Instituto Federal de Educação, Ciência e Tecnologia de Santa Catarina
Departamento Acadêmico de Eletrônica

Eletrônica de Potência

Conversores CA-CA

Parte 2

Prof. Clovis Antonio Petry.

Florianópolis, novembro de 2025.

Eletrônica de Potência

O material do curso está disponível em:

1. Moodle para os alunos matriculados na disciplina.
2. Página do professor.
3. Canal no youtube do professor.

https://moodle.ifsc.edu.br

www.ProfessorPetry.com.br

https://www.youtube.com

Agenda

Conversores ca-ca:

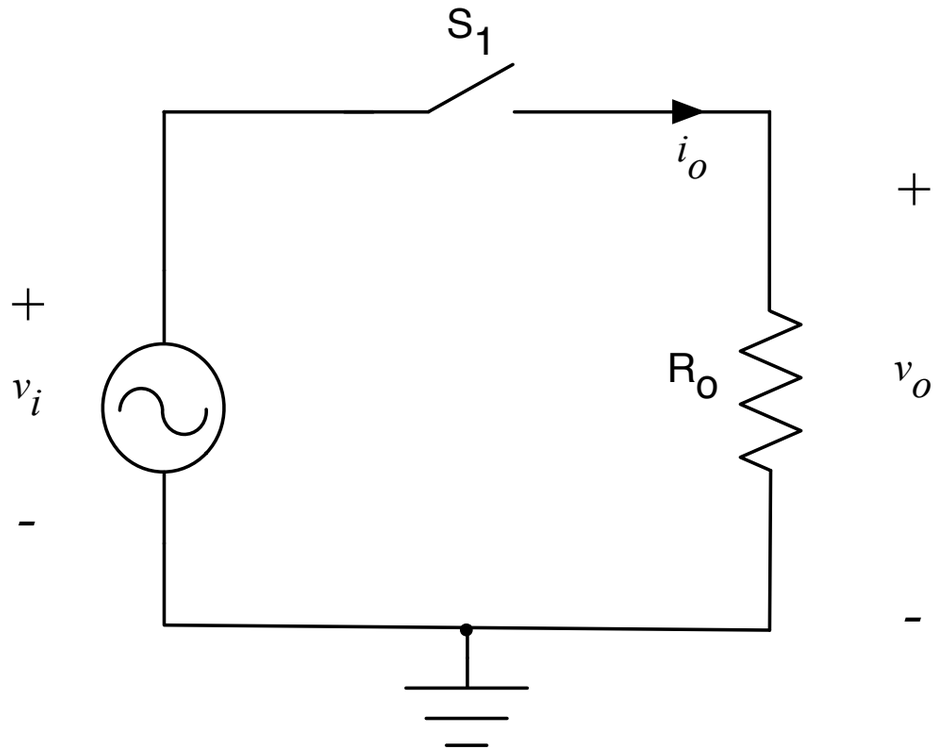
- Conversor ca-ca com tiristores e controle por ângulo de fase;
- Aplicações de conversores ca-ca.

Motivação

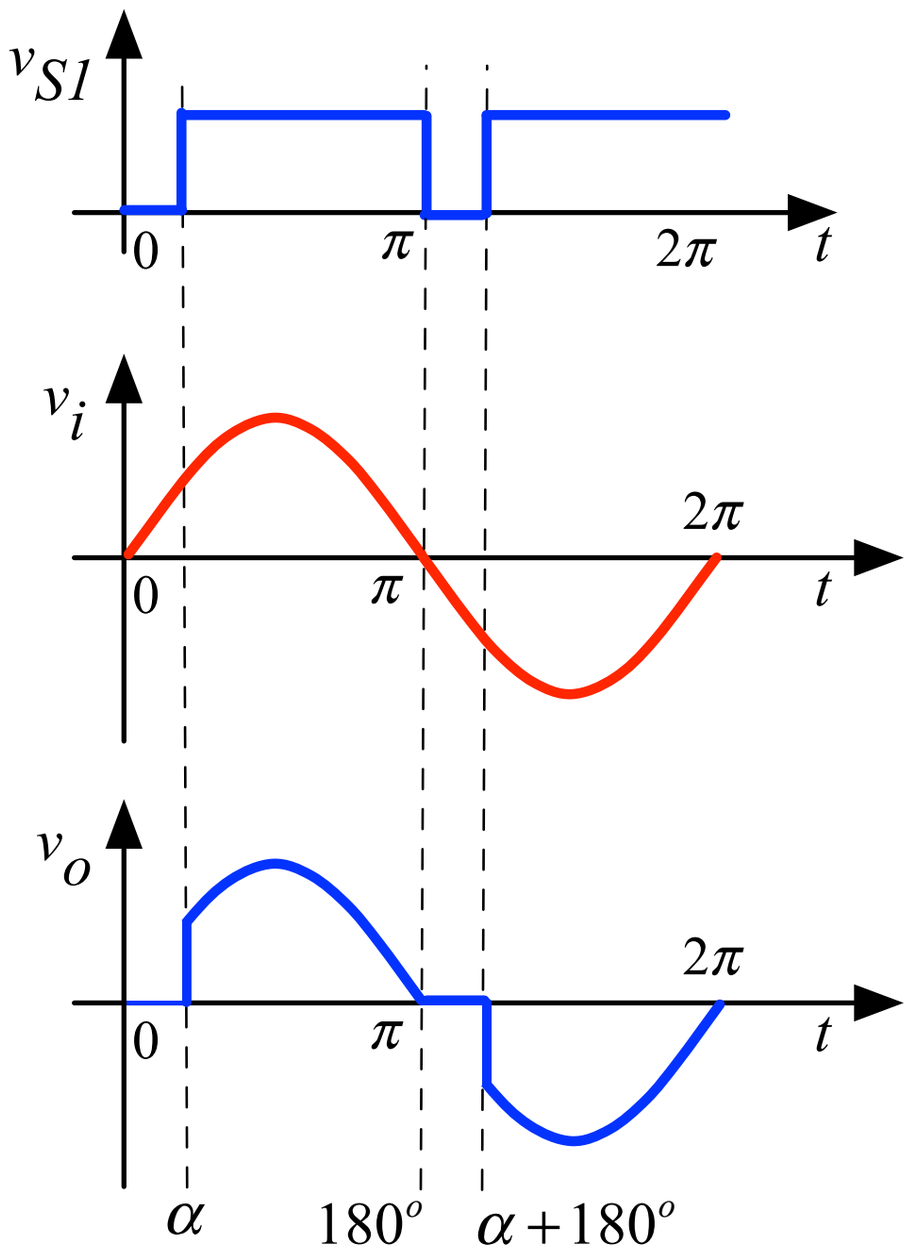
Os conversores ca-ca tem diversas aplicações, como por exemplo, na partida de motores de indução.

