第十六章 二端口网络

二端口网络

二端口的方程和参数

二端口的等效电路

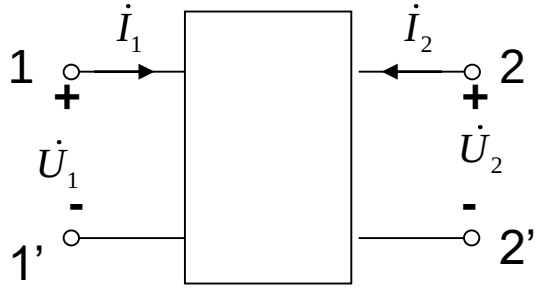
§16-1　二端口网络

如果在任何时间，从端子1流入的电流等于从端子1’流出的电流，从端子2流入的电流等于从端子2’流出的电流，这种电路称为二端口电路。

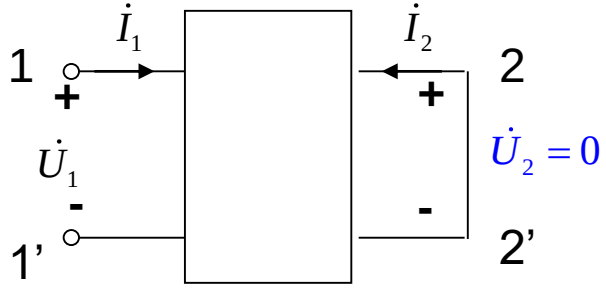
§16-2 二端口方程和参数

$$\dot{I}_1 = Y_{11}\dot{U}_1 + Y_{12}\dot{U}_2$$
$$\dot{I}_2 = Y_{21}\dot{U}_1 + Y_{22}\dot{U}_2$$

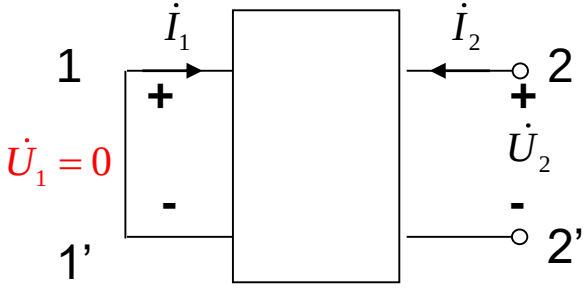
$$\begin{bmatrix}\dot{I}_1\\ \dot{I}_2\end{bmatrix} = \begin{bmatrix}Y_{11} & Y_{12}\\ Y_{21} & Y_{22}\end{bmatrix}\begin{bmatrix}\dot{U}_1\\ \dot{U}_2\end{bmatrix}$$



$$Y_{11} = \left.\frac{\dot{I}_1}{\dot{U}_1}\right|_{\dot{U}_2=0} \qquad Y_{21} = \left.\frac{\dot{I}_2}{\dot{U}_1}\right|_{\dot{U}_2=0}$$



$$Y_{12} = \left.\frac{\dot{I}_1}{\dot{U}_2}\right|_{\dot{U}_1=0} \qquad Y_{22} = \left.\frac{\dot{I}_2}{\dot{U}_2}\right|_{\dot{U}_1=0}$$



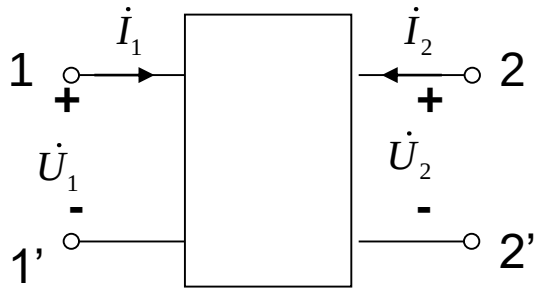
Y：短路导纳参数

§16-2 二端口方程和参数

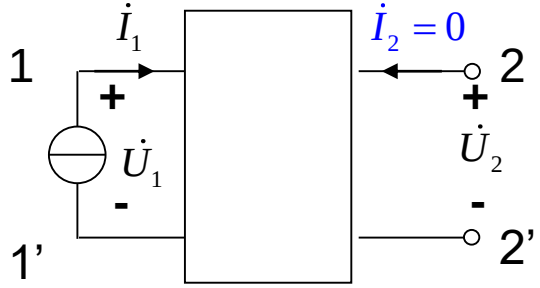
$$\dot{U}_1 = Z_{11}\dot{I}_1 + Z_{12}\dot{I}_2$$

