清华大学2021春季学期

电路原理C

第17讲

三相交流电路

内容

1 三相电源与三相电路 相线关系

2 对称三相电路的分析 抽单相

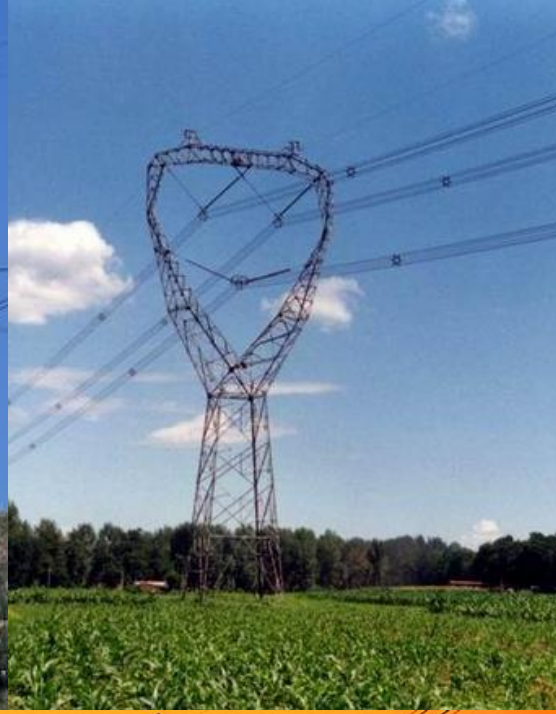
3 不对称三相电路分析简介

4 三相电路的功率 三相功率的计算

本讲重难点

- Y 接和 Δ 接对称三相电路的相 — 线关系
- 对称三相电路的抽单相法
- 测量三相电路有功功率的两表法



chinamarket.com


昵图网 www.nipic.com


分裂导线

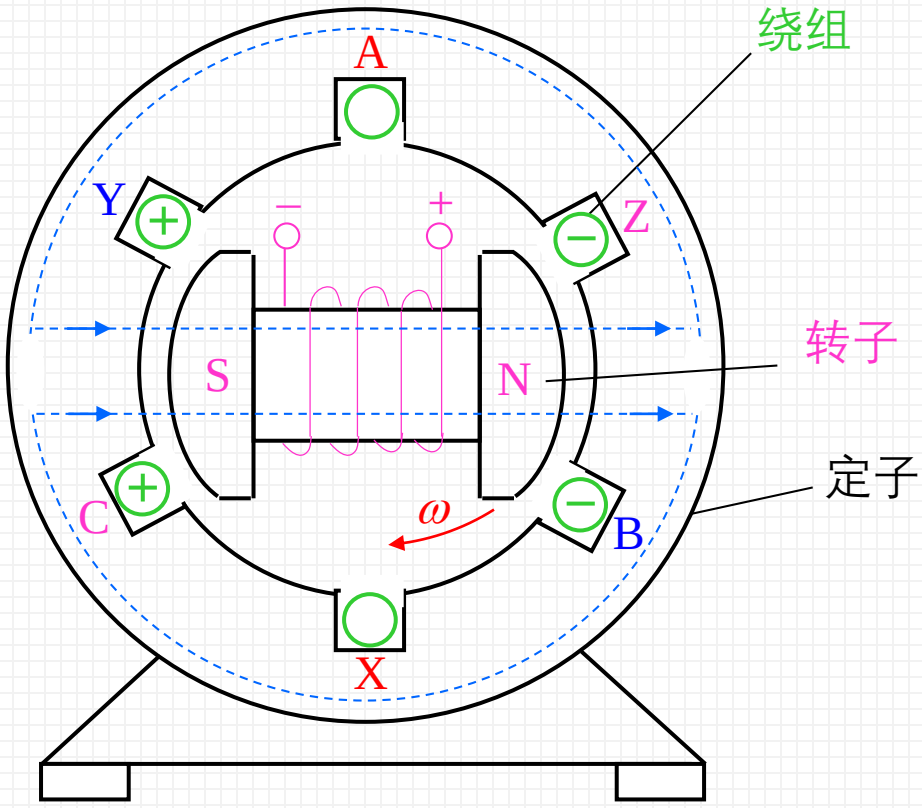
复合绝缘子

三相电动势的产生

- 定子中放三个线圈
- 三线圈空间位置相间120°

首端	末端
A	X
B	Y
C	Z

转子装有磁极并以ω的角速度旋转。三个线圈中便产生三个单相正弦电动势。



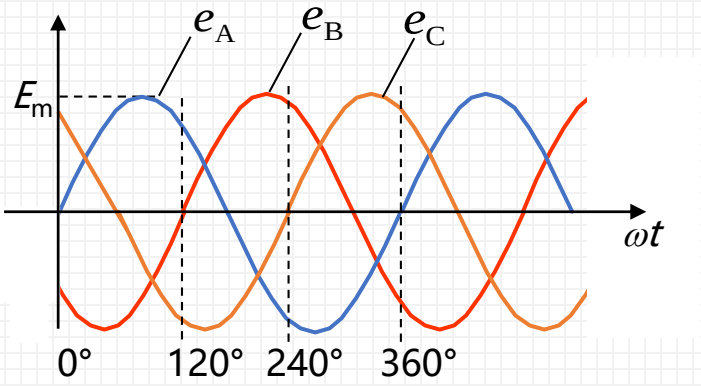
三相交流发电机原理示意图

三相电动势的三角函数表示式

$$e_A = E_m \sin \omega t$$
$$e_B = E_m \sin(\omega t - 120°)$$
$$e_C = E_m \sin(\omega t - 240°)$$
$$= E_m \sin(\omega t + 120°)$$

三相电动势的特征：

大小相等，频率相同，相位互差120°

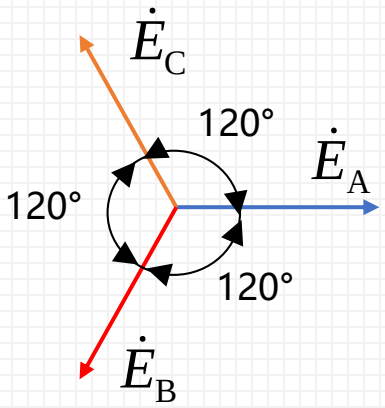


三相电动势波形图

三相电动势的相量表示式

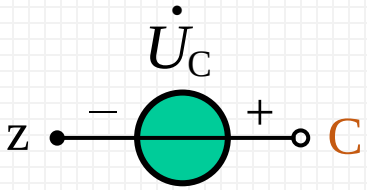
$$\begin{cases} \dot{E}_A = E\angle 0° \\ \dot{E}_B = E\angle -120° \\ \dot{E}_C = E\angle 120° \end{cases}$$

$$\dot{E}_A + \dot{E}_B + \dot{E}_C = 0$$

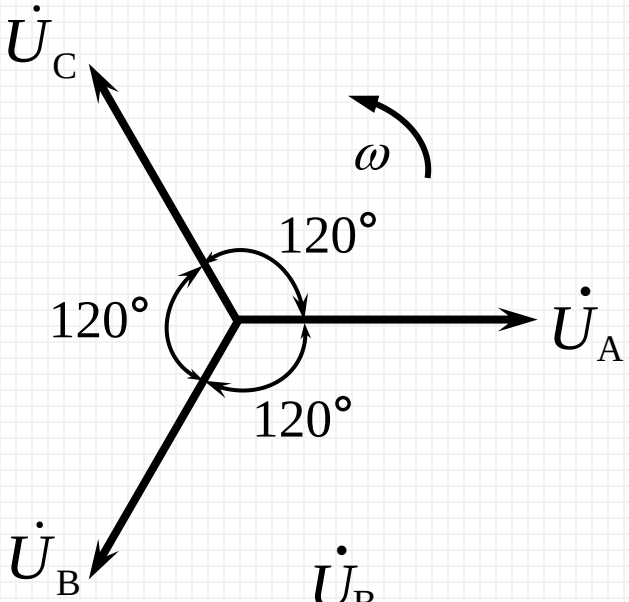


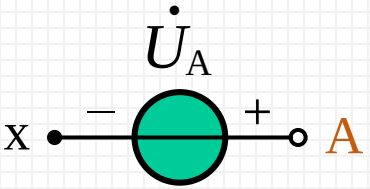
1、三相电源与三相电路

(1) 对称三相电源

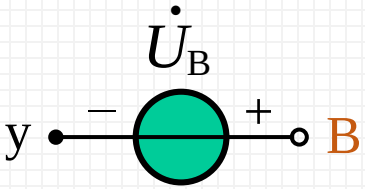


$\dot{U}_C = U\angle -240^o = U\angle 120^o$





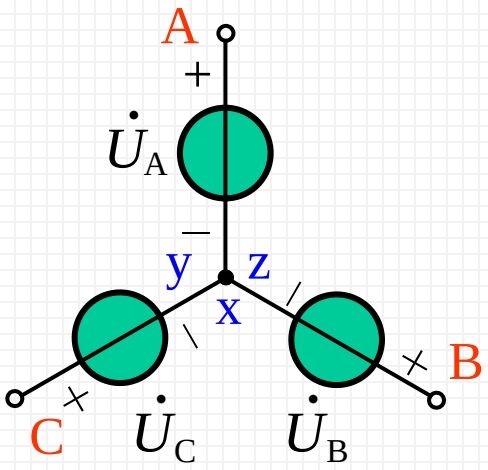
$\dot{U}_A = U\angle 0^o$

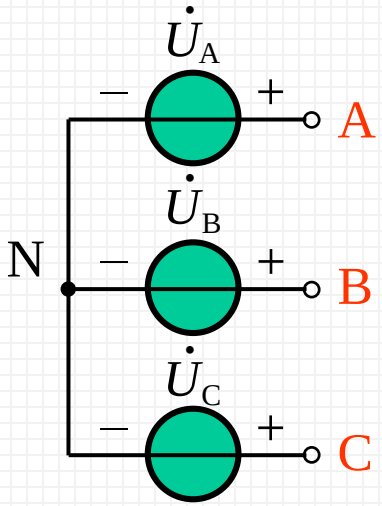


$\dot{U}_B = U\angle -120^o$

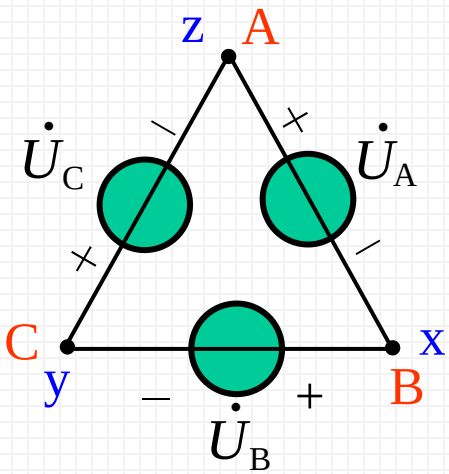
(2) 对称三相电源连接

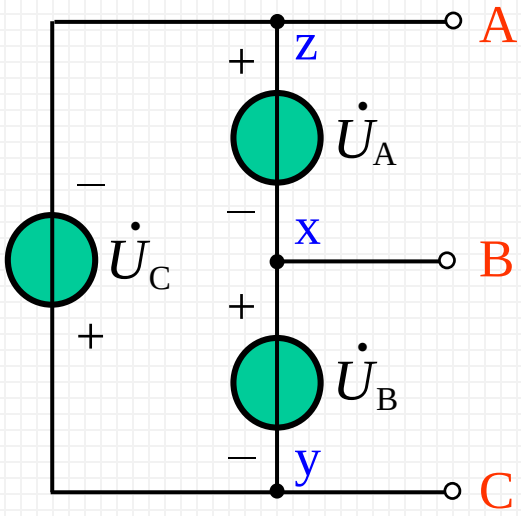
星形联接(Y接)



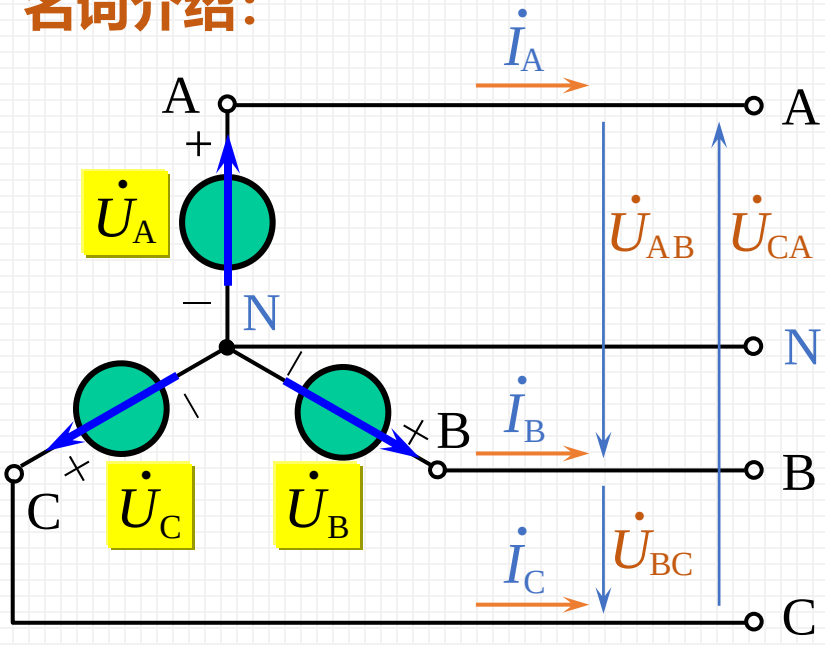


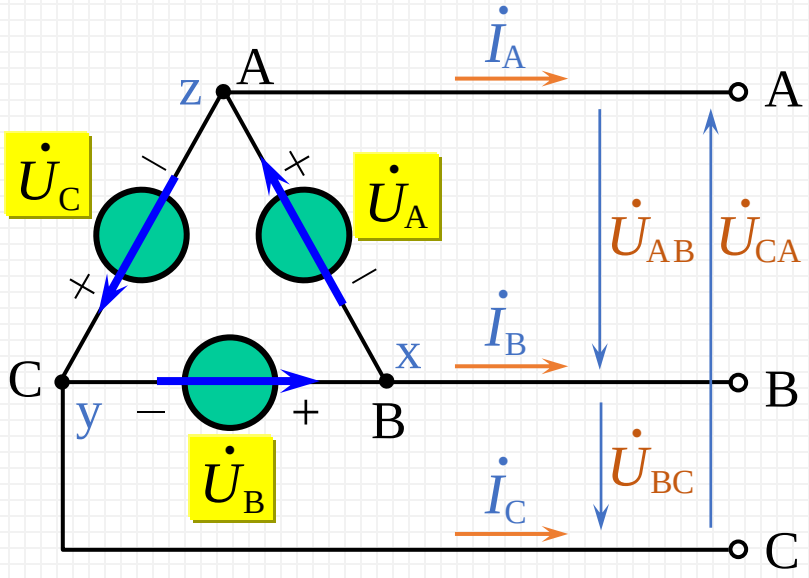
三角形联接(Δ 接)