https://new.abb.com/br

Conversores CA-CA: Princípio de Funcionamento

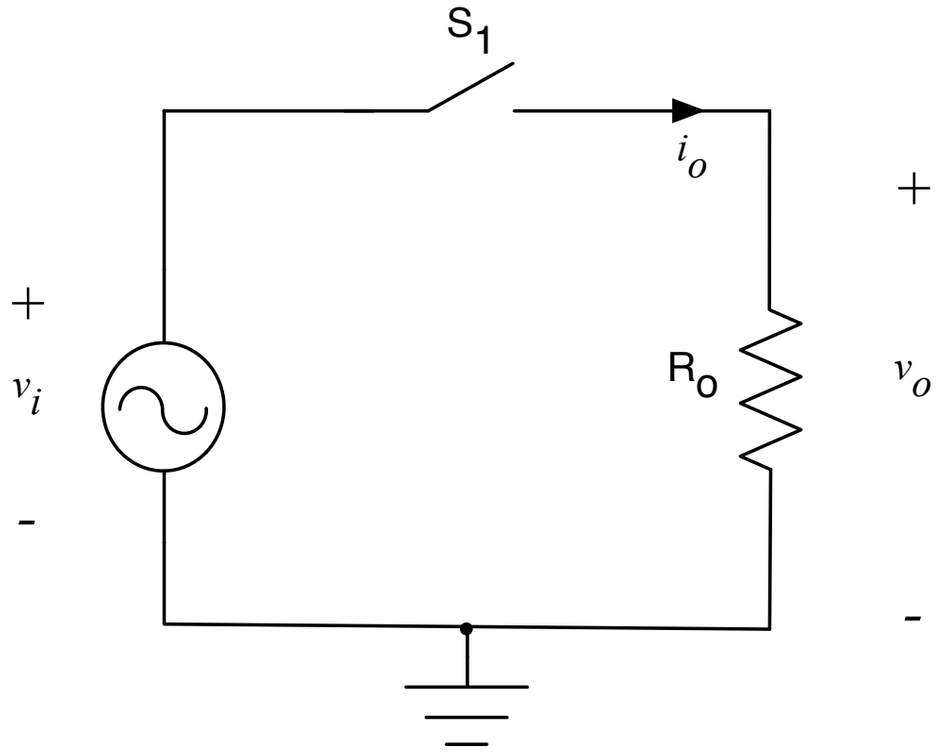


Conversor ca-ca simples



Controle por ângulo de fase

Conversores CA-CA: Princípio de Funcionamento



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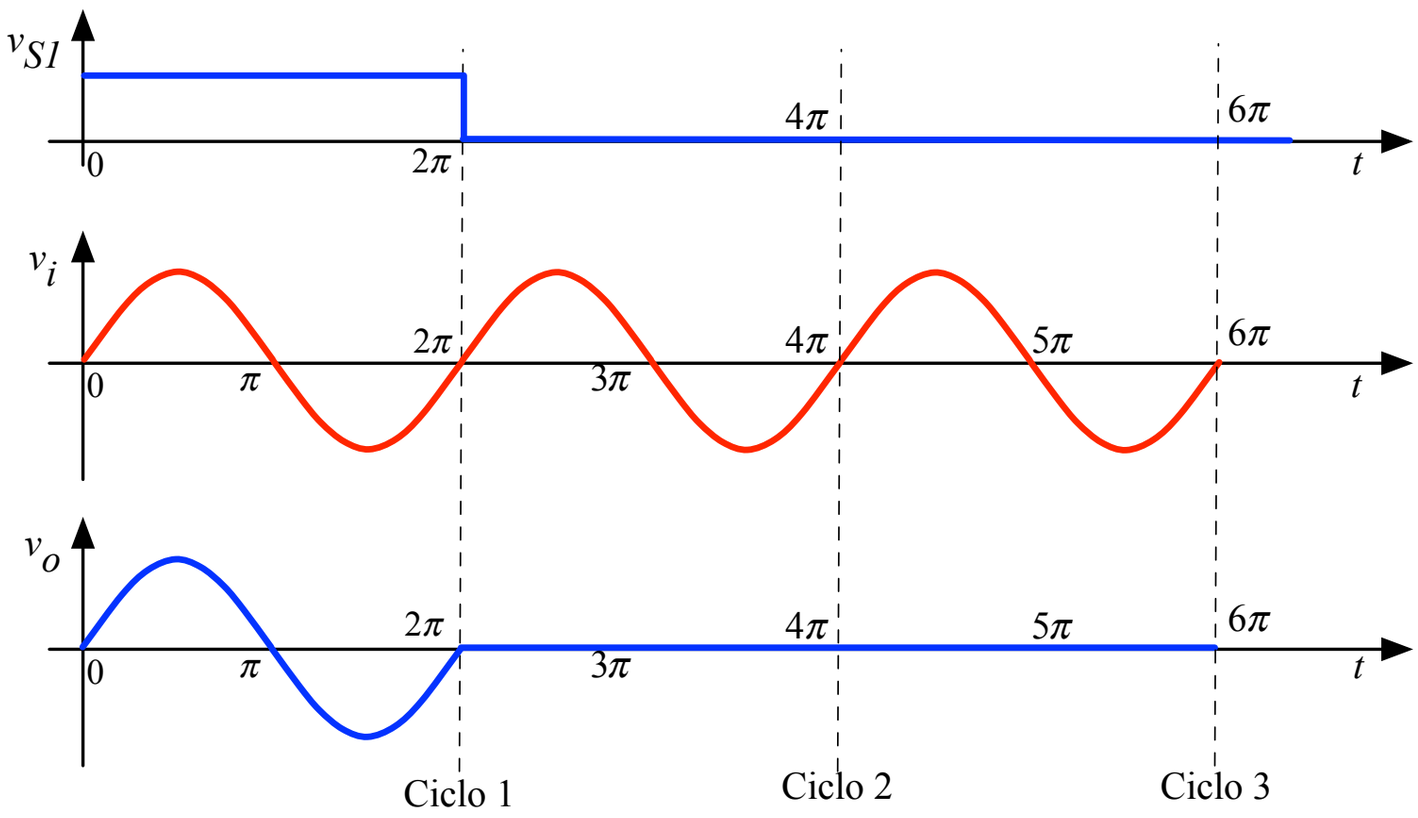
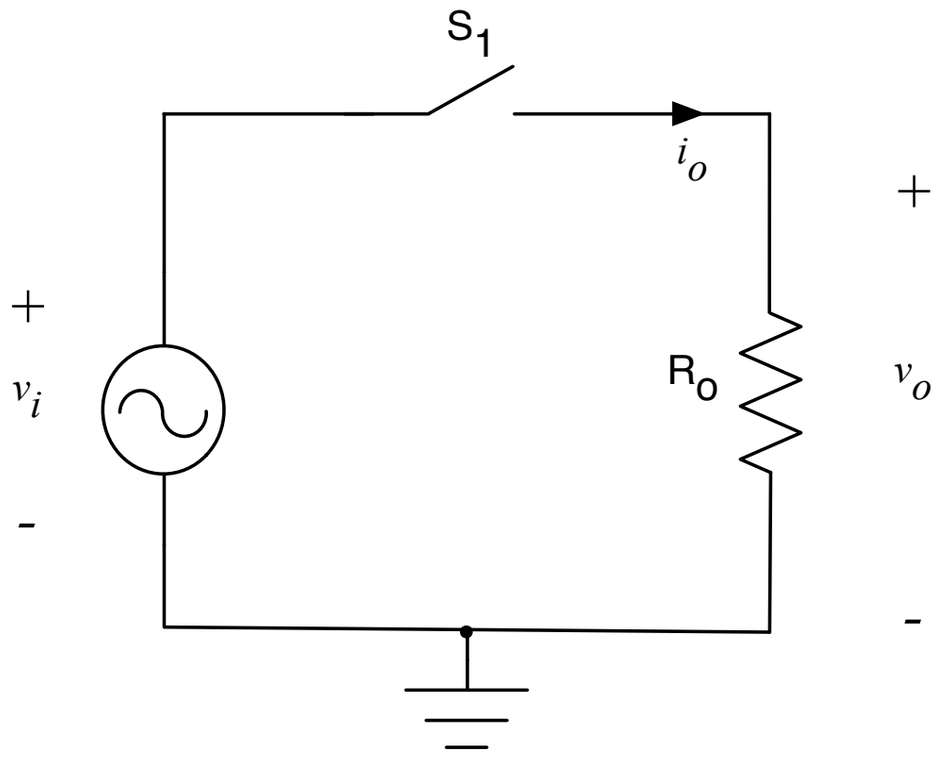
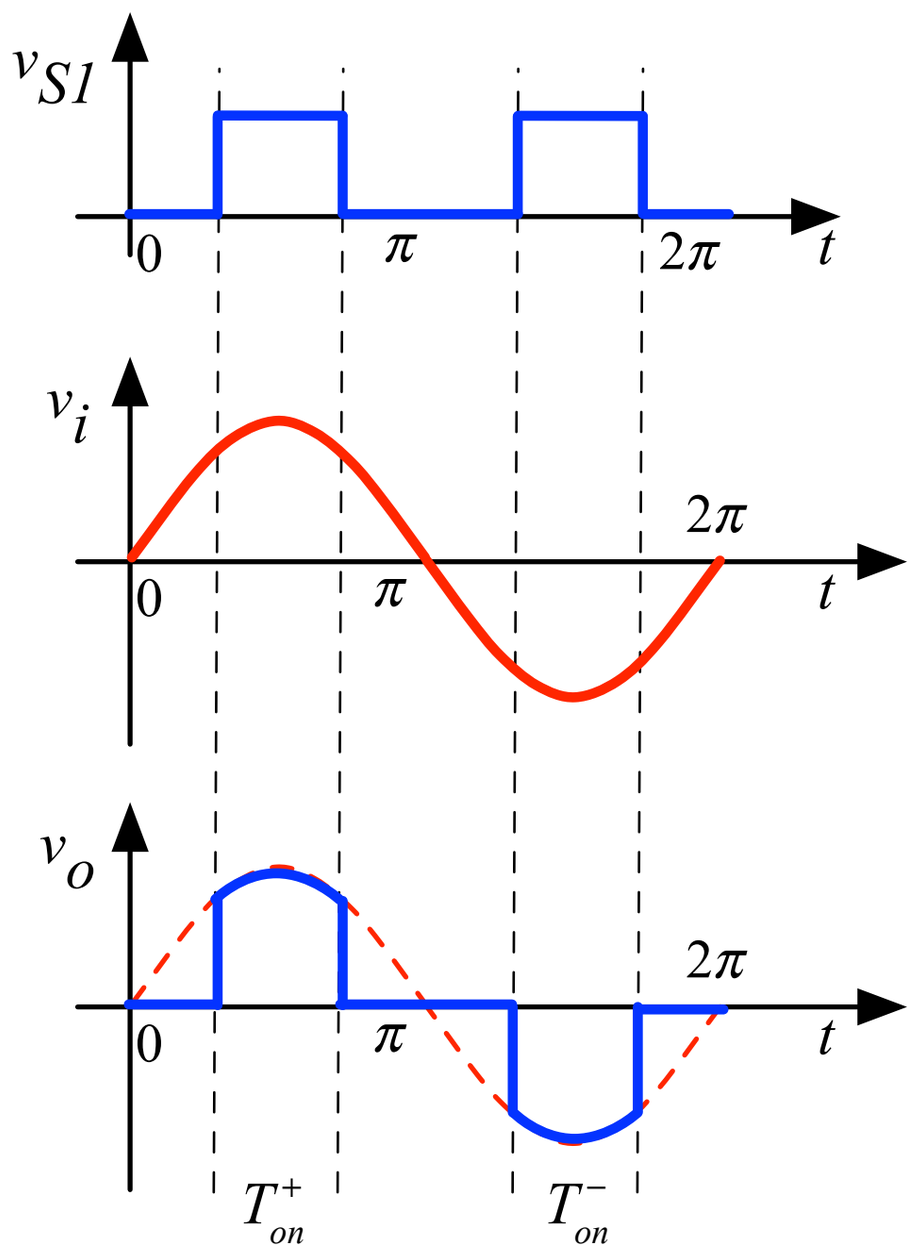


Controle por ciclos inteiros

Conversores CA-CA: Princípio de Funcionamento

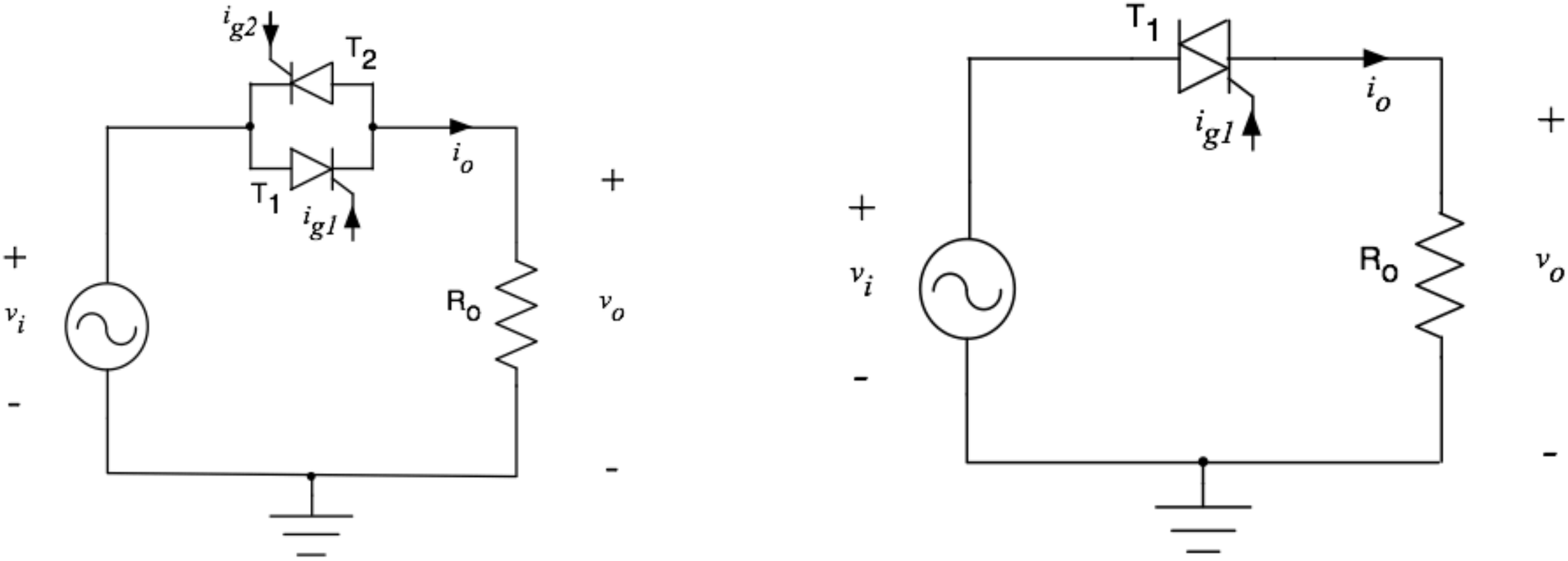


Conversor ca-ca simples



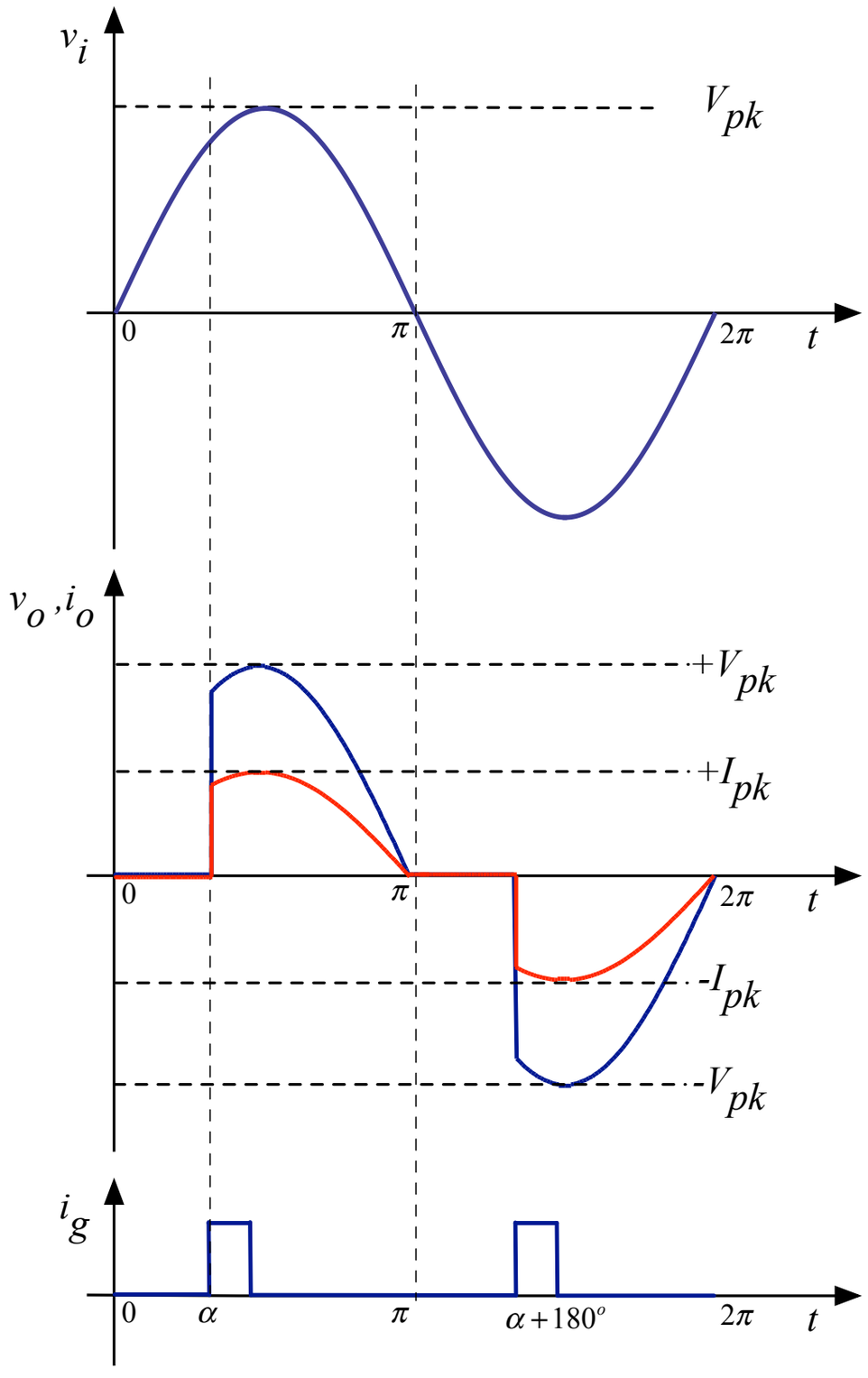
Modulação PWM

Conversores CA-CA: Controle por Ângulo de Fase



Conversores ca-ca com tiristores

Conversores CA-CA: Controle por Ângulo de Fase



$$v_{i(t)} = V_{i(pk)} \cdot seno\left(\omega \cdot t \pm \phi\right)$$

$$V_{i(ef)} = \frac{V_{i(pk)}}{\sqrt{2}} \rightarrow \text{tensão eficaz}$$

$$\omega = 2 \cdot \pi \cdot F\left[rad/s\right] \rightarrow \text{frequência angular}$$

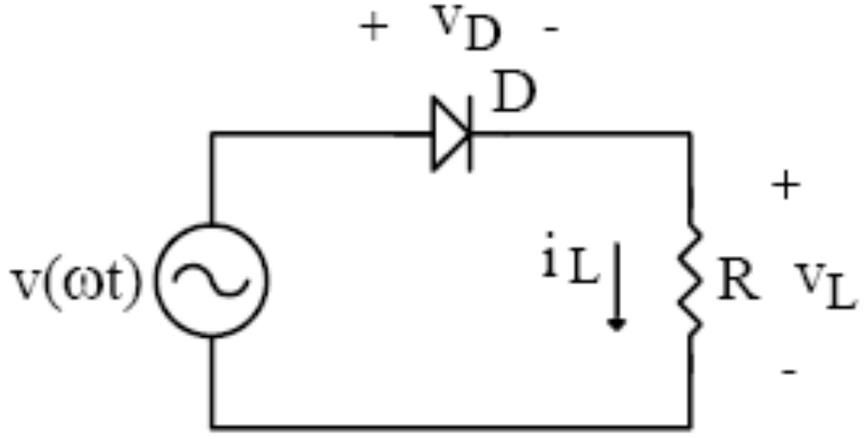
$$\phi \rightarrow \text{ângulo de defasagem}$$

