Last class: 2 port network parameters
- Z- parameters
- Y- parameters

Hybrid parameters (h- parameters)

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

$I_2 = h_{21} I_1 + h_{22} V_2$

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

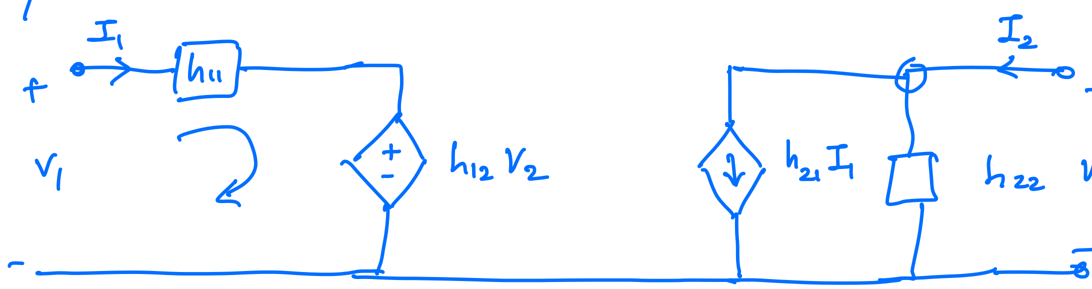
$h_{11} = \left.\dfrac{V_1}{I_1}\right|_{V_2=0}$ input impedance w/ output shorted

$h_{21} = \left.\dfrac{I_2}{I_1}\right|_{V_2=0}$ forward current gain output shorted

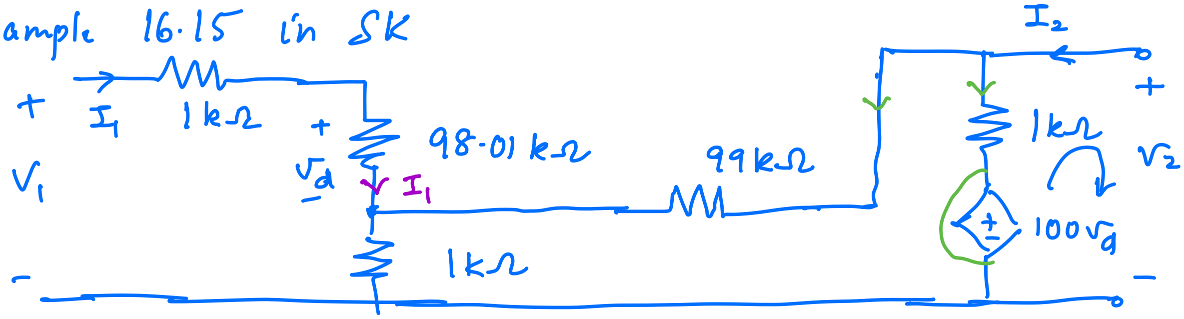
$h_{12} = \left.\dfrac{V_1}{V_2}\right|_{I_1=0}$ reverse voltage gain input open

$h_{22} = \left.\dfrac{I_2}{V_2}\right|_{I_1=0}$ output admittance. input open

Equivalent circuit



Example 16.15 in SK



h_{11} & h_{21} $\quad V_2 = 0$

$I_1 = 0 \quad v_d = 0$

$h_{11} = \frac{V_1}{I_1} \quad V_1 = I_1 \left(1k\Omega + 98.01k\Omega + 1k\Omega \parallel 99k\Omega \right)$

$= I_1 \cdot 100k\Omega$

$h_{11} = \frac{V_1}{I_1} = 100k\Omega$ //.

$\frac{100 v_d + 1k\Omega \times}{I_x}$

$= 0$

$h_{21} = I_2 / I_1 \big|_{V_2 = 0}$

$I_2 = I_x + I_y$

$I_x = -\frac{100 v_d}{1k\Omega}$

$-I_y = I_1 \times \frac{1k\Omega}{1k\Omega + 99k\Omega} = \frac{I_1}{100}$

$v_d = I_1 \times 98.01k\Omega$

$I_x = -\frac{100}{1\cancel{k\Omega}} \times 98.01\cancel{k\Omega} \times I_1$

$= -9801 I_1$

$I_2 = I_x + I_y = -9801 I_1 - \frac{I_1}{100}$

$\frac{I_2}{I_1} \approx -9801$ //

h_{12} & h_{22} $\quad I_1 = 0$

$h_{22} = I_2 / V_2 \big|_{I_1 = 0}$

$$\frac{I_2}{V_2} \quad \approx \quad V_2 = (1k\Omega \parallel 100k\Omega)\, I_2$$

$$\frac{I_2}{V_2} = \frac{1}{1k\Omega \parallel 100k\Omega} \simeq \frac{1}{1k\Omega}$$

