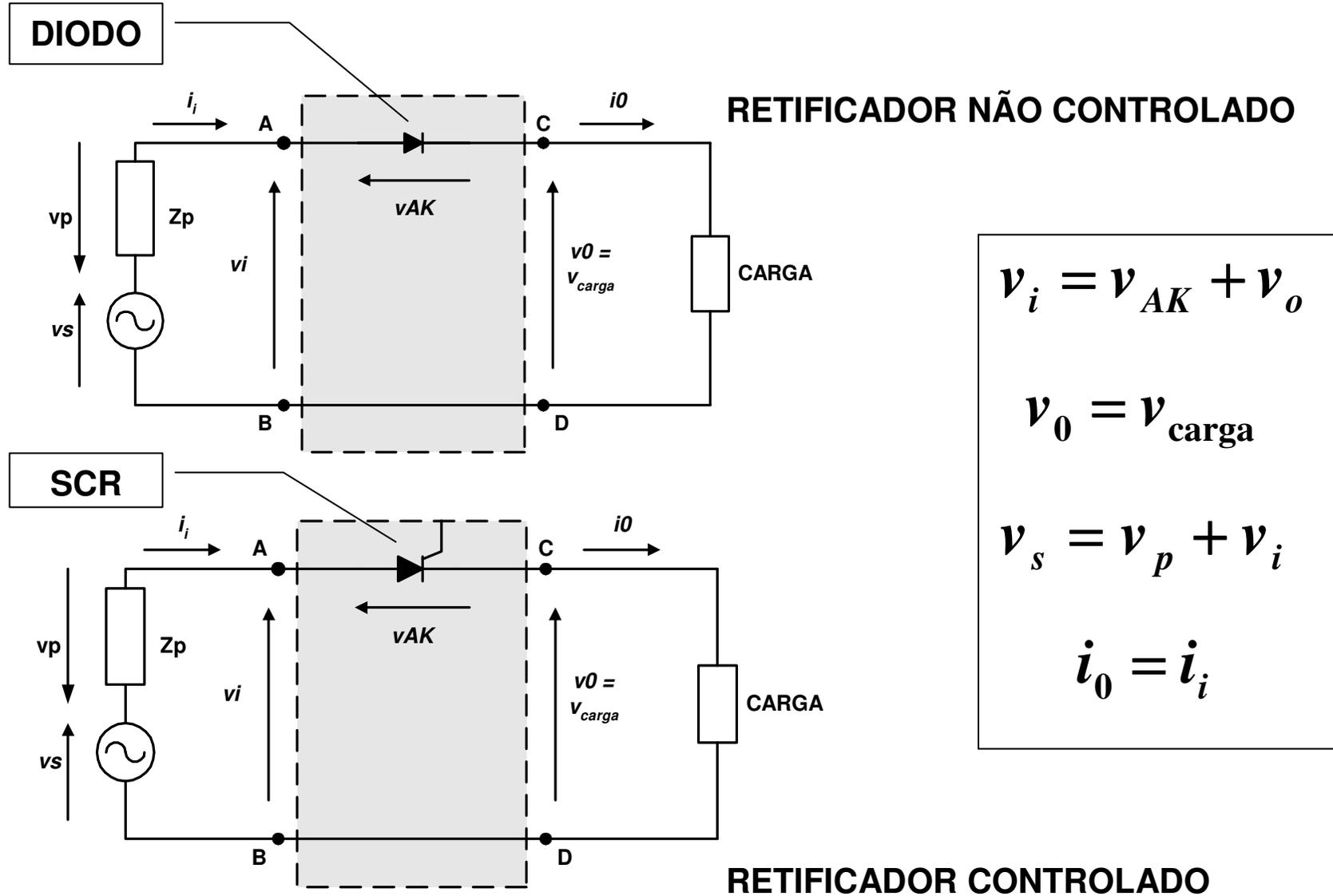


RETIFICADORES MONOFÁSICOS DE MEIA-ONDA

PARTE I

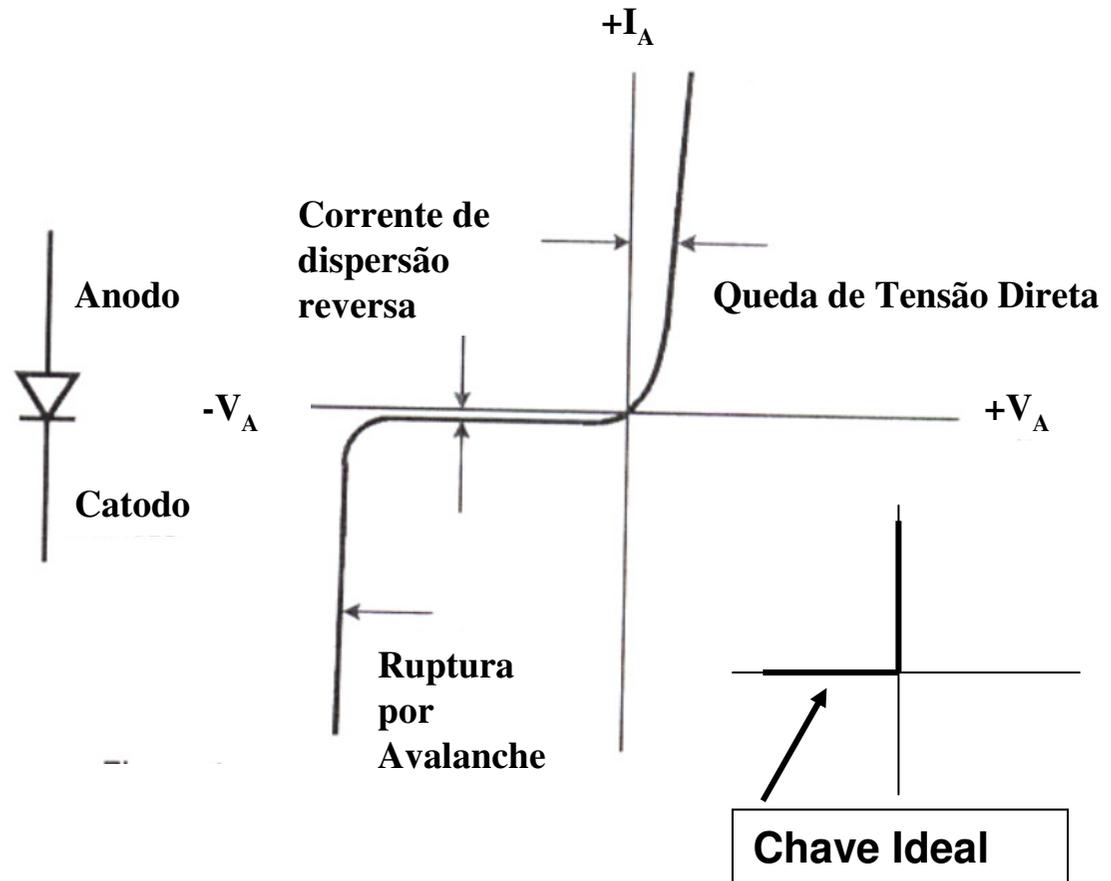
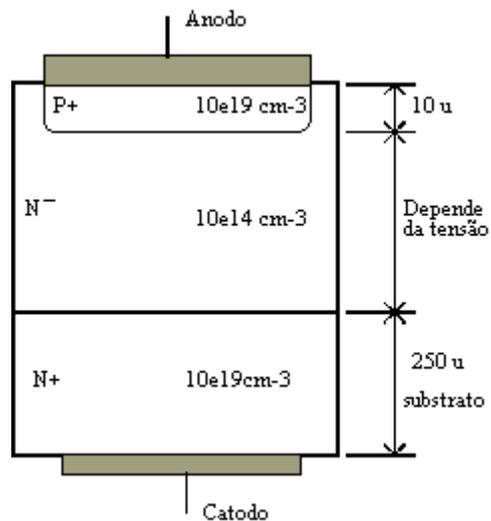
Prof. Azauri A. de Oliveira Jr.

RETIFICADOR MONOFÁSICO DE MEIA-ONDA (ESTRUTURA BÁSICA)



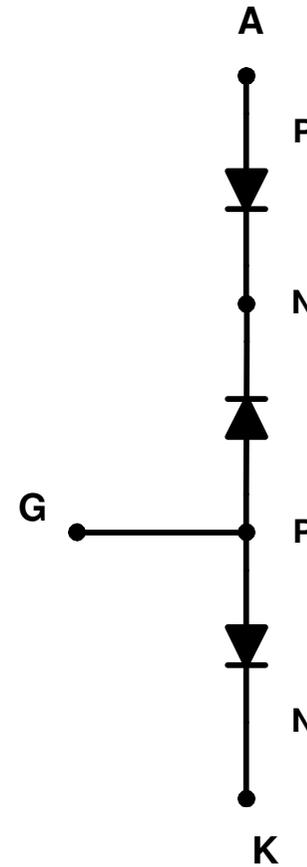
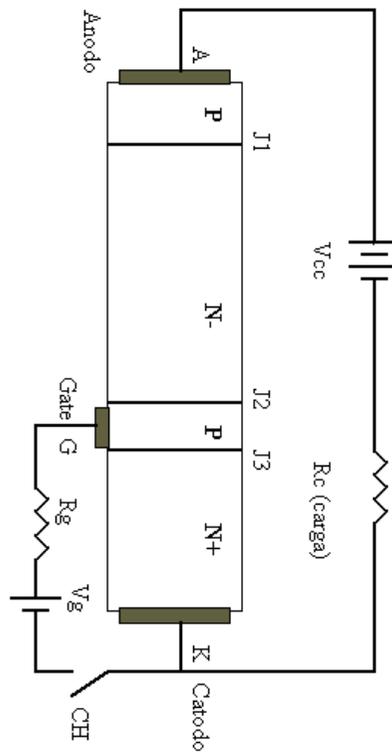
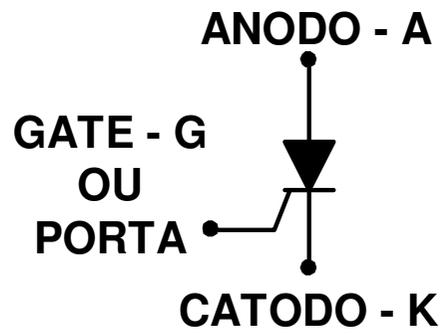
DIODO SEMICONDUTOR DE POTÊNCIA

