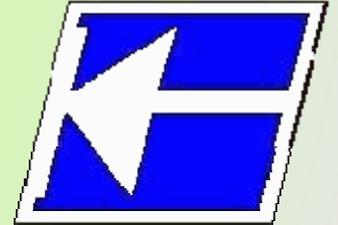


Centro Federal de Educação Tecnológica de Santa Catarina
Departamento Acadêmico de Eletrônica
Conversores Estáticos



Conversores CA-CA

Gradadores

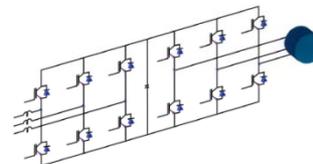
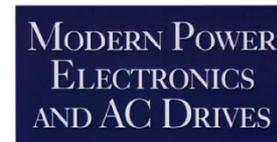
Prof. Clóvis Antônio Petry.

Florianópolis, março de 2008.

Bibliografia para esta aula

Capítulo 11: Controlador de tensão AC

1. Gradadores.



BIMAL K. BOSE

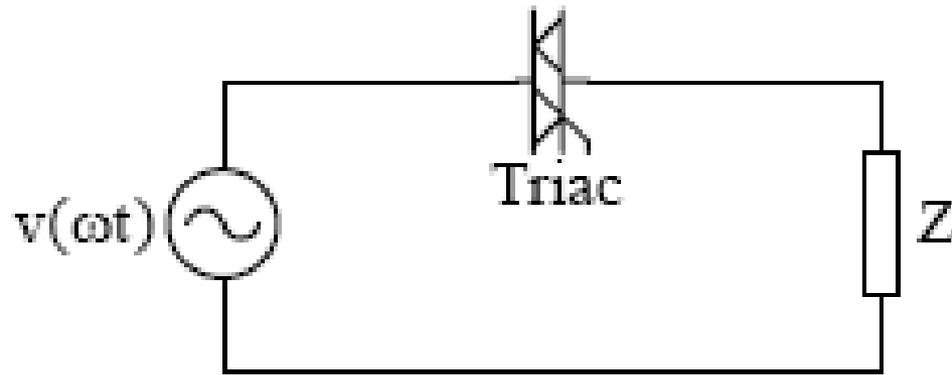
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Nesta aula

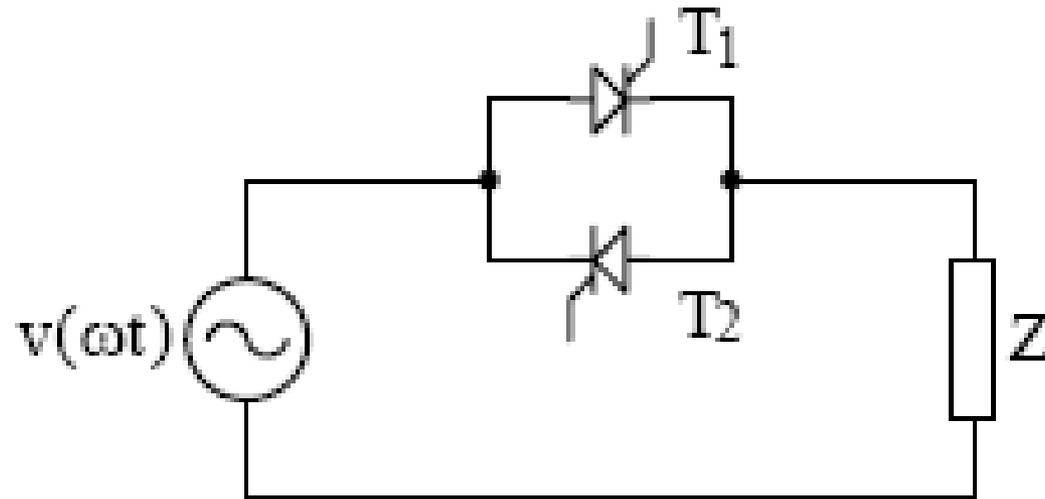
Gradadores:

1. Introdução;
2. Gradadores monofásicos:
 - Carga resistiva;
 - Carga RL.
3. Gradadores trifásicos;
4. Controle por ciclos inteiros;
5. Compensador estático de potência reativa.

Gradadores monofásicos



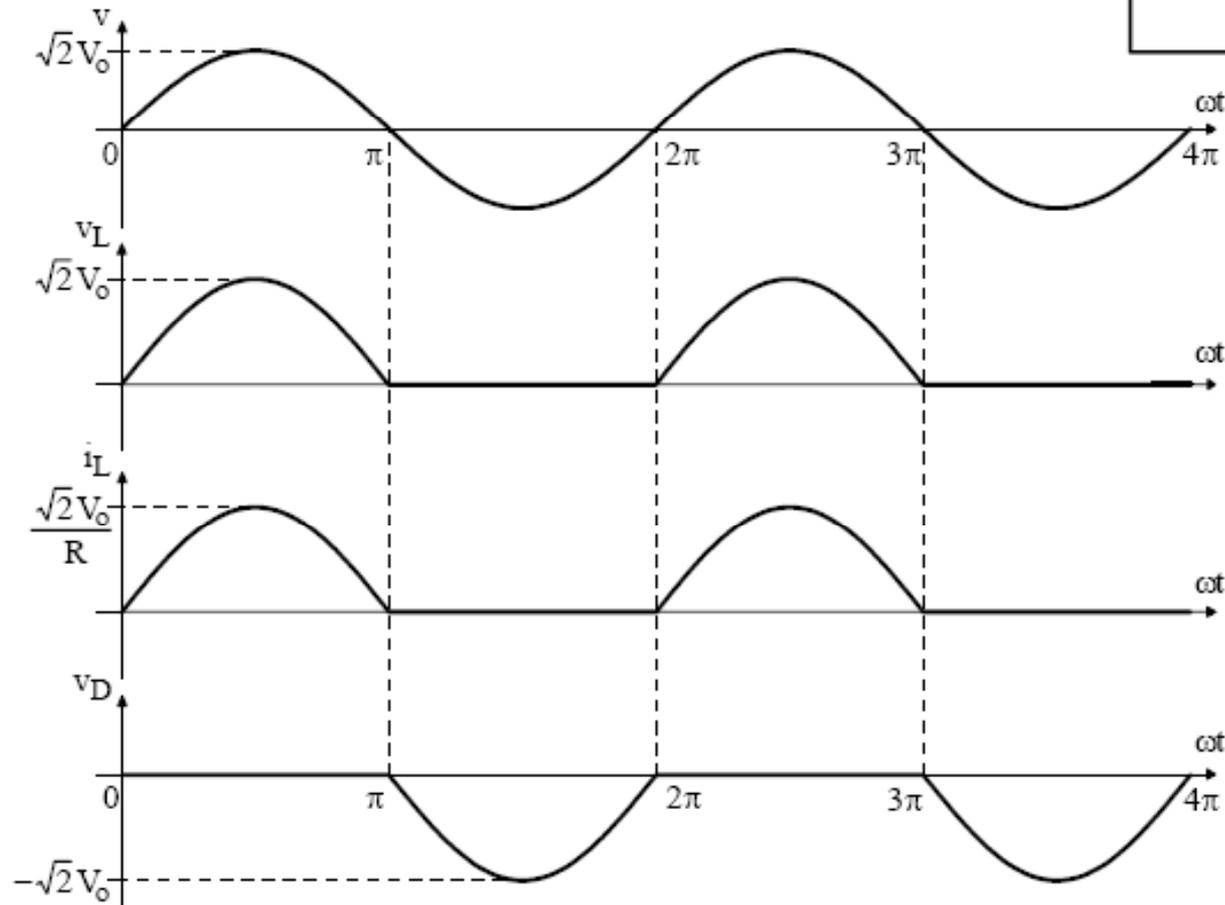
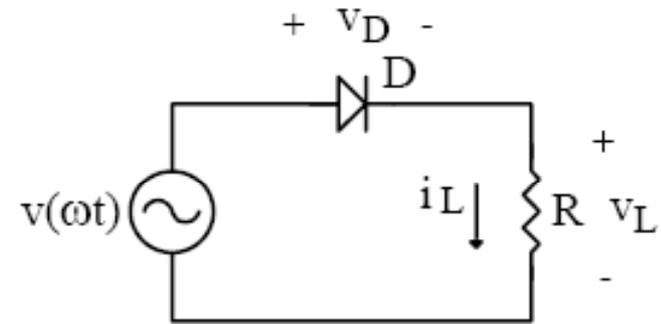
Gradador usando triac



