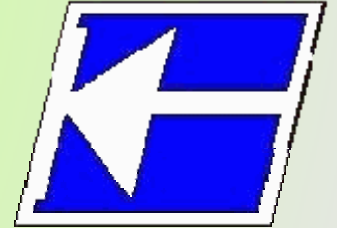


**Centro Federal de Educação Tecnológica de Santa Catarina**  
**Departamento Acadêmico de Eletrônica**  
**Conversores Estáticos**



# **Conversores CA-CA**

## **Variadores CA Monofásicos**

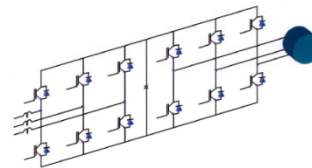
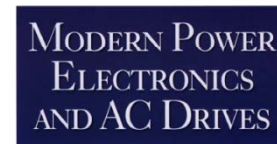
**Prof. Clóvis Antônio Petry.**

**Florianópolis, abril de 2008.**

# Bibliografia para esta aula

## Capítulo 11: Controlador de tensão AC

### 1. Variadores CA monofásicos.



BIMAL K. BOSE

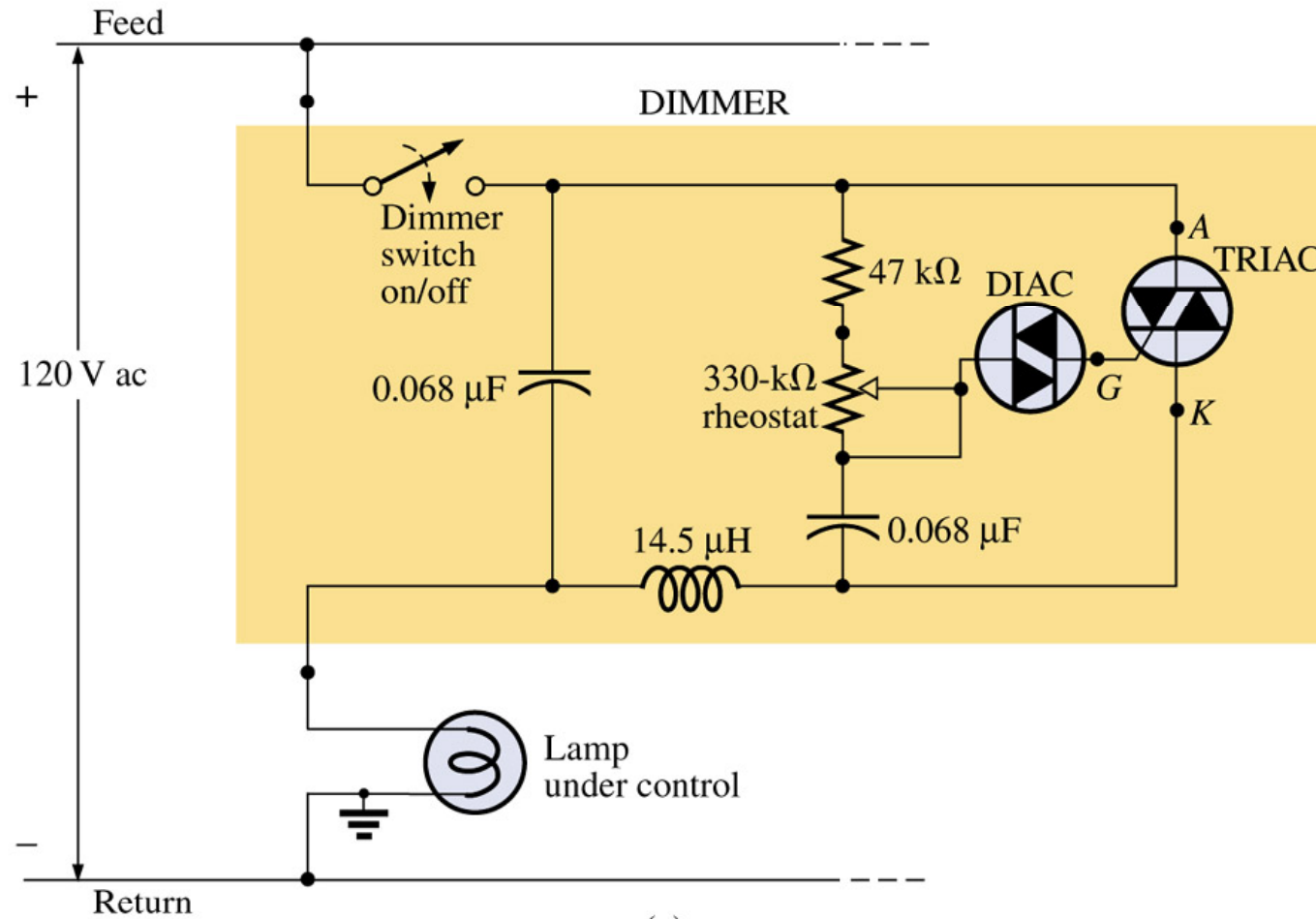
[www.cefetsc.edu.br/~petry](http://www.cefetsc.edu.br/~petry)

# Nesta aula

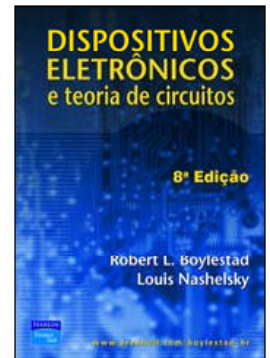
## **Gradadores:**

1. Introdução;
2. Implementação de um gradador monofásico;
3. Partida de cargas com gradadores;
4. Disparo de tiristores;
5. Chaves bidirecionais para CA-CA;
6. Estabilizadores com tap variável;
7. Chopper CA-CA;
8. Conversor CA-CA indireto.

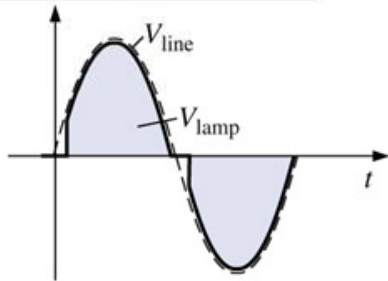
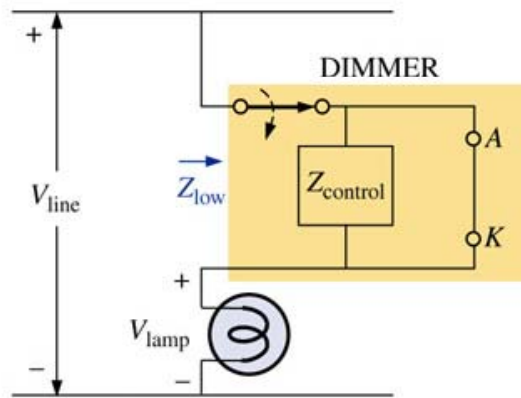
# Implementação do gradador monofásico (dimmer)



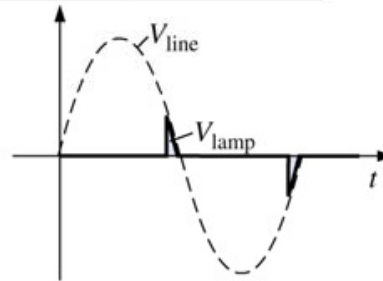
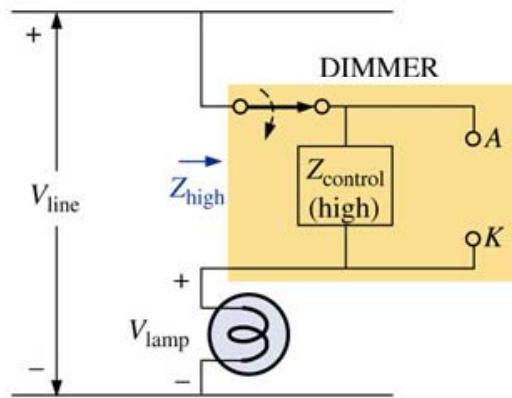
(c)



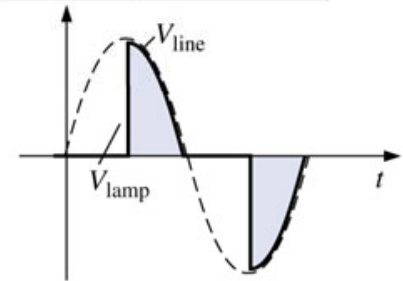
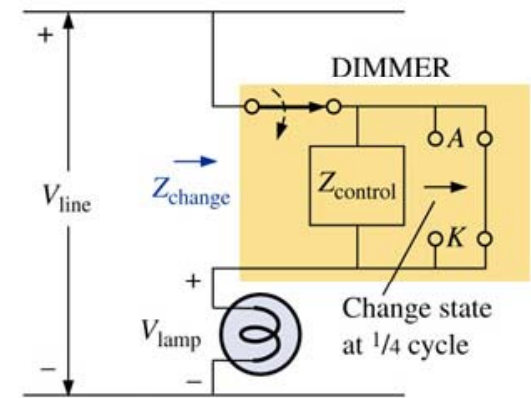
# Implementação do gradador monofásico (dimmer)



(a)

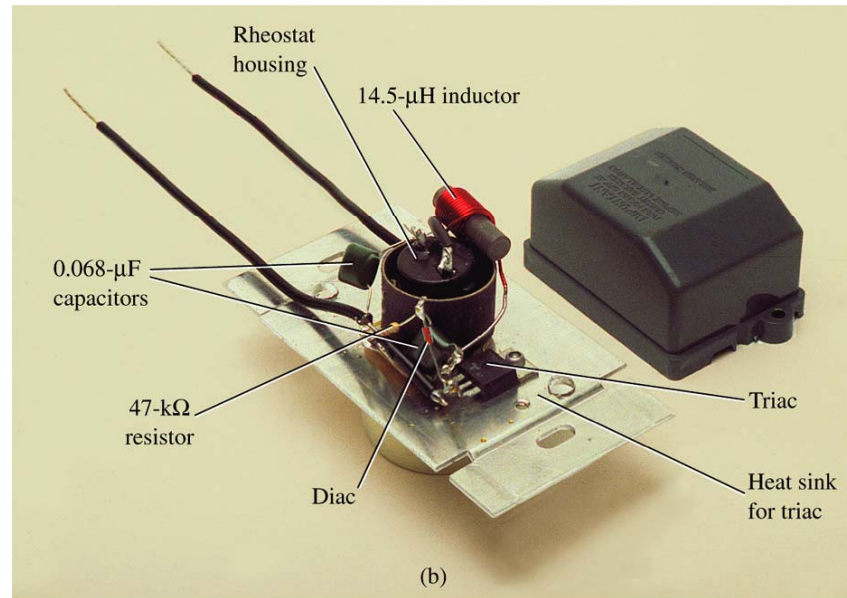
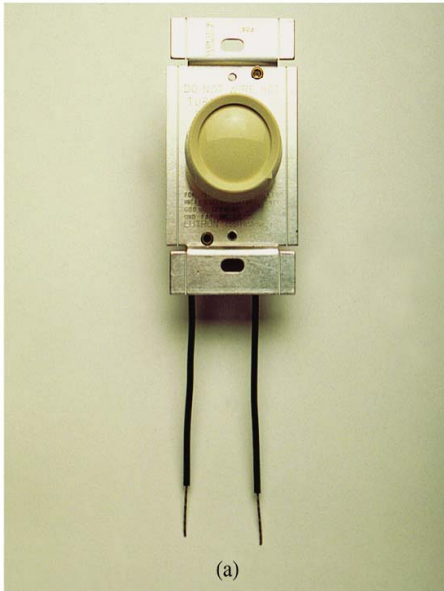