名词介绍：





(1) 端线(火线、相线)　(2) 中线(零线)

(3) 三相三线制与三相四线制。

(4) 线电流 $\dot{I}_A$, $\dot{I}_B$, $\dot{I}_C$

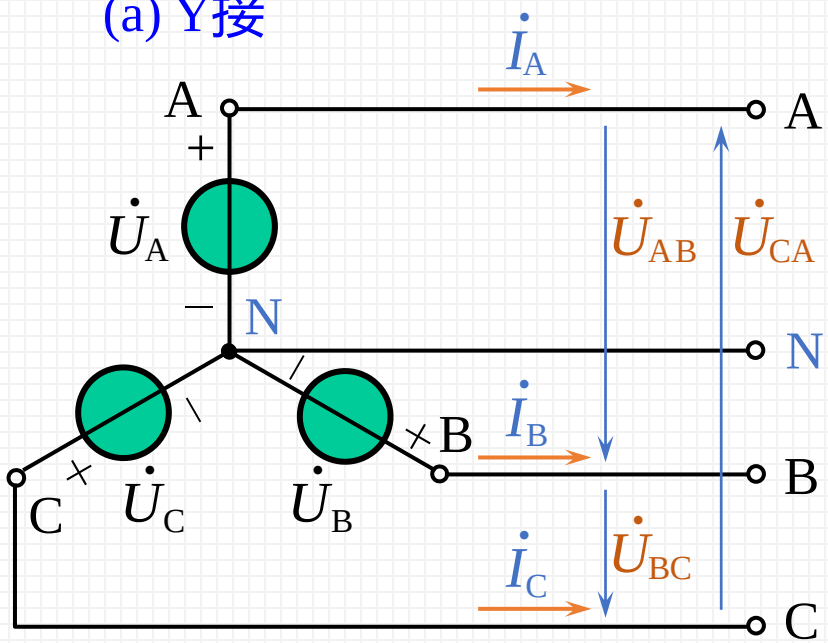
(5) 线电压 $\dot{U}_{AB}$, $\dot{U}_{BC}$, $\dot{U}_{CA}$

(6) 相电流

(7) 相电压 $\dot{U}_A$, $\dot{U}_B$, $\dot{U}_C$

(3) 对称三相电源的相线关系

(a) Y接



$$\dot{U}_{AB} = \dot{U}_{AN} - \dot{U}_{BN} = \sqrt{3}U\angle 30^\circ$$

$$\dot{U}_{BC} = \dot{U}_{BN} - \dot{U}_{CN} = \sqrt{3}U\angle -90^\circ$$

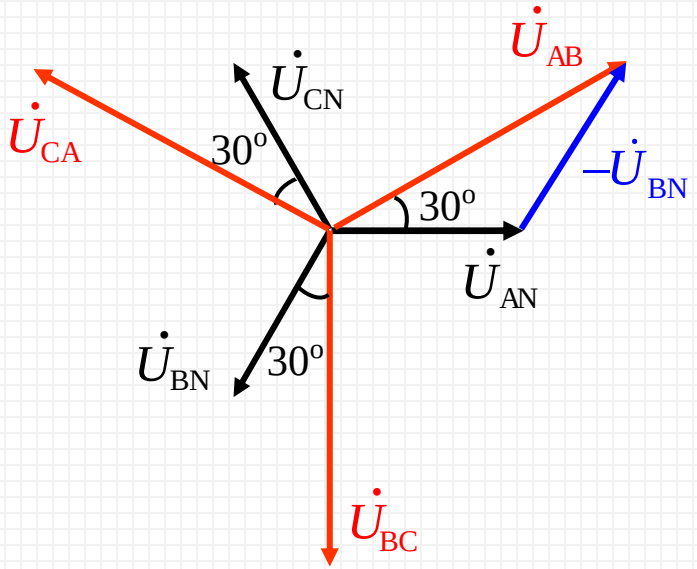
$$\dot{U}_{CA} = \dot{U}_{CN} - \dot{U}_{AN} = \sqrt{3}U\angle 150^\circ$$

设 $\dot{U}_{AN} = \dot{U}_A = U\angle 0^\circ$

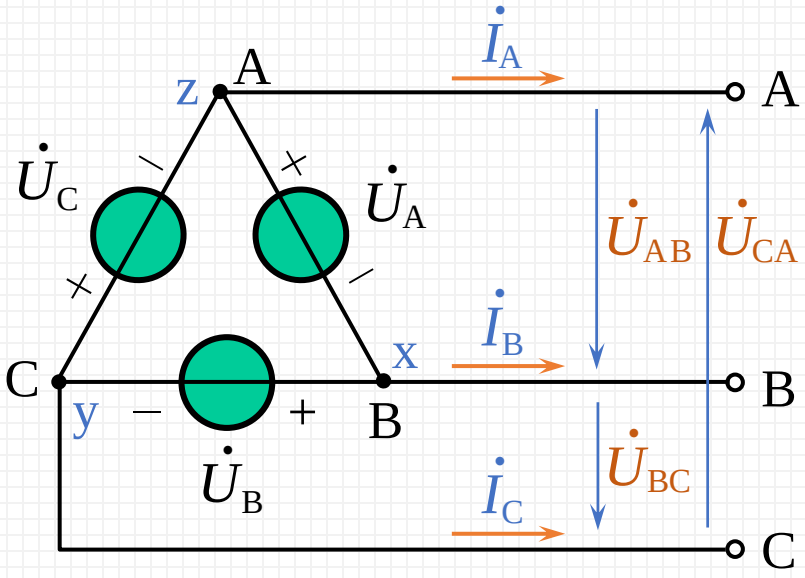
$\dot{U}_{BN} = \dot{U}_B = U\angle -120^\circ$

$\dot{U}_{CN} = \dot{U}_C = U\angle 120^\circ$

- 线电压对称
- $U_L = \sqrt{3}U_P$
- 线电压相位领先对应相电压30°
- 线电流 = 相电流



(b) Δ接（x与B相连）



设 $\dot{U}_A = U\angle 0^o$

$\dot{U}_B = U\angle -120^o$

$\dot{U}_C = U\angle 120^o$

$\dot{U}_{AB} = \dot{U}_A = U\angle 0^o$

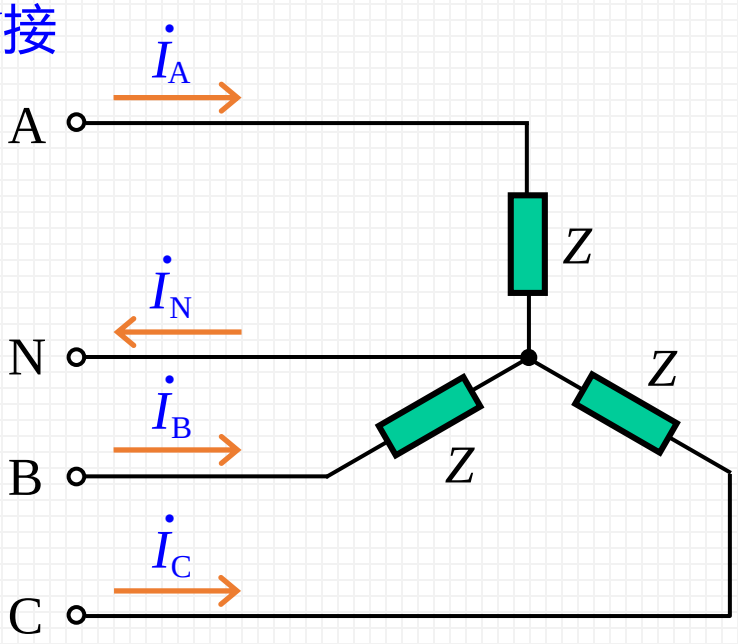
$\dot{U}_{BC} = \dot{U}_B = U\angle -120^o$

$\dot{U}_{CA} = \dot{U}_C = U\angle 120^o$

线电压 = 相电压

(4) 对称三相负载的相线关系

(a) Y接



设 $\dot{U}_{AN}=\dot{U}_A=U\angle 0^\circ$

$\dot{U}_{BN}=\dot{U}_B=U\angle -120^\circ$

$\dot{U}_{CN}=\dot{U}_C=U\angle 120^\circ$

对Y接法的对称电源讨论得出的结论对Y接法的对称负载一样成立。

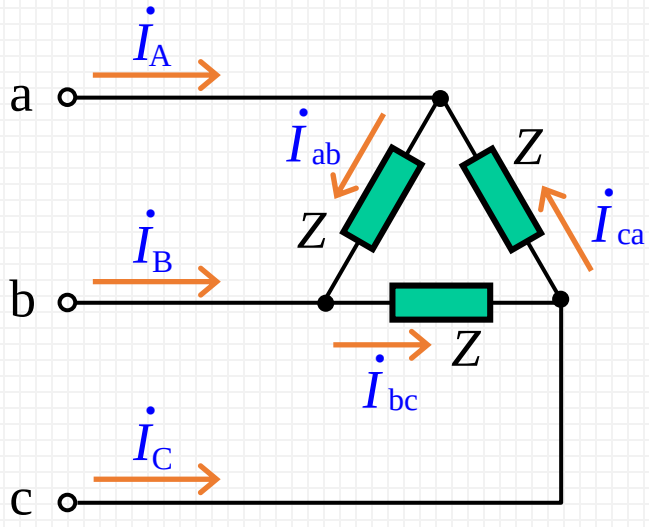
$$\dot{U}_{AB}=\dot{U}_{AN}-\dot{U}_{BN}=\sqrt{3}U\angle 30^\circ$$

$$\dot{U}_{BC}=\dot{U}_{BN}-\dot{U}_{CN}=\sqrt{3}U\angle -90^\circ$$

$$\dot{U}_{CA}=\dot{U}_{CN}-\dot{U}_{AN}=\sqrt{3}U\angle 150^\circ$$

- 线电压对称
- $U_L=\sqrt{3}U_P$
- 线电压相位领先对应相电压30°
- 线电流 = 相电流

(b) Δ接



线电压(即相电压)对称

$$\dot{I}_{ab}=\frac{\dot{U}_{ab}}{Z}\quad \dot{I}_{bc}=\frac{\dot{U}_{bc}}{Z}\quad \dot{I}_{ca}=\frac{\dot{U}_{ca}}{Z}$$

相电流对称

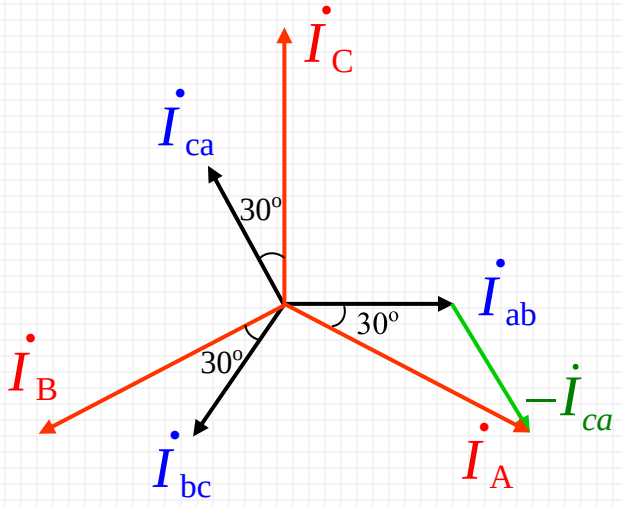
$$\dot{I}_{ab}=I\angle 0^{o}\quad \dot{I}_{bc}=I\angle -120^{o}\quad \dot{I}_{ca}=I\angle 120^{o}$$

