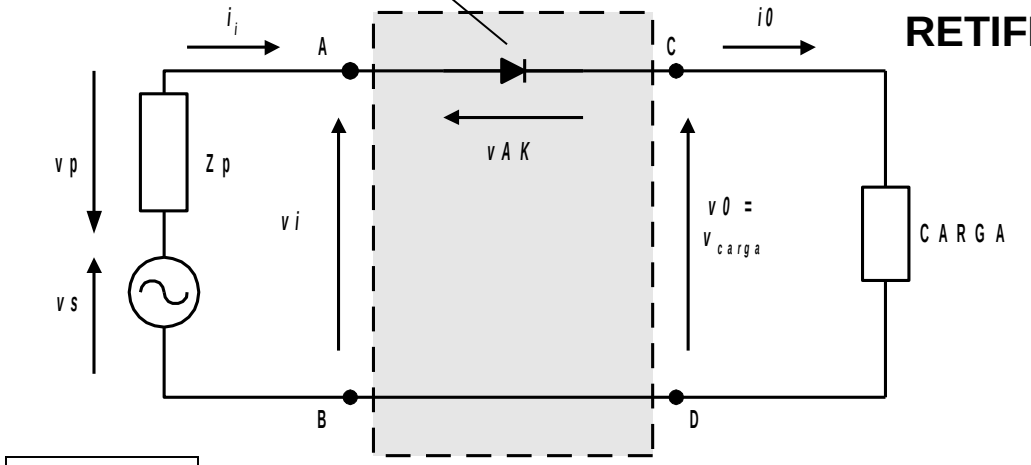
RETIFICADORES MONOFÁSICOS DE MEIA-ONDA

PARTE I

Prof. Azauri A. de Oliveira Jr.

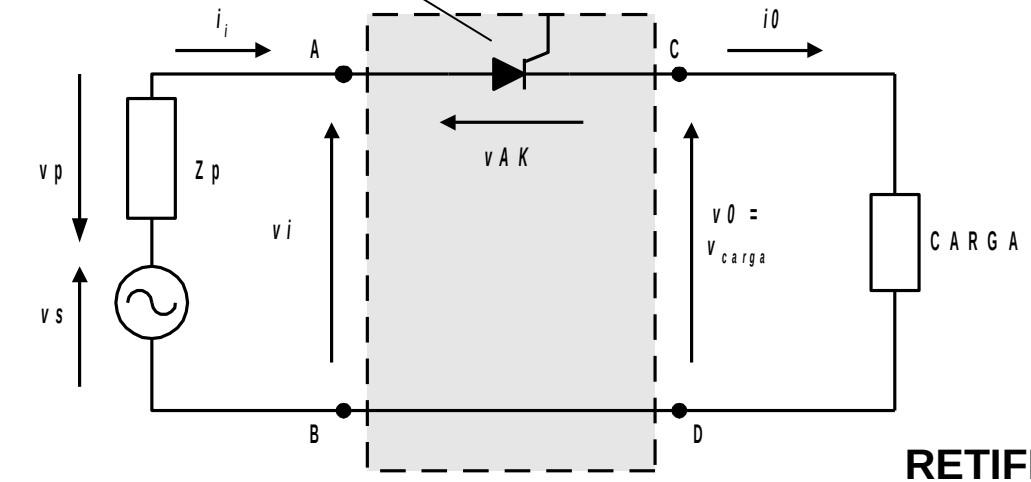
RETIFICADOR MONOFÁSICO DE MEIA-ONDA (ESTRUTURA BÁSICA)