Gradador usando tiristores

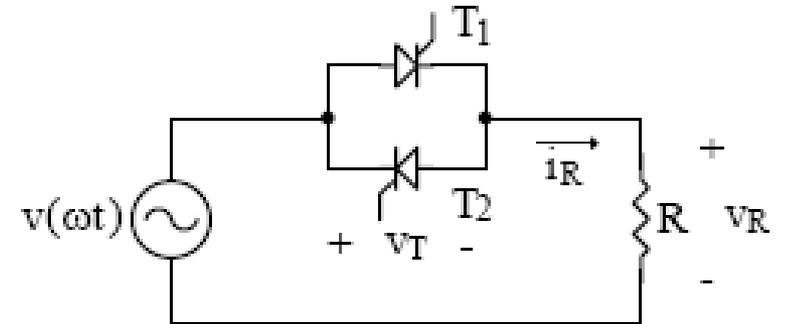
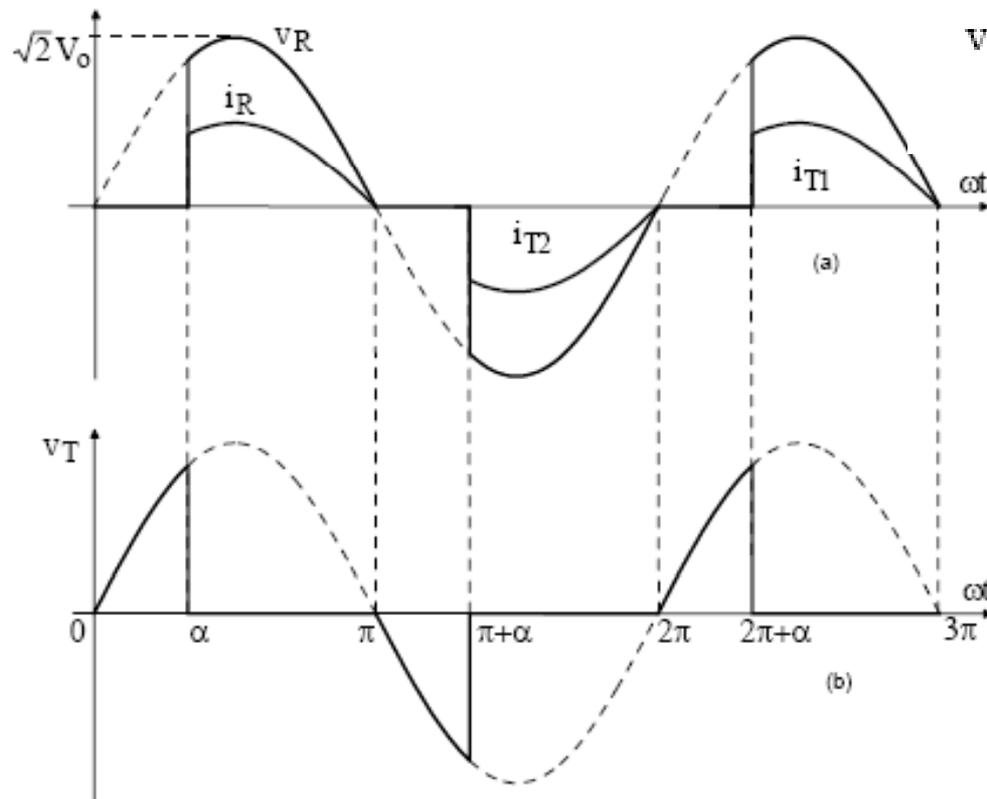
Gradadores monofásicos

Retificador com carga resistiva pura:



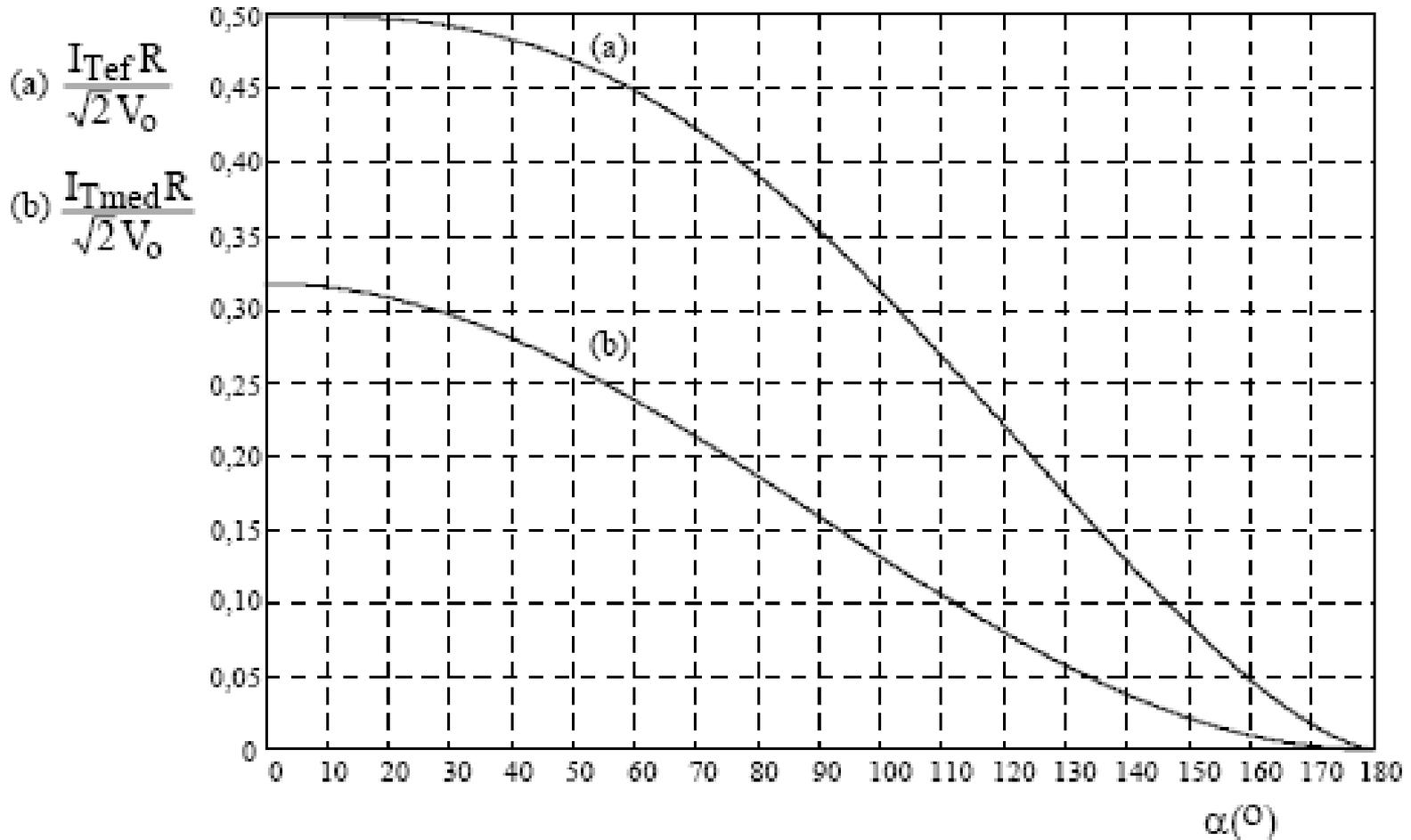
Gradadores monofásicos

Gradador com carga resistiva pura:



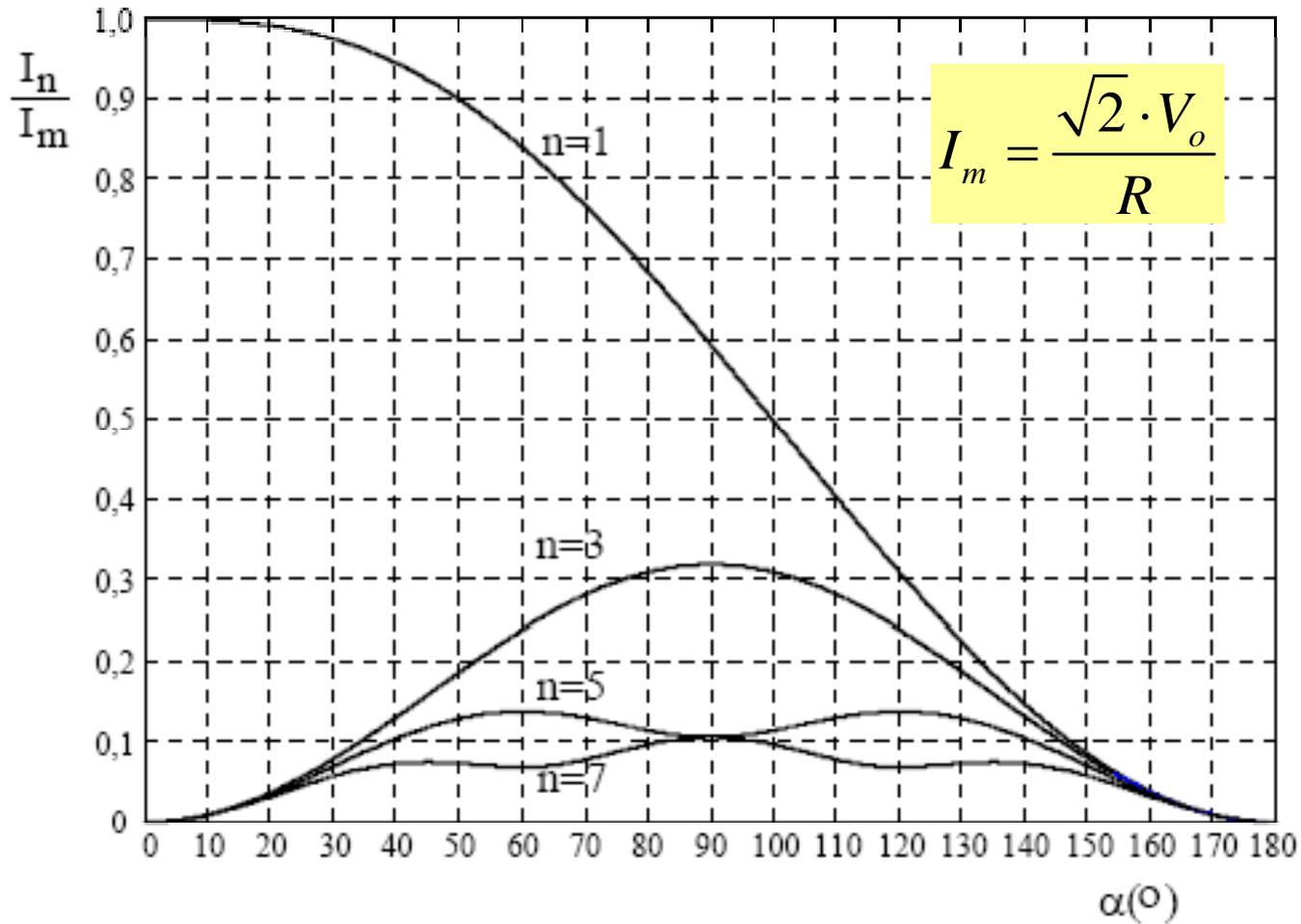
Gradadores monofásicos

Correntes média e eficaz na carga:



Gradadores monofásicos

Harmônicas da corrente de carga:



Gradadores monofásicos

Harmônicas da corrente de carga, exemplo:

$$V_o = 220V$$

$$P_o = 4800W$$

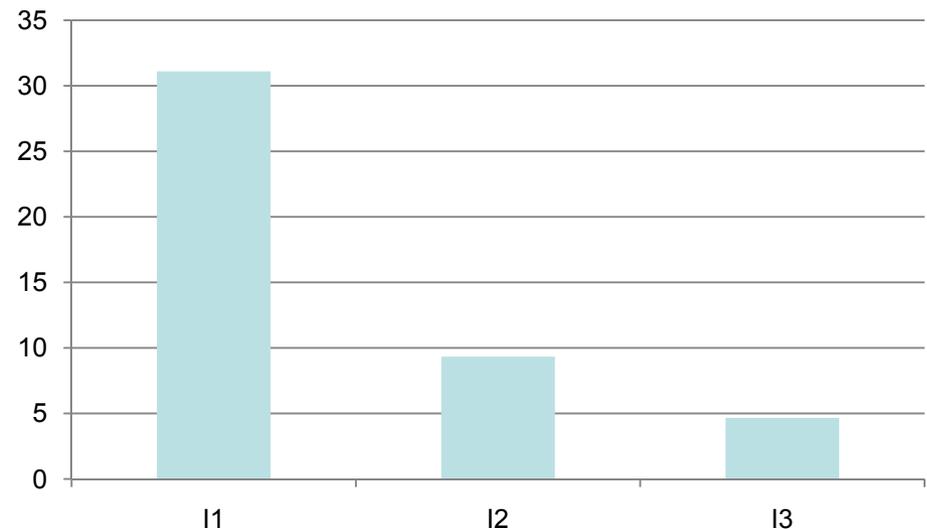
$$R = \frac{V_o^2}{P_o} = \frac{220^2}{4800} = 10\Omega$$

