Power Electronics Lab

Single phase controlled rectifier

Eng :Eman Abu Hany

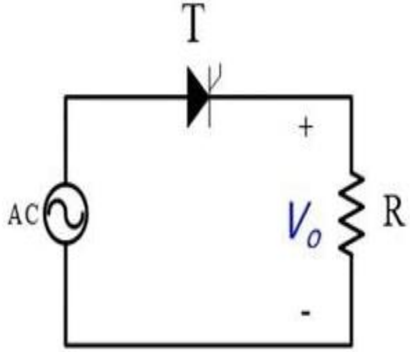
Single Phase controlled Rectifier

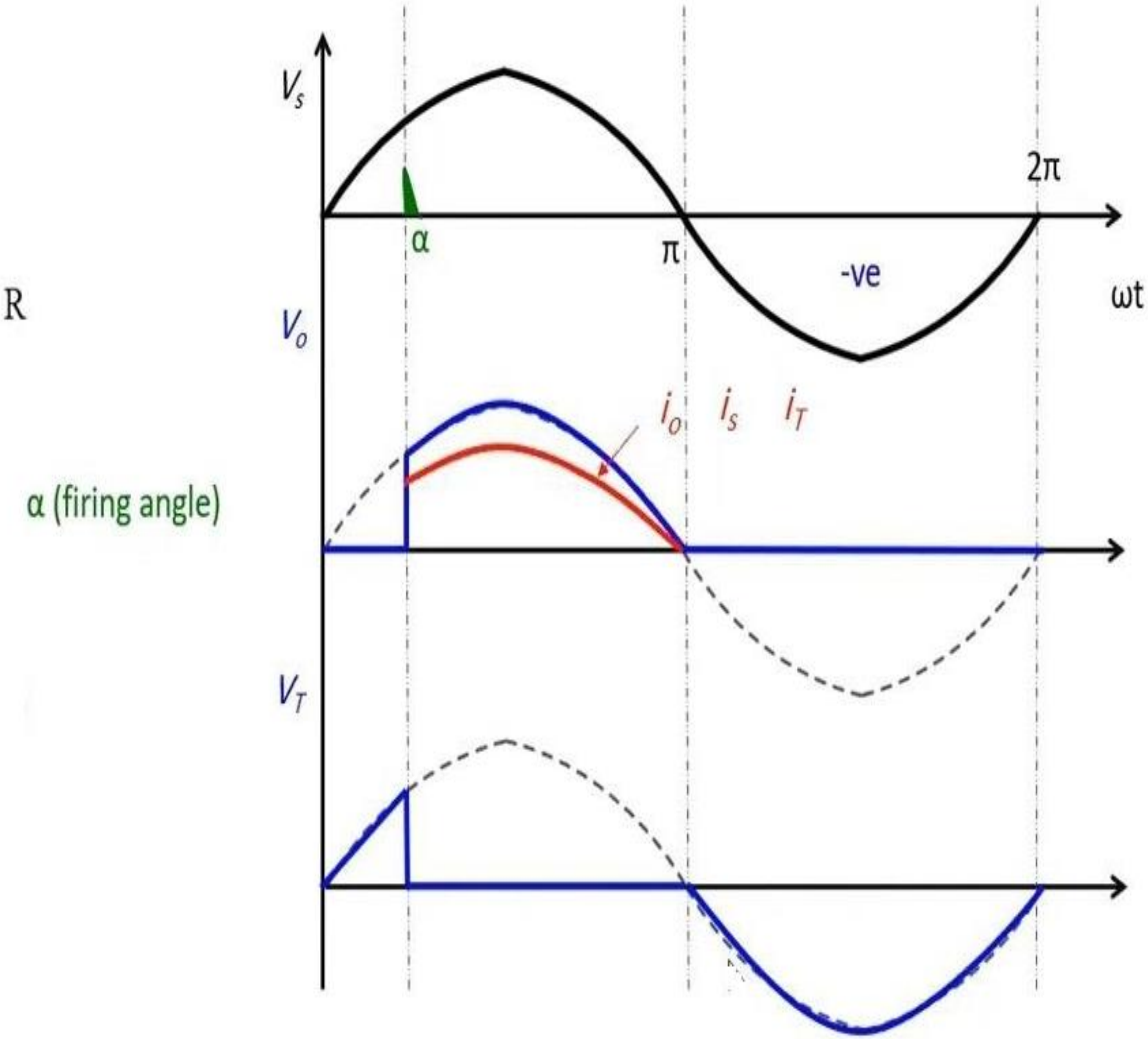
1- the controlled single - pulse Mid – point circuit M1C