DIODO



RETIFICADOR NÃO CONTROLADO

SCR



RETIFICADOR CONTROLADO

$$v_i = v_{AK} + v_o$$

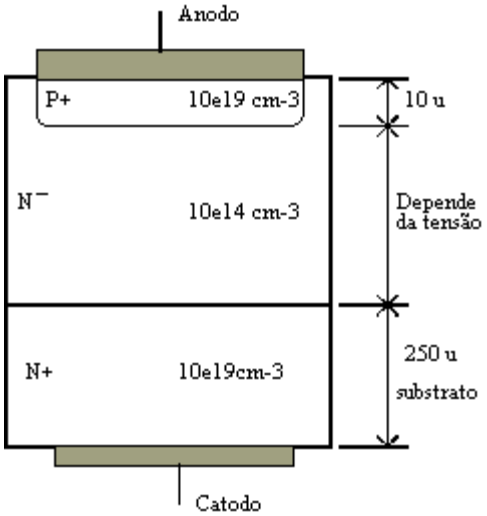
$$v_0 = v_{\text{carga}}$$

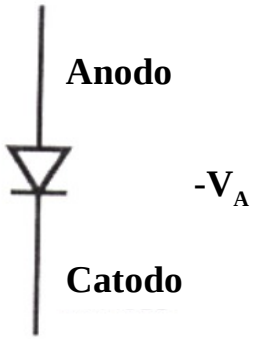
$$v_s = v_p + v_i$$

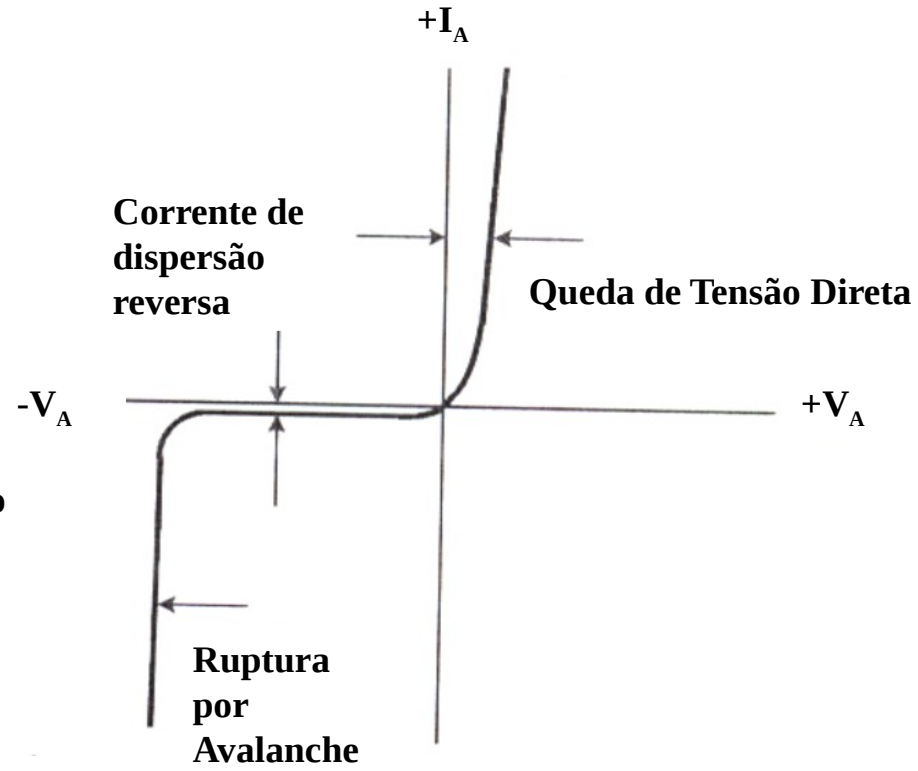
$$i_0 = i_i$$

DIODO SEMICONDUTOR DE POTÊNCIA

ESTRUTURA FÍSICA E CARACTERÍSTICAS ESTÁTICAS

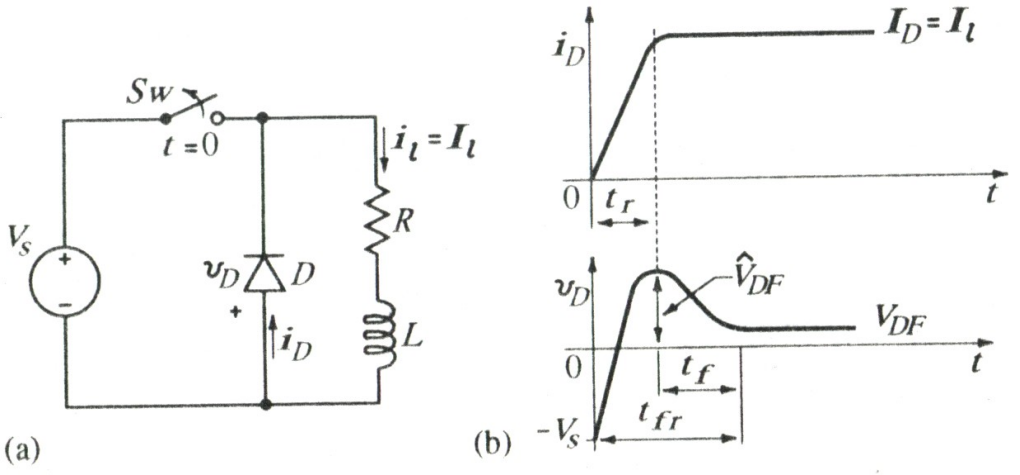




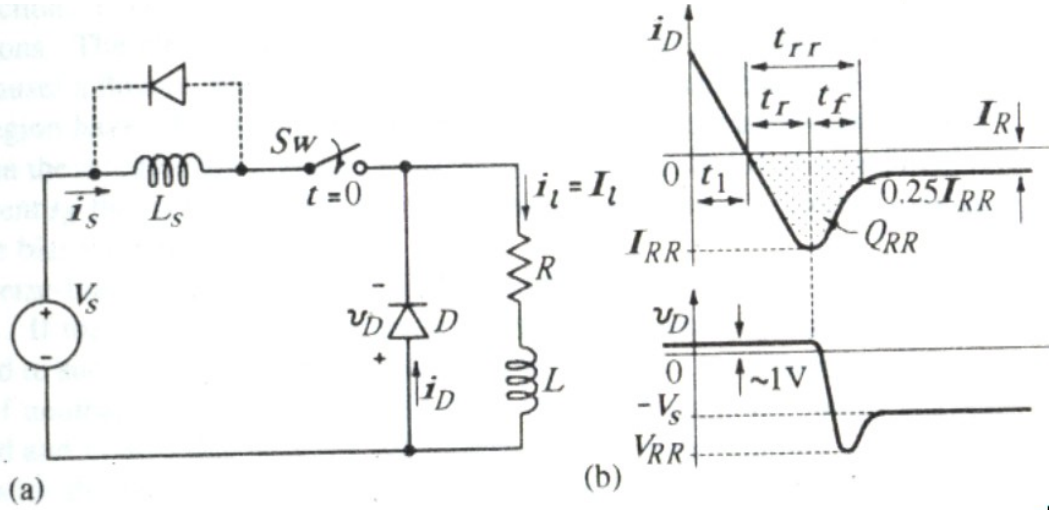


DIODO SEMICONDUTOR DE POTÊNCIA
CARACTERÍSTICAS DINÂMICAS

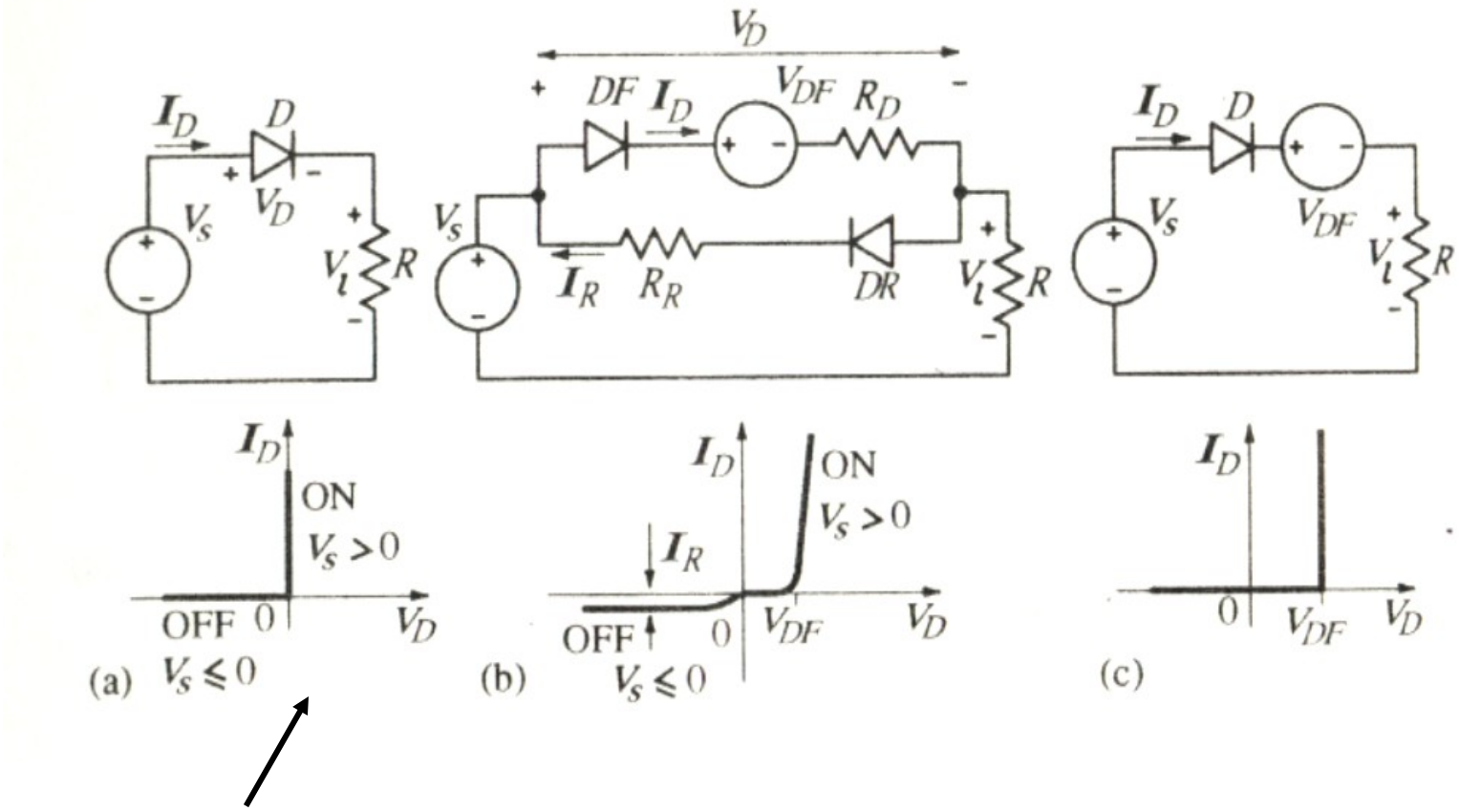
Características de disparo – “turn-on”



Características de bloqueio – “turn-off”