$$I_m = \frac{\sqrt{2} \cdot V_o}{R} = \frac{311}{10} = 31,1A$$

$$I_1 = 1 \cdot I_m = 31,1A$$

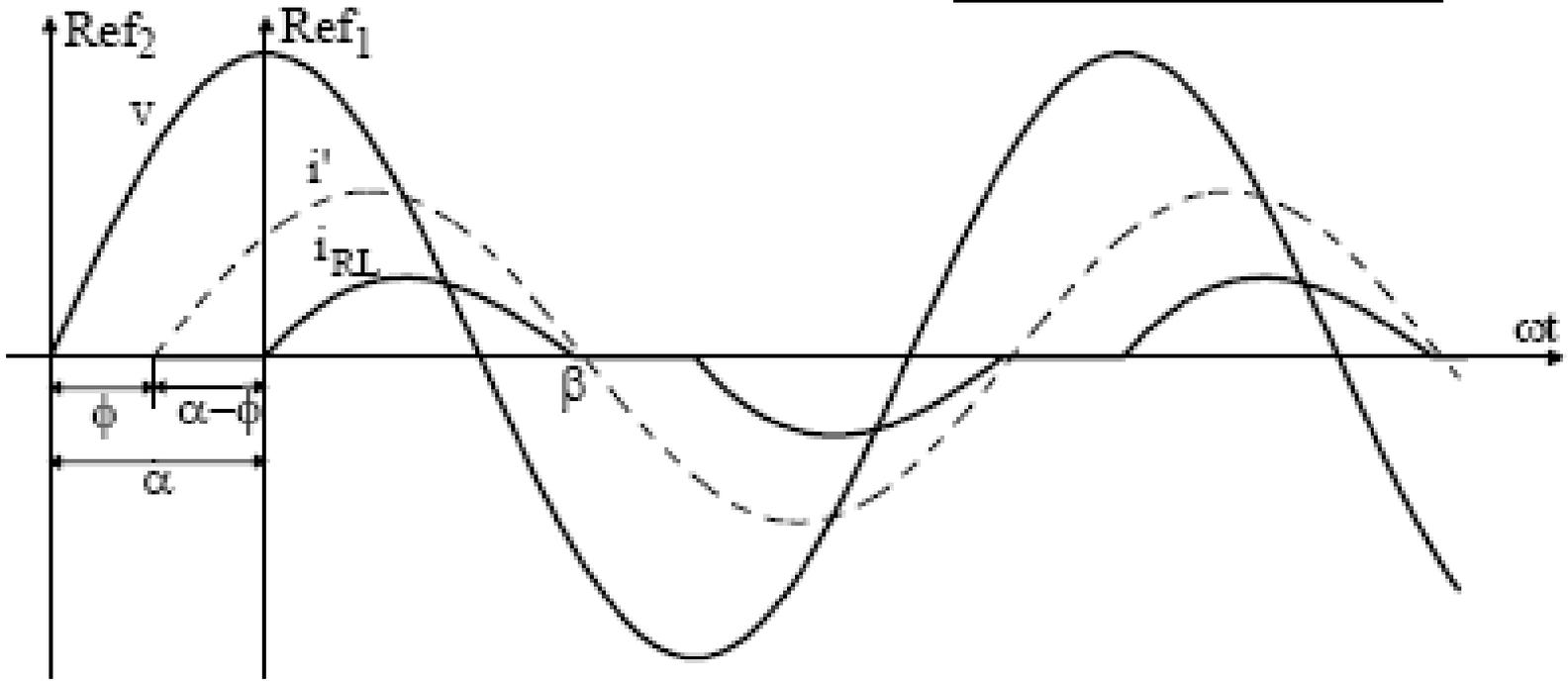
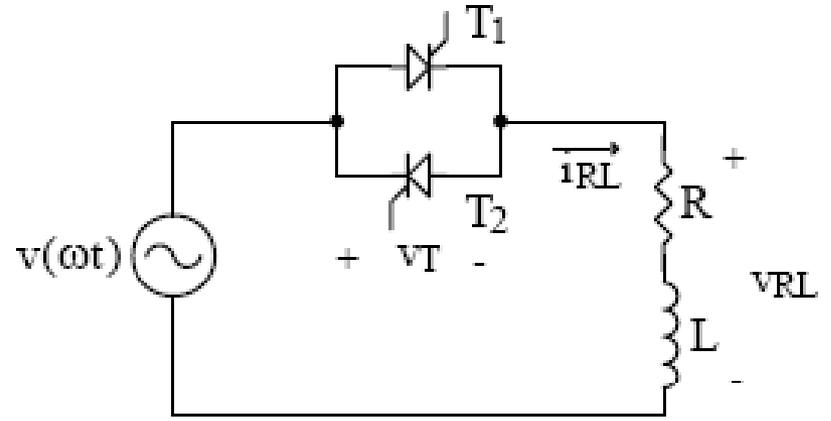
$$I_3 = 0,3 \cdot I_m = 9,33A$$

$$I_5 = 0,15 \cdot I_m = 4,66A$$



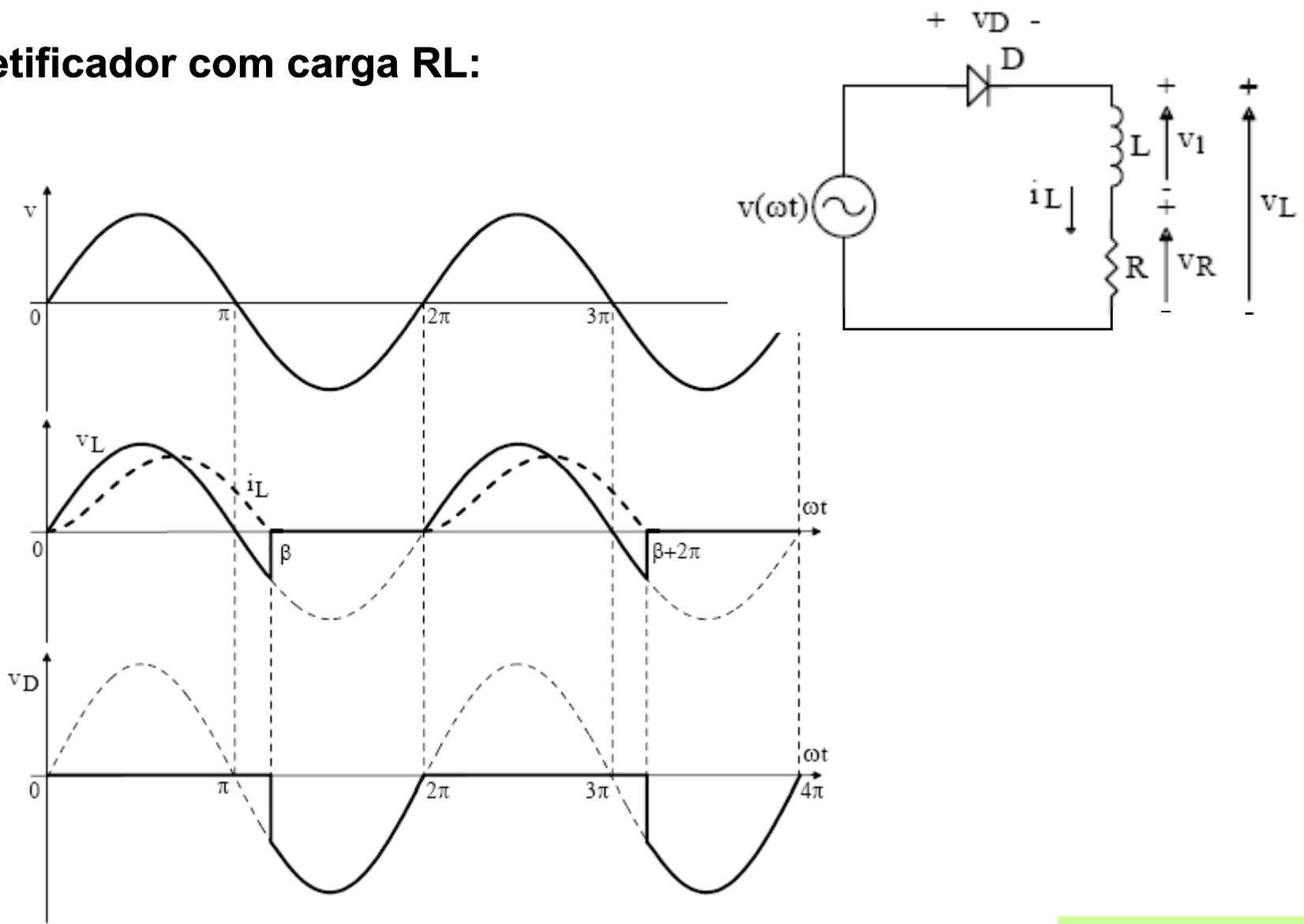
Gradadores monofásicos

Retificador com carga RL:



