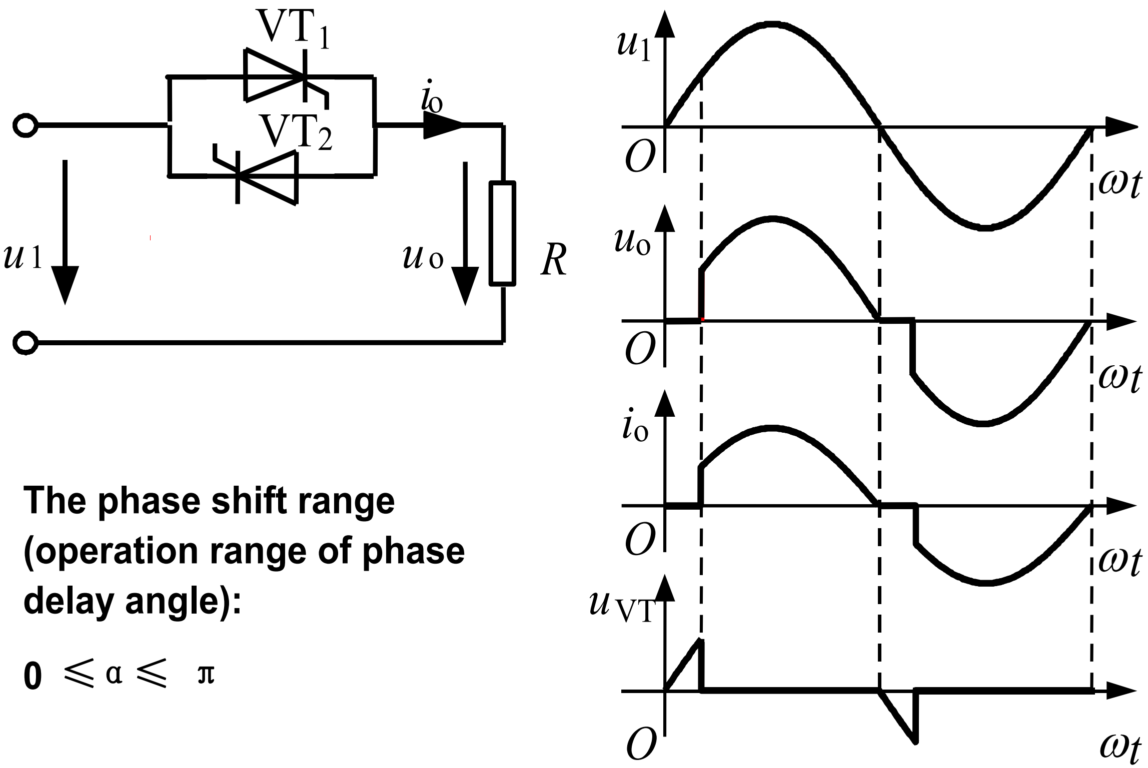
Single-phase AC voltage controller



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

$0 \leqslant \alpha \leqslant \pi$

- **Resistive load, quantitative analysis**

RMS value of output voltage

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

RMS value of output current

$$I_o = \frac{U_o}{R} \qquad (4\text{-}2)$$

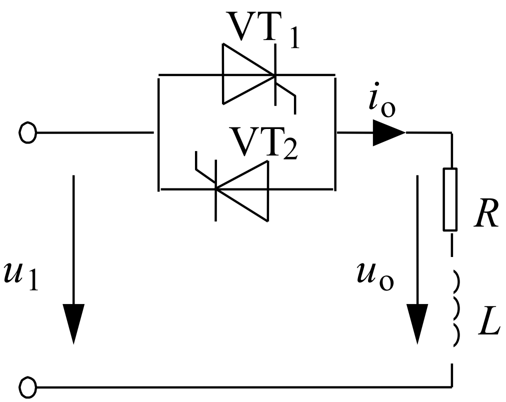
RMS value of thyristor current

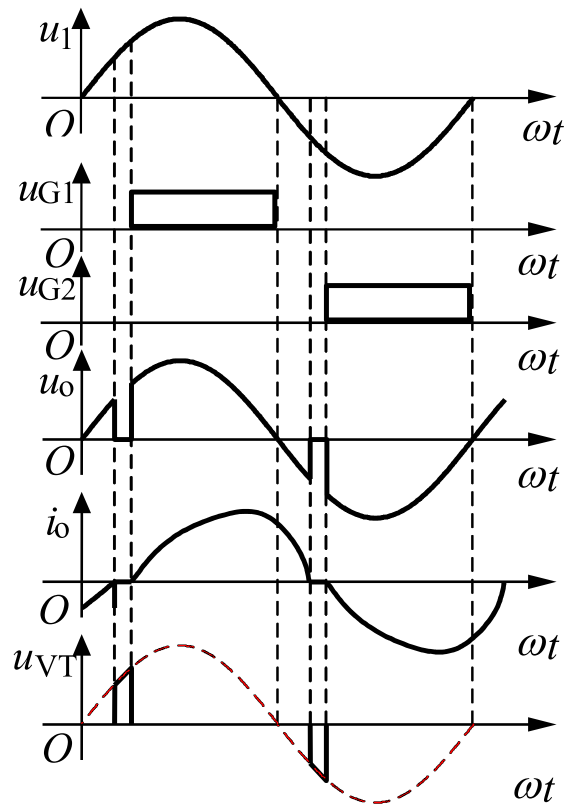
$$I_T = \sqrt{\frac{1}{2\pi}\int_\alpha^\pi \left(\frac{\sqrt{2}U_1 \sin\omega t}{R}\right)^2 d(\omega t)} = \frac{U_1}{R}\sqrt{\frac{1}{2}\left(1-\frac{\alpha}{\pi}+\frac{\sin 2\alpha}{2\pi}\right)} \qquad (4\text{-}3)$$