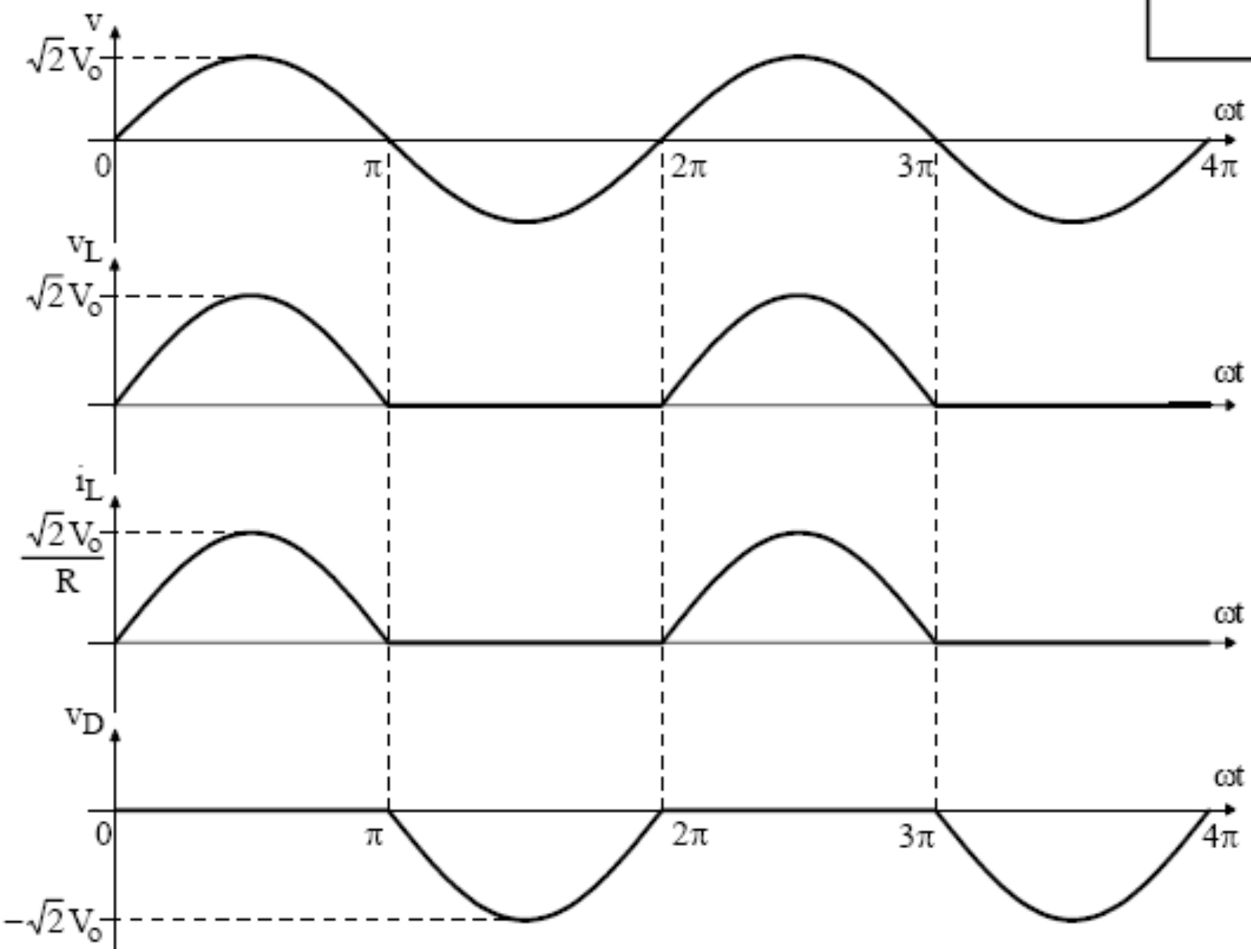
$$V_{o(pk)} = \begin{cases} V_{i(pk)} \rightarrow 0 \le \alpha \le 90^o \\ V_{i(pk)} \cdot seno\left(\alpha\right) \rightarrow 90^o \le \alpha \le 180^o \end{cases}$$

$$V_{o(ef)} = V_{i(ef)} \cdot \sqrt{1 - \frac{\alpha}{\pi} + \frac{seno\left(2 \cdot \alpha\right)}{2 \cdot \pi}}$$

Conversores CA-CA: Controle por Ângulo de Fase

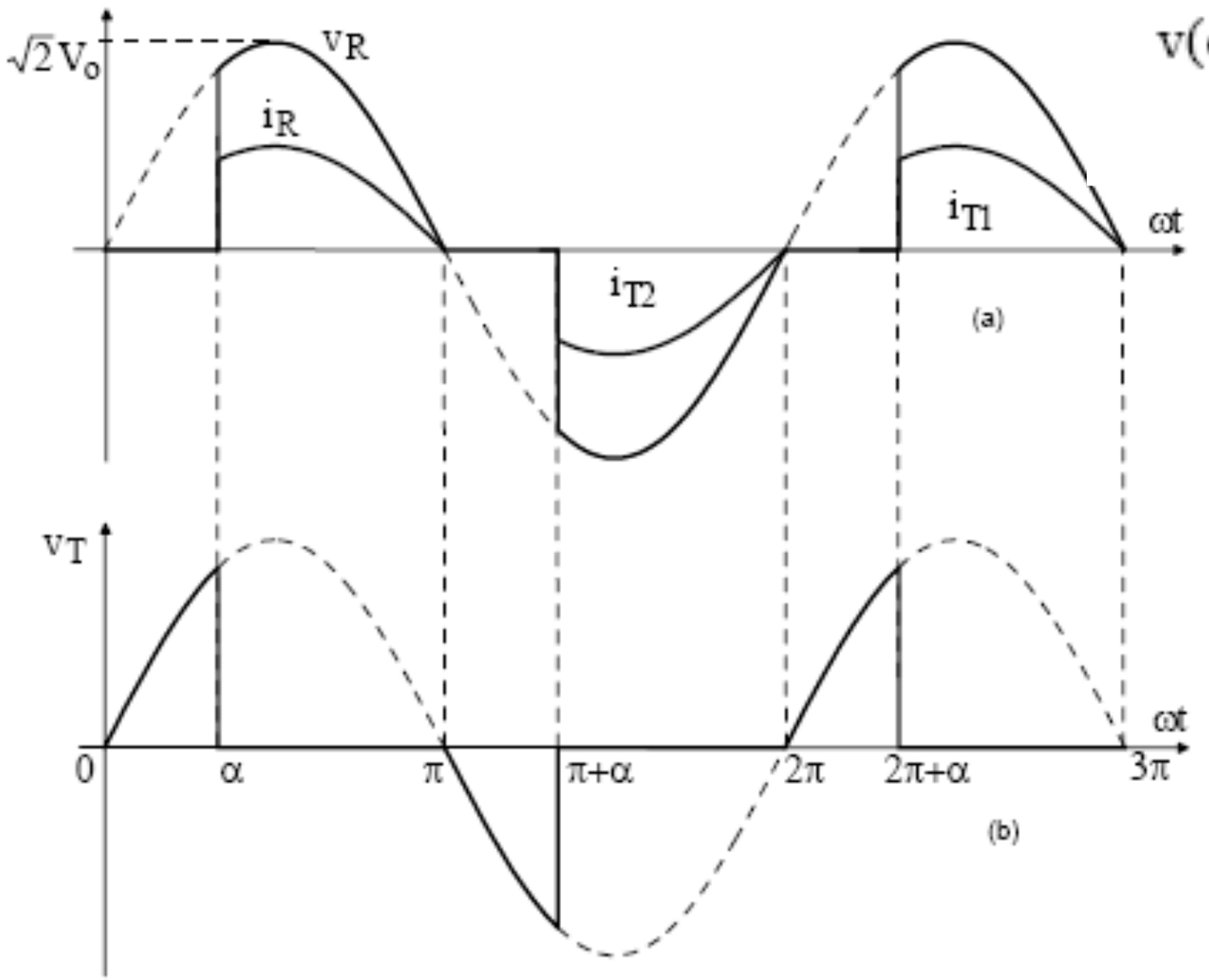
Retificador com carga resistiva pura:

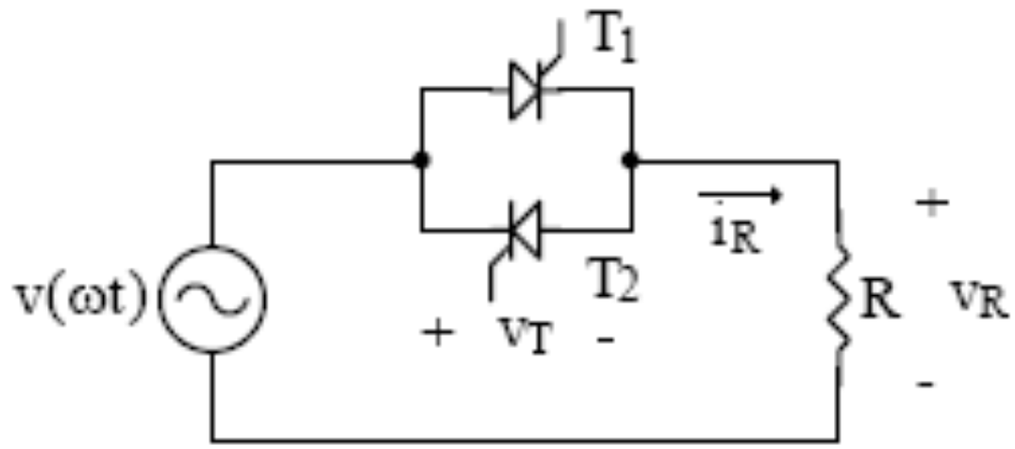




Conversores CA-CA: Controle por Ângulo de Fase

Gradador com carga resistiva pura:

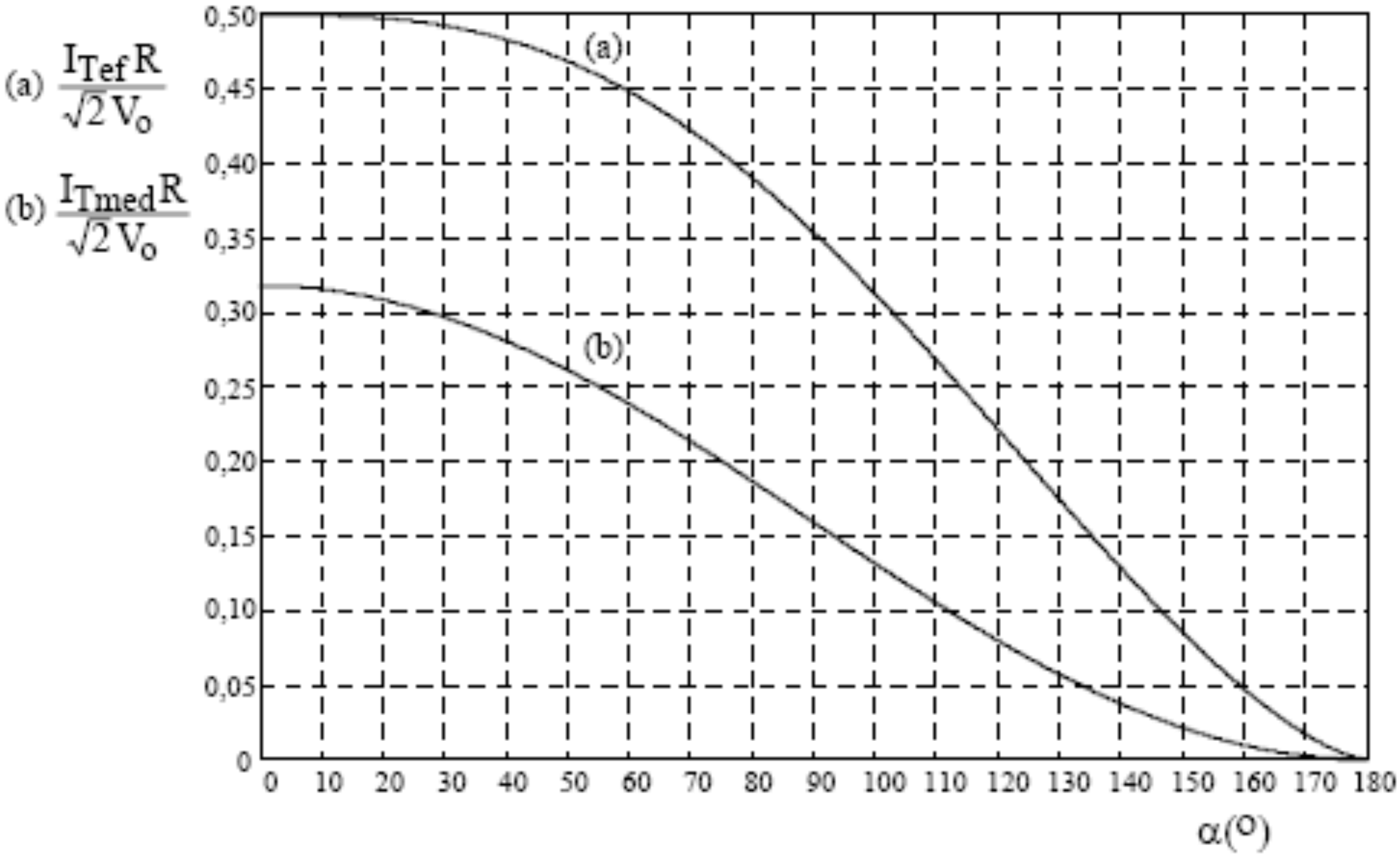




$$V_o = V_i \cdot \sqrt{1 - \frac{\alpha}{\pi} + \frac{sen(2 \cdot \alpha)}{2 \cdot \pi}}$$

