{33}} \times Y_{21} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = Y_{11}' \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} + Y_{12} v_3 = \underbrace{\begin{bmatrix} Y_{11} - Y_{12} \cdot \frac{1}{y_{33}} Y_{21} \end{bmatrix}}_{Y \text{ (of the 2-port)}} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$



$$Y_{11}'\Big|_{v_2 = v_3 = 0} = i_1 / v_1$$