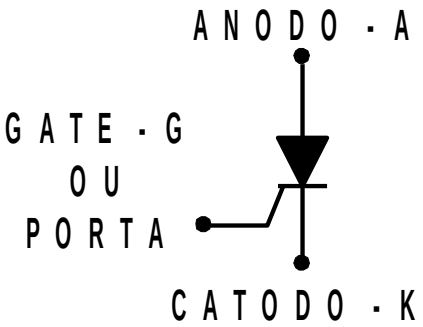


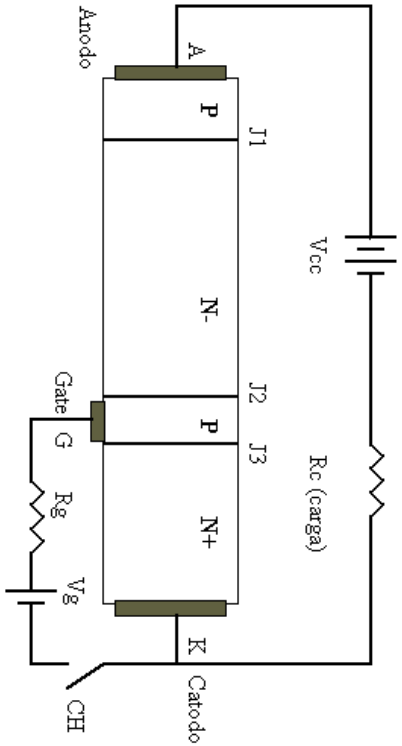
MODELOS DE DIODOS

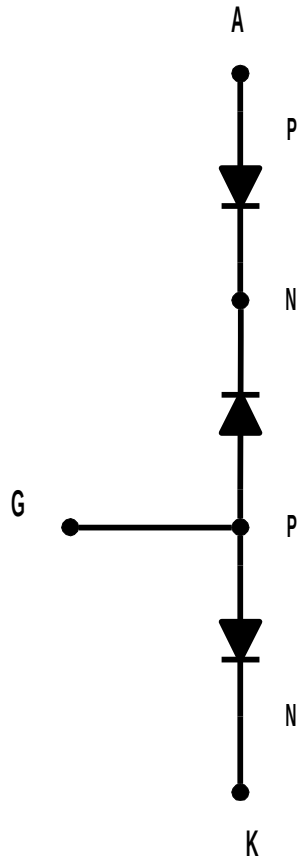


Chave Ideal → **Características Dinâmicas – ton = toff = 0**

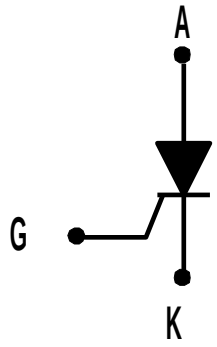
TIRISTORES – A ESTRUTURA DE 4 CAMADAS

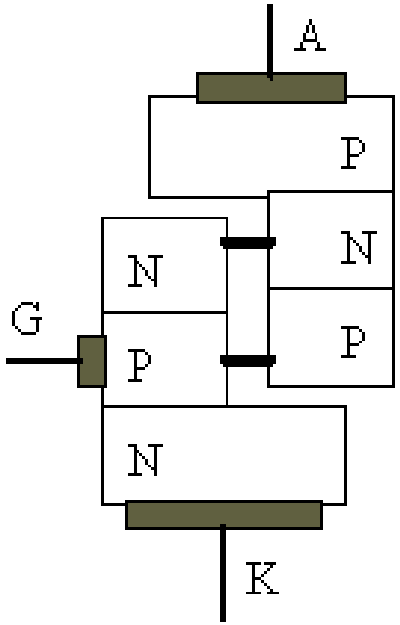


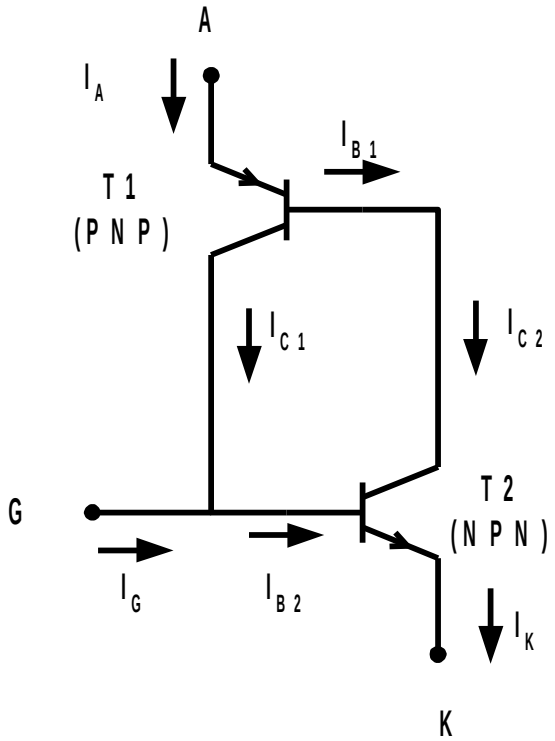




SCR – SILICON CONTROLLED RECTIFIER
MODELO DOS DOIS TRANSISTORES

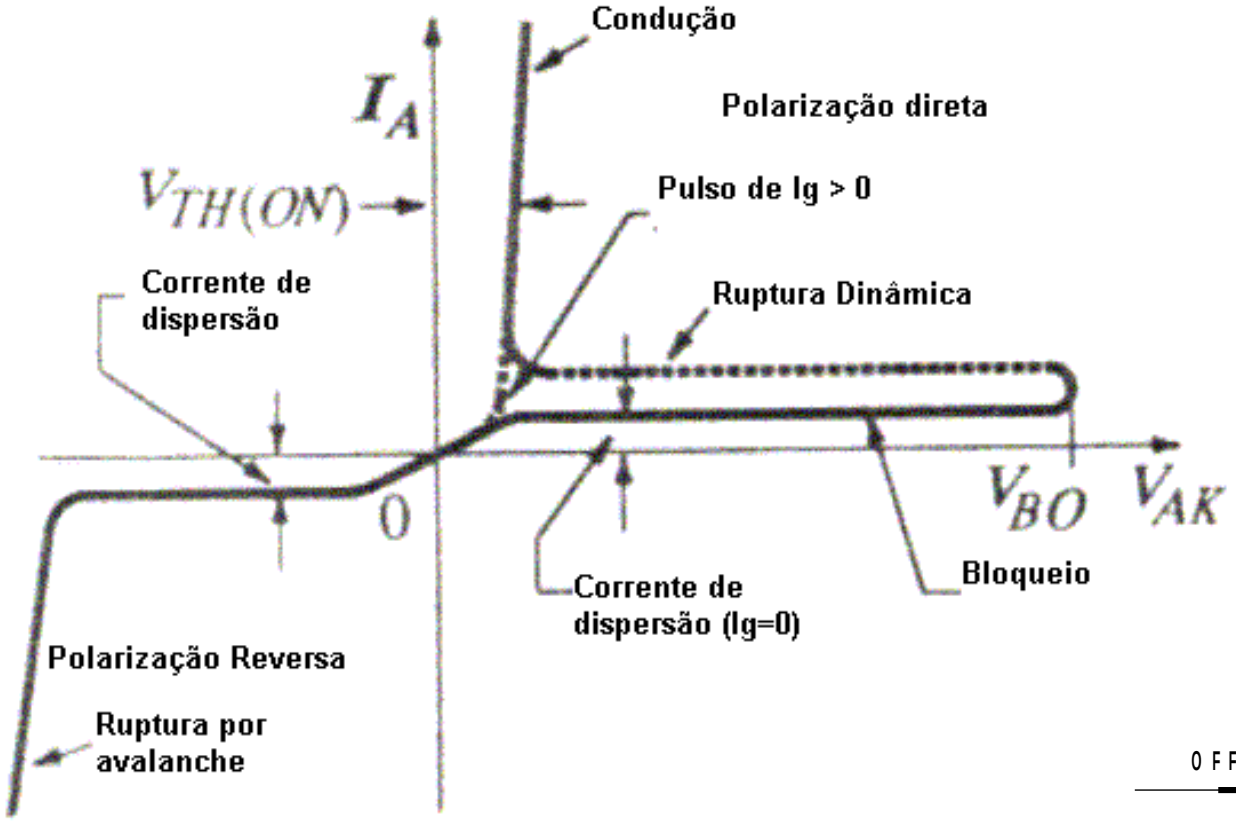


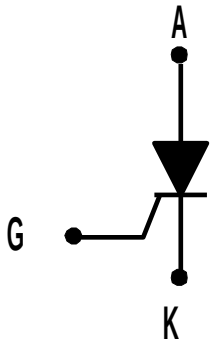


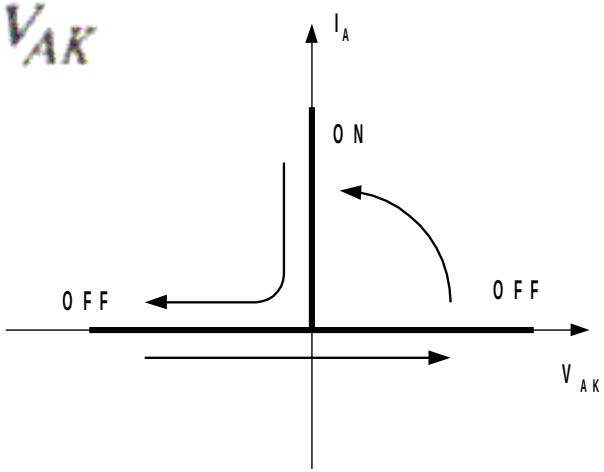


SCR – SILICON CONTROLLED RECTIFIER

CARACTERÍSTICAS ESTÁTICAS

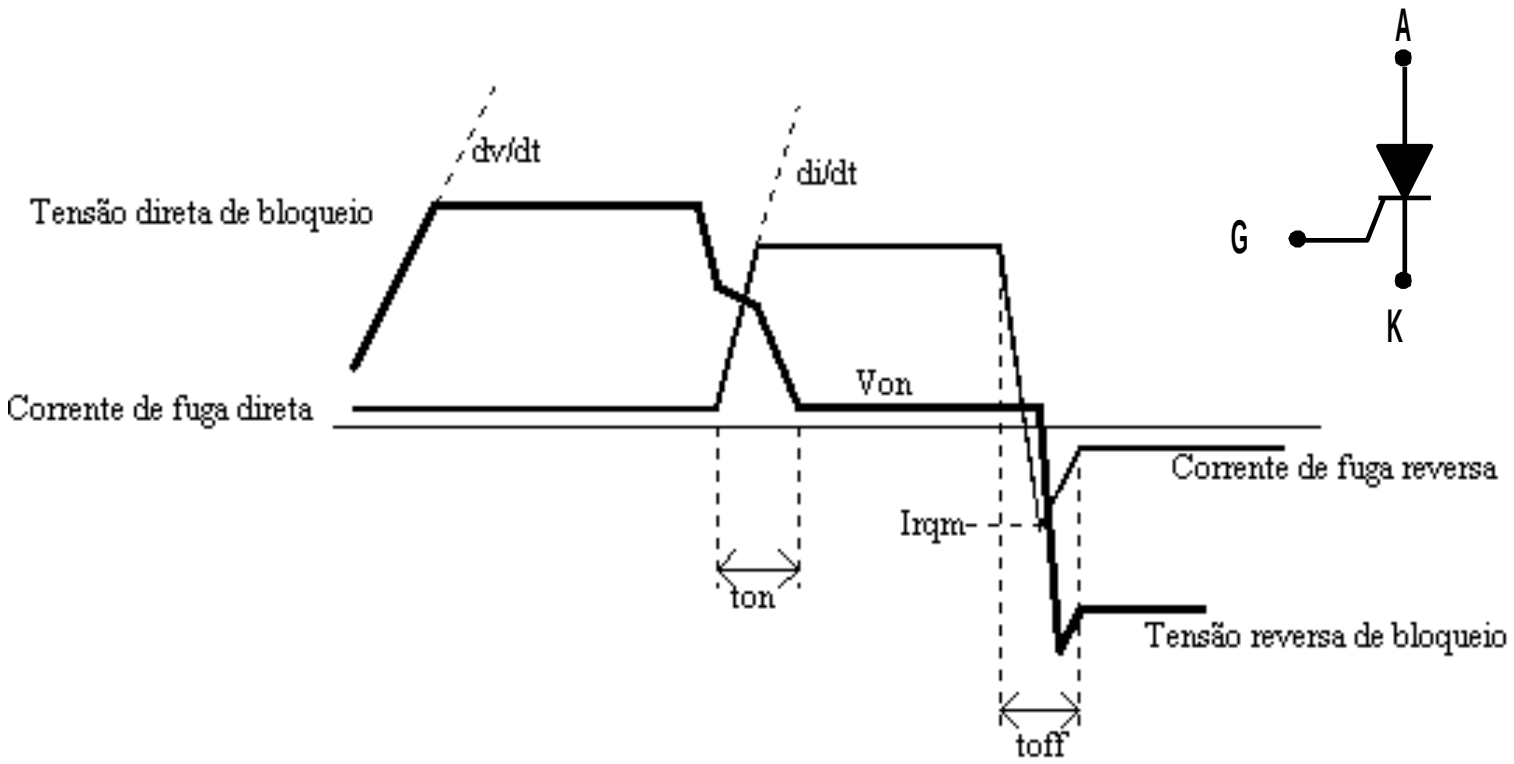






CARACTERÍSTICAS ESTÁTICAS IDEAIS

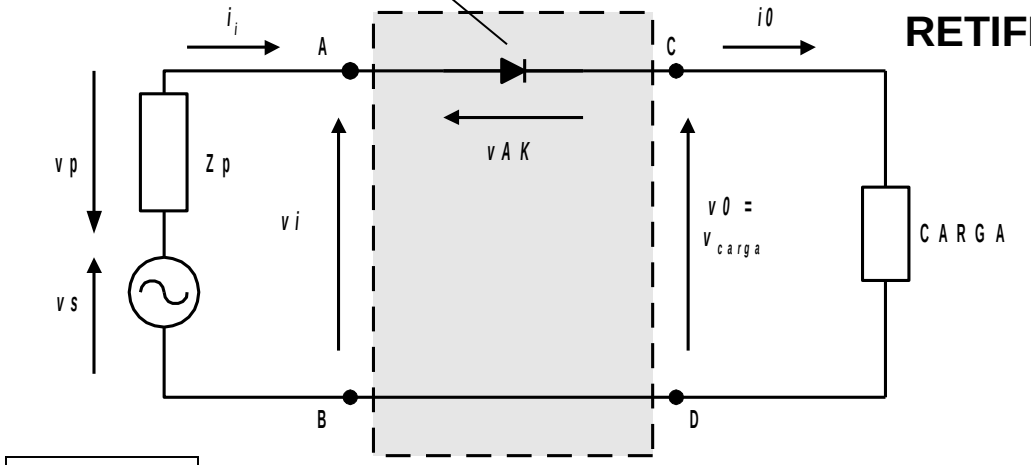
SCR – SILICON CONTROLLED RECTIFIER
CARACTERÍSTICAS DINÂMICAS



Chave Ideal → **Características Dinâmicas – ton = toff = 0**

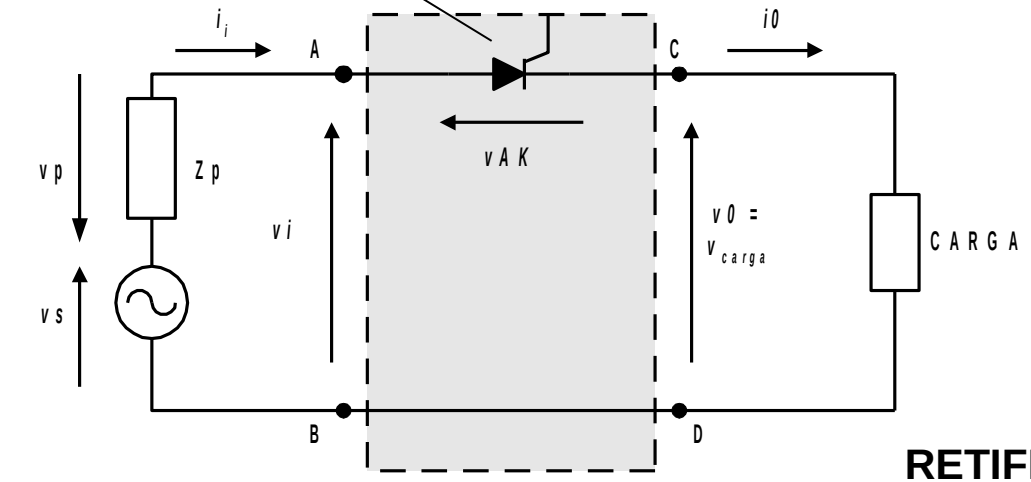
RETIFICADOR MONOFÁSICO DE MEIA-ONDA (ESTRUTURA BÁSICA)

