8-3　互感的去耦等效

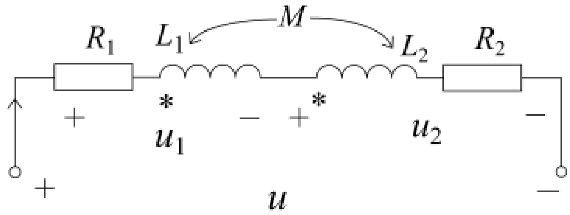
计算含有耦合电感电路有两种方法：

① 直接对含有耦合电感的电路采用支路电流法或回路法。

② 将含有耦合电感的电路通过去耦等效，化成无耦合电感的电路。

1. 耦合电感串联的去耦等效

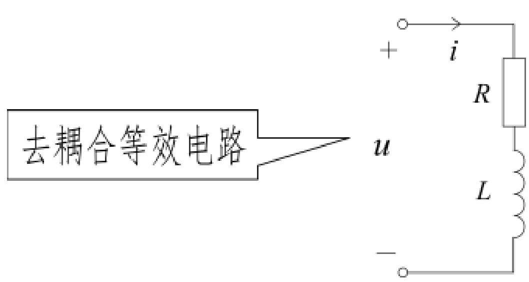
①顺接串联



$$u = R_1 i + L_1\frac{di}{dt} + M\frac{di}{dt} + L_2\frac{di}{dt} + M\frac{di}{dt} + R_2 i$$

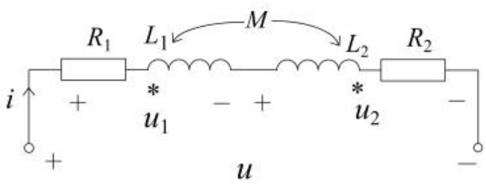
$$= (R_1 + R_2)i + (L_1 + L_2 + 2M)\frac{di}{dt}$$

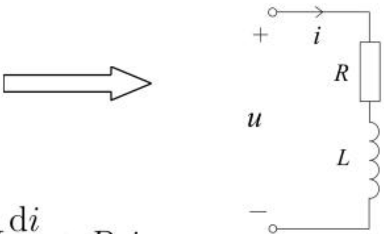
$$= Ri + L\frac{di}{dt}$$



$$R = R_1 + R_2 \qquad L = L_1 + L_2 + 2M$$

②反接串联





$$u = R_1 i + L_1\frac{di}{dt} - M\frac{di}{dt} + L_2\frac{di}{dt} - M\frac{di}{dt} + R_2 i$$

$$= (R_1 + R_2)i + (L_1 + L_2 - 2M)\frac{di}{dt} = Ri + L\frac{di}{dt}$$

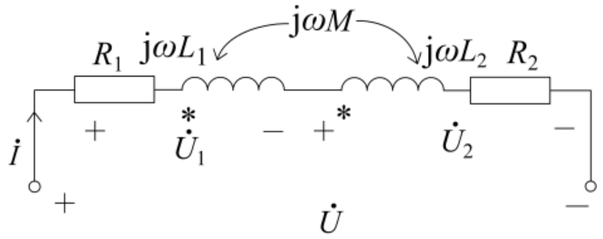
$$R = R_1 + R_2 \quad L = L_1 + L_2 - 2M$$

