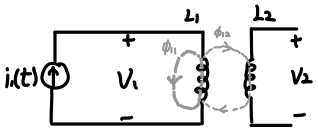
互感

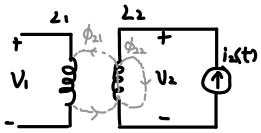
$$V = N\frac{d\phi}{dt} = N\frac{d\phi}{di}\frac{di}{dt} = L\frac{di}{dt} \qquad L = N\frac{d\phi}{di}\ \text{自感}$$



$$\phi_1 = \phi_{11} + \phi_{12}$$

线圈1感应电压 $V_1 = N_1\frac{d\phi_1}{dt} = L_1\frac{di}{dt}$

-- 2 -- $V_2 = N_2\frac{d\phi_{12}}{dt} = N_2\frac{d\phi_{12}}{di_1}\frac{di_1}{dt} = M_{21}\frac{di_1}{dt}$

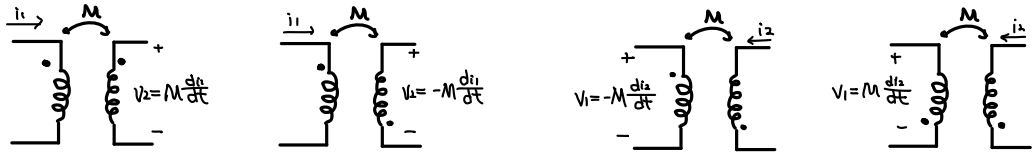


$$V_2 = N_2\frac{d\phi_2}{dt} = L_2\frac{di}{dt}$$

$$V_1 = N_1\frac{d\phi_{21}}{di_2}\frac{di_2}{dt} = M_{12}\frac{di_2}{dt} \qquad \text{可证 } M_{12} = M_{21}$$

互感是指一个电感器在与其相邻的电感器两端感应出电压的能力. 亨利(H)

判断互感电压极性:

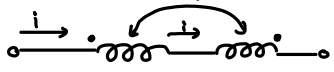


- 和参考极性. 电流从·流入, 感应v与另一·的+,-相同

  电流从·流出, 感应v与另一·的+,-相反

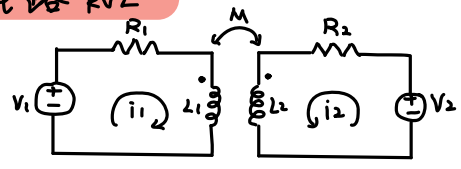
- **串联耦合线圈同名端规则.** 总电感量 $L = L_1 + L_2 + 2M$ (同向串联连接)

$L = L_1 + L_2 - 2M$ (反向串联连接)



- **分析互感电路 KVL**

时域



$$v_1 = i_1R_1 + L_1\frac{di_1}{dt} + M\frac{di_2}{dt}$$

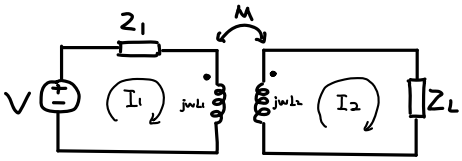
$$v_2 = i_2R_2 + L_2\frac{di_2}{dt} + M\frac{di_1}{dt}$$

频域

$$V_1 = (R_1 + j\omega L_1)I_1 + j\omega M I_2$$

$$V_2 = (R_2 + j\omega L_2)I_2 + j\omega M I_1$$

频域



对1: $V = (Z_1 + j\omega L_1)I_1 - j\omega M I_2$

对2: $0 = -j\omega M I_1 + (Z_L + j\omega L_2)I_2$

耦合电路中的能量

电路中储存的瞬时能量 $W = \frac{1}{2}L_1 i_1^2 + \frac{1}{2}L_2 i_2^2 \pm M i_1 i_2$ (换回时域 i.)

两电流均从线圈的同名端流入或流出时, 互感取正. 否则取负.