ESTRUTURA FÍSICA E CARACTERÍSTICAS ESTÁTICAS



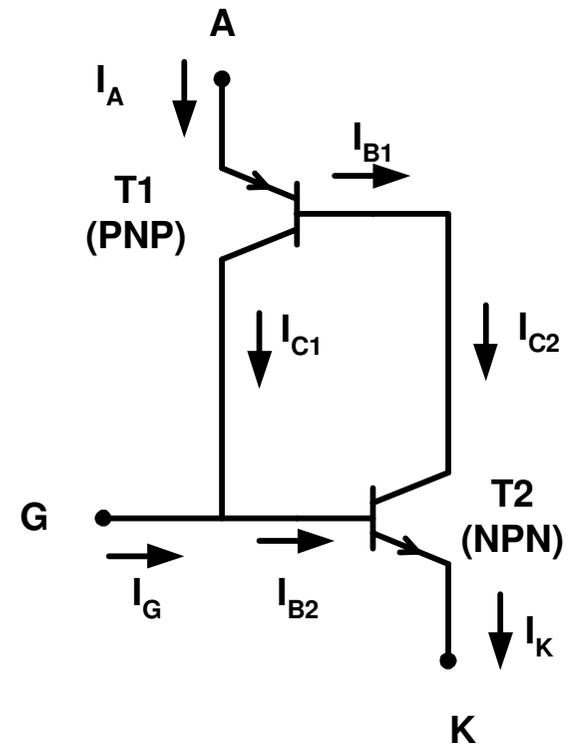
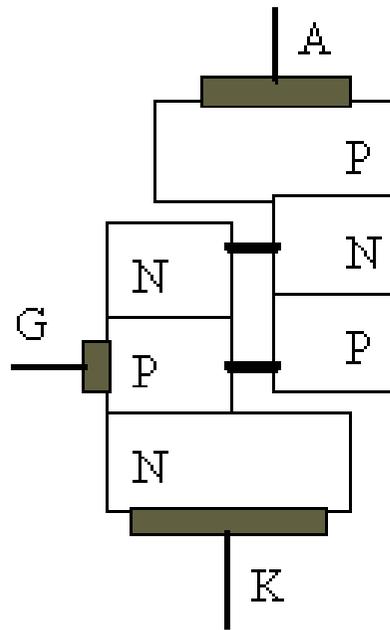
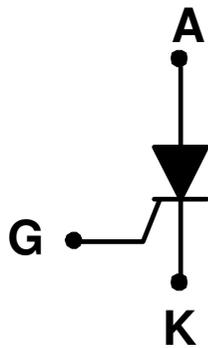
Características Dinâmicas – $t_{on} = t_{off} = 0$

TIRISTORES – A ESTRUTURA DE 4 CAMADAS



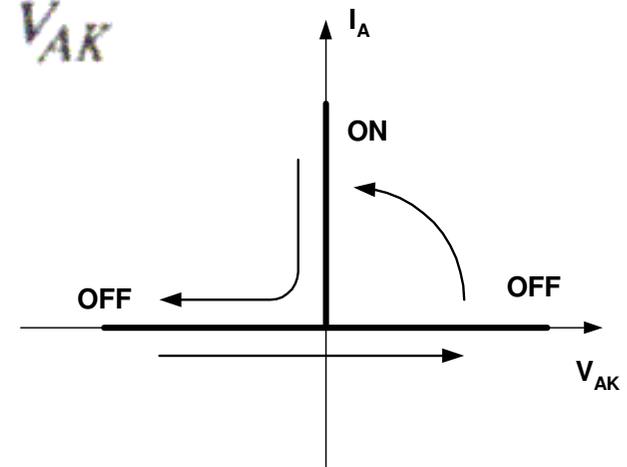
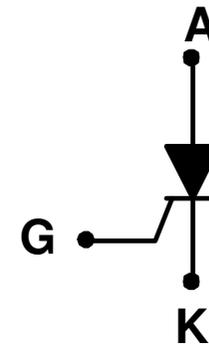
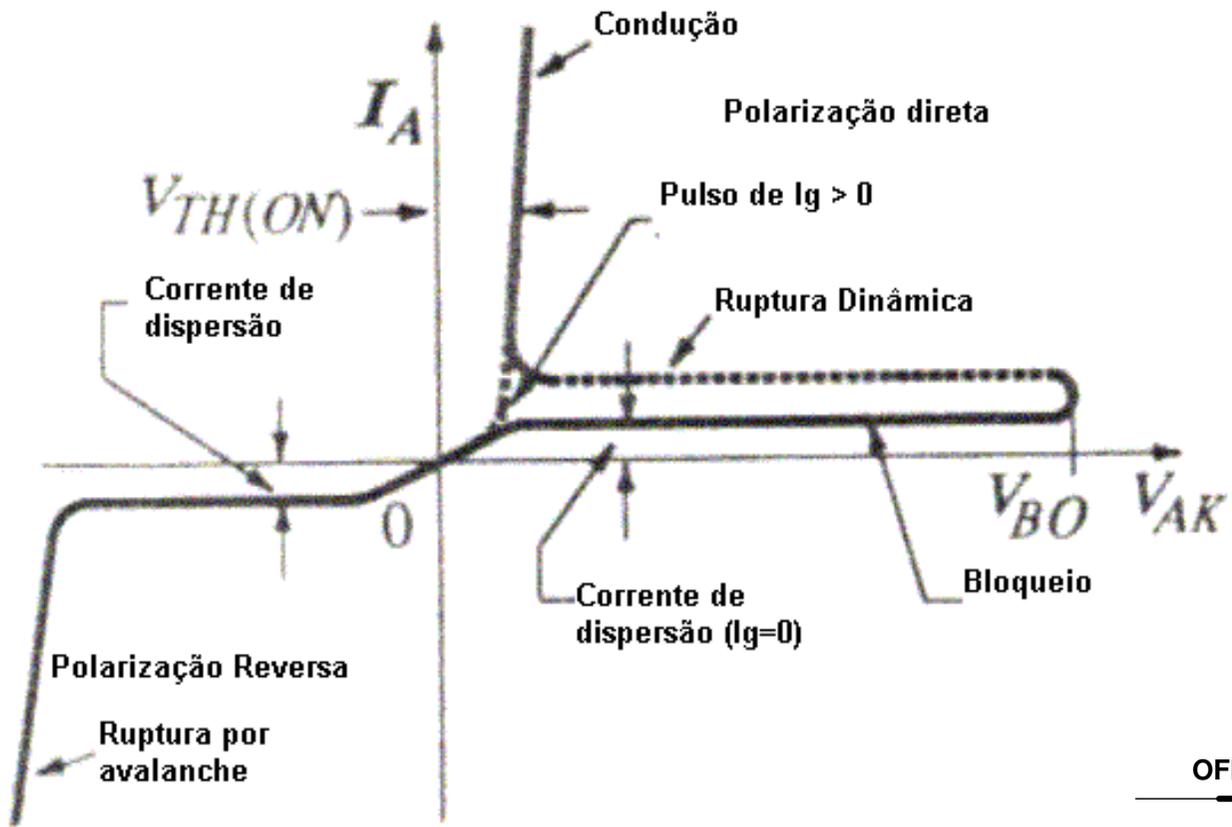
SCR – SILICON CONTROLLED RECTIFIER