(b)



(c)

# Implementação do gradador monofásico (dimmer)

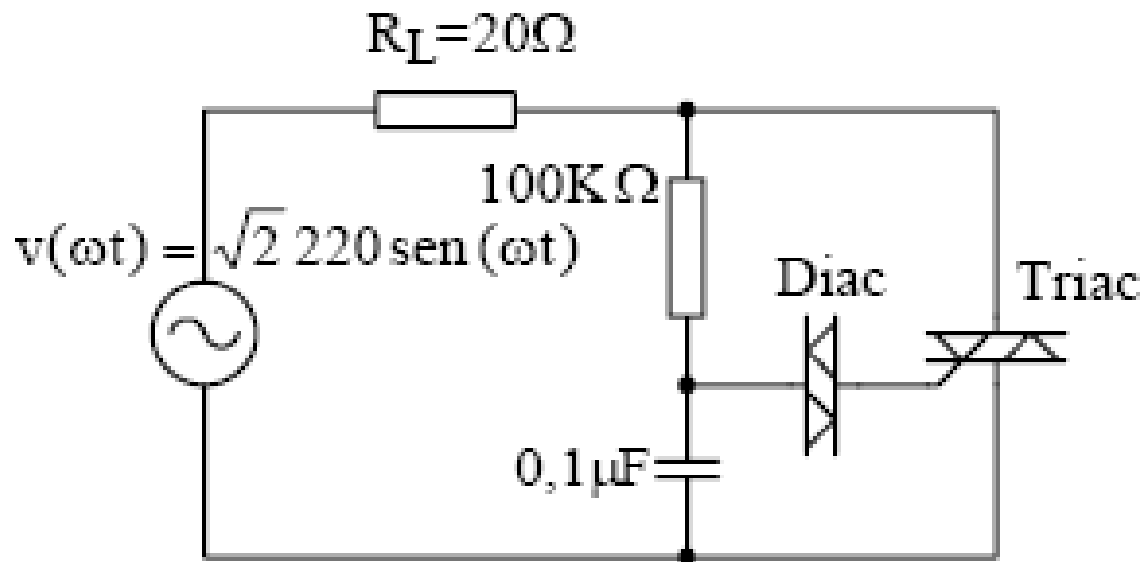


# Implementação do gradador monofásico (dimmer)

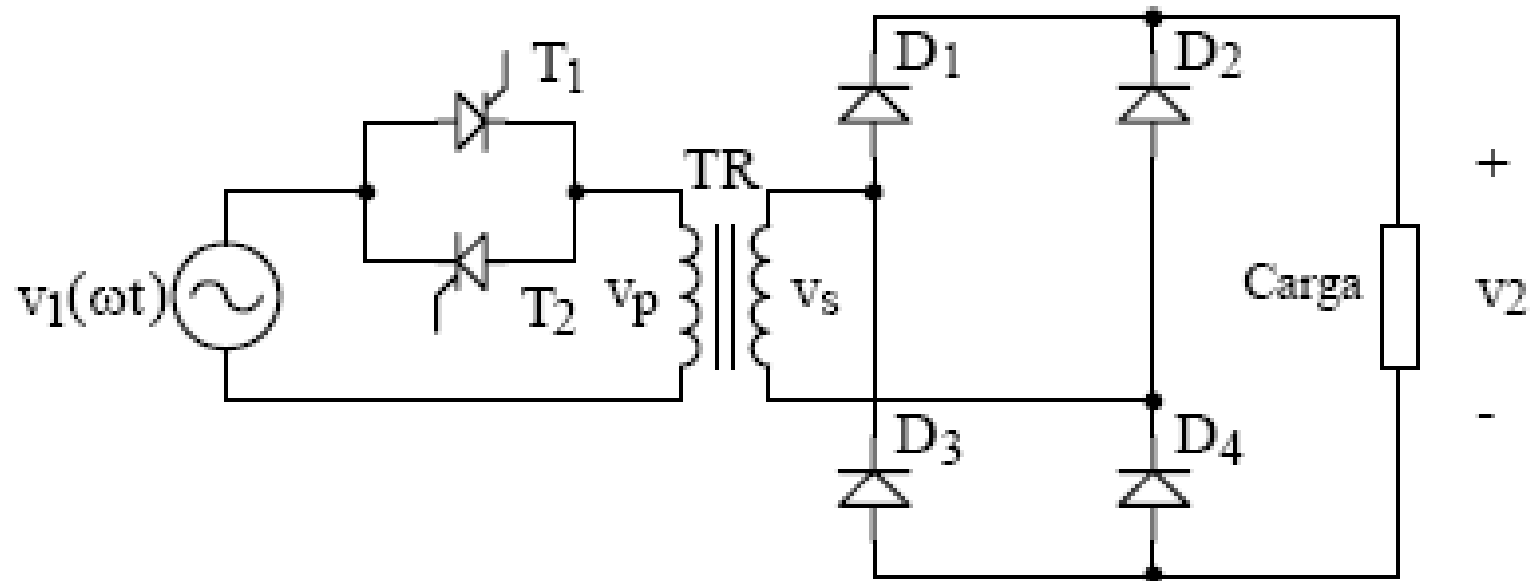
## Tarefa:

Estudar o exercício 6, do  
Capítulo 7 – Gradadores.

Diac de  $\pm 42$  V.



# Partida de cargas com gradadores



Controle da tensão de saída do retificador pelo gradador

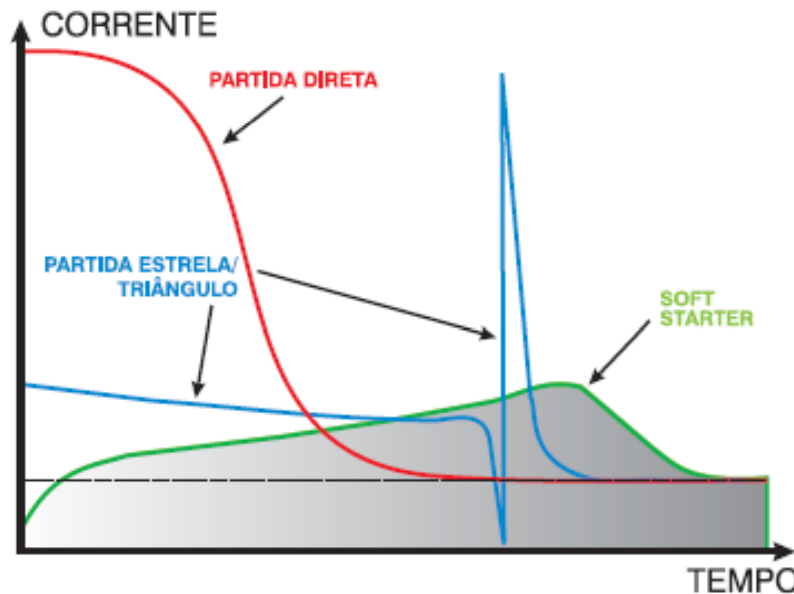
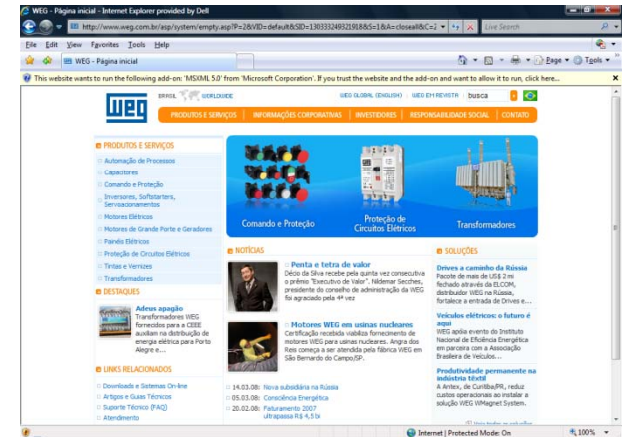


# Partida de cargas com gradadores



**SSW 05**  
SOFT-STARTER *Plus*

- Potência : 0,75 a 75cv
- Tensão : 220 a 575 V
- By-pass incorporado
- Controle com DSP
- HMI remota (opcional)
- Proteções do motor incorporadas
- Operação em ambientes de até 55°



[www.weg.com.br](http://www.weg.com.br)

Controle da corrente de partida de motores usando gradadores

# Disparo de tiristores

## 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
- Strobos and Flashes
- Ignitors
- High Voltage Regulators
- Pulse Generators
- Used to Trigger Gates of SCR's and Triacs
- $\Psi$  Indicates UL Registered — File #E116110
- These are Pb-Free Devices\*

#### MAXIMUM RATINGS (T<sub>J</sub> = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Peak Repetitive Off-State Voltage (Sine Wave, 50 to 60 Hz, T <sub>J</sub> = -40 to 125°C) MKP1V120, MKP1V130, MKP1V180 MKP1V240	V <sub>DRM</sub> V <sub>RRM</sub>	± 90 ± 120	V
On-State Current RMS (T <sub>J</sub> = 80°C, Lead Length = 3/16", All Conduction Angles)	I <sub>TRMS</sub>	± 0.9	A
Peak Non-repetitive Surge Current (80 Hz One Cycle Sine Wave, T <sub>J</sub> = 125°C)	I <sub>TSM</sub>	± 4.0	A
Operating Junction Temperature Range	T <sub>J</sub>	-40 to +125	°C
Storage Temperature Range	T <sub>stg</sub>	-40 to +150	°C

#### THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction-to-Lead (Lead Length = 3/16")	R <sub>θJL</sub>	40	°C/W
Lead Solder Temperature (Lead Length = 1/16" from Case, 10 s Max)	T <sub>L</sub>	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.



ON Semiconductor®

http://onsemi.com

SIDAC(S $\Psi$ )  
0.9 AMPERES RMS  
120 - 240 VOLTS



AXIAL LEAD  
CASE 58  
STYLE 2

#### MARKING DIAGRAM



- A = Assembly Location
  - MKP1Vxxx = Device Number
  - YY = Year
  - WW = Week/Week
  - = Pb-Free Package
- (Note: Microdot may be in either location)

