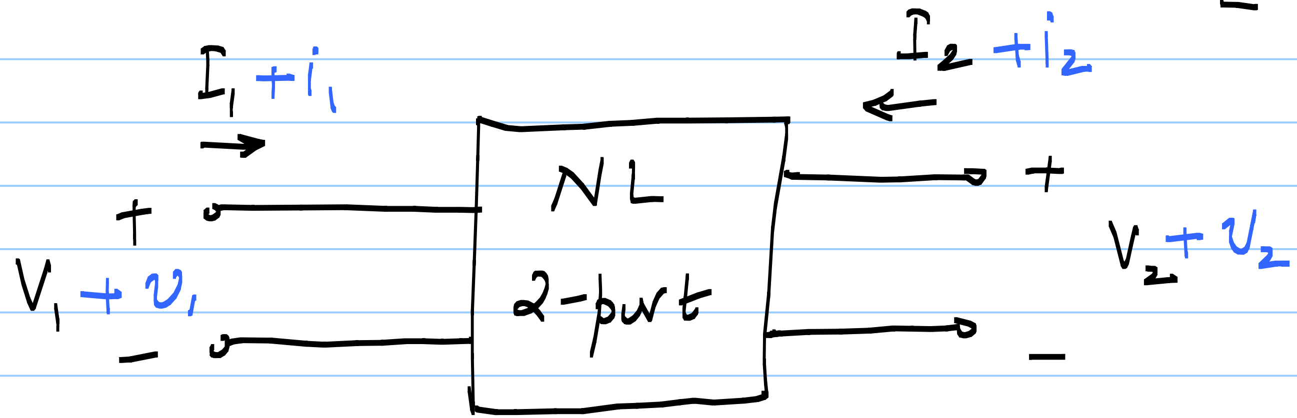
13/8/20

Lecture 6

$$[I] = [Y][V]$$



$$I_1 = f(V_1, V_2)$$

$$I_2 = g(V_1, V_2)$$

$$I_1' = I_1 + i_1 = f(V_1 + v_1, V_2 + v_2)$$

$$I_1 = f(V_1, V_2)$$

* If v_1 & v_2 are small, $f(\,)$ & $g(\,)$ can be expanded in a 2-D Taylor Series around op. pt. {approx. 3D surface by a tangential plane @ op. pt.}

$$I_1' = I_1 + i_1 \approx I_1 + \frac{\partial f}{\partial V_1} \cdot v_1 + \frac{\partial f}{\partial V_2} \cdot v_2$$

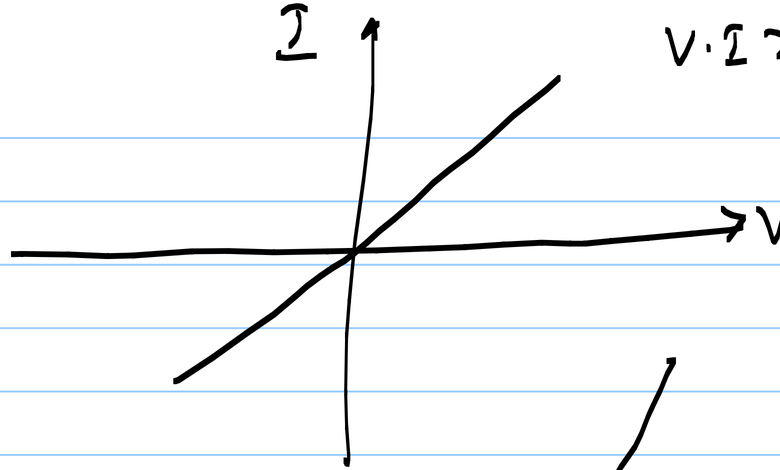
$$\Rightarrow \left.\begin{aligned} i_1 &= \frac{\partial f}{\partial V_1} \cdot v_1 + \frac{\partial f}{\partial V_2} \cdot v_2 \\ i_2 &= \frac{\partial g}{\partial V_1} \cdot v_1 + \frac{\partial g}{\partial V_2} \cdot v_2 \end{aligned}\right\} \text{linear relationship between } i_1, i_2, v_1, v_2$$