MODELO DOS DOIS TRANSISTORES



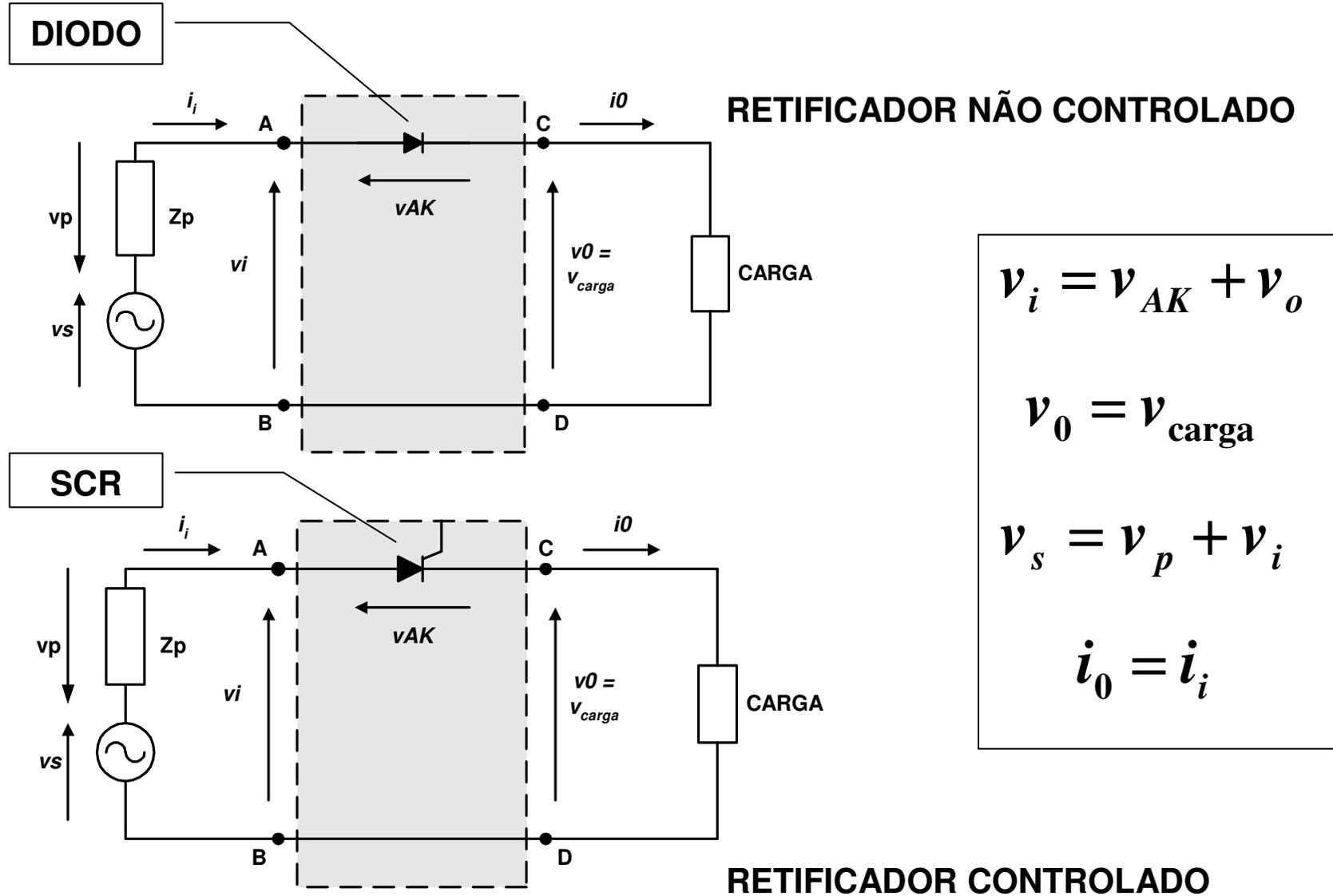
SCR – SILICON CONTROLLED RECTIFIER

CARACTERÍSTICAS ESTÁTICAS

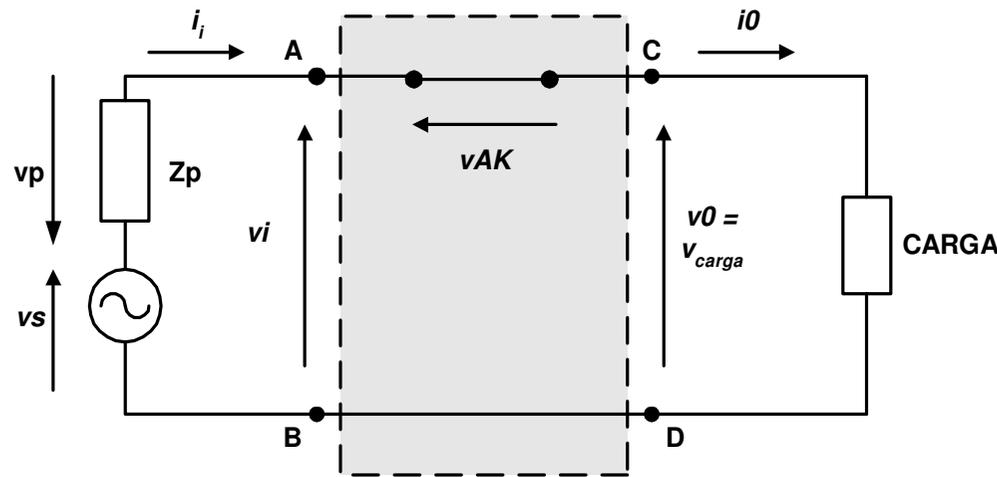


CARACTERÍSTICAS ESTÁTICAS IDEAIS

RETIFICADOR MONOFÁSICO DE MEIA-ONDA (ESTRUTURA BÁSICA)



TOPOLOGIAS DO RETIFICADOR RELACIONADAS AOS ESTADOS DE CHAVEAMENTO DO DIODO (OU SCR IDEAL)



DIODO OU (SCR) EM CONDUÇÃO

$$v_{AK} = 0$$

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

$$v_s = v_p + v_i = v_p + v_0 = v_p + v_{\text{carga}}$$

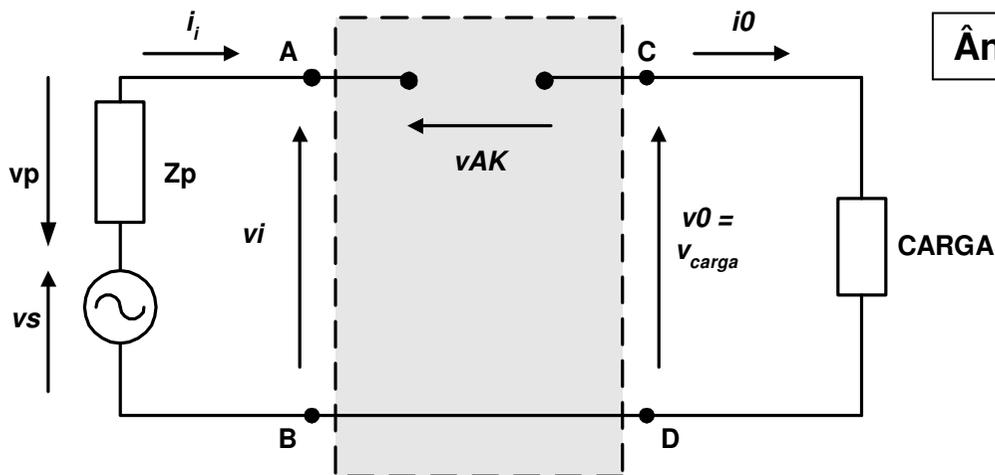
$$i_0 = i_i$$

Ângulo de Corte

Ângulo de Disparo

Ângulo de Condução

$$\gamma = \beta - \alpha$$



DIODO (OU SCR) EM BLOQUEIO

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

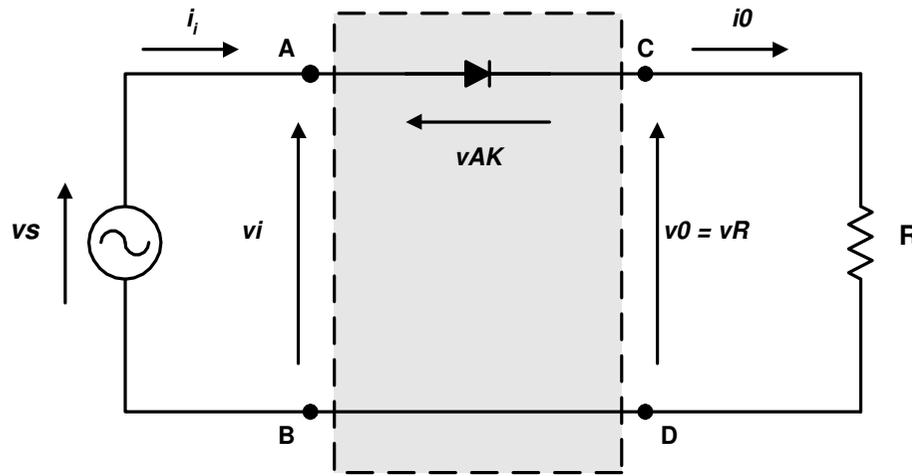
$$v_{AK} = v_i - v_0 = v_i - v_{\text{carga}}$$

$$i_0 = i_i = 0$$

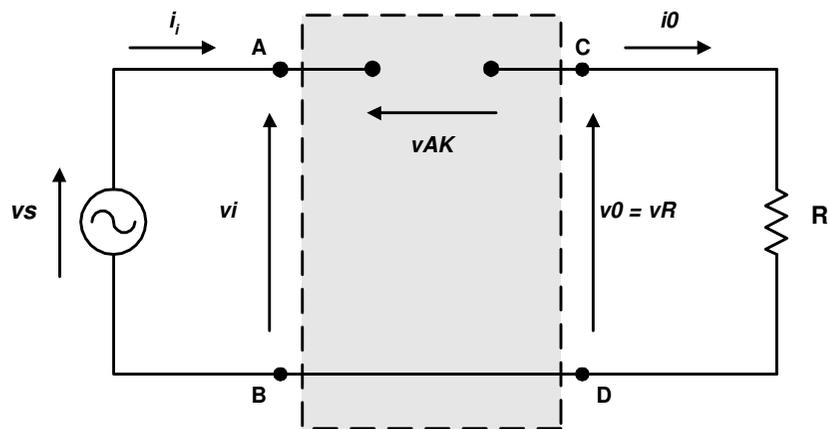
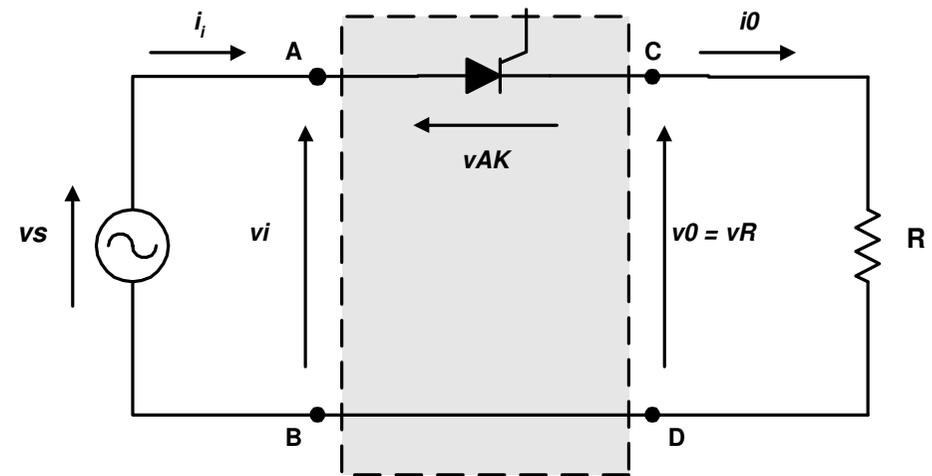
$$v_i = v_s - v_p$$

