<table>
<tr><th>元 件</th><th>VCR 的相量形式</th><th>$U \sim I$, $\psi_u \sim \psi_i$</th></tr>
<tr><td>电阻
</td><td>$\dot{U}_R = R\cdot\dot{I}_R$</td><td>$U_R = R\cdot I_R$
$\psi_u = \psi_i$</td></tr>
<tr><td>电感
</td><td>$\dot{U}_L = j\omega L\cdot\dot{I}_L$
$\dot{I}_L = \frac{\dot{U}_L}{j\omega L}$</td><td>$U_L = \omega L\cdot I_L$
$\psi_u = \psi_i + 90°$</td></tr>
<tr><td>电容
</td><td>$\dot{U}_C = \frac{1}{j\omega C}\dot{I}_C$
$\dot{I}_C = j\omega C\cdot\dot{U}_C$</td><td>$U_C = I$
$\psi_u = \psi_i - 90°$</td></tr>
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第九章 正弦稳态电路的分析

- §9-1 阻抗和导纳
- §9-2 电路的相量图
- §9-3 正弦稳态电路的分析
- §9-4 正弦稳态电路的功率
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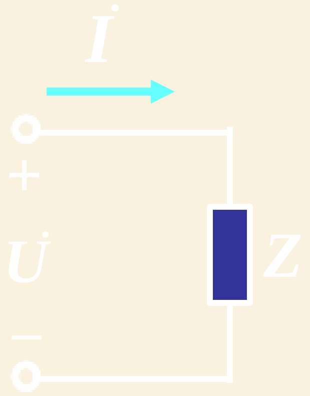
- §9-6 最大功率传输

9.1 阻抗和导纳

1.阻抗

在正弦稳态情况下，无源一端口的阻抗定义为:

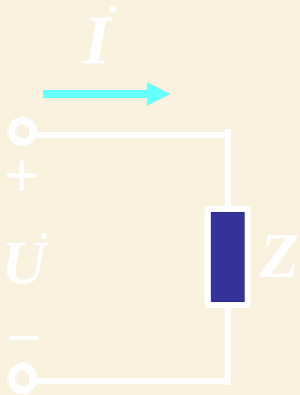
$$Z = \frac{\dot{U}}{\dot{I}} = |Z| \angle \varphi_z$$ 复阻抗　单位:Ω



设 $\dot{U} = U \angle \psi_u \quad \dot{I} = I \angle \psi_i$

$$|Z| = \frac{U}{I}$$ 阻抗模

$$\varphi_z = \psi_u - \psi_i$$ 阻抗角

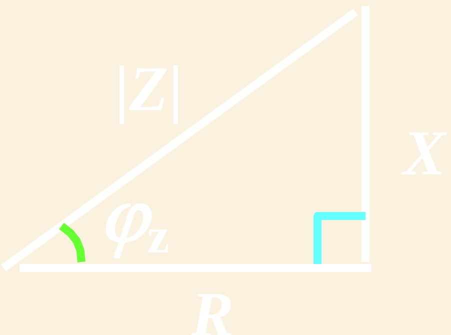


$$\dot{U} = Z\dot{I}$$ 欧姆定律的相量形式

阻抗的代数形式： $Z = R + \mathrm{j}X$

$R = \mathrm{Re}[Z]$ 电阻 $X = \mathrm{Im}[Z]$ 电抗

$$\begin{cases} |Z| = \sqrt{R^2 + X^2} \\ \varphi_Z = \arctan\dfrac{X}{R} \end{cases}$$



