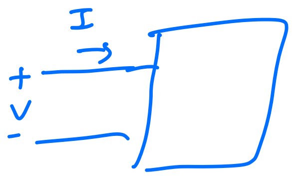
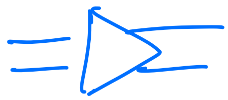
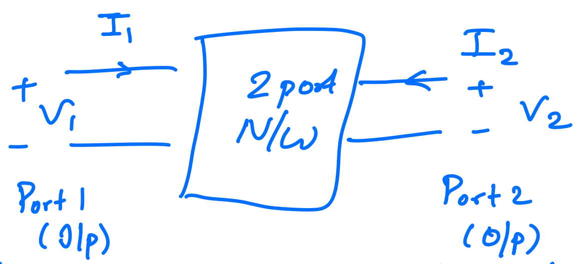
Two Port Network Parameters



Impedance





Open circuit impedance parameters (Z-parameters)

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

Matrix notation

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

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2 = 0}$$

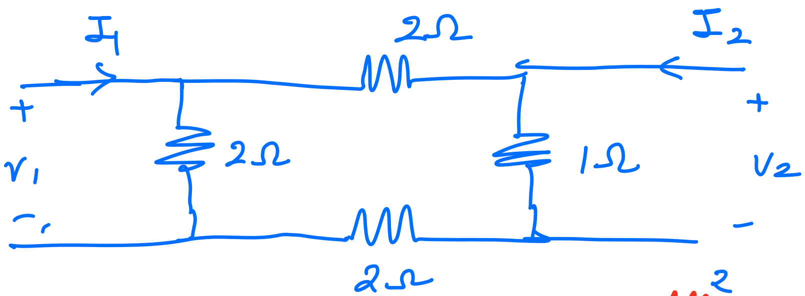
$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2 = 0}$$

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1 = 0}$$

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

Open Circuit Impedance

Example:



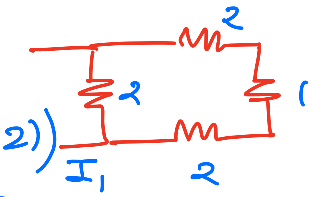
Z_{22}

Z_{12}

Z_{11}, Z_{21}

$I_2 = 0$

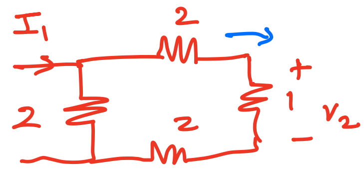
$V_1 = (2 \parallel (2+1+2))$



$= (2 \parallel 5) \, I_1$

$= 10/7 \; I_1$

$Z_{11} = \frac{V_1}{I_1} = 10/7$



$$Z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}$$

$$V_2 = I_1 \cdot \frac{2}{2+(2+1+2)} \times 1$$

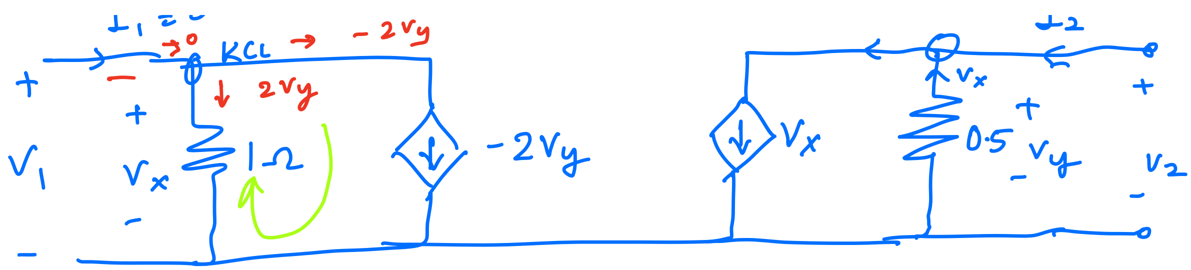
$$= I_1 \cdot 2/(2+5)$$

$Z_{21} = V_2/I_1 = 2/7$

$Z_{22} = 6/7 \qquad Z_{12} = 2/7$

Example 16.14 (SK)

KCL



Z- parameters.

