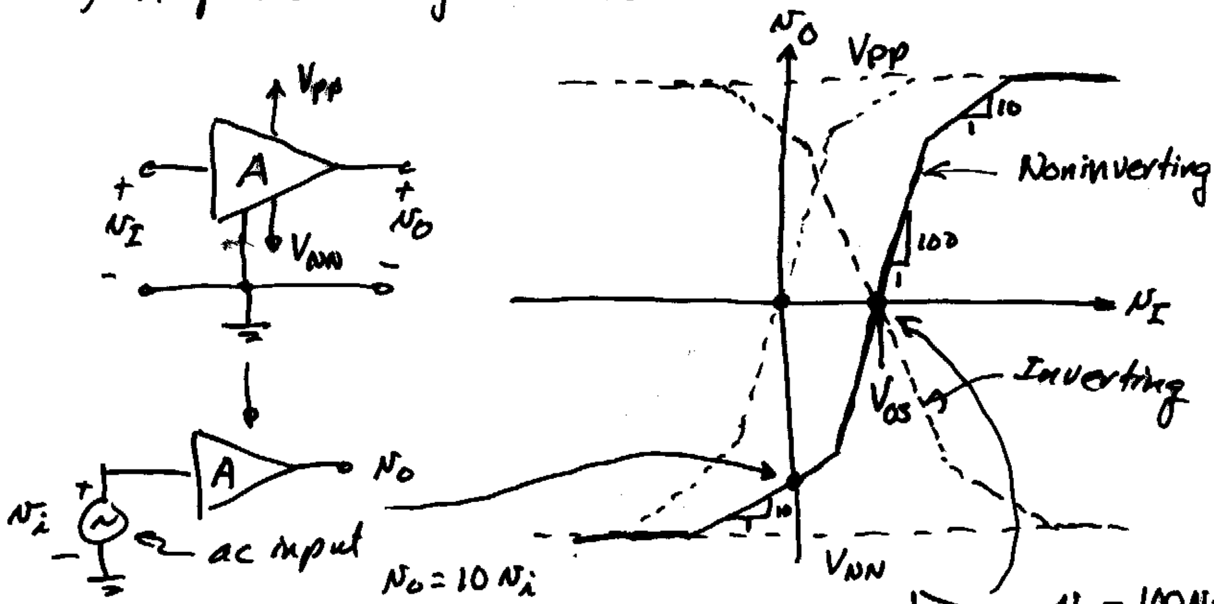
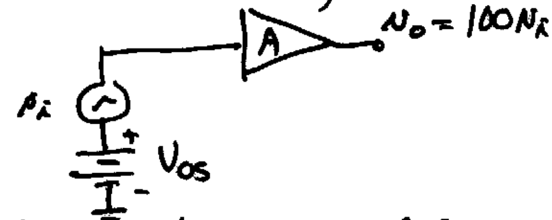
Amplifiers - Chapter 11

1.) Amplifier Voltage Transfer Characteristic

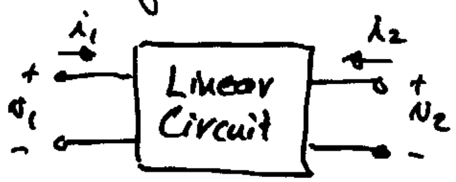




Small-signal Gain $\equiv A_v = \left.\dfrac{dv_O}{dv_I}\right|_Q$

2.) Two-port network models for linear amplifiers.

a.) g-parameters

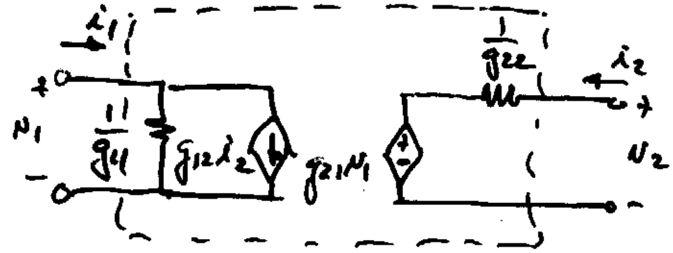


$i_1 = g_{11} v_1 + g_{12} i_2$

$v_2 = g_{21} v_1 + g_{22} i_2$

$g_{11} = \left.\dfrac{i_1}{v_1}\right|_{i_2=0}$, $g_{12} = \left.\dfrac{i_1}{i_2}\right|_{v_1=0}$, $g_{21} = \left.\dfrac{v_2}{v_1}\right|_{i_2=0}$, $g_{22} = \left.\dfrac{v_2}{i_2}\right|_{v_1=0}$

Schematic model -



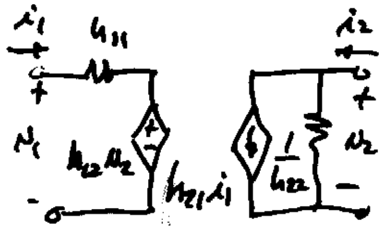
b.) h-parameter

$v_1 = h_{11} i_1 + h_{12} v_2$

$i_2 = h_{21} i_1 + h_{22} v_2$

$h_{11} = \left.\frac{v_1}{i_1}\right|_{v_2=0}$ $h_{12} = \left.\frac{v_1}{v_2}\right|_{i_1=0}$

