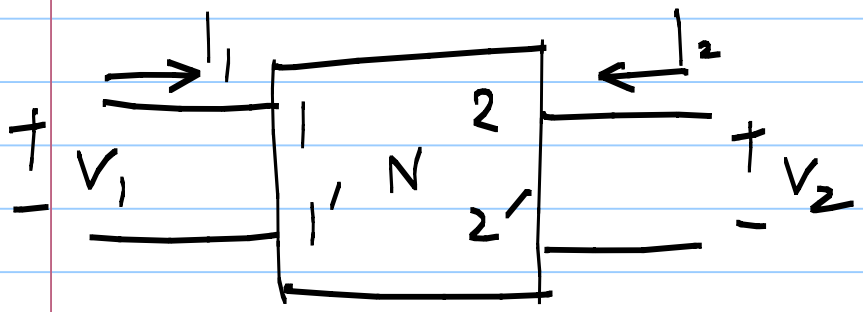
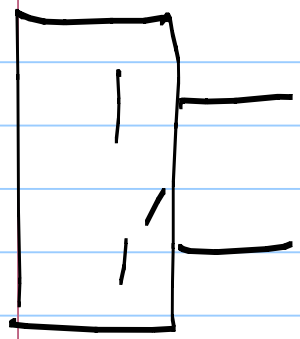
EE 2015 Two-port networks 30/8/2017



$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$



R or G

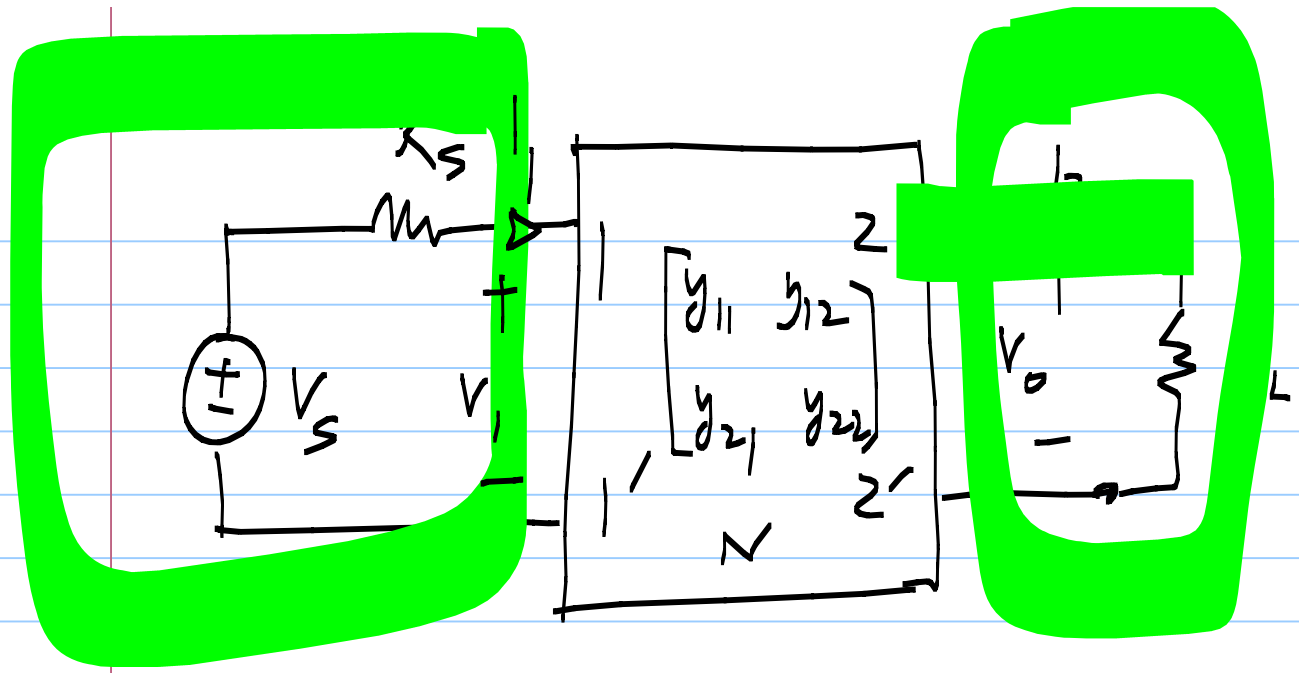
y-parameters

admittance parameters

conductance

$$\underline{I} = [Y]\,\underline{V}$$

$$I = G \cdot V$$



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

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

$$\frac{V_s}{R_s} = \left(\frac{1}{R_s} + y_{11}\right) V_1 + y_{12} V_2$$

$$-\frac{V_2}{R_L} = y_{21} V_1 + y_{22} V_2$$

2

Eliminate V_1, I_1, I_2

(V_s, V_2)