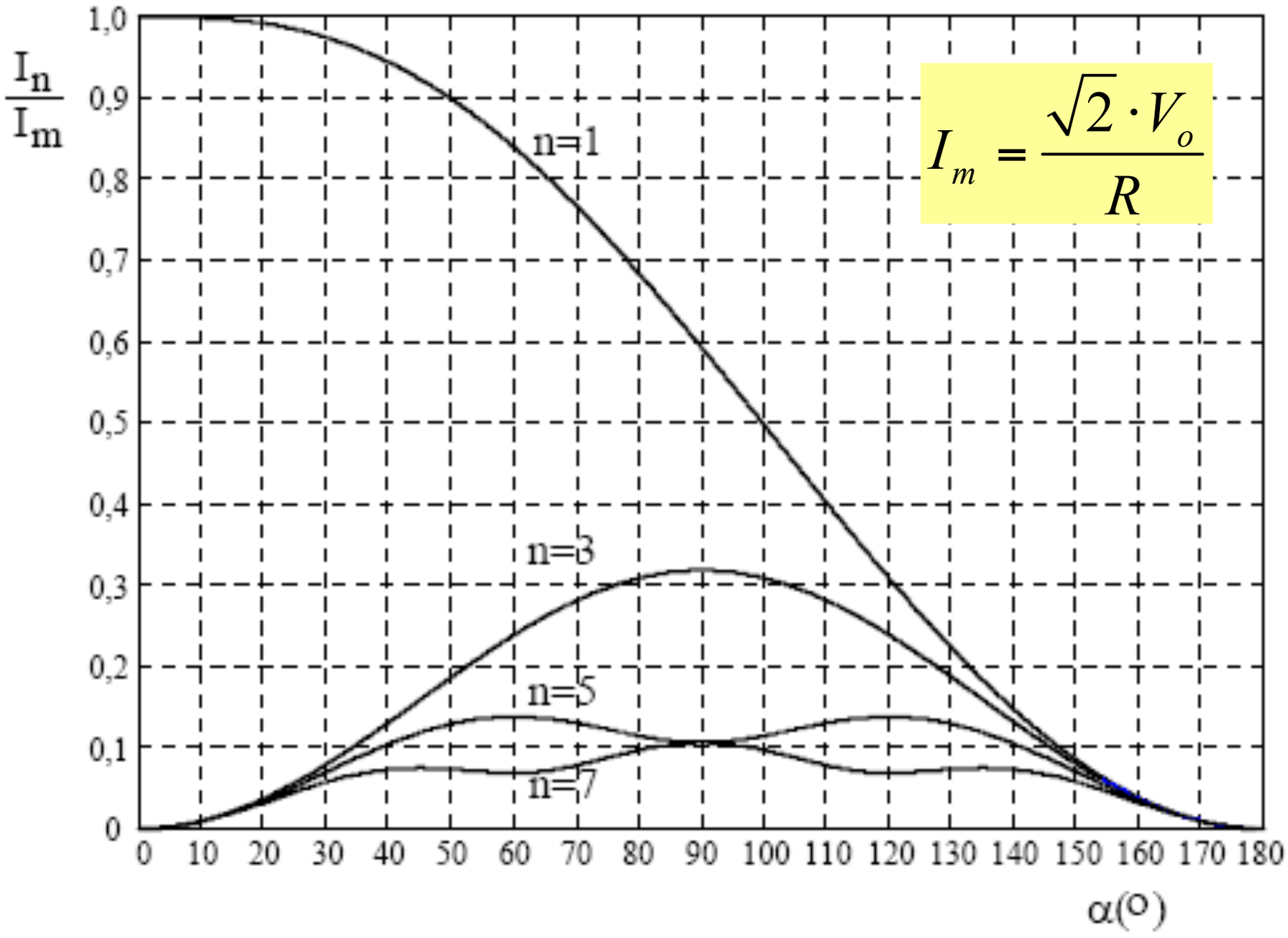
Conversores CA-CA: Controle por Ângulo de Fase

Correntes média e eficaz na carga:



Conversores CA-CA: Controle por Ângulo de Fase

Harmônicas da corrente de carga:



$$I_m = \frac{\sqrt{2} \cdot V_o}{R}$$

Conversores CA-CA: Controle por Ângulo de Fase

Harmônicas da corrente de carga, exemplo:

$$V_o = 220V$$

$$Po = 4800W$$

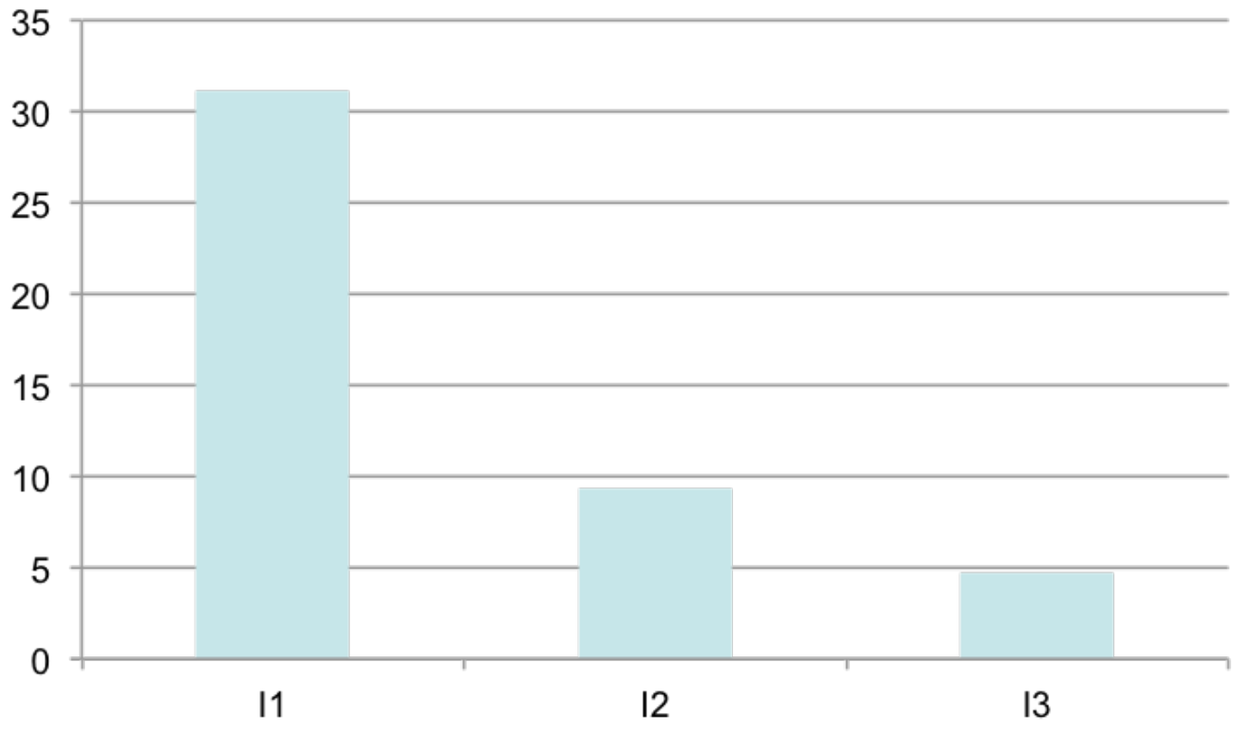
$$R = \frac{V_o^{\,2}}{P_o} = \frac{220^2}{4800} = 10\,\Omega$$

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

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

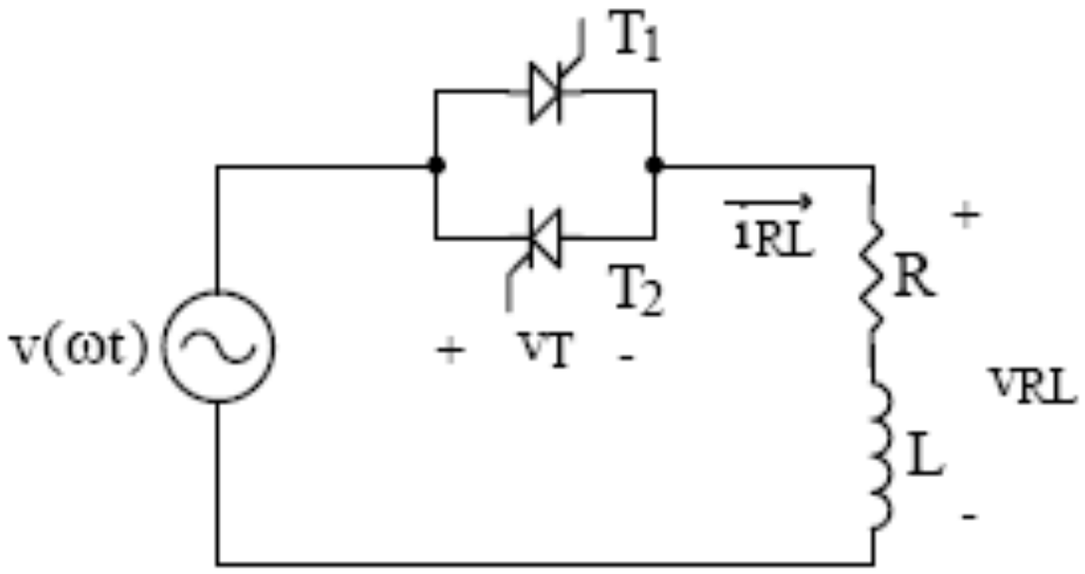
$$I_3 = 0{,}3\cdot I_m = 9{,}33\,A$$

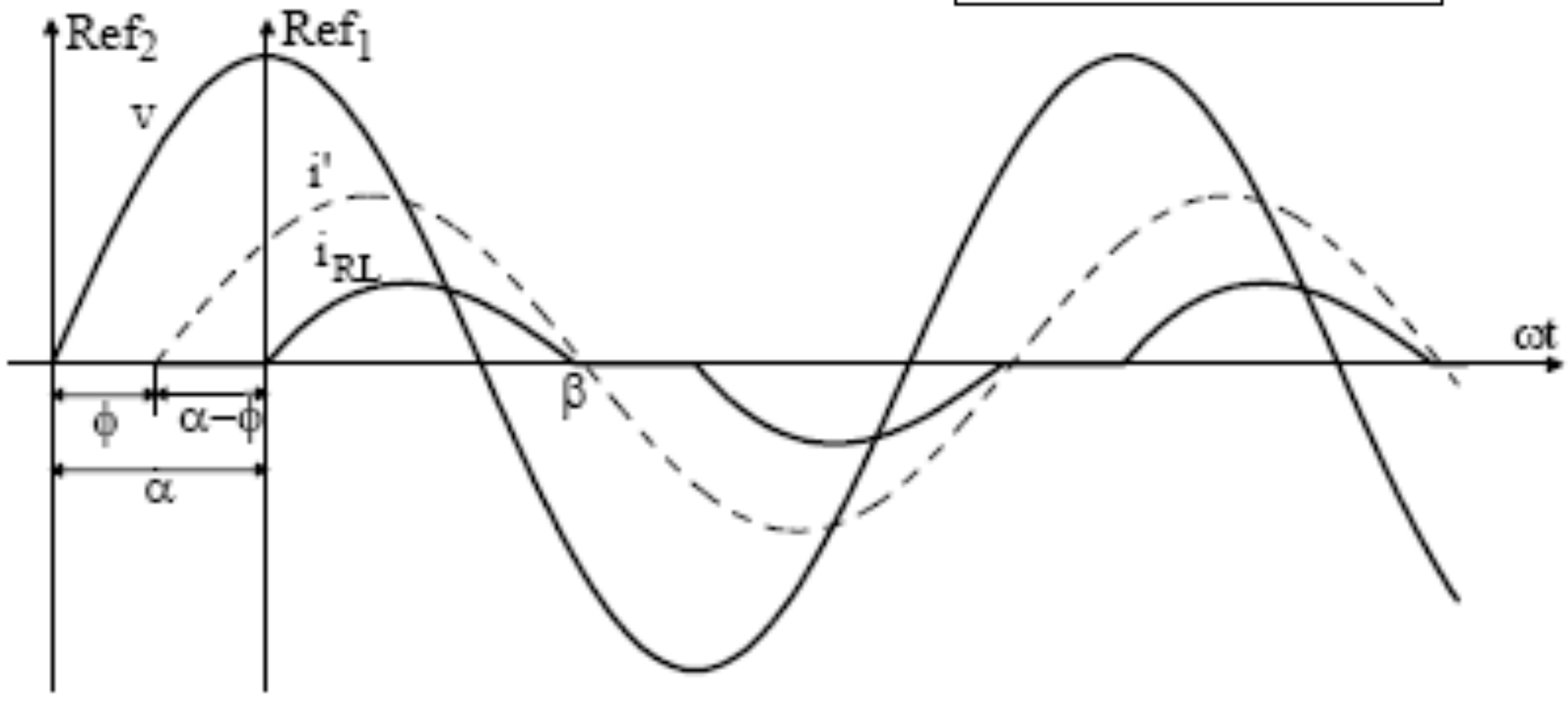
$$I_5 = 0{,}15\cdot I_m = 4{,}66\,A$$



Conversores CA-CA: Controle por Ângulo de Fase

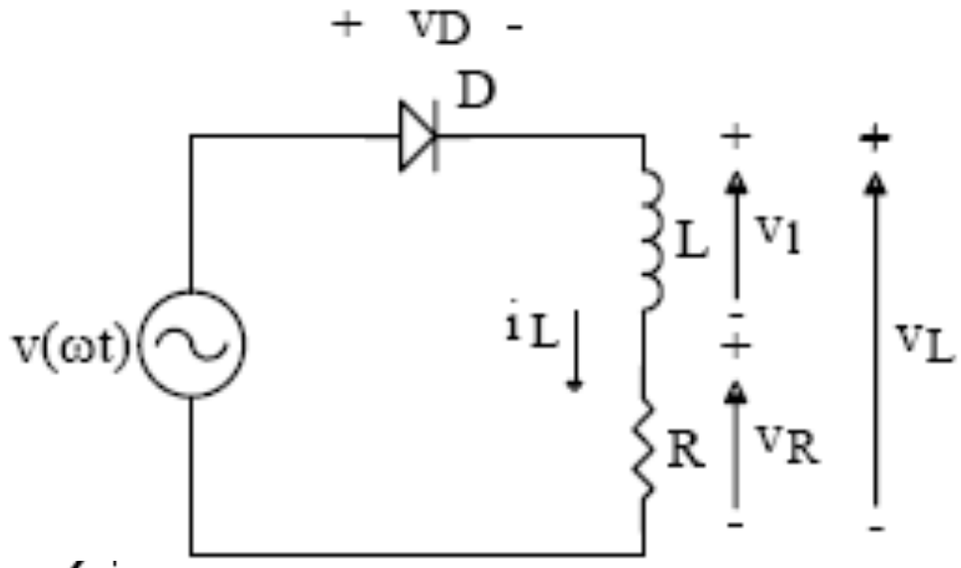
Retificador com carga RL:

