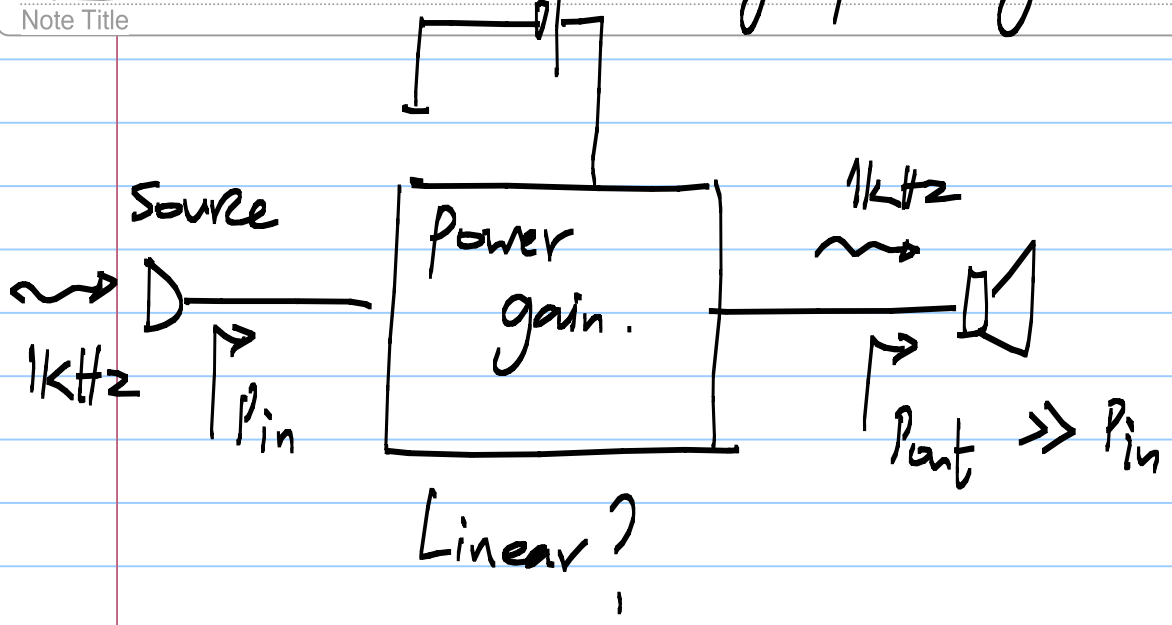
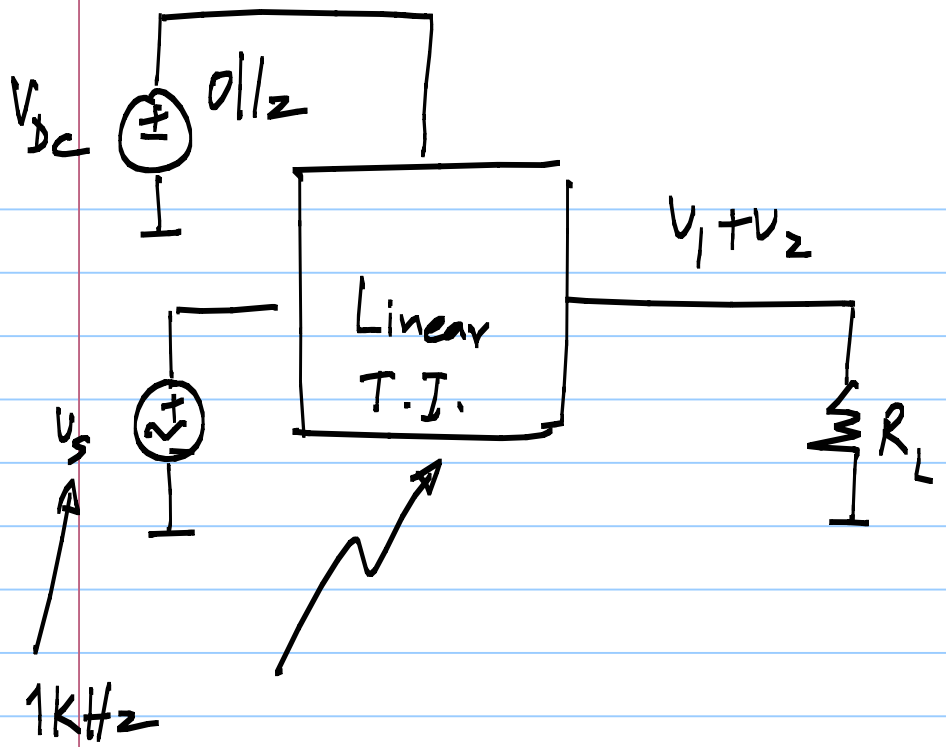
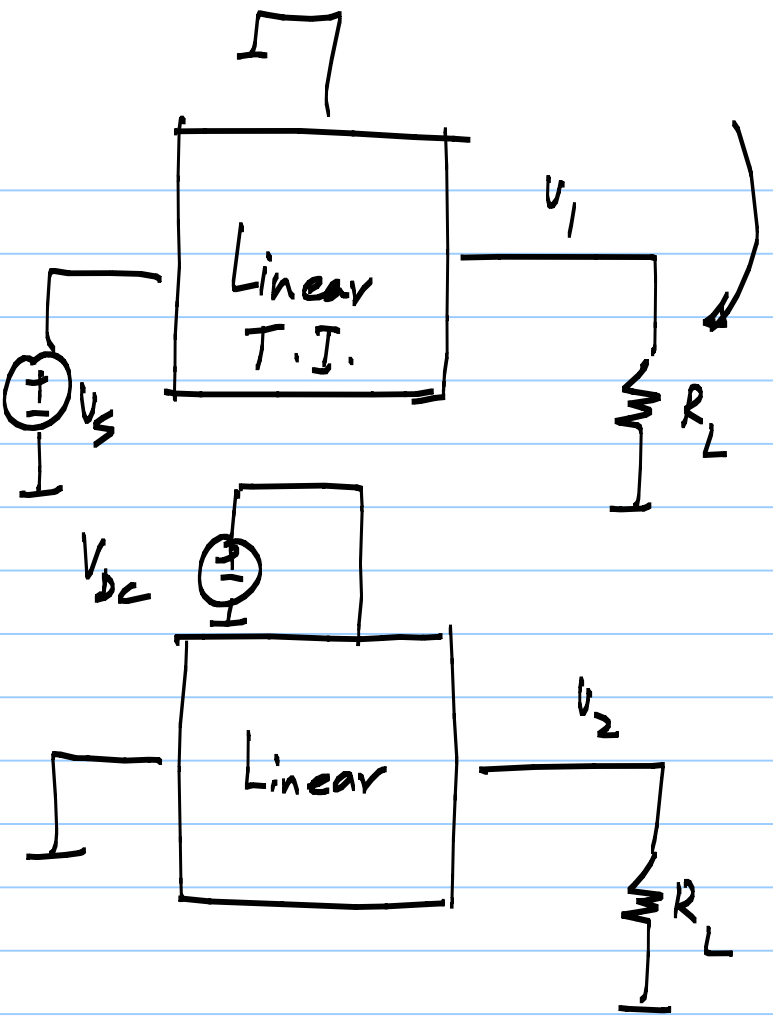
Lecture 1. obtaining power gain?

