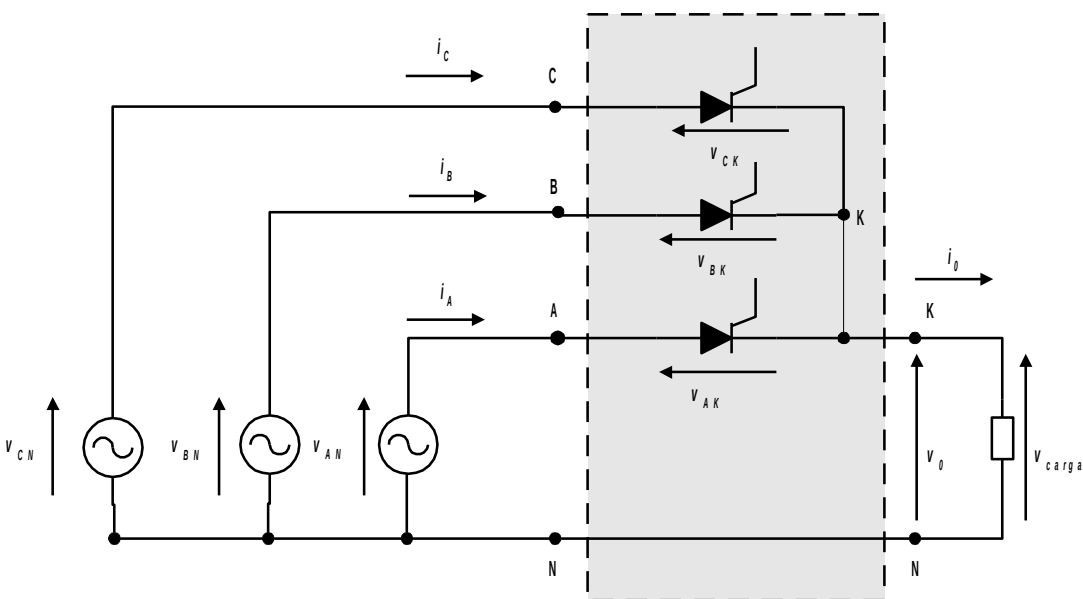


RETIFICADORES POLIFÁSICOS – PARTE II

Prof. Azauri A. de Oliveira Jr

RETIFICADOR TRIFÁSICO DE UM CAMINHO (MEIA-ONDA)



