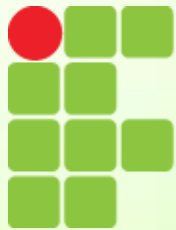


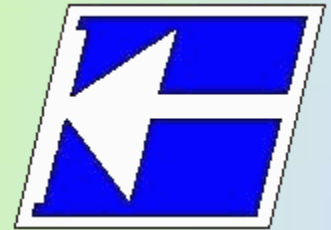
Instituto Federal de Educação, Ciência e Tecnologia de Santa Catarina

Departamento Acadêmico de Eletrônica

Projeto de Fontes Chaveadas



**INSTITUTO FEDERAL
SANTA CATARINA**



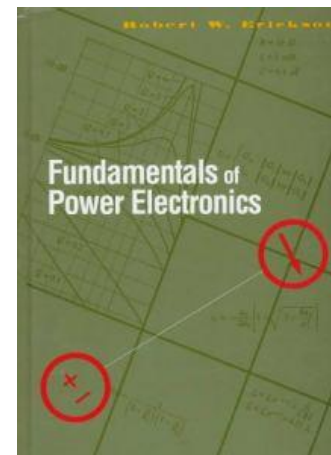
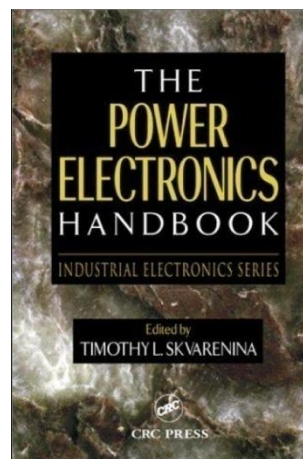
Parte 3 – Fontes Chaveadas

Circuitos auxiliares (snubber, partida, fonte, etc)

Prof. Clóvis Antônio Petry.

Florianópolis, junho de 2009.

Bibliografia para esta aula



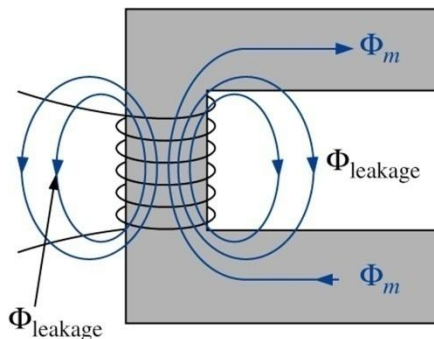
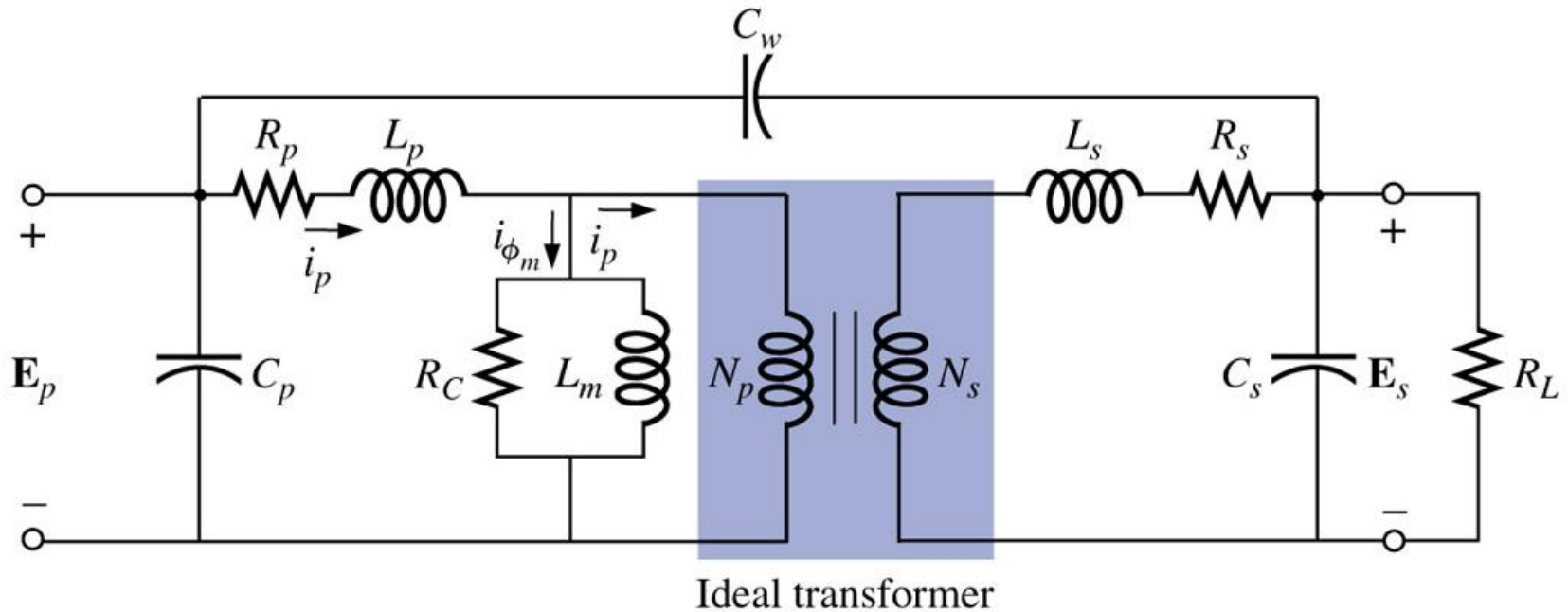
Nesta aula