2- the controlled Double - pulse Bridge Circuit B2C

Half Wave Controlled Rectifier

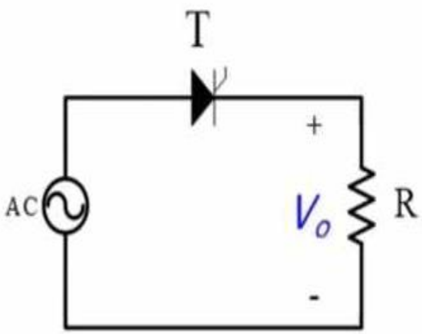
With R Load

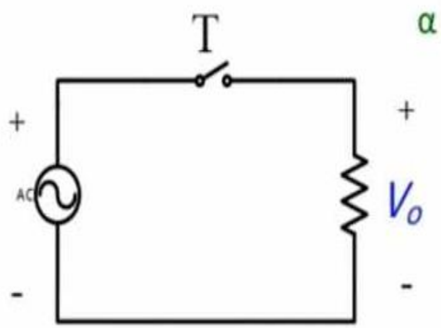




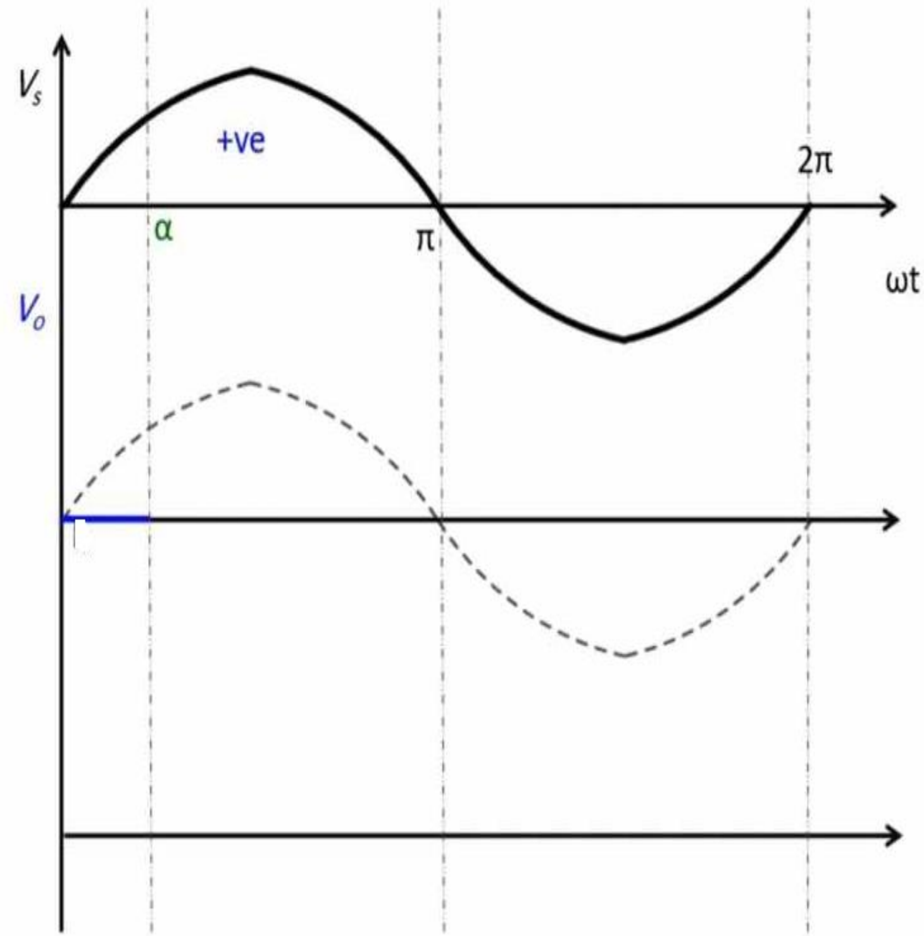
Half Wave Controlled Rectifier

With R Load





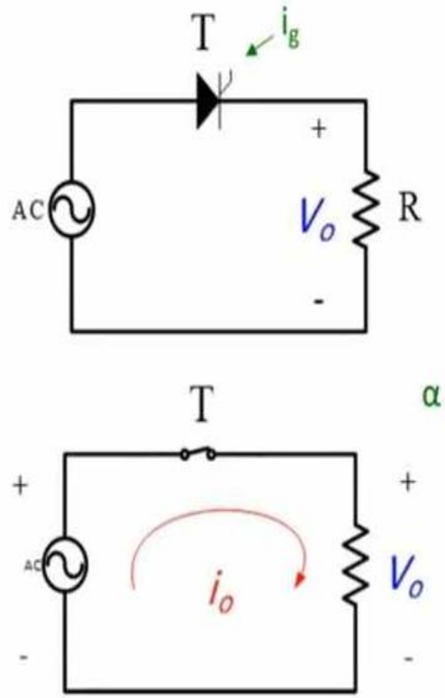
α (firing angle)



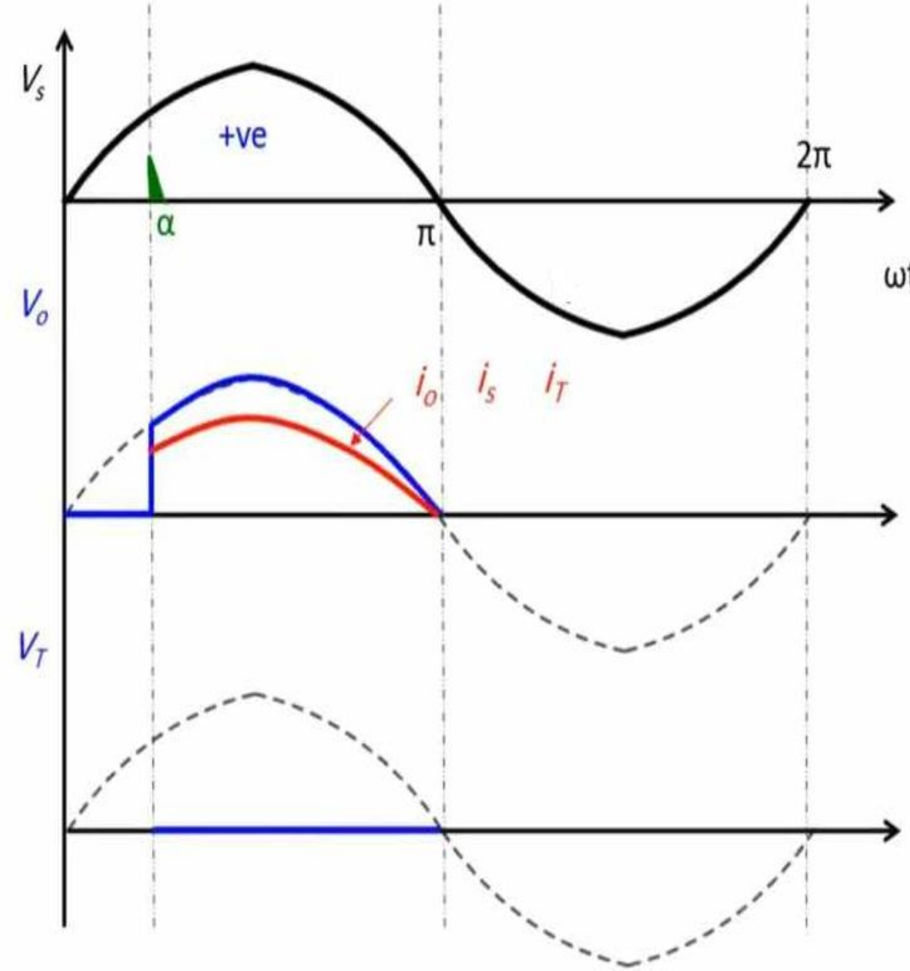
$0 \leq \omega t \leq \alpha$

Half Wave Controlled Rectifier

With R Load



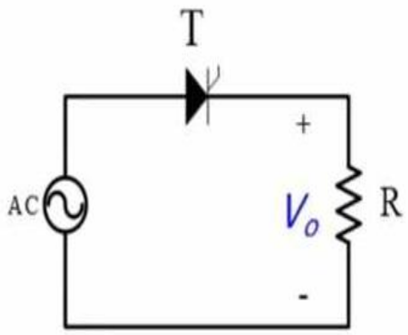
α (firing angle)