$$v_{AN} = v_{i1} = \sqrt{2}.V \text{ sen}(\omega.t)$$

$$v_{BN} = v_{i2} = \sqrt{2}.V \text{ sen}(\omega.t - 120^\circ)$$

$$v_{CN} = v_{i3} = \sqrt{2}.V \text{ sen}(\omega.t + 120^\circ)$$

$$v_{i1} = v_{AK} + v_0$$

$$v_{i2} = v_{BK} + v_0$$

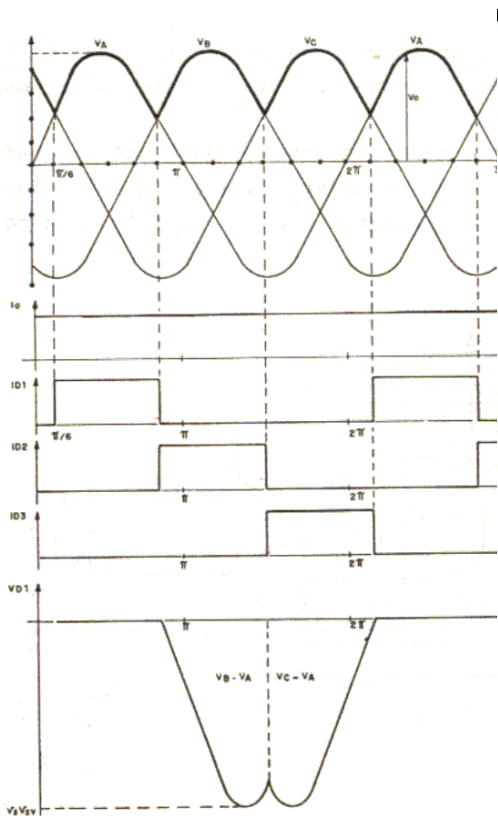
$$v_{i3} = v_{CK} + v_0$$

$$v_0 = v_{carga}$$

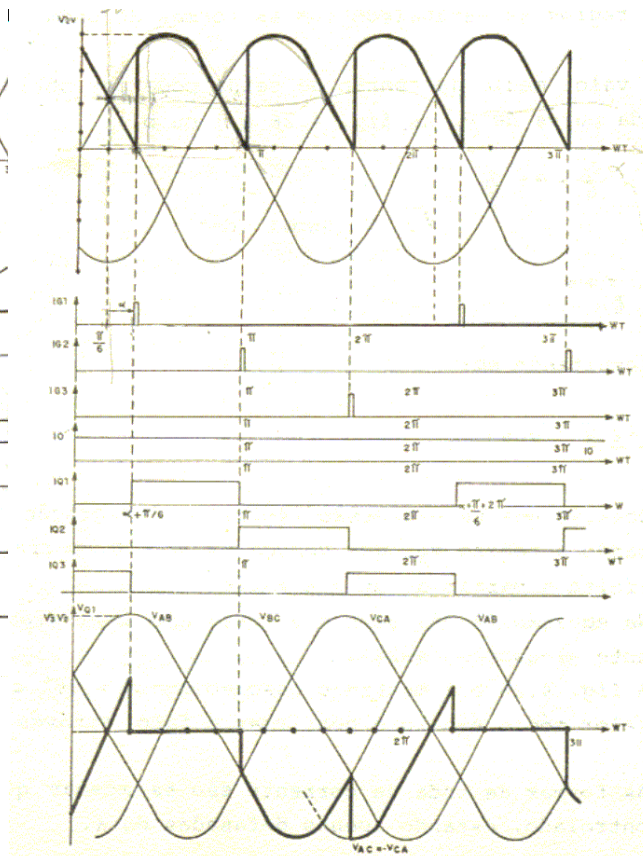
$$i_0 = i_A + i_B + i_C$$

RETIFICADOR TRIFÁSICO DE UM CAMINHO

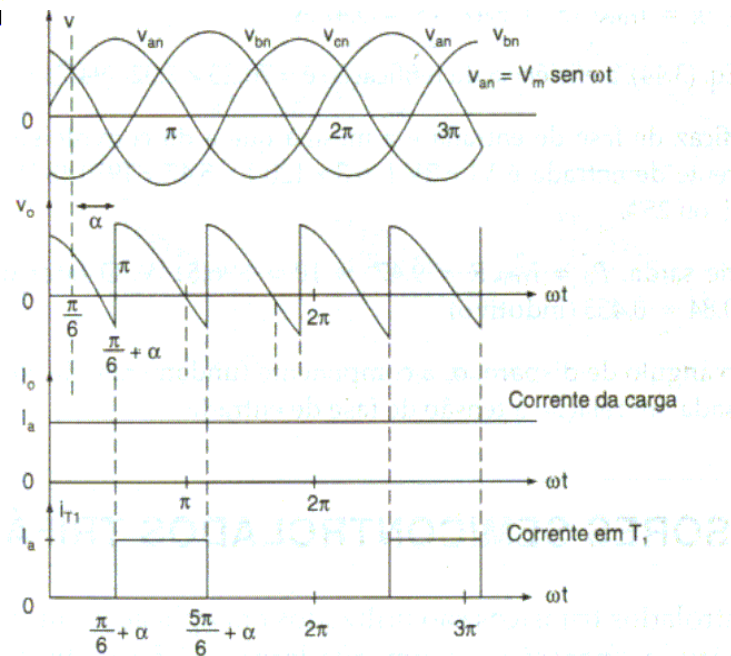
formas de onda – condução contínua



$\alpha = 0^\circ$

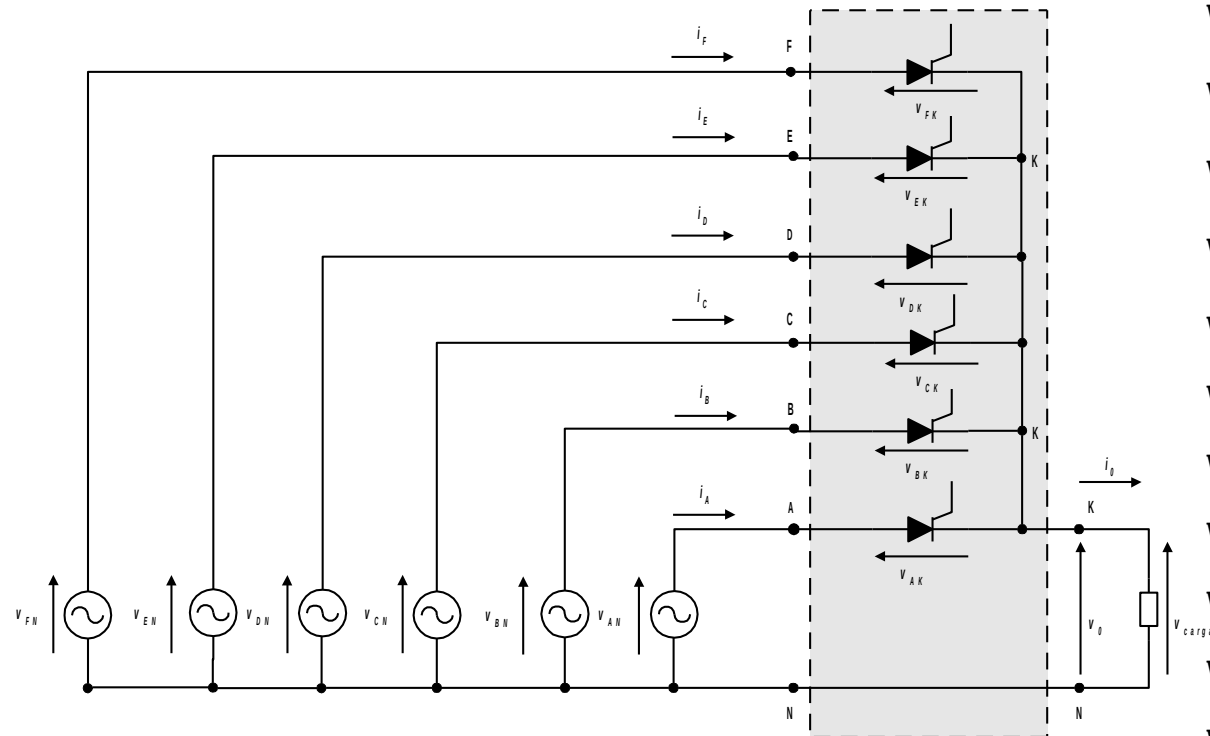


$\alpha = 30^\circ$



$\alpha = 60^\circ$

RETIFICADOR HEXAFÁSICO DE UM CAMINHO (MEIA-ONDA)