DIODO



RETIFICADOR NÃO CONTROLADO

SCR



RETIFICADOR CONTROLADO

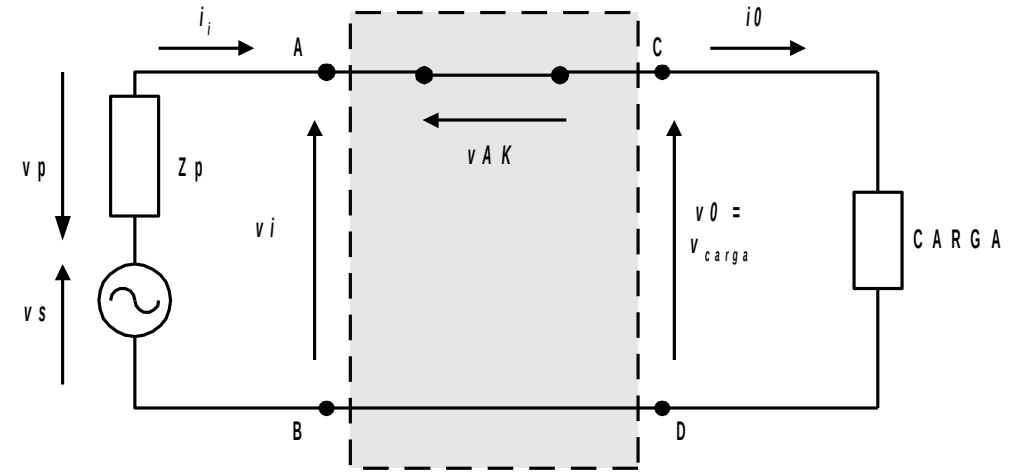
$$v_i = v_{AK} + v_o$$

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

$$v_s = v_p + v_i$$

$$i_0 = i_i$$

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



DIODO OU (SCR) EM CONDUÇÃO

$$v_{AK} = 0$$

$$V_0 = V_i = V_{\text{carga}}$$

$$V_s = V_p + V_i = V_p + V_0 = V_p + V_{\text{carga}}$$

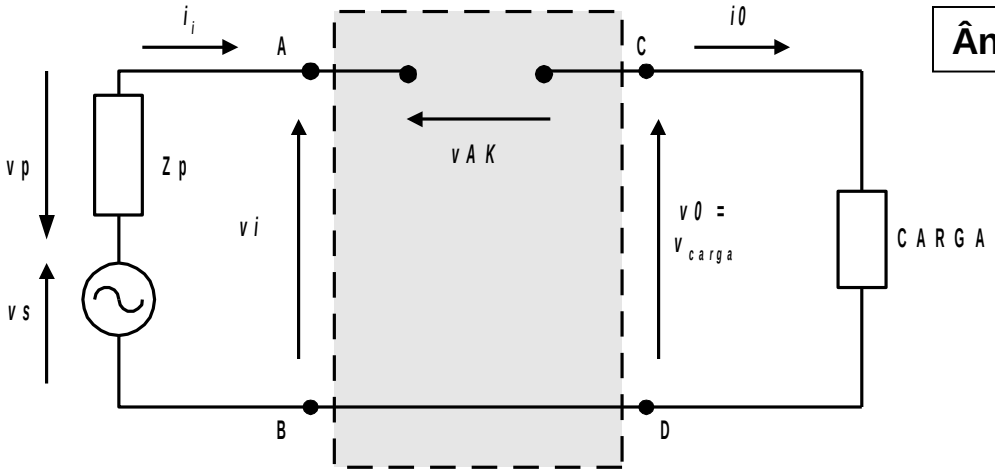
$$i_0 = i_i$$

Ângulo de Corte

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

Ângulo de Disparo

Ângulo de Condução



DIODO (OU SCR) EM BLOQUEIO

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

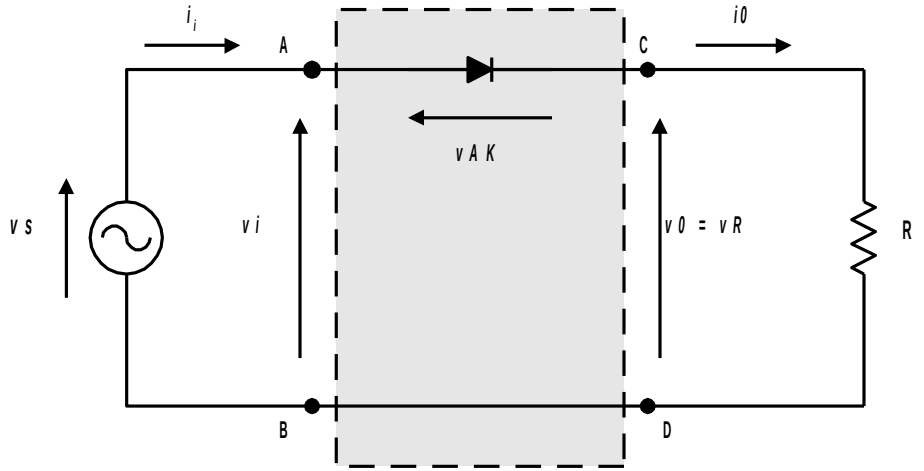
$$v_{AK} = v_i - v_0 = v_i - v_{\text{carga}}$$

$$i_0 = i_i = 0$$

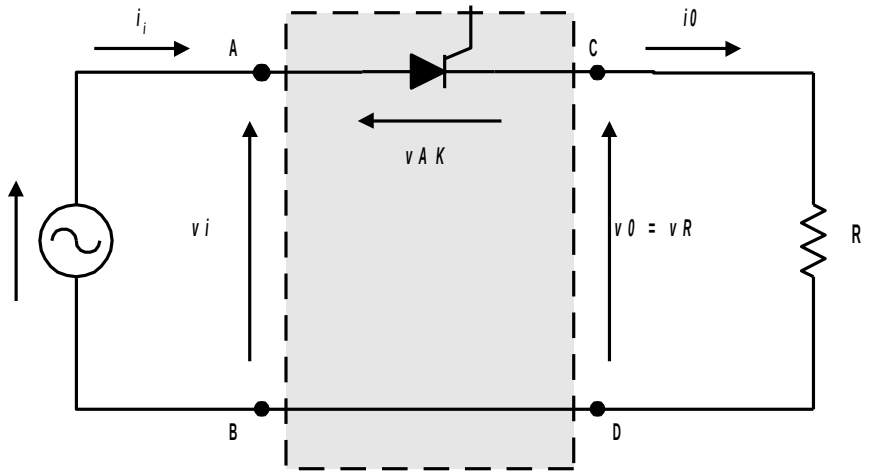
$$v_i = v_s - v_p$$

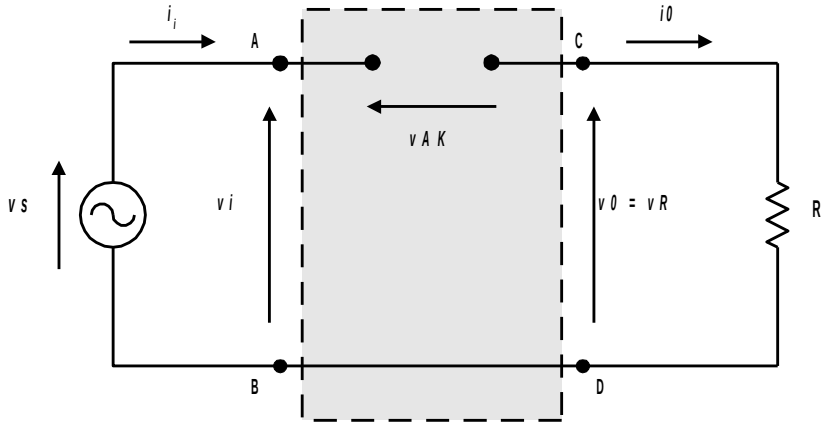
RETIFICADOR MONOFÁSICO DE MEIA-ONDA (CARGA RESISTIVA)