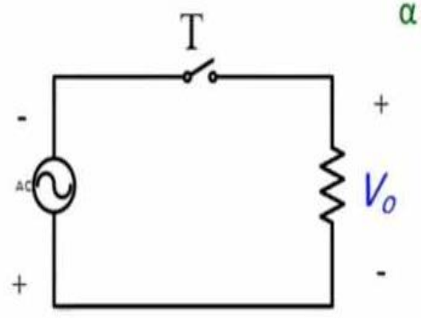


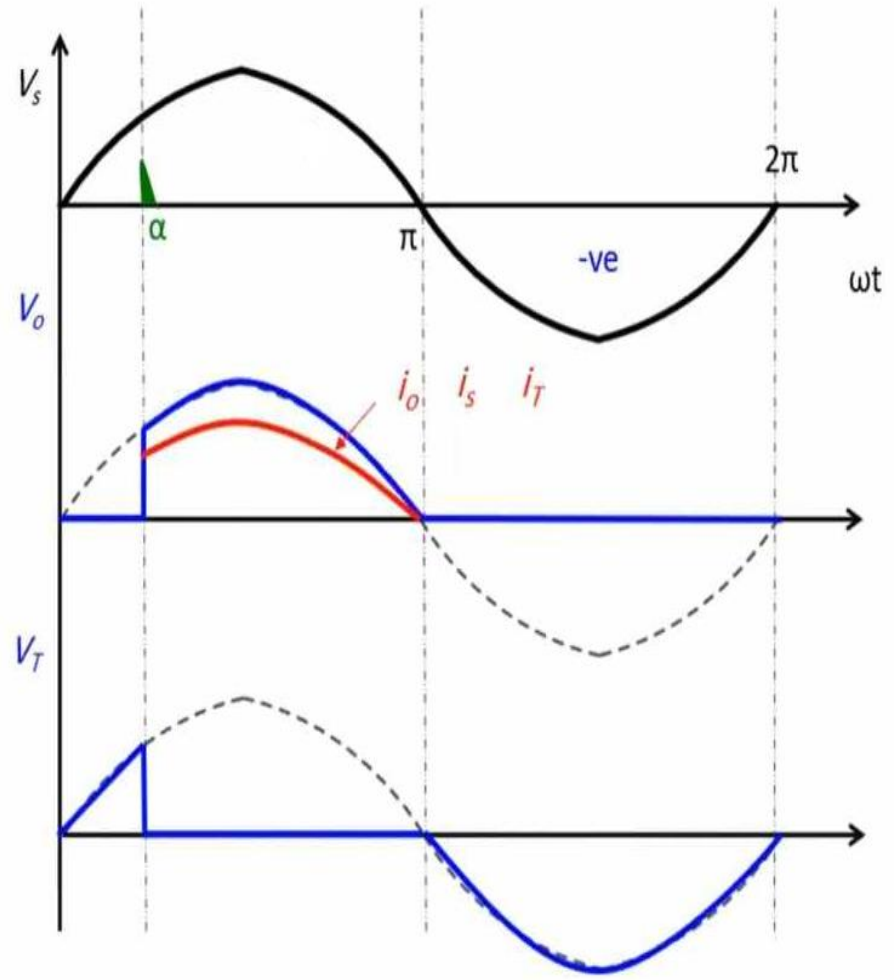
$\alpha \leq \omega t \leq \pi$

Half Wave Controlled Rectifier

With R Load







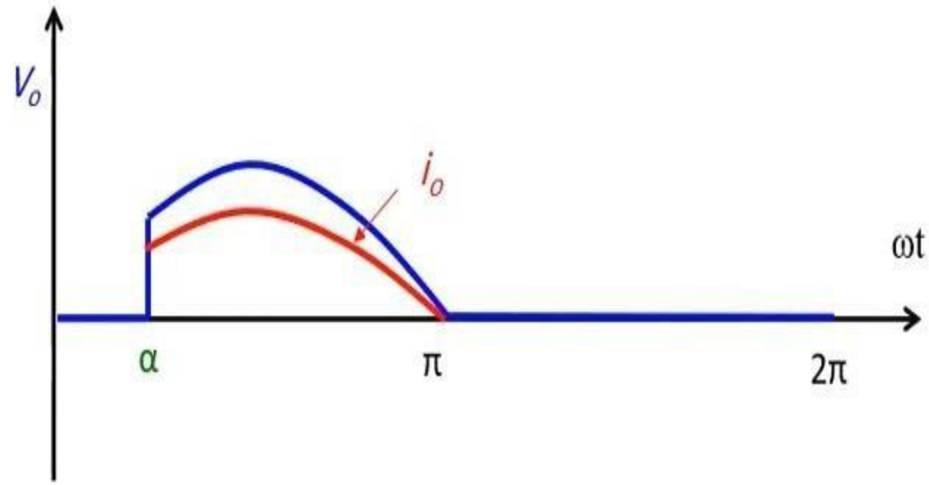
α (firing angle)

$\pi \le \omega t \le 2\pi$

Output voltage and output current

The average output voltage

$$v_{o,avg} = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \sin(\omega t)\, d\omega t = \frac{V_m}{2\pi}[\cos(\alpha)+1]$$



The average output current

$$I_{o,avg} = \frac{V_{o,avg}}{R}$$

The rms output voltage

$$v_{o,rms} = \sqrt{\frac{1}{2\pi}\int_{\alpha}^{\pi} \left(V_m \sin(\omega t)\right)^2 d\omega t}$$

