第九章 正弦稳态电路的分析

本章重点：

1．阻抗和导纳；

2．正弦稳态电路的分析；

3．正弦稳态电路的功率分析；

作业：9-1，9-3，9-7，9-15，9-17，9-18，9-23，9-24，9-27

HOME BACK

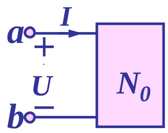
§9-1 阻抗和导纳

一、定义

复阻抗 $Z \overset{def}{=} \dfrac{\dot{U}}{\dot{I}}$

$Z = \dfrac{1}{Y}$

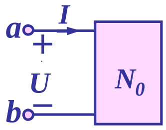
复导纳 $Y \overset{def}{=} \dfrac{\dot{I}}{\dot{U}}$



无源网络

HOME NEXT

欧姆定律的相量形式



$|Z| = \dfrac{U}{I}$

$\varphi_Z = \psi_u - \psi_i$

$Z = \dfrac{\dot{U}}{\dot{I}} = \dfrac{U\angle\psi_u}{I\angle\psi_i}$

$= |Z|\angle\varphi_Z$ 阻抗 阻抗角

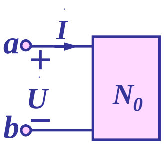
$= R + jX$ 电抗

$Z_R = R$

$Z_L = j\omega L$

$Z_C = \dfrac{1}{j\omega C}$

HOME BACK NEXT



$|Y| = \dfrac{I}{U}$

$\varphi_Y = \psi_i - \psi_u$

$Y = \dfrac{1}{Z} = \dfrac{1}{|Z|\angle\varphi_Z}$

$= |Y|\angle\varphi_Y$ 导纳 导纳角

$= G + jB$ 电纳

$Y_R = G$

$Y_L = \dfrac{1}{j\omega L}$

$Y_C = j\omega C$

HOME BACK NEXT

二、串并联的计算

转换原则： $\dot{i} \to \dot{I}$，$R \to Z$；$u \to \dot{U}$，$G \to Y$

$R_{eq} = \sum_{k=1}^{n} R_k$

$u_k = \dfrac{R_k u}{R_{eq}}$

$\dfrac{1}{R_{eq}} = \sum_{k=1}^{n} \dfrac{1}{R_k}$

$G_{eq} = \sum_{k=1}^{n} G_k$

$i_k = \dfrac{G_k i}{G_{eq}} = \dfrac{R_{eq} i}{R_k}$

HOME BACK NEXT

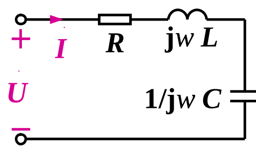
二、串并联的计算

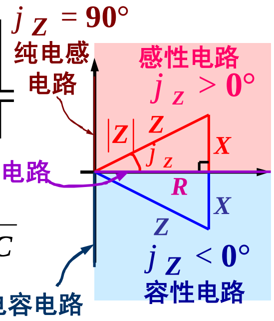
转换原则：$\dot{i} \to \dot{I}$　$u \to \dot{U}$　$R \to Z$　$G \to Y$

$$Z_{eq} = \sum_{k=1}^{n} Z_k \qquad \dot{U}_k = \frac{Z_k \dot{U}}{Z_{eq}}$$

$$\frac{1}{Z_{eq}} = \sum_{k=1}^{n} \frac{1}{Z_k} \qquad Y_{eq} = \sum_{k=1}^{n} Y_k$$

