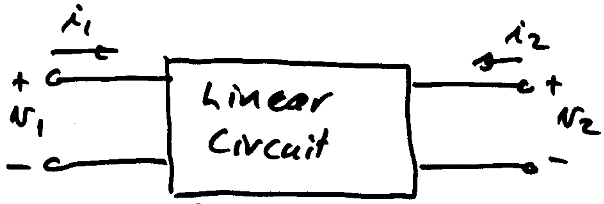
Today's Lecture
- Two-port parameters (10.5)
- Amplifiers (10.6)
- Frequency response (10.7)

Quiz #1 on Friday
Aug. 27, 2004
9 – 9:25am

Dr. Susanta Sengupta – 8/27

Two Port Parameters (10.5)



$y_1 = f_1(v_1, v_2)$
$y_2 = f_2(v_1, v_2)$

1.) g-parameters

$$i_1 = g_{11} v_1 + g_{12} i_2$$
$$v_2 = g_{21} v_1 + g_{22} i_2$$

$g_{11} = \frac{i_1}{v_1}\Big|_{i_2=0}$ $g_{21} = \frac{v_2}{v_1}\Big|_{i_2=0}$

$g_{12} = \frac{i_1}{i_2}\Big|_{v_1=0}$ $g_{22} = \frac{v_2}{i_2}\Big|_{v_1=0}$

2.) h-parameters

$$v_1 = h_{11} i_1 + h_{12} v_2$$
$$i_2 = h_{21} i_1 + h_{22} v_2$$

$h_{11} = \frac{v_1}{i_1}\Big|_{v_2=0}$ $h_{12} = \frac{v_1}{v_2}\Big|_{i_1=0}$

$h_{21} = \frac{i_2}{i_1}\Big|_{v_2=0}$ $h_{22} = \frac{i_2}{v_2}\Big|_{i_1=0}$

3.) y-parameters

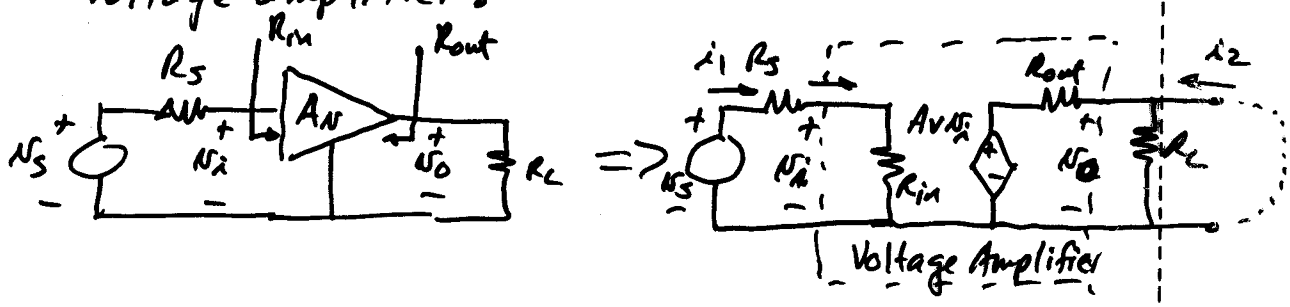
$$i_1 = y_{11} v_1 + y_{12} v_2$$
$$i_2 = y_{21} v_1 + y_{22} v_2$$

4.) z-parameters

$$v_1 = z_{11} i_1 + z_{12} i_2$$
$$v_2 = z_{21} i_1 + z_{22} i_2$$

Example

Voltage amplifier:



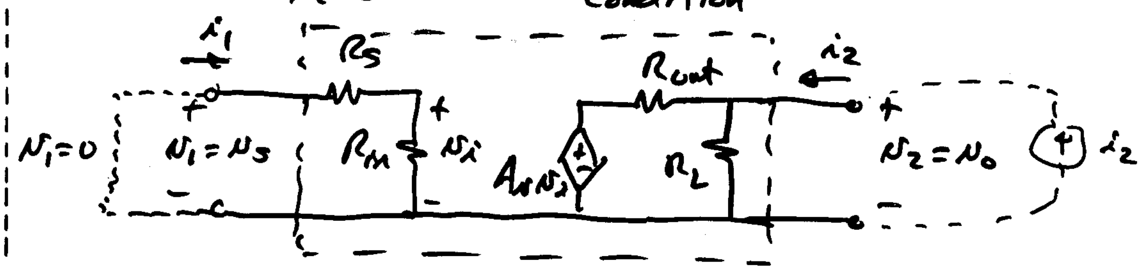
Example - Cont'd

$$v_o = A_v v_i \frac{R_L}{R_{out}+R_L} = A_v \left(\frac{R_L}{R_{out}+R_L}\right)\left(\frac{R_{in}}{R_{in}+R_S}\right) v_s$$

$$\frac{v_o}{v_s} = A_V = \frac{R_L R_{in} A_v}{(R_{out}+R_L)(R_{in}+R_S)} = g_{21}$$

Find the g-parameters if $v_1 = v_S$ & $v_o = v_2$

$$g_{11} = \frac{i_1}{v_1}\Big|_{i_2=0} = \frac{\text{Response}}{\text{Excitation}}\Big|_{\text{Condition}}$$



$$g_{11} = \frac{i_1}{v_1} = \frac{1}{R_S+R_{in}} \qquad g_{21} = \frac{v_2}{v_1}\Big|_{i_2=0} = \frac{A_v R_L R_{in}}{(R_{out}+R_L)(R_S+R_{in})}$$

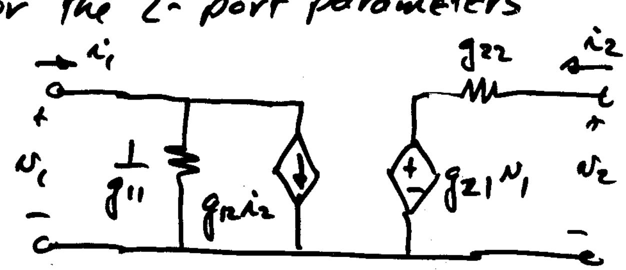
$$g_{12} = \frac{i_1}{i_2}\Big|_{v_1=0} = 0 \qquad g_{22} = \frac{v_2}{i_2}\Big|_{v_1=0 \to v_i=0} = R_L \| R_{out}$$

The 2-port parameters are useful for taking a more complicated ckt. and simplifying.