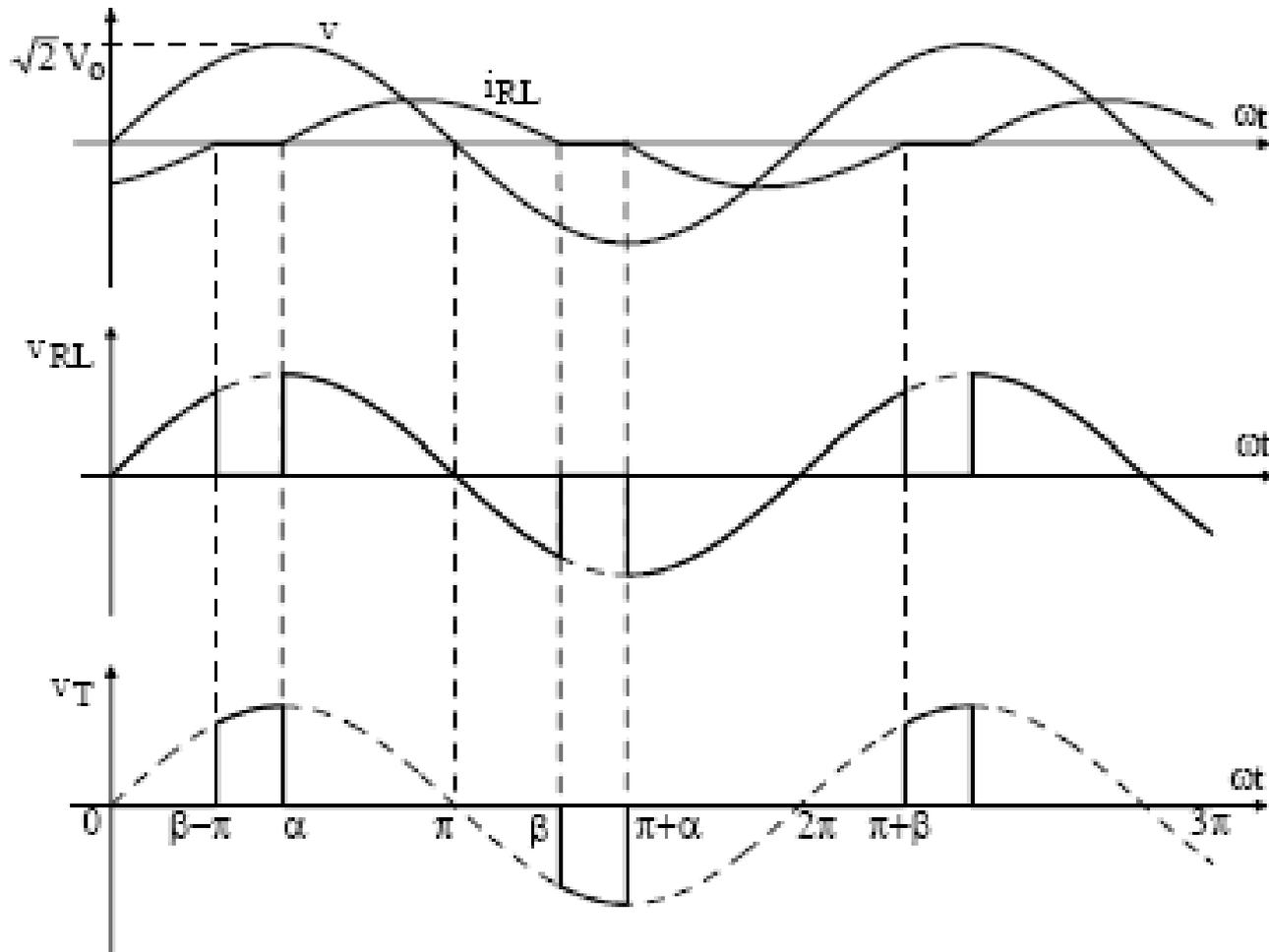
Gradadores monofásicos

Retificador com carga RL:

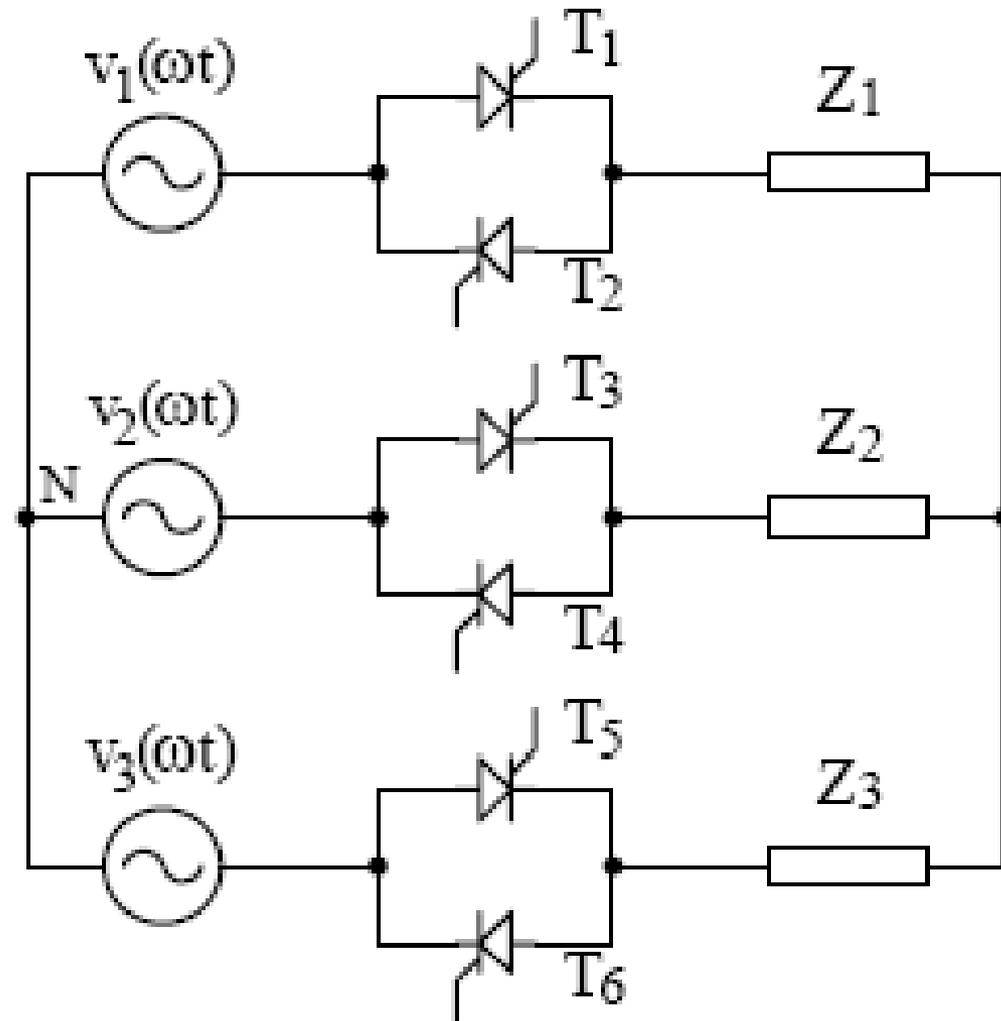


Gradadores monofásicos

Retificador com carga RL:

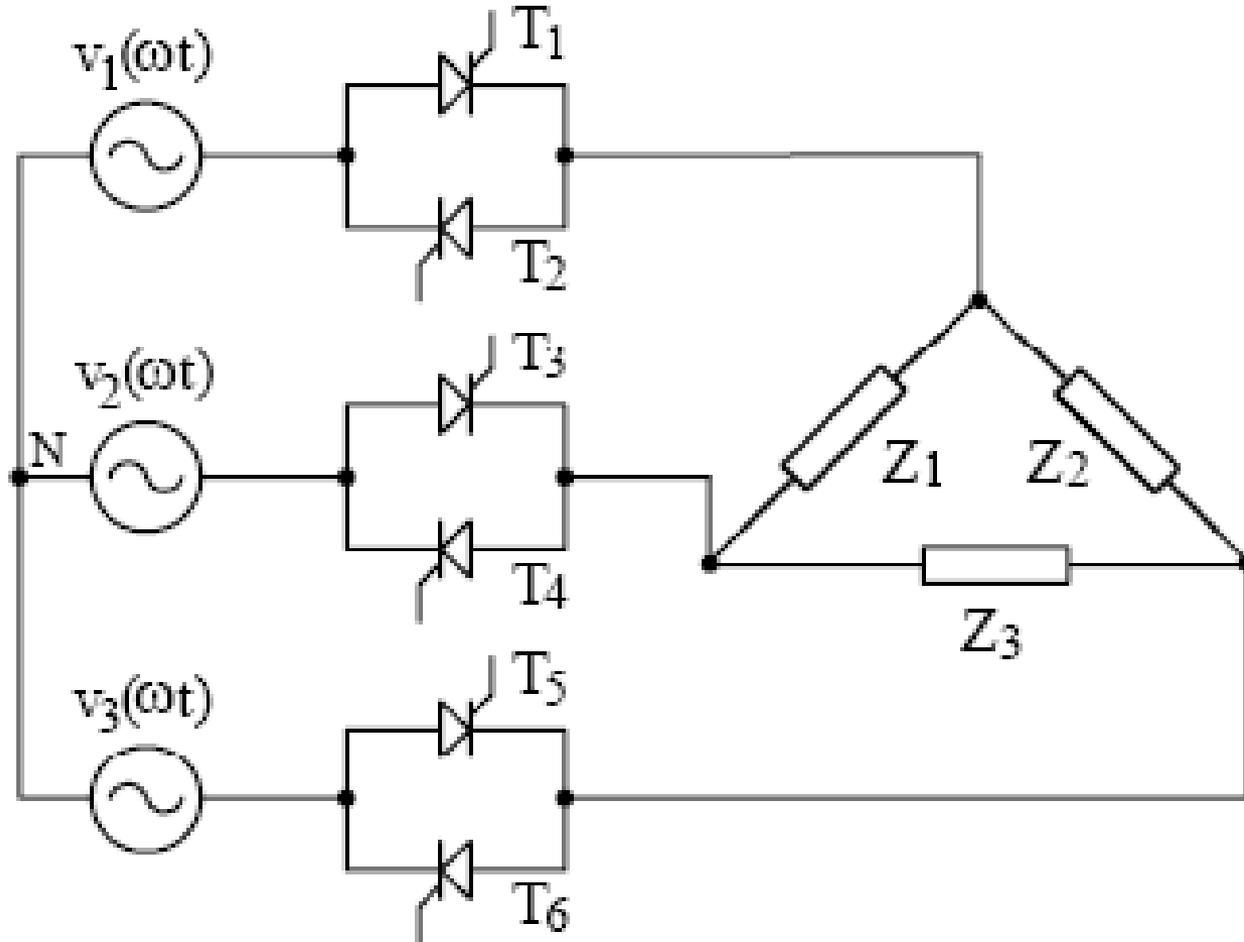


Gradadores trifásicos



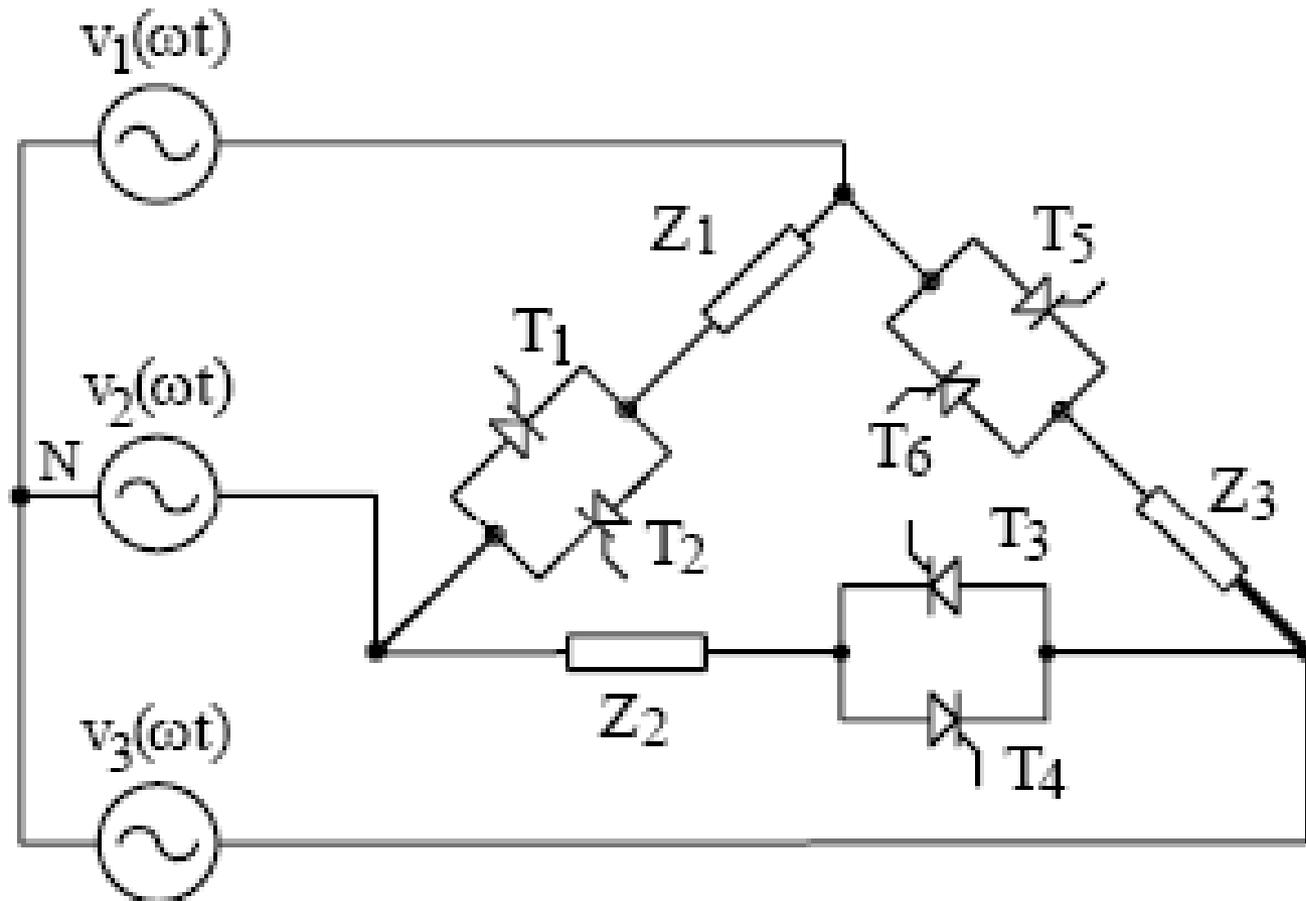
Carga conectada em estrela (Y)

Gradadores trifásicos



Carga conectada em delta (Δ)

Gradadores trifásicos



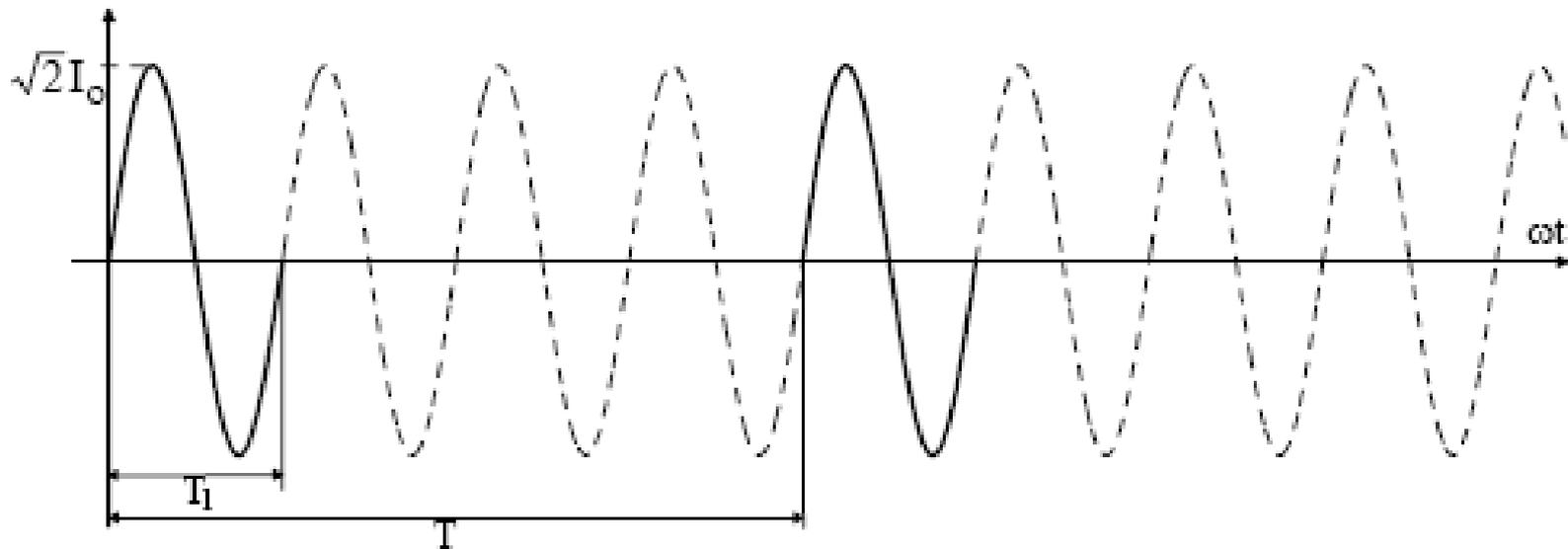
Carga conectada em delta (Δ)