$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \underbrace{\begin{bmatrix} \overset{y_{11}}{\partial f/\partial V_1} & \overset{y_{12}}{\partial f/\partial V_2} \\ \underset{y_{21}}{\partial g/\partial V_1} & \underset{y_{22}}{\partial g/\partial V_2} \end{bmatrix}}_{\text{incremental } y\text{-matrix}} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

Graphical Representation

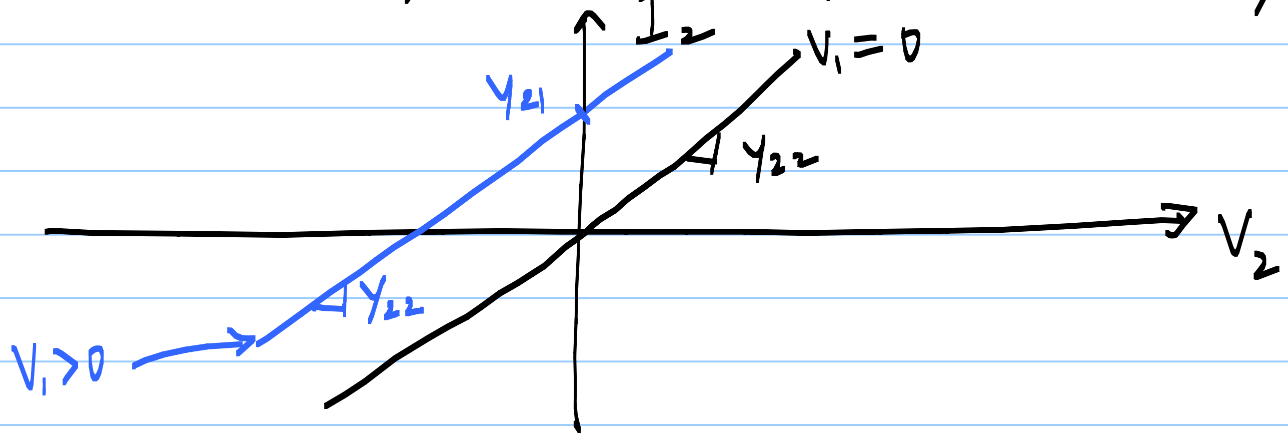
1) Linear passive 1-port

$V \cdot I \geq 0$



2) NL passive 1-port $V \cdot I \geq 0$