线电流

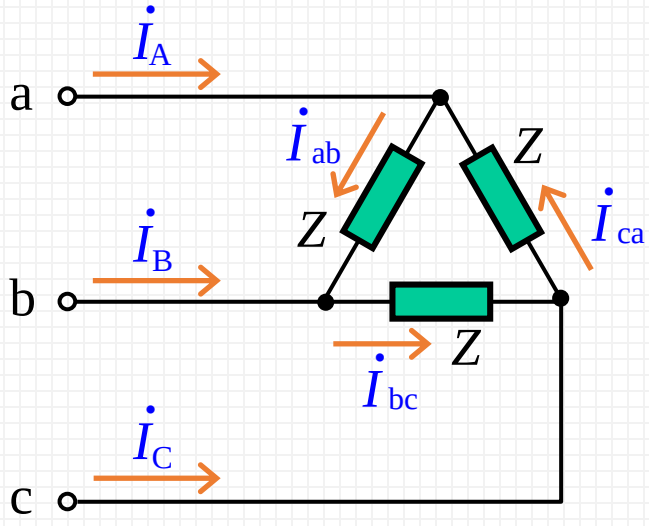
$$\dot{I}_A=\dot{I}_{ab}-\dot{I}_{ca}=\sqrt{3}\,\dot{I}_{ab}\angle -30^{o}$$

$$\dot{I}_B=\dot{I}_{bc}-\dot{I}_{ab}=\sqrt{3}\,\dot{I}_{bc}\angle -30^{o}$$

$$\dot{I}_C=\dot{I}_{ca}-\dot{I}_{bc}=\sqrt{3}\,\dot{I}_{ca}\angle -30^{o}$$



(b) Δ接

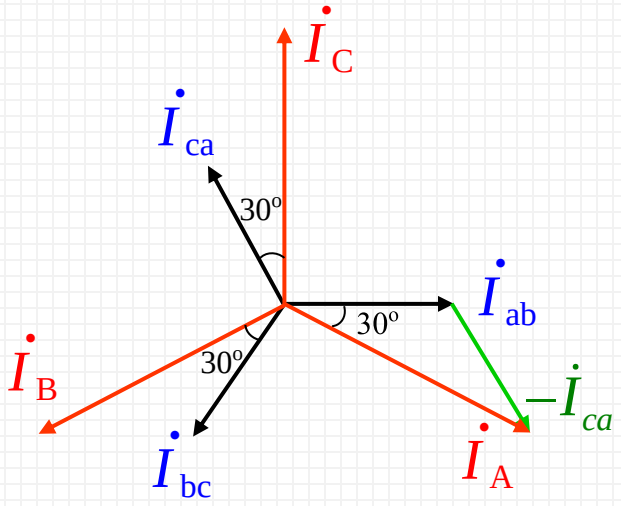


- 线电流对称
- $I_L = \sqrt{3} I_P$
- 线电流**落后**对应相电流**30°**
- 线电压 = 相电压

$$\dot{I}_A = \dot{I}_{ab} - \dot{I}_{ca} = \sqrt{3}\,\dot{I}_{ab} \angle -30^\circ$$

$$\dot{I}_B = \dot{I}_{bc} - \dot{I}_{ab} = \sqrt{3}\,\dot{I}_{bc} \angle -30^\circ$$

$$\dot{I}_C = \dot{I}_{ca} - \dot{I}_{bc} = \sqrt{3}\,\dot{I}_{ca} \angle -30^\circ$$



(5) 三相电路

三相制电力系统：由三个频率相同、相位互差120°的正弦交流电源供电的系统。

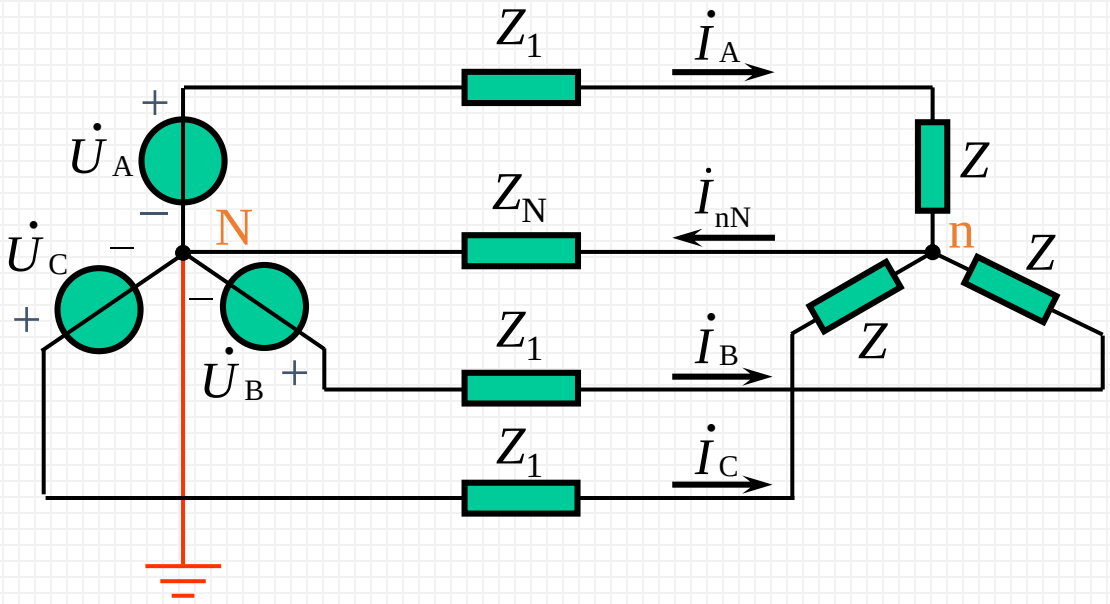
三相制优点：见课后推送的补充材料

对称三相电路：由对称三相电源和对称三相负载联接而成

对称三相负载：三相负载阻抗模相等，阻抗角相同

不对称
- 电源不对称 — 程度小 (由系统保证)
- 负载不对称 — 情况很多

2 对称三相电路的分析



设：$\dot{U}_A = U\angle 0^\circ$

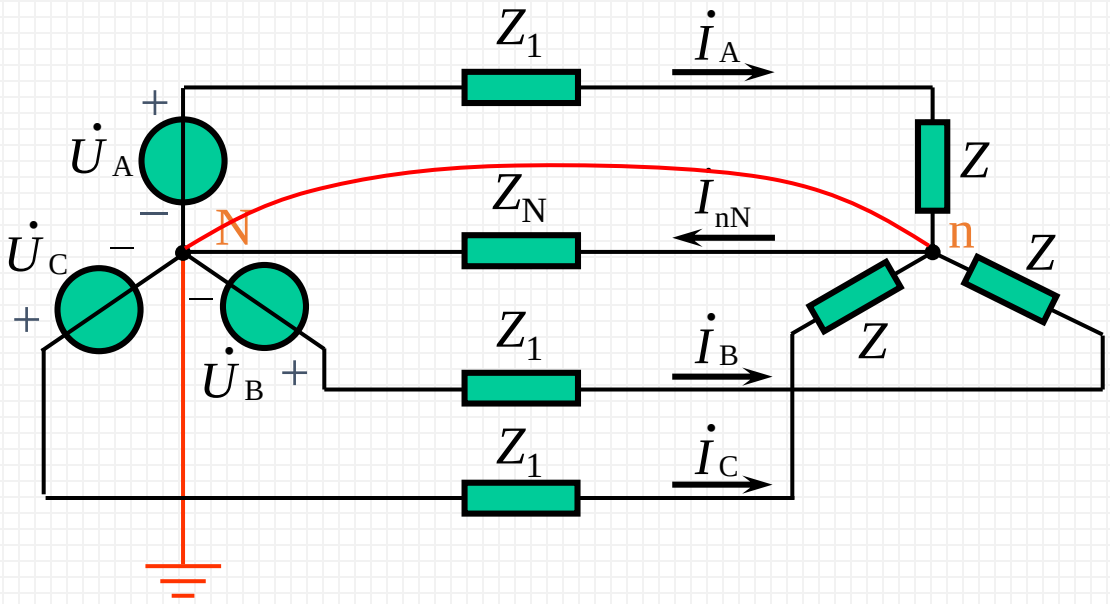
$\dot{U}_B = U\angle -120^\circ$

$\dot{U}_C = U\angle +120^\circ$

$$\left(\frac{3}{Z+Z_1}+\frac{1}{Z_N}\right)\dot{U}_{nN}=\frac{\dot{U}_A+\dot{U}_B+\dot{U}_C}{Z+Z_1}=0$$

$$\Rightarrow \dot{U}_{nN}=0$$

2 对称三相电路的分析



设：$\dot{U}_A = U\angle 0^\circ$

$\dot{U}_B = U\angle -120^\circ$

$\dot{U}_C = U\angle +120^\circ$

$$(\frac{3}{Z+Z_1}+\frac{1}{Z_N})\dot{U}_{nN}=\frac{\dot{U}_A+\dot{U}_B+\dot{U}_C}{Z+Z_1}=0$$

电源中点与负载中点等电位

$$\rightarrow \quad \dot{U}_{nN}=0$$

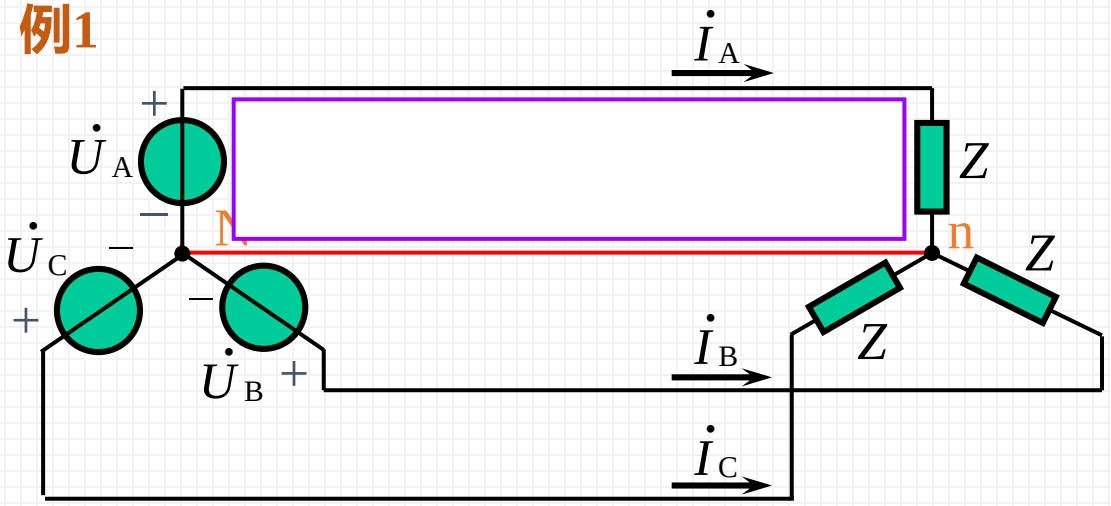
(1) 三个单相可单独计算

(2) $\dot{I}_A$，$\dot{I}_B$，$\dot{I}_C$ 对称

因此可只抽**A相**计算**抽单相**

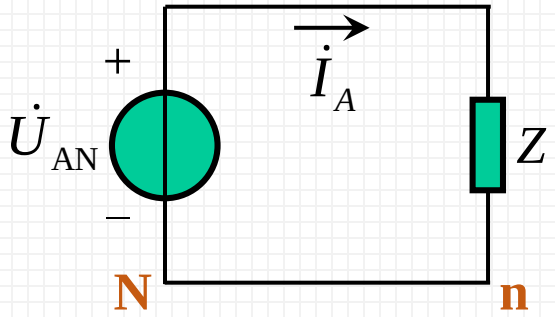
$$\dot{I}_A=\frac{\dot{U}_A}{Z+Z_1} \qquad \dot{I}_B=\frac{\dot{U}_B}{Z+Z_1} \qquad \dot{I}_C=\frac{\dot{U}_C}{Z+Z_1}$$

例1



已知对称三相电源的线电压为380V，对称负载 $Z=100\angle 30°\Omega$ 求线电流。

解：连接中线 **N-n**，取A相为例计算



设 $\dot{U}_{AB}=380\angle 30^{o}\,\mathrm{V}$ 则 $\dot{U}_{AN}=220\angle 0^{o}\,\mathrm{V}$

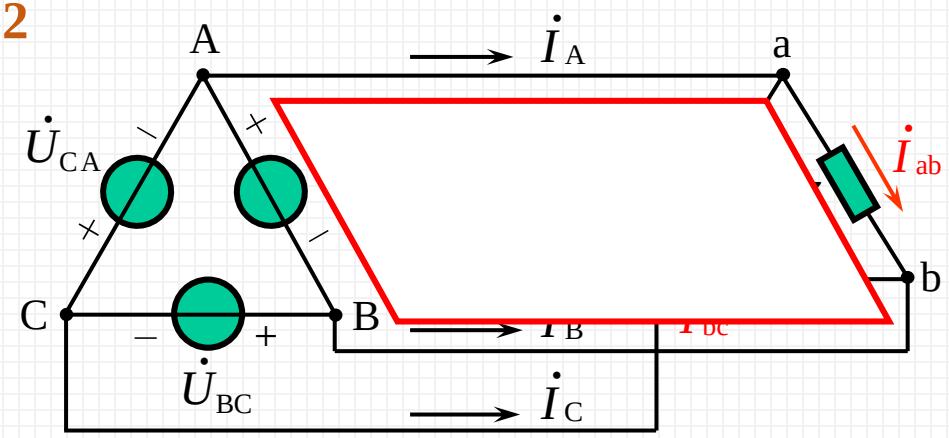
$$\dot{I}_A=\frac{\dot{U}_{AN}}{Z}=\frac{220\angle 0^{o}}{100\angle 30^{o}}=2.2\angle -30^{o}\,\mathrm{A}$$

$$\dot{I}_B=2.2\angle -150^{o}\,\mathrm{A}$$

由对称性，得

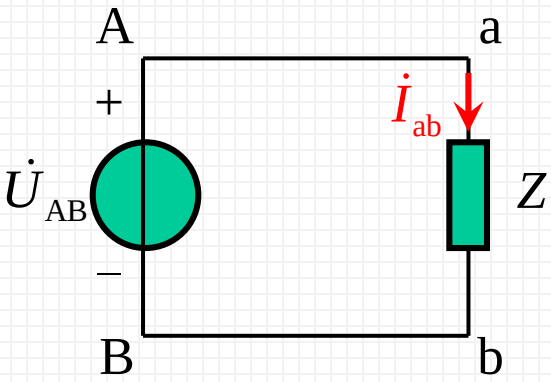
$$\dot{I}_C=2.2\angle 90^{o}\,\mathrm{A}$$