#### ORDERING INFORMATION

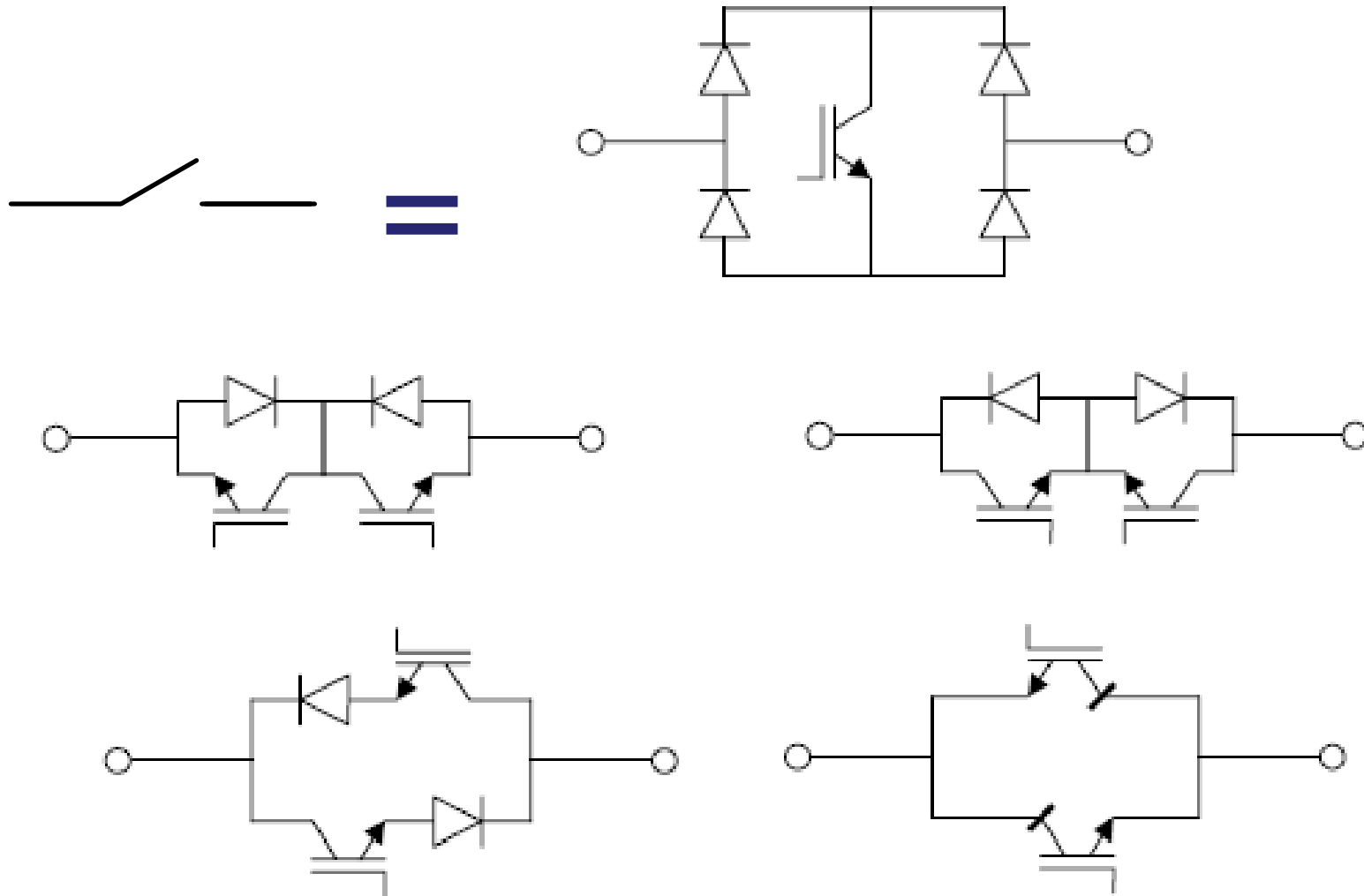
See detailed ordering and shipping information on page 2 of this data sheet.

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

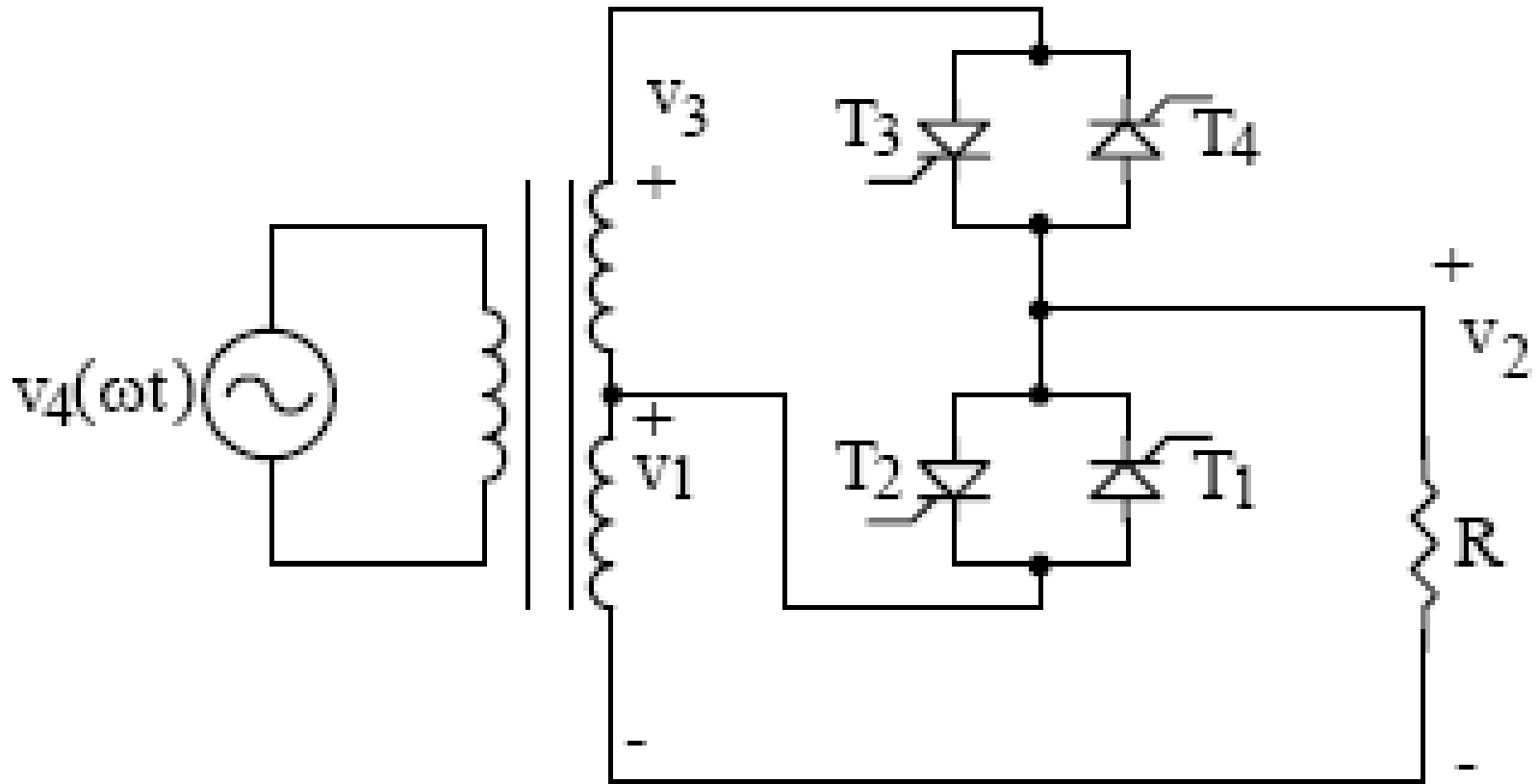
\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

www.onsemi.com

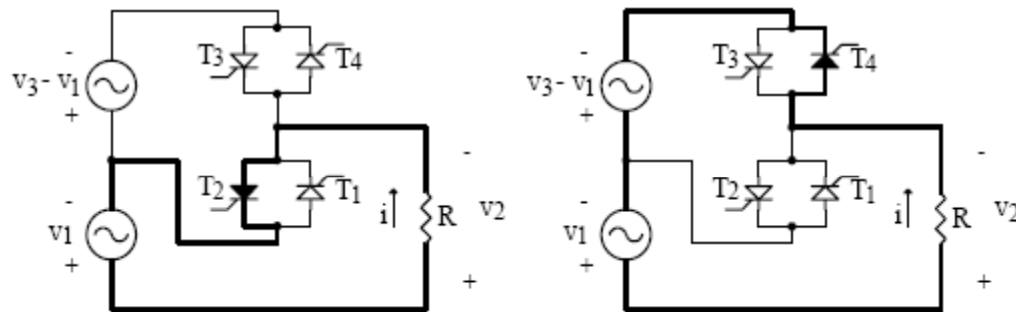
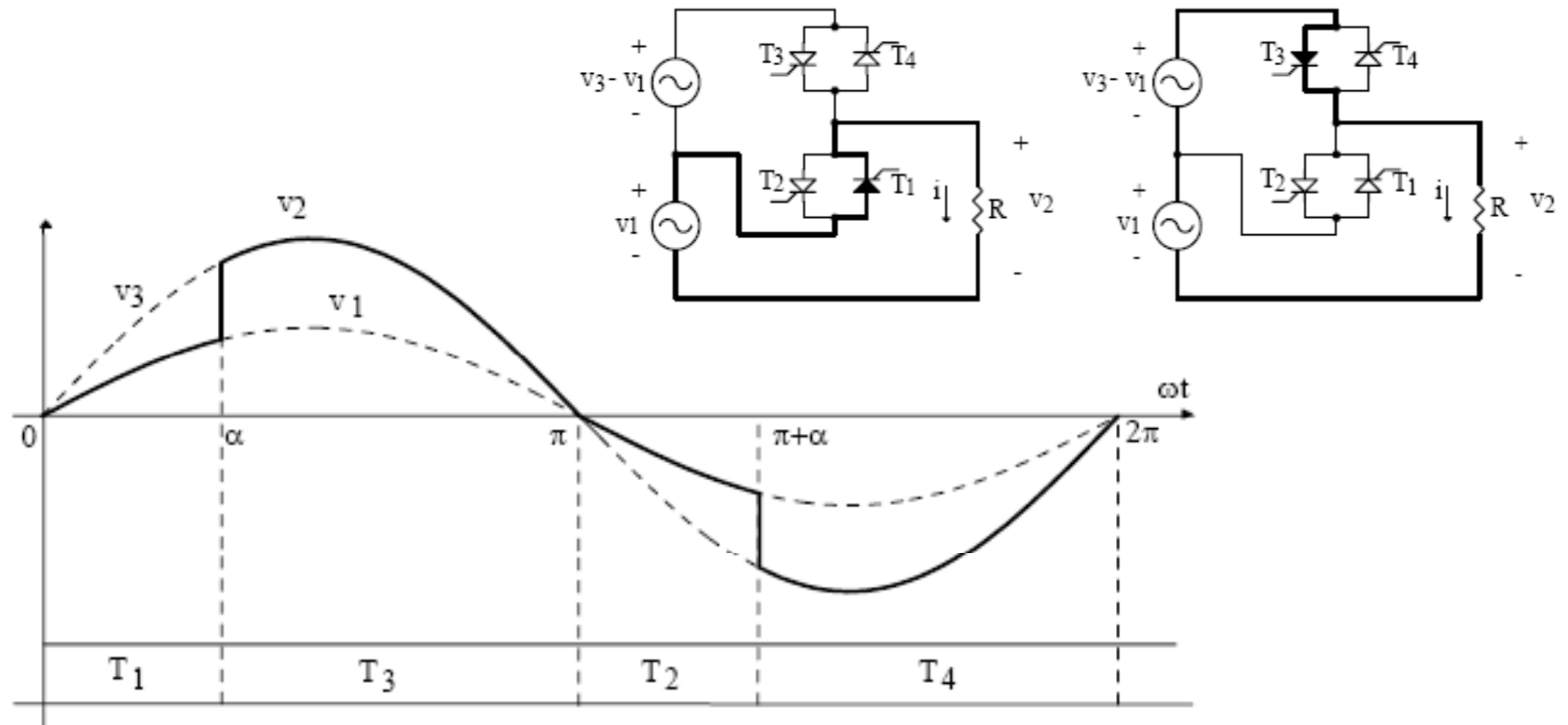
# Chaves bidirecionais para conversores CA-CA