$$= \frac{V_m}{2}\sqrt{1 - \frac{\alpha}{\pi} - \frac{\sin(2\alpha)}{2\pi}}$$

The rms output current/Supply current

$$I_{o,rms} = \frac{V_{o,rms}}{R} = I_{S,rms}$$

Output power and power factor

The output power

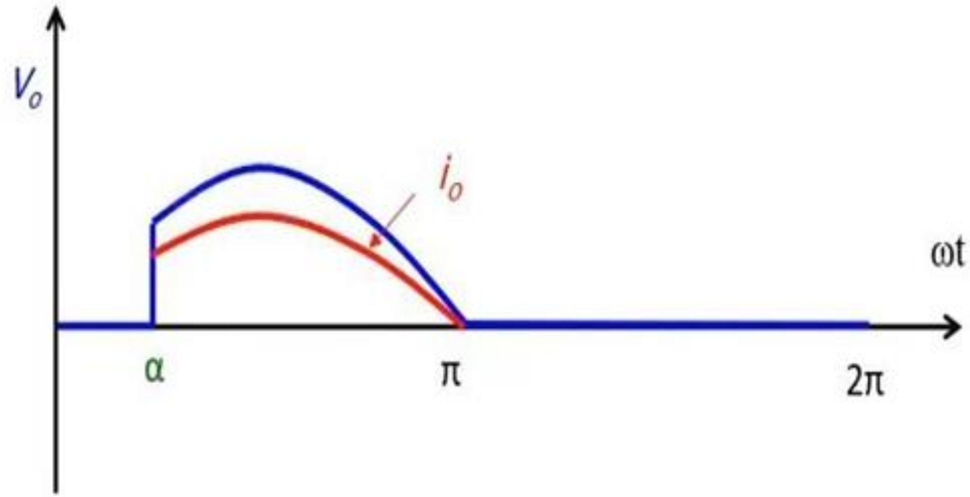
$$P_o = I_{o,rms}{}^2 R$$

The apparent power

$$S = V_{s,rms} I_{s,rms}$$

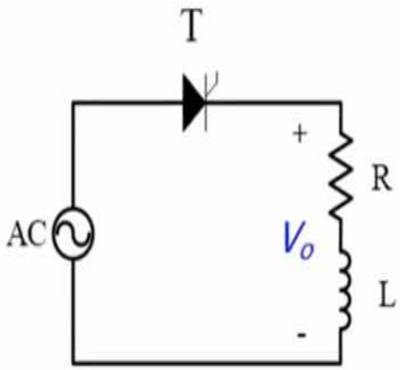
The supply power factor

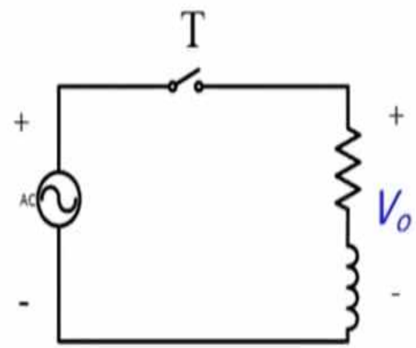
$$pf = \frac{P_o}{S}$$



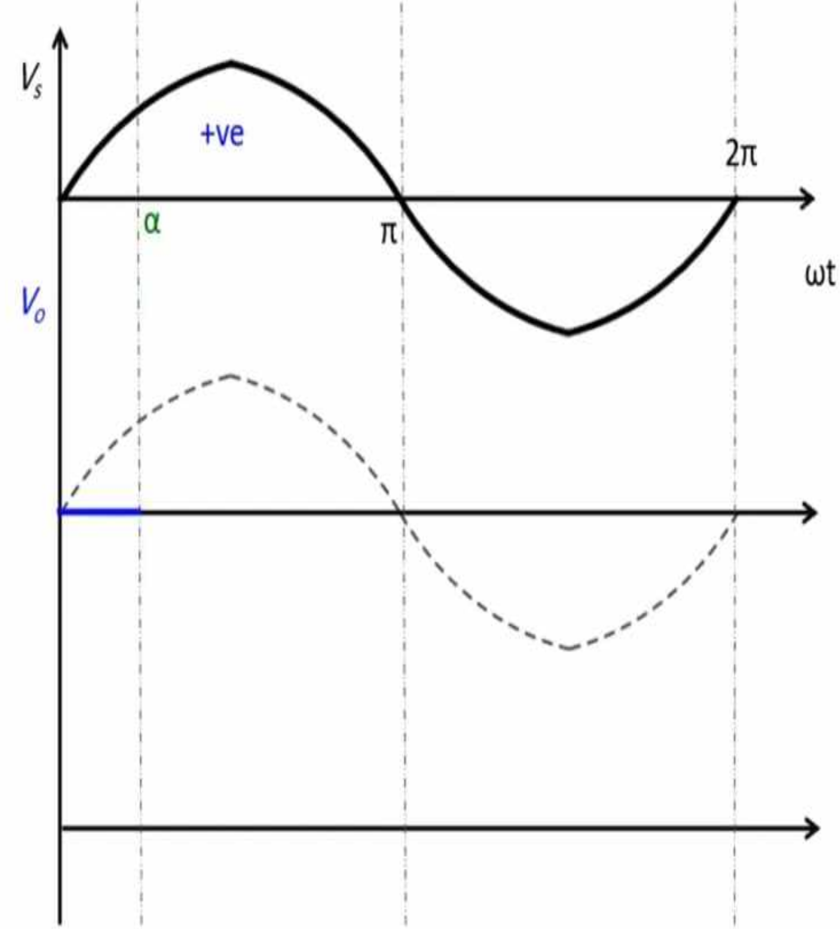
Half Wave Controlled Rectifier

With RL Load



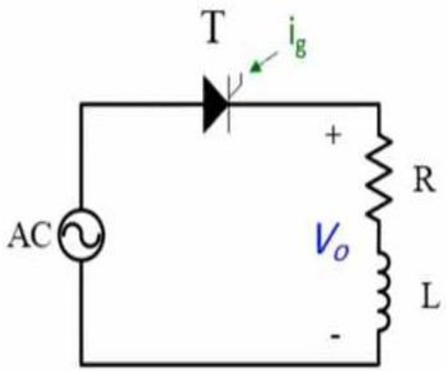


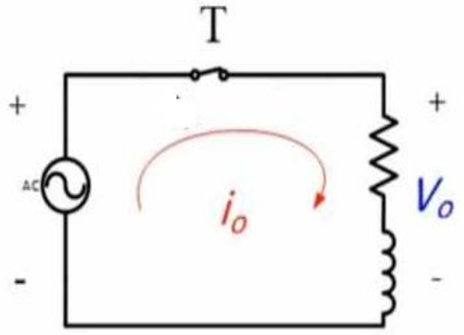