例2



已知对称三相电源的线电压为380V，对称负载$Z=100\angle 30°\Omega$求线电流。

解1 取A相求相电流 $\dot{I}_{ab}$　　设 $\dot{U}_{AB}=380\angle 0^{o}\,\mathrm{V}$



$$\dot{I}_{ab}=\frac{\dot{U}_{AB}}{Z}=\frac{380\angle 0^{o}}{100\angle 30^{o}}=3.8\angle -30^{o}\,\mathrm{A}$$

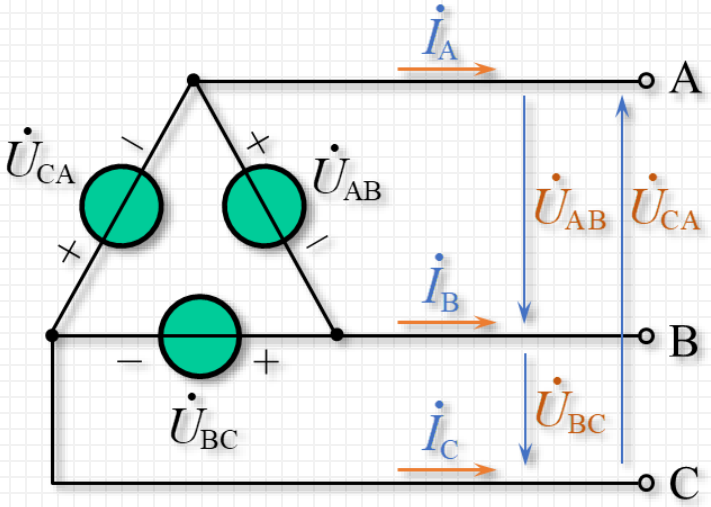
$$\dot{I}_{A}=\sqrt{3}\times 3.8\angle -30^{o}-30^{o}=6.58\angle -60^{o}\,\mathrm{A}$$

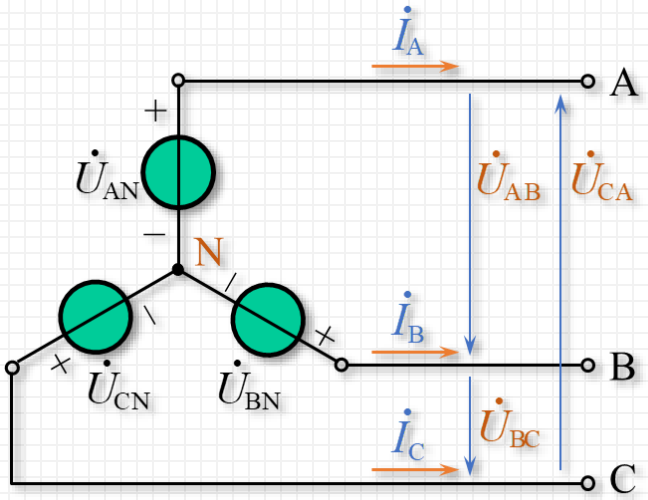
$$\dot{I}_{B}=6.58\angle -180^{o}=-6.58\mathrm{A}$$

由对称性，得　$\dot{I}_{C}=6.58\angle 60^{o}\,\mathrm{A}$

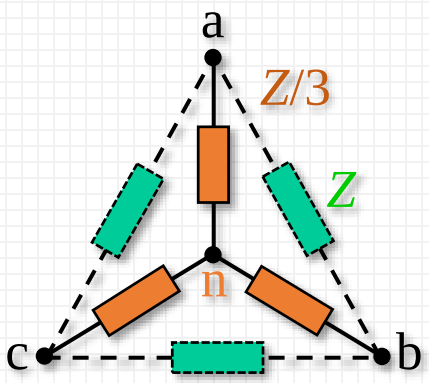
解2 化为Y - Y

将Δ接电源用Y接电源替代，保证其线电压相等





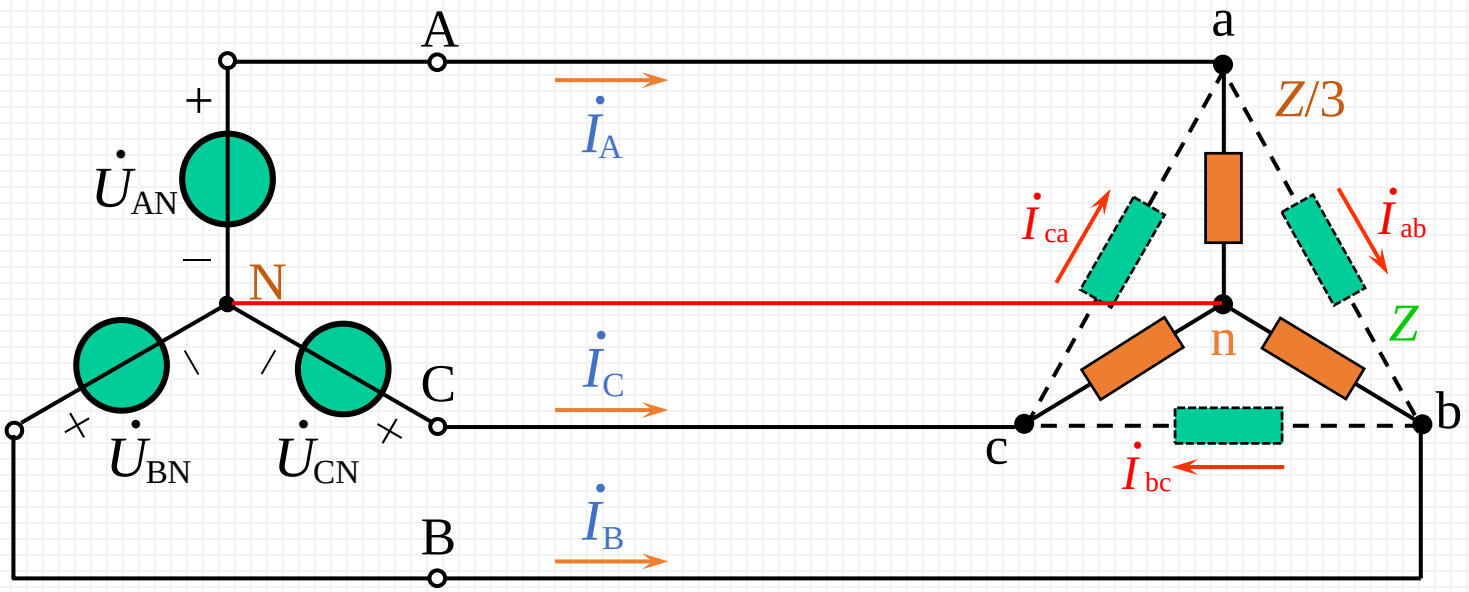
将负载Δ -Y变换



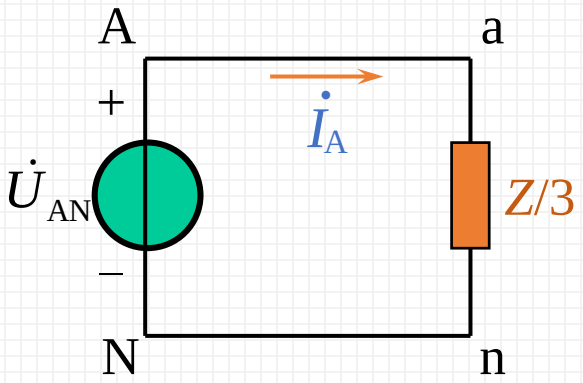
$$\dot{U}_{AN}=\frac{1}{\sqrt{3}}\dot{U}_{AB}\angle-30^{o}$$

$$\dot{U}_{BN}=\frac{1}{\sqrt{3}}\dot{U}_{BC}\angle-30^{o}$$

$$\dot{U}_{CN}=\frac{1}{\sqrt{3}}\dot{U}_{CA}\angle-30^{o}$$



解：连接中线N-n，取A相为例计算



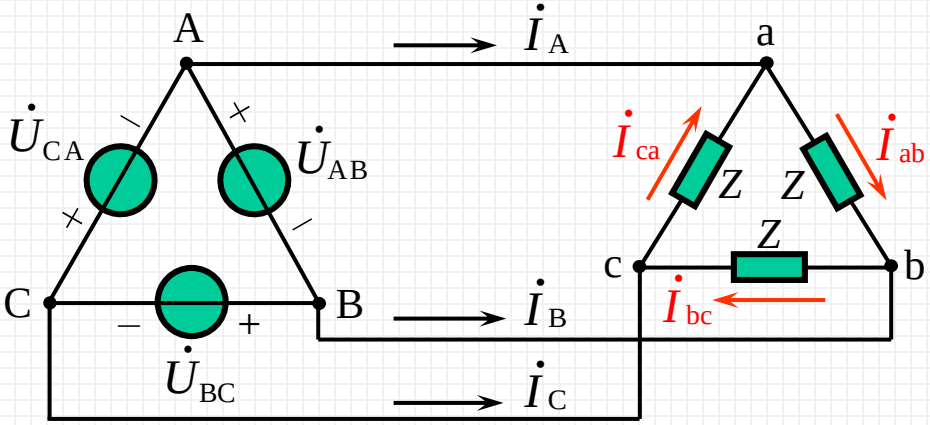
设 $\dot{U}_{AB} = 380\angle 0^\circ \text{ V}$

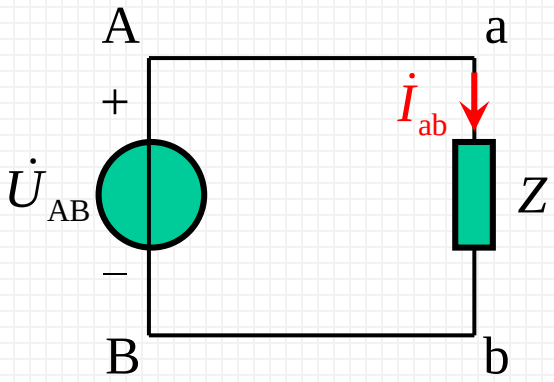
则 $\dot{U}_{AN} = 220\angle -30^\circ \text{ V}$

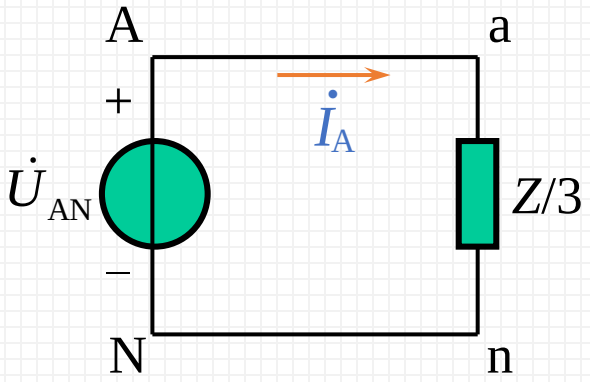
$$\dot{I}_A = \frac{\dot{U}_{AN}}{Z/3} = \frac{220\angle -30^\circ}{100\angle 30^\circ / 3} = 6.6\angle -60^\circ \text{ A}$$

$$\dot{I}_B = 6.6\angle -180^\circ = -6.6\text{A}$$

由对称性，得 $\dot{I}_C = 6.6\angle 60^\circ \text{ A}$

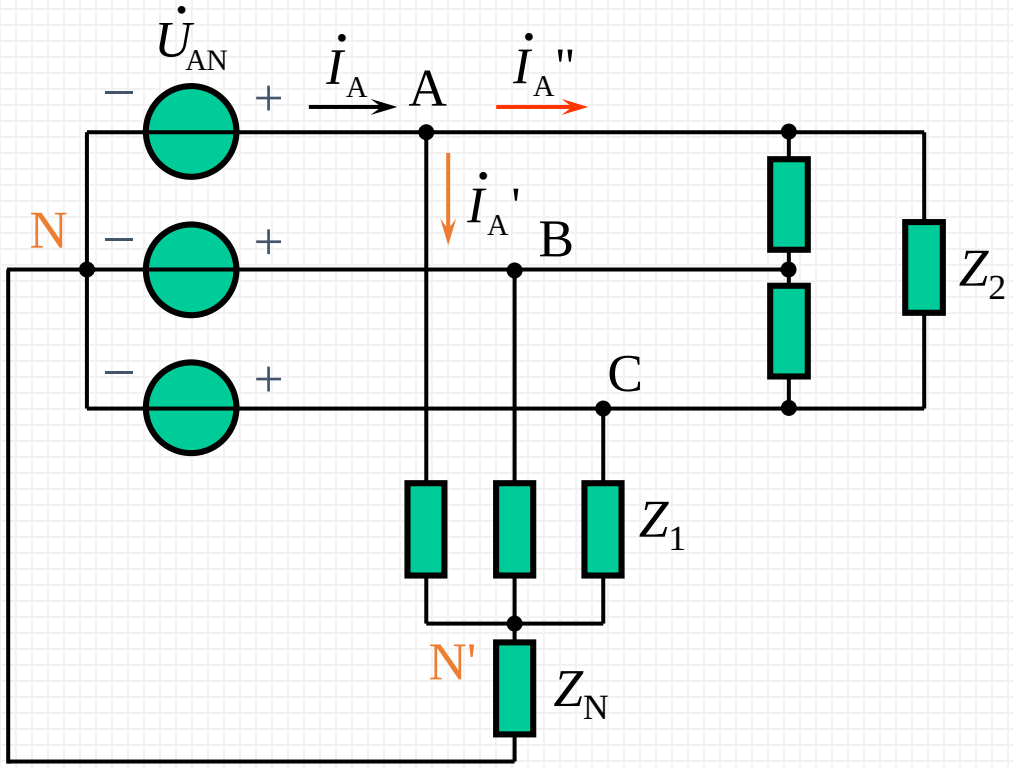

A
a
$\dot{I}_A$
$\dot{U}_{CA}$
$\dot{U}_{AB}$
$\dot{I}_{ca}$
$\dot{I}_{ab}$
Z
Z
Z
c
b
C
B
$\dot{I}_B$
$\dot{I}_{bc}$
$\dot{U}_{BC}$
$\dot{I}_C$