$$\dot{U}_2 = Z_{21}\dot{I}_1 + Z_{22}\dot{I}_2$$

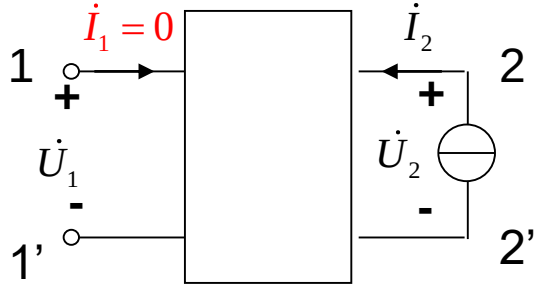
$$\begin{bmatrix}\dot{U}_1\\ \dot{U}_2\end{bmatrix} = \begin{bmatrix}Z_{11} & Z_{12}\\ Z_{21} & Z_{22}\end{bmatrix}\begin{bmatrix}\dot{I}_1\\ \dot{I}_2\end{bmatrix}$$



$$Z_{11} = \left.\frac{\dot{U}_1}{\dot{I}_1}\right|_{\dot{I}_2=0} \qquad Z_{21} = \left.\frac{\dot{U}_2}{\dot{I}_1}\right|_{\dot{I}_2=0}$$



$$Z_{12} = \left.\frac{\dot{U}_1}{\dot{I}_2}\right|_{\dot{I}_1=0} \qquad Z_{22} = \left.\frac{\dot{U}_2}{\dot{I}_2}\right|_{\dot{I}_1=0}$$



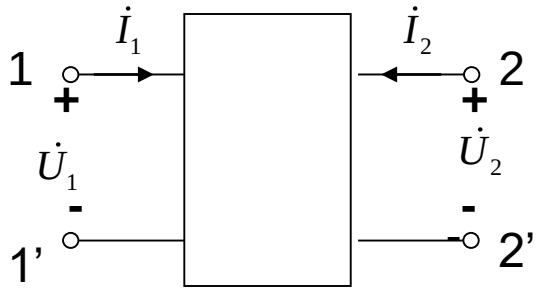
Z：开路阻抗矩阵

§16-2 二端口方程和参数

Y参数方程：

$$\dot{I}_1 = Y_{11}\dot{U}_1 + Y_{12}\dot{U}_2$$

$$\dot{I}_2 = Y_{21}\dot{U}_1 + Y_{22}\dot{U}_2$$



Y：短路导纳矩阵 $\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$

Z参数方程：

$$\dot{U}_1 = Z_{11}\dot{I}_1 + Z_{12}\dot{I}_2$$

$$\dot{U}_2 = Z_{21}\dot{I}_1 + Z_{22}\dot{I}_2$$

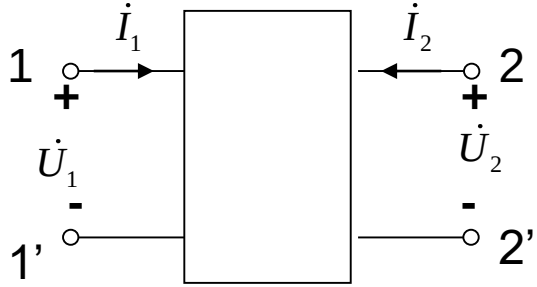
Z：开路阻抗矩阵 $\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$

$Z = Y^{-1}$ $Y = Z^{-1}$

§16-2 二端口方程和参数

A参数方程：$\dot{U}_1 = A_{11}\dot{U}_2 + A_{12}(-\dot{I}_2)$

$\dot{I}_1 = A_{21}\dot{U}_2 + A_{22}(-\dot{I}_2)$



$$A_{11} = \left.\frac{\dot{U}_1}{\dot{U}_2}\right|_{\dot{I}_2=0} \qquad A_{21} = \left.\frac{\dot{I}_1}{\dot{U}_2}\right|_{\dot{I}_2=0}$$

$$A_{12} = \left.\frac{\dot{U}_1}{-\dot{I}_2}\right|_{\dot{U}_2=0} \qquad A_{22} = \left.\frac{\dot{I}_1}{-\dot{I}_2}\right|_{\dot{U}_2=0}$$

$$\begin{bmatrix}\dot{U}_1\\ \dot{I}_1\end{bmatrix} = \begin{bmatrix}A_{11} & A_{12}\\ A_{21} & A_{22}\end{bmatrix}\begin{bmatrix}\dot{U}_2\\ -\dot{I}_2\end{bmatrix}$$