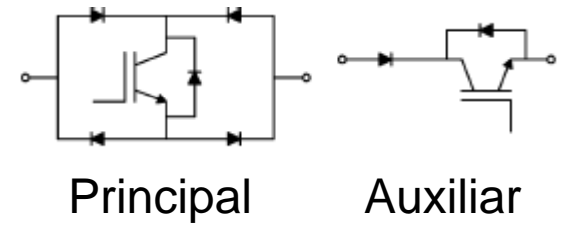
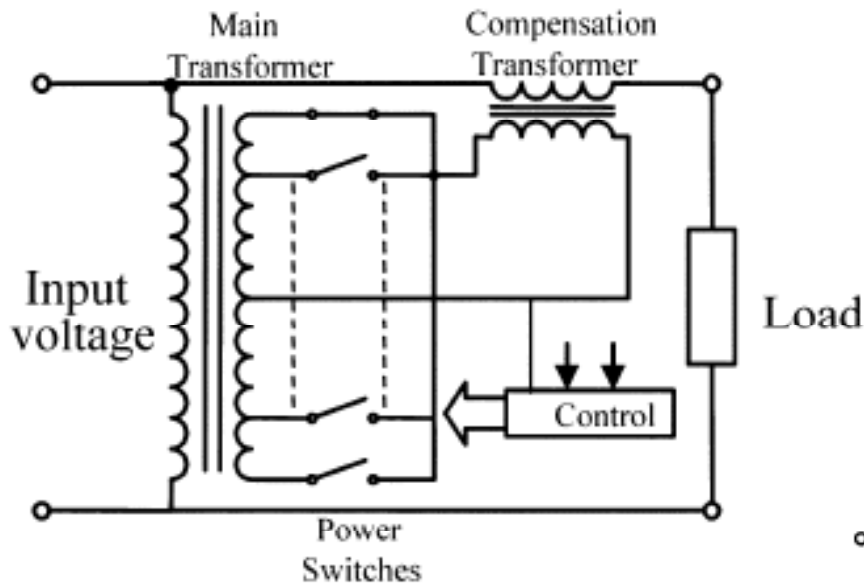
# Estabilizador com tap variável



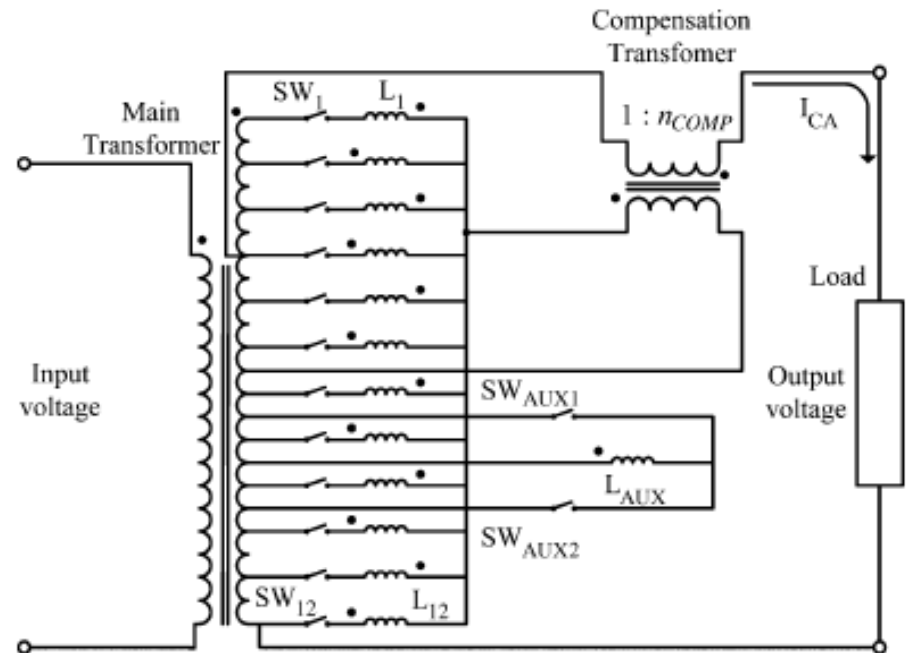
# Estabilizador com tap variável



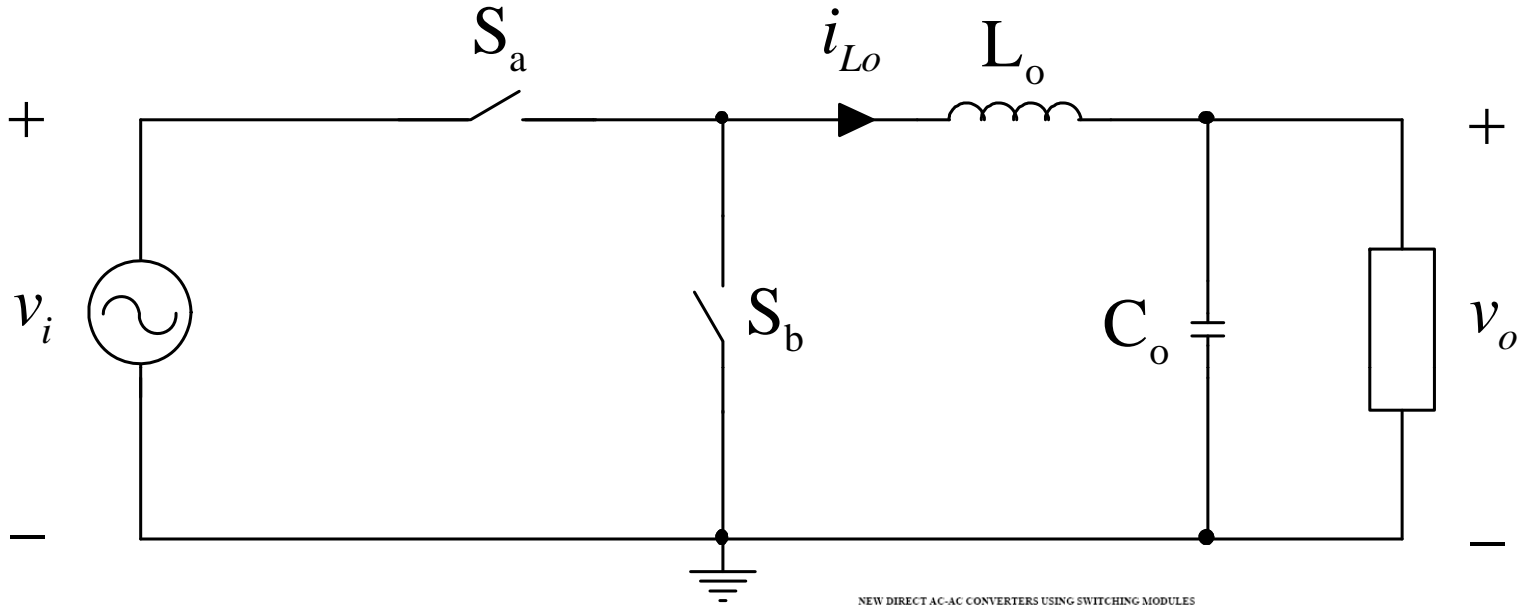
# Estabilizador com tap variável



Echavarría et al, 2007.



# Chopper CA-CA



## NEW DIRECT AC-AC CONVERTERS USING SWITCHING MODULES WITHOUT COMMUTATION PROBLEMS

C. A. Petry<sup>1</sup>, J. C. Fagnuolo<sup>2</sup>, I. Barbi<sup>3</sup>

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<sup>2</sup>Dept. of Electrical Engineering - EEL  
 Federal University of Santa Catarina - UFSC  
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 {petry, fagnuolo, barbi}@ipep.ufsc.br

**Abstract** - In this paper the study of direct AC-AC converter topologies, which make use of switches in commercial settings, will be performed. Several topologies are presented, including some already known in the literature and new ones. For one of the presented topologies, the design of a 3 kVA line conditioner is developed and experimental results are shown, certifying the correct operation of the drive strategy used.

**Keywords** - direct converters, AC-AC converters, line conditioner, switching modules.

### INTRODUCTION

Line conditioners are equipment used in industrial, residential and commercial environments in order to regulate the voltage provided by the grid. One of the main difficulties of employing alternating current converters using fast switches and PWM has always been the switching, which remained without a solution for many years. Choosing Fig. 2 it can be seen that in order to switch from  $S_{12}$  to  $S_{14}$ , there are two alternatives: the reapposition of the drive signals or the use of dead-time. In the first case, a short-circuit in the voltage source is provided, while in the second case the current through inductor  $L_o$  is interrupted, resulting in overvoltage across the switches [14].

One solution for the switching problem is the use of indirect converters [1], which discontinuously use a larger number of switches than direct converters.

A switching proposal for AC-AC converters was presented in [2] and improved in [3-7], eliminating the need for changing currents. In this switching strategy it is necessary to synchronize the drive signals with the converter input voltage signal.

In [8] a switching cell was proposed for direct AC-AC converters, studied later in [9]. These converters are robust, with few controlled switches and solve the switching problem. However, there is a problem with average current through the inductor and switches cannot be used in commercial configurations.

The arrangement of the switches in commercial configurations for AC-AC converters were proposed in [4-7, 10]. These arrangements allow the use of commercial modules, an attractive feature especially at high power.

The main idea of this work is to employ the switching strategies of [3-7] in several topologies, among which some are well known and others are new, always using switches arranged in a way that permits the usage of commercial modules [4-7, 10].

In [11] several converter topologies were proposed. However, the main focus was neither on switching nor on the commercial arrangement of the switches. In this manner, among the topologies presented in this paper, one was chosen to implement a 3 kVA line conditioner, controlled by the orthogonal detection principle [12, 13].

### II. ORIGIN AND COMBINATION OF THE PROPOSED TOPOLOGIES

To show the origin of the topologies that are going to be presented, an AC-AC Buck converter in a standard configuration will be shown, as depicted in Fig. 2. Note that this converter is bidirectional in both voltage and current by using commercial modules. However, the usage of commercial modules is not possible. Allowing the position of switch  $S_a$ , a configuration which allows the usage of commercial modules is obtained, as shown in Fig. 3.

The switching is performed as shown in Fig. 3, note that during the positive semi-cycle of the grid voltage, switches  $S_1$  and  $S_2$  conduct and switches  $S_3$  and  $S_4$  are driven by PWM. During the negative semi-cycle of the grid voltage, switches  $S_3$  and  $S_4$  conduct and switches  $S_1$  and  $S_2$  are modulated at high frequency.

### III. PROPOSED TOPOLOGIES

Using the same procedure adopted in Fig. 2, that is, rearranging the switches in a way to obtain configurations that allow the usage of commercial modules, several AC-AC converter topologies can be obtained. With these topologies several voltage compensating AC voltage conditioners can be implemented, which have the advantage of processing just the difference between the desired output voltage and the input voltage, consequently, processing just part of the load's power, guaranteeing a high performance. The state space will be expressed as a function of the switches' duty-cycle and the turns ratio, for the structure that use transformers.