3) Linear 2-port : Input & output characteristics ↙



$$I_1 = Y_{11} V_1 + Y_{12} V_2$$

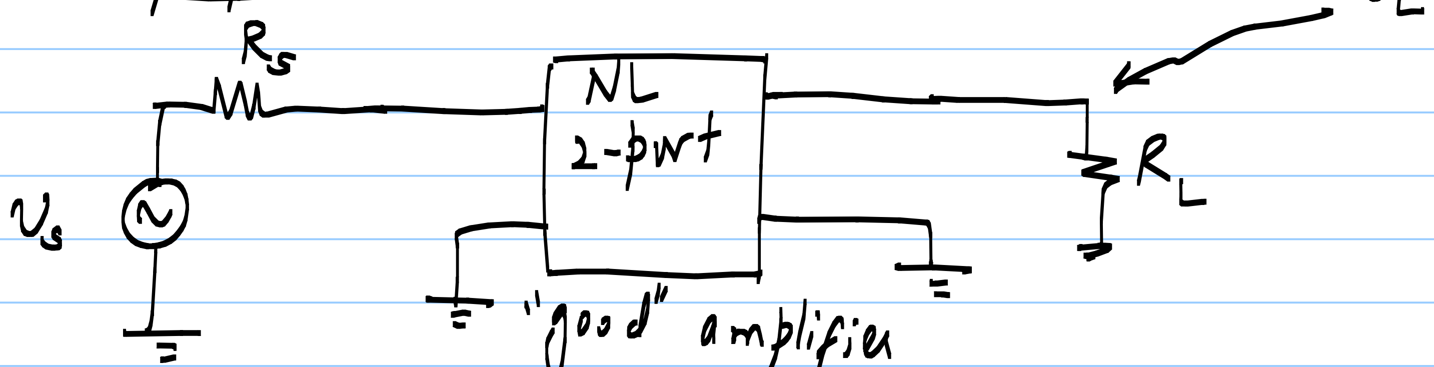
$$I_2 = Y_{21} V_1 + Y_{22} V_2$$

Input characteristics $\Rightarrow$ I_1 vs. V_1 for various V_2

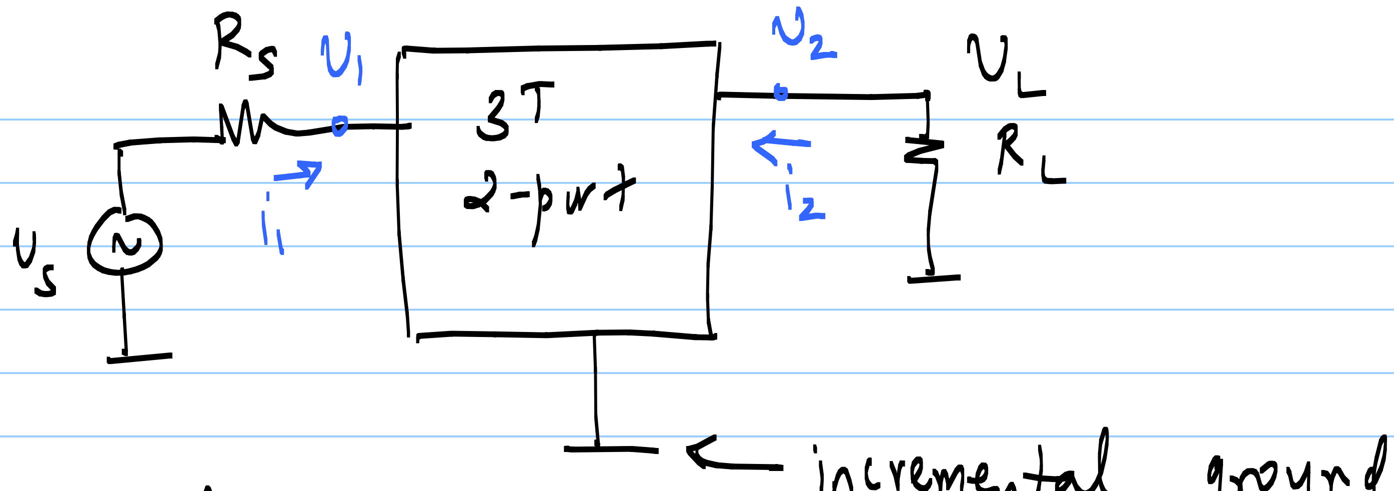
passivity : $V_1 I_1 + V_2 I_2 \geq 0$

(Lin. or NonLin)

<u>Amplifiers</u>



"good" amplifier



Good Amplifier:

1) Large gain: $\frac{v_L}{v_s}$ as large as possible

2) Independent of source quality: v_L independent of R_s and gain independent of R_s