$$v_{AN} = v_{i1} = \sqrt{2} \cdot V \sin(\omega \cdot t)$$

$$v_{BN} = v_{i2} = \sqrt{2} \cdot V \sin(\omega \cdot t - 60^\circ)$$

$$v_{CN} = v_{i2} = \sqrt{2} \cdot V \sin(\omega \cdot t - 120^\circ)$$

$$v_{DN} = v_{i2} = \sqrt{2} \cdot V \sin(\omega \cdot t - 180^\circ)$$

$$v_{EN} = v_{i2} = \sqrt{2} \cdot V \sin(\omega \cdot t - 240^\circ)$$

$$v_{FN} = v_{i2} = \sqrt{2} \cdot V \sin(\omega \cdot t - 300^\circ)$$

$$v_{i1} = v_{AK} + v_0$$

$$v_{i2} = v_{BK} + v_0$$

$$v_{i3} = v_{CK} + v_0$$

$$v_{i4} = v_{DK} + v_0$$

$$v_{i5} = v_{EK} + v_0$$

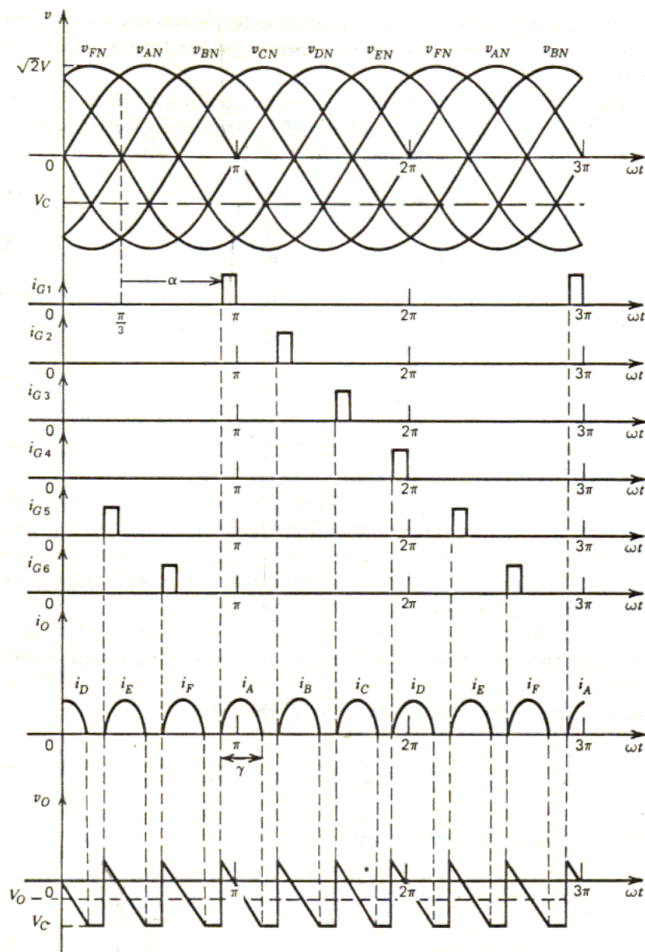
$$v_{i6} = v_{FK} + v_0$$

$$v_0 = v_{\text{carga}}$$

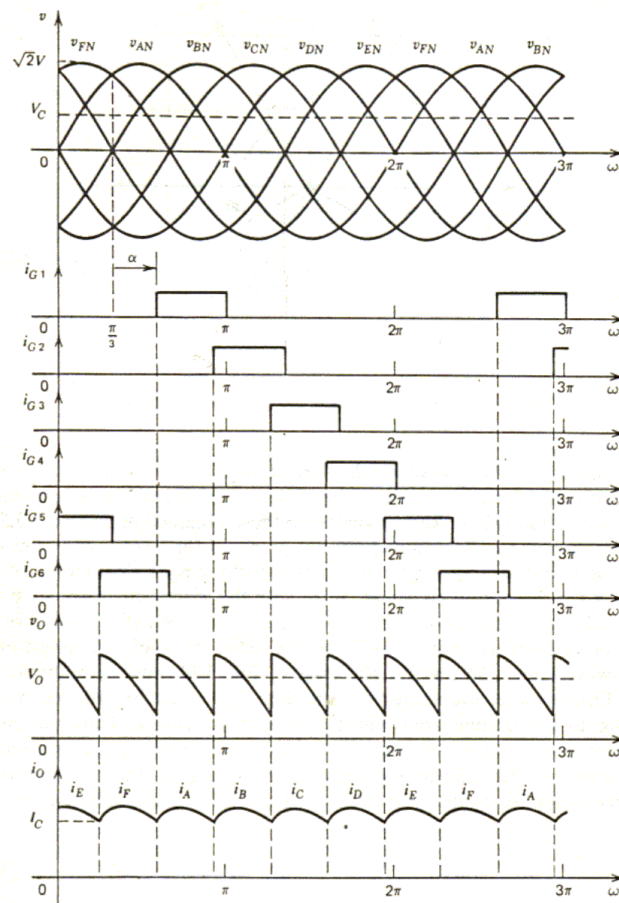
$$i_0 = i_A + i_B + i_C + i_D + i_E + i_F$$

RETIFICADOR HEXAFÁSICO DE UM CAMINHO

formas de onda - carga RL-fem



Condução descontínua
 $\gamma < 60^\circ$



Condução contínua

RETIFICADOR TRIFÁSICO DE UM CAMINHO série de Fourier da tensão na carga condução contínua

$$v_0 = V_{DC} + \sum_{n=1}^{\infty} V_{pn} \text{sen}(n\omega.t + \theta_{vn})$$

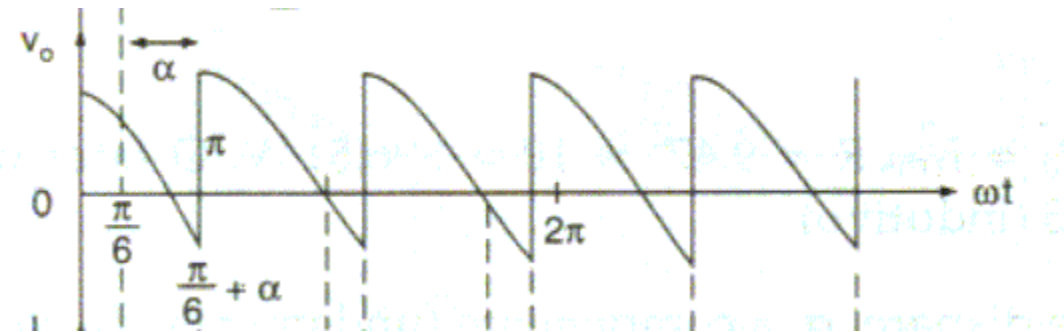
$$V_{pn} = \sqrt{a_n^2 + b_n^2}$$

$$a_n = \frac{3}{\pi} \int_{\alpha+\pi/6}^{\alpha+5\pi/6} v_0 \cdot \text{sen}(n\omega.t) \cdot d(\omega t)$$

$$b_n = \frac{3}{\pi} \int_{\alpha+\pi/6}^{\alpha+5\pi/6} v_0 \cdot \text{cos}(n\omega.t) \cdot d(\omega t)$$

$$V_0 = V_{DC} = \frac{3}{2\pi} \int_{\alpha+\pi/6}^{\alpha+5\pi/6} \sqrt{2} \cdot V \cdot \text{sen}(\omega.t) \cdot d\omega t$$

$$V_0 = \frac{3 \cdot \sqrt{3}}{2\pi} \cdot \sqrt{2} \cdot V \cos \alpha = 1,17 \cdot V \cos \alpha$$