Controle por ciclos inteiros

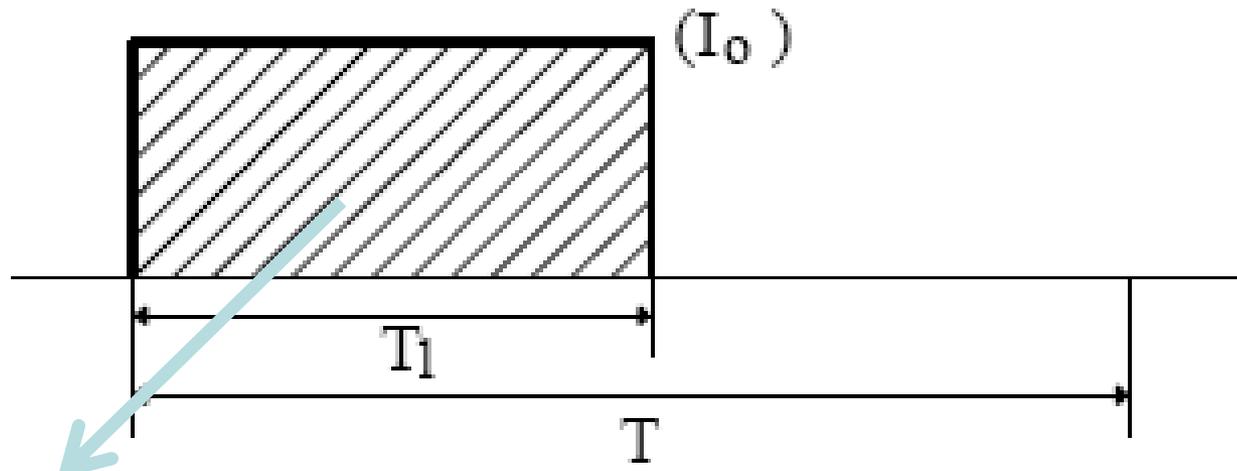
Deficiências dos gradadores:

1. Introduzem harmônicas significativas de corrente na rede;
2. Para ângulos de disparo (α) elevados o fator de potência é baixo.

Controle por ciclos inteiros:



Controle por ciclos inteiros



$$W_1 = R \cdot I_o^2 \cdot T_1$$

$$W_2 = R \cdot I^2 \cdot T$$

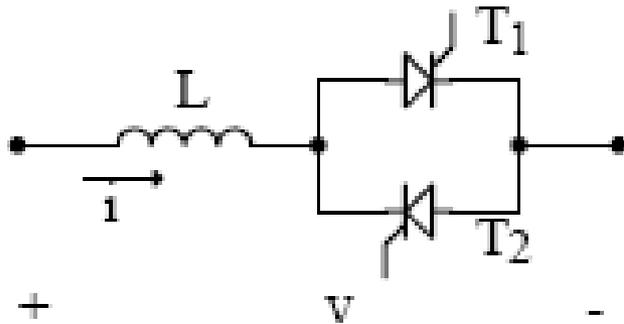
m = número de ciclos aplicados à carga;
M = número de ciclos da rede.

$$W_1 = W_2$$

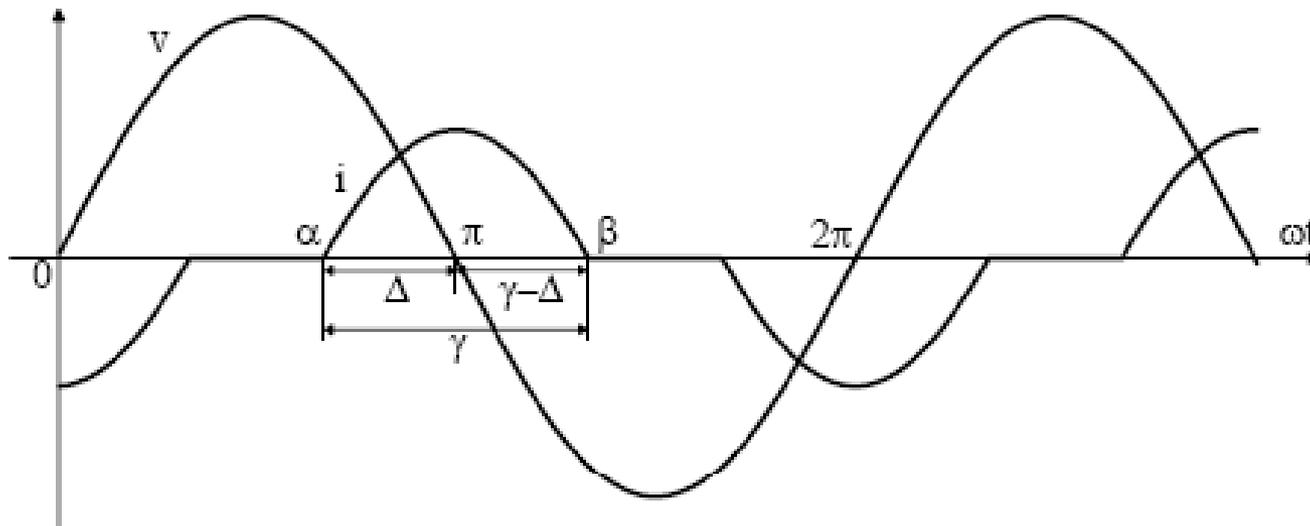
$$R \cdot I_o^2 \cdot T_1 = R \cdot I^2 \cdot T$$