阻抗三角形

$$\begin{cases} R = |Z|\cos\varphi_Z \\ X = |Z| \end{cases}$$

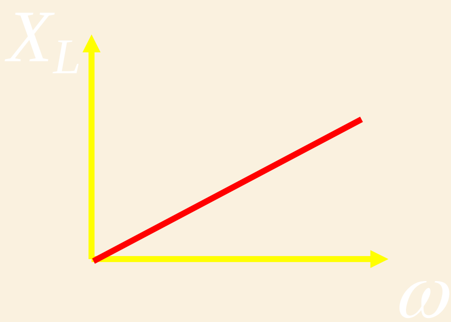
R、L、C的阻抗：

$$\dot{U} = R\dot{I}$$ $Z = R$ 实数，与ω无关

$$\dot{U} = j\omega L\,\dot{I} = jX_L\dot{I}$$ $Z = j\omega L = jX_L$

● 感抗 $X_L = \omega L = 2\pi f L$ 单位为Ω

● 感抗的性质



① 表示限制电流的能力；

② 感抗和频率成正比。通低频，阻高频

$\omega = 0$， $X_L = 0$， 直流短路

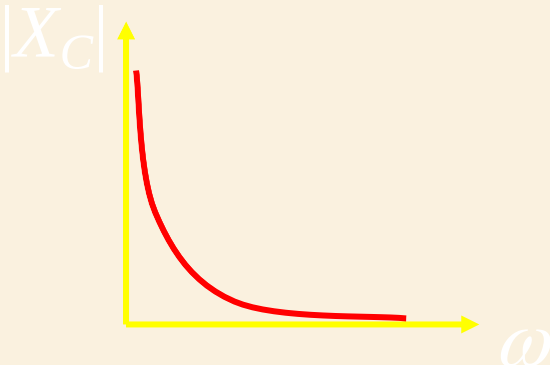
$\omega \to \infty$， $X_L \to \infty$ 高频开路

$$\dot{U}=\frac{1}{j\omega C}\dot{I}=-j\frac{1}{\omega C}\dot{I}=jX_C\dot{I}$$

$$Z=-j\frac{1}{\omega C}=jX_C$$

- **容抗**

$X_C=-$ 单位为Ω



- **容抗的性质**

容抗和频率成反比 。**通高频，阻低频**

$\omega\to 0$，$|X_C|\to\infty$ 直流开路(隔直)