Parte 3 – Fontes chaveadas:

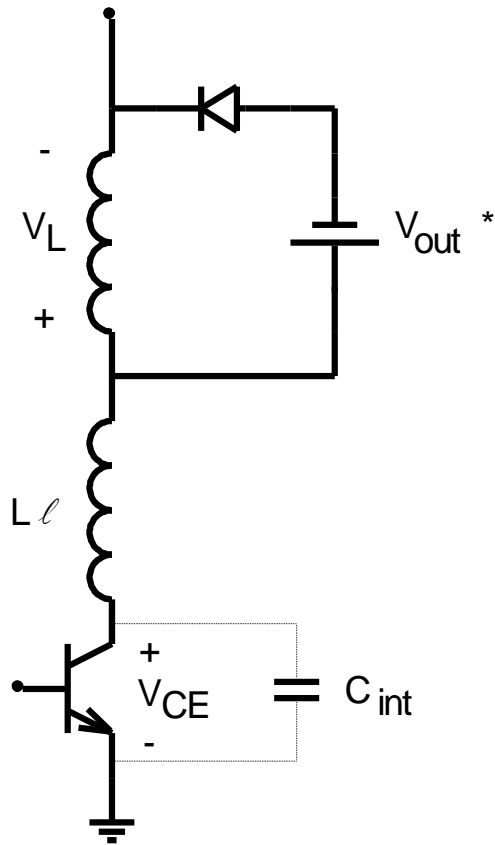
1. Snubber;
2. Soft-starter;
3. Alimentação auxiliar;
4. Proteções;
5. PCB;
6. Layout.

Grampeamento da tensão no interruptor

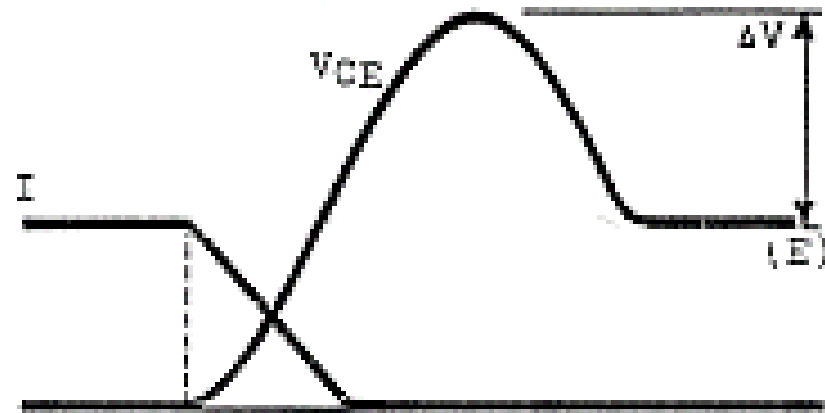
Circuito equivalente completo de um transformador de núcleo de ferro real:



Grampeamento da tensão no interruptor

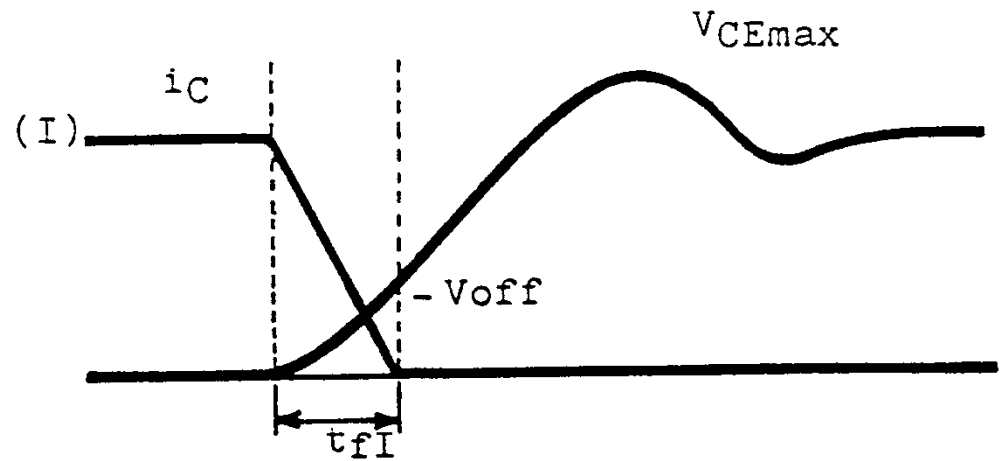
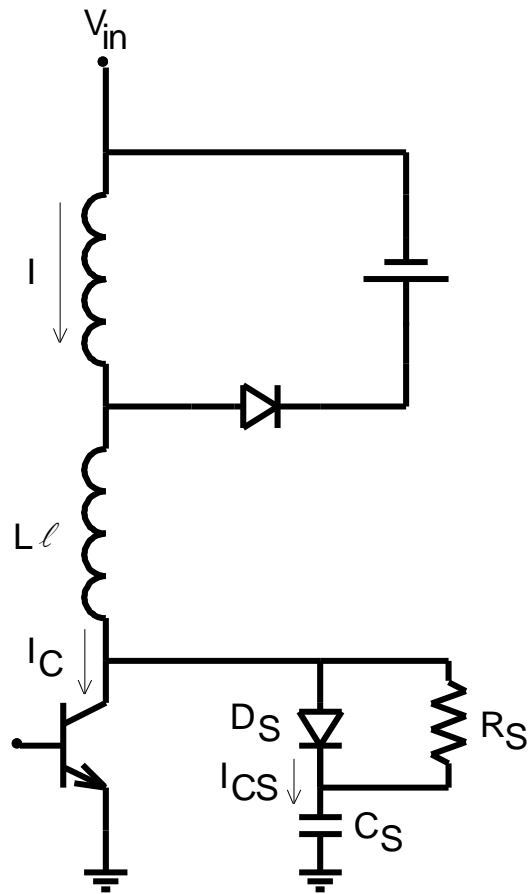


Conversor Flyback



Sobretenção causada por L_l

Grampeamento da tensão no interruptor



Controle da sobretensão com o snubber

Emprego de snubber

Grampeamento da tensão no interruptor

Cálculo do snubber:

- Medir ou estimar a indutância parasita;
- Fixar a tensão máxima sobre o interruptor;
- Cálculo do capacitor;
- Estimar um tempo de descarga do capacitor via resistor;
- Calcular o resistor.