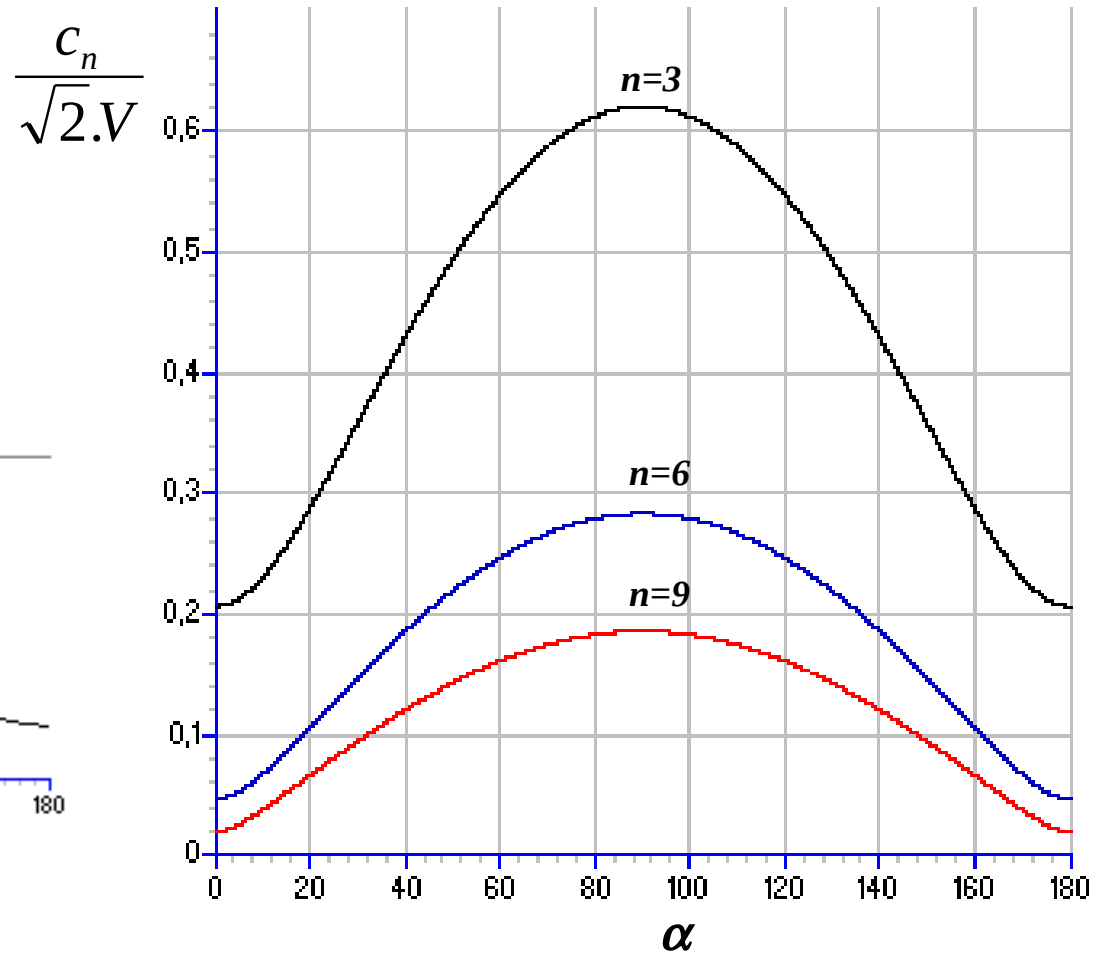
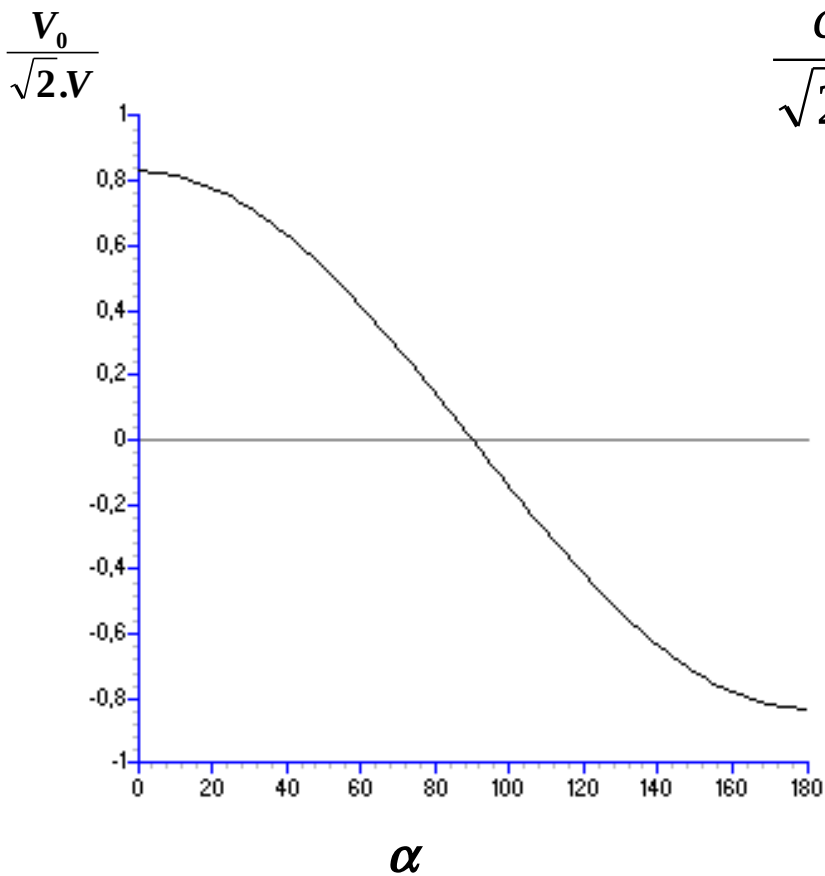


**Coefficientes de Fourier
válidos para n ímpar
múltiplo de 3**

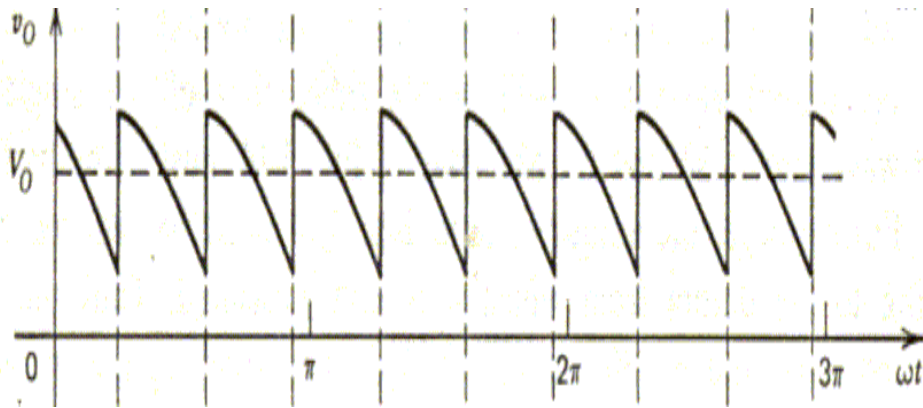
RETIFICADOR TRIFÁSICO DE UM CAMINHO

série de Fourier da tensão na carga

condução contínua



RETIFICADOR HEXAFÁSICO DE UM CAMINHO série de Fourier da tensão na carga condução contínua