H参数方程：$\dot{U}_1 = H_{11}\dot{I}_1 + H_{12}\dot{U}_2$

$\dot{I}_2 = H_{21}\dot{I}_1 + H_{22}\dot{U}_2$

$$H_{11} = \left.\frac{\dot{U}_1}{\dot{I}_1}\right|_{\dot{U}_2=0} \qquad H_{21} = \left.\frac{\dot{I}_2}{\dot{I}_1}\right|_{\dot{U}_2=0}$$

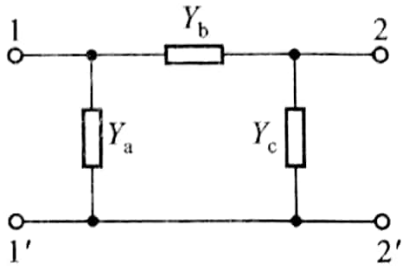
$$H_{12} = \left.\frac{\dot{U}_1}{\dot{U}_2}\right|_{\dot{I}_1=0} \qquad H_{22} = \left.\frac{\dot{I}_2}{\dot{U}_2}\right|_{\dot{I}_1=0}$$

$$\begin{bmatrix}\dot{U}_1\\ \dot{I}_2\end{bmatrix} = \begin{bmatrix}H_{11} & H_{12}\\ H_{21} & H_{22}\end{bmatrix}\begin{bmatrix}\dot{I}_1\\ \dot{U}_2\end{bmatrix}$$

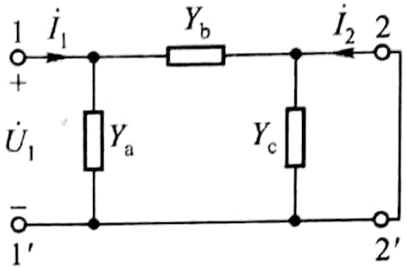
§16-2 二端口方程和参数

	互易条件	对称条件
Y参数：	$Y_{12}=Y_{21}$	$Y_{12}=Y_{21}$　$Y_{11}=Y_{22}$
Z参数：	$Z_{12}=Z_{21}$	$Z_{12}=Z_{21}$　$Z_{11}=Z_{22}$
A参数：	$A_{11}A_{22}-A_{12}A_{21}=1$	$A_{11}A_{22}-A_{12}A_{21}=1$ $A_{11}=A_{22}$
H参数：	$H_{12}=-H_{21}$	$H_{11}H_{22}-H_{12}H_{21}=1$ $H_{12}=-H_{21}$

例16-1 求二端口的Y参数



(a)



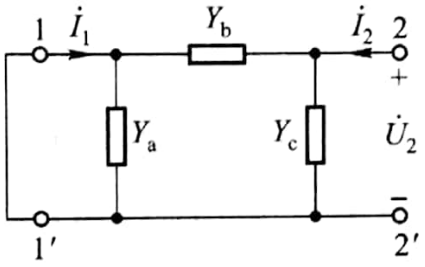
(b)

$$\dot{I}_1 = \dot{U}_1 (Y_a + Y_b)$$

$$- \dot{I}_2 = \dot{U}_1 Y_b$$

$$Y_{11} = \left. \frac{\dot{I}_1}{\dot{U}_1} \right|_{\dot{U}_2 = 0} = Y_a + Y_b$$

$$Y_{21} = \left. \frac{\dot{I}_2}{\dot{U}_1} \right|_{\dot{U}_2 = 0} = - Y_b$$



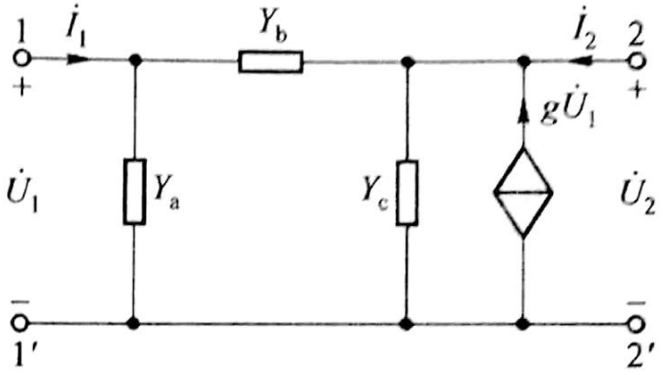
(c)