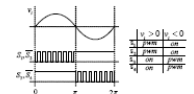
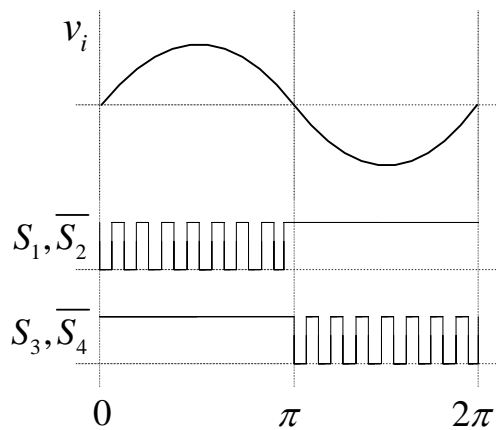
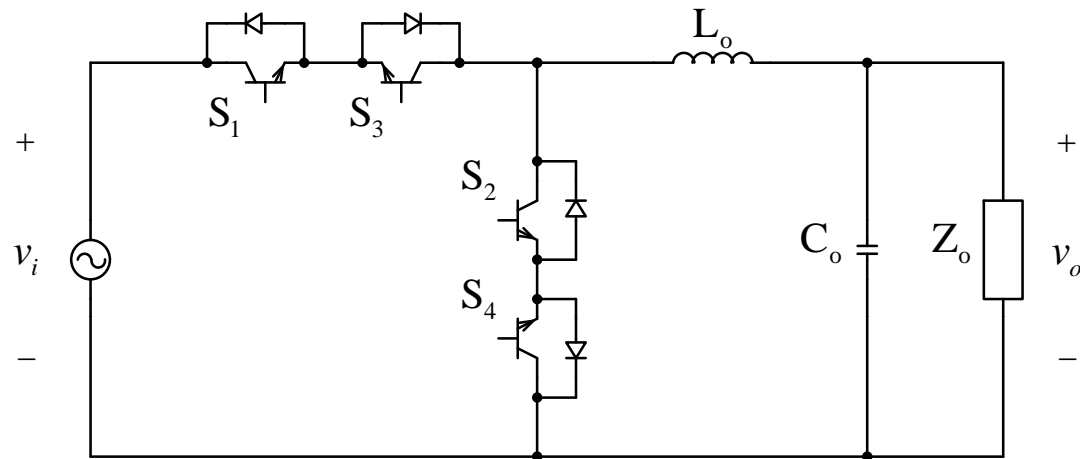
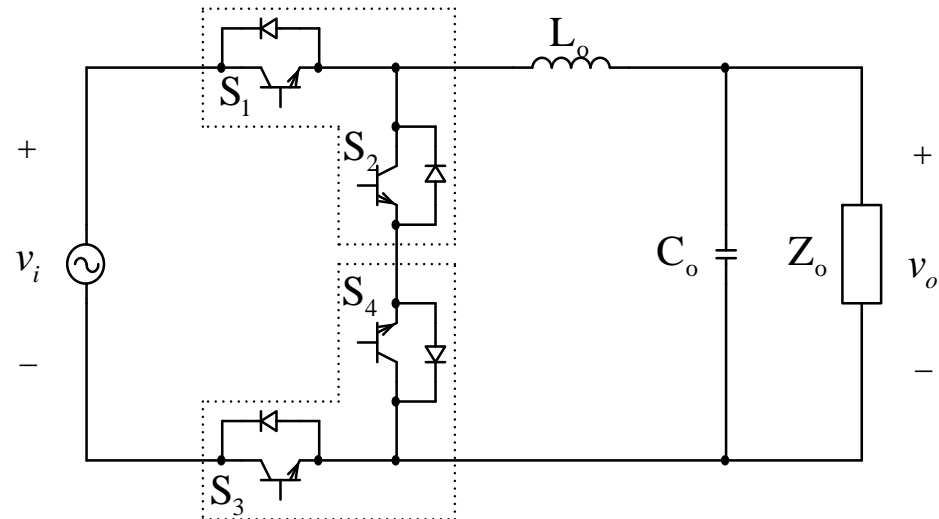


Fig. 3 - Switching of the converter switches of Fig. 2.

# Chopper CA-CA



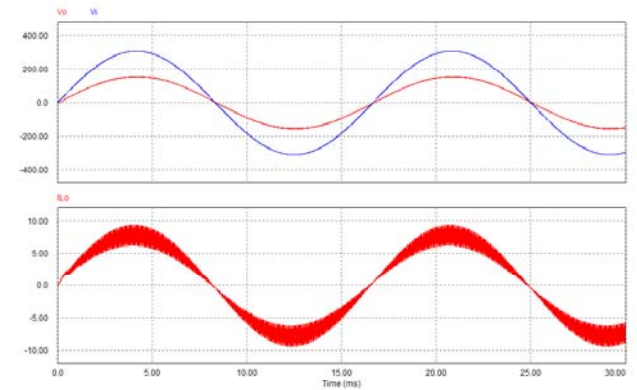
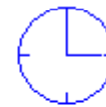
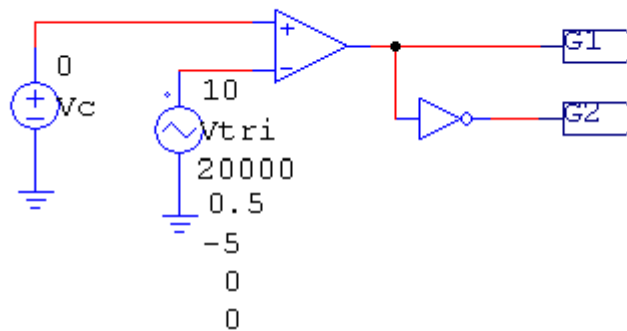
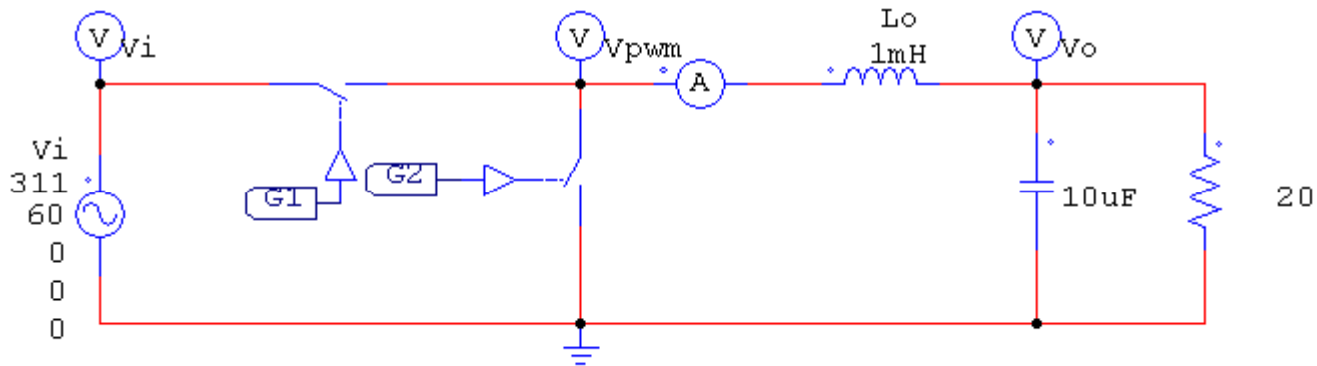
	$v_i > 0$	$v_i < 0$
$S_1$	<i>pwm</i>	<i>on</i>
$S_2$	<i>pwm</i>	<i>on</i>
$S_3$	<i>on</i>	<i>pwm</i>
$S_4$	<i>on</i>	<i>pwm</i>