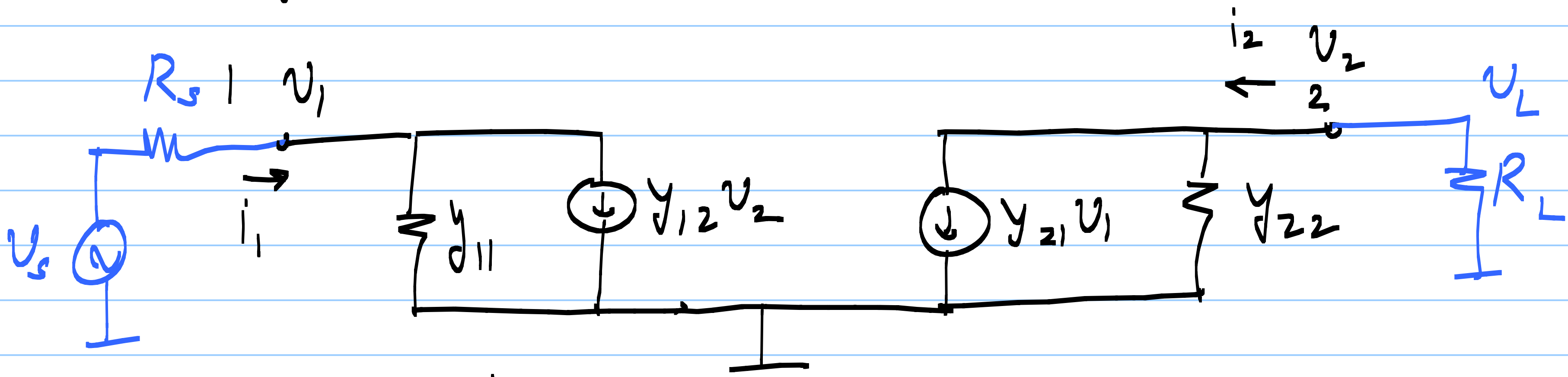
3) gain independent of R_L too.

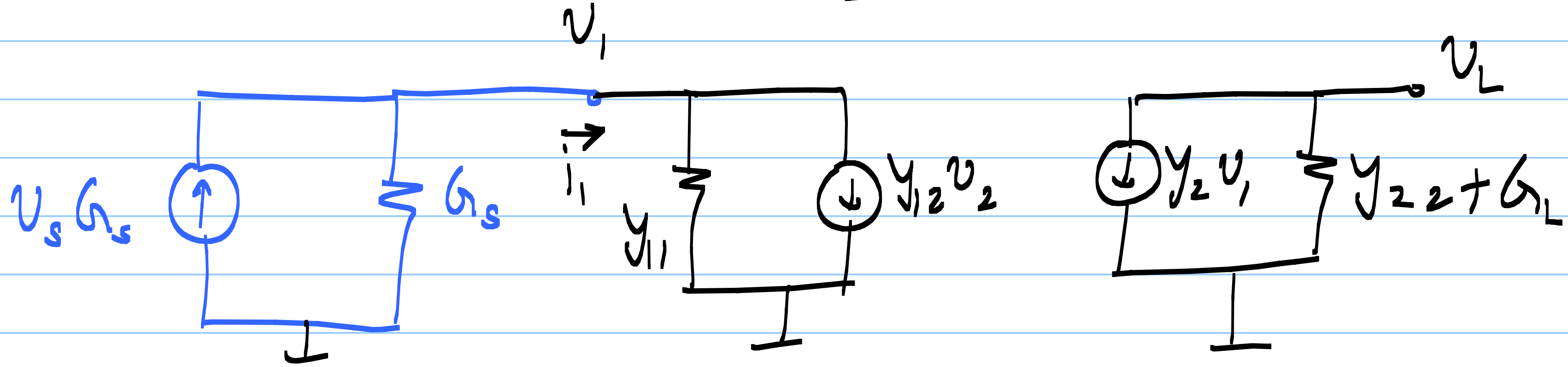
4) We want i_1 independent of v_2
"unilateral" $y_{12} = 0$ is desired