$$I = \sqrt{\frac{T_1}{T}} \cdot I_o = \sqrt{\frac{m}{M}} \cdot I_o$$

Compensador estático de potência reativa

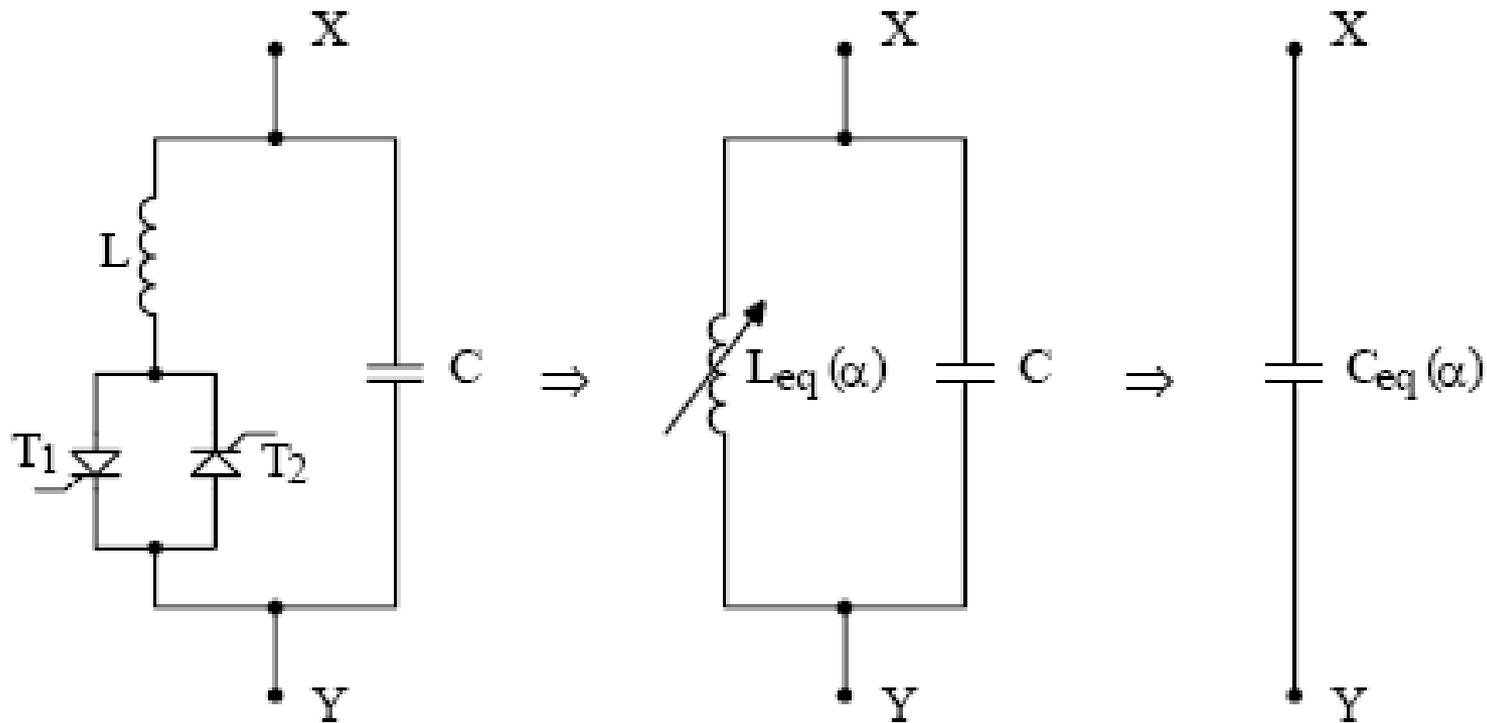


$$L_{eq} = \frac{\pi \cdot L}{2(\pi - \alpha) - \text{sen}(2 \cdot (\pi - \alpha))}$$



Indutor controlado por tiristores

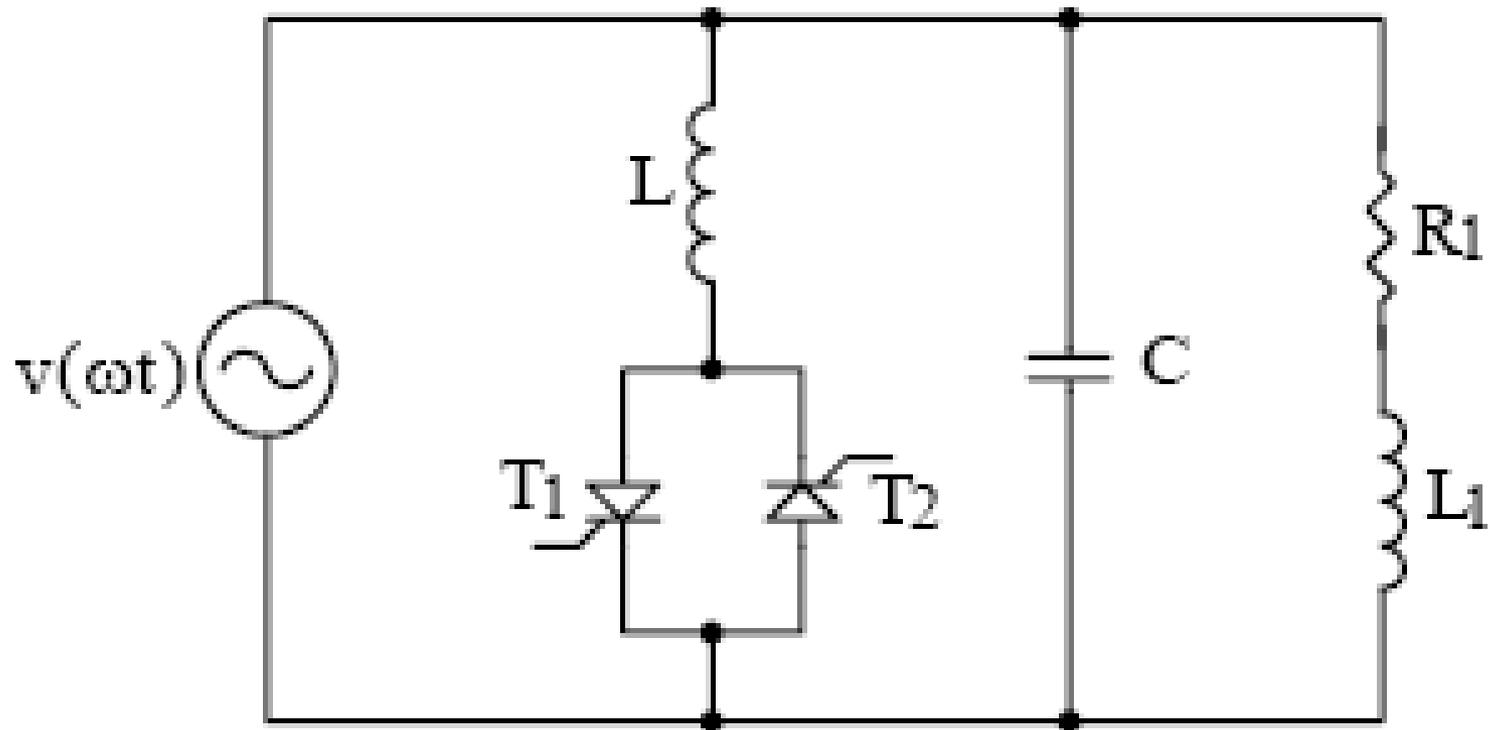
Compensador estático de potência reativa



Capacitor controlado por tiristores

Compensador estático de potência reativa

$$Z_{eq} = |Z| \angle \theta_Z = f(\alpha, L, C, R_1, L_1)$$

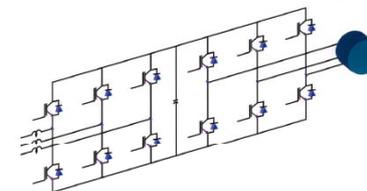
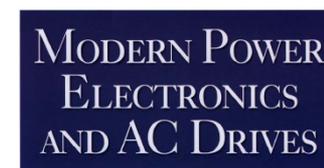
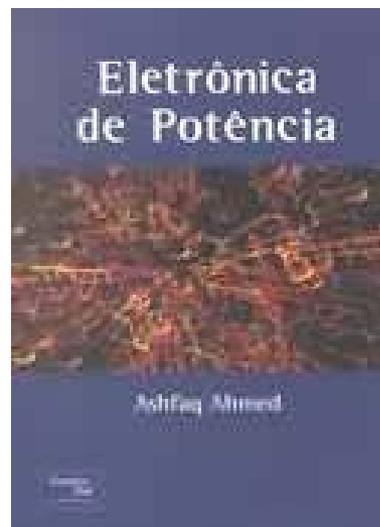
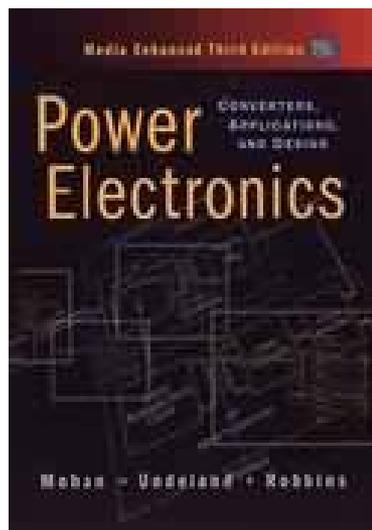


Controle do fator de potência do circuito pelos tiristores

Próxima aula

Conversores CA-CA:

1. Variadores CA monofásicos.



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