$0 \leq \omega t \leq \alpha$



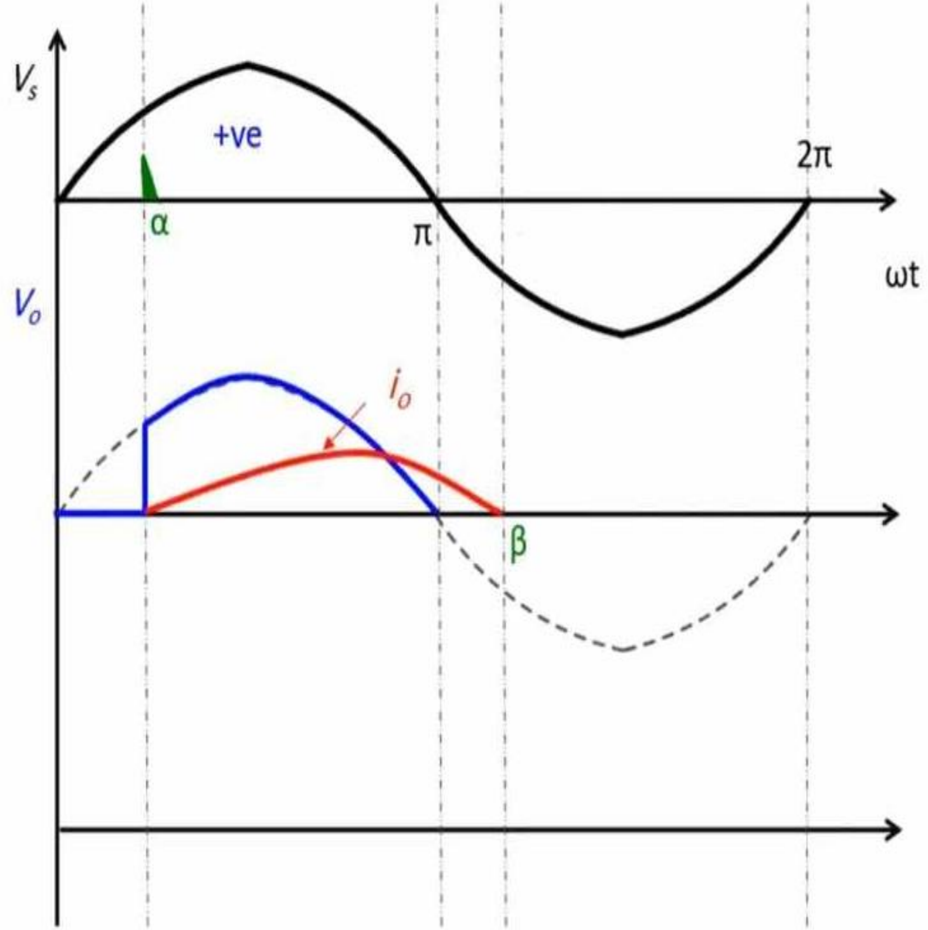
Half Wave Controlled Rectifier

With RL Load



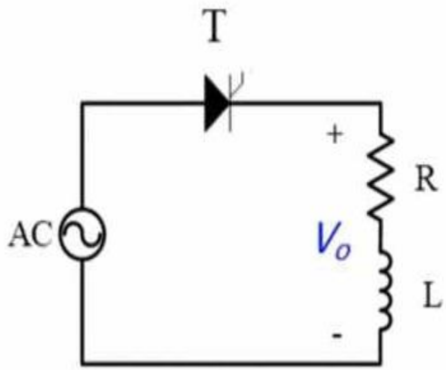


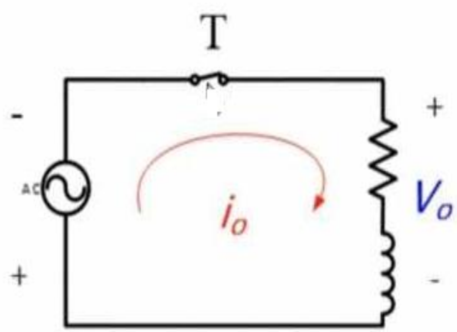
$\alpha \leq \omega t \leq \pi$



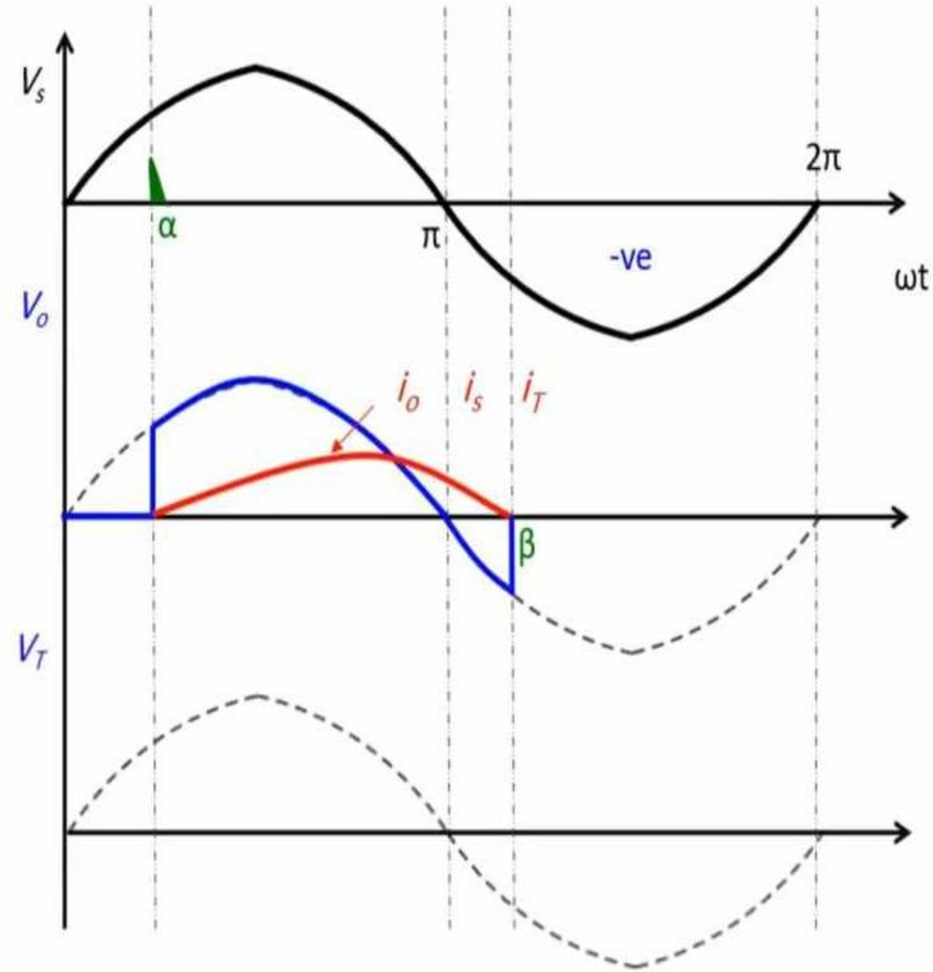
Half Wave Controlled Rectifier

With RL Load



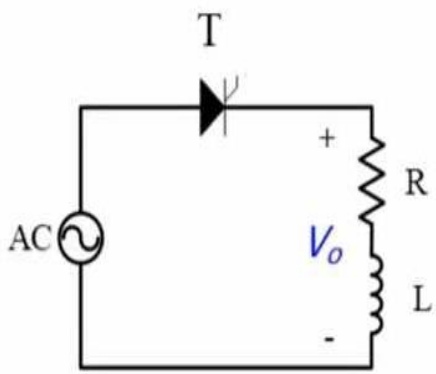


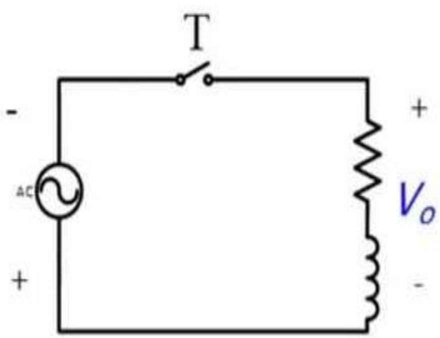
$\pi \leq \omega t \leq \beta$



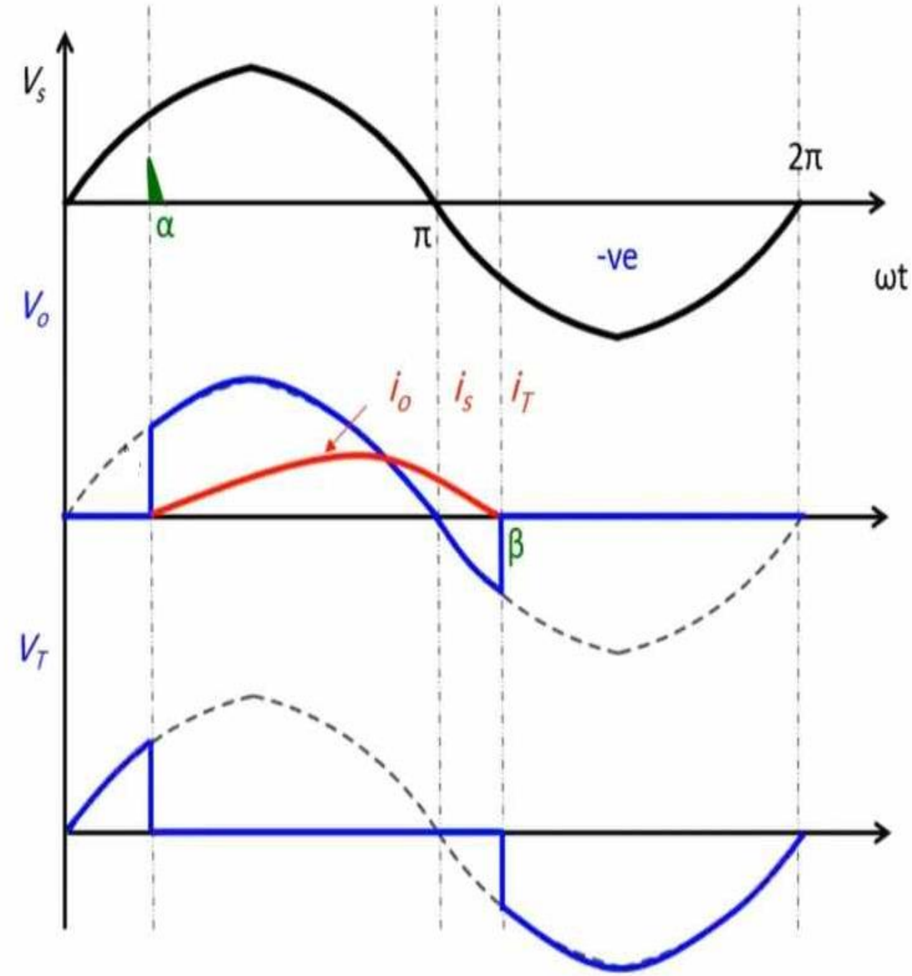
Half Wave Controlled Rectifier

With RL Load



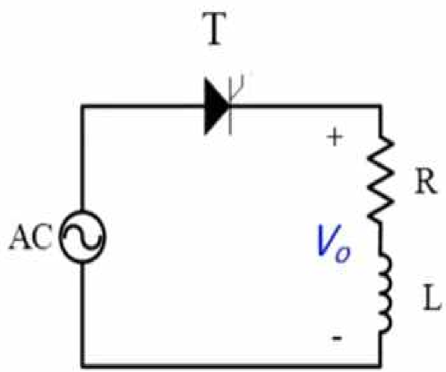


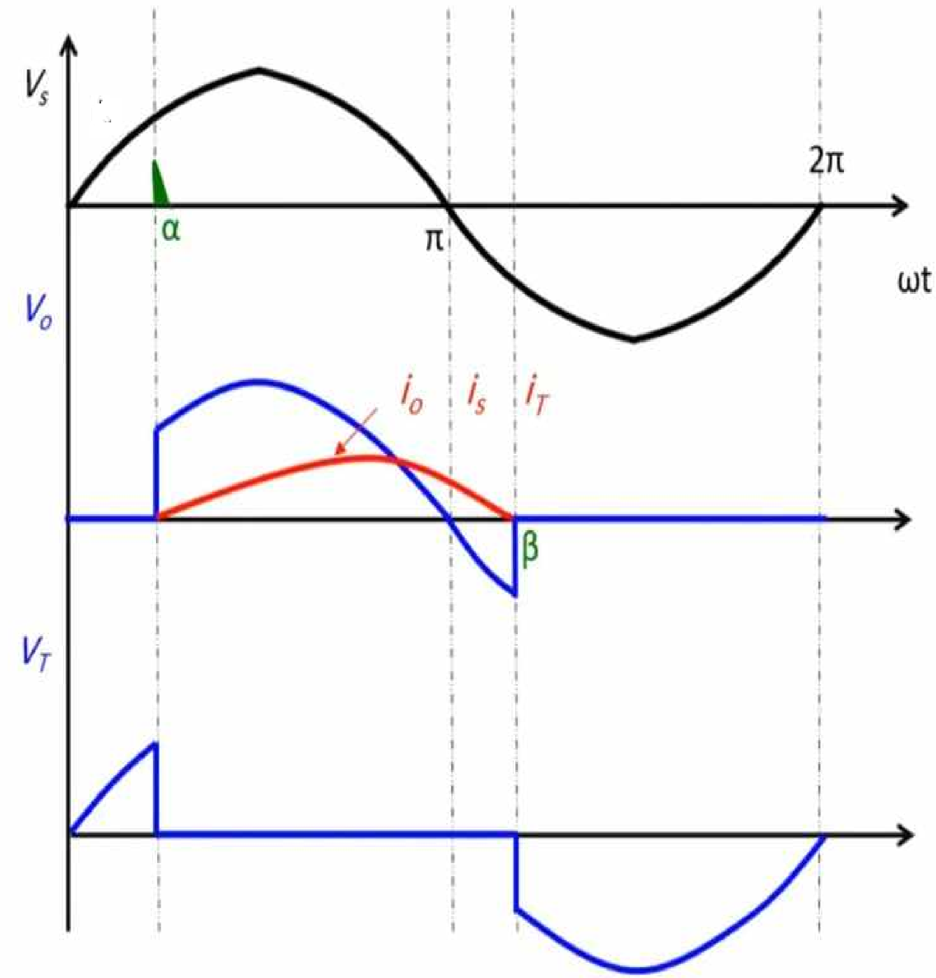
$$\beta \leq \omega t \leq 2\pi$$