RETIFICADOR MONOFÁSICO DE MEIA-ONDA (CARGA RESISTIVA)

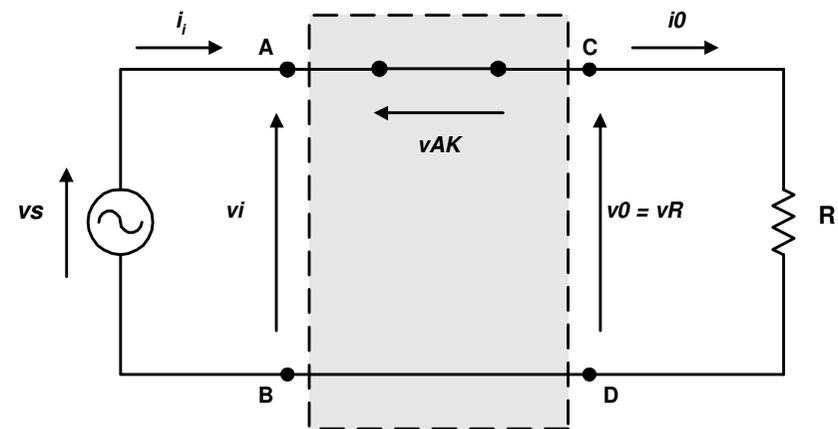
RETIFICADOR NÃO CONTROLADO



RETIFICADOR CONTROLADO

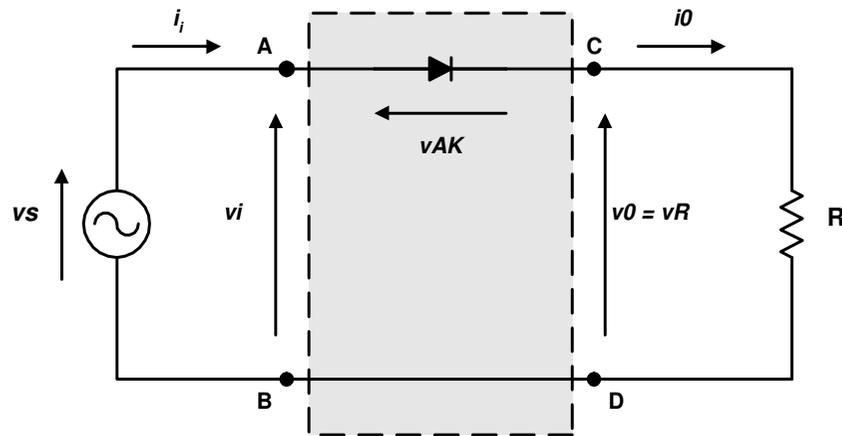


DIODO (OU SCR) EM BLOQUEIO

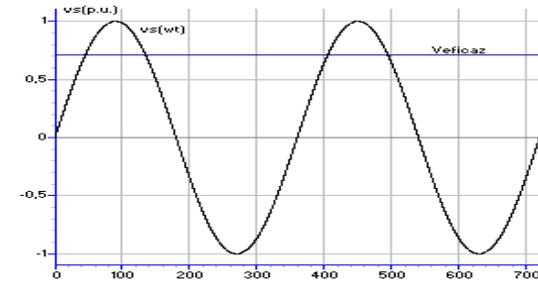


DIODO (OU SCR) EM CONDUÇÃO

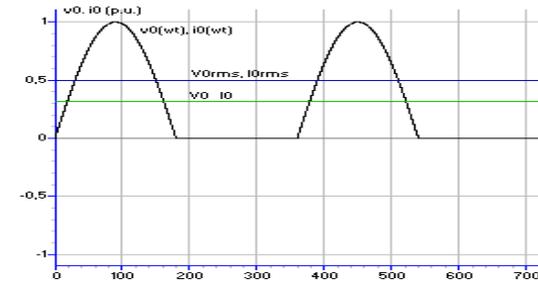
RETIFICADOR NÃO CONTROLADO COM CARGA RESISTIVA - FORMAS DE ONDA



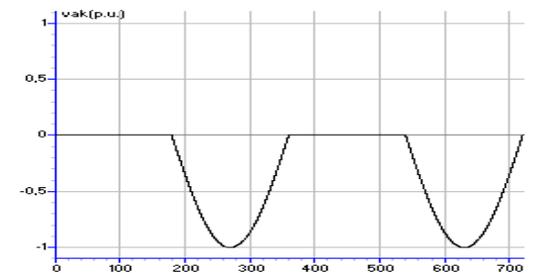
Tensão da Fonte



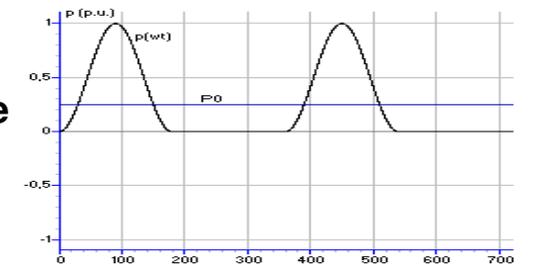
Tensão na Carga



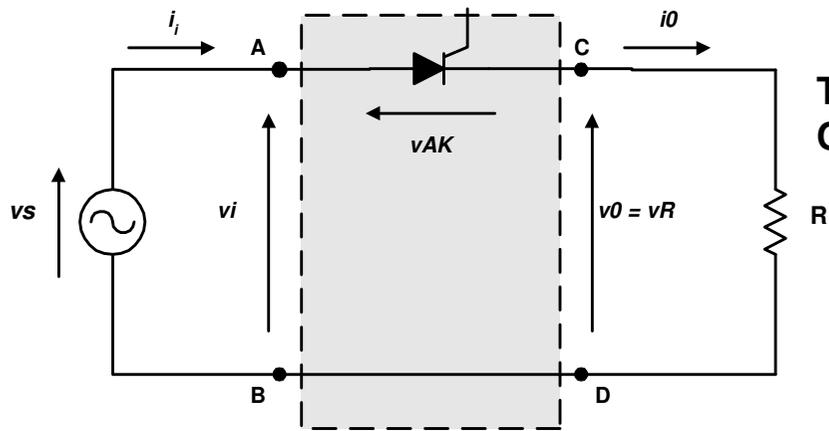
Tensão no Diodo