**Coeficientes de Fourier
válidos para n múltiplos de 6**

$$v_0 = V_{DC} + \sum_{n=1}^{\infty} V_{pn} \text{sen}(n\omega.t + \theta_{vn})$$

$$V_{pn} = \sqrt{a_n^2 + b_n^2}$$

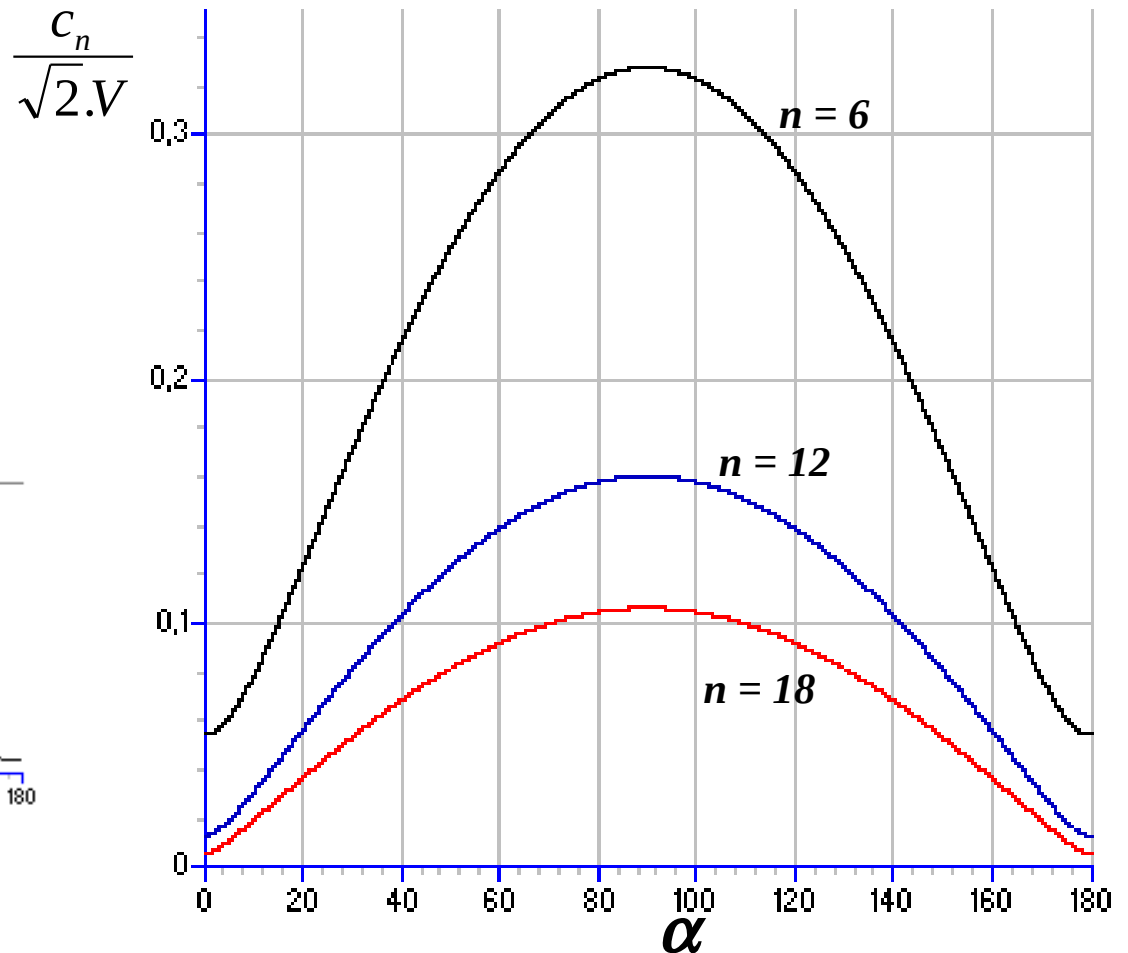
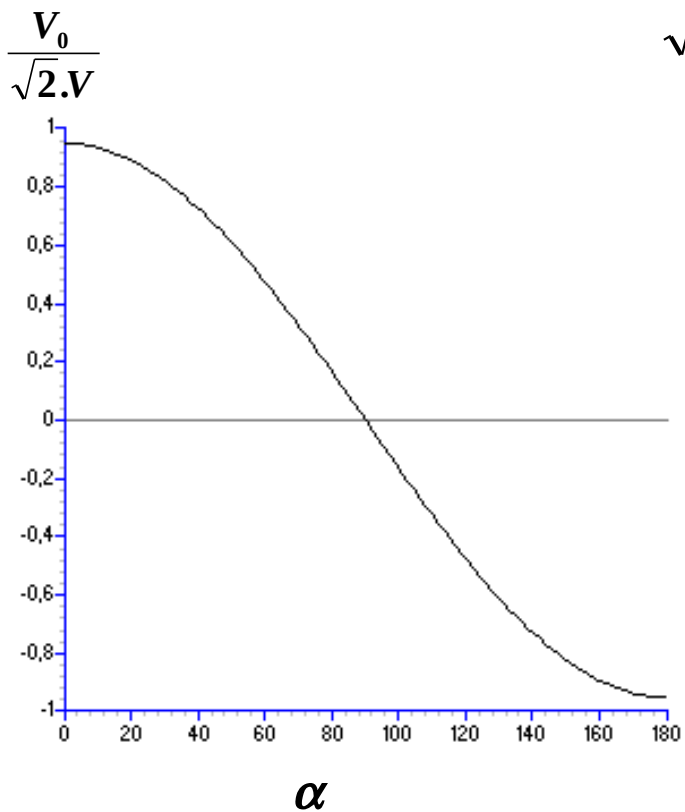
$$a_n = \frac{6}{\pi} \int_{\alpha+\pi/3}^{\alpha+2\pi/3} v_0 \cdot \text{sen}(n\omega.t) \cdot d(\omega t)$$

$$b_n = \frac{6}{\pi} \int_{\alpha+\pi/3}^{\alpha+2\pi/3} v_0 \cdot \text{cos}(n\omega.t) \cdot d(\omega t)$$