$$\frac{1}{2} \cdot L_l \cdot I_{pk}^2 = \frac{1}{2} \cdot C_s \cdot V_{CE}^2$$

$$C_s = \frac{L_l \cdot I_{pk}^2}{V_{CE}^2}$$

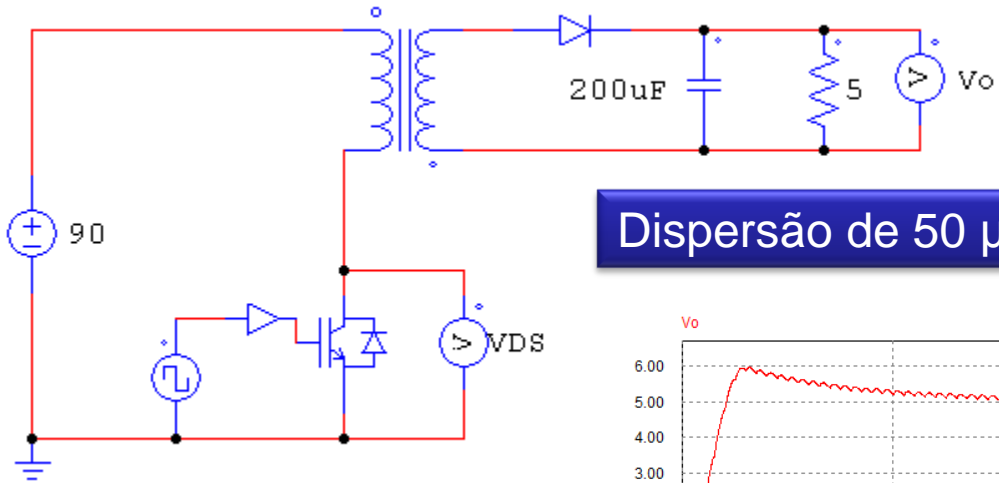
$$t_{onmin} = 3 \cdot \tau = 3 \cdot R_s \cdot C_s$$

$$t_{onmin} = D_{min} \cdot T_s$$

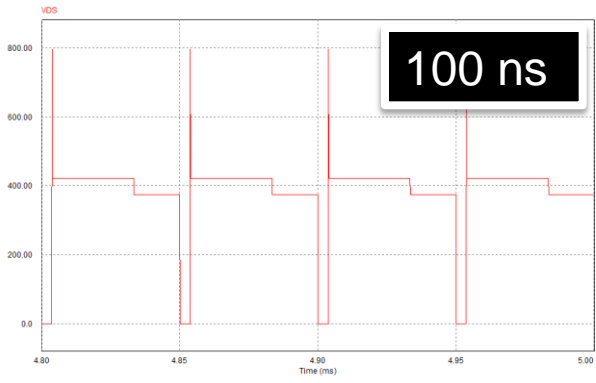
$$R_s = \frac{D_{min} \cdot T_s}{3 \cdot C_s}$$