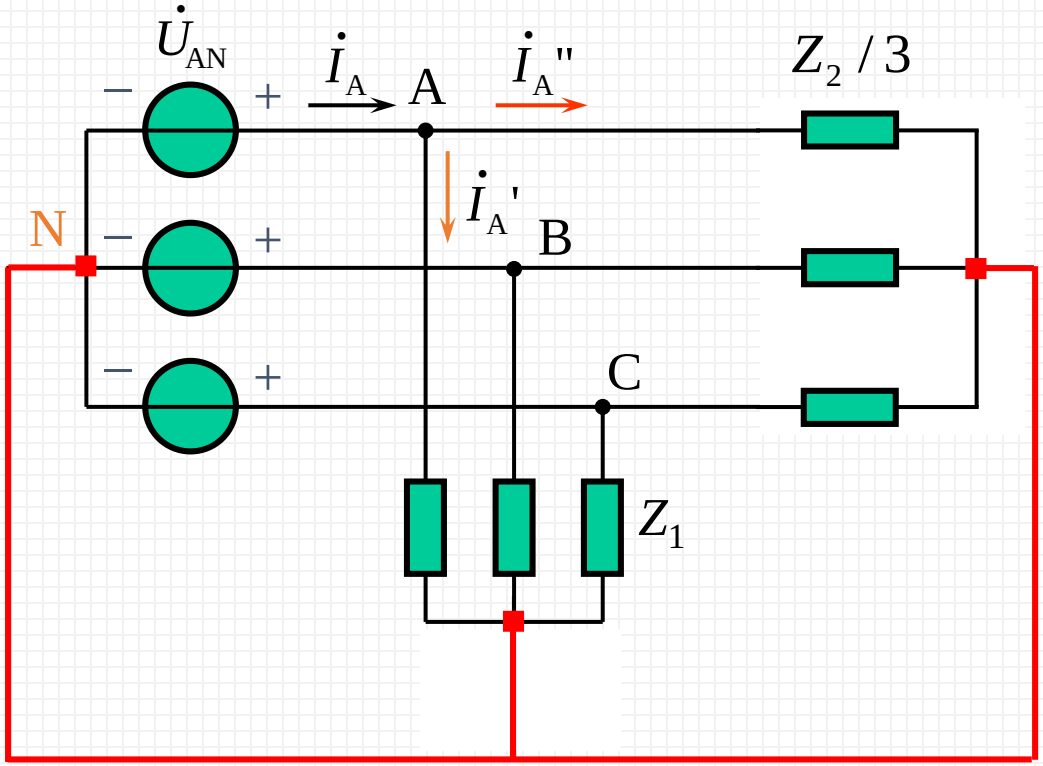

A
a
+
$\dot{I}_{ab}$
$\dot{U}_{AB}$
Z
–
B
b


A
a
+
$\dot{I}_A$
$\dot{U}_{AN}$
Z/3
–
N
n

哪种方法好？为什么？

例3 如图对称三相电路，电源线电压为380V，$|Z_1|=10\Omega$，$\cos\varphi_1=0.6$(滞后)，$Z_2=-j50\Omega$，$Z_N=1+j2\Omega$。求 $\dot{I}_A$





负载进行Δ—Y变换

短路中线阻抗Z_n

连接电源和负载中点

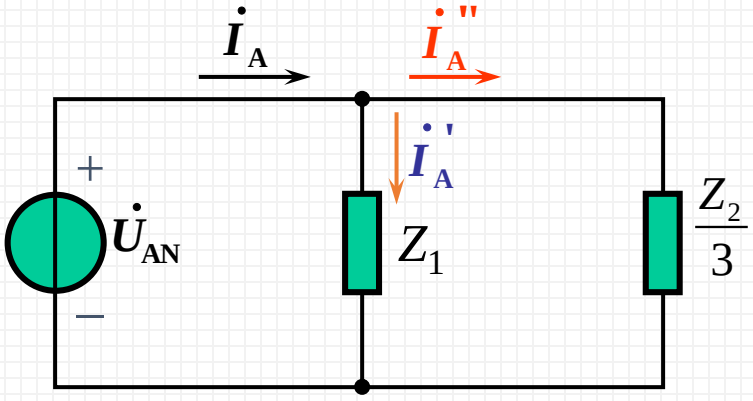
设 $\dot{U}_{AB}=380\angle 30^{o}\ \mathrm{V}$

$\dot{U}_{AN}=220\angle 0^{o}\mathrm{V}$

$\dot{I}_A=13.9\angle -18.4^{o}\,\mathrm{A}$

其余课后计算

画A相计算电路



对称三相电路的一般计算方法

1) 将所有三相电源、负载都化为等值 **Y** 连接；

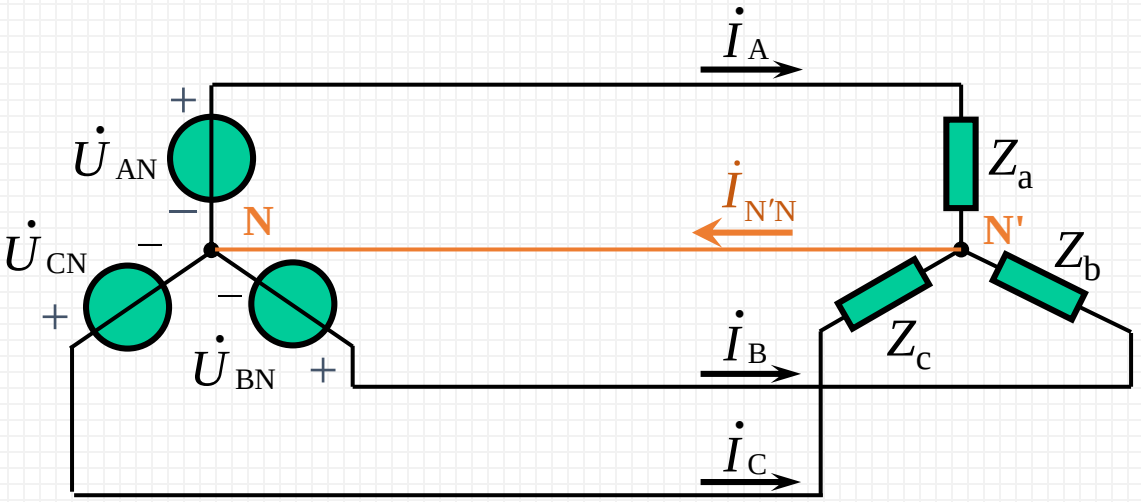
2) 连接各负载和电源中点，中线上若有阻抗则不计；

3) 画出 **A** 相计算电路，求出 **A** 相的电压、电流；

4) 根据 **Δ** 接、**Y** 接时线量、相量之间的关系和对称性，求出原电路其他相的电流、电压。

3、不对称三相电路分析简介

(1) 有中线



1) 负载上的相电压仍为对称三相电压；

$$\dot{I}_A = \frac{\dot{U}_{AN}}{Z_a} \qquad \dot{I}_B = \frac{\dot{U}_{BN}}{Z_b} \qquad \dot{I}_C = \frac{\dot{U}_{CN}}{Z_c}$$

各相可分别计算

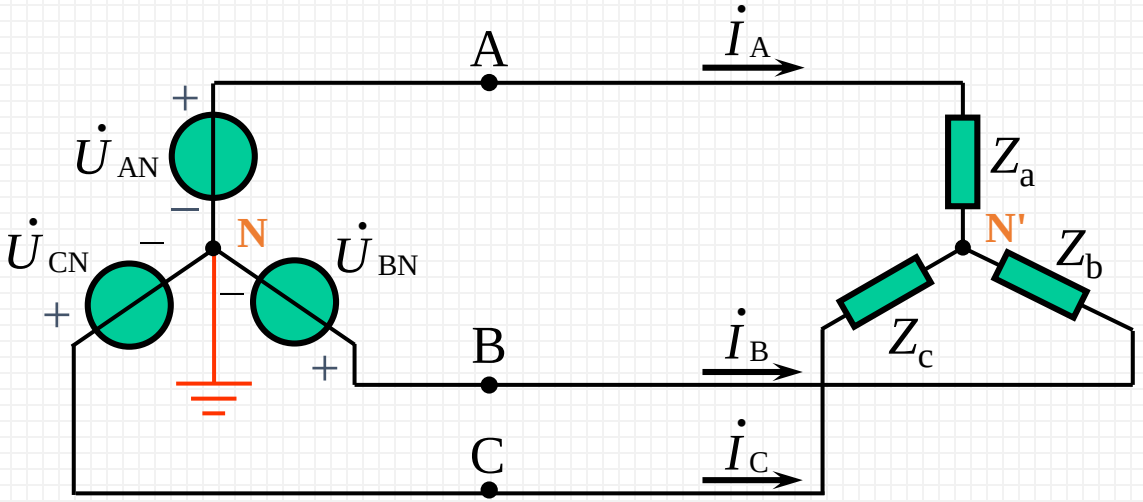
2) 由于三相负载不对称，则三相电流不对称；

不能只抽A相

$$\dot{I}_{N'N} = \dot{I}_A + \dot{I}_B + \dot{I}_C = \frac{\dot{U}_{AN}}{Z_a} + \frac{\dot{U}_{BN}}{Z_b} + \frac{\dot{U}_{CN}}{Z_c} \neq 0$$

3) 中线电流一般不为零。

(2) 无中线 三相负载Z_a、Z_b、Z_c不相同。



无法分别计算各相

节点电压法

$$\dot{U}_{N'N}=\frac{\dot{U}_{AN}/Z_a+\dot{U}_{BN}/Z_b+\dot{U}_{CN}/Z_c}{1/Z_a+1/Z_b+1/Z_c}\neq 0$$

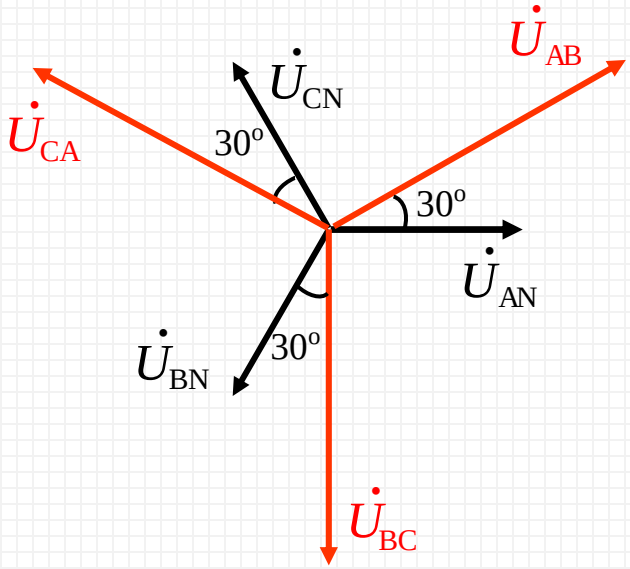
负载各相电压:

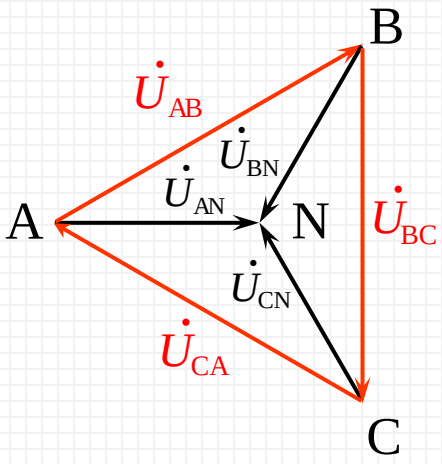
$$\dot{U}_{AN'}=\dot{U}_{AN}-\dot{U}_{N'N}$$
$$\dot{U}_{BN'}=\dot{U}_{BN}-\dot{U}_{N'N}$$
$$\dot{U}_{CN'}=\dot{U}_{CN}-\dot{U}_{N'N}$$