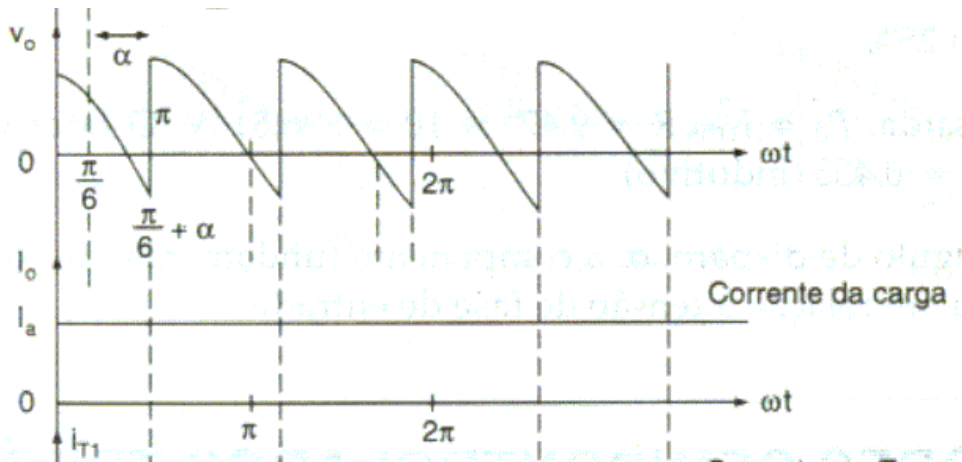
$$V_0 = V_{DC} = \frac{3}{\pi} \int_{\alpha+\pi/3}^{\alpha+2\pi/3} \sqrt{2} \cdot V \cdot \text{sen}(\omega.t) \cdot d\omega t$$

$$V_0 = \frac{3 \cdot \sqrt{2}}{\pi} \cdot V \cos \alpha = 1,35 \cdot V \cos \alpha$$

RETIFICADOR HEXAFÁSICO DE UM CAMINHO série de Fourier da tensão na carga condução contínua



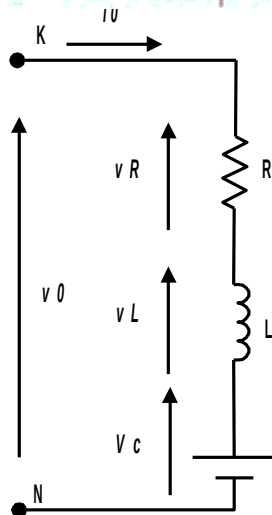
RETIFICADOR TRIFÁSICO DE UM CAMINHO série de Fourier da corrente na carga condução contínua – carga RL-fem



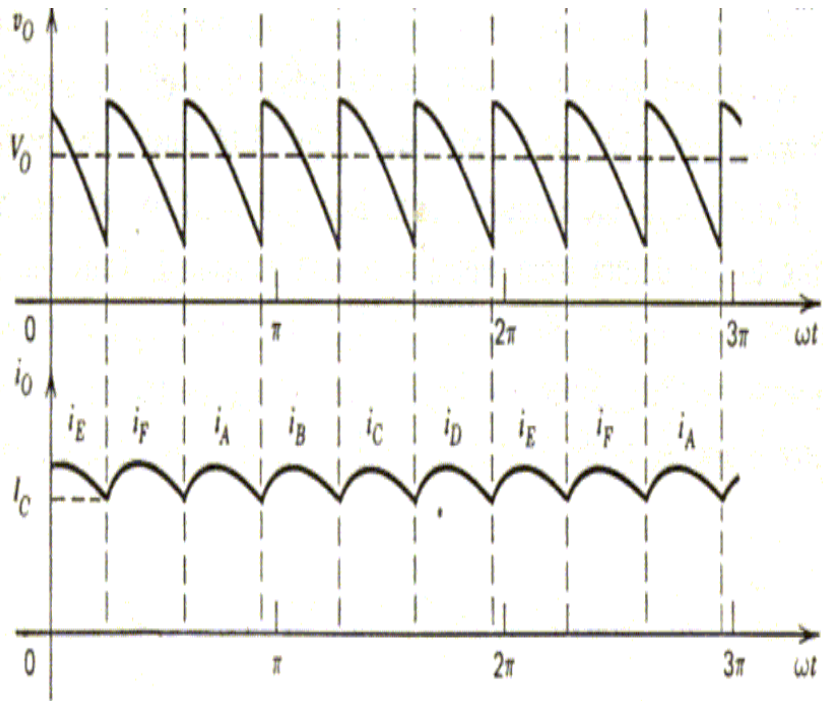
$$i_0 = I_{DC} + \sum_{n=1}^{\infty} I_{pn} \text{sen}(n\omega.t + \theta_{in})$$

$$I_{DC} = I_0 = \frac{V_0 - V_C}{R}$$

$$I_{pn} = \frac{V_{pn}}{Z_n} = \frac{V_{pn}}{\sqrt{R^2 + (n.\omega.L)^2}}$$



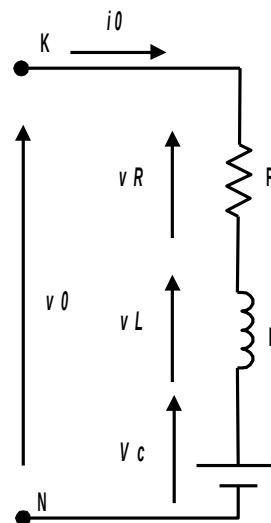
RETIFICADOR HEXAFÁSICO DE UM CAMINHO série de Fourier da corrente na carga condução contínua – carga RL-fem



$$i_0 = I_{DC} + \sum_{n=1}^{\infty} I_{pn} \text{sen}(n\omega.t + \theta_{in})$$