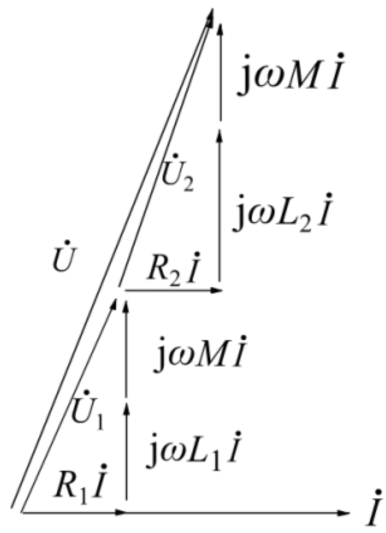
互感的测量方法：

顺接一次，反接一次，就可以测出互感：$M = \dfrac{L_{顺} - L_{反}}{4}$

在正弦激励下：

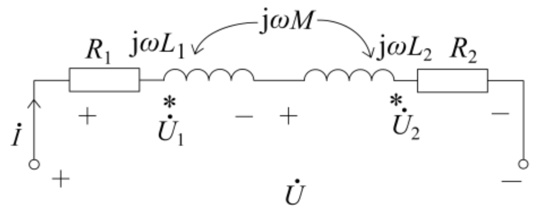
（a） 顺接

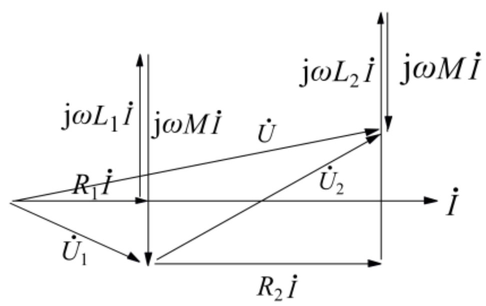




$$\dot{U} = (R_1 + R_2)\dot{I} + j\omega(L_1 + L_2 + 2M)\dot{I}$$

（b） 反接

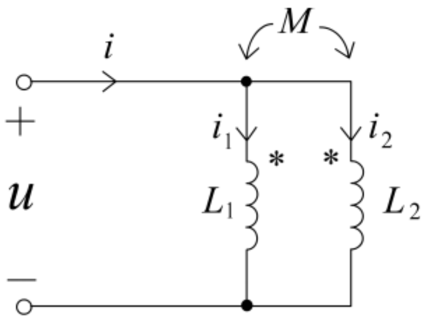




$$\dot{U} = (R_1 + R_2)\dot{I} + j\omega(L_1 + L_2 - 2M)\dot{I}$$

2. 耦合电感并联的去耦等效

①同侧并联



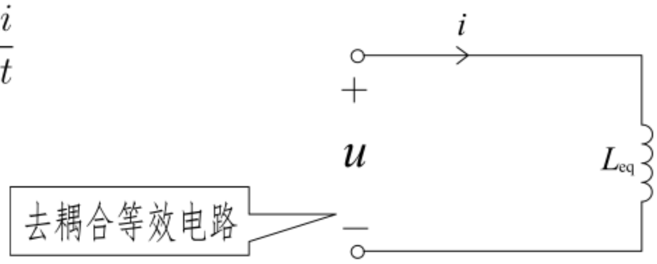
$$u = L_1\frac{\mathrm{d}i_1}{\mathrm{d}t} + M\frac{\mathrm{d}i_2}{\mathrm{d}t}$$

$$u = L_2\frac{\mathrm{d}i_2}{\mathrm{d}t} + M\frac{\mathrm{d}i_1}{\mathrm{d}t}$$

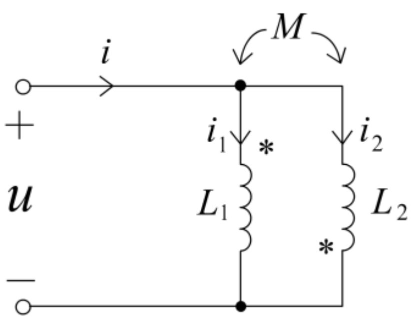
$$i = i_1 + i_2$$

解得u，i的关系 $u = \dfrac{(L_1L_2 - M^2)}{L_1 + L_2 - 2M}\dfrac{\mathrm{d}i}{\mathrm{d}t}$

等效电感：$L_{eq} = \dfrac{(L_1L_2 - M^2)}{L_1 + L_2 - 2M} \geqslant 0$



②异侧并联



$$u = L_1\frac{\mathrm{d}i_1}{\mathrm{d}t} - M\frac{\mathrm{d}i_2}{\mathrm{d}t}$$

$$u = L_2\frac{\mathrm{d}i_2}{\mathrm{d}t} - M\frac{\mathrm{d}i_1}{\mathrm{d}t}$$