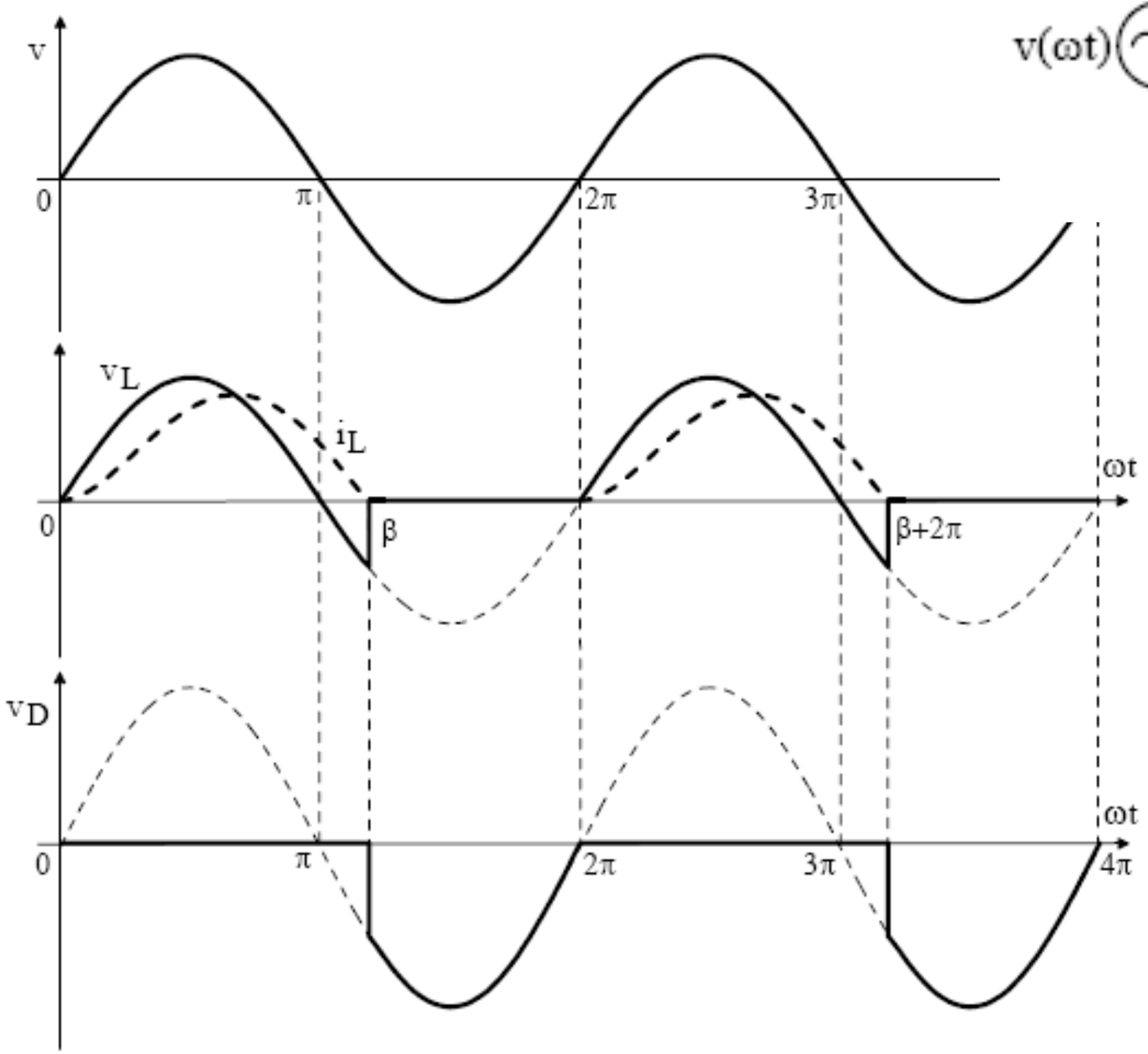




Conversores CA-CA: Controle por Ângulo de Fase

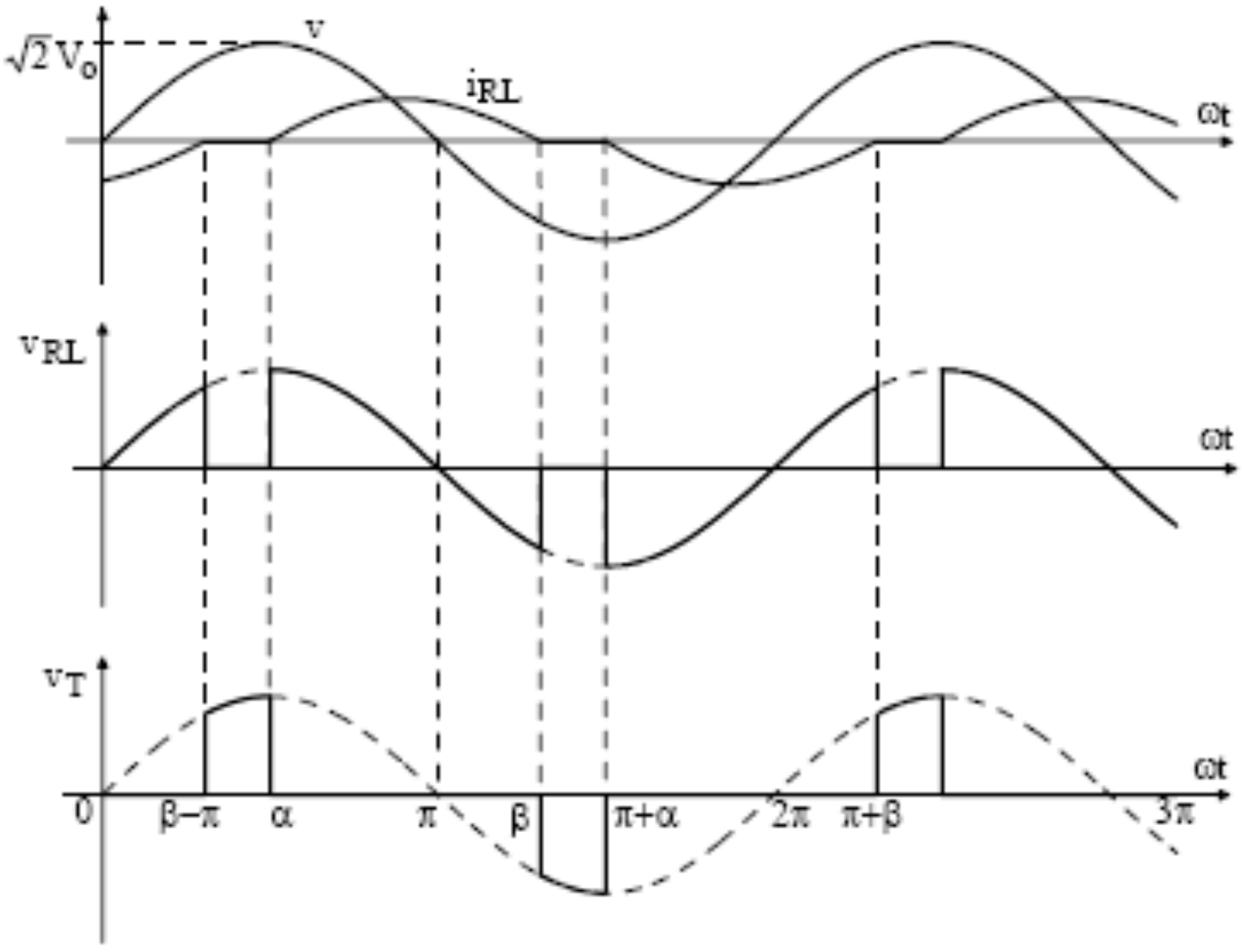
Retificador com carga RL:



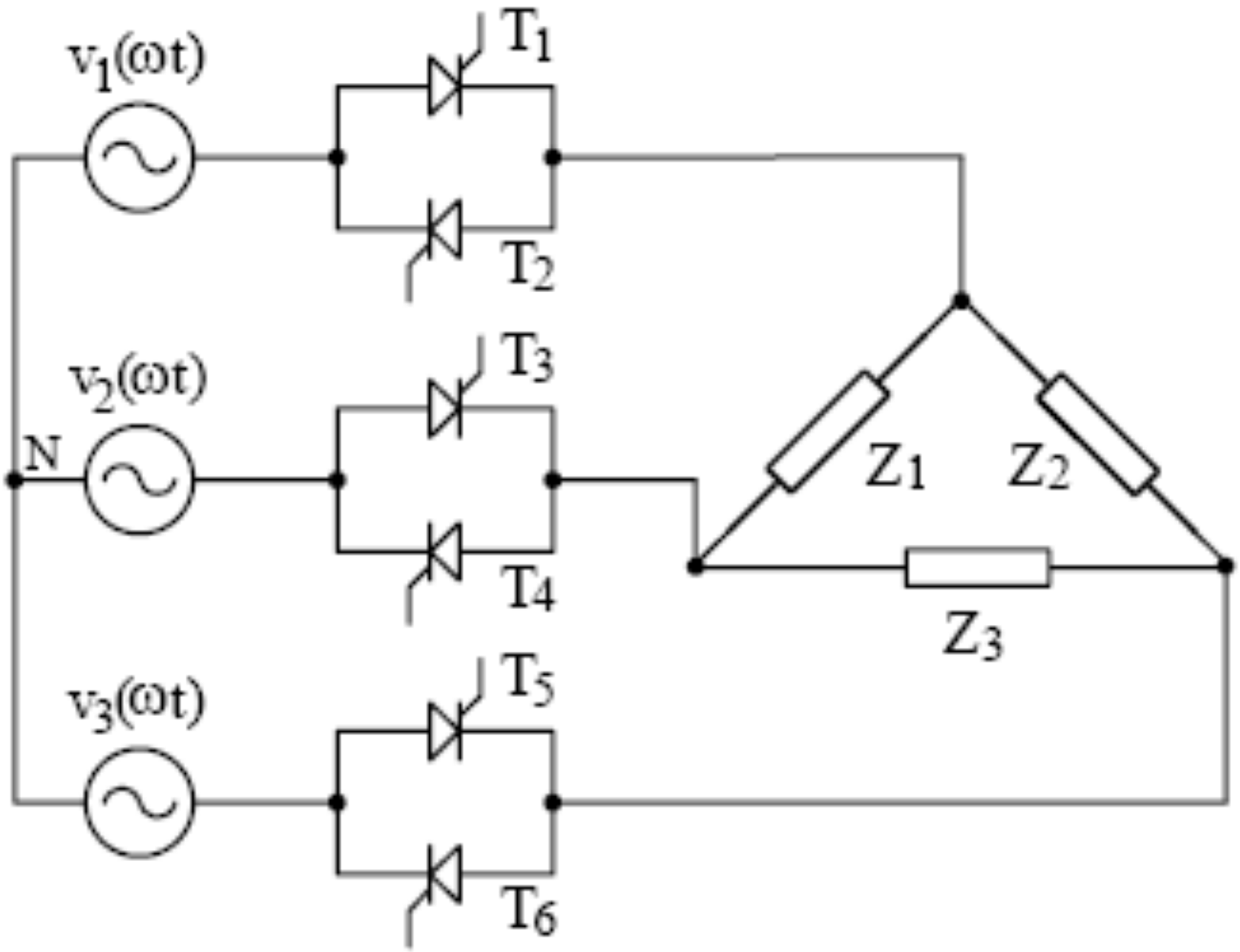


Conversores CA-CA: Controle por Ângulo de Fase

Gradador com carga RL:

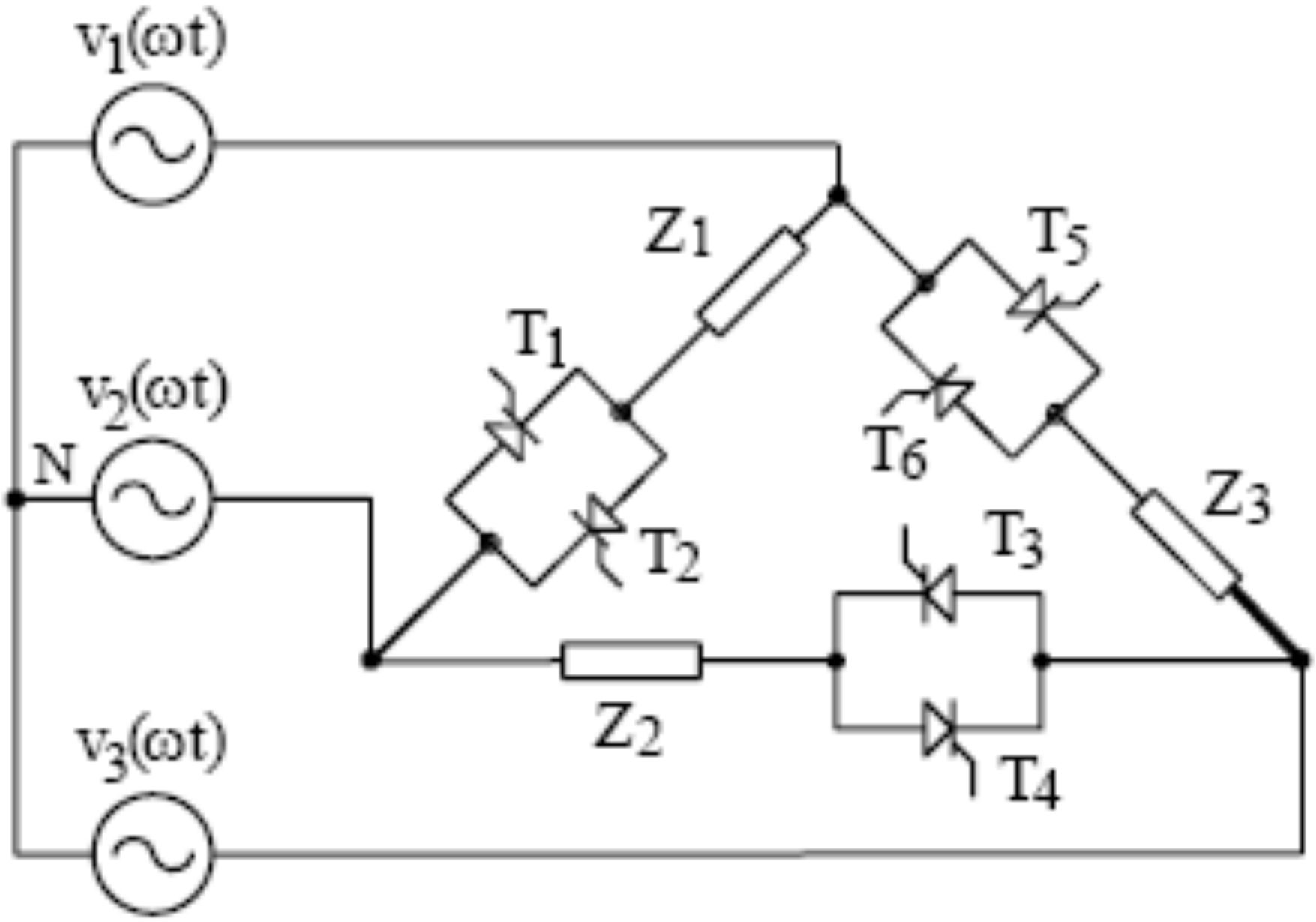


Conversores CA-CA: Topologias



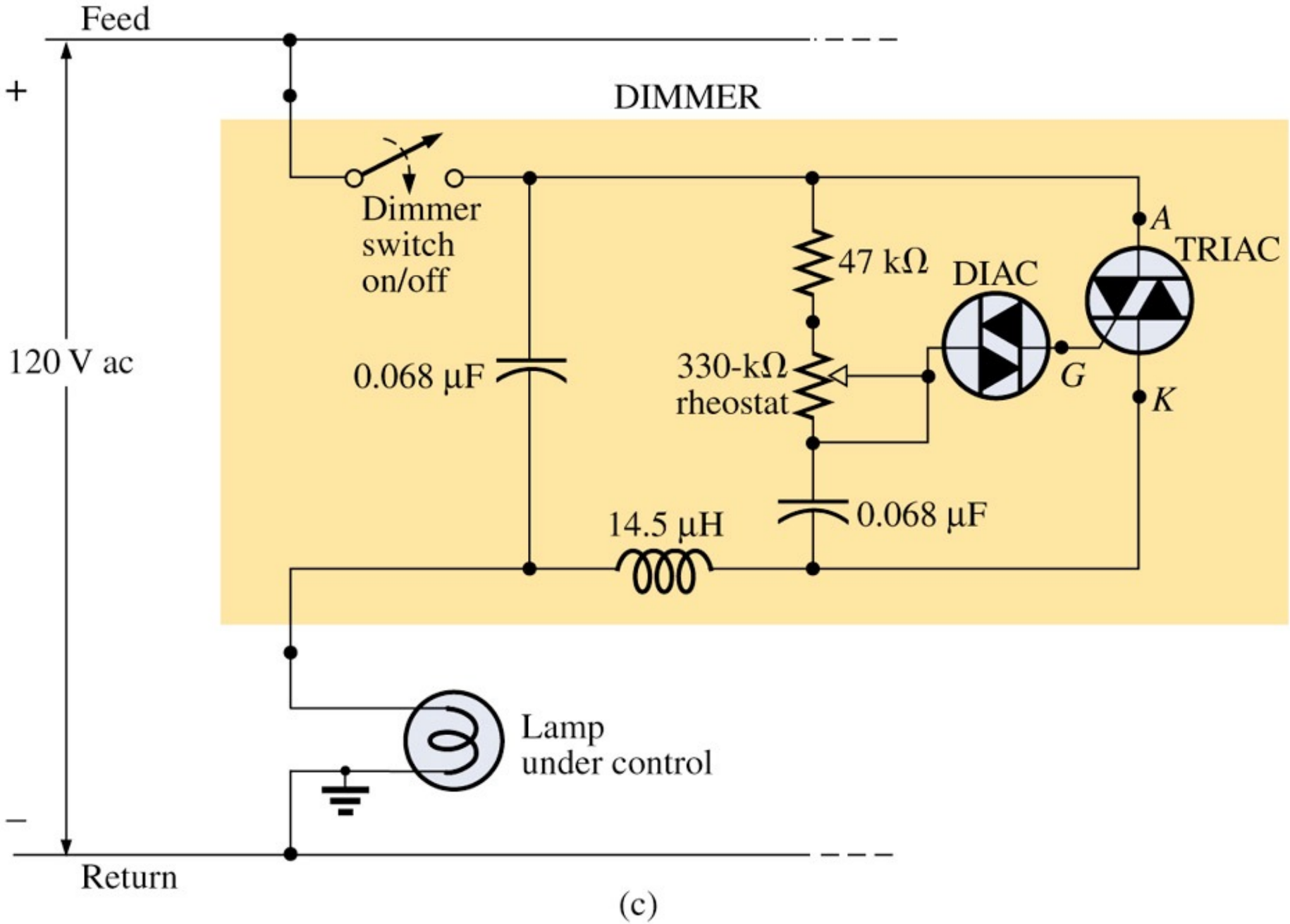
Carga conectada em delta (Δ)

Conversores CA-CA: Topologias

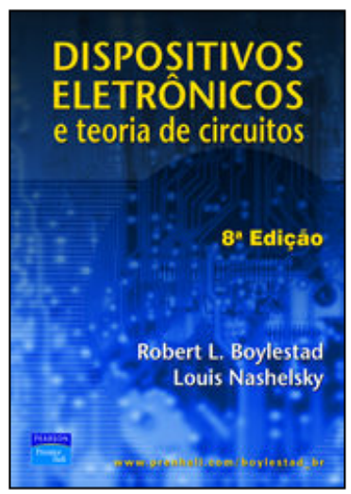


Carga conectada em delta (Δ)

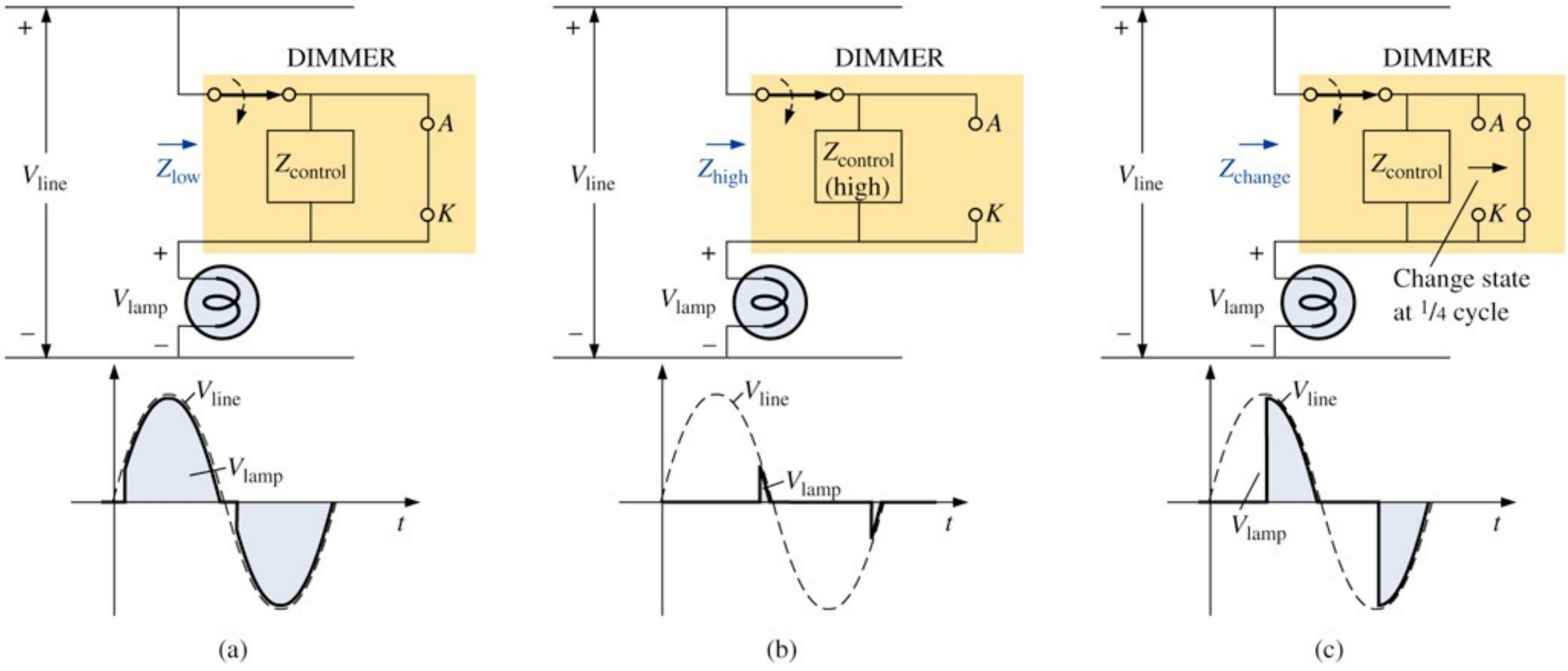
Conversores CA-CA: Topologias



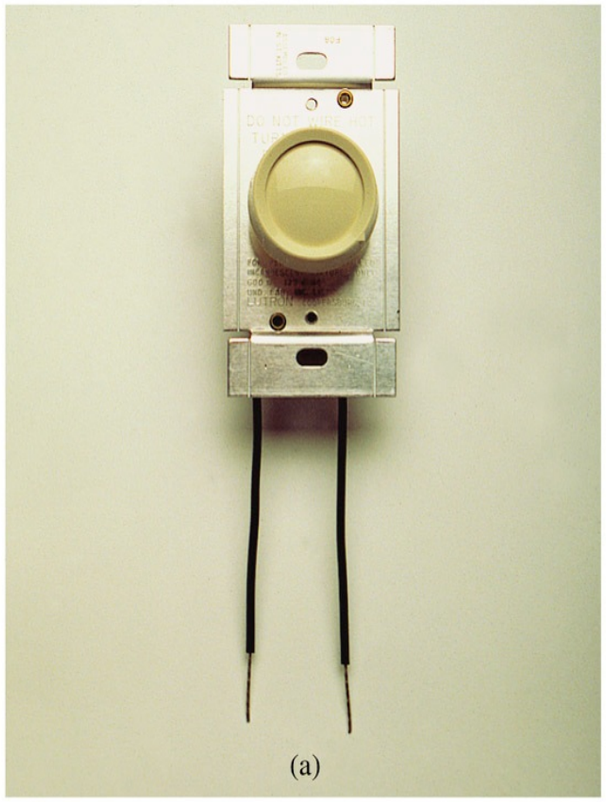
(c)



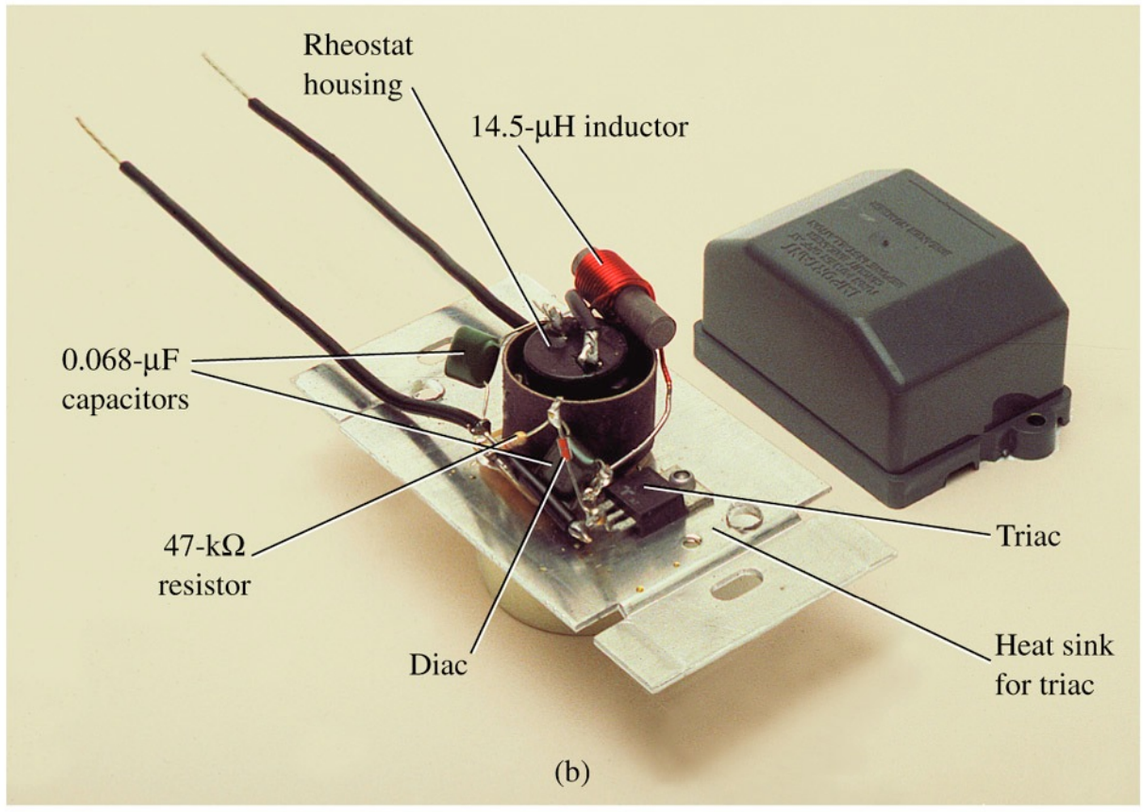
Conversores CA-CA: Topologias



Conversores CA-CA: Topologias

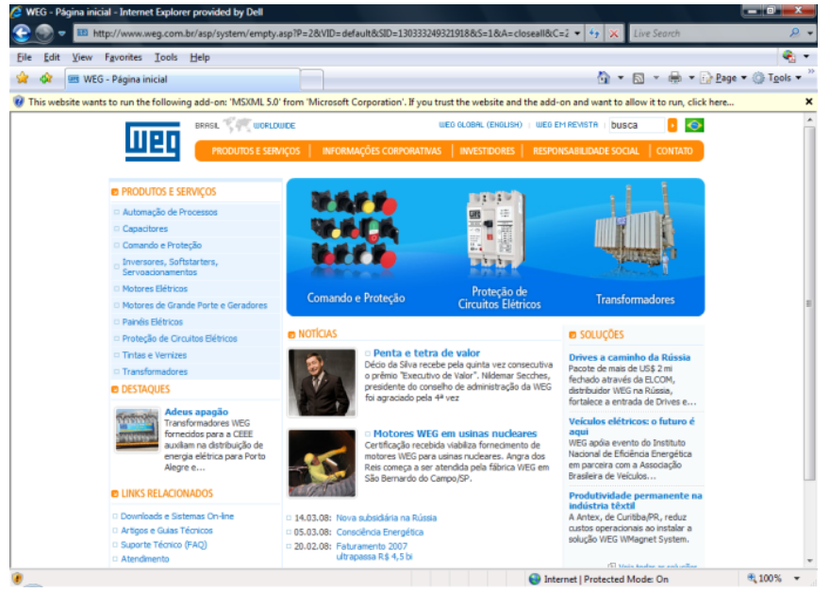


(a)