$\omega\to\infty$，$|X_C|\to 0$ 高频短路

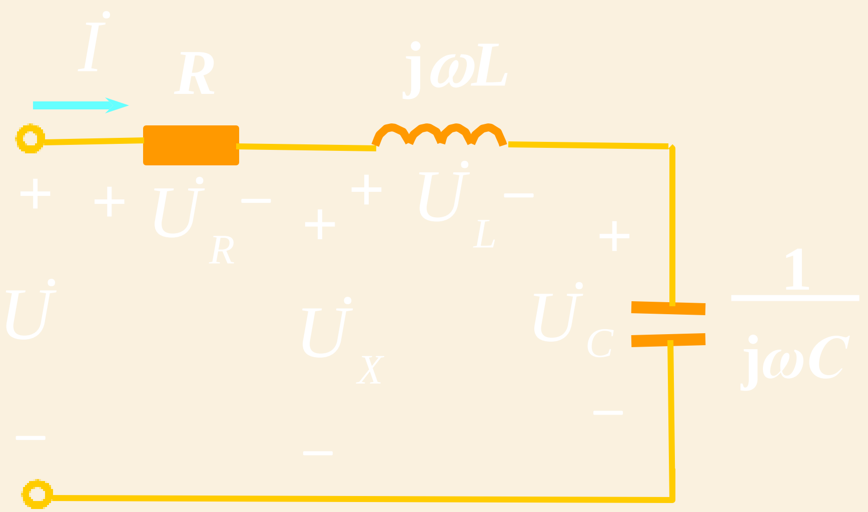
RLC串联电路的阻抗：

$$\dot{U}=\dot{U}_R+\dot{U}_L+\dot{U}_C$$

$$=R\dot{I}+\mathrm{j}X_L\dot{I}+\mathrm{j}X_C\dot{I}$$

$$Z=\frac{\dot{U}}{\dot{I}}=R+\mathrm{j}(\omega L-\frac{1}{\omega C})$$

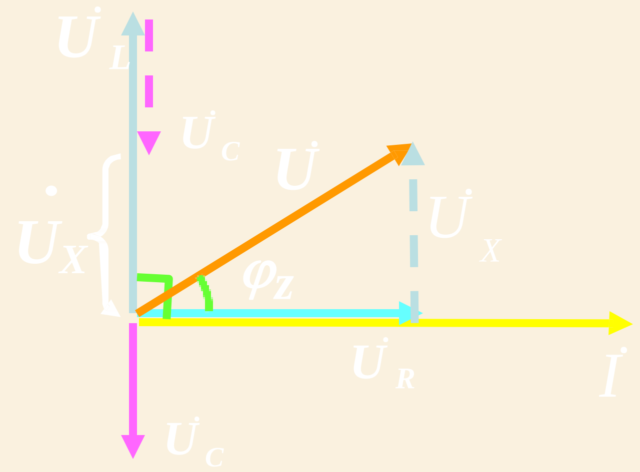
$$=R+\mathrm{j}X$$



$$\begin{cases}\dot{U}_R \text{ 为 } \dot{U} \text{ 的电阻分量} \\ \dot{U}_X=\dot{U}_L+\dot{U}_C \text{ 电抗分量}\end{cases}$$