Half Wave Controlled Rectifier

With RL Load

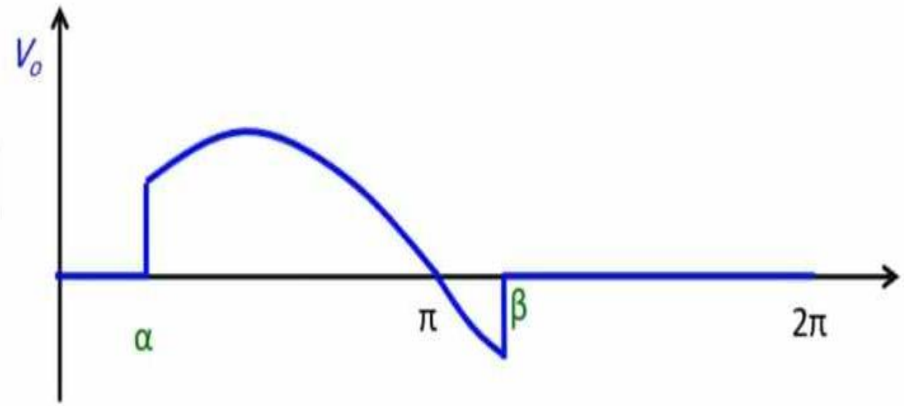




Output voltage and output current

The average output voltage

$$v_{o,avg} = \frac{1}{2\pi}\int_{\alpha}^{\beta} V_m \sin(\omega t)\, d\omega t = \frac{V_m}{2\pi}\left[\cos(\alpha) - \cos(\beta)\right]$$



The average output current

$$I_{o,avg} = \frac{V_{o,avg}}{R}$$

The rms output voltage

$$v_{o,rms} = \sqrt{\frac{1}{2\pi}\int_{\alpha}^{\beta} \left(V_m \sin(\omega t)\right)^2 d\omega t}$$

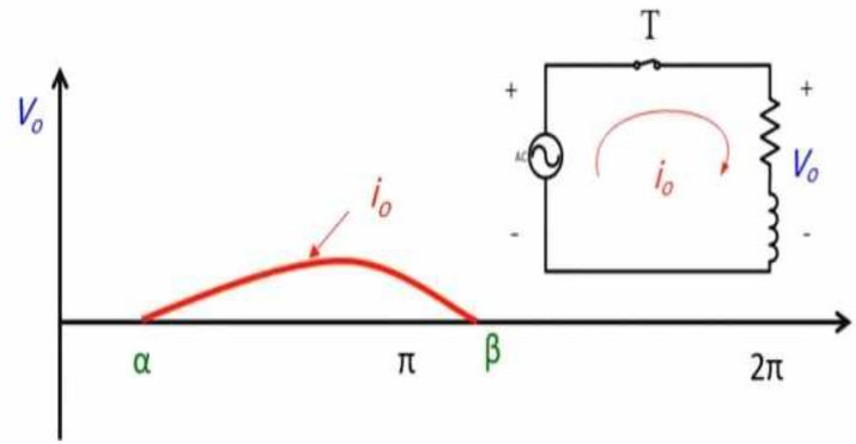
$$= \frac{V_m}{2}\sqrt{\frac{\beta-\alpha}{\pi} - \frac{\sin(2\beta) - \sin(2\alpha)}{2\pi}}$$