相电压不对称

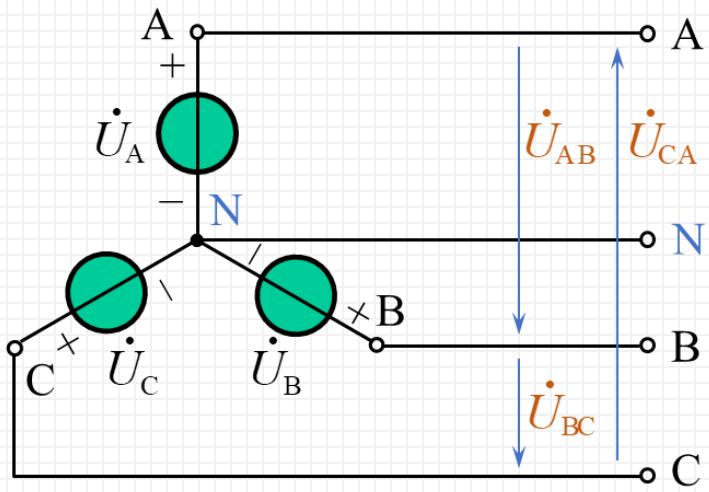
线 (相) 电流也不对称

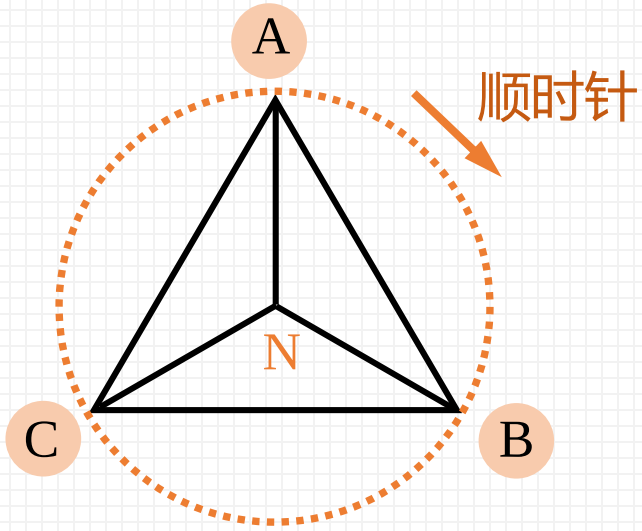
相量图 以N为参考点，图中各点的电位由该点与N点的距离决定





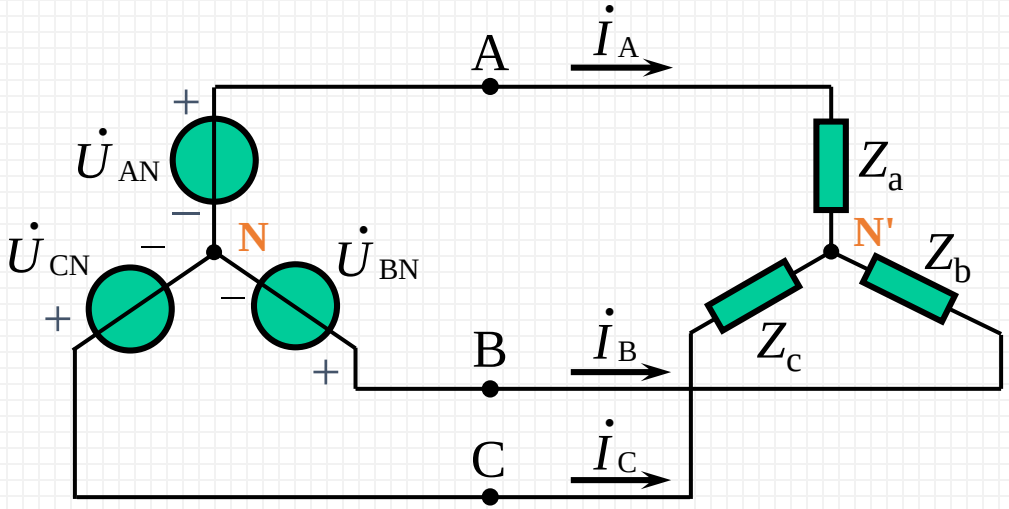
位形图：用图形方式表示电位的相量图

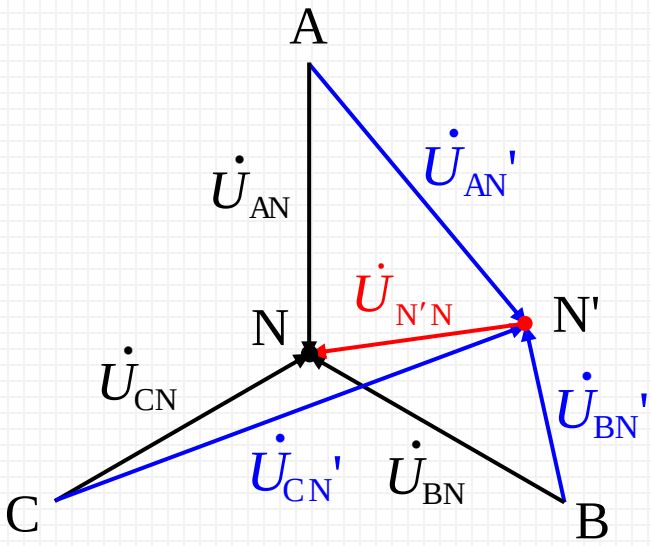




有的用户电压高

有的用户电压低





$$\dot{U}_{N'N} \neq 0$$

$$\dot{U}_{AN'} = \dot{U}_{AN} - \dot{U}_{N'N}$$

$$\dot{U}_{BN'} = \dot{U}_{BN} - \dot{U}_{N'N}$$

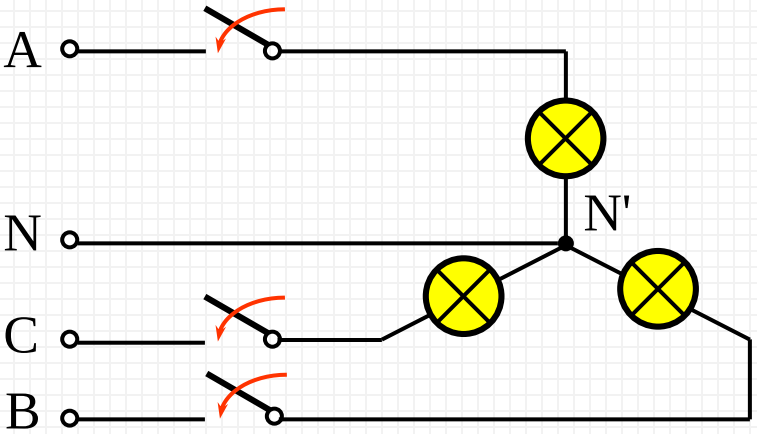
$$\dot{U}_{CN'} = \dot{U}_{CN} - \dot{U}_{N'N}$$

负载中点与电源中点不重合，这个现象称为**中点位移**。

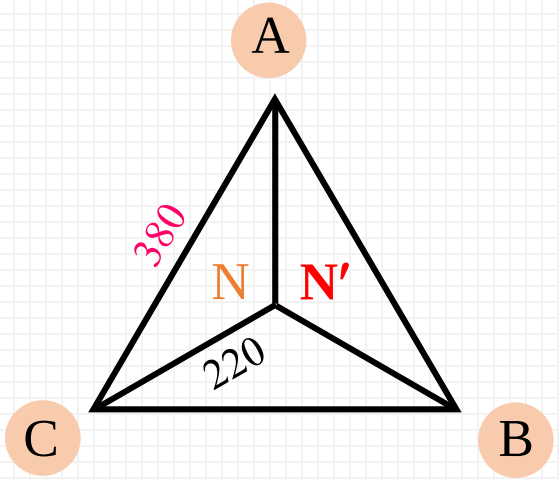
$\dot{U}_{N'N}$ 称为中点位移电压

例1 照明电路。

(1) 正常情况下，三相四线制，中线阻抗为零。

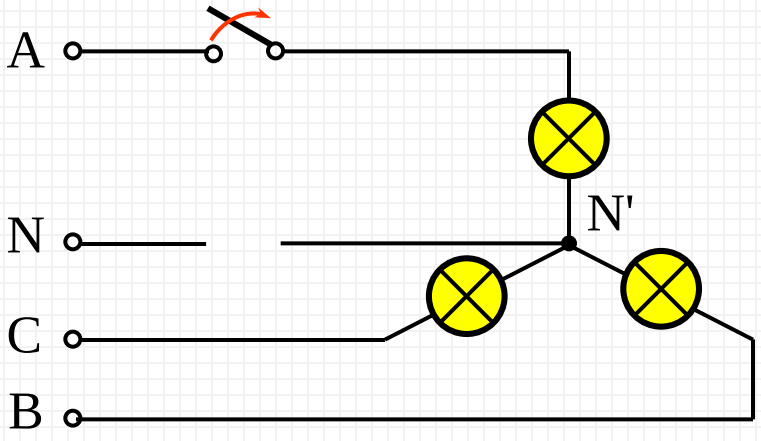


位形图

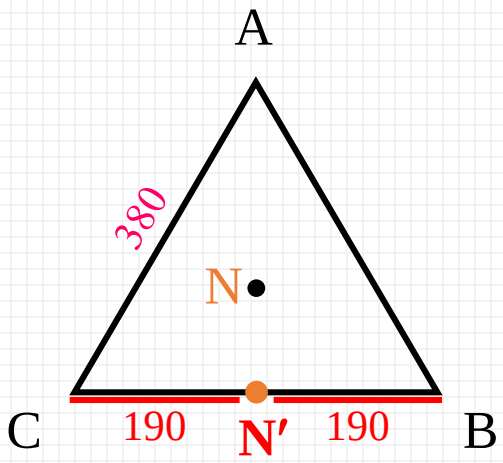


N' 在哪里?

(2) 假设中线断了(三相三线制), A相电灯没有接入电路(三相不对称)



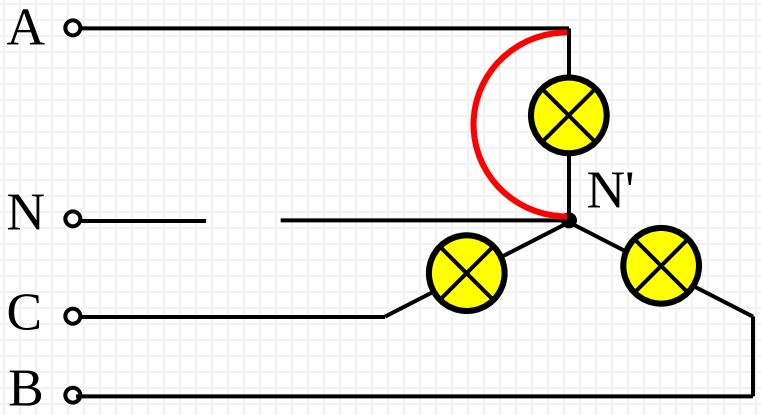
位形图



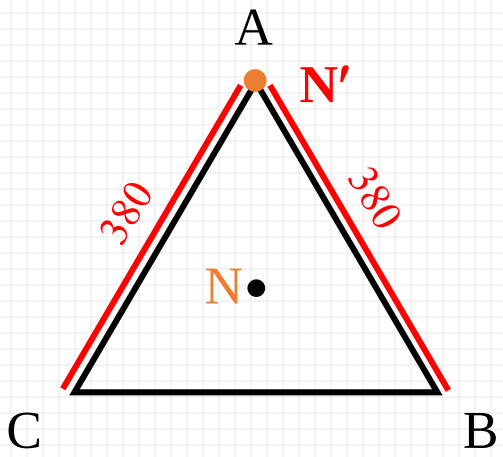
灯泡未在额定电压下工作，灯光昏暗。

N' 在哪里?

(3) 中线断了且A相短路

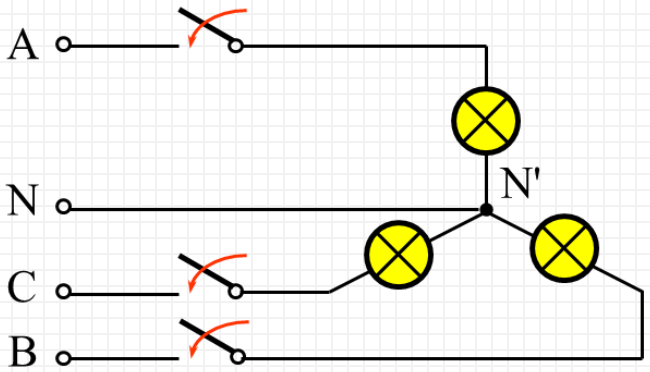


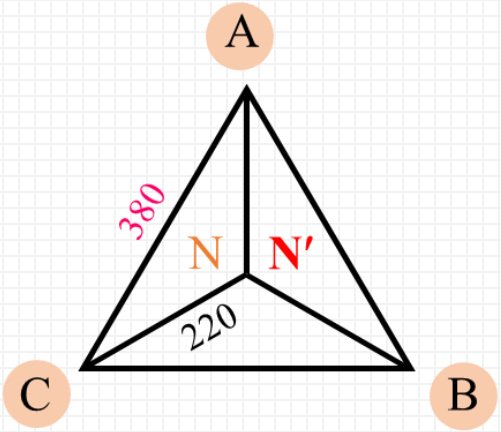
位形图

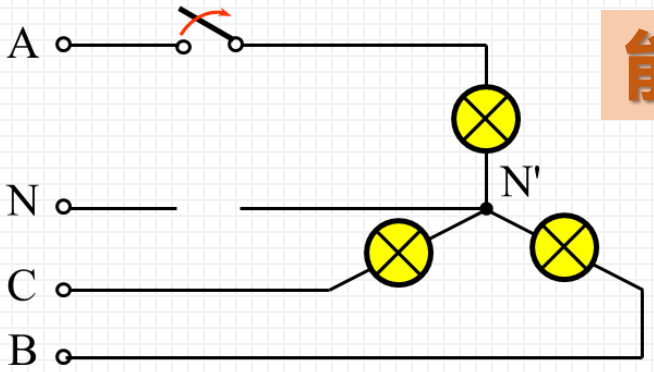


灯泡电压超过额定工作电压，烧坏了。

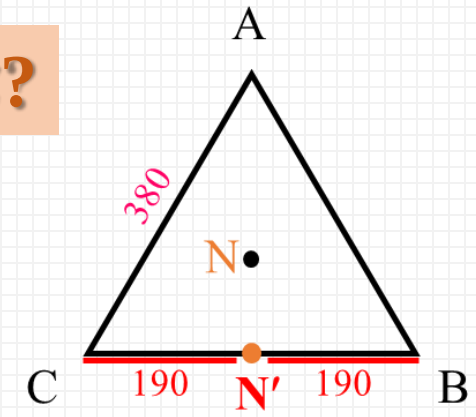
N' 在哪里?