Power factor of the circuit

$$\lambda = \frac{P}{S} = \frac{U_o I_o}{U_1 I_o} = \frac{U_o}{U_1} = \sqrt{\frac{1}{2\pi}\sin 2\alpha + \frac{\pi-\alpha}{\pi}} \qquad (4\text{-}4)$$

Inductive (Inductor- resistor) load , operation principle





The phase shift range:

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

Inductive load, quantitative analysis

Differential equation

$$L\frac{\mathrm{d}i_o}{\mathrm{d}t} + Ri_o = \sqrt{2}U_1 \sin \omega t$$

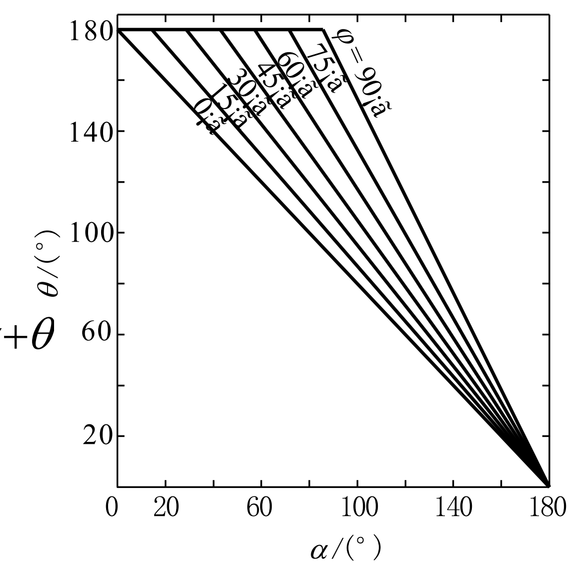
$$i_o\big|_{\omega t=\alpha} = 0 \qquad (4\text{-}5)$$

Solution

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

(4-6)