The schematic model for the 2-port parameters

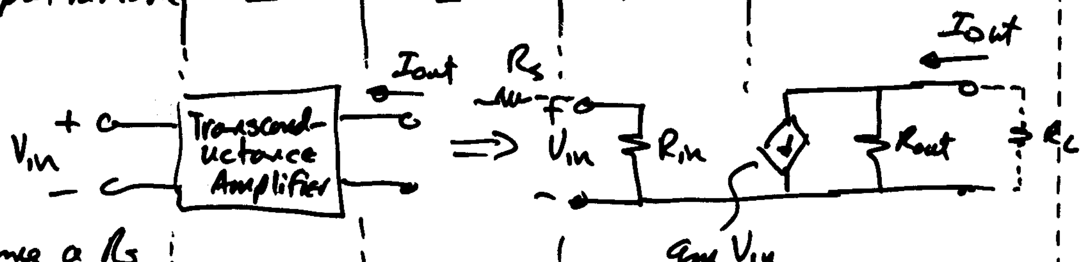
$i_1 = g_{11} v_1 + g_{12} i_2$ ⟶

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

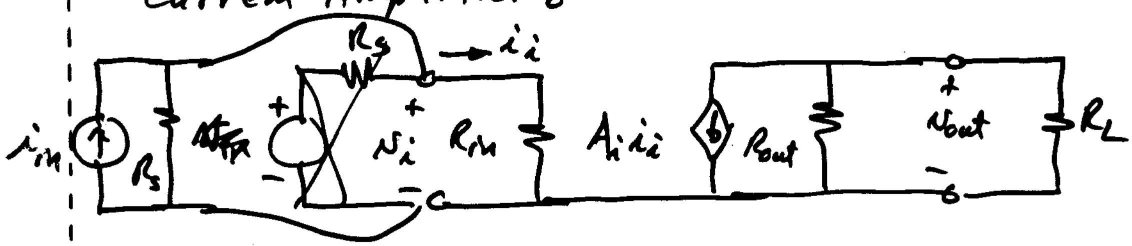


Amplifiers

	Type of Amplifier			
	Current	Transconductance	Trans-resistance	Voltage
Input variable	I	V	I	V
Output variable	I	I	V	V
Assume a R_s and an R_L				
Ideal cond. at input	$R_{in} << R_s$	$R_{in} >> R_s$	$R_{in} << R_s$	$R_{in} >> R_s$
Ideal condition at the output	$R_{out} >> R_L$	$R_{out} >> R_L$	$R_{out} << R_L$	$R_{out} << R_L$

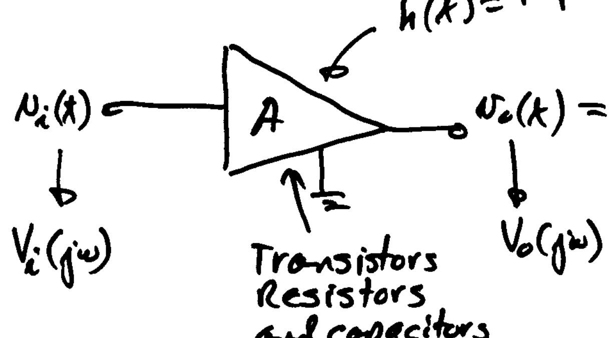


Current Amplifier:



Frequency Response

$h(t)$ = impulse response

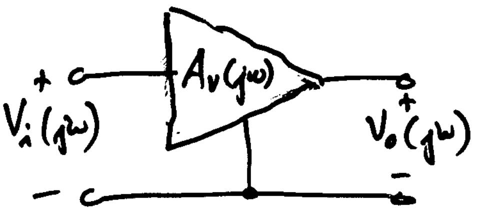


$v_o(t) = h(t) * v_{in}(t)$

Frequency domain

$\Longrightarrow V_o(j\omega) = A(j\omega) V_i(j\omega)$

Frequency Domain Analysis of Amplifiers



$A_v(j\omega) \to A_v(s)$

s = Complex freq. variable

$s = \sigma + j\omega$

Typically the amplifier can be described in the s-domain as,

$$A_v(s) = \frac{a_m s^m + \cdots + a_1 s + a_0}{b_n s^n + \cdots + b_1 s + b_0} \quad \text{where } n \geq m$$

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

Zeros: Values of s where $A_v(s) = 0$, i.e., $s = -z_1, -z_2, \cdots$

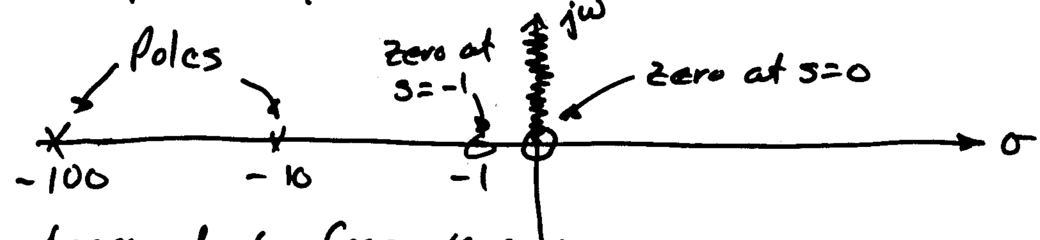
Poles: " " " " $A_v(s) = \infty$, i.e., $s = -p_1, -p_2, \cdots$

$$A_v(s) = \frac{100\,s(s+1)}{(s+10)(s+100)}$$

zeros at $s=0$ and $s=-1$

poles at $s=-10$ and $s=-100$

Complex frequency plane



Approach to freq. response -

1.) Find $A(s)$
2.) $s \to j\omega \to A(j\omega)$
3.) Find & plot $|A(j\omega)|$ $\quad 20\log_{10}|A(j\omega)|$
4.) Find & plot $\text{Arg}[A(j\omega)]$

} -3dB bandwidth