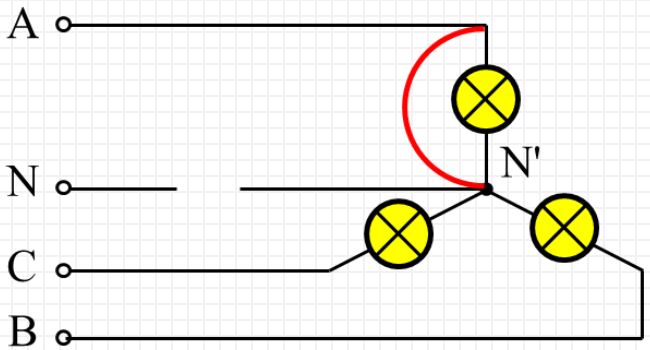

A
N
C
B
N'

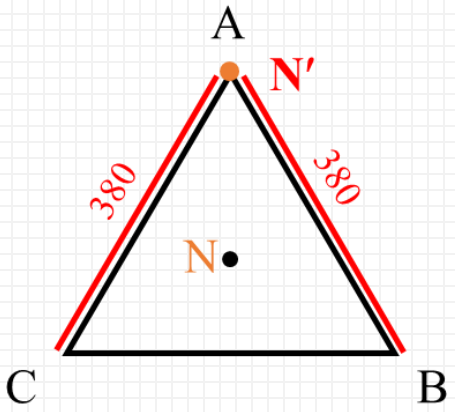

A
380
N
N'
220
C
B


A
N
C
B
N'

能得出什么结论?

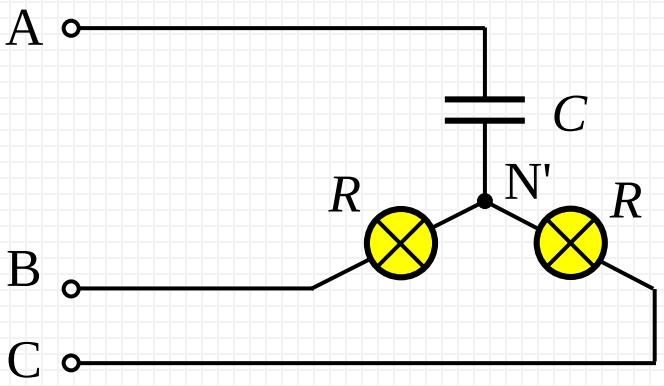

A
380
N
C
190
N'
190
B


A
N
C
B
N'


A
N'
380
380
N
C
B

例2 已知$1/(\omega C)=R$，三相电源对称。

求：灯泡承受的电压。



解

设 $\dot{U}_{AN}=U\angle 0^{o}\text{V},\ \dot{U}_{BN}=U\angle -120^{o}\text{V},\ \dot{U}_{CN}=U\angle 120^{o}\text{V}$

$$\dot{U}_{N'N}=\frac{\mathrm{j}\omega C\dot{U}_{AN}+\dot{U}_{BN}/R+\dot{U}_{CN}/R}{\mathrm{j}\omega C+1/R+1/R}=\frac{\mathrm{j}\dot{U}_{AN}+\dot{U}_{BN}+\dot{U}_{CN}}{2+\mathrm{j}1}\longrightarrow -\dot{U}_{AN}$$

$$=\frac{(-1+\mathrm{j})\dot{U}_{AN}}{2+\mathrm{j}1}=0.632\angle 108.4^{o}\,\dot{U}_{AN}=0.632U\angle 108.4^{o}\text{V}$$

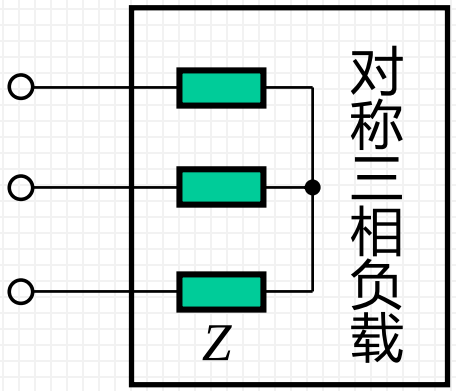
$$\dot{U}_{BN'}=\dot{U}_{BN}-\dot{U}_{N'N}=U\angle -120^{o}-0.632U\angle 108.4^{o}=1.5U\angle -101.5^{o}\text{V}$$

$$\dot{U}_{CN'}=\dot{U}_{CN}-\dot{U}_{N'N}=U\angle 120^{o}-0.632U\angle 108.4^{o}=0.4U\angle 138.4^{o}\text{V}$$

假设灯泡承载 $1.5U$ 电压不会坏这个电路什么实际应用功能?

4、三相电路的功率

(1) 对称三相电路的平均功率



$Z=|Z|\angle\varphi_p$

一相负载的功率：$P_p = U_P I_P \cos\varphi_P$ → phase

三相总功率：$P_3 = 3P_P = 3U_P I_P \cos\varphi_P$

Y接：$U_L = \sqrt{3}U_P,\quad I_L = I_P$ ← line

$$P_3 = 3\cdot\frac{1}{\sqrt{3}}U_L I_L \cos\varphi_P = \sqrt{3}U_L I_L \cos\varphi_p$$

Δ接：$U_L = U_P,\quad I_L = \sqrt{3}I_P$

$$P_3 = 3U_L\cdot\frac{1}{\sqrt{3}}I_L \cos\varphi_P = \sqrt{3}U_L I_L \cos\varphi_P$$

注意： φ_P 为相电压与相电流的相位差角 (Y接负载单相阻抗角)。

(2) 对称三相电路的无功功率

$$Q_3 = 3U_{\mathrm{P}} I_{\mathrm{P}} \sin\varphi_{\mathrm{P}} = \sqrt{3} U_{\mathrm{L}} I_{\mathrm{L}} \sin\varphi_{\mathrm{P}}$$

(3) 对称三相电路的复功率

$$\bar{S}_3 = 3\dot{U}_{\mathrm{P}} \dot{I}_{\mathrm{P}}^{*}$$

(4) 对称三相电路的瞬时功率

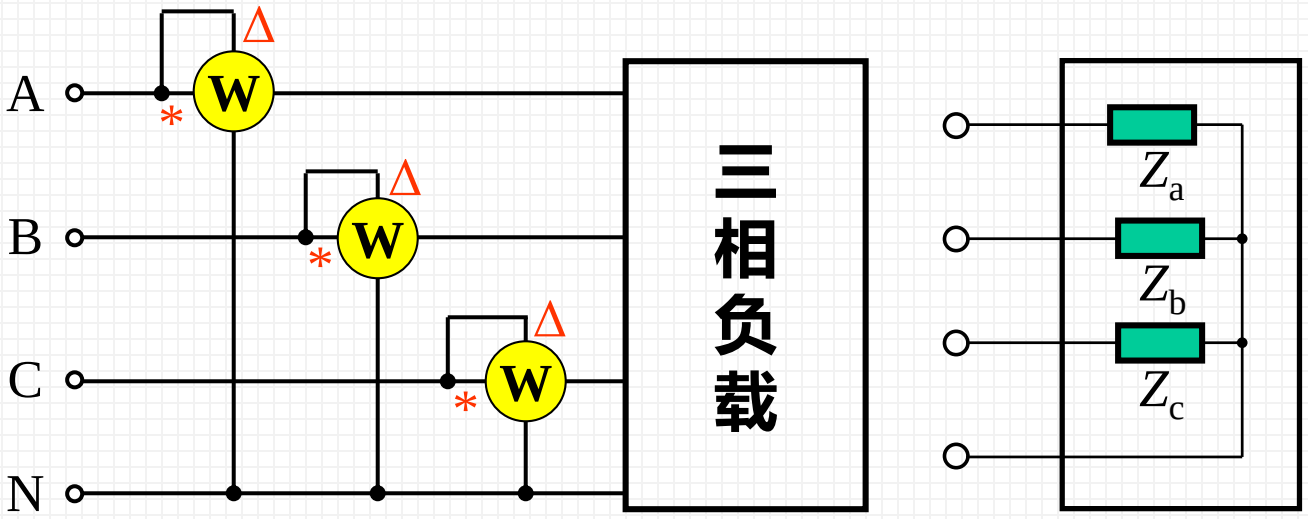
$$p = p_{\mathrm{A}} + p_{\mathrm{B}} + p_{\mathrm{C}} = 3U_{\mathrm{p}} I_{\mathrm{p}} \cos\varphi_{\mathrm{p}} = P$$

(5) 三相电路功率的测量（可以不对称）

(a) 三表法：

$$P_{总} = P_A + P_B + P_C$$

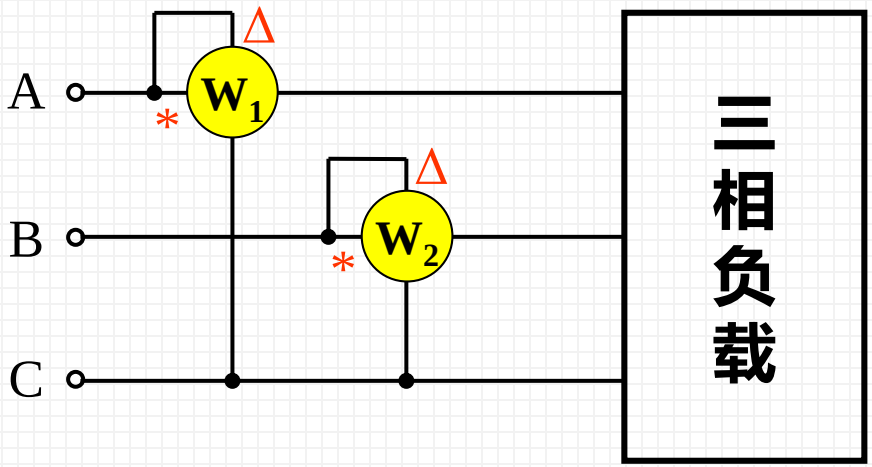
适用于
三相四线制



若负载对称，则需一块表，读数乘以 3。

(b) 二表法：

如果是三相三线制怎么办？



若W_1的读数为P_1，W_2的读数为P_2，

则 $P_{总}=P_1+P_2$ 即为三相总功率。

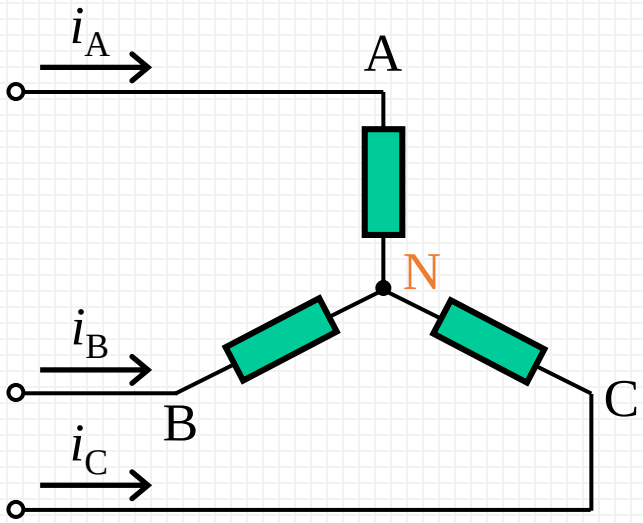
证明：(设负载为Y接)