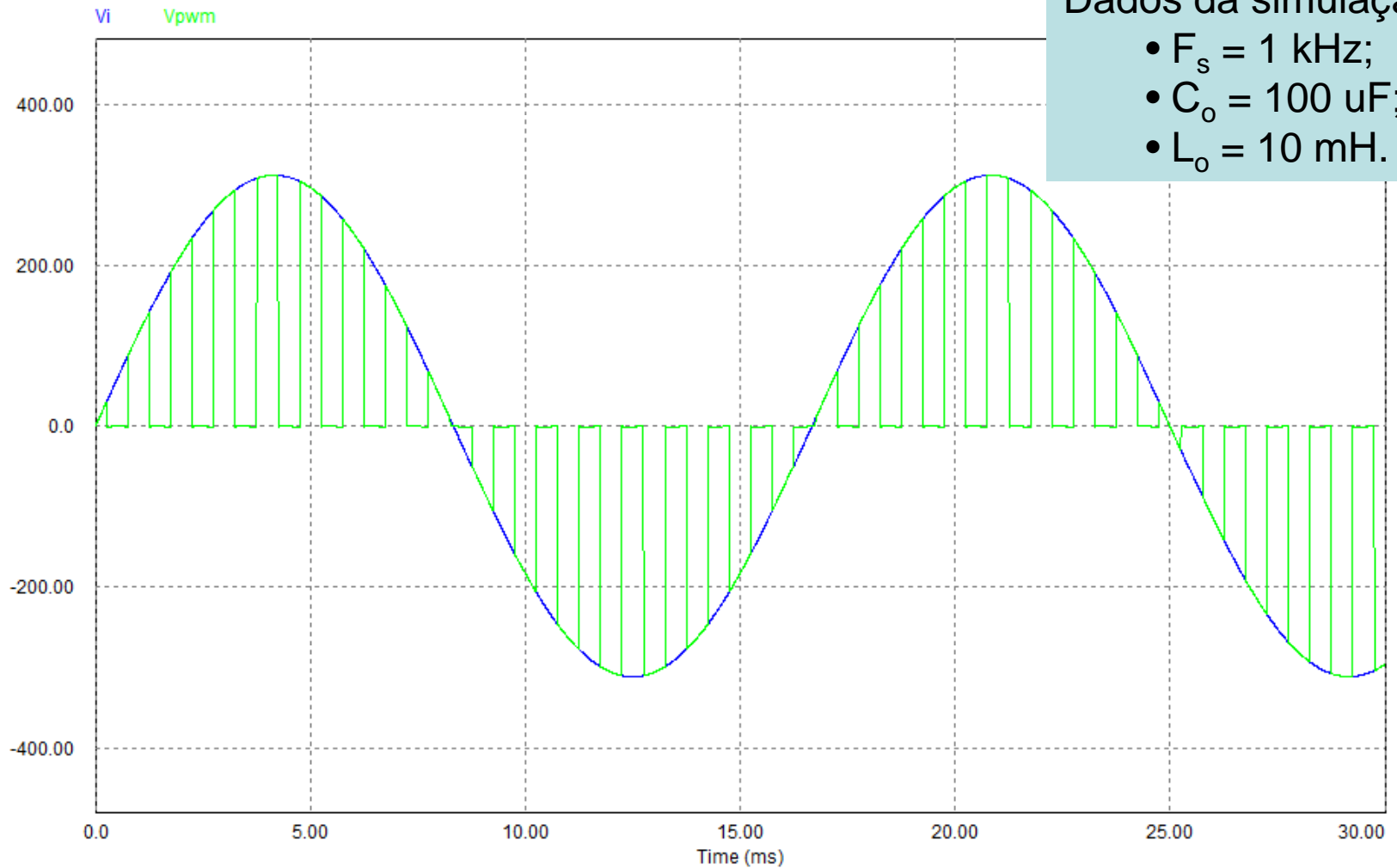


# Chopper CA-CA

## Chopper CA-CA



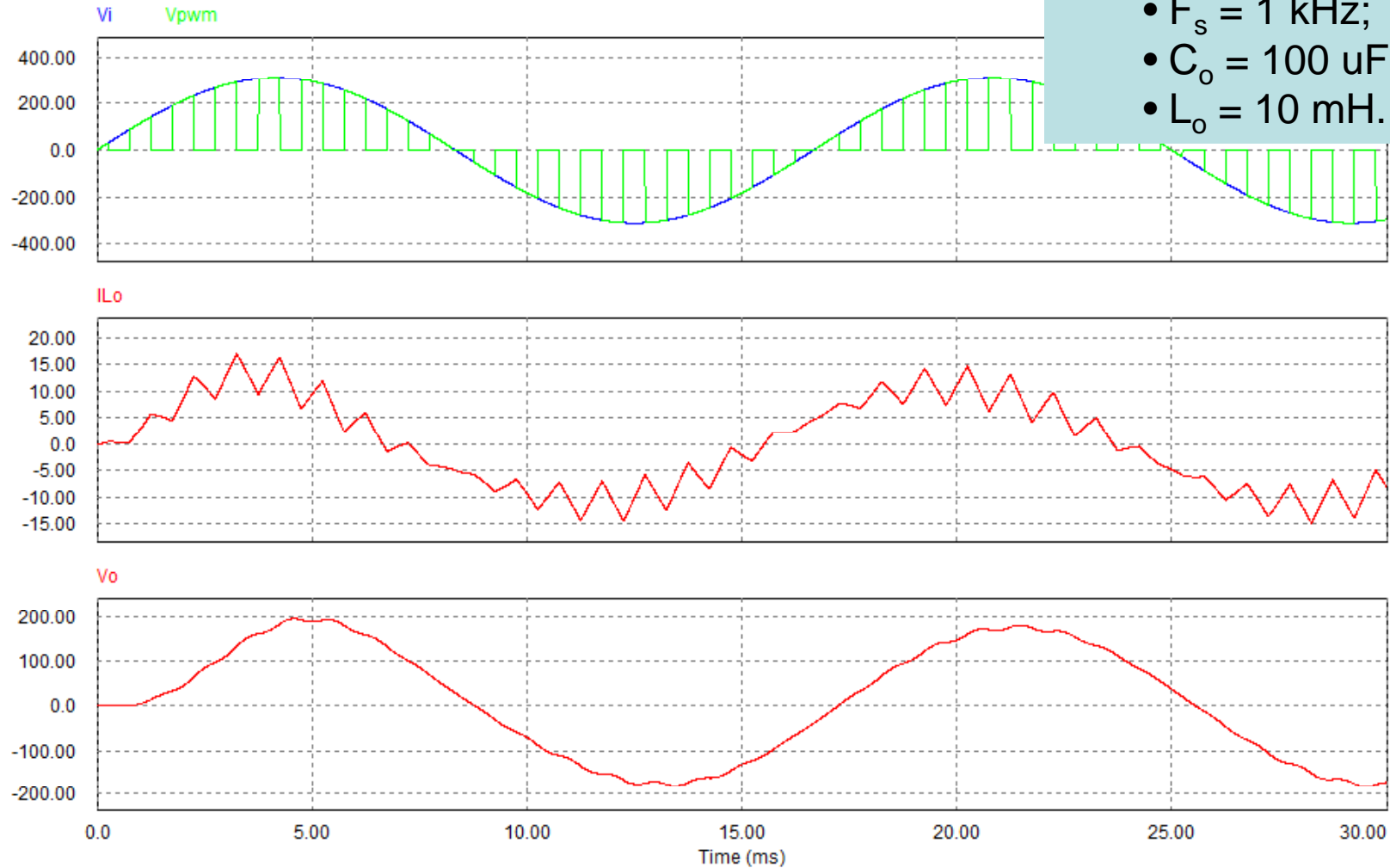
# Chopper CA-CA



# Chopper CA-CA

Dados da simulação:

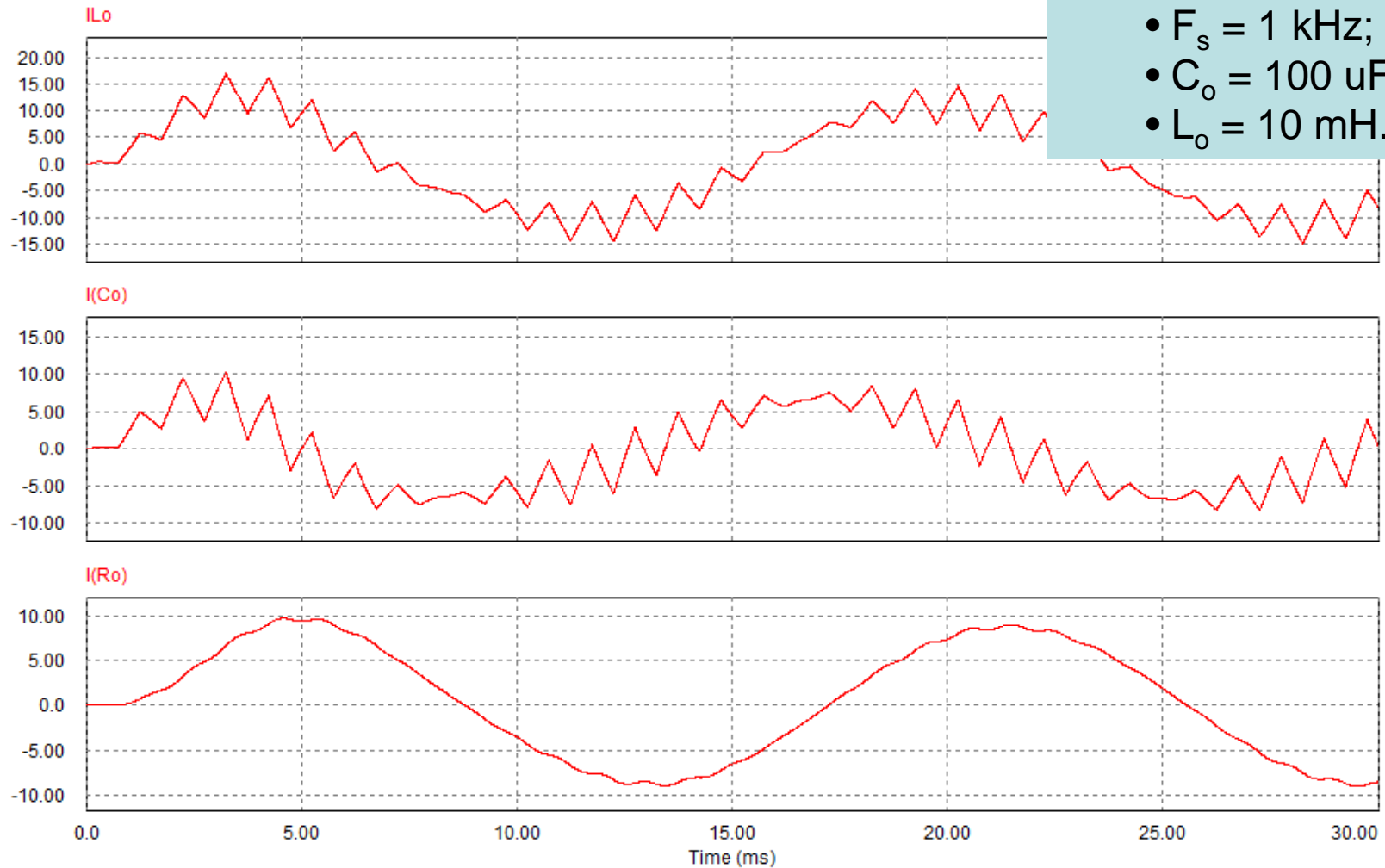
- $F_s = 1$  kHz;
- $C_o = 100$   $\mu$ F;
- $L_o = 10$  mH.



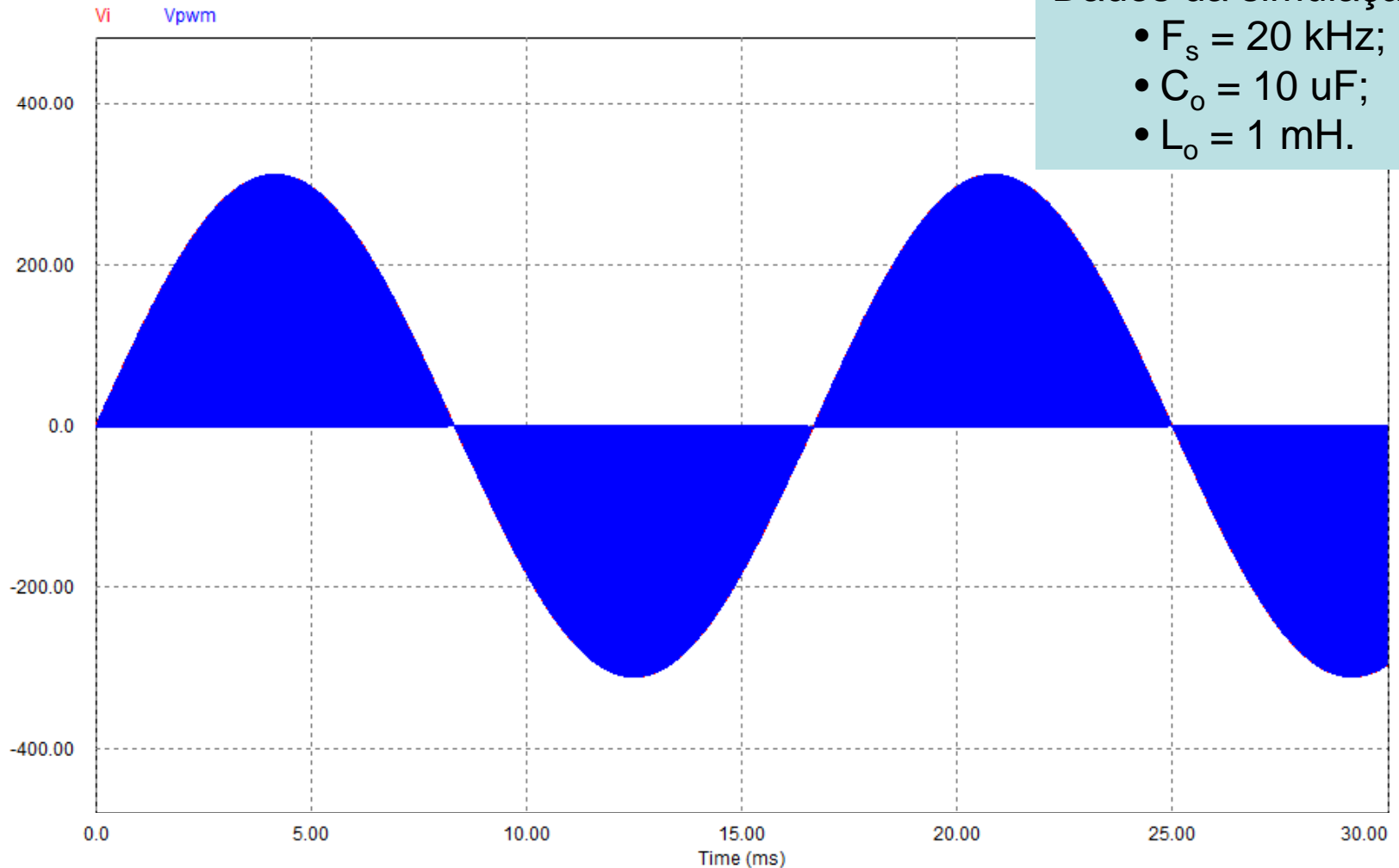
# Chopper CA-CA

Dados da simulação:

- $F_s = 1$  kHz;
- $C_o = 100$   $\mu$ F;
- $L_o = 10$  mH.