Note Title 7/31/2014



* Everything is passive (except batteries / power source)


V_{DC}
0 Hz
Linear
T.I.
$V_1 + V_2$
V_S
R_L
1kHz

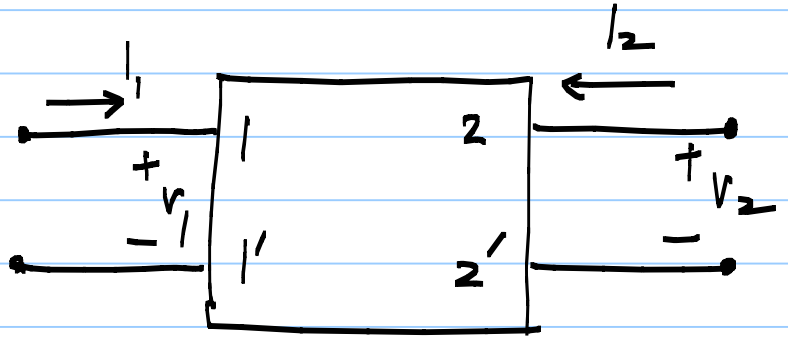

Linear
T.I.
V_1
V_S
R_L
V_{DC}
Linear
V_2
R_L

Nonlinearity is essential for power amplification

[Increased signal power at some desired frequency]

Cannot be done at all with linear, time-invariant systems.