(b)

Aplicações de Conversores CA-CA



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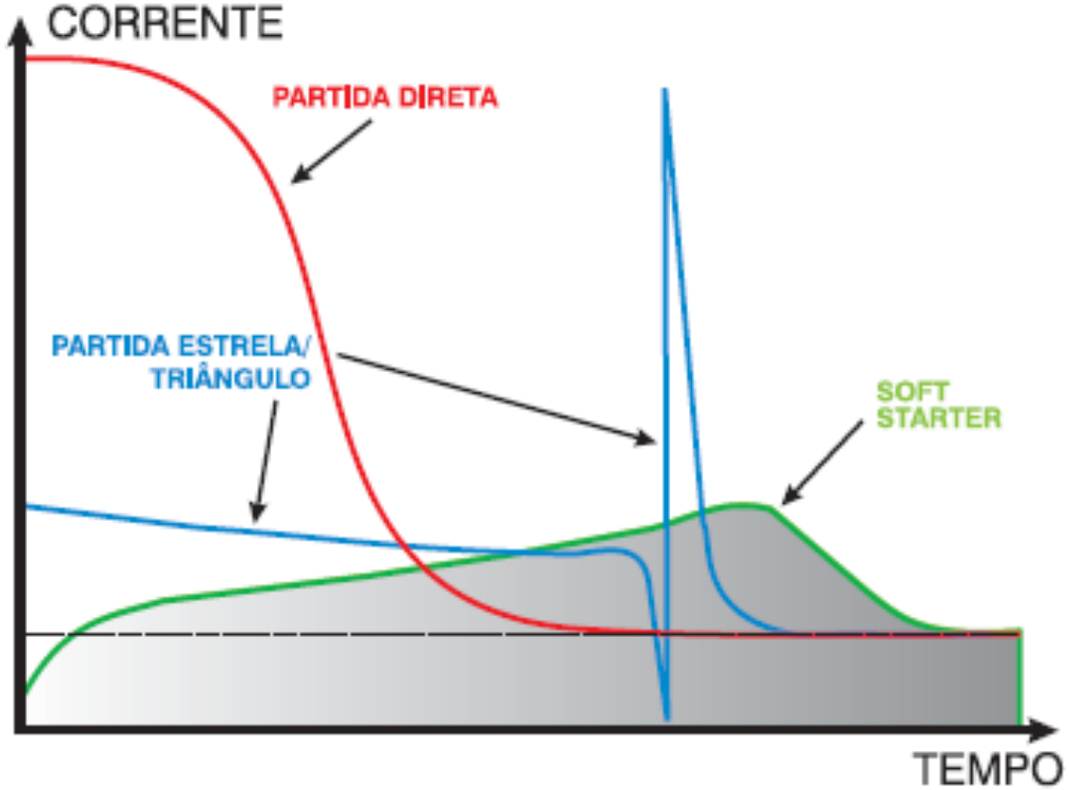
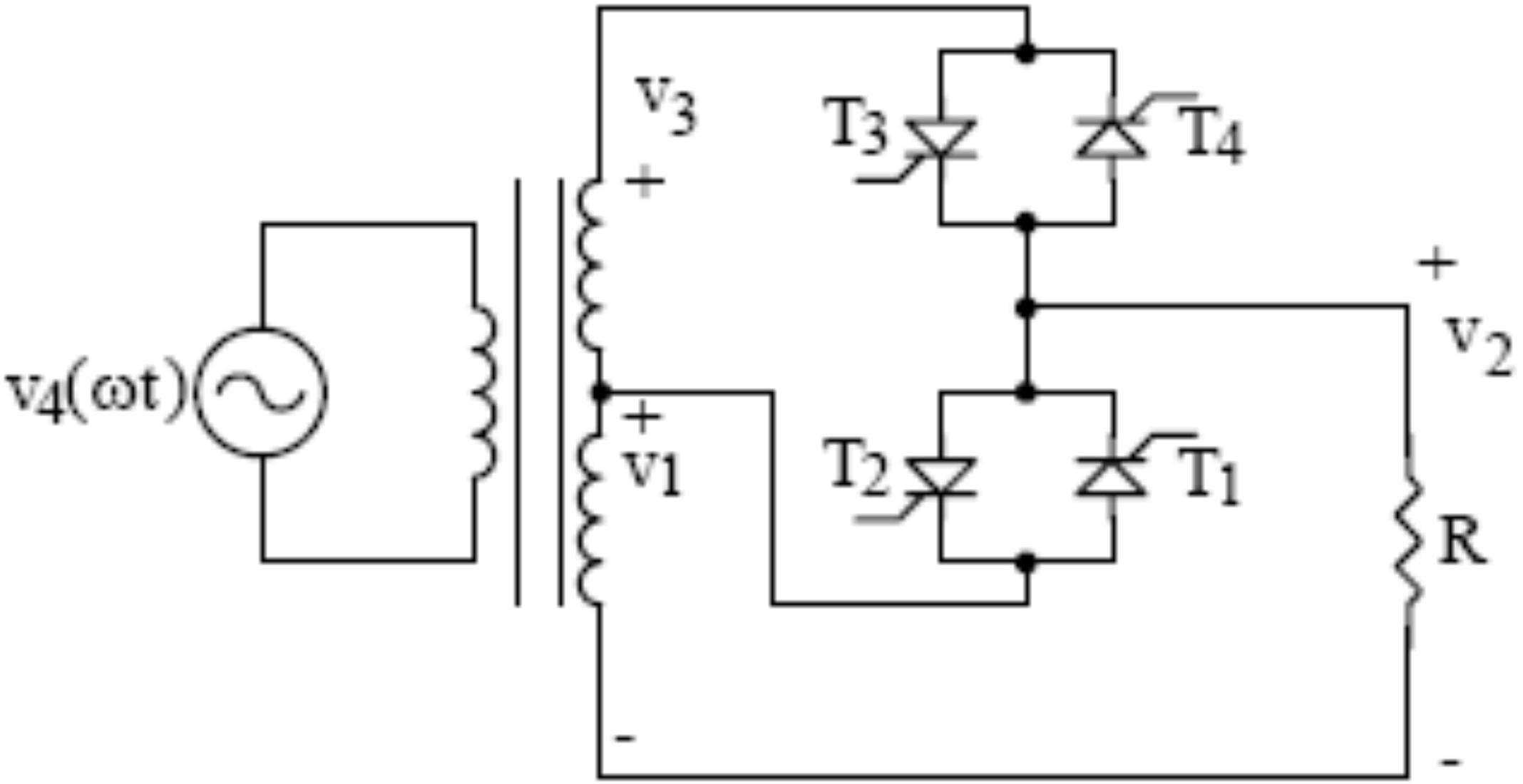
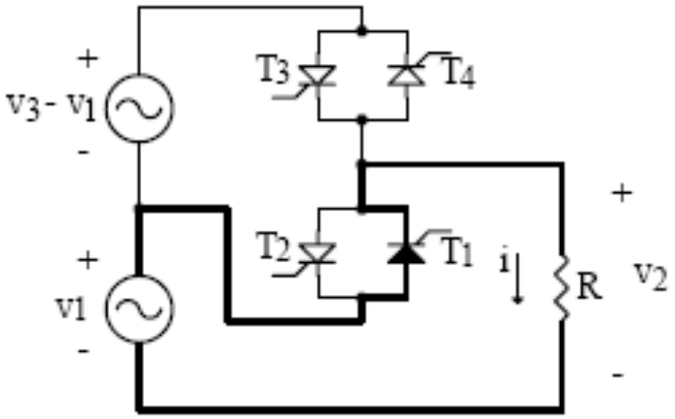


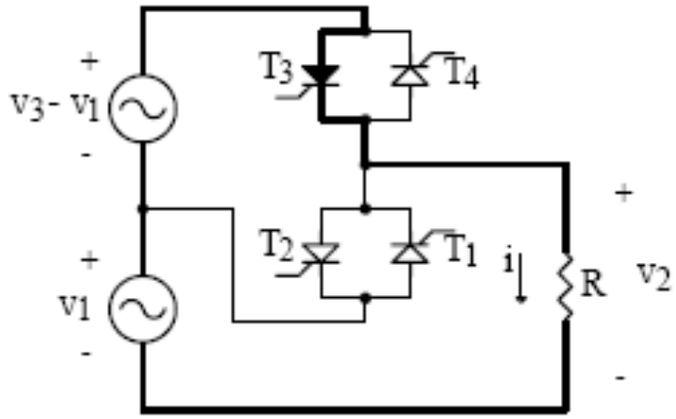
Controle da corrente de partida de motores usando gradadores