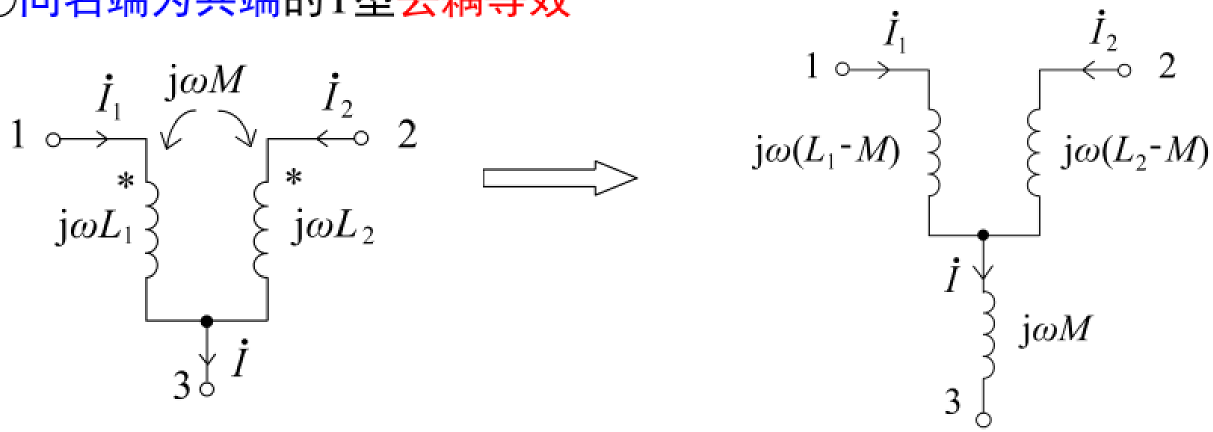
$$i = i_1 + i_2$$

解得u，i的关系 $u = \dfrac{(L_1L_2 - M^2)}{L_1 + L_2 + 2M}\dfrac{\mathrm{d}i}{\mathrm{d}t}$

等效电感：$L_{eq} = \dfrac{(L_1L_2 - M^2)}{L_1 + L_2 + 2M} \geqslant 0$

3. 耦合电感的T型等效

①同名端为共端的T型去耦等效

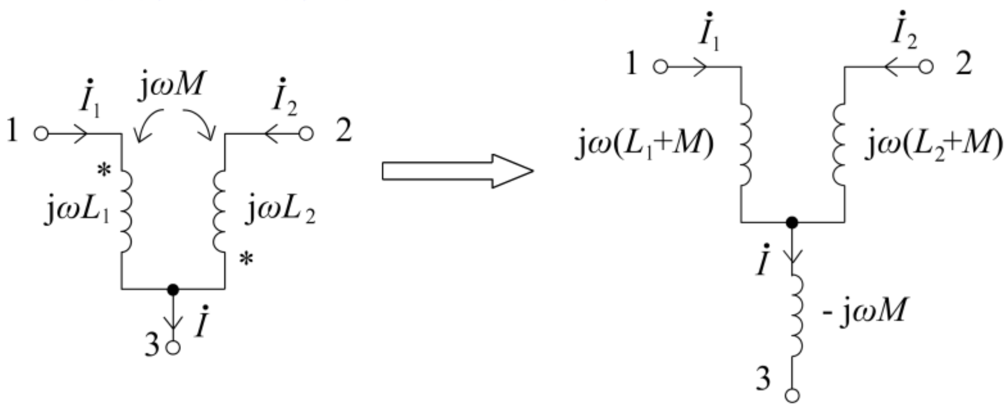


$$\dot{U}_{13} = j\omega L_1 \dot{I}_1 + j\omega M \dot{I}_2 = j\omega\left(L_1 - M\right)\dot{I}_1 + j\omega M \dot{I}$$

$$\dot{U}_{23} = j\omega L_2 \dot{I}_2 + j\omega M \dot{I}_1 = j\omega\left(L_2 - M\right)\dot{I}_2 + j\omega M \dot{I}$$