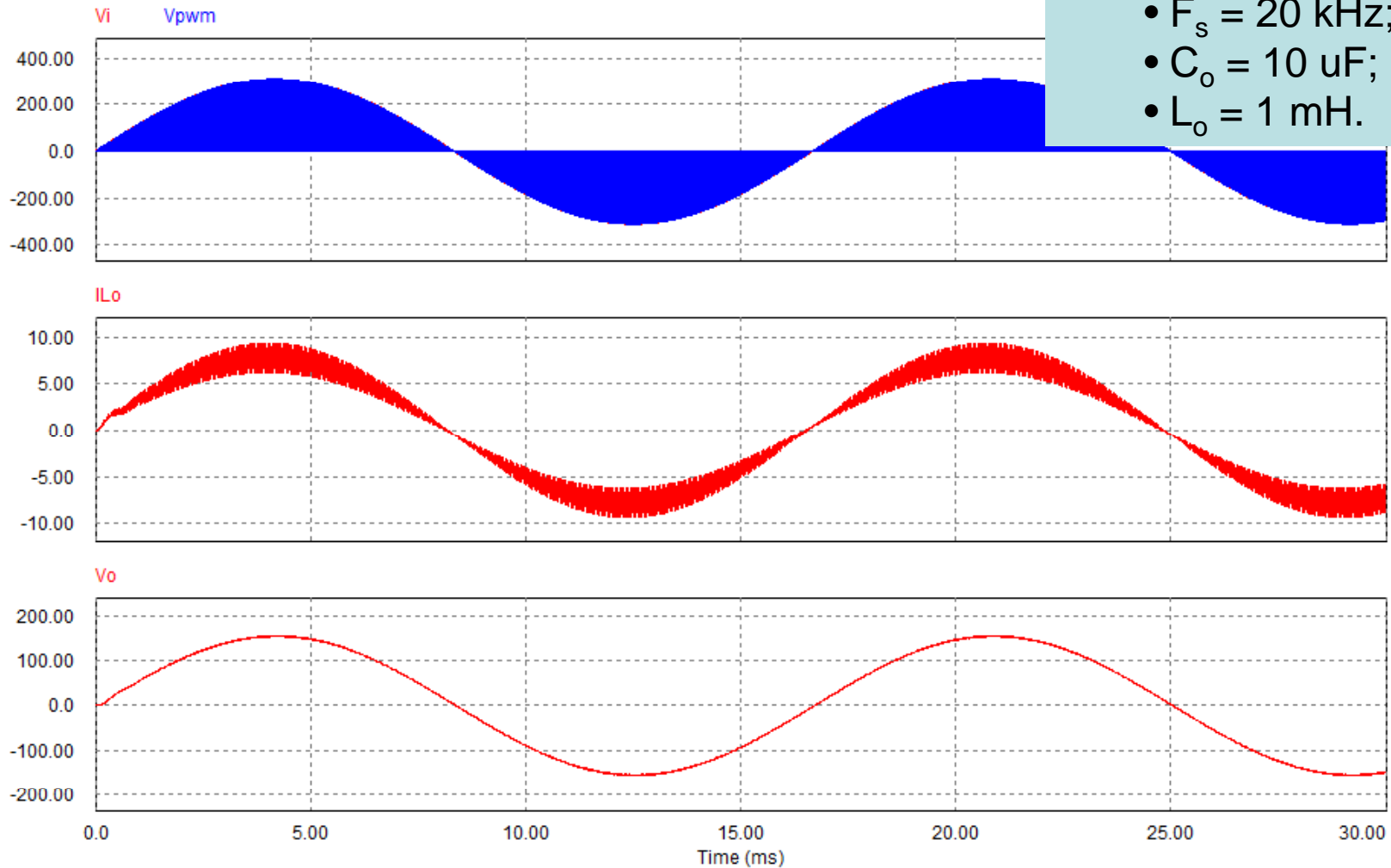
# Chopper CA-CA



# Chopper CA-CA

Dados da simulação:

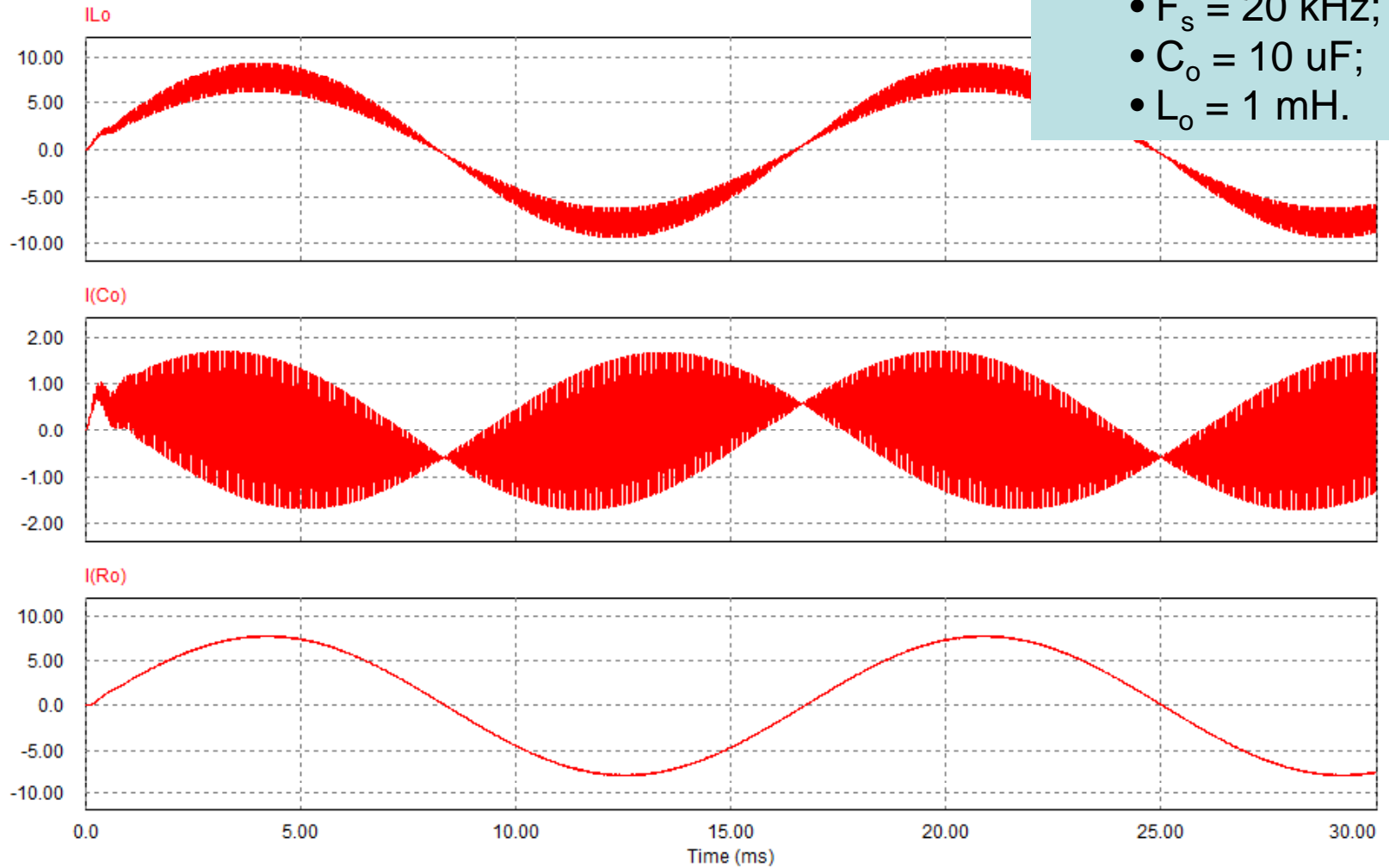
- $F_s = 20$  kHz;
- $C_o = 10$   $\mu$ F;
- $L_o = 1$  mH.



# Chopper CA-CA

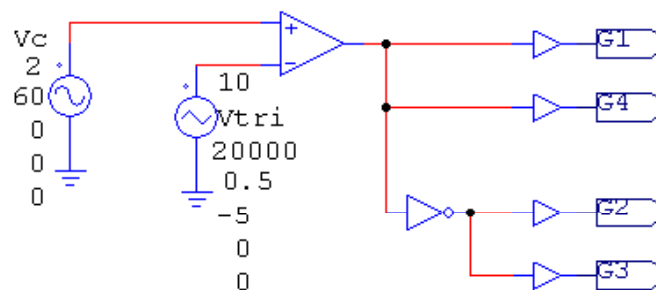
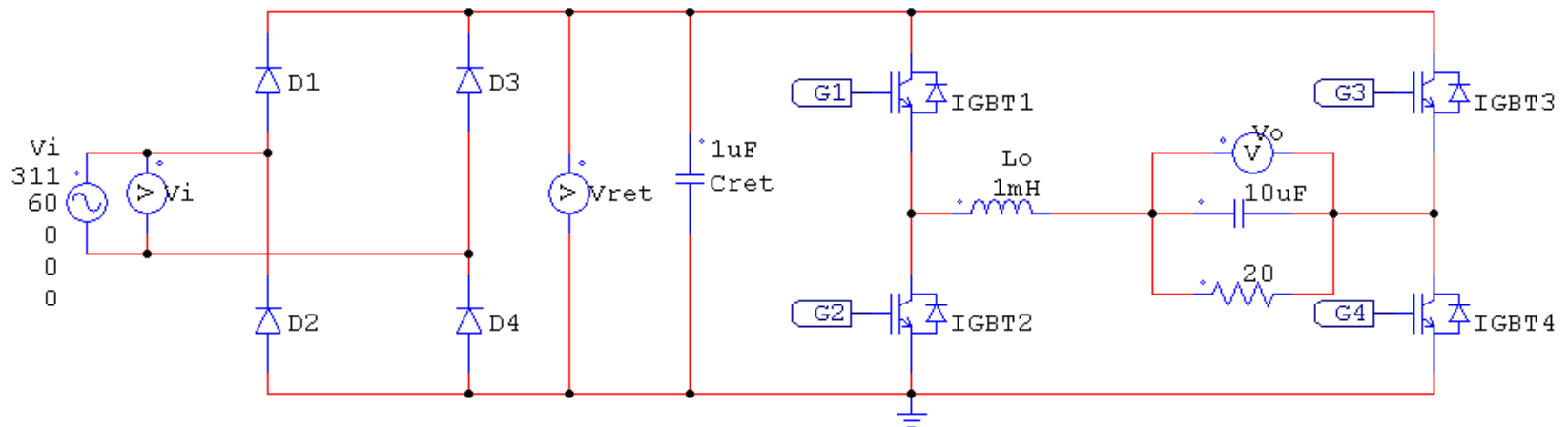
Dados da simulação:

- $F_s = 20$  kHz;
- $C_o = 10$   $\mu$ F;
- $L_o = 1$  mH.