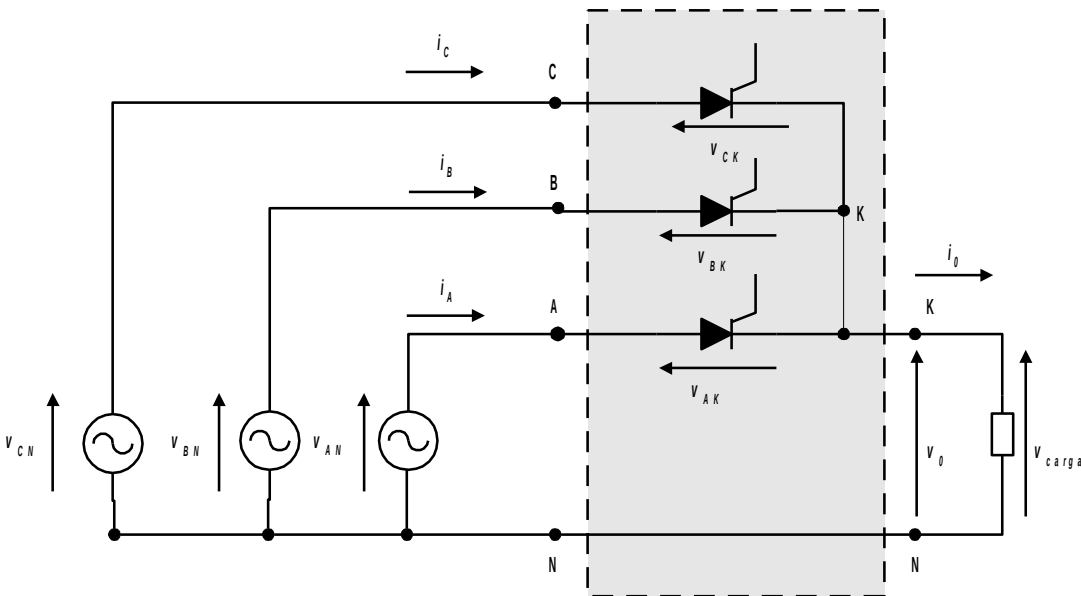
$$I_{DC} = I_0 = \frac{V_0 - V_C}{R}$$

$$I_{pn} = \frac{V_{pn}}{Z_n} = \frac{V_{pn}}{\sqrt{R^2 + (n.\omega.L)^2}}$$



RETIFICADOR TRIFÁSICO DE UM CAMINHO

relação entre as correntes nos tiristores e nas fases com a corrente de carga



Valores Médios

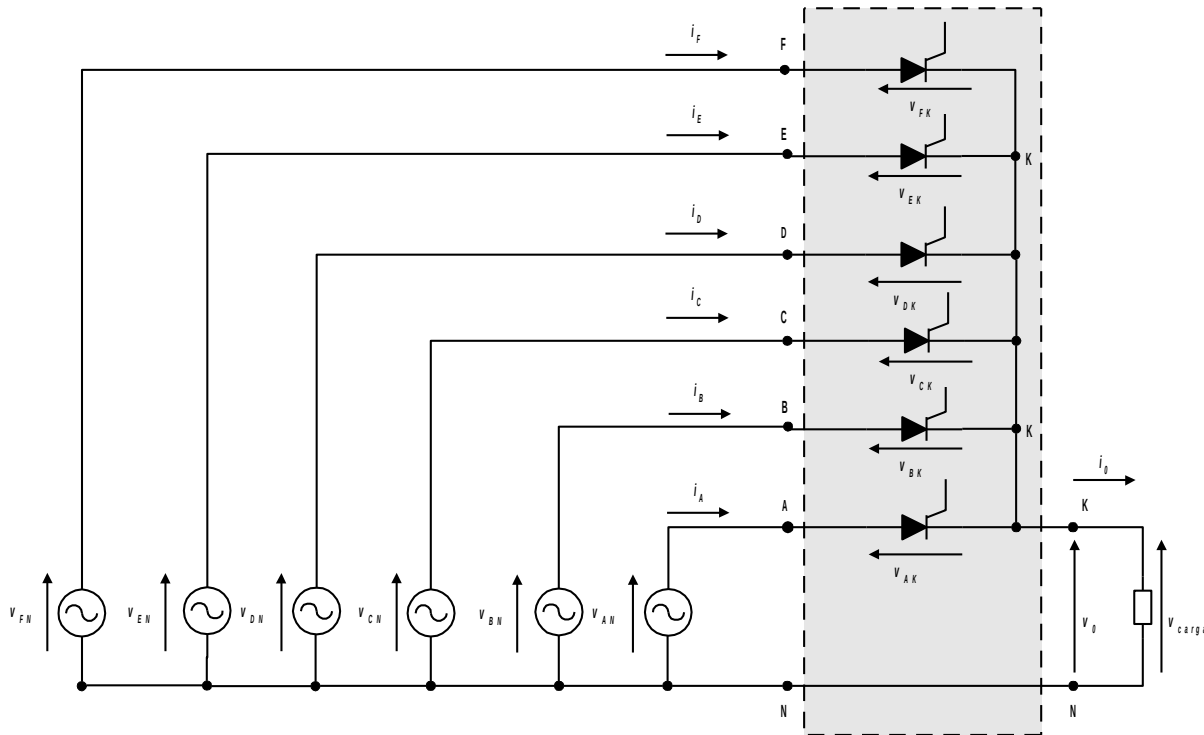
$$I_{A0} = I_{B0} = I_{C0} = I_{Q0} = \frac{I_0}{3}$$