$$\dot{I} = \dot{I}_1 + \dot{I}_2$$

② 异名端为共端的T型去耦等效

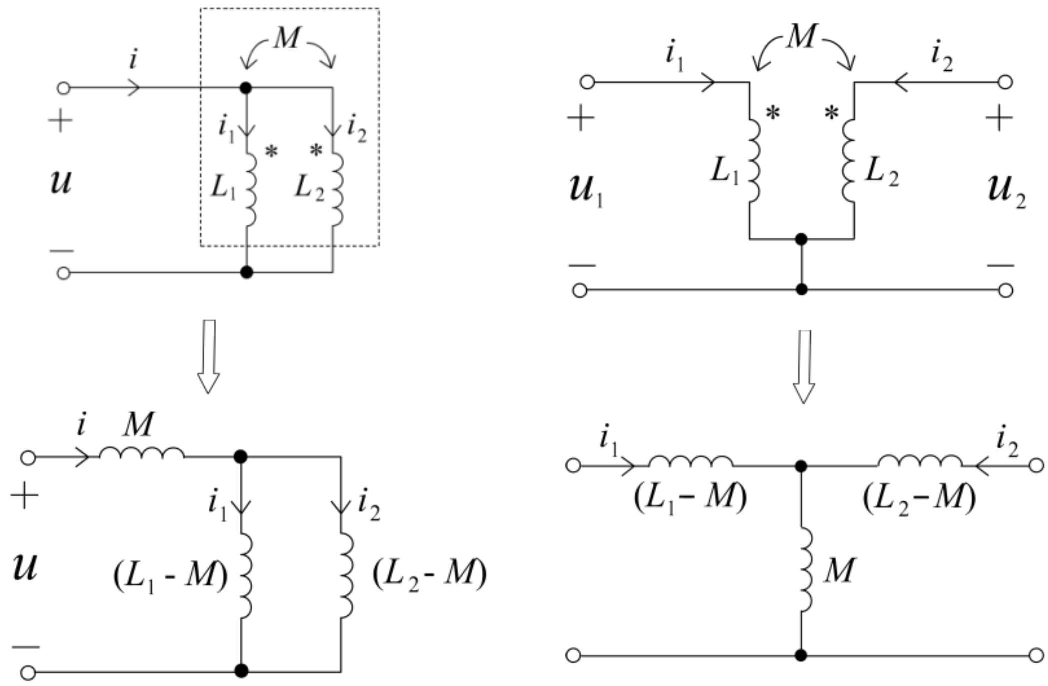


$$\dot{U}_{13} = j\omega L_1 \dot{I}_1 - j\omega M \dot{I}_2 = j\omega\left(L_1 + M\right)\dot{I}_1 - j\omega M \dot{I}$$

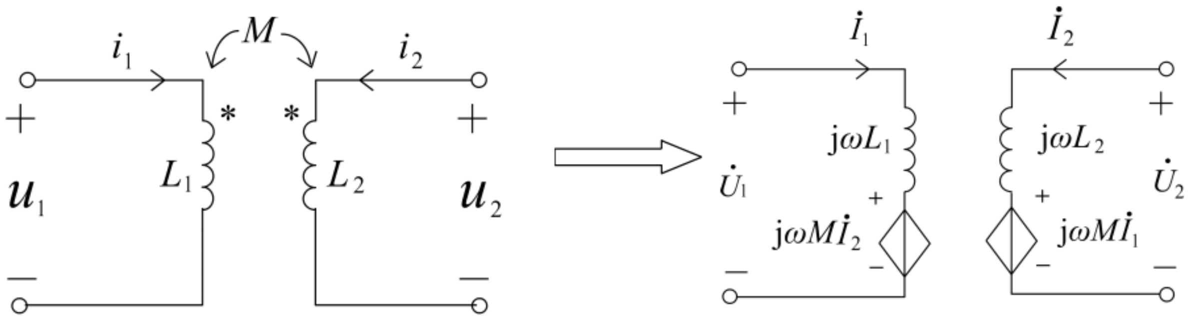
$$\dot{U}_{23} = j\omega L_2 \dot{I}_2 - j\omega M \dot{I}_1 = j\omega\left(L_2 + M\right)\dot{I}_2 - j\omega M \dot{I}$$

$$\dot{I} = \dot{I}_1 + \dot{I}_2$$

例题1:



4. 受控源等效电路



$$\dot{U}_1 = j\omega L_1 \dot{I}_1 + j\omega M \dot{I}_2$$

$$\dot{U}_2 = j\omega L_2 \dot{I}_2 + j\omega M \dot{I}_1$$