$$P_{R_s} = E \cdot F = \frac{1}{2} \cdot L_l \cdot I_{pk}^2 \cdot F_s$$

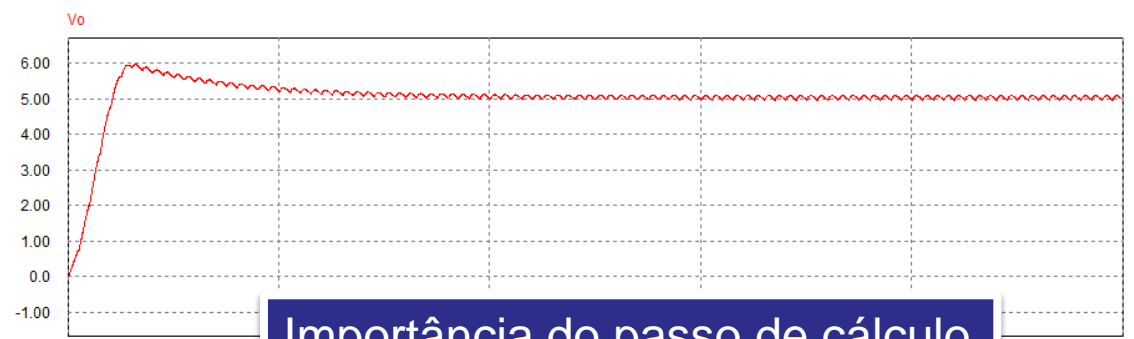
Grampeamento da tensão no interruptor



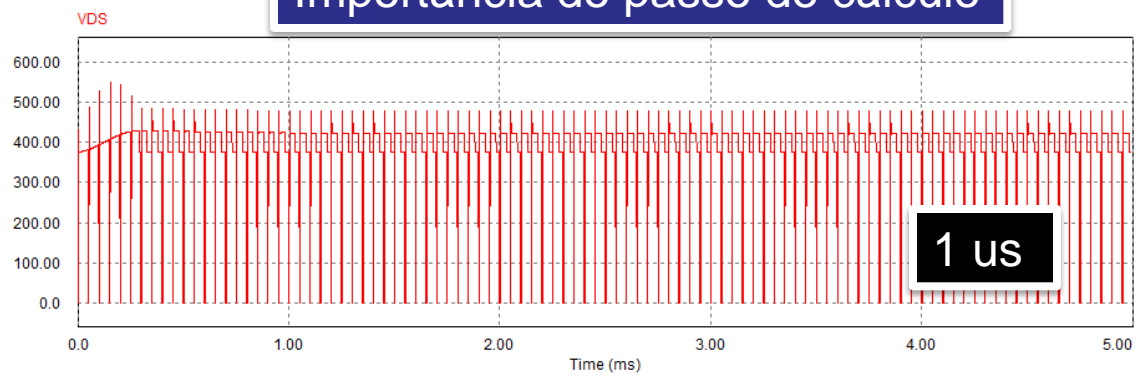
Dispersão de 50 μH



Sobretensão de 800 V



Importância do passo de cálculo



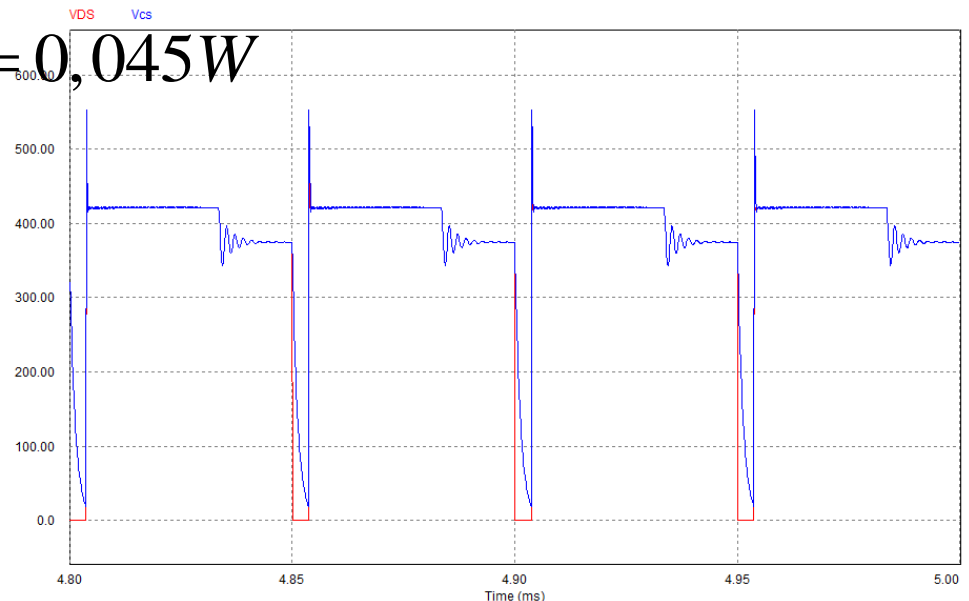
Grampeamento da tensão no interruptor

$$C_s = \frac{L_l \cdot I_{pk}^2}{V_{CE}^2} = \frac{50 \mu \cdot 0,3^2}{450^2} = 22 \text{ pF}$$

$$R_s = \frac{D_{\min} \cdot T_s}{3 \cdot C_s} = \frac{0,075 \cdot 50 \cdot 10^{-6}}{3 \cdot 22 \cdot 10^{-12}} = 57 \text{ k}\Omega$$