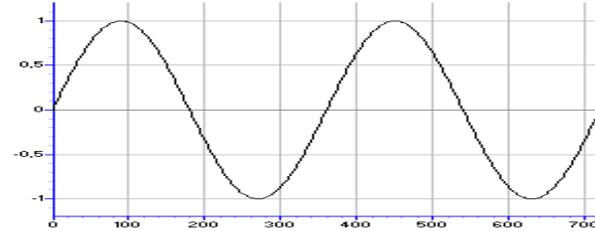
Potência na Fonte e na Carga



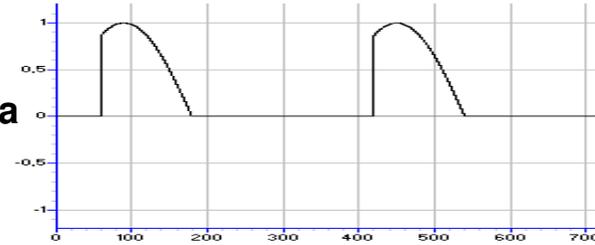
RETIFICADOR CONTROLADO COM CARGA RESISTIVA - FORMAS DE ONDA



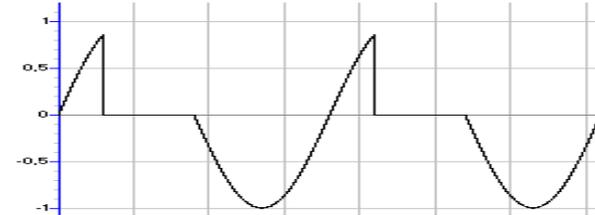
Tensão da Fonte



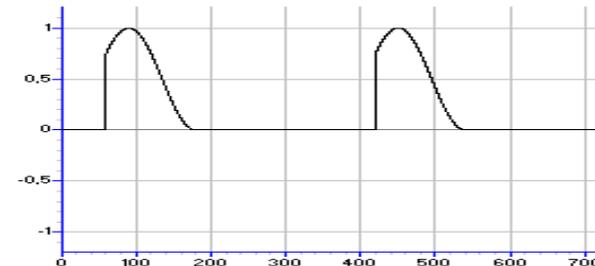
Tensão e corrente na Carga



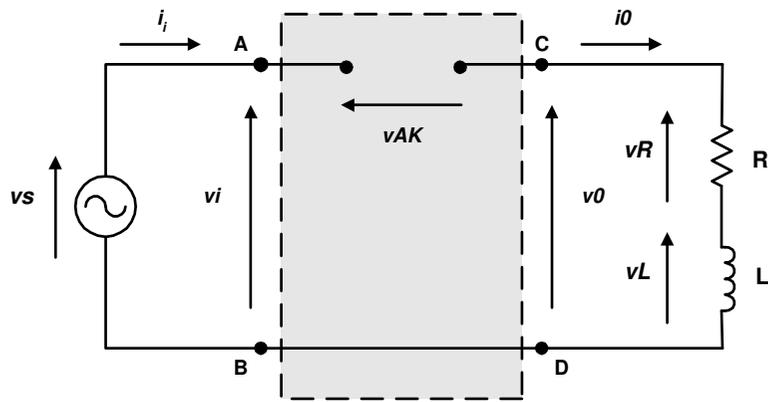
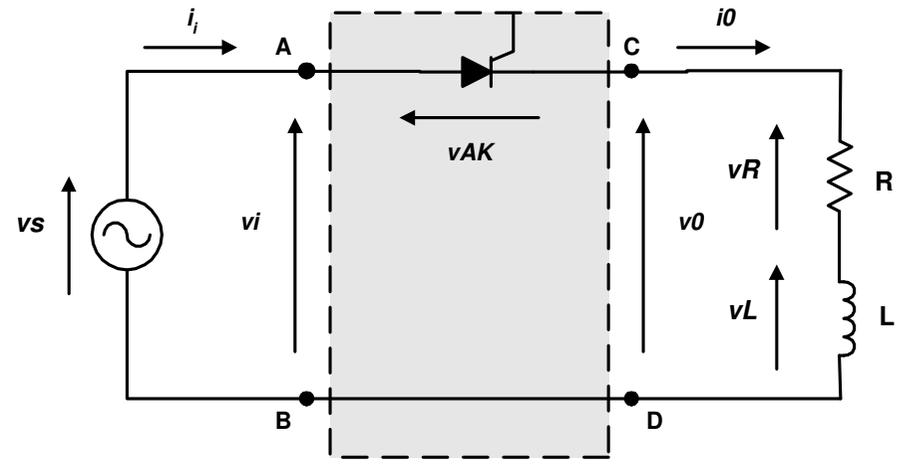
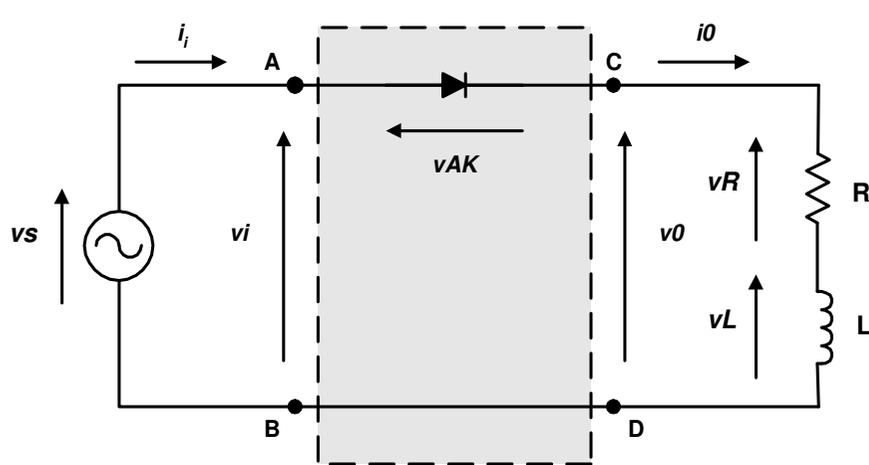
Tensão no SCR



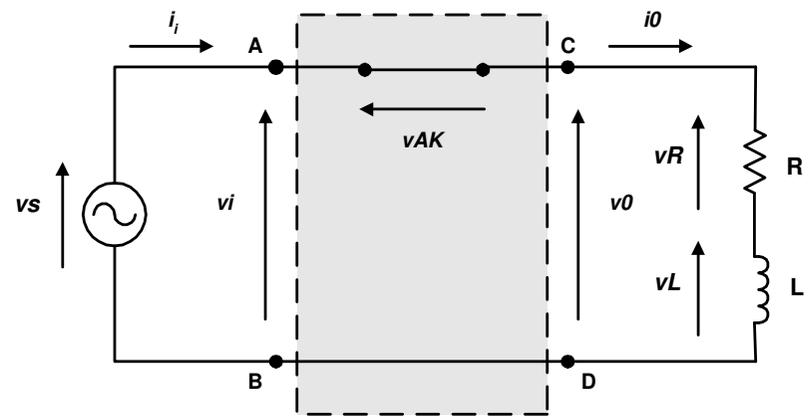
Potência na Fonte e na Carga



RETIFICADOR MONOFÁSICO DE MEIA-ONDA (CARGA INDUTIVA)