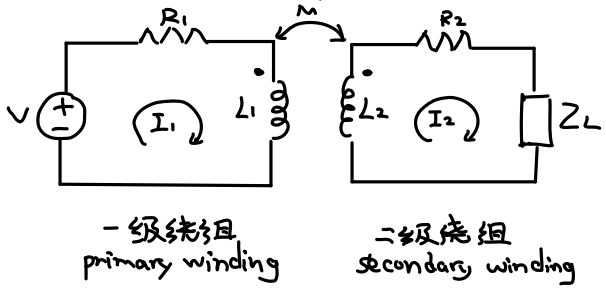
耦合系数 (coefficient of coupling) $k = \frac{M}{\sqrt{L_1 L_2}}$ $0 \le k \le 1$, $0 \le M \le \sqrt{L_1 L_2}$

$k=1$ 完全耦合 perfectly coupled　　$k<0.5$ 松散耦合 loosely coupled

$k>0.5$ 固紧耦合 tightly coupled

- **线性变压器**

变压器 - 一般由两个(或多个)磁耦合线圈组成的四端器件

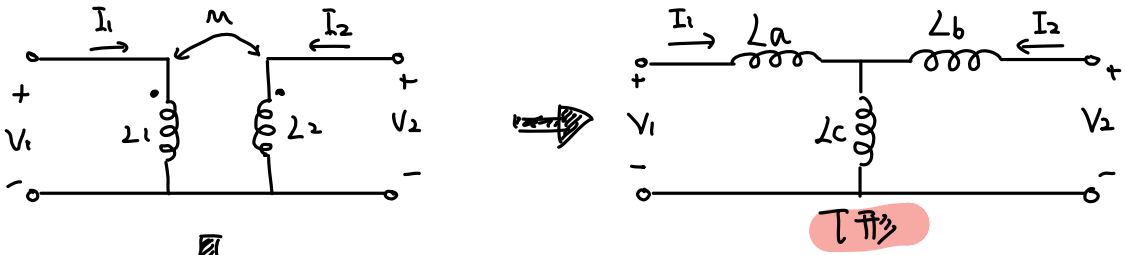


$$V=(R_1+j\omega L_1)I_1-j\omega MI_2$$

$$0=-j\omega MI_1+(R_2+j\omega L_2+Z_L)I_2$$

$$Z_{in}=\frac{V}{I_1}=R_1+j\omega L_1+\frac{\omega^2M^2}{R_2+j\omega L_2+Z_L}$$

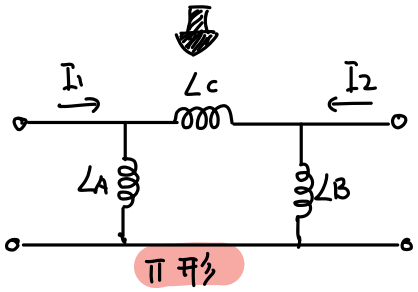
- 用没有互感的 T 形或 π 形等效电路取代此线性变压器



$$L_a=L_1-M$$

$$L_b=L_2-M$$

$$L_c=M$$



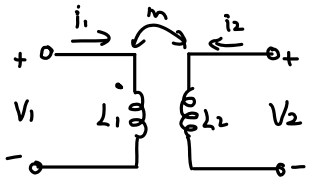
$$L_A=\frac{L_1L_2-M^2}{L_2-M}$$

$$L_B=\frac{L_1L_2-M^2}{L_1-M}$$

$$L_C=\frac{L_1L_2-M^2}{M}$$

?? 作业无.

- **理想变压器**



$$V_1=j\omega L_1I_1+j\omega MI_2 \rightarrow I_1=(V_1-j\omega MI_2)/j\omega L_1$$

$$V_2=j\omega L_2I_2+j\omega MI_1 \quad =nV_1$$

(完全耦合)

$n=\sqrt{L_2/L_1}$ 匝数比.

理想变压器:

① $L_1, L_2, M \rightarrow \infty$. n不变

② $k=1$.

③ 一次绕组与二次绕组无损耗 ($R_1=0=R_2$)

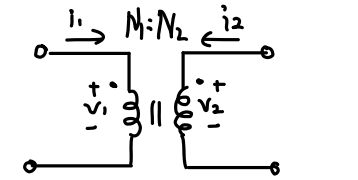
性质：

$\frac{V_2}{V_1} = \frac{N_2}{N_1} = n.$

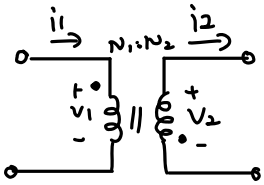
$\frac{I_1}{I_2} = \frac{V_2}{V_1} = n.$　　$n>1$ 升压变压器　　$n<1$ 降压变压器