# Conversor CA-CA indireto

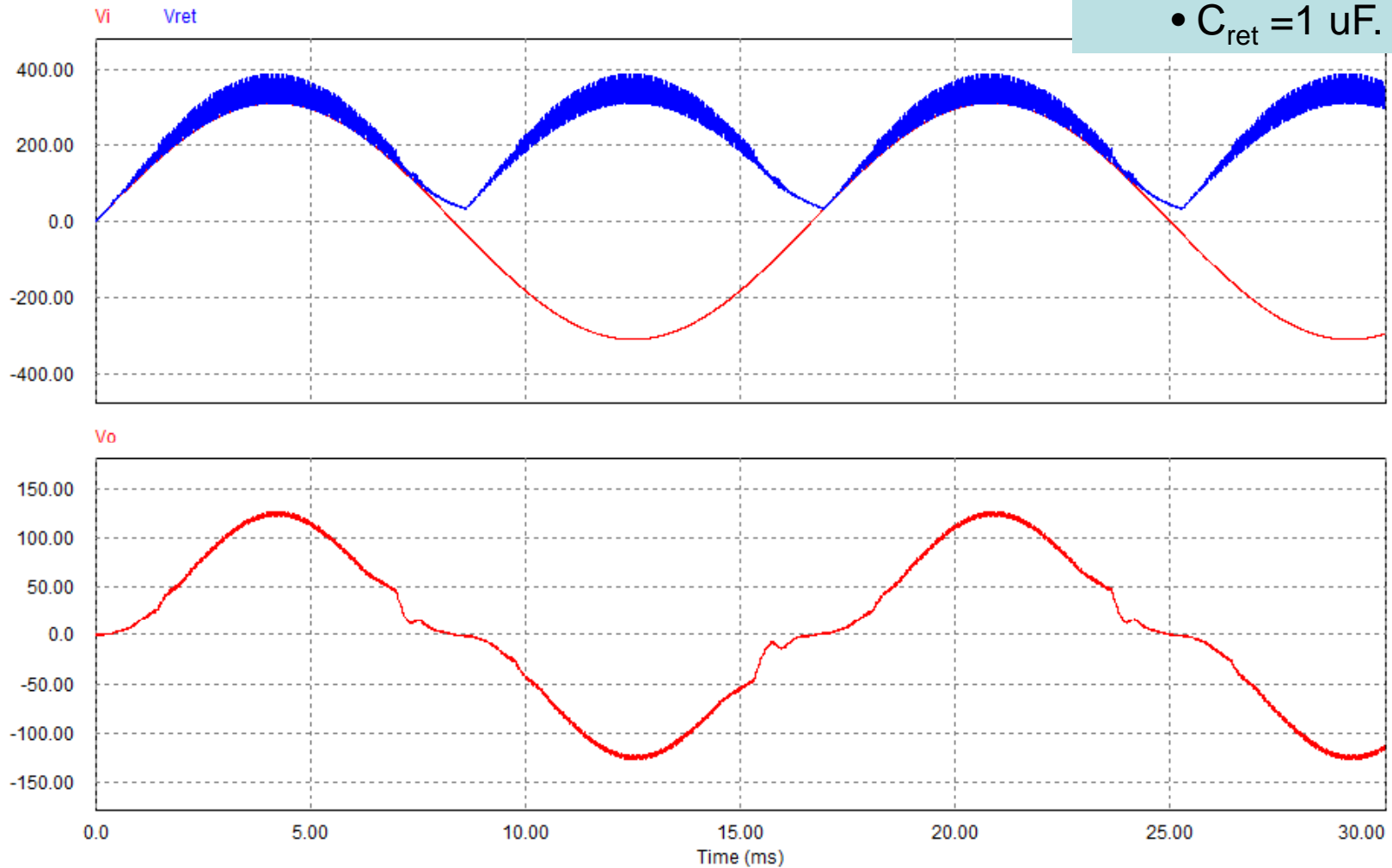
## Conversor CA-CA Indireto





# Conversor CA-CA indireto

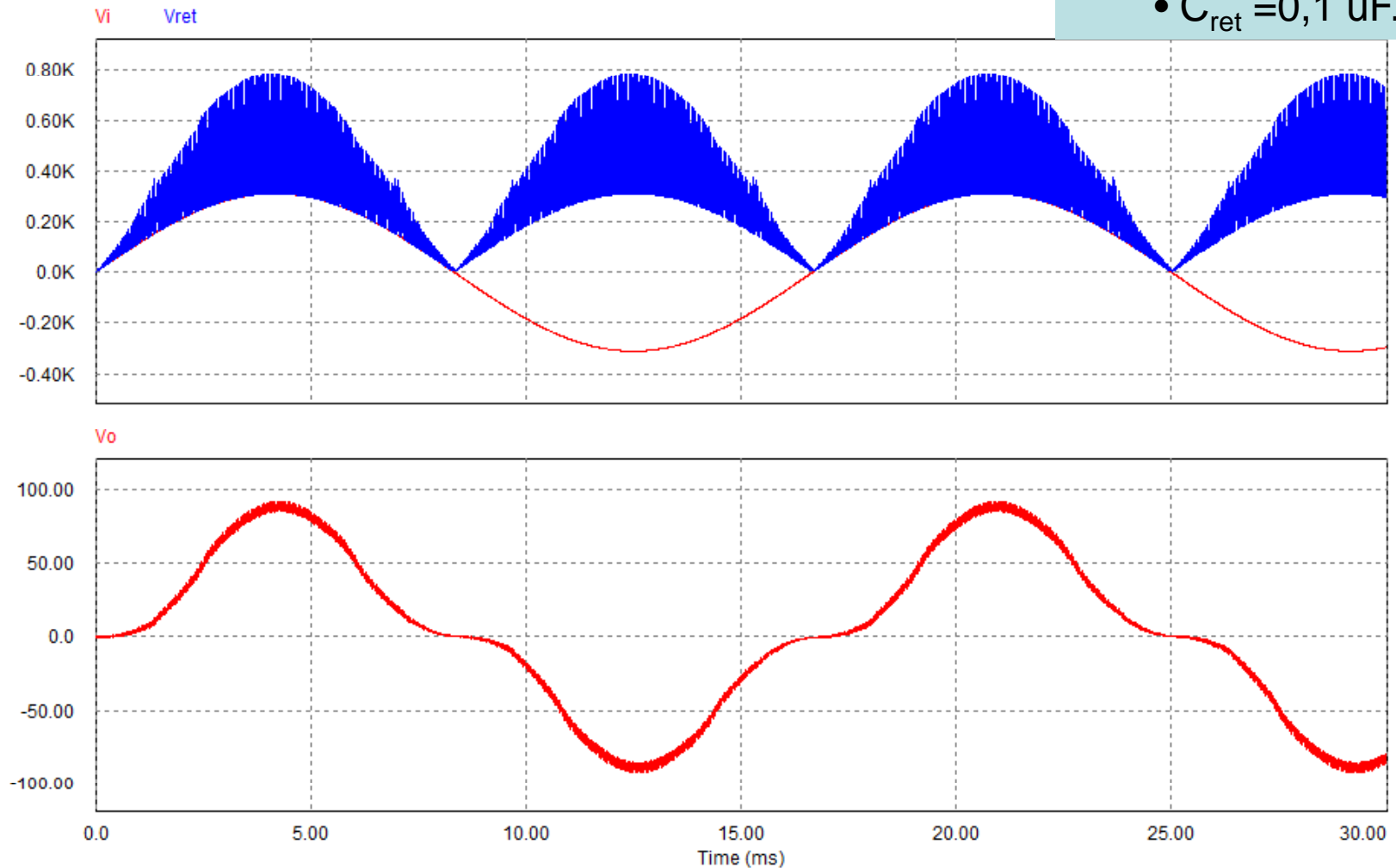
Dados da simulação:  
•  $C_{ret} = 1 \text{ uF}$ .



# Conversor CA-CA indireto

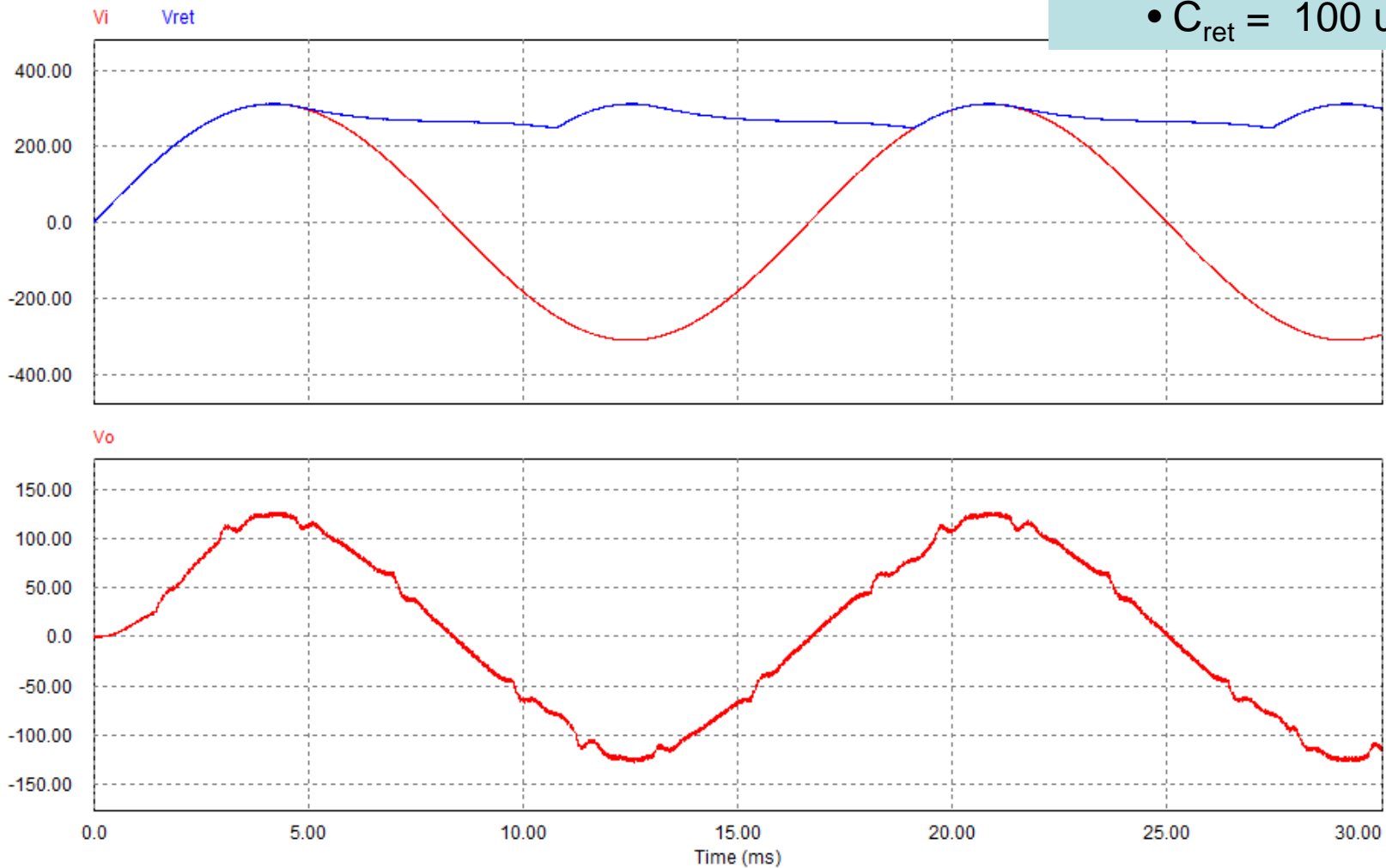
Dados da simulação:

- $C_{ret} = 0,1 \mu\text{F}$ .



# Conversor CA-CA indireto

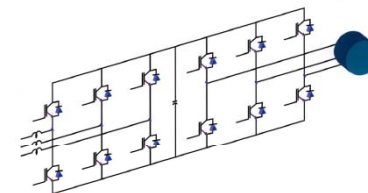
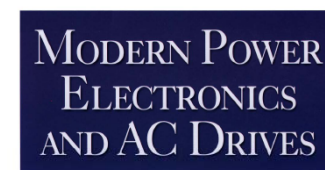
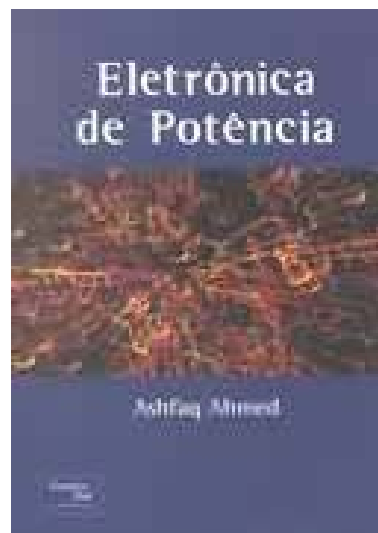
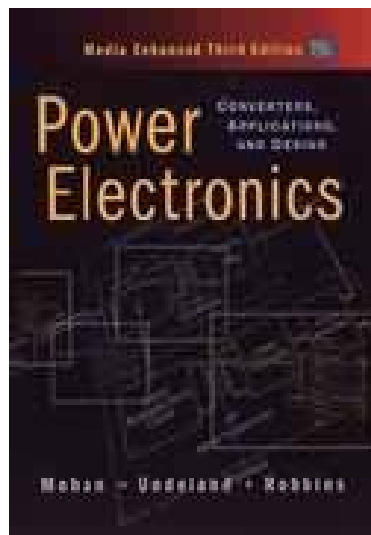
Dados da simulação:  
•  $C_{ret} = 100 \mu\text{F}$ .



# Próxima aula

## Conversores CA-CA:

1. Simulação de conversores CA-CA.



[www.cefetsc.edu.br/~petry](http://www.cefetsc.edu.br/~petry)