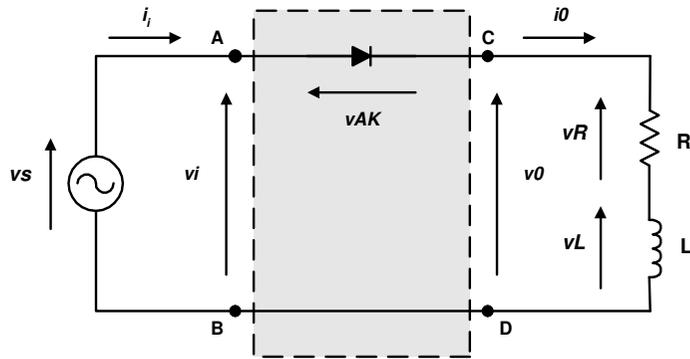


DIODO (OU SCR) EM BLOQUEIO

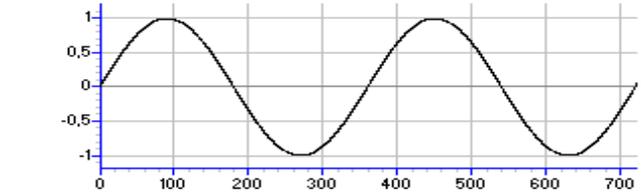


DIODO (OU SCR) EM CONDUÇÃO

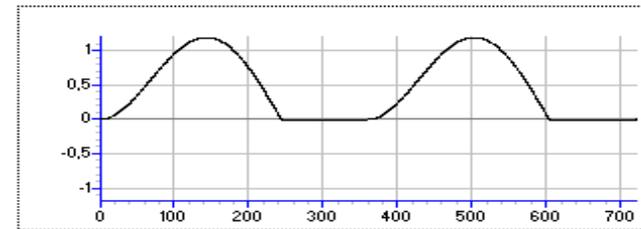
RETIFICADOR NÃO CONTROLADO COM CARGA INDUTIVA - FORMAS DE ONDA



Tensão da Fonte

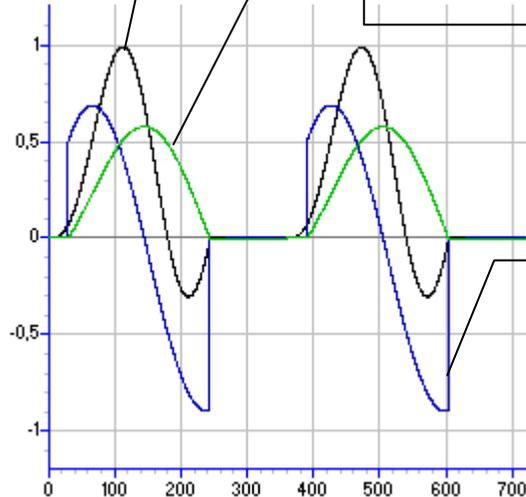


Corrente



Potência na Fonte

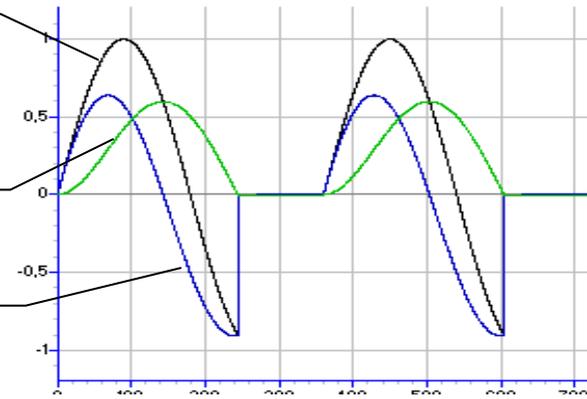
Potência em R



Tensão de saída

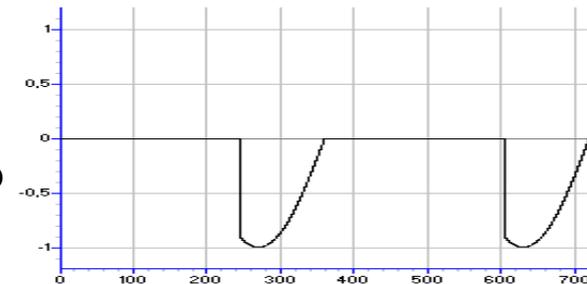
Tensão em R

Tensão em L

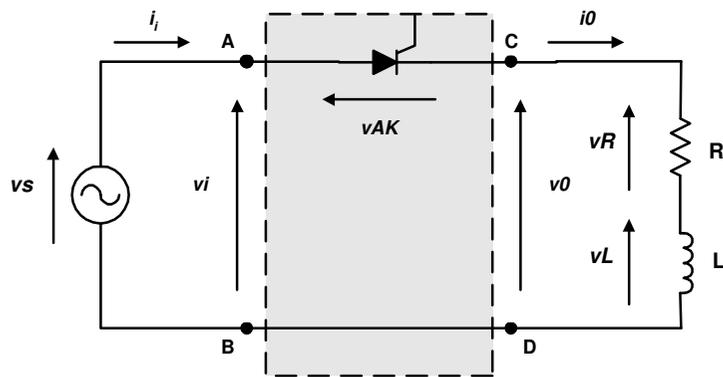


Potência em L

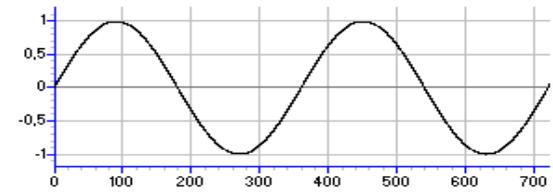
Tensão no Diodo



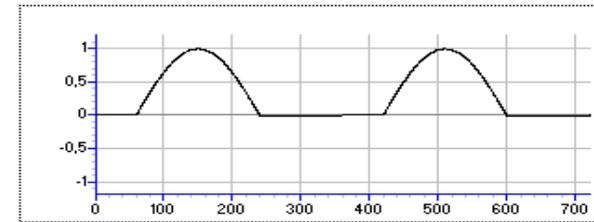
RETIFICADOR CONTROLADO COM CARGA INDUTIVA - FORMAS DE ONDA



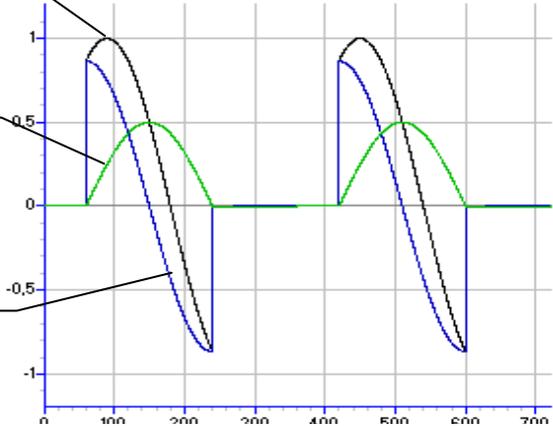
Tensão da Fonte



Corrente



Tensão de saída



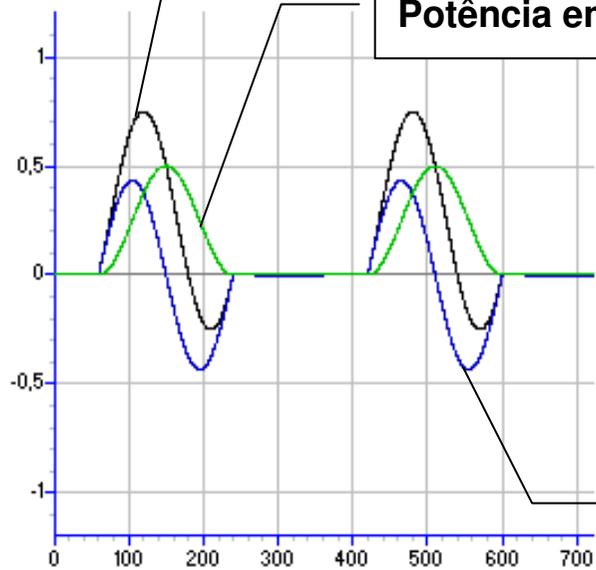
Tensão em R

Tensão em L

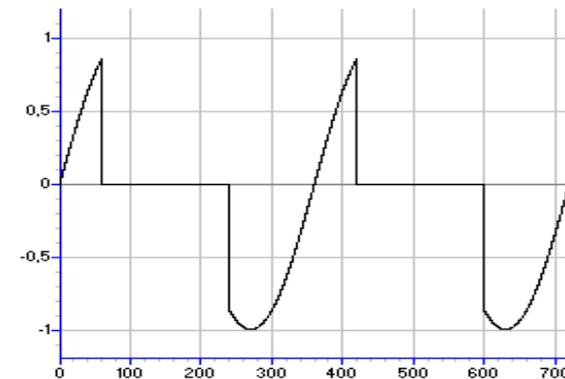
Potência na Fonte

Potência em R

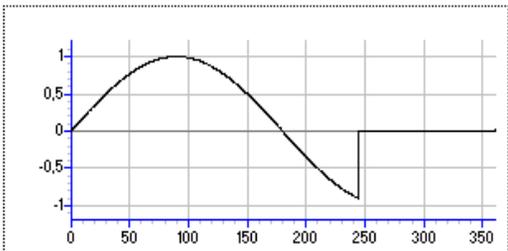
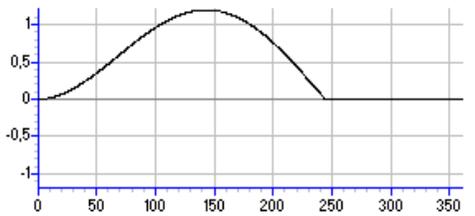
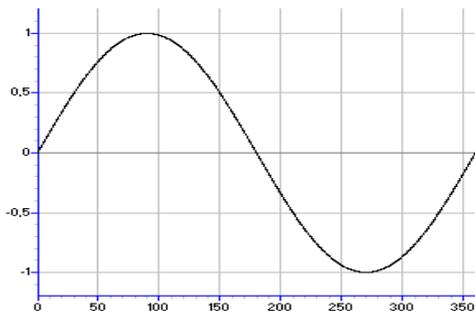
Potência em L



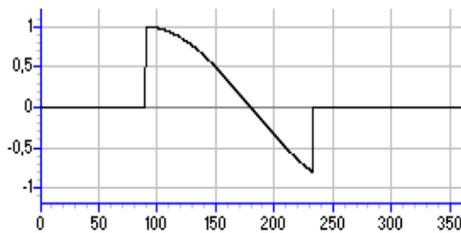
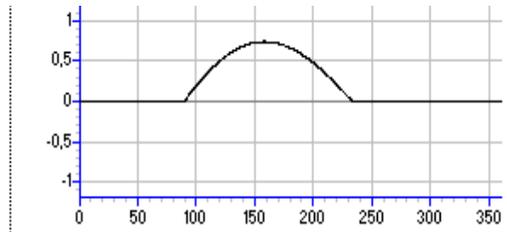
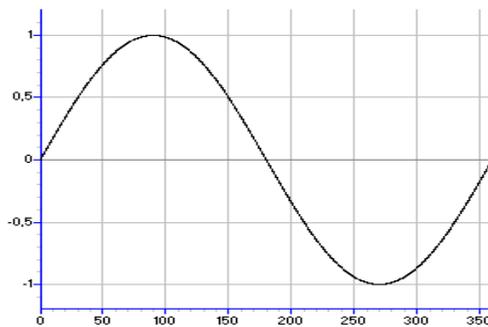
Tensão no SCR



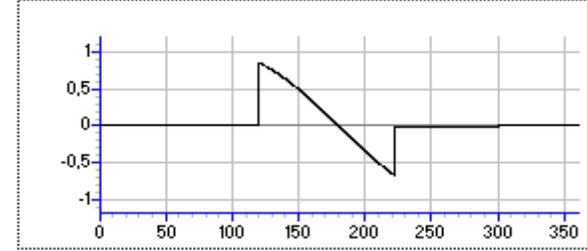
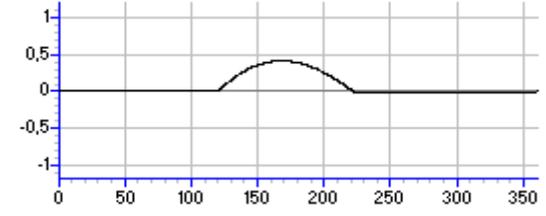
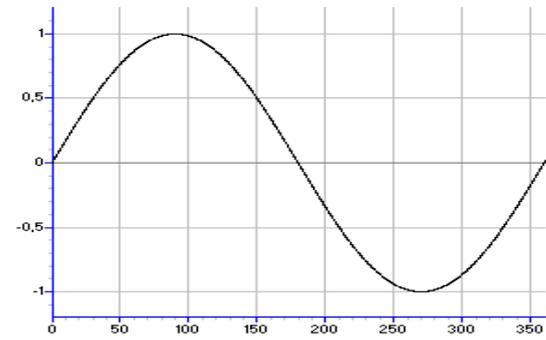
VARIAÇÕES DA CORRENTE E DA TENSÃO NA CARGA COM O ÂNGULO DE DISPARO