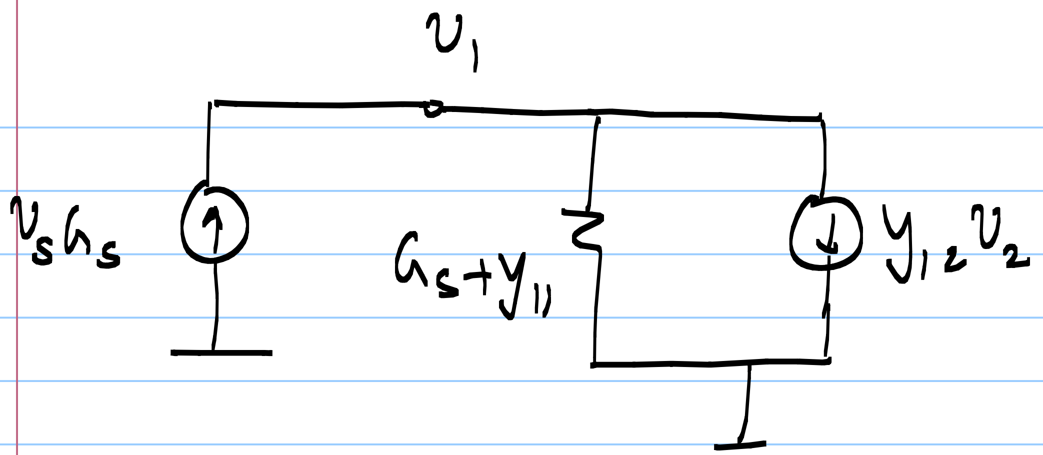
Derive constraints on [y] to achieve a "good" amp.

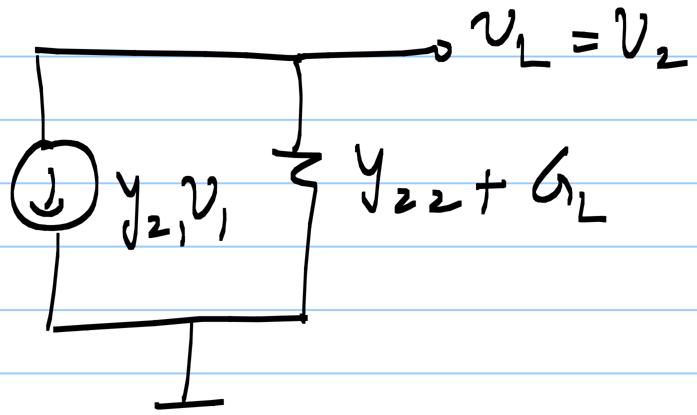
$$i_1 = y_{11} v_1 + y_{12} v_2$$
$$i_2 = y_{21} v_1 + y_{22} v_2$$

replace by equivalent network









KCL @ input & output.

@ input: $v_s G_s = v_1 (G_s + y_{11}) + y_{12} v_2$

$$\Rightarrow \quad v_1 = \frac{v_s G_s - y_{12} v_2}{G_s + y_{11}}$$

plug into

@ output: $y_{21} v_1 + v_2 (y_{22} + G_L) = 0$

$$y_{21} \left[\frac{v_s G_s - y_{12} v_2}{y_{11} + G_s} \right] + (y_{22} + G_L) \cdot v_2 = 0$$

$$v_s\left[\frac{y_{21}\cdot G_s}{y_{11}+G_s}\right] = v_2\left[\frac{y_{12}y_{21}}{y_{11}+G_s} - (y_{22}+G_L)\right]$$

$$= v_2\left[\frac{y_{12}y_{21} - (y_{22}+G_L)(y_{11}+G_s)}{y_{11}+G_s}\right]$$

$$\frac{v_2}{v_s} = \frac{v_L}{v_s} = \frac{y_{21}G_s}{y_{12}y_{21} - (y_{22}+G_L)(y_{11}+G_s)}$$

* If $y_{12}y_{21} = (y_{22}+G_L)(y_{11}+G_s)$, gain $=\infty$

undesired situation, gain needs to be a function of y_{11} etc.

* Make amplifier unilateral : $y_{12}=0$

$$\Rightarrow \quad \frac{v_L}{v_S} = \frac{-\,y_{21} G_S}{(y_{22}+G_L)(y_{11}+G_S)}$$