The rms output current/Supply current

$$I_{o,rms} = ??$$

Current Expression

$\alpha \le \omega t \le \beta$



$$V_s = i_o R + L\frac{di_o}{dt}$$

$$i_o(t) = i_{ss} + i_{tr}$$

$$i_o(t) = \frac{Vm}{Z}\sin(\omega t - \phi) + Ae^{\frac{-t}{\tau}}$$

$$i_o(t) = \frac{Vm}{Z}\sin(\omega t - \phi) + Ae^{\frac{-\omega t}{\tan(\phi)}}$$

From initial value $\quad \omega t = \alpha \quad i_o = 0$

$$A = \frac{Vm}{Z}\sin(\phi - \alpha)e^{\frac{\alpha}{\tan(\phi)}}$$

where

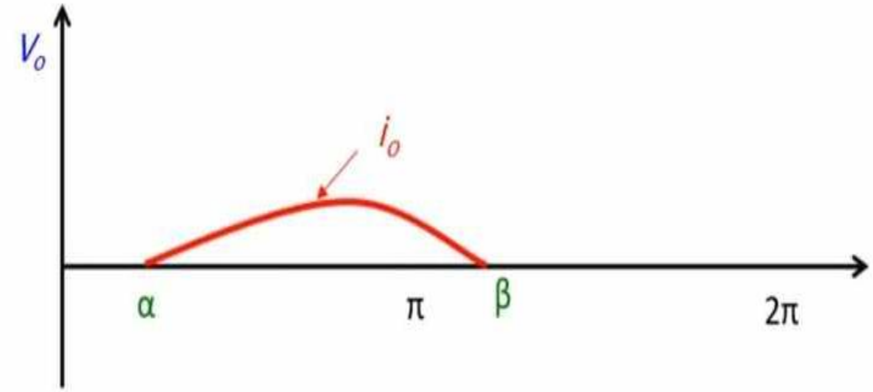
$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$\tau = \frac{L}{R}$$

Current Expression and Extinction Angle

$$i_o(t)=\frac{Vm}{Z}\left[\sin(\omega t-\phi)+\sin(\phi-\alpha)e^{\frac{\alpha-\omega t}{\tan(\phi)}}\right]$$



Extinction angle

$$\omega t=\beta \quad i_o=0$$

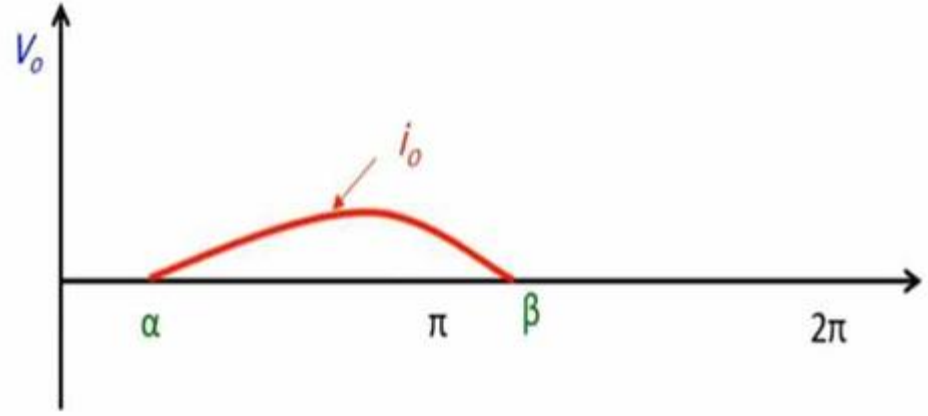
$$0=\left[\sin(\beta-\phi)+\sin(\phi-\alpha)e^{\frac{\alpha-\beta}{\tan(\phi)}}\right] \longrightarrow \text{By calculator} \longrightarrow \beta=??$$

Output power and power factor

The rms output current/Supply current

$$I_{o,rms} = \sqrt{\frac{1}{2\pi}\int_{\alpha}^{\beta}\left(\frac{Vm}{Z}\left[\sin(\omega t-\phi)+\sin(\phi-\alpha)e^{\frac{\alpha-\omega t}{\tan(\phi)}}\right]\right)^2 d\omega t}$$