$$p_{总}=u_{AN}\,i_A+u_{BN}\,i_B+u_{CN}\,i_C$$

$$i_C=-(i_A+i_B)$$

$$p_{总}=(u_{AN}-u_{CN})i_A+(u_{BN}-u_{CN})\,i_B$$

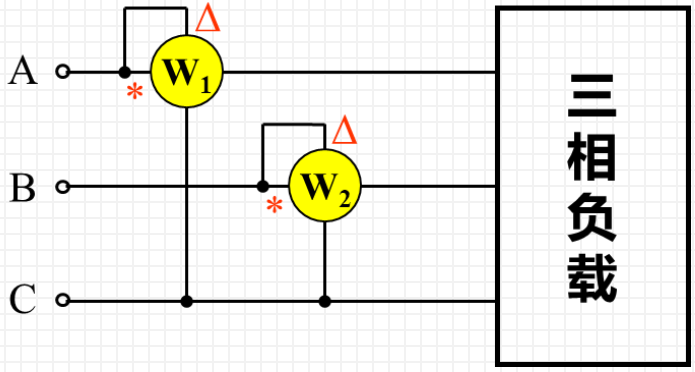
$$=u_{AC}i_A+u_{BC}\,i_B$$



$$P_{总}=U_{AC}I_A\cos\varphi_1+U_{BC}I_B\cos\varphi_2$$

φ_1：$\boldsymbol{u_{AC}}$ 领先 $\boldsymbol{i_A}$ 的相位角，

φ_2：$\boldsymbol{u_{BC}}$ 领先 $\boldsymbol{i_B}$ 的相位角。



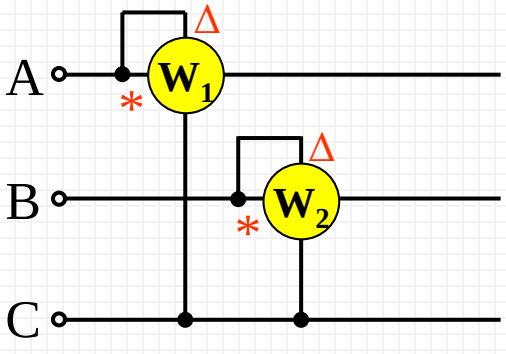
注意：

1. 只有在 $i_A+i_B+i_C=0$ 这个条件下，才能用二表法。二表法不能用于不对称三相四线制，但对称三相四线制可用。

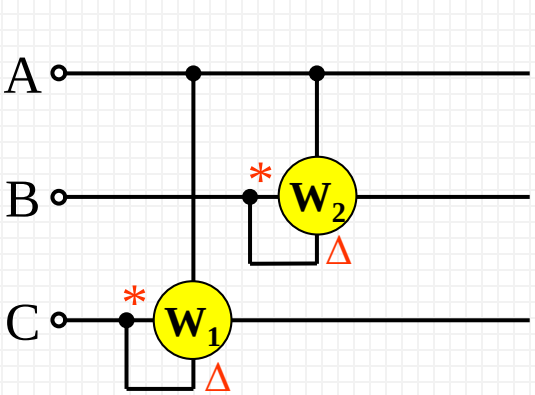
2. 两块表读数的代数和为三相总功率，单块表的单独读数无意义。

3. 按正确极性接线时，二表中可能有一个表的读数为负。

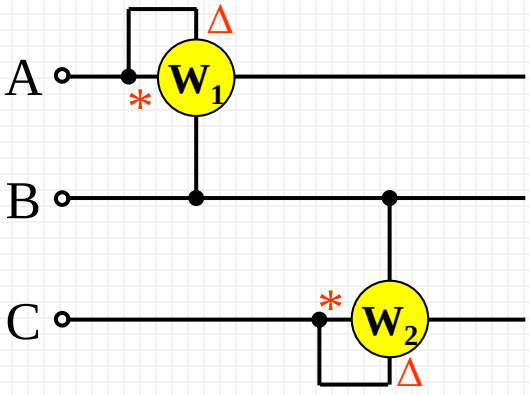
4. 两表法测三相功率的接线方式有三种。



共C



共A

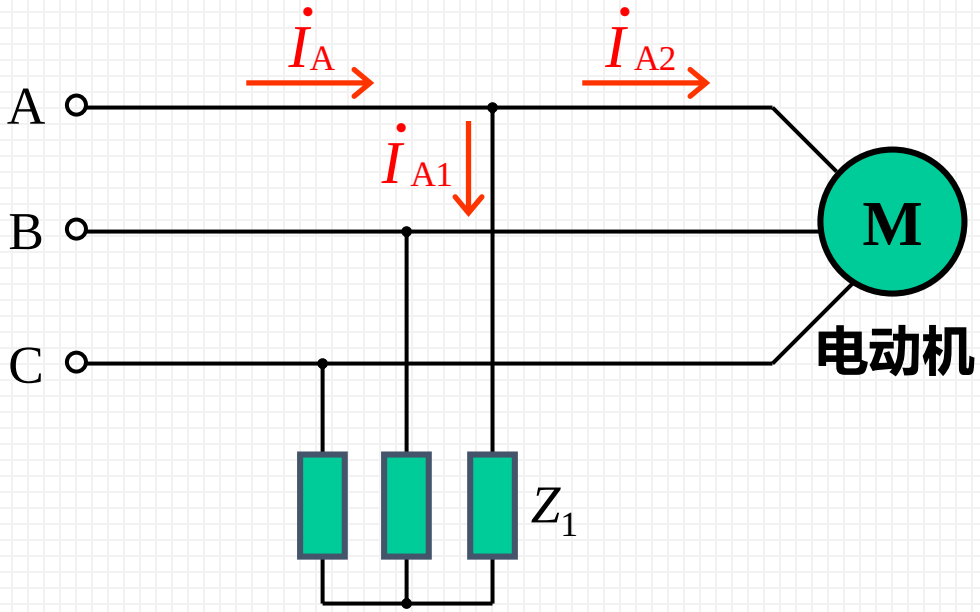


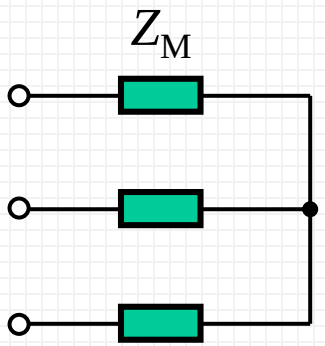
共B

例： U_L =380V, Z_1=30+j40Ω, 电动机 P_M =1700W, cosφ =0.8(滞后)。

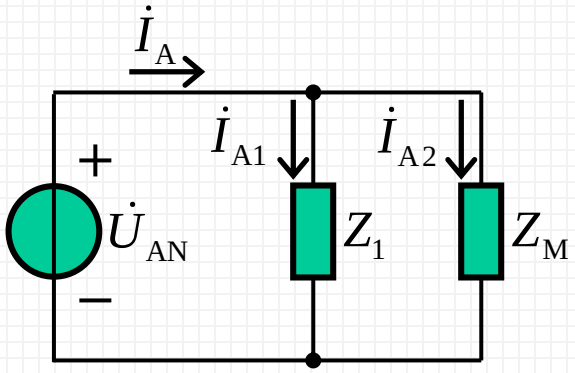
求：(1) 线电流和电源发出总功率；

(2) 用两表法测电动机负载的功率，画接线图，求两表读数。





一相电路：

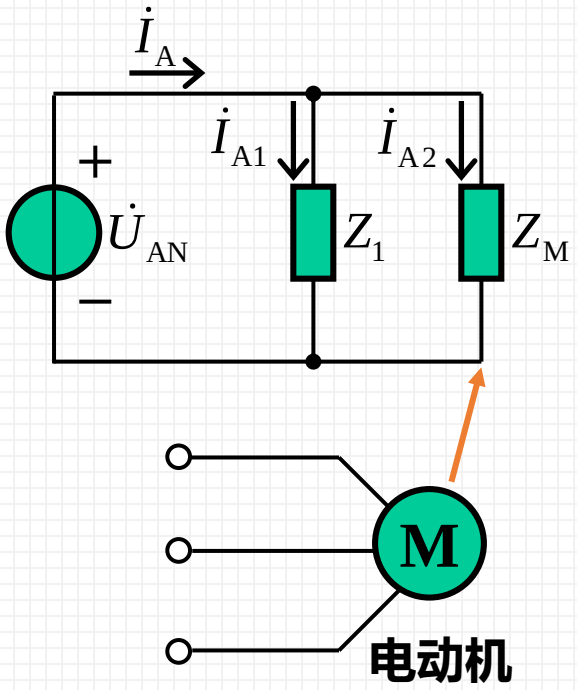


U_L =380V, Z_1=30+j40Ω, 电动机 P_M =1700W, cosφ =0.8(滞后)。

解

(1) 设 $\dot{U}_{AN} = 220\angle 0^\circ$ V

$$\dot{I}_{A1} = \frac{\dot{U}_{AN}}{Z_1} = \frac{220\angle 0^\circ}{30 + j40} = 4.41\angle -53.1^\circ \text{ A}$$



电动机负载:

$$P_M = \sqrt{3} U_L I_{A2} \cos\varphi = 1700\text{W}$$

$$I_{A2} = \frac{P_M}{\sqrt{3} U_L \cos\varphi} = \frac{P_M}{\sqrt{3} \times 380 \times 0.8} = 3.23\text{A}$$

$\cos\varphi = 0.8$(滞后), $\varphi = 36.9^\circ$ → Y接模型单相阻抗角

↓

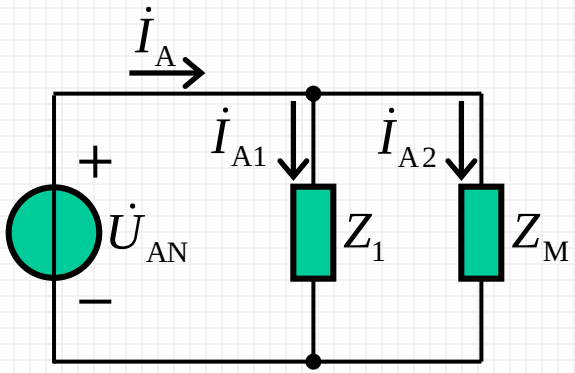
A相电压电流相位差

$$\dot{I}_{A2} = 3.23\angle -36.9^\circ \text{ A}$$

$$\dot{U}_{AN} = 220\angle 0^\circ \text{ V}$$

$$\dot{I}_{A1} = 4.41\angle -53.1^\circ \text{ A}$$

$$\dot{I}_{A2} = 3.23\angle -36.9^\circ \text{ A}$$



总电流：

$$\dot{I}_A = \dot{I}_{A1} + \dot{I}_{A2}$$

$$= 4.41\angle -53.1^\circ + 3.23\angle -36.9^\circ = 7.56\angle -46.2^\circ \text{ A}$$

$$P_{总} = \sqrt{3} U_L I_A \cos\varphi_{P总} \qquad \varphi_{P总} = \psi_{\dot{U}_{AN}} - \psi_{\dot{I}_A} = 46.2^\circ$$

$$= \sqrt{3} \times 380 \times 7.56 \times \cos 46.2^\circ = 3.44\text{kW}$$

(2) 两表的接法如图。

$\dot{U}_{AN} = 220\angle 0^\circ \text{ V}$

$\dot{I}_{A2} = 3.23\angle -36.9^\circ \text{ A}$

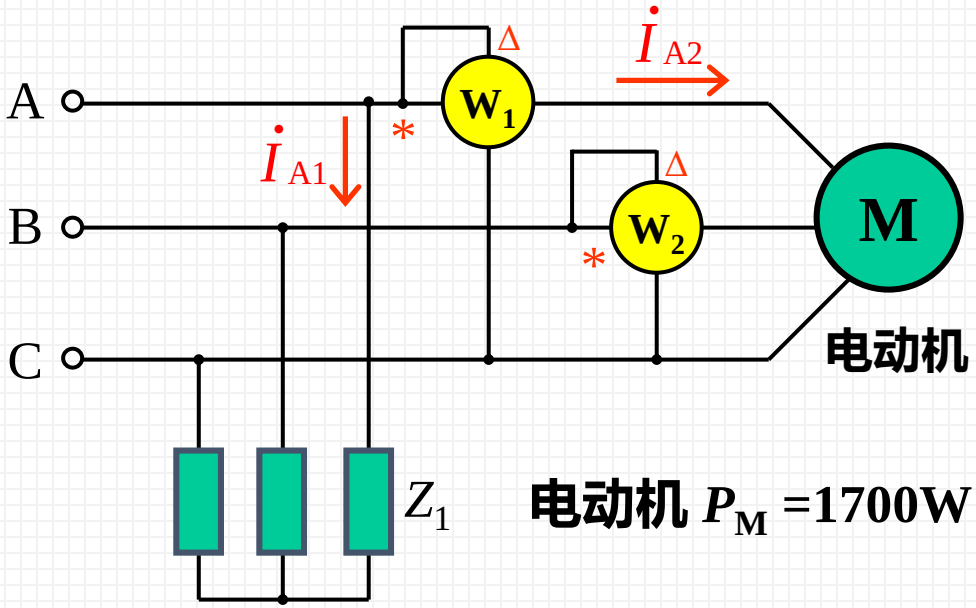
$\dot{I}_{B2} = 3.23\angle -156.9^\circ \text{ A}$

$\dot{U}_{AB} = 380\angle 30^\circ \text{ V}$

$\dot{U}_{AC} = -\dot{U}_{CA} = -380\angle 150^\circ \text{ V}$

$= 380\angle -30^\circ \text{ V}$

$\dot{U}_{BC} = 380\angle -90^\circ \text{ V}$



(2) 两表的接法如图。

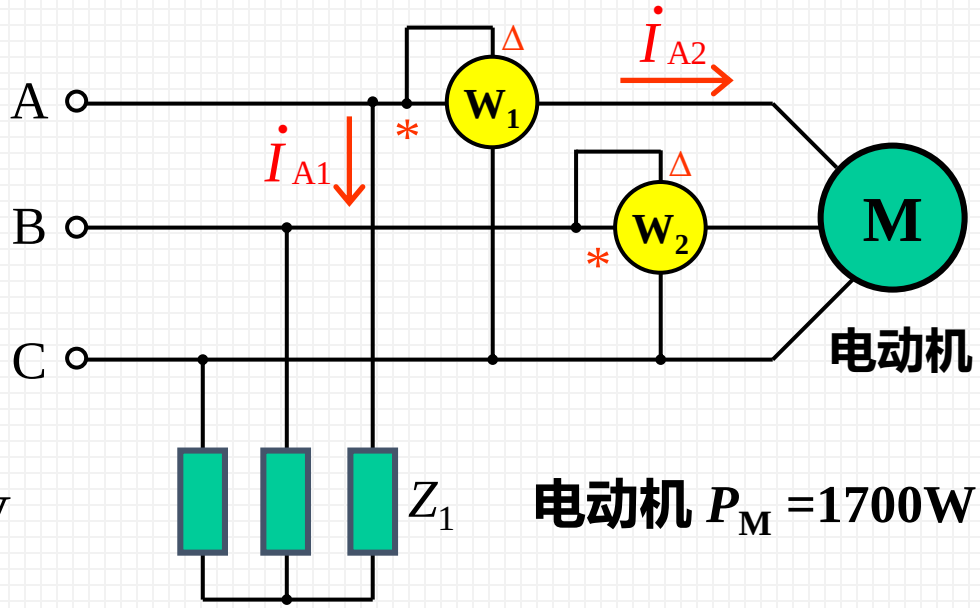
$\dot{I}_{A2} = 3.23\angle -36.9^{o}\,\text{A}$

$\dot{I}_{B2} = 3.23\angle -156.9^{\circ}\,\text{A}$

$\dot{U}_{AB} = 380\angle 30^{o}\,\text{V}$

$\dot{U}_{AC} = -\dot{U}_{CA} = 380\angle -30^{o}\,\text{V}$

$\dot{U}_{BC} = 380\angle -90^{o}\,\text{V}$



电动机 P_M =1700W

表W_1的读数：$P_1 = U_{AC}I_{A2}\cos\varphi_1 = 380\times 3.23\cos(-30^{\circ}+36.9^{\circ})$

$= 380\times 3.23\cos(6.9^{\circ}) = 1219\text{W}$ → 1700W

表W_2的读数：$P_2 = U_{BC}I_{B2}\cos\varphi_2 = 380\times 3.23\cos(-90^{\circ}+156.9^{\circ})$

$= 380\times 3.23\cos(66.9^{\circ}) = 481\text{W}$