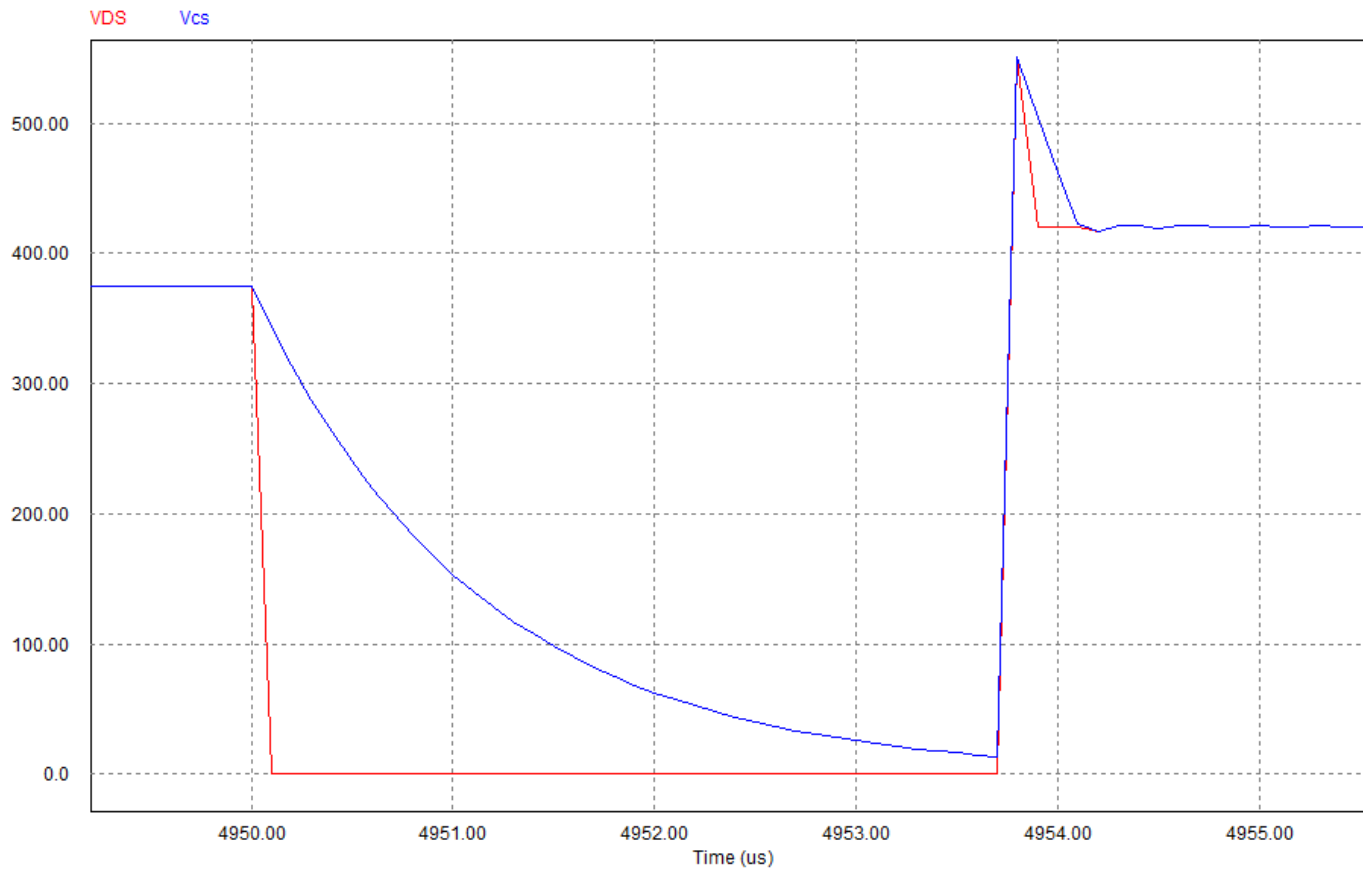
$$P_{R_s} = \frac{1}{2} \cdot 50 \mu \cdot 0,3^2 \cdot 20000 = 0,045 \text{ W}$$

