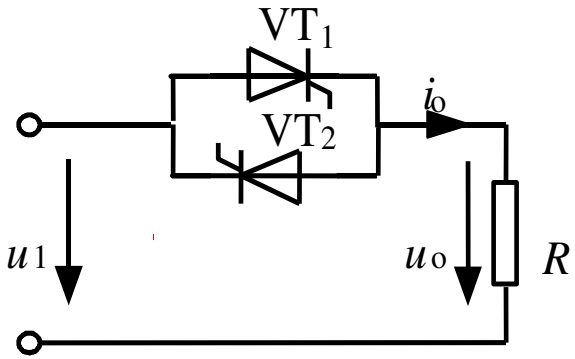
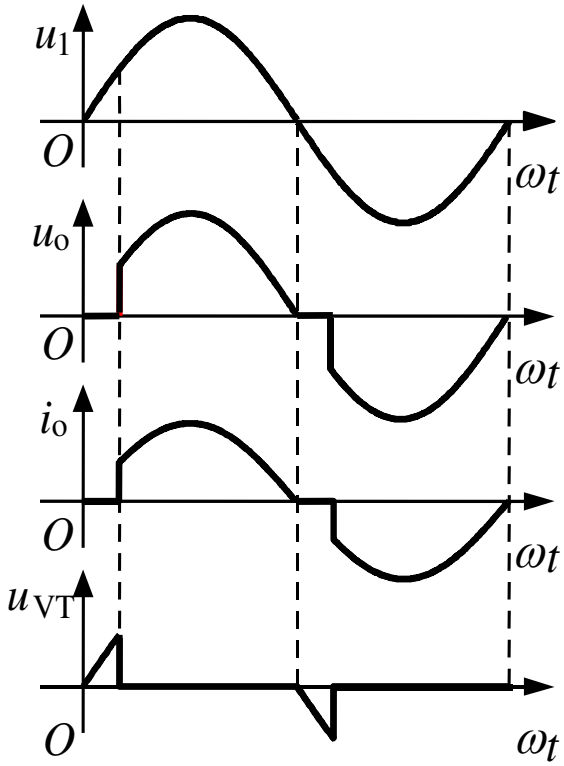
Single-phase AC voltage controller





The phase shift range (operation range of phase delay angle):

0 ⩽ α ⩽ π

- **Resistive load, quantitative analysis**

RMS value of output voltage

$$U_{\mathrm{o}}=\sqrt{\frac{1}{\pi}\int_{\alpha}^{\pi}\left(\sqrt{2}U_1\sin\omega t\right)^2\mathrm{d}(\omega t)}=U_1\sqrt{\frac{1}{2\pi}\sin 2\alpha+\frac{\pi-\alpha}{\pi}} \qquad (4\text{-}1)$$

RMS value of output current

$$I_{\mathrm{o}}=\frac{U_{\mathrm{o}}}{R} \qquad (4\text{-}2)$$

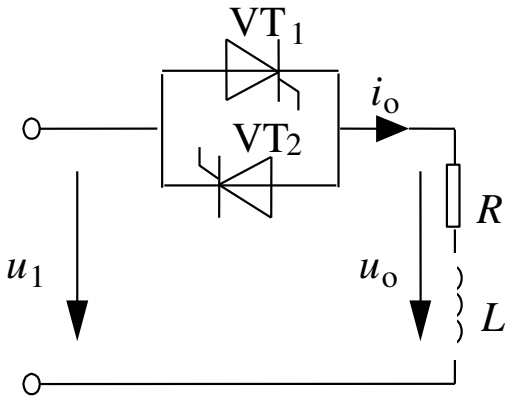
RMS value of thyristor current

$$I_T=\sqrt{\frac{1}{2\pi}\int_{\alpha}^{\pi}\left(\frac{\sqrt{2}U_1\sin\omega t}{R}\right)^2 d(\omega t)}=\frac{U_1}{R}\sqrt{\frac{1}{2}(1-\frac{\alpha}{\pi}+\frac{\sin 2\alpha}{2\pi})} \qquad (4\text{-}3)$$