RETIFICADOR NÃO CONTROLADO

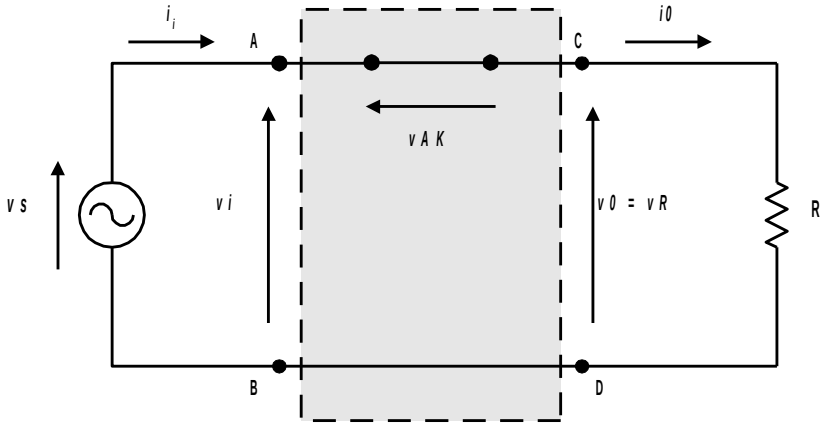


RETIFICADOR CONTROLADO



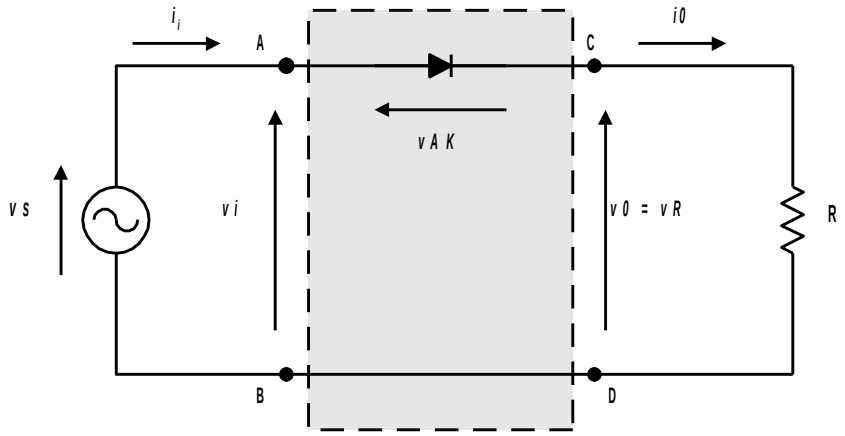


DIODO (OU SCR) EM BLOQUEIO

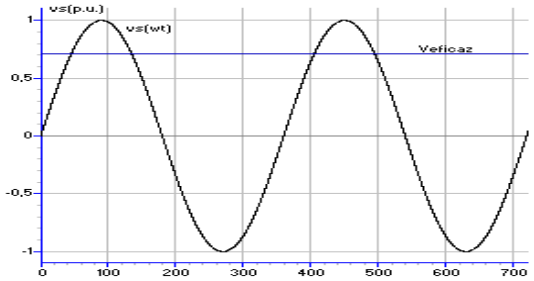


DIODO (OU SCR) EM CONDUÇÃO

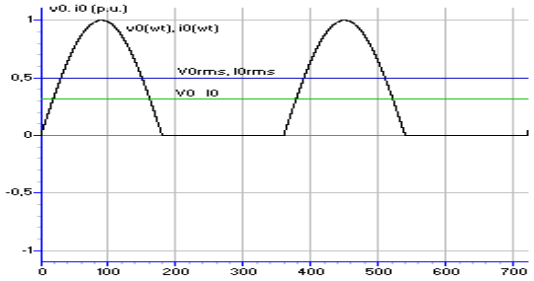
RETIFICADOR NÃO CONTROLADO COM CARGA RESISTIVA - FORMAS DE ONDA



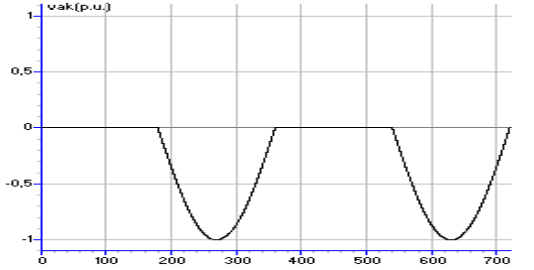
Tensão da Fonte



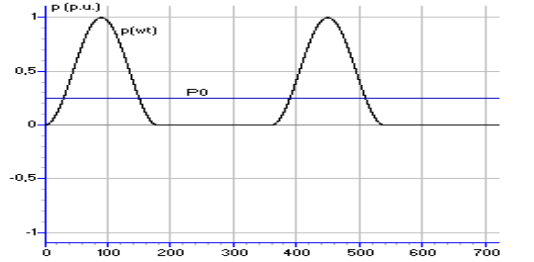
Tensão na Carga



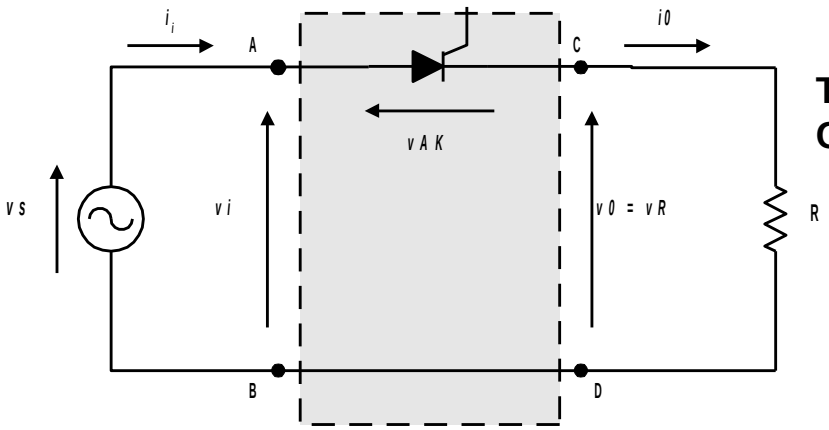
Tensão no Diodo



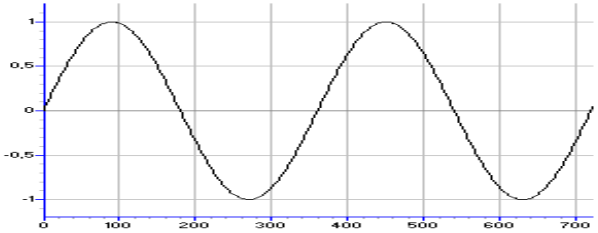
Potência na Fonte e na Carga



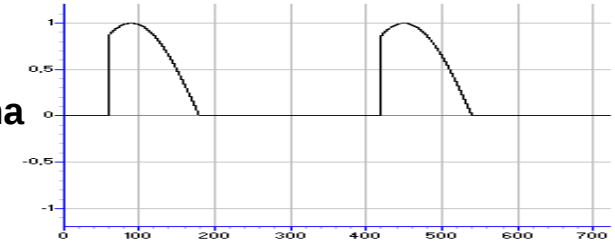
RETIFICADOR CONTROLADO COM CARGA RESISTIVA - FORMAS DE ONDA



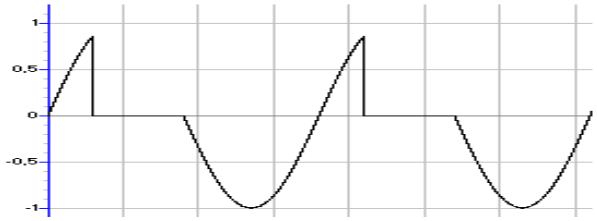
Tensão da Fonte



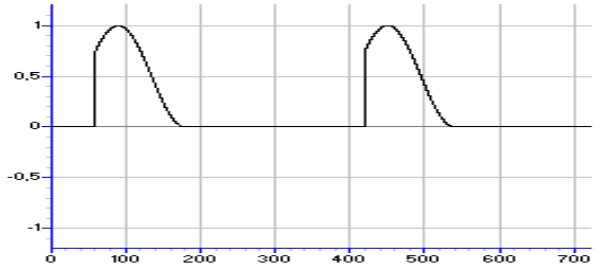
Tensão e corrente na Carga



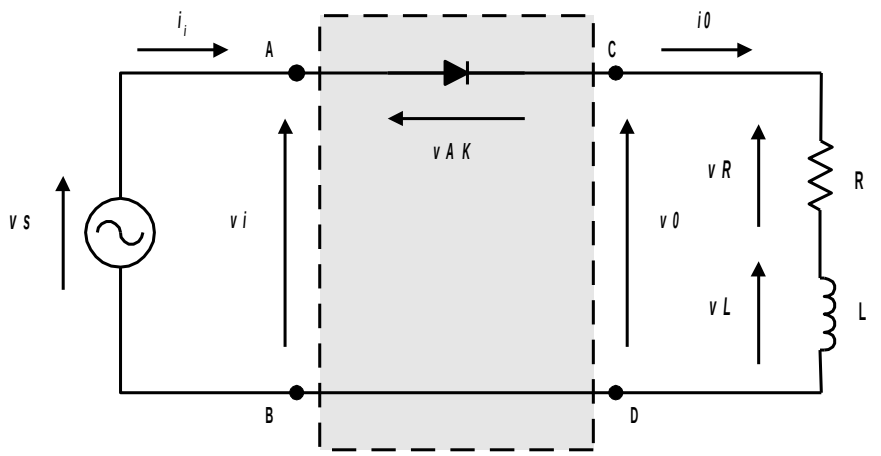
Tensão no SCR

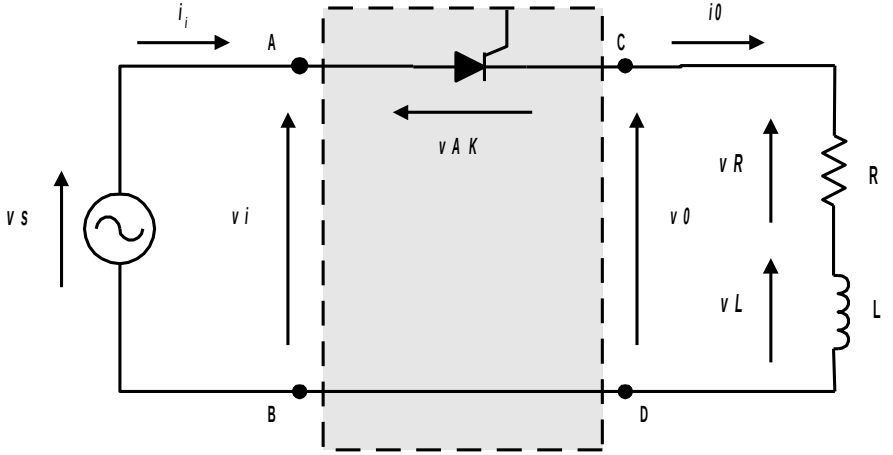


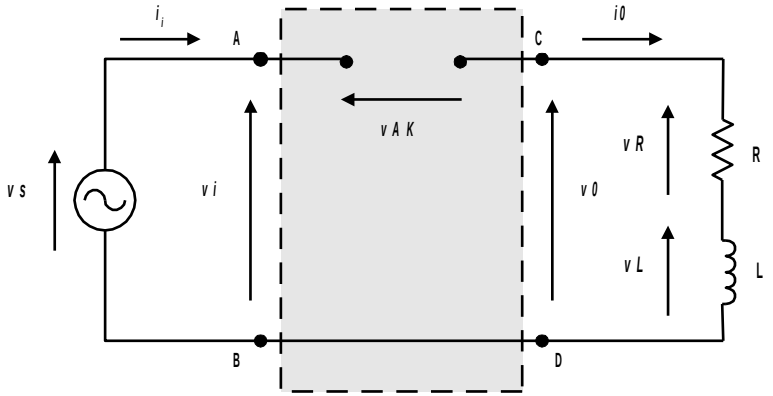
Potência na Fonte e na Carga



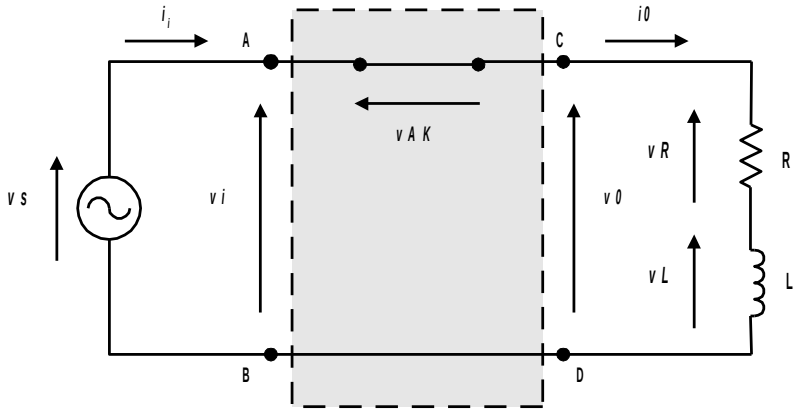
RETIFICADOR MONOFÁSICO DE MEIA-ONDA (CARGA INDUTIVA)