By calculator



The output power

$$P_o = I_{o,rms}{}^2 R$$

The apparent power

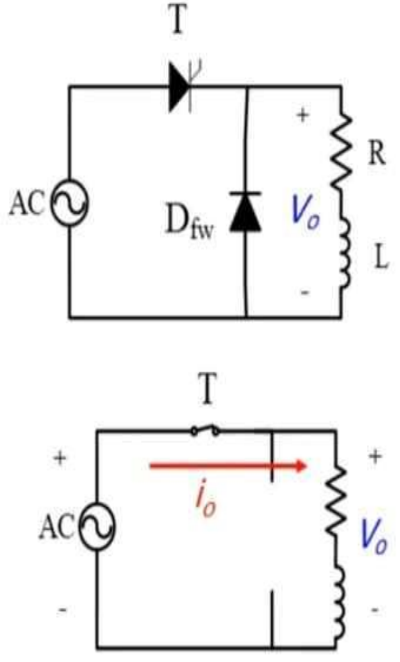
$$S = V_{s,rms} I_{s,rms}$$

The supply power factor

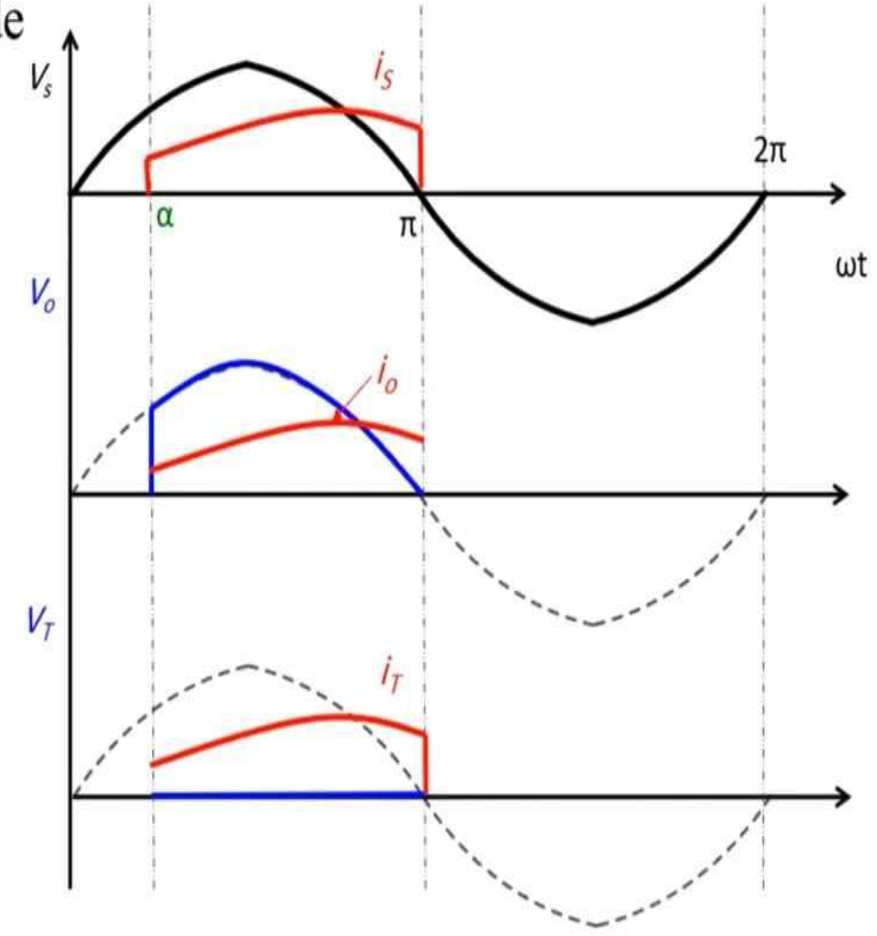
$$pf = \frac{P_o}{S}$$

Half Wave Controlled Rectifier

RL Load with freewheeling diode

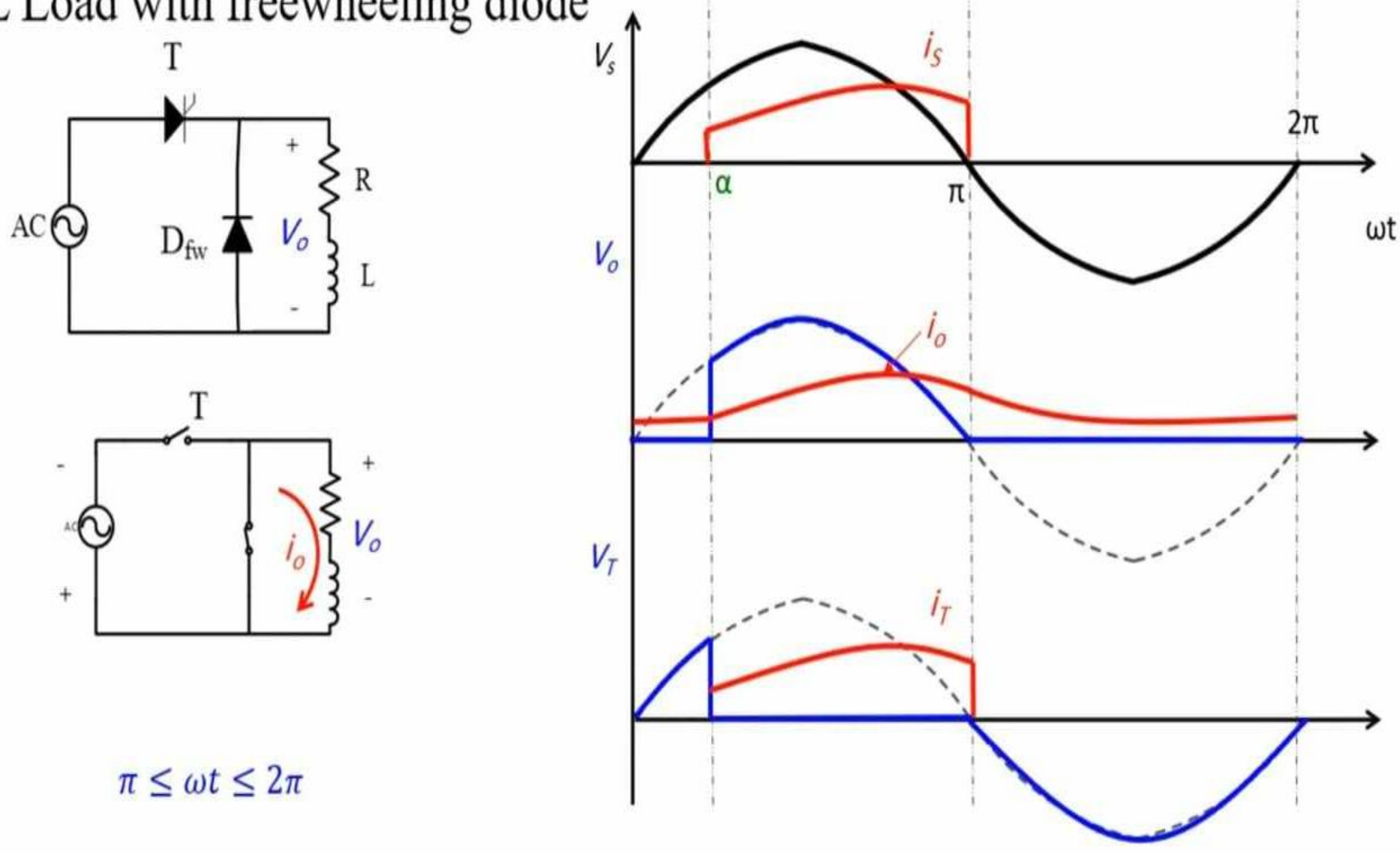


$\alpha \leq \omega t \leq \pi$



Half Wave Controlled Rectifier

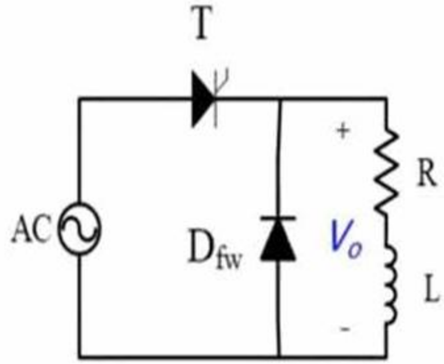
RL Load with freewheeling diode

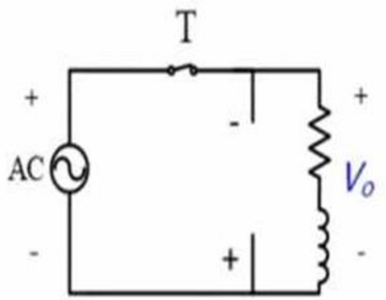


$\pi \le \omega t \le 2\pi$

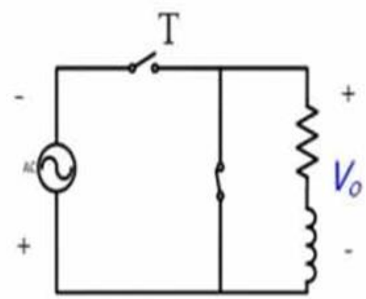
Half Wave Controlled Rectifier

RL Load with freewheeling diode





$\alpha \leq \omega t \leq \pi$



$\pi \leq \omega t \leq 2\pi$

$0 \leq \omega t \leq \alpha$