Considering *io* =0 when ω*t*= α + θ



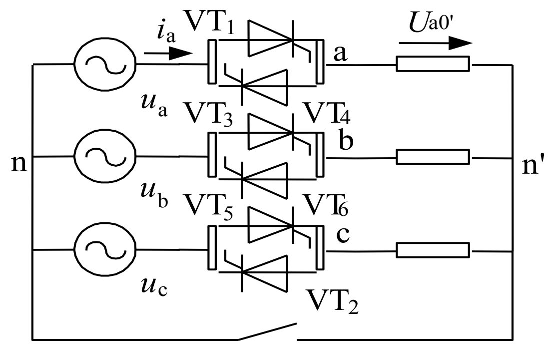
We have

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

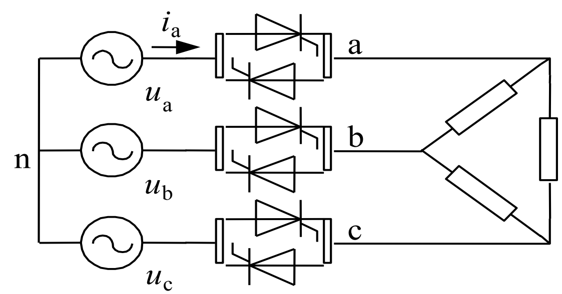
The RMS value of output voltage, output current, and thyristor current can then be calculated.

4.1.2 Three-phase AC voltage controller

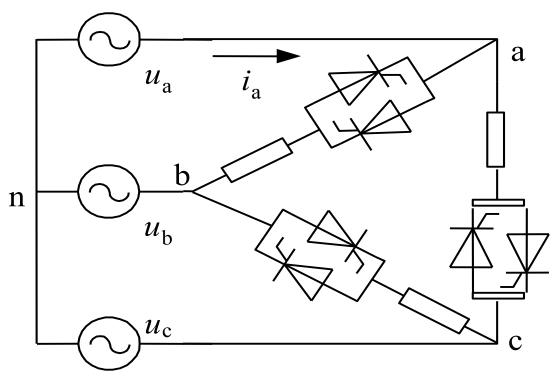
Classification of three- phase circuits



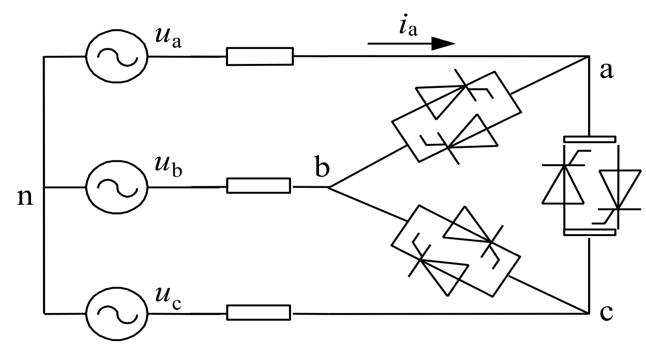
Y connection



Line- controlled Δ connection

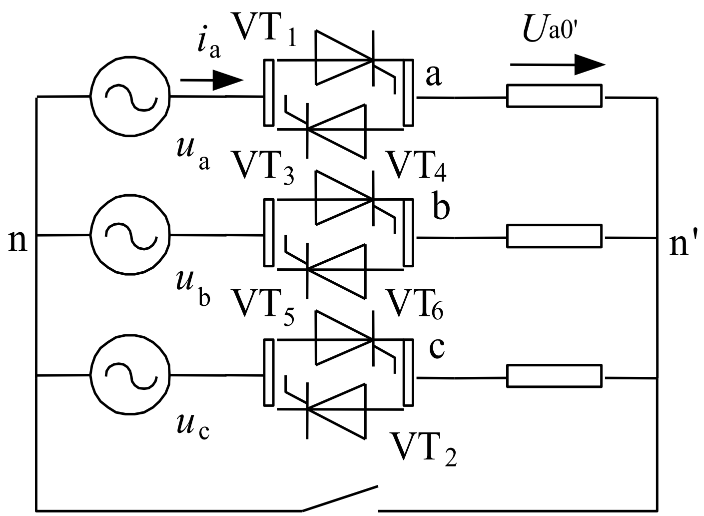


Branch-controlled Δ connection



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.