$$\dot{I}_k = \frac{Y_k \dot{I}}{Y_{eq}} = \frac{Z_{eq} \dot{I}}{Z_k}$$



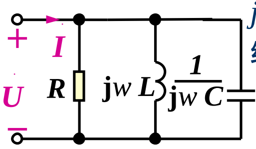


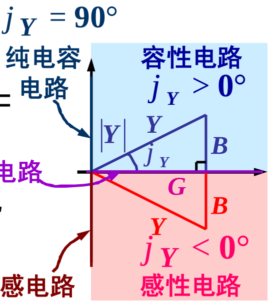
$\varphi_Z = 0°$ 纯电阻电路

$$Z = R + j\omega L + \frac{1}{j\omega C} = R + jX$$

纯电容电路 $\varphi_Z = -90°$

阻抗三角形





$\varphi_Z = 0°$ 纯电阻电路

$$Y = G + \frac{1}{j\omega L} + j\omega C = G + jB$$

纯电感电路 $\varphi_Y = -90°$

导纳三角形

注意

①一端口N_0的阻抗或导纳是由其内部的参数、结构和正弦电源的频率决定的，在一般情况下，其每一部分都是频率的函数，随频率而变；

②一端口N_0中如不含受控源，则有

$|\varphi_z| \le 90°$　或　$|\varphi_y| \le 90°$

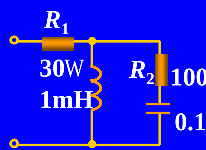
但有受控源时，可能会出现

$|\varphi_z| \ge 90°$　或　$|\varphi_y| \ge 90°$

其实部将为负值，其等效电路要设定受控源来表示实部；

补例1

$\omega = 10^5$rad/s，判断图示电路对外呈现感性还是容性？



解　感抗和容抗为：

$$X_L = \omega L = 100\Omega$$

$$X_C = -\frac{1}{\omega C} = -100\Omega$$

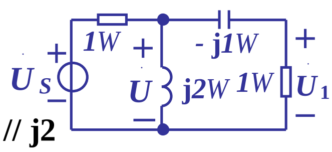
$$Z = R_1 + \frac{jX_L(R_2 + jX_C)}{jX_L + R_2 + jX_C}$$　感性

$$= 30 + \frac{j100 \times (100 - j100)}{100} = 130 + j100\Omega$$

补例2

$u_S(t) = 6\sqrt{2}\cos(2t)\,V$，求：$u_1(t)$

解：



$$\dot{U}_S = 6\angle 0°V$$

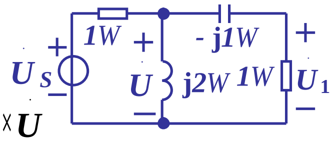
$$Z_{并} = (1 - j1) // j2$$

$$= \frac{(1 - j1) \times j2}{1 - j1 + j2} = \frac{\sqrt{2}\angle -45° \times 2\angle 90°}{\sqrt{2}\angle 45°} = 2\Omega$$

$$\dot{U} = \frac{Z_{并}}{Z_{并} + 1} \times \dot{U}_S = \frac{2}{2+1} \times \dot{U}_S = 4\angle 0°V$$

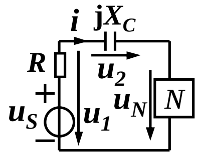
$$\dot U_1 = \frac{1}{1-j1}\times \dot U$$

$$= \frac{1}{\sqrt2\angle -45°}\times 4\angle 0° = 2\sqrt2\angle 45° V$$



$$u_1(t) = 4\cos(2t + 45°)V$$

补例3 $u_1 = 10\cos(t+60°)V$，$u_2 = 5\cos(t-30°)V$，$X_C = -10Ω$，求无源网络N的Z、Y和等效电路。



解：

$$\dot U_1 = 5\sqrt2\angle 60° V$$

$$\dot U_2 = \frac{5}{\sqrt2}\angle -30° V$$

$$\dot I = \frac{\dot U_2}{jX_C} \qquad \dot U_N = \dot U_1 - \dot U_2 = Z\dot I$$

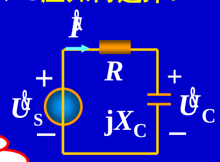
$$Z = \frac{\dot U_N}{\dot I} = 20 + j10Ω$$

$$Y = \frac{1}{Z} = \frac{1}{20+j10} = 0.04 - j0.02S$$

补例4 图示电路为阻容移相装置，如要求电容电压滞后电源电压π/3，问R、C应如何选择。

解

$$\dot U_C = jX_C\frac{\dot U_S}{R + jX_C}$$



$$\frac{\dot U_S}{\dot U_C} = j\omega CR + 1$$

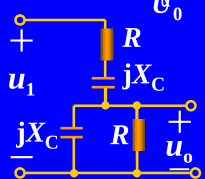
→ $\omega CR = \tan 60^0 = \sqrt3$

如果输出电压为电阻电压，这时相移如何？

补例5

RC选频网络，求u_1和u_0同相位条件及 $\frac{\dot U_1}{\dot U_0}$

解 设：$Z_1 = R + jX_C$，$Z_2 = R//jX_C$

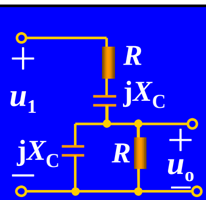


$$\dot U_o = \frac{\dot U_1 Z_2}{Z_1 + Z_2}$$

$$\rightarrow \frac{\dot U_1}{\dot U_o} = 1 + \frac{Z_1}{Z_2}$$

$Z_1 = R + jX_C$，$Z_2 = R//jX_C$

$$\frac{\dot U_1}{\dot U_o} = 1 + \frac{Z_1}{Z_2}$$



$$\frac{Z_1}{Z_2} = \frac{R + jX_C}{jRX_C/(R + jX_C)}$$

$$= \frac{R^2 - X_C^2 + j2RX_C}{jRX_C}$$

$$= 2 - j\frac{R^2 - X_C^2}{RX_C} = \text{实数}$$

→ $R = |X_C|$

$$\frac{\dot U_1}{\dot U_o} = 1 + 2 = 3$$

THE END