$\alpha = 0^\circ$



$\alpha = 90^\circ$



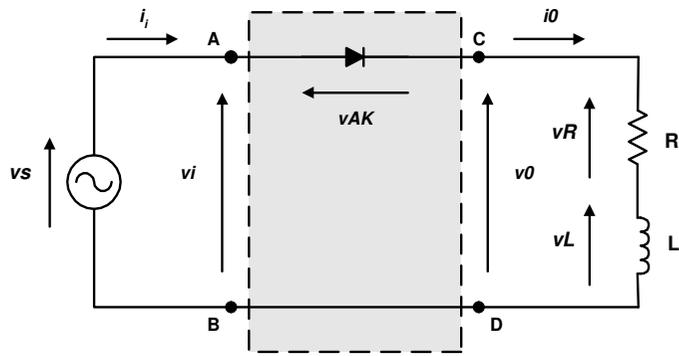
$\alpha = 120^\circ$

Retificadores Monofásicos de Meia-Onda

Curvas de Projeto

RETIFICADOR MONOFÁSICO DE MEIA-ONDA NÃO CONTROLADO

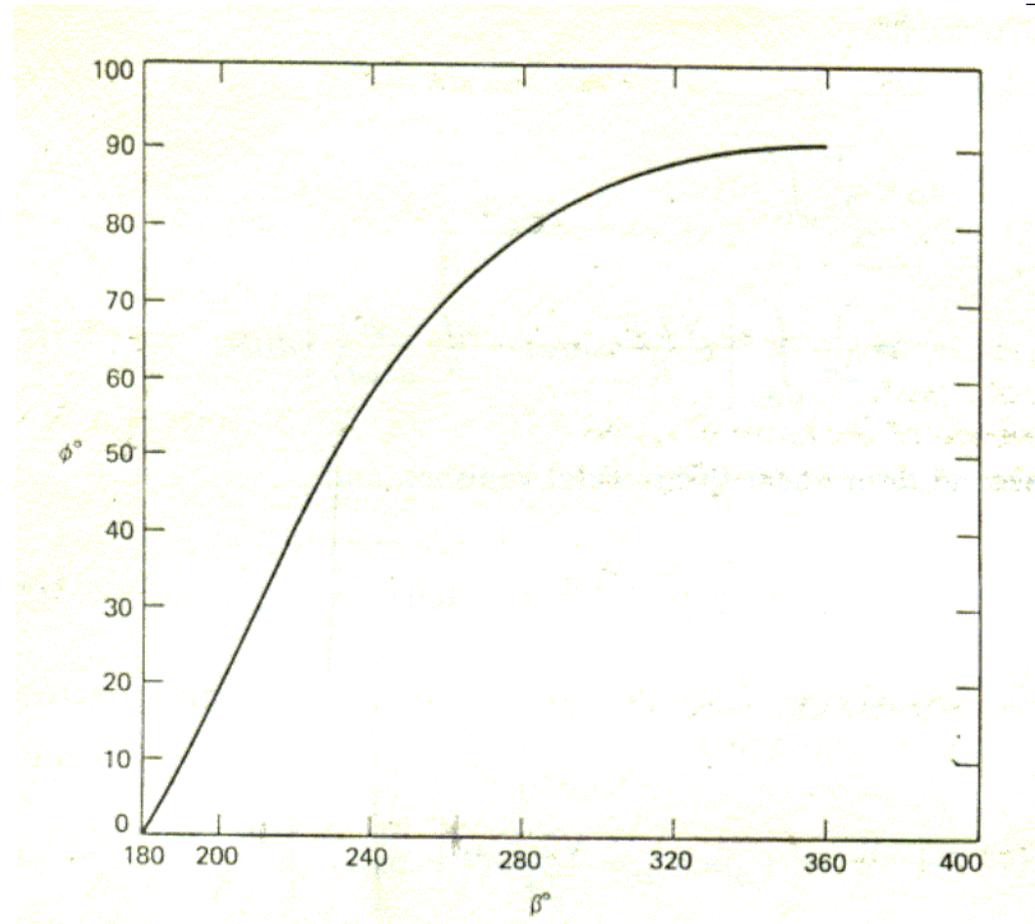
Ângulo de Condução – Carga RL



$$\sin(\beta - \phi) + e^{-\beta / \tan \phi} \cdot \sin \phi = 0$$

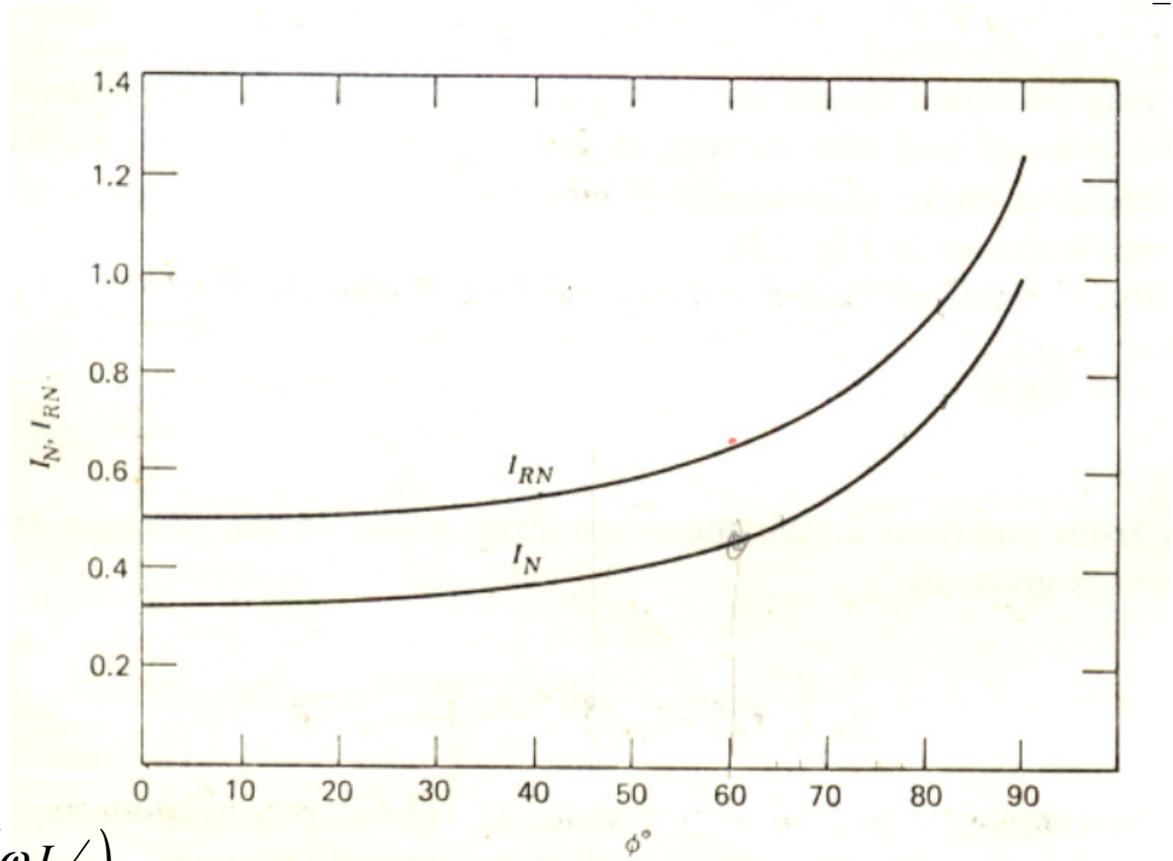
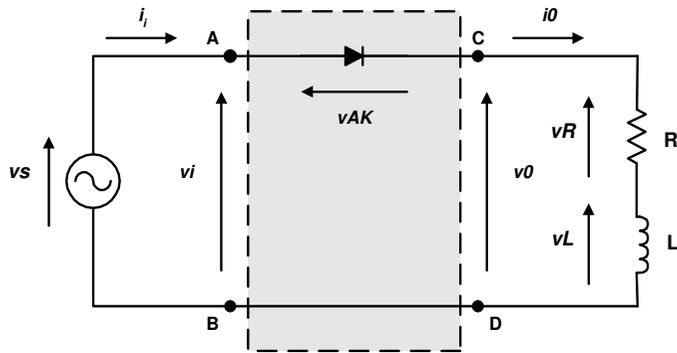
$$\gamma = \beta - \alpha$$

$$\alpha = 0^\circ$$



RETIFICADOR MONOFÁSICO DE MEIA-ONDA NÃO CONTROLADO

Correntes média e rms normalizadas – Carga RL



$$i_N = \text{sen}(\omega.t - \phi) + e^{-\omega.t / \tan \phi} \cdot \text{sen} \phi$$

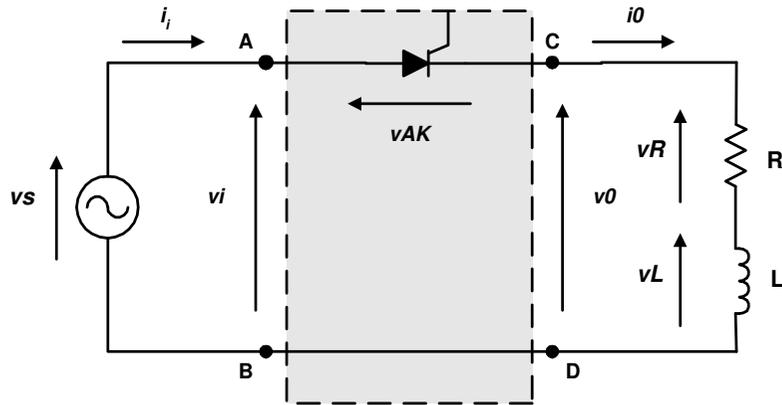
$$i_N = \frac{i(\omega.t)}{I_{base}} \quad ; \quad I_{base} = \frac{\sqrt{2} \cdot V}{Z}$$

$$Z = \sqrt{R^2 + (\omega.L)^2} \quad ; \quad \phi = \arctan\left(\frac{\omega.L}{R}\right)$$

$$I_N = \frac{1}{2.\pi} \int_{\alpha=0}^{\beta=\gamma+\alpha=\gamma} i_N \cdot d\omega t \quad ; \quad I_{RN} = \sqrt{\frac{1}{2.\pi} \int_{\alpha=0}^{\beta=\gamma+\alpha=\gamma} i_N^2 \cdot d\omega t}$$