Power factor of the circuit

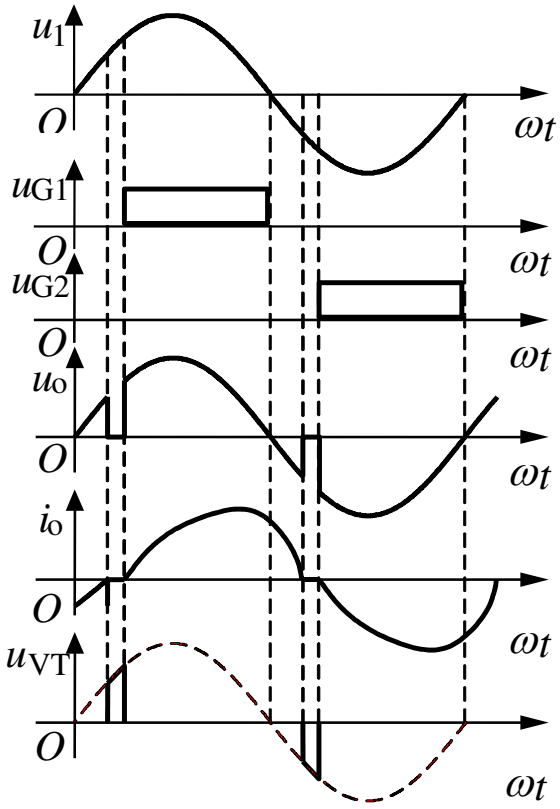
$$\lambda=\frac{P}{S}=\frac{U_{\mathrm{o}}I_{\mathrm{o}}}{U_1I_{\mathrm{o}}}=\frac{U_{\mathrm{o}}}{U_1}=\sqrt{\frac{1}{2\pi}\sin 2\alpha+\frac{\pi-\alpha}{\pi}} \qquad (4\text{-}4)$$

Inductive (Inductor- resistor) load , operation principle



The phase shift range:

$\varphi \leqslant \alpha \leqslant \pi$



Inductive load, quantitative analysis

Differential equation

$$L\frac{\mathrm{d}i_{\mathrm{o}}}{\mathrm{d}t}+Ri_{\mathrm{o}}=\sqrt{2}U_1\sin\omega t$$

$$i_{\mathrm{o}}\big|_{\omega t=\alpha}=0 \qquad (4\text{-}5)$$

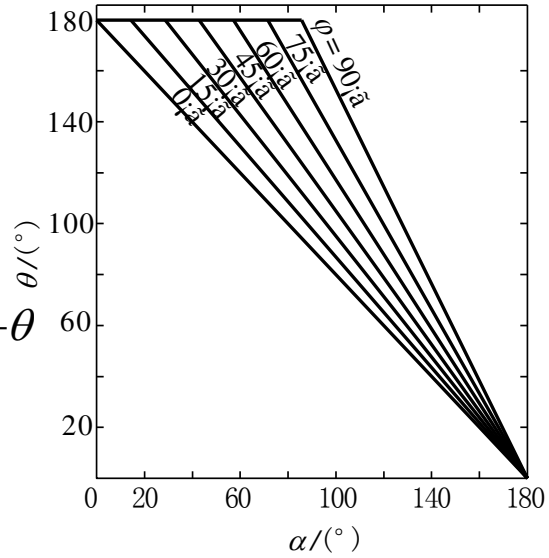
Solution

$$i_{\mathrm{o}}=\frac{\sqrt{2}U_1}{Z}\left[\sin(\omega t-\varphi)-\sin(\alpha-\varphi)e^{\frac{\alpha-\omega t}{\mathrm{tg}\varphi}}\right] \qquad \alpha\le\omega t\le\alpha+\theta \qquad (4\text{-}6)$$

Considering *i*o =0 when ω *t*= α + θ

We have

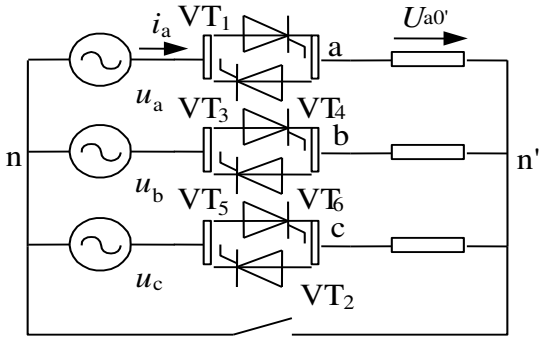
$$\sin(\alpha+\theta-\varphi)=\sin(\alpha-\varphi)e^{\frac{-\theta}{\mathrm{tg}\varphi}} \qquad (4\text{-}7)$$