- 规则：若同名端 V_1 与 V_2 均正或均负，式中是 $+n$. 否则 $-n$

若 I_1 与 I_2 均进入或流出同名端，式中是 $-n$. 否则 $+n$



$\frac{V_2}{V_1} = \frac{N_2}{N_1}$　$\frac{I_2}{I_1} = -\frac{N_1}{N_2}$



$\frac{V_2}{V_1} = -\frac{N_2}{N_1}$　$\frac{I_2}{I_1} = \frac{N_1}{N_2}.$

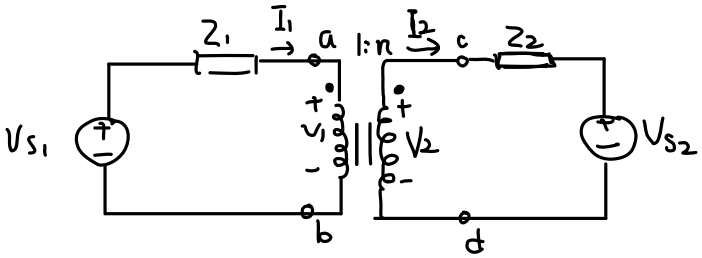
$\therefore V_1 = \frac{V_2}{N}.$

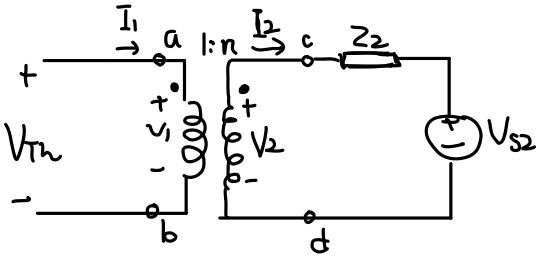
$I_1 = nI_2.$

$Z_{in} = \frac{V_1}{I_1} = \frac{1}{n^2}\frac{V_2}{I_2} = \frac{Z_L}{n^2}$

- 求理想变压器等效电路

做题！



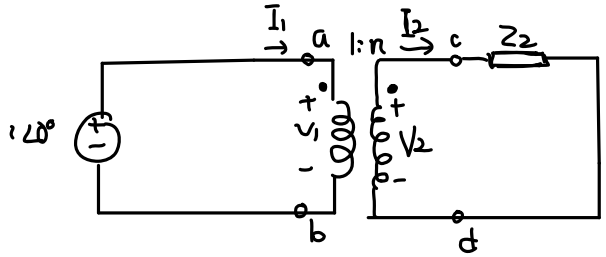


求 V_{Th}

a,b 开路，$I_1=0=I_2.$

$V_2 = V_{S2}.$

$V_{Th} = V_1 = \frac{V_2}{n} = \frac{V_{S2}}{n}$



求 Z_{Th}

$Z_{Th} = \frac{V_1}{I_1} = \frac{V_2/n}{nI_2} = \frac{Z_2}{n^2}$

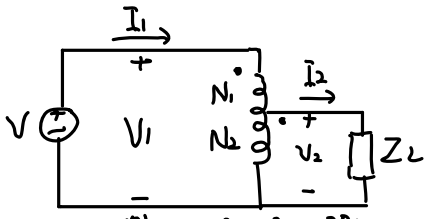
$\therefore$ 将二次电路映射到一次侧：消去变压器规则：二次阻抗除以 n^2，二次电压除以 n，且二次电流乘以 n.

将一次电路映射到二次侧：消去变压器规则：一次阻抗乘以 n^2，一次电压

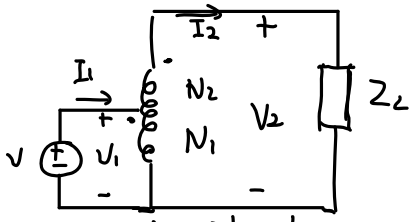
乘以 n，且一次电流除以 n.

- **理想自耦变压器**

自耦变压器是一次侧与二次侧为同一绕组的变压器



降压自耦变压器



升压自耦变压器

学的不好.

$$\frac{V_1}{V_2}=\frac{N_1+N_2}{N_2}$$

$$\frac{I_1}{I_2}=\frac{N_2}{N_1+N_2}$$

$$\frac{V_1}{V_2}=\frac{N_1}{N_1+N_2}$$

$$\frac{I_1}{I_2}=\frac{N_1+N_2}{N_1}$$

$$(2+6j)I_1+jI_2=24.$$

$$jI_1+(2+3j)I_2=0.$$

$$(2+6j)I_1+(18+14j)I_2=0.$$

$$(18+13j)I_2=-24.$$