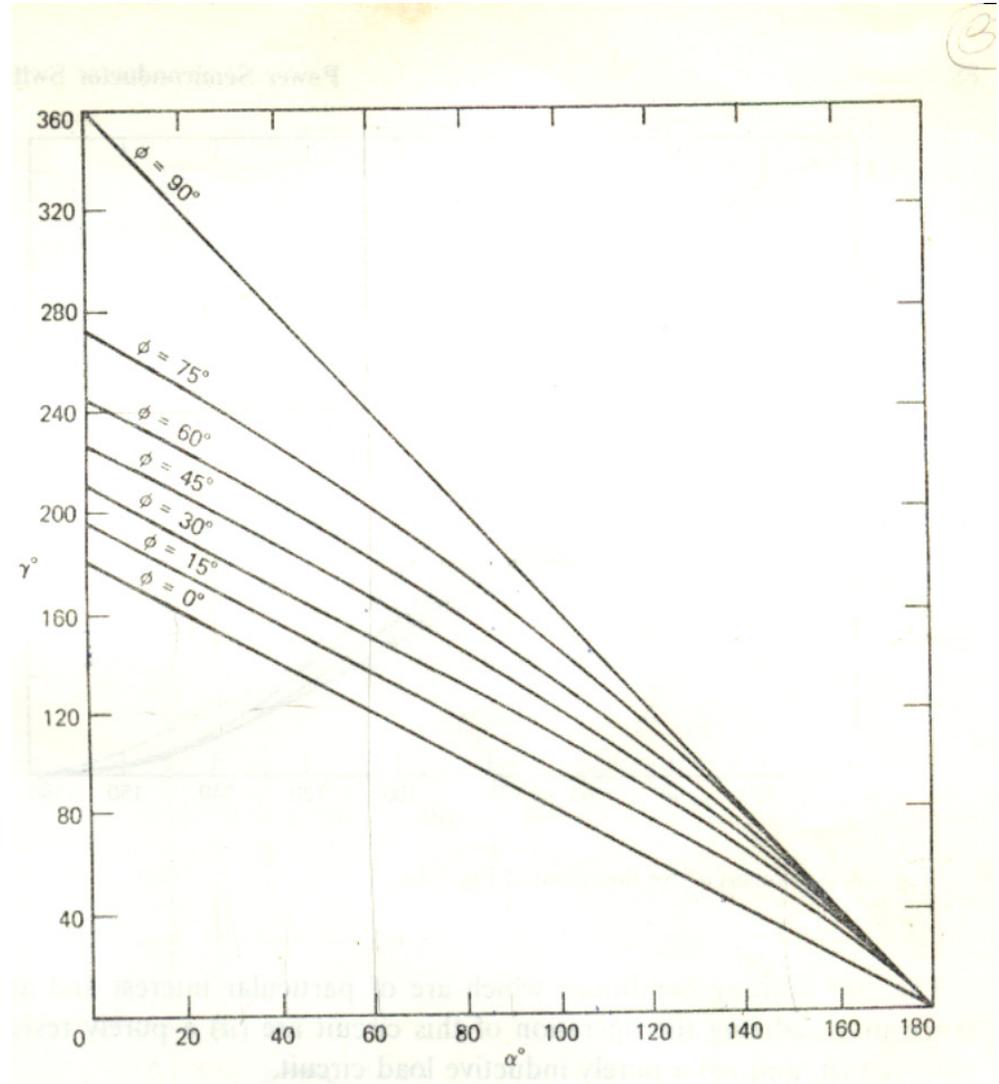
RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO

Ângulo de Condução – Carga RL



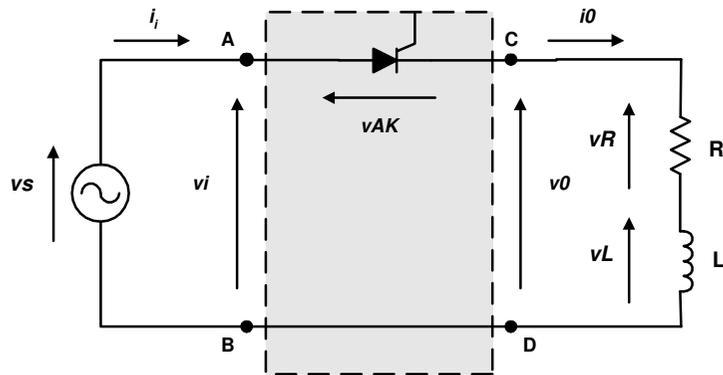
$$\text{sen}(\beta - \phi) = \text{sen}(\alpha - \phi) \cdot e^{[\alpha - \beta] / \tan \phi}$$

$$\gamma = \beta - \alpha$$



RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO

Corrente Média Normalizada – Carga RL

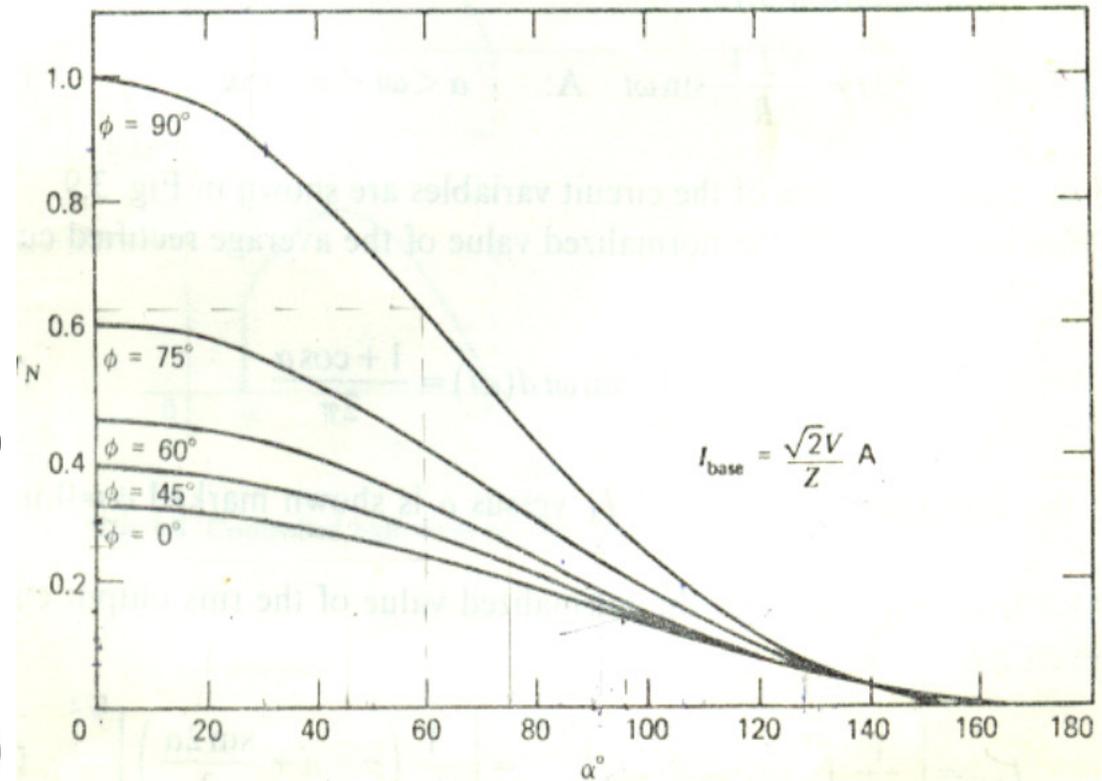


$$i_N = \text{sen}(\omega.t - \phi) - e^{(\alpha - \omega.t)/\tan\phi} \cdot \text{sen}(\alpha - \phi)$$

$$i_N = \frac{i(\omega.t)}{I_{base}} \quad ; \quad I_{base} = \frac{\sqrt{2} \cdot V}{Z}$$

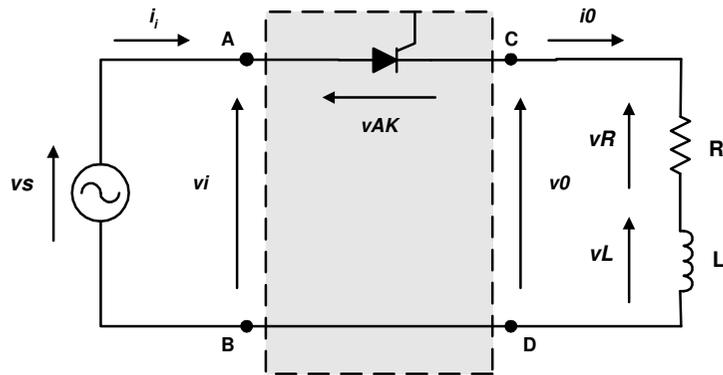
$$Z = \sqrt{R^2 + (\omega \cdot L)^2} \quad ; \quad \phi = \arctan\left(\frac{\omega \cdot L}{R}\right)$$

$$I_N = \frac{1}{2\pi} \int_{\alpha}^{\beta = \gamma + \alpha} i_N \cdot d\omega t$$



RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO

Corrente RMS Normalizada – Carga RL



$$i_N = \text{sen}(\omega.t - \phi) - e^{(\alpha - \omega.t)/\tan\phi} \cdot \text{sen}(\alpha - \phi)$$

$$i_N = \frac{i(\omega.t)}{I_{base}} \quad ; \quad I_{base} = \frac{\sqrt{2} \cdot V}{Z}$$

$$Z = \sqrt{R^2 + (\omega \cdot L)^2} \quad ; \quad \phi = \arctan\left(\frac{\omega \cdot L}{R}\right)$$

$$I_{RN} = \sqrt{\frac{1}{2\pi} \int_{\alpha}^{\beta = \gamma + \alpha} i_N^2 \cdot d\omega t}$$