$$\frac{V_s}{R_s} = \left(\frac{1}{R_s} + y_{11}\right) V_1 + y_{12} V_2$$

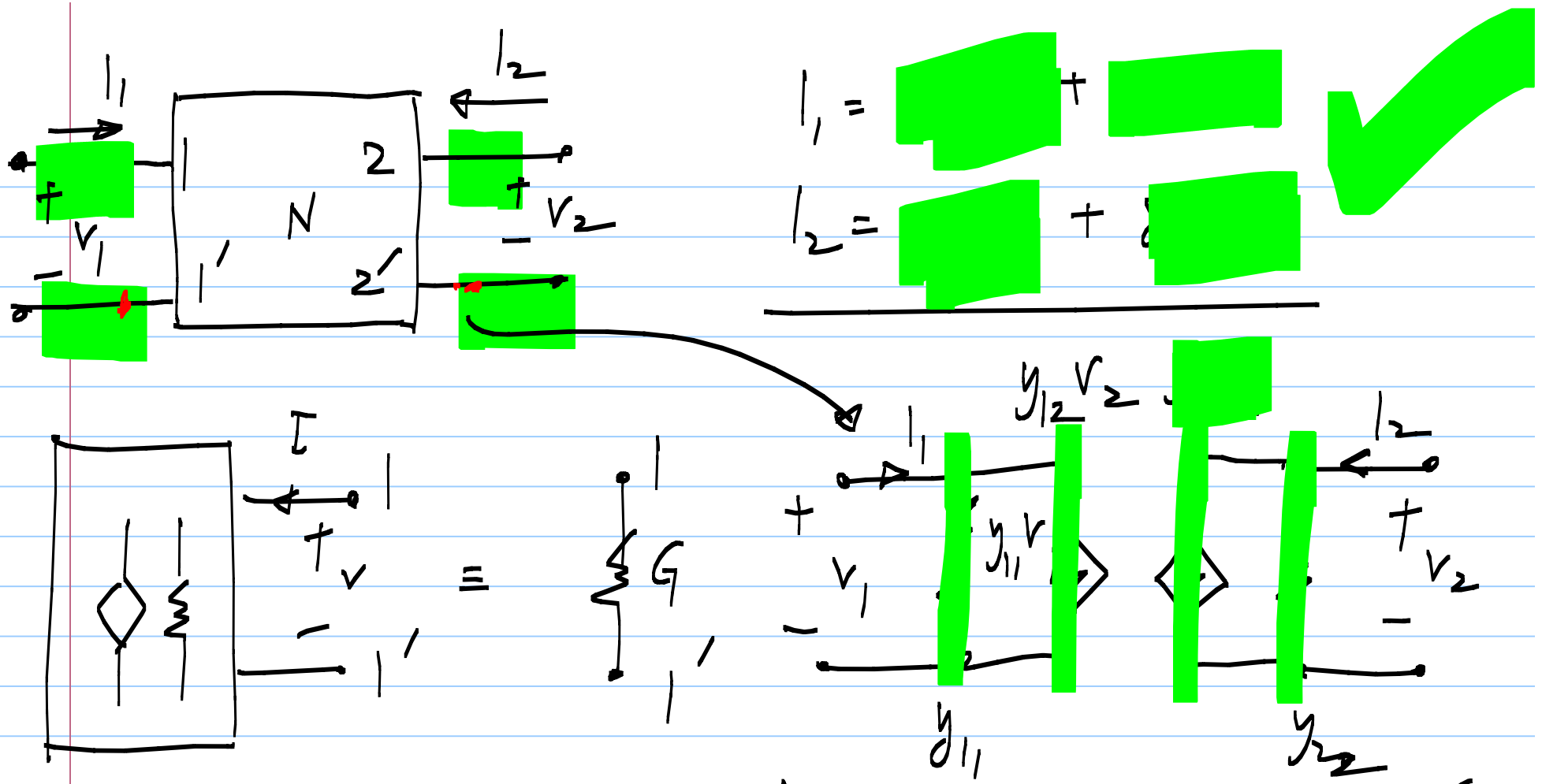
$$-\frac{V_2}{R_L} = y_{21} V_1 + y_{22} V_2$$