Sobretensão de 553 V



Grampeamento da tensão no interruptor

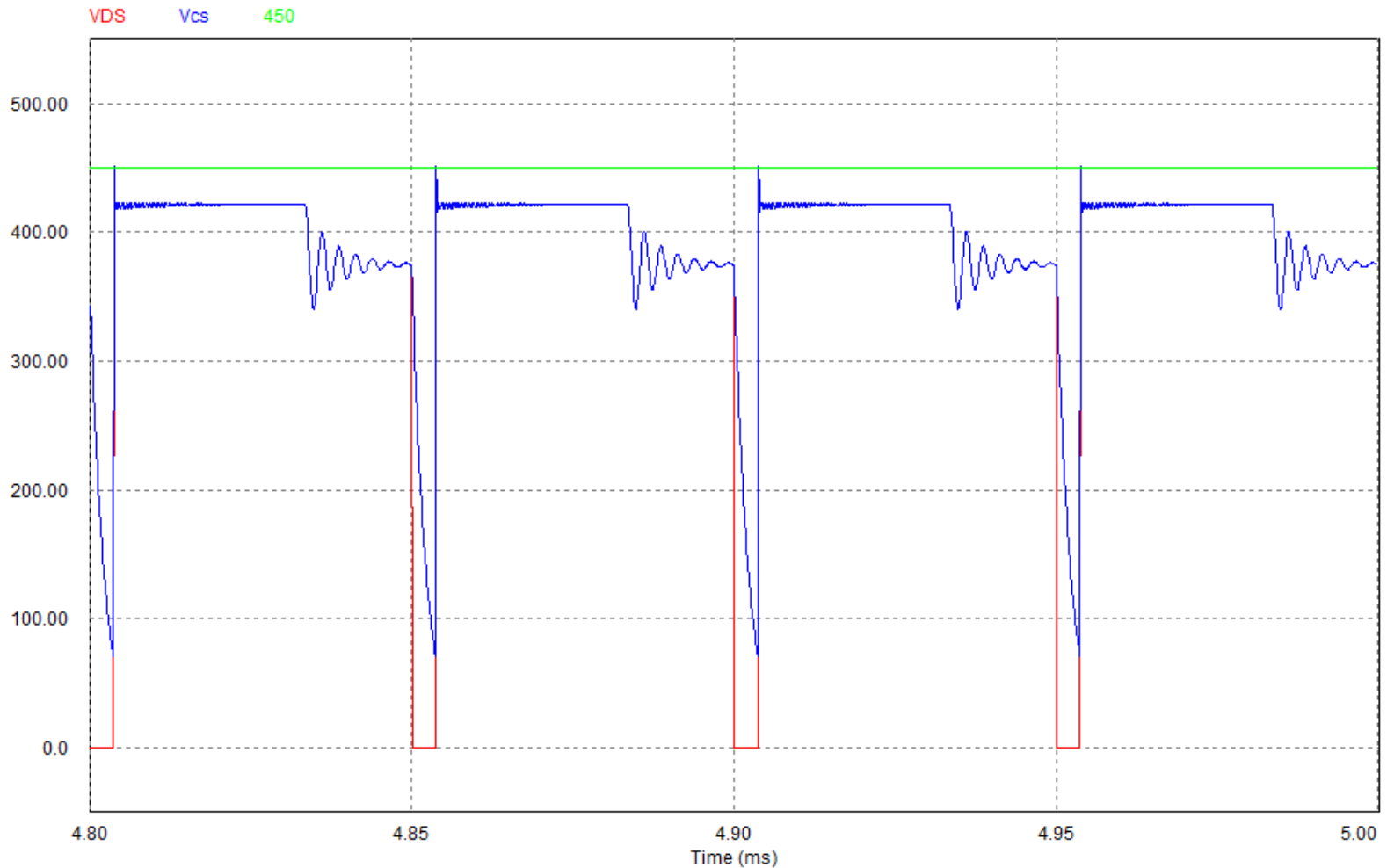
$$R_s = 57\text{ k}\Omega \rightarrow 51\text{ k}\Omega$$