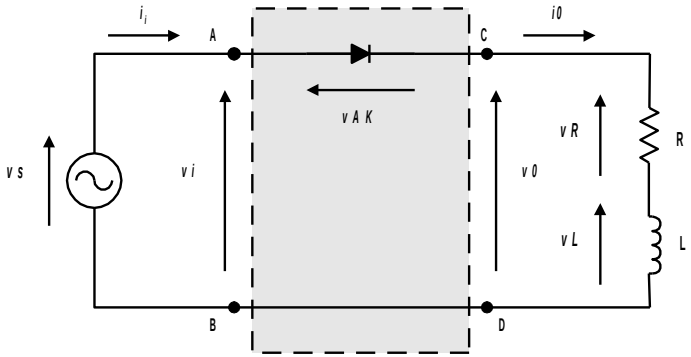


DIODO (OU SCR) EM BLOQUEIO

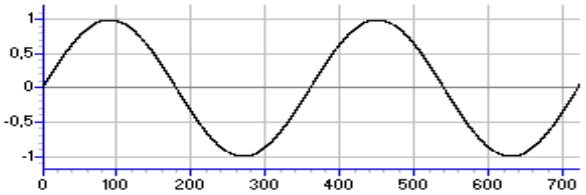


DIODO (OU SCR) EM CONDUÇÃO

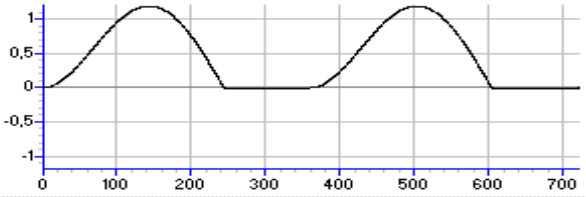
RETIFICADOR NÃO CONTROLADO COM CARGA INDUTIVA - FORMAS DE ONDA



Tensão da Fonte



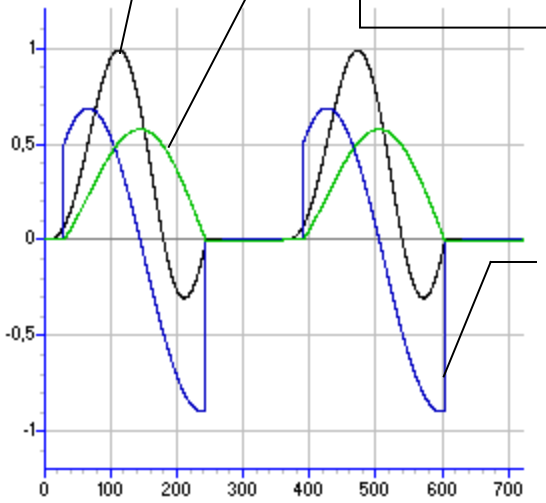
Corrente



Potência na Fonte

Potência em R

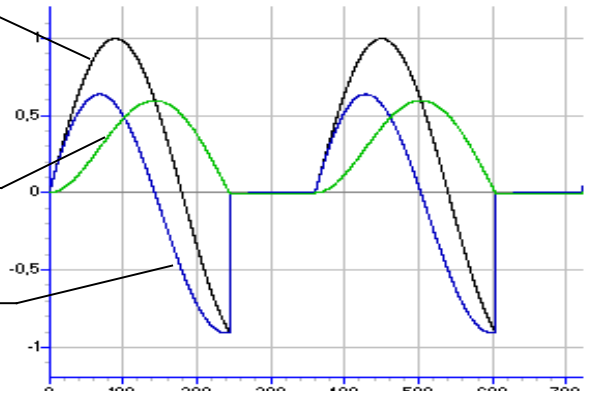
Potência em L



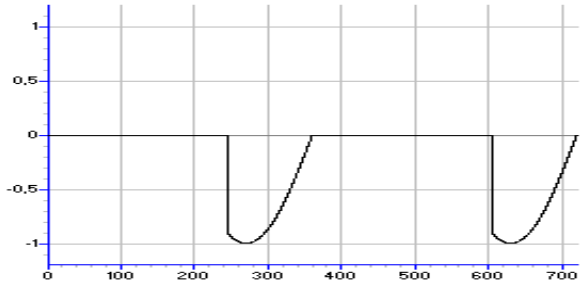
Tensão de saída

Tensão em R

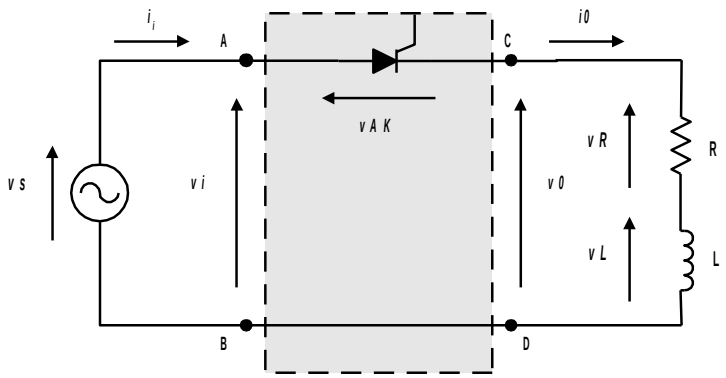
Tensão em L



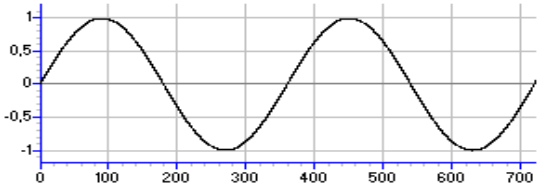
Tensão no Diodo



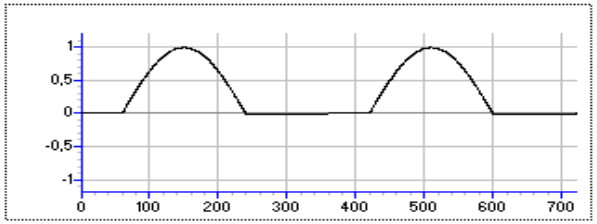
RETIFICADOR CONTROLADO COM CARGA INDUTIVA - FORMAS DE ONDA



Tensão da Fonte



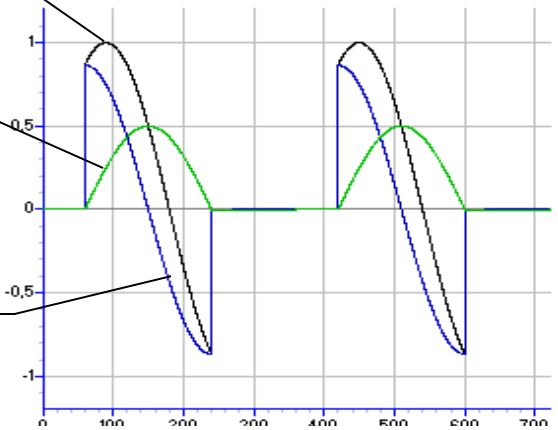
Corrente



Tensão de saída

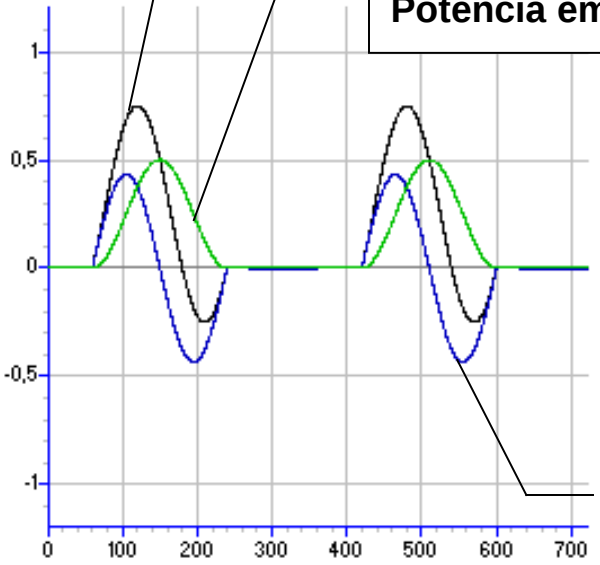
Tensão em R

Tensão em L