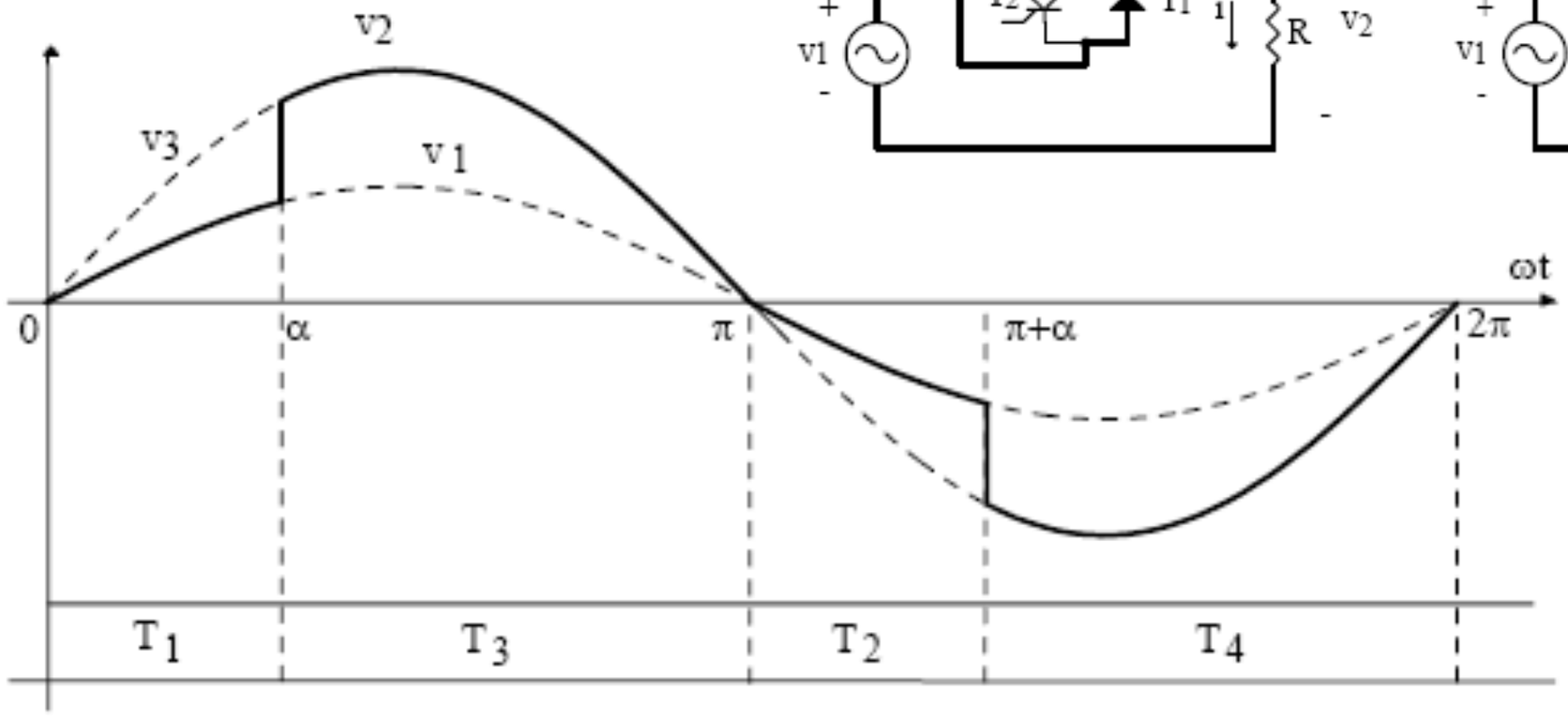
Aplicações de Conversores CA-CA

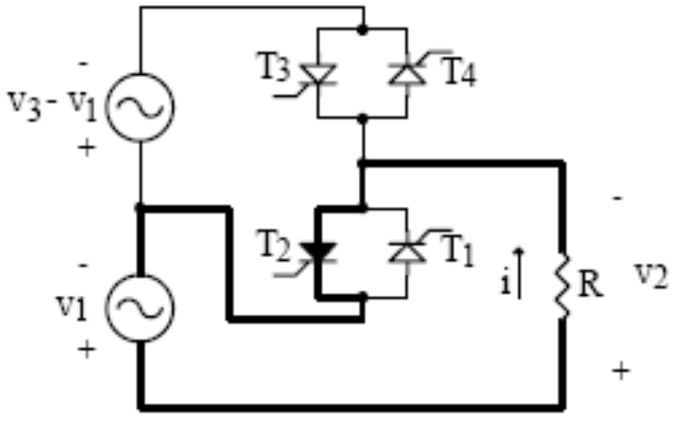


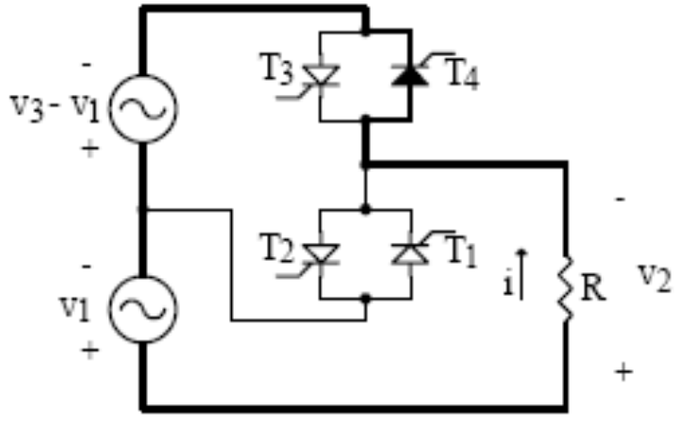
Aplicações de Conversores CA-CA



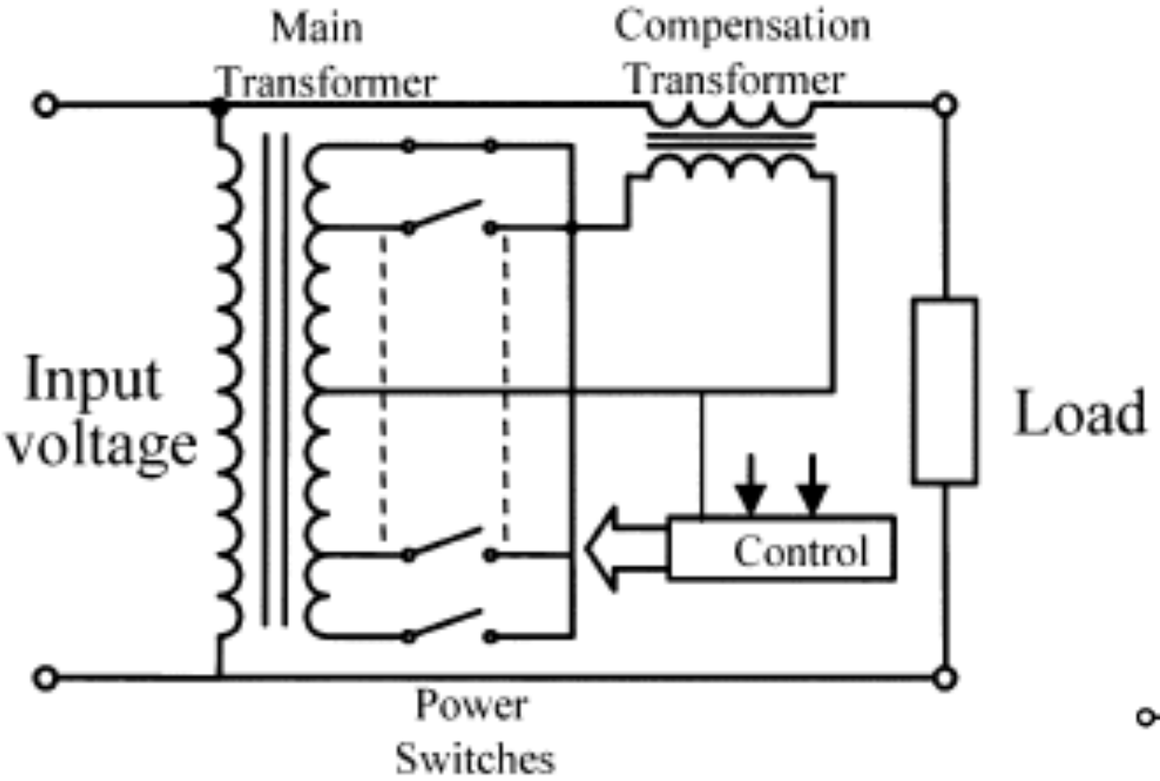




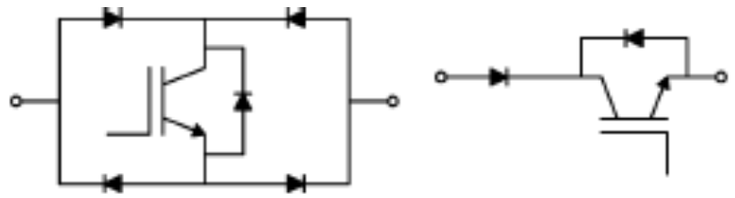




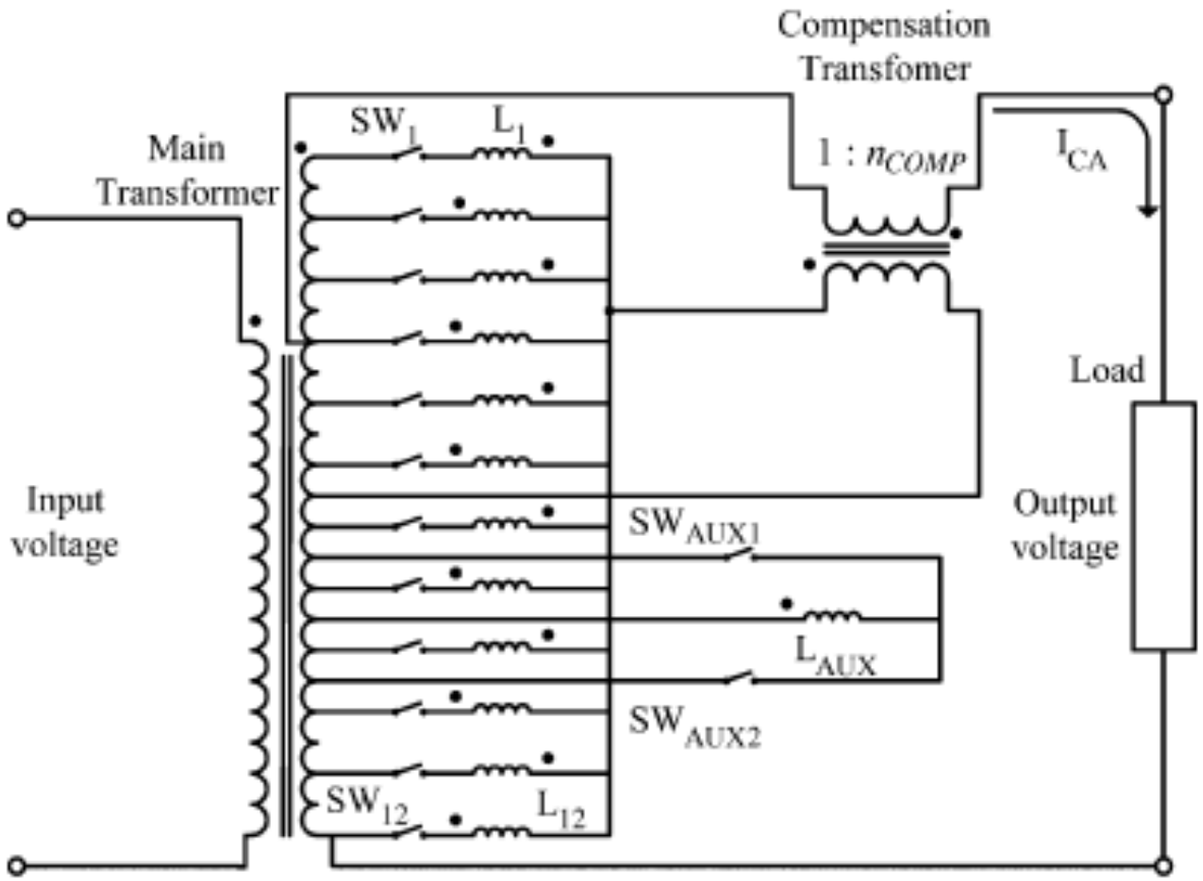
Aplicações de Conversores CA-CA



Echavarría et al, 2007.



Principal



Aplicações de Conversores CA-CA

MKP1V120 Series

Preferred Device

Sidac High Voltage

Bidirectional Triggers

Bidirectional devices designed for direct interface with the ac power line. Upon reaching the breakover voltage in each direction, the device switches from a blocking state to a low voltage on−state. Conduction will continue like a Triac until the main terminal current drops below the holding current. The plastic axial lead package provides high pulse current capability at low cost. Glass passivation insures reliable operation.

Features

- High Pressure Sodium Vapor Lighting
- Strobes and Flashers
- Ignitors
- High Voltage Regulators
- Pulse Generators
- Used to Trigger Gates of SCR's and Triacs
- Ⓤ Indicates UL Registered — File #E116110
- These are Pb−Free Devices*

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Repetitive Off−State Voltage (Sine Wave, 50 to 60 Hz, T_J = −40 to 125°C) MKP1V120, MKP1V130, MKP1V160 MKP1V240	V_{DRM}, V_{RRM}	± 90 ± 180	V
On-State Current RMS (T_L = 50°C, Lead Length = 3/8", All Conduction Angles)	$I_{T(RMS)}$	± 0.9	A
Peak Non−repetitive Surge Current (60 Hz One Cycle Sine Wave, T_J = 125°C)	I_{TSM}	± 4.0	A
Operating Junction Temperature Range	T_J	−40 to +125	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction−to−Lead Lead Length = 3/8"	$R_{\theta JL}$	40	°C/W
Lead Solder Temperature (Lead Length ≥ 1/16" from Case, 10 s Max)	T_L	260	°C

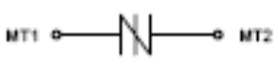
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ON Semiconductor®

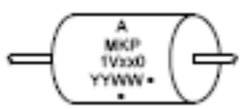
http://onsemi.com

SIDACS(Ⓤ)
0.9 AMPERES RMS
120 − 240 VOLTS



AXIAL LEAD
CASE 59
STYLE 2

MARKING DIAGRAM

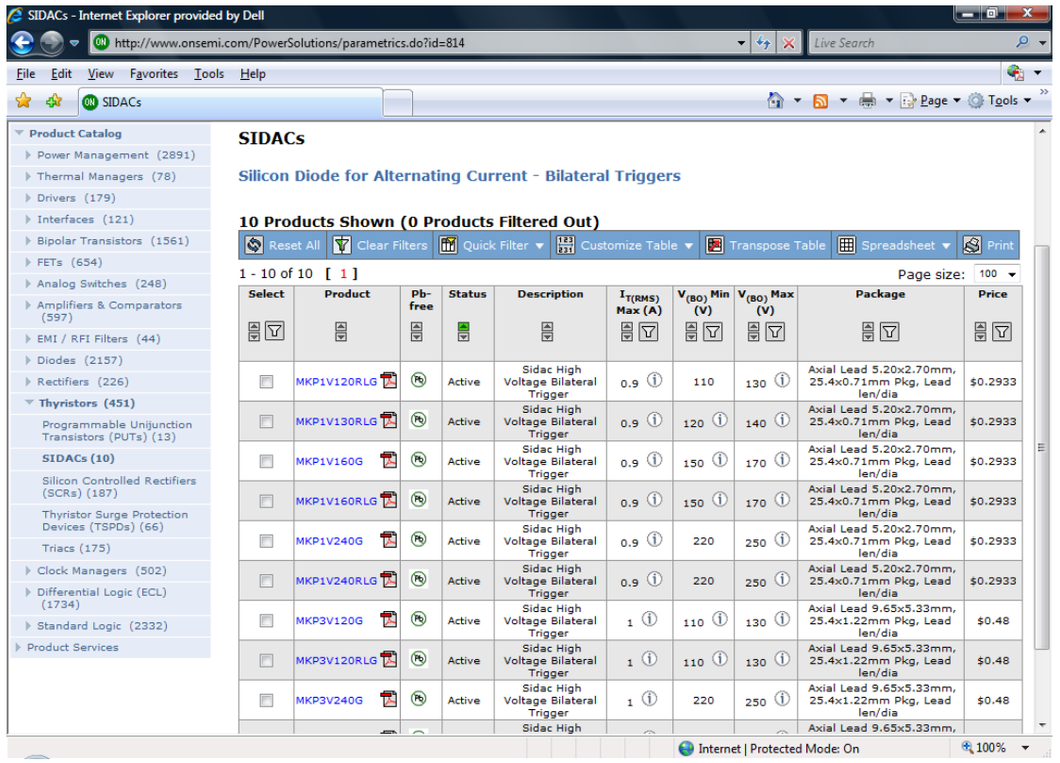


A = Assembly Location
MKP1Vxx0 = Device Number
xx= 12, 13, 16 or 24
YY = Year
WW = Work Week
• = Pb−Free Package
(Note: Microdot may be in either location)

ORDERING INFORMATION

See detailed ordering and shipping information on page 2 of this data sheet.

Preferred devices are recommended choices for future use and best overall value.



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INSTITUTO FEDERAL
SANTA CATARINA

Próxima Aula

Conversores ca-ca:

- Estabilizadores de tensão.

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