$$V_1 = -\frac{V_2 \left(y_{22} + \frac{1}{R_L}\right)}{y_{21}}$$

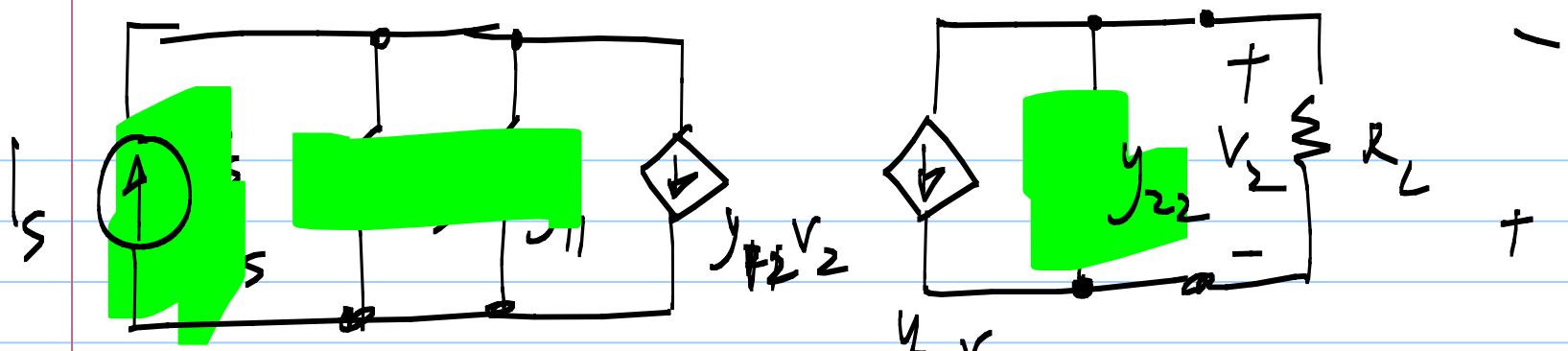
$$\frac{V_s}{R_s} = \left[-\frac{\left(\frac{1}{R_s} + y_{11}\right)\left(\frac{1}{R_L} + y_{22}\right)}{y_{21}} + y_{12} \right] \cdot V_2$$

$$\frac{V_s}{R_s} = \left[-\left(\frac{1}{R_s} + y_{11}\right)\left(\frac{1}{R_2} + y_{22}\right) + \; \right] \cdot V_2$$

$$\frac{V_2}{V_s} = \frac{-y_{21}/R_s}{\left(\frac{1}{R_s} + y_{11}\right)\left(\frac{1}{R_2} + y_{22}\right) - y_{12}y_{21}}$$

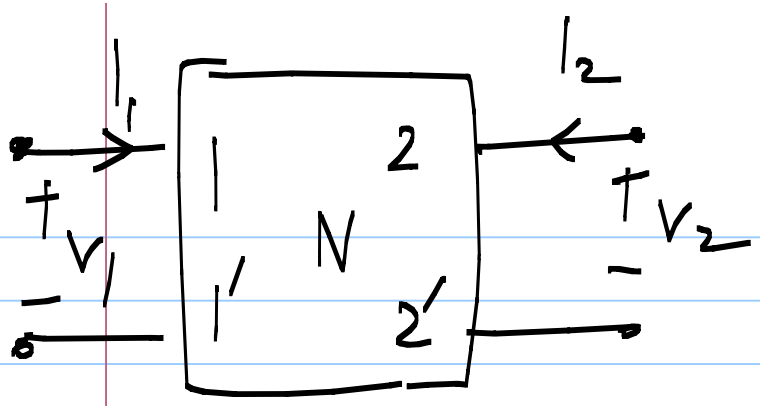


Circuit representation of a two-port



$y_{21}V_1$

$$V_2 = \frac{-y_{21}\left(V_S/R_S\right)}{\left(\quad\right)\left(\quad\right) - y_{12}y_{21}}$$



y-parameters

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}^{-1}$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \underbrace{\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}}_{\text{z-parameter}} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\frac{1}{y_{11}y_{22} - y_{12}y_{21}} \begin{bmatrix} y_{22} & -y_{12} \\ -y_{21} & y_{11} \end{bmatrix}$$

z-parameter
Impedance parameters

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

h - parameters
(hybrid)

$h_{11} : \left. \frac{V_1}{I_1} \right|_{V_2=0}$ resistance

$h_{12} : \left. \frac{V_1}{V_2} \right|_{I_1=0}$ dimensionless

$h_{21} : \left. \frac{I_2}{I_1} \right|_{V_2=0}$ dimensionless current gain

$h_{22} : \left. \frac{I_2}{V_2} \right|_{I_1=0}$ conductance

$$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ I_2 \end{bmatrix}$$

g - parameters

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* Draw the circuit representation for z-, h-, g- parameters
* Express h- & g- parameters in terms of y- parameters