$$Y_{12} = - Y_b$$

$$Y_{22} = Y_b + Y_c$$

对R、L、C构成的任何无源二端口，总有：$Y_{12} = Y_{21}$

例16-2 求二端口的Y参数



把端口 2－2′短路，在端口 1－1′外施电压$\dot{U}_1$，得

$$\dot{I}_1 = \dot{U}_1(Y_a + Y_b)$$

$$\dot{I}_2 = -\dot{U}_1 Y_b - g\dot{U}_1$$

$$Y_{11} = \frac{\dot{I}_1}{\dot{U}_1} = Y_a + Y_b$$

$$Y_{21} = \frac{\dot{I}_2}{\dot{U}_1} = -Y_b - g$$

同理，为了求 Y_{12}、Y_{22}，把端口 1－1′短路，即令$\dot{U}_1 = 0$，这时受控源的电流也等于零，故得

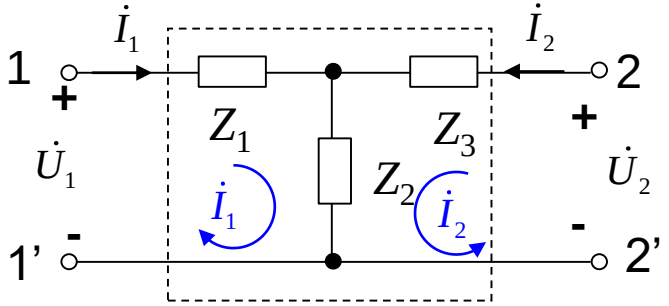
$$Y_{12} = \frac{\dot{U}_1}{\dot{U}_2} = -Y_b$$

$$Y_{22} = \frac{\dot{I}_2}{\dot{U}_2} = Y_b + Y_c$$

含受控源时，$Y_{12} \neq Y_{21}$

§16-3 二端口的等效电路

T形电路



网孔电流方程：

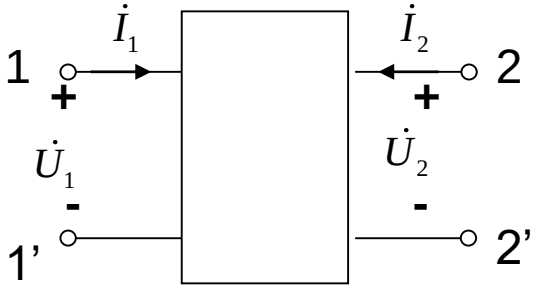
$$\dot{U}_1 = (Z_1 + Z_2)\dot{I}_1 + Z_2\dot{I}_2$$

$$\dot{U}_2 = Z_2\dot{I}_1 + (Z_2 + Z_3)\dot{I}_2$$

前面已知：

$$\dot{U}_1 = Z_{11}\dot{I}_1 + Z_{12}\dot{I}_2$$

$$\dot{U}_2 = Z_{21}\dot{I}_1 + Z_{22}\dot{I}_2$$



则有：

$$Z_1 = Z_{11} - Z_{12}$$

$$Z_2 = Z_{12}$$

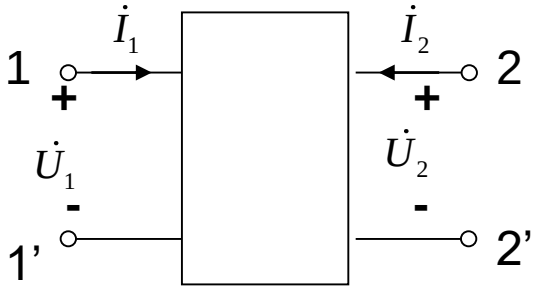
$$Z_3 = Z_{22} - Z_{12}$$

§16-3 二端口的等效电路

若二端口内部含有受控源 $Z_{12} \neq Z_{21}$

$$\dot{U}_1 = Z_{11}\dot{I}_1 + Z_{12}\dot{I}_2$$

$$\dot{U}_2 = Z_{21}\dot{I}_1 + Z_{22}\dot{I}_2$$



先构建一个不含受控源的电路，再加上受控源

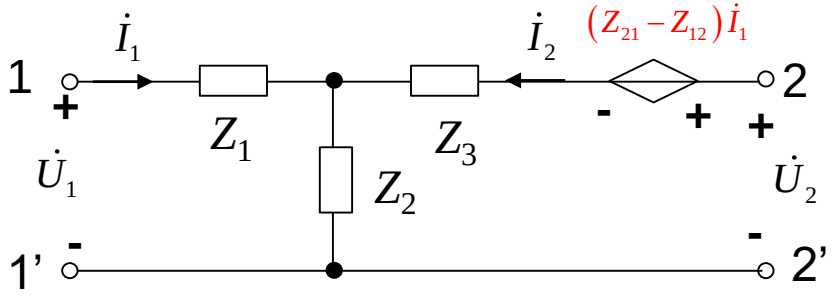
$$\dot{U}_2 = Z_{12}\dot{I}_1 + Z_{22}\dot{I}_2 + (Z_{21} - Z_{12})\dot{I}_1$$