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

$$V_1 = V_2 \cdot \frac{1k\Omega}{1k\Omega + 99k\Omega} = V_2 \cdot \frac{1}{100}$$

$$\frac{V_1}{V_2} = \frac{1}{100} \;//$$

Inverse hybrid parameter

$$I_1 = g_{11} V_1 + g_{12} I_2$$

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

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

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

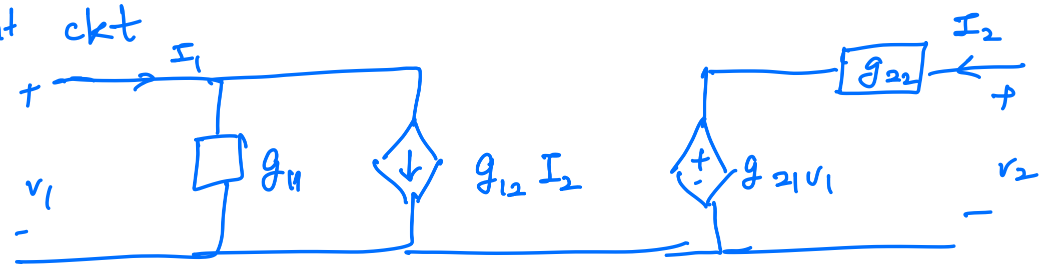
$g_{11} = \left.\frac{I_1}{V_1}\right|_{I_2=0}$ input admittance with o/p open

$g_{21} = \left.\frac{V_2}{V_1}\right|_{I_2=0}$ forward voltage gain with o/p open

$g_{12} = \left.\frac{I_1}{I_2}\right|_{V_1=0}$ reverse current gain with i/p short

$g_{22} = \left.\frac{V_2}{I_2}\right|_{V_1=0}$ output impedance with i/p short

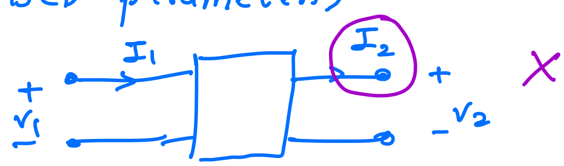
Equivalent ckt

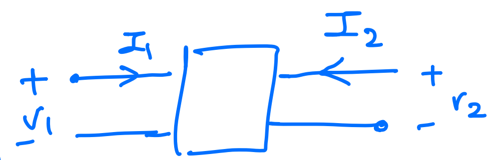


Transmission Parameters (ABCD parameters)

$$V_1 = A \; V_2 + B \; (-I_2)$$

$$I_1 = C \; V_2 + D \; (-I_2)$$





$$\begin{pmatrix} V_1 \\ I_1 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} V_2 \\ -I_2 \end{pmatrix}$$

← Port 1 →   ← Port 2 →

$$A = \left. \frac{V_1}{V_2} \right|_{I_2 = 0}$$: Reverse voltage gain

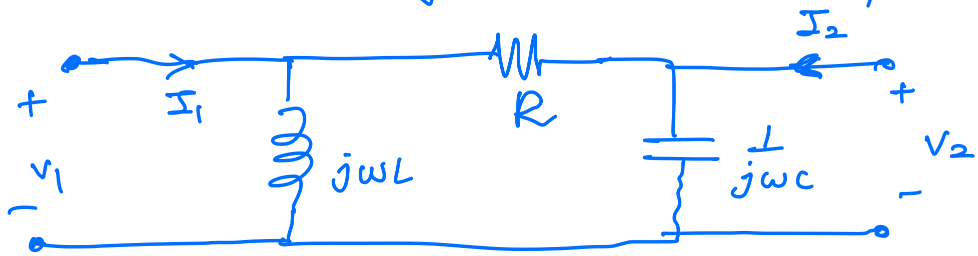
$$C = \left. \frac{I_1}{V_2} \right|_{I_2 = 0}$$: open ckt transfer admittance

$$B = \left. \frac{V_1}{-I_2} \right|_{V_2 = 0}$$: Short ckt transfer impedance

$$D = \left. \frac{I_1}{-I_2} \right|_{V_2 = 0}$$: Reverse current gain

Example 16.3.1 in SK

[Find the steady state ABCD parameters]



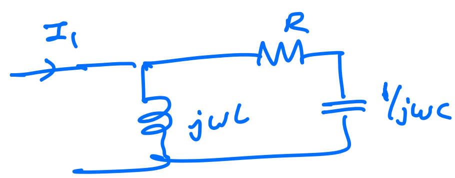
A & C $\quad I_2 = 0$

$$A = \frac{V_1}{V_2} \qquad V_2 = V_1 \frac{1/j\omega C}{R + 1/j\omega C}$$

$$= \frac{V_1}{1 + j\omega RC}$$

$$A = \frac{V_1}{V_2} = \underline{\underline{1 + j\omega RC}}$$

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



$I_1 \overset{?}{=} \quad V_1.$

$$I_1 = \frac{V_1}{j\omega L \parallel \left(R + \frac{1}{j\omega C}\right)}$$

$$= \frac{V_1}{\dfrac{j\omega L \left(R + \frac{1}{j\omega C}\right)}{j\omega L + R + \frac{1}{j\omega C}}} = \frac{V_1}{\dfrac{j\omega L\,(1 + j\omega RC)}{1 + j\omega C\,(R + j\omega L)}}$$

$$= V_1 \cdot \frac{[1 + j\omega C\,(R + j\omega L)]}{j\omega L\,(1 + j\omega RC)}$$

$$= \cancel{(1+j\omega RC)}\, V_2 \quad \frac{[1 + j\omega C(R+j\omega L)]}{j\omega C\ \cancel{(1+j\omega RC)}}$$

$$\frac{I_1}{V_2} = \frac{1 + j\omega C(R+j\omega L)}{j\omega C}$$

Exercise : Find B & D ?

$$B = R$$

$$D = 1 + R/j\omega L$$