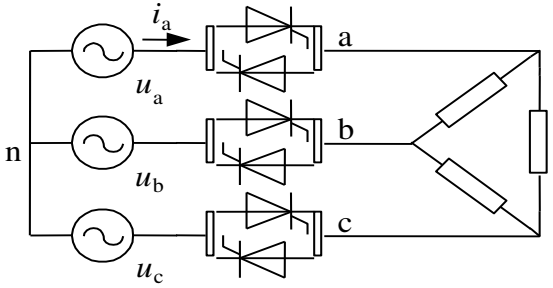
The RMS value of output voltage, output current, and thyristor current can then be calculated.

4.1.2 Three-phase AC voltage controller

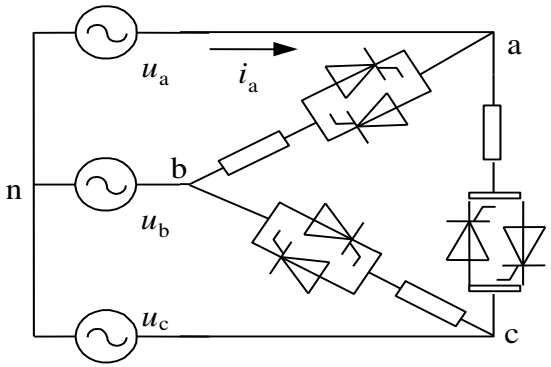
Classification of three- phase circuits



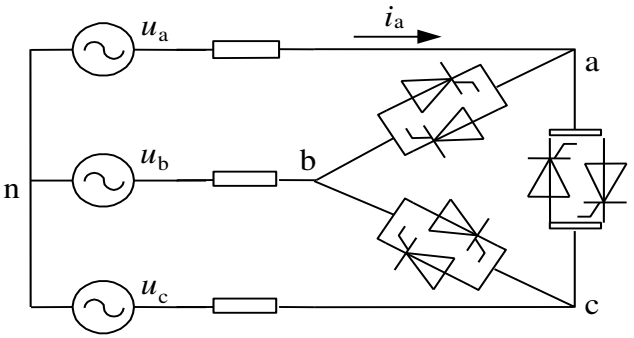
Y connection



Line- controlled Δ connection

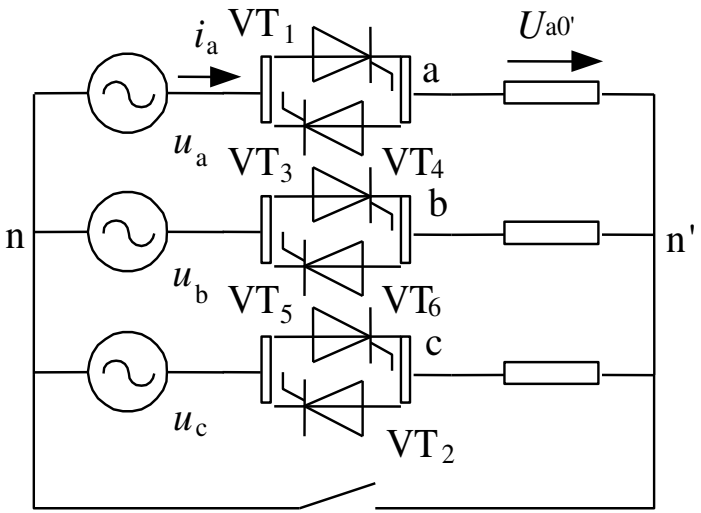


Branch-controlled Δ connection



Neutral-point controlled Δ connection

- **3- phase 3- wire Y connection AC voltage controller**



For a time instant, there are 2 possible conduction states:

–Each phase has a thyristor conducting. Load voltages are the same as the source voltages.

–There are only 2 thyristors conducting, each from a phase. The load voltages of the two conducting phases are half of the corresponding line to line voltage, while the load voltage of the other phase is 0.