$$V_1 = V_x \qquad V_2 = V_y$$

$I_2 = 0$, Z_{11} , Z_{21}

$$V_2 = V_y = -0.5 V_x$$

$$= -0.5 V_1$$

$$I_1 = \frac{V_x}{1} - 2V_y$$

$$I_1 = V_1 - 2(-0.5 V_1)$$

$$I_1 = V_1 + V_1 = 2V_1$$

$$Z_{11} = \frac{V_1}{I_1} = \frac{1}{2}$$

$$Z_{21} = \frac{V_2}{I_1} = \frac{-0.5 V_1}{2 V_1} = -\frac{1}{4}$$

$I_2 = 0$

$$Z_{22} = \frac{V_2}{I_2}$$

$$V_1 = V_x = -1(-2V_y) = +2V_2.$$

KCL at end node.

$$I_2 = \frac{V_y}{0.5} + V_x$$

$$= 2V_2 + 2V_2$$

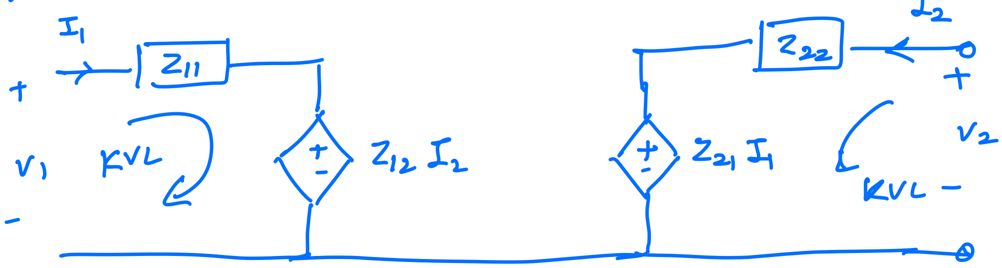
$= 4V_2$

$Z_{22} = V_2/I_2 = 1/4$

Exercise: $Z_{12} = 0.5$ //.

$$\begin{cases} V_1 = Z_{11} I_1 + Z_{12} I_2 \\ V_2 = Z_{21} I_1 + Z_{22} I_2 \end{cases}$$

Equivalent ckt



Short Circuit Admittance Parameters. (Y-parameters)

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

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

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} \quad -(1)$$

$Y_{11} = \left.\dfrac{I_1}{V_1}\right|_{V_2=0}$

$Y_{21} = \left.\dfrac{I_2}{V_1}\right|_{V_2=0}$

$Y_{12} = \left.\dfrac{I_1}{V_2}\right|_{V_1=0}$

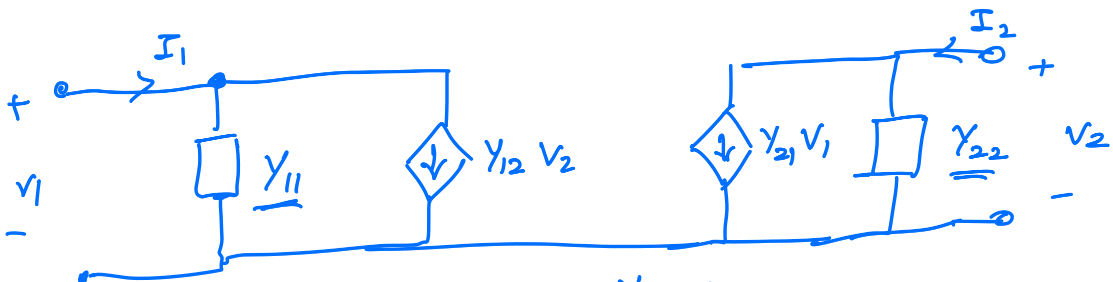
$Y_{22} = \left.\dfrac{I_2}{V_2}\right|_{V_1=0}$

Short Circuit Admittance

$$\begin{pmatrix} V_1 \\ V_2 \end{pmatrix} = \begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} \begin{pmatrix} I_1 \\ I_2 \end{pmatrix} \quad -(2)$$

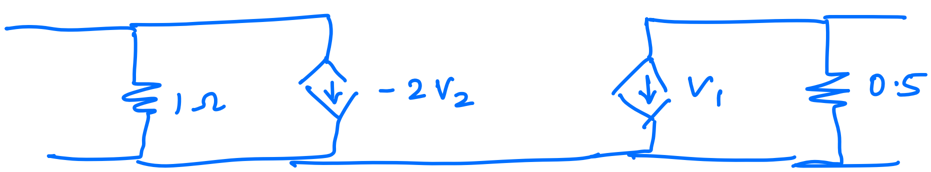
$$\begin{pmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{pmatrix} = \begin{pmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{pmatrix}^{-1}$$

Equivalent circuit (Y-parameters)



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

(Example)



$$Z = \begin{pmatrix} 1 & -2 \\ 1 & 2 \end{pmatrix}^{-1}$$

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