$$\dot{U}_2 - (Z_{21} - Z_{12})\dot{I}_1 = Z_{12}\dot{I}_1 + Z_{22}\dot{I}_2$$

$$Z_1 = Z_{11} - Z_{12}$$

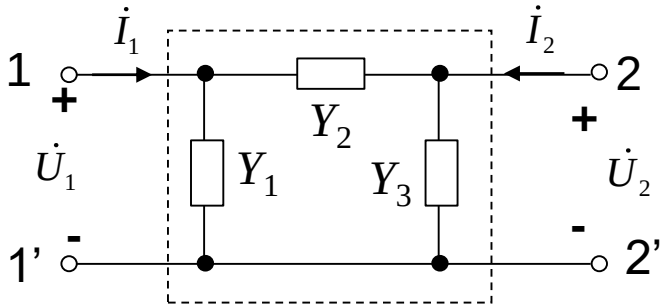
$$Z_2 = Z_{12}$$

$$Z_3 = Z_{22} - Z_{12}$$



§16-3 二端口的等效电路

π形电路



由例16-1，

$$Y_{11}=Y_1+Y_2$$

$$Y_{21}=-Y_2$$

$$Y_{22}=Y_2+Y_3$$

则有：

$$Y_1=Y_{11}+Y_{12}$$

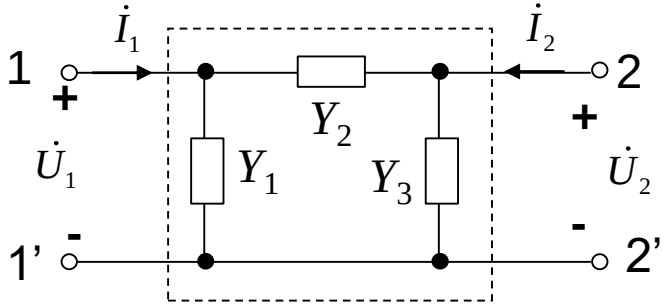
$$Y_2=-Y_{12}=-Y_{21}$$

$$Y_3=Y_{22}+Y_{21}$$

§16-3 二端口的等效电路

π形电路

若二端口内部含有受控源 $Y_{12} \neq Y_{21}$



$$\dot{I}_1 = Y_{11}\dot{U}_1 + Y_{12}\dot{U}_2$$

$$\dot{I}_2 = Y_{21}\dot{U}_1 + Y_{22}\dot{U}_2$$

先构建一个不含受控源的电路，再加上受控源

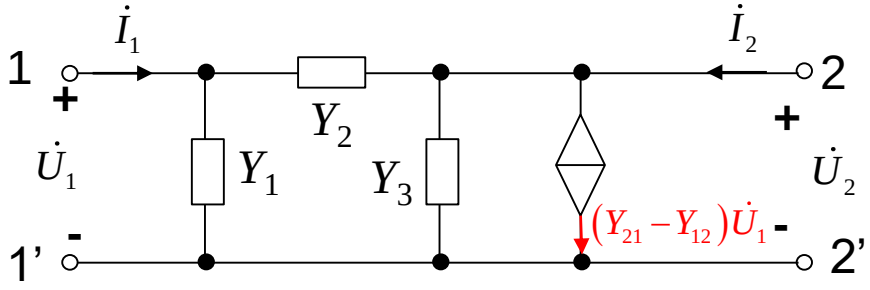
$$\dot{I}_2 = Y_{12}\dot{U}_1 + Y_{22}\dot{U}_2 + (Y_{21} - Y_{12})\dot{U}_1$$

$$\dot{I}_2 - (Y_{21} - Y_{12})\dot{U}_1 = Y_{12}\dot{U}_1 + Y_{22}\dot{U}_2$$

$$Y_1 = Y_{11} + Y_{12}$$

$$Y_2 = -Y_{12} = -Y_{21}$$

$$Y_3 = Y_{22} + Y_{12}$$



作业

P439

16-9

16-10

下周是最后一节课，答疑。因此本次作业不用交，自行练习、参考书上的答案。