U_R、U_X、U称为电压三角形

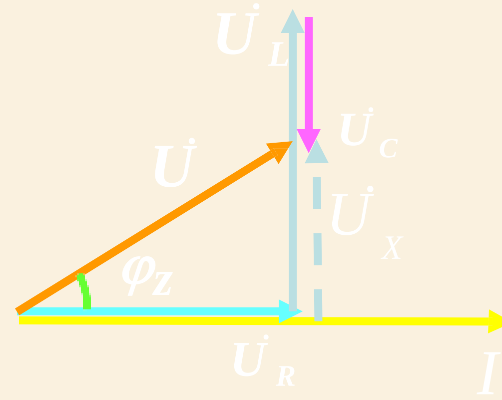
与阻抗三角形相似



阻抗的性质：

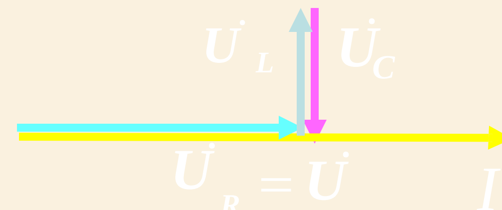
1. 感性：$X>0, \omega L>1/\omega C,$

$\varphi_Z>0$, 电压超前电流



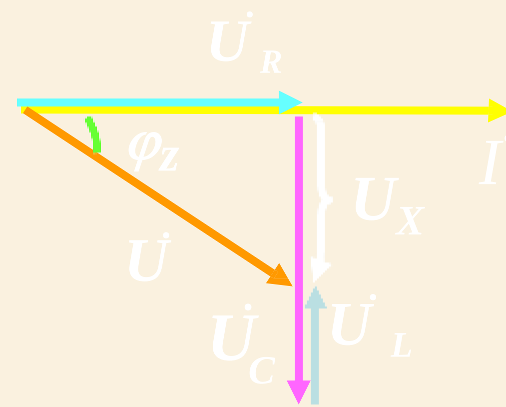
2. 阻性：$X=0, \omega L=1/\omega C,$

$\varphi_Z=0$, 电压电流同相



3. 容性：$X<0, \omega L<1/\omega C,$

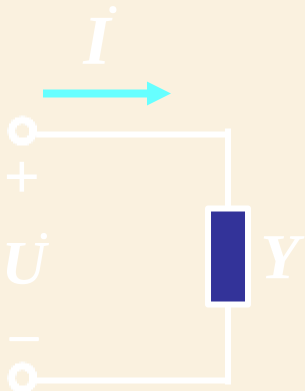
$\varphi_Z<0$, 电压滞后电流



2.导纳

在正弦稳态情况下，无源一端口的导纳定义为：

$$Y=\frac{\dot{I}}{\dot{U}}=|Y|\angle\varphi_Y$$ 单位：S



$$\dot{I}=Y\dot{U}$$

设 $\dot{U}=U\angle\psi_u$ $\dot{I}=I\angle\psi_i$

$$\left\{\begin{array}{l}|Y|=\frac{I}{U} \\ \varphi_Y=\psi\end{array}\right.$$

导纳模

导纳角

对同一二端网络，导纳与阻抗的关系：

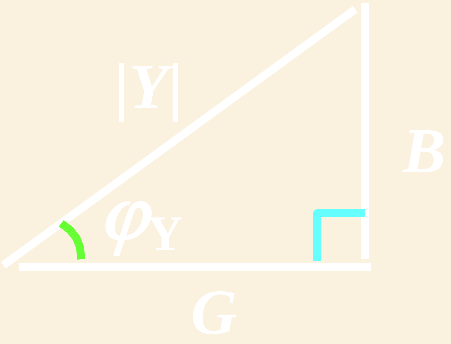
$$Z = \frac{1}{Y},\ Y = \frac{1}{Z}$$

$$\begin{cases} |Y| = \dfrac{1}{|Z|} \\ \varphi_Y = -\varphi_Z \end{cases}$$

导纳的代数形式： $Y = G + \mathrm{j}B$

$G = \mathrm{Re}[Y]$ 电导　　$B = \mathrm{Im}[Y]$ 电纳

$$\begin{cases} |Y| = \sqrt{G^2 + B^2} \\ \varphi_Y = \mathrm{ar} \end{cases}$$



导纳三角形

$$\begin{cases} G = |Y| \cos \varphi_Y \\ B = |Y| \sin \varphi_Y \end{cases}$$

R、L、C的导纳：

$\dot{I} = G\dot{U}$ $\quad Y = G$ **实数，与ω无关**

$$\dot{I} = -\mathrm{j}\frac{1}{\omega L}\dot{U} \qquad Y = -\mathrm{j}\frac{1}{\omega L} = \mathrm{j}B_L$$

$$B_L = -\frac{1}{\omega L}$$ **感纳**

$$\dot{I} = \mathrm{j}\omega C\dot{U} \qquad Y = \mathrm{j}\omega C$$

$$B_C = \omega C$$ **容纳**

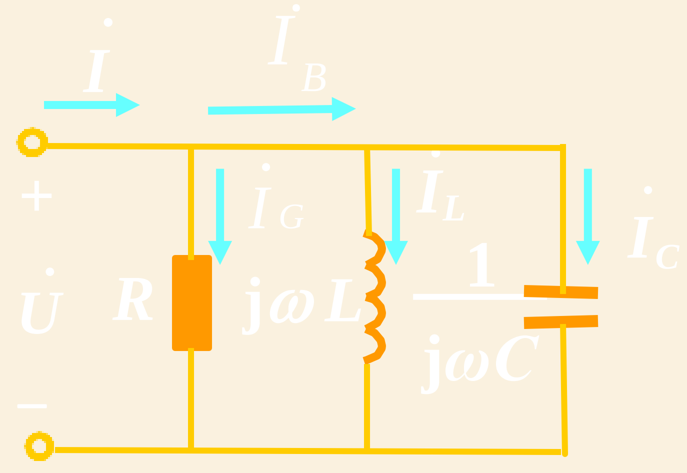
RLC并联电路的导纳：

$$\dot{I} = \dot{I}_G + \dot{I}_L + \dot{I}_C$$

$$= G\dot{U} + \mathrm{j}B_L\dot{U} + \mathrm{j}B_C\dot{U}$$

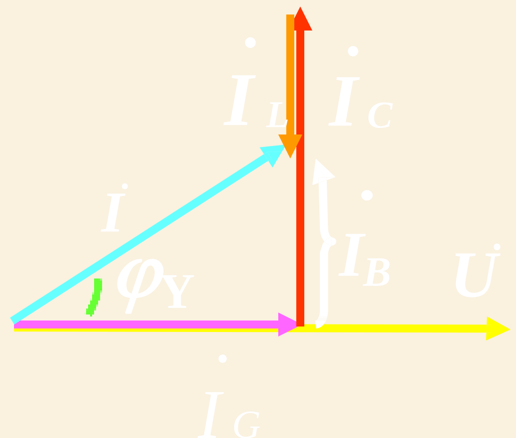
$$Y = \frac{\dot{I}}{\dot{U}} = G + \mathrm{j}\left(-\frac{1}{\omega L} + \omega C\right)$$

$$= G + \mathrm{j}B$$



$\dot{I}_G$ 为 $\dot{I}$ 的电导分量

$\dot{I}_B = \dot{I}_L + \dot{I}_C$ 电纳分量



I_G、I_B、I称为电流三角形

与导纳三角形相似

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