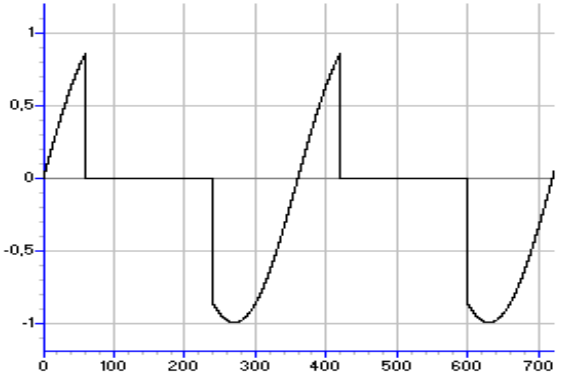
Potência na Fonte

Potência em R

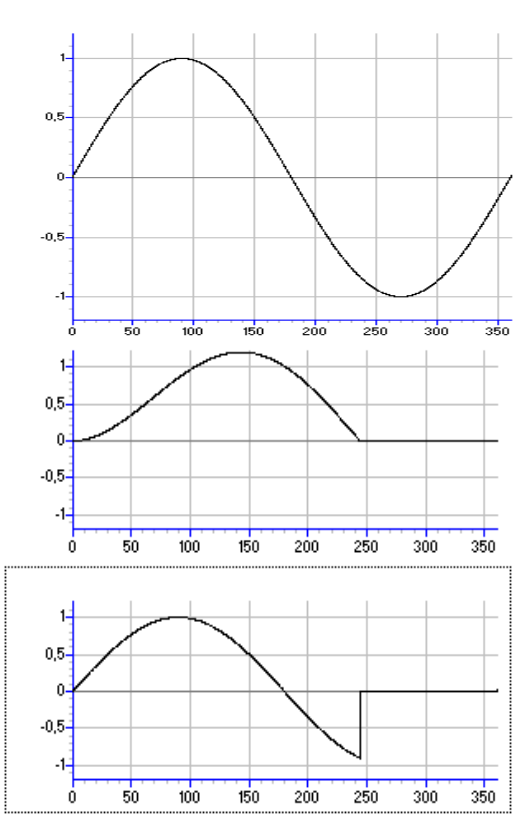


Potência em L

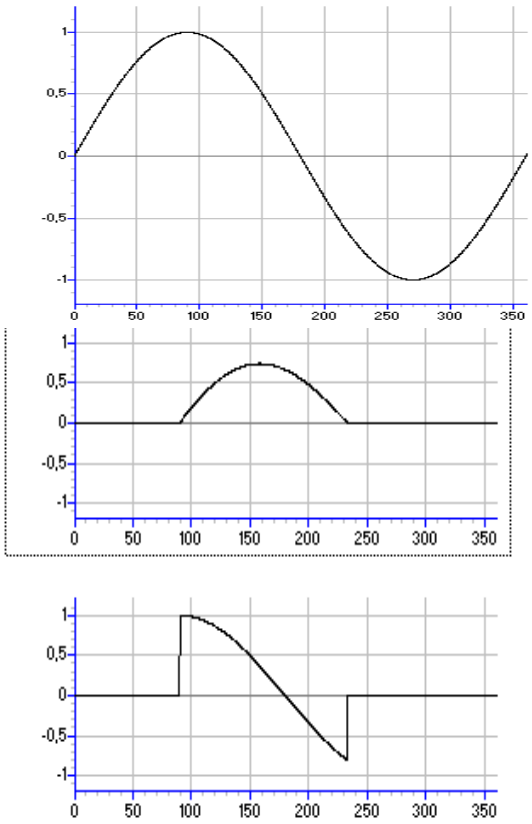
Tensão no SCR



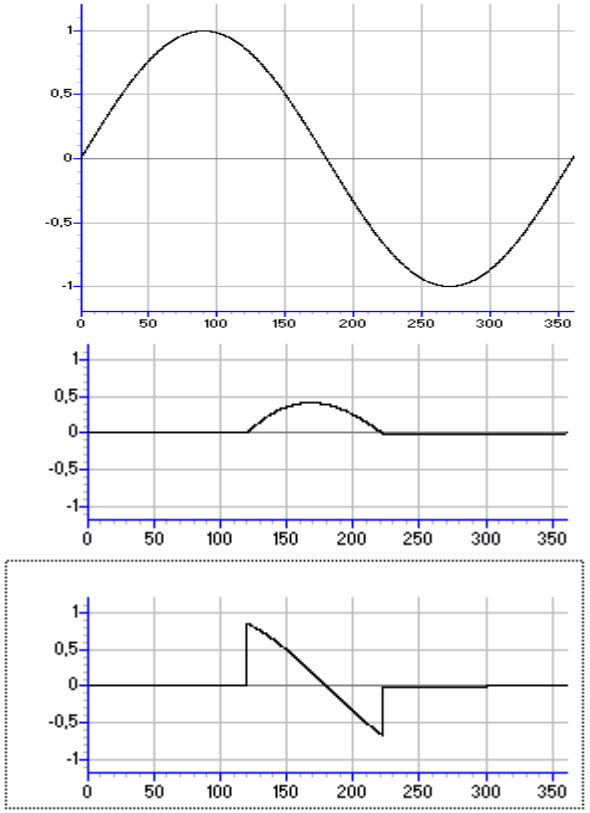
VARIAÇÕES DA CORRENTE E DA TENSÃO NA CARGA COM O ÂNGULO DE DISPARO



$\alpha = 0^0$



$\alpha = 90^0$

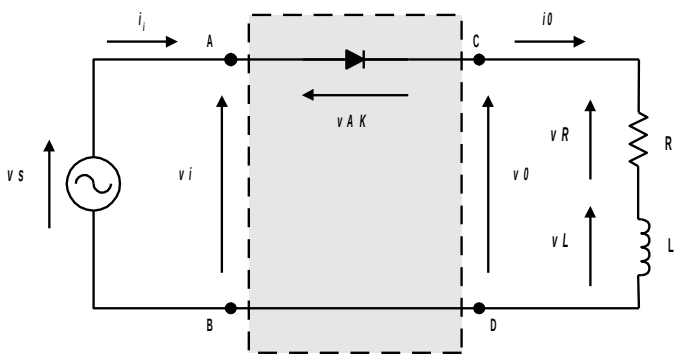


$\alpha = 120^0$

Retificadores Monofásicos de Meia-Onda

Curvas de Projeto

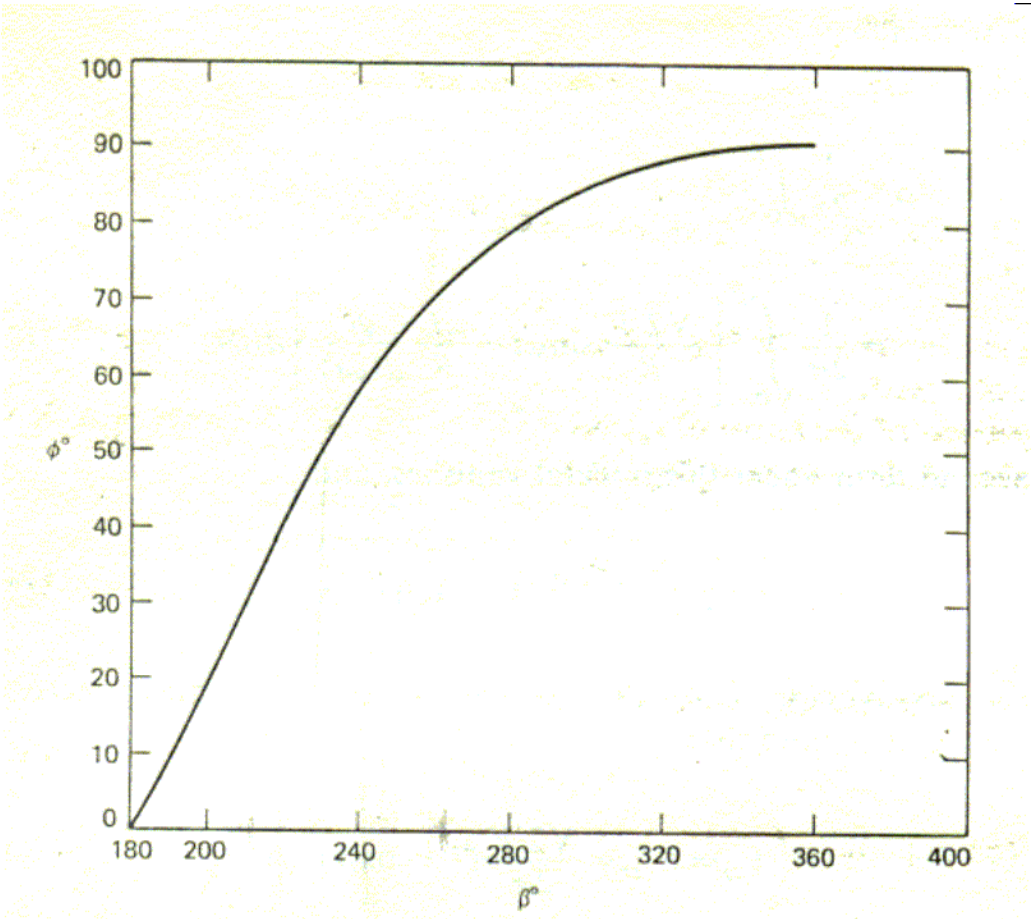
RETIFICADOR MONOFÁSICO DE MEIA-ONDA NÃO CONTROLADO
Ângulo de Condução – Carga RL



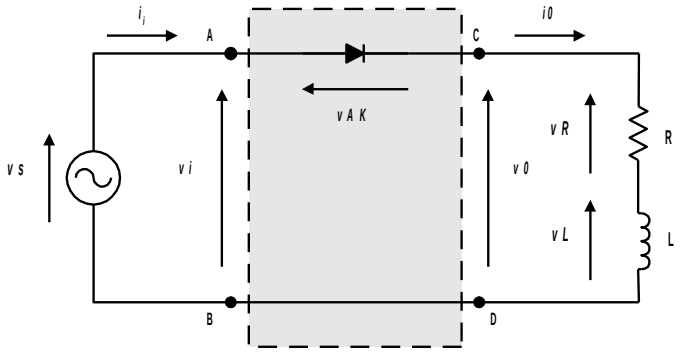
$$\operatorname{sen}(\beta-\phi)+e^{-\beta/\tan\phi}.\operatorname{sen}\phi=0$$

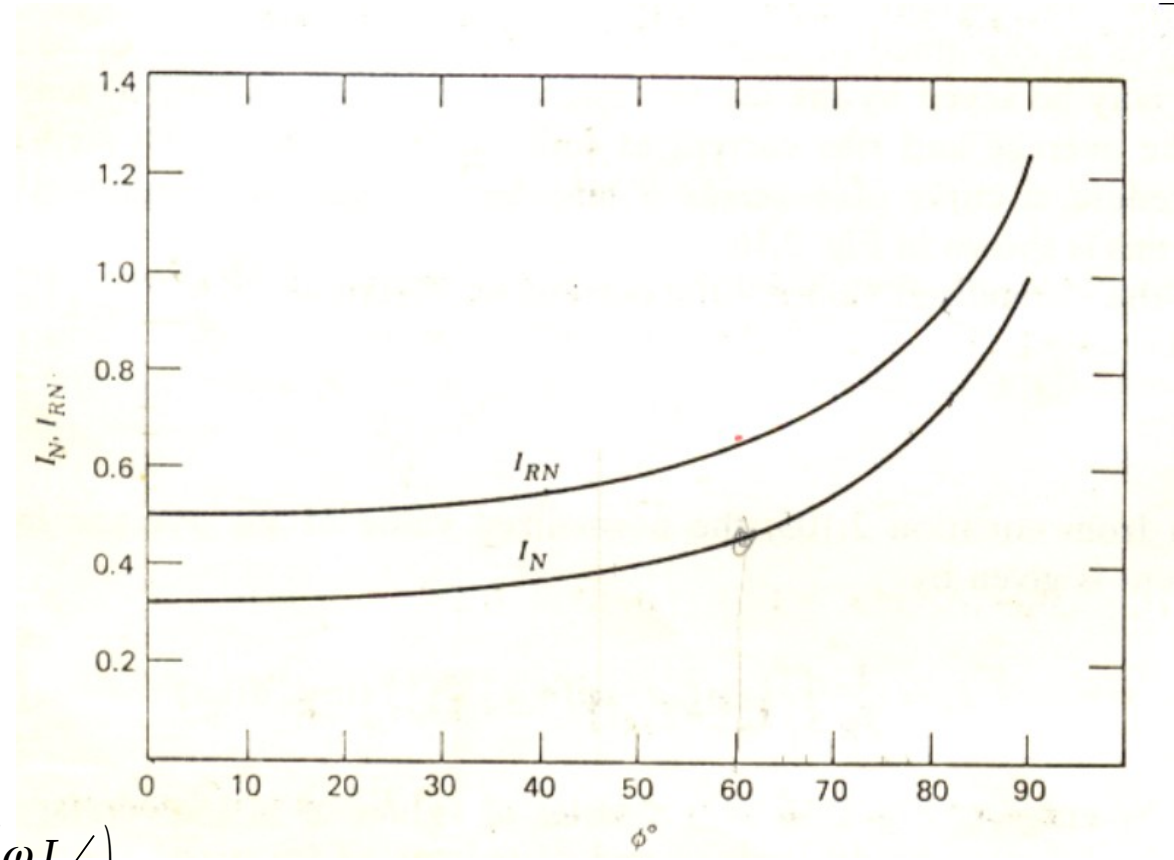
$$\gamma=\beta-\alpha$$

$$\alpha=0^0$$



RETIFICADOR MONOFÁSICO DE MEIA-ONDA NÃO CONTROLADO
Correntes média e rms normalizadas – Carga RL