Valores RMS

$$I_{AR} = I_{BR} = I_{CR} = I_{QR} = \frac{I_R}{\sqrt{3}}$$

RETIFICADOR TRIFÁSICO DE UM CAMINHO

relação entre as correntes nos tiristores e nas fases com a corrente de carga



Valores Médios

$$I_{A0} = I_{B0} = I_{C0} =$$

$$I_{D0} = I_{E0} = I_{F0} = I_{Q0} = \frac{I_o}{6}$$

Valores RMS

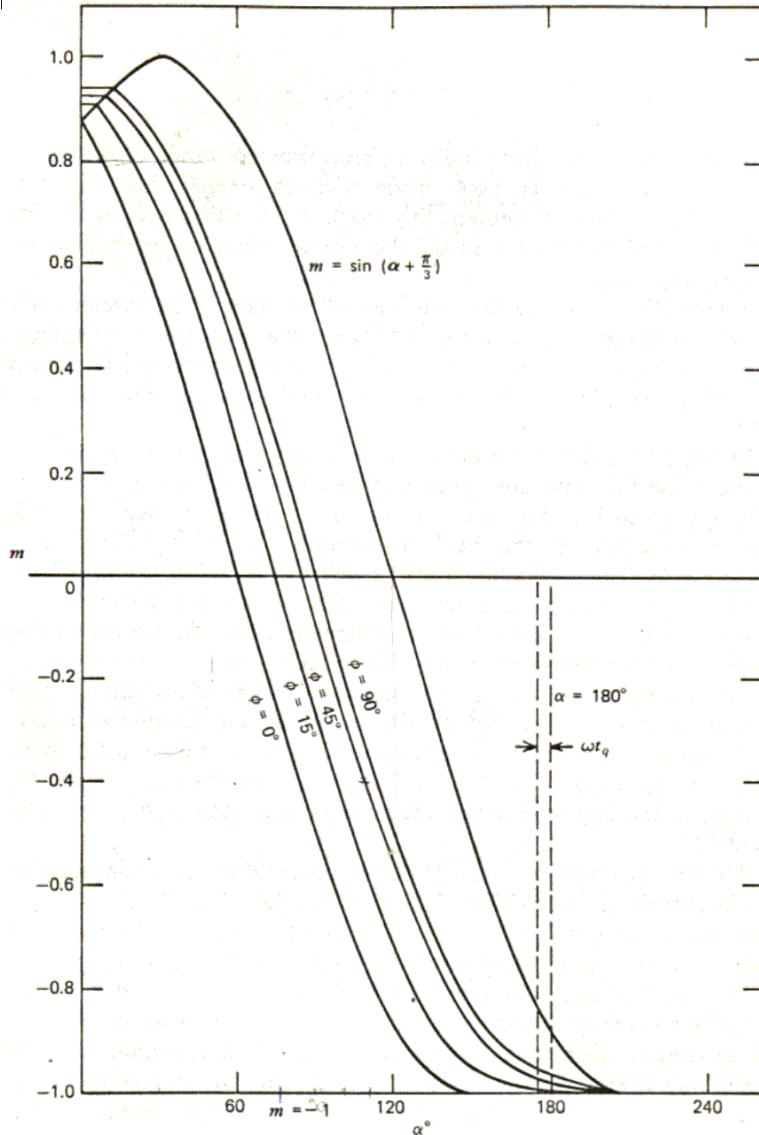
$$I_{AR} = I_{BR} = I_{CR} =$$

$$I_{DR} = I_{ER} = I_{FR} = I_{QR} = \frac{I_R}{\sqrt{6}}$$

RETIFICADOR HEXAFÁSICO DE UM CAMINHO

transição entre condução contínua e descontínua

carga RL-fem

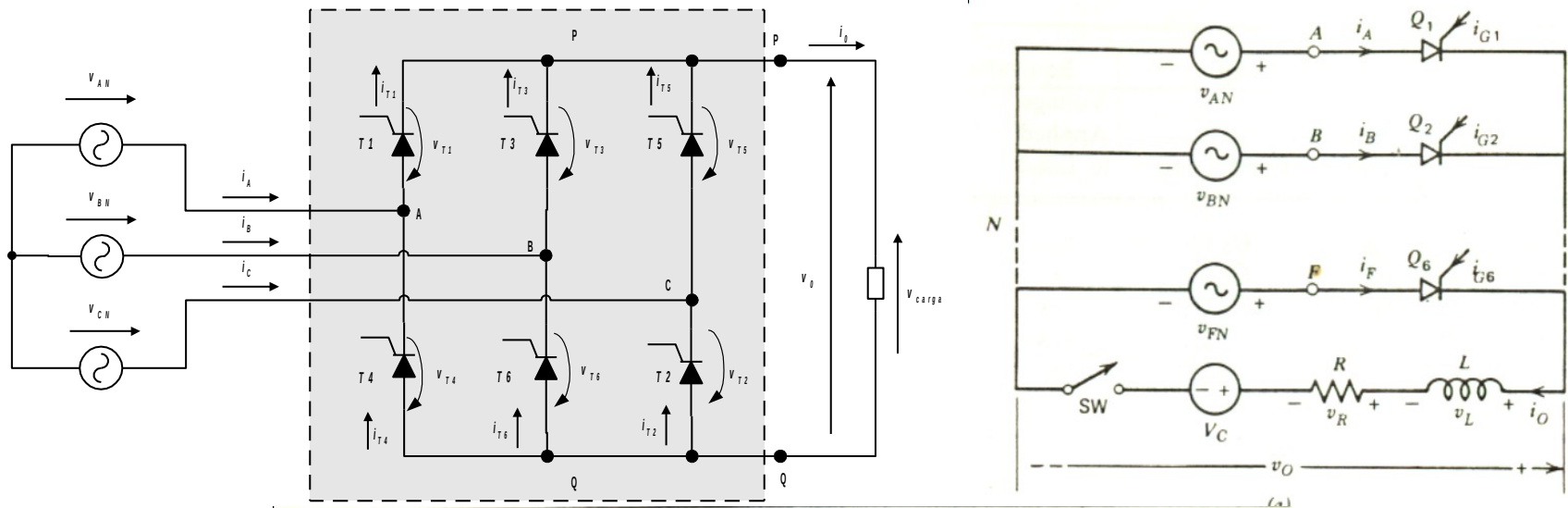


$$\frac{(m / \cos \phi) - \text{sen}(\alpha + \gamma - \phi)}{(m / \cos \phi) - \text{sen}(\alpha - \phi)} = e^{-\gamma / \tan \phi}$$

$$\gamma = 60^\circ$$

RETIFICADOR TRIFÁSICO DE DOIS CAMINHOS TOTALMENTE CONTROLADO (RETIFICADOR EM PONTE)

equivalência com o retificador hexafásico de um caminho do ponto de vista da carga



Interval	Actual Circuit		Equivalent Circuit	
	Voltage Applied to Load	Thyristors Conducting	Voltage Applied to Load	Thyristor Conducting
$\pi/3 < \omega t < 2\pi/3$	v_{ab}	Q_6, Q_1	v_{AN}	Q_1
$2\pi/3 < \omega t < \pi$	v_{ac}	Q_1, Q_2	v_{BN}	Q_2
$\pi < \omega t < 4\pi/3$	v_{bc}	Q_2, Q_3	v_{CN}	Q_3
$4\pi/3 < \omega t < 5\pi/3$	v_{ba}	Q_3, Q_4	v_{DN}	Q_4
$5\pi/3 < \omega t < 2\pi$	v_{ca}	Q_4, Q_5	v_{EN}	Q_5
$2\pi < \omega t < 7\pi/3$	v_{cb}	Q_5, Q_6	v_{FN}	Q_6

RETIFICADOR TRIFÁSICO EM PONTE

formas de onda – condução contínua