Nonlinear two-port



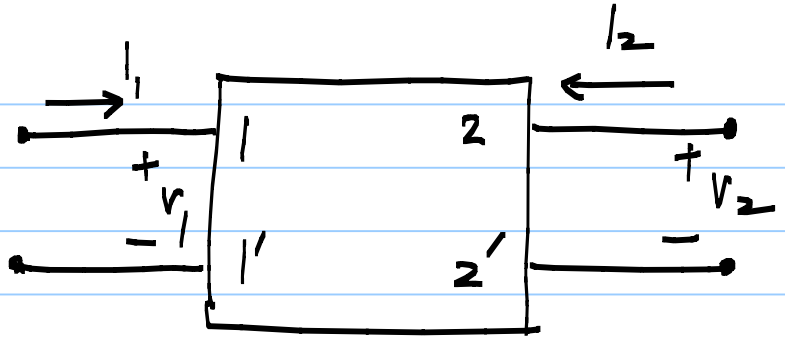
$$I_1 = f_1(V_1, V_2)$$

$$I_2 = f_2(V_1, V_2)$$

operating point: V_{1o}, V_{2o}

$$I_{1o} = f_1(V_{1o}, V_{2o})$$

$$I_{2o} = f_2(V_{1o}, V_{2o})$$



$$I_1 = f_1(V_{10}+v_1, V_{20}+v_2)$$

$$I_2 = f_2(V_{10}+v_1, V_{20}+v_2)$$

$$I_{10} = f_1(V_{10}, V_{20})$$

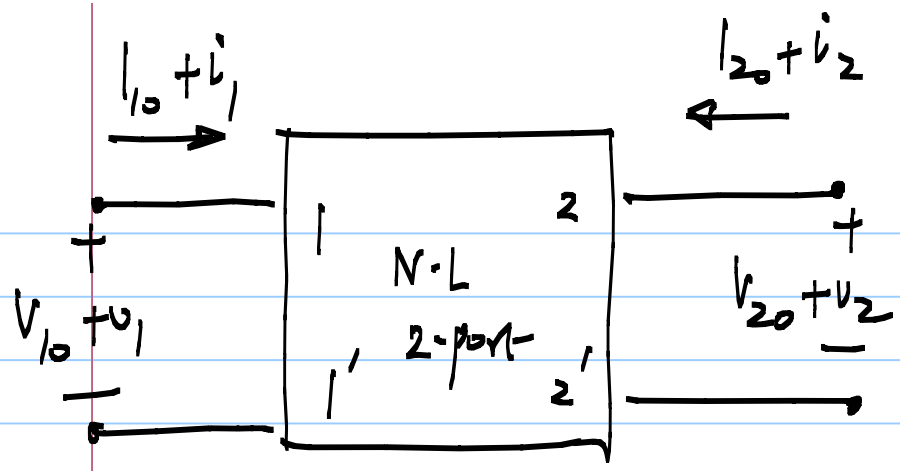
$$I_{20} = f_2(V_{10}, V_{20})$$

operating point: V_{10}, V_{20}

signals (incremental): v_1, v_2

$$i_1 = I_1 - I_{10} \simeq \left.\frac{\partial f_1}{\partial V_1}\right|_{op} \cdot v_1 + \left.\frac{\partial f_1}{\partial V_2}\right|_{op} \cdot v_2$$

$$i_2 = I_2 - I_{20} \simeq \left.\frac{\partial f_2}{\partial V_1}\right|_{op} \cdot v_1 + \left.\frac{\partial f_2}{\partial V_2}\right|_{op} \cdot v_2$$