$h_{21} = \left.\frac{i_2}{i_1}\right|_{v_2=0}$ $h_{22} = \left.\frac{i_2}{v_2}\right|_{i_1=0}$



c.) g-parameters

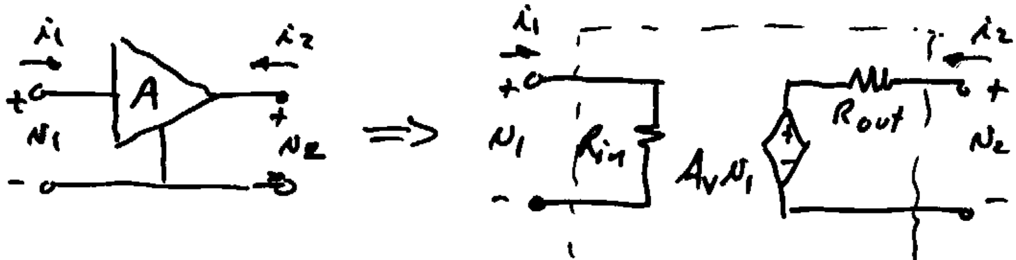
d.) y-parameters

3.) Back to voltage amplifiers

Essentially any amplifier is a circuit where

$p_{12} << p_{21}$ where $p = h, g, y,$ or z

A voltage amplifier can be modelled as follows,



Find the g-parameters for this voltage amplifier.

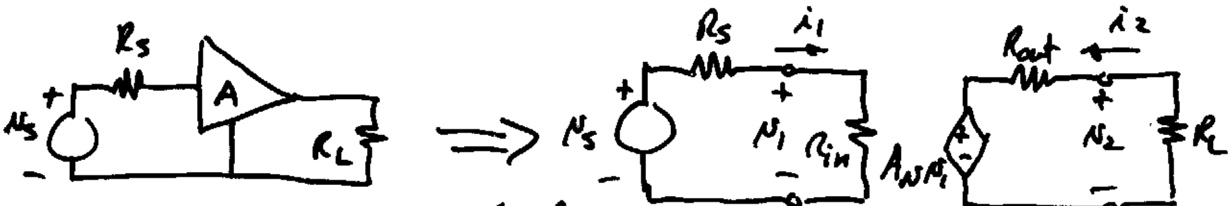
$i_1 = g_{11} v_1 + g_{12} i_2$

$v_2 = g_{21} v_1 + g_{22} i_2$

$g_{11} = \left.\frac{i_1}{v_1}\right|_{i_2=0} = \frac{1}{R_{in}}$, $g_{12} = \left.\frac{i_1}{i_2}\right|_{v_1} = 0$

$g_{21} = \left.\frac{v_2}{v_1}\right|_{i_2=0} = A_v$ $g_{22} = \left.\frac{v_2}{i_2}\right|_{v_1=0} = R_{out}$

Loaded amplifier –



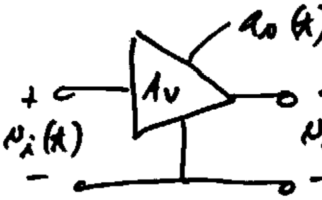
$$\frac{v_2}{v_S} = ? = \left(\frac{v_2}{v_1}\right)\left(\frac{v_1}{v_S}\right) = \left(\frac{A_v R_L}{R_{out} + R_L}\right)\left(\frac{R_{in}}{R_S + R_{in}}\right) = \frac{A_v R_L R_{in}}{(R_{out} + R_L)(R_S + R_{in})} = A_V$$

If $R_L \to \infty$ and $R_S \to 0$, then $A_V \to A_{V}$

FREQUENCY RESPONSE OF AMPLIFIERS

Assuming our amplifier is time-dependent, then how do you characterize the amplifier?

Time domain -



Convolution

$$v_o(t) = v_i(t) * a_v(t) = \int_0^t v_i(t-\tau)\, a_v(\tau)\, d\tau$$

Frequency domain -

$$V_o(j\omega) = A_v(j\omega)\, V_i(j\omega) \to A_v(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)}$$

Complex frequency domain -

$$s = \sigma + j\omega \qquad A_v(s) = \frac{V_o(s)}{V_i(s)} \xrightarrow{s=j\omega} A_v(j\omega) = \frac{V_o(j\omega)}{V_i(j\omega)}$$

General Frequency Domain Transfer Function -

$$A_v(s) = \frac{N(s)}{D(s)} = \frac{a_m s^m + a_{m-1} s^{m-1} + \cdots + a_1 s + a_0}{b_n s^n + b_{n-1} s^{n-1} + \cdots + b_1 s + b_0}$$

$$= K \frac{(s+z_1)(s+z_2)\cdots(s+z_m)}{(s+p_1)(s+p_2)\cdots(s+p_n)}$$

z_i are called zeros $[A_v(z_i)=0]$

p_k are called poles $\to A_v(p_k) = \infty$

Example

$$A_v(s) = \frac{100(s^2+s+0)}{s^2+110s+1000} = \frac{100\, s\,(s+1)}{(s+10)(s+100)}$$

Zeros are at $z_1 = 0$ and $z_2 = -1$ Poles are at $p_1 = -10$ & $p_2 = -100$