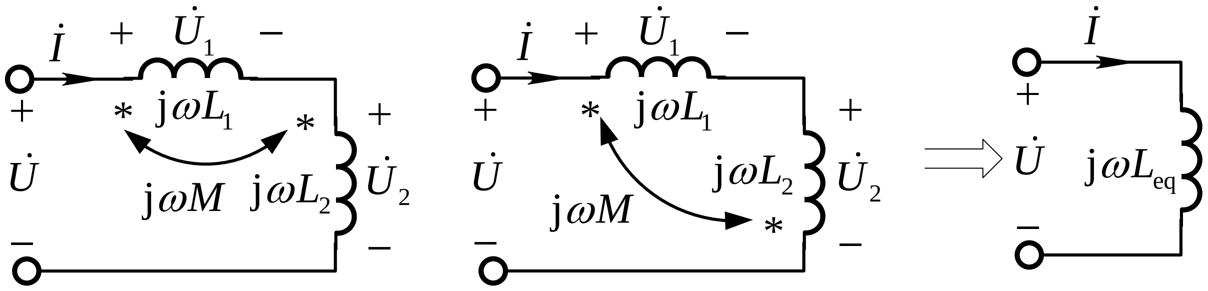
去耦等效电路

互感元件的串联



$$L_{eq} = L_1 + L_2 \pm 2M$$

正串(或顺接)　　　反串(或逆接)

顺接

$$\dot{U} = \dot{U}_1 + \dot{U}_2$$
$$= (j\omega L_1\dot{I} + j\omega M\dot{I}) + (j\omega M\dot{I} + j\omega L_2\dot{I})$$
$$= j\omega(L_1 + L_2 + 2M)\dot{I} = j\omega L_{eq}\dot{I}$$

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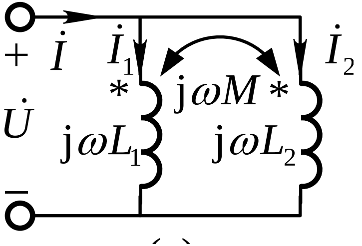
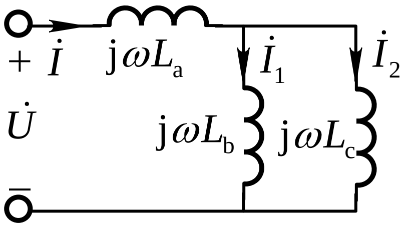
互感元件的并联



消互感电路

$$\left.\begin{aligned} L_a &= M \\ L_b &= L_1 - M \\ L_c &= L_2 - M \end{aligned}\right\}$$



$$\dot I = \dot I_1 + \dot I_2$$

$$\dot I_2 = \dot I - \dot I_1$$

$$\dot U = j\omega L_1 \dot I_1 + j\omega M \dot I_2$$

$$\dot I_1 = \dot I - \dot I_2$$

$$\dot U = j\omega M \dot I_1 + j\omega L_2 \dot I_2$$

等效电感

$$L_{eq} = L_a + \frac{L_b L_c}{L_b + L_c} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

$$\dot U = j\omega L_1 \dot I_1 + j\omega M(\dot I - \dot I_1) = j\omega M \dot I + j\omega (L_1 - M)\dot I_1 = j\omega L_a \dot I + j\omega L_b \dot I_1$$

$$\dot U = j\omega M(\dot I - \dot I_2) + j\omega L_2 \dot I_2 = j\omega M \dot I + j\omega (L_2 - M)\dot I_2 = j\omega L_a \dot I + j\omega L_c \dot I_2$$

去耦等效电路

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耦合系数 对于实际耦合线圈，无论何种串联或何种并联，其等效电感均为正值。所以自感和互感满足如下关系

$$M \leq \frac{1}{2}(L_1 + L_2) \qquad M \leq \sqrt{L_1 L_2}$$

耦合系数满足 $$k = \frac{M}{\sqrt{L_1 L_2}} \leq 1$$

用来衡量互感耦合的程度

$$0 \leq k \leq 1 \quad \begin{cases} k = 0 & \text{两个线圈无耦合} \\ k = 1 & \text{两个线圈全耦合} \end{cases}$$

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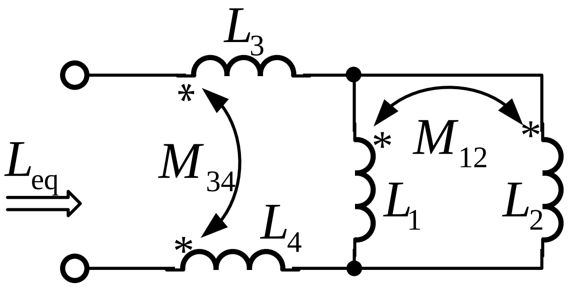
例1 图示电路已知 $L_1 = L_2 = 4\text{H}$, M_{12}=2H ，$L_3 = L_4 = 3\text{H}$, M_{34}=1H ，求效电感 L_{eq} 。



解：L_1、L_2为同名端并联，

L_3、L_4为反串联接

$$L_{\text{eq}} = (L_3 + L_4 - 2M) + \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$

$$= (3+3-2\times 1) + \frac{4\times 4 - 2^2}{4+4-2\times 2} = 7\text{H}$$