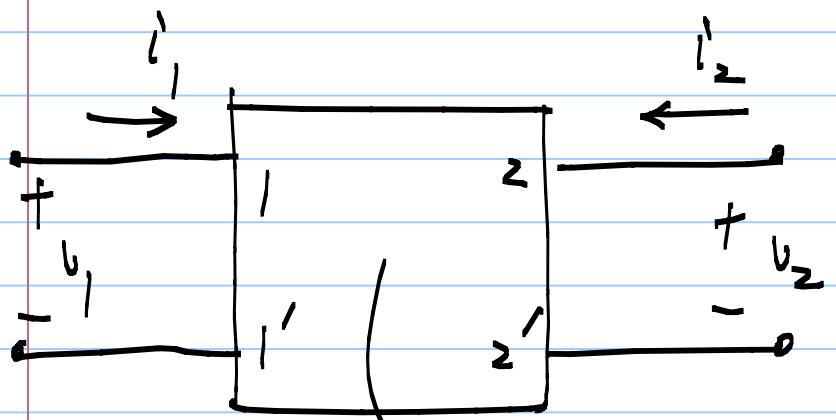
$$i_1 = y_{11} v_1 + y_{12} v_2$$

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

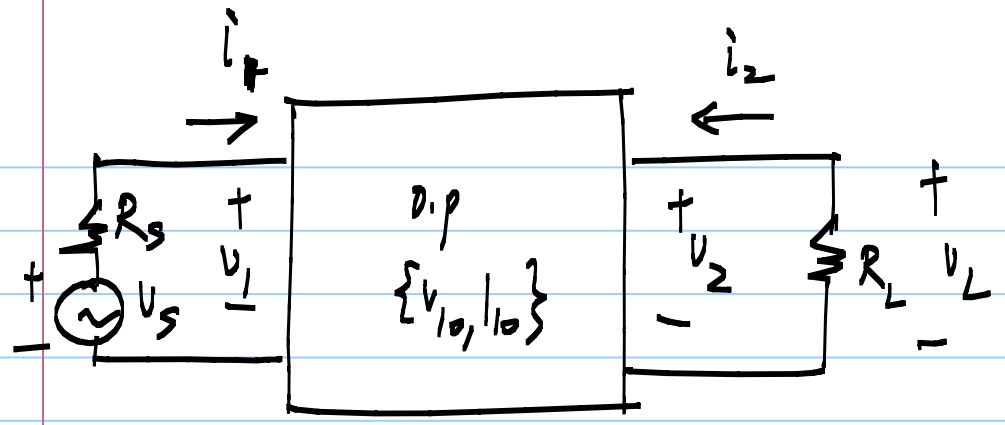
$$\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

Incremental y-parameters @ op. point

$$\left. \frac{\partial f_1}{\partial v_1} \right|_{op}$$



Linear small-signal eq. circuit $\Big|_{op\ \{V_{10},\ V_{20}\}}$



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

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

$$v_1 = v_s - i_1 R_s \quad \text{or}$$

$$v_2 = -i_2 R_L$$

$$v_L = v_2$$

$$\frac{v_L}{v_s} :$$

$$y_{11} v_1 + y_{12} v_2 = \frac{v_s}{R_s} - \frac{v_1}{R_s}$$

$$y_{21} v_1 + y_{22} v_2 = -\frac{v_2}{R_L}$$

$$y_{21} v_1 = -\left(y_{22} + \frac{1}{R_L}\right) v_2$$

$$\left(y_{11} + \frac{1}{R_s}\right) \frac{\left(-\left(y_{22} + 1/R_L\right)\right)}{y_{21}} \cdot v_2 + y_{12} v_2 = \frac{v_s}{R_s}$$

$$\frac{v_2}{v_s} = \frac{y_{21} \cdot 1/R_s}{y_{12} y_{21} - \left(y_{11} + \frac{1}{R_s}\right)\left(y_{22} + \frac{1}{R_L}\right)}$$

$$= \frac{-y_{21} \cdot 1/R_s}{\left(y_{11} + \frac{1}{R_s}\right)\left(y_{22} + \frac{1}{R_L}\right) - y_{12} y_{21}}$$

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