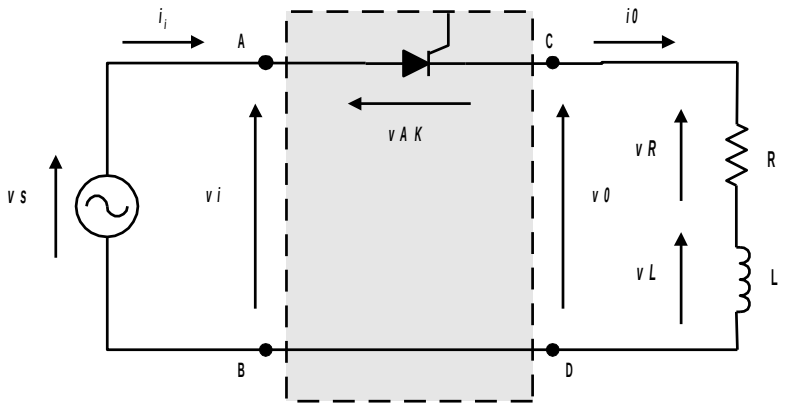
$$i_N = sen(\omega.t - \phi) + e^{-\omega.t/\tan\phi}.sen\phi$$

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

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

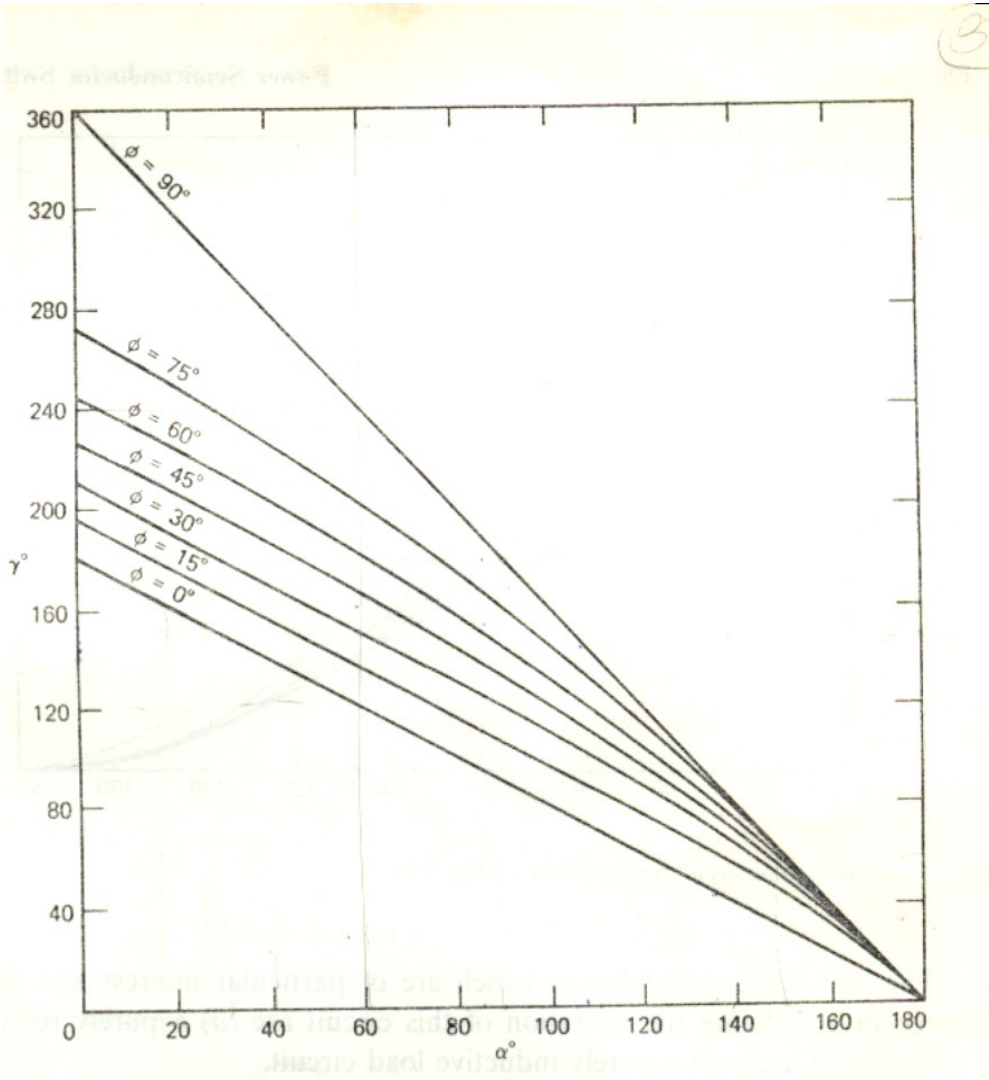
$$I_N = \frac{1}{2.\pi}\int_{\alpha=0}^{\beta=\gamma+\alpha=\gamma} i_N.d\omega t \quad ; \quad I_{RN} = \sqrt{\frac{1}{2.\pi}\int_{\alpha=0}^{\beta=\gamma+\alpha=\gamma} i_N^2.d\omega t}$$

RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO
Ângulo de Condução – Carga RL

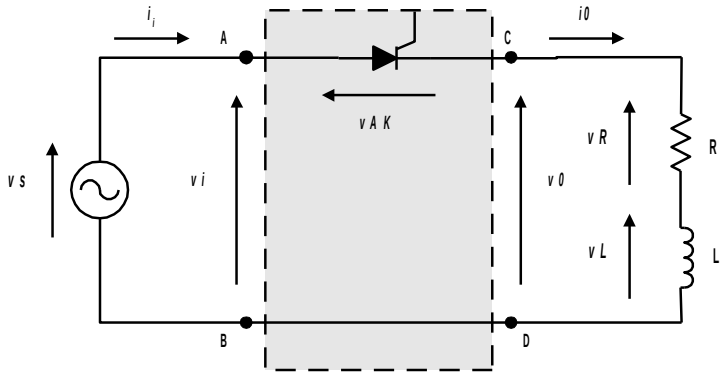


$$\text{sen}(\beta-\phi)=\text{sen}(\alpha-\phi).e^{[\alpha-\beta]/\tan\phi}$$

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



RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO
Corrente Média Normalizada – Carga RL

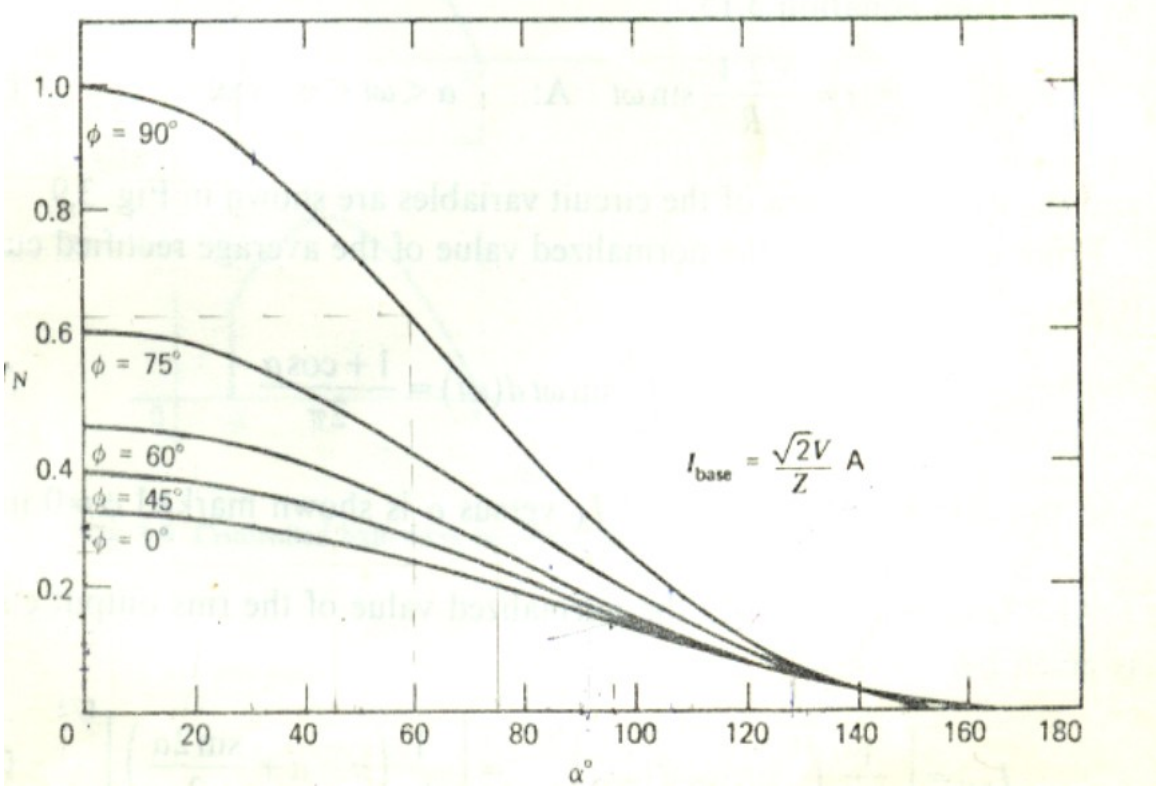


$$i_N = \text{sen}(\omega.t - \phi) - e^{(\alpha - \omega.t)/\tan\phi}.\text{sen}(\alpha - \phi)$$

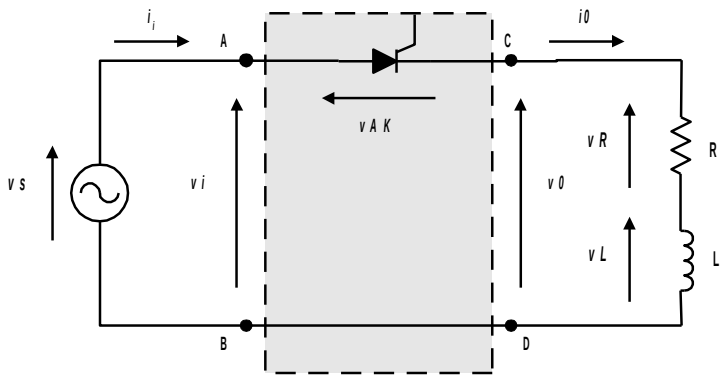
$$i_N = {i(\omega.t)}/{I_{base}} \quad ; \quad I_{base} = {\sqrt{2}.V}/{Z}$$

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

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



RETIFICADOR MONOFÁSICO DE MEIA-ONDA CONTROLADO
Corrente RMS Normalizada – Carga RL



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

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

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

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