Grampeamento da tensão no interruptor

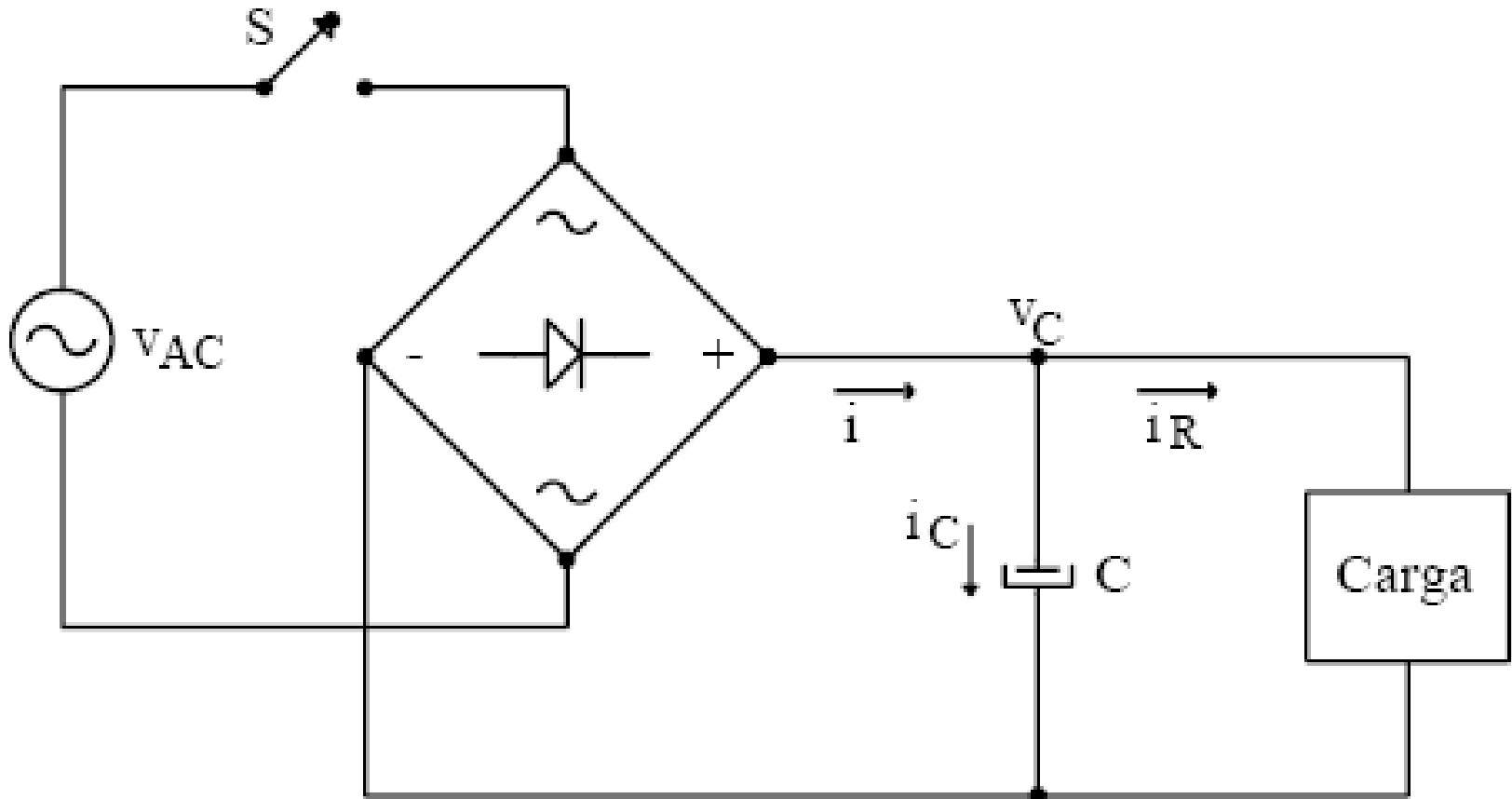
$$C_s = 22 \text{ pF} \rightarrow 44 \text{ pF}$$

$$R_s = 57 \text{ k}\Omega \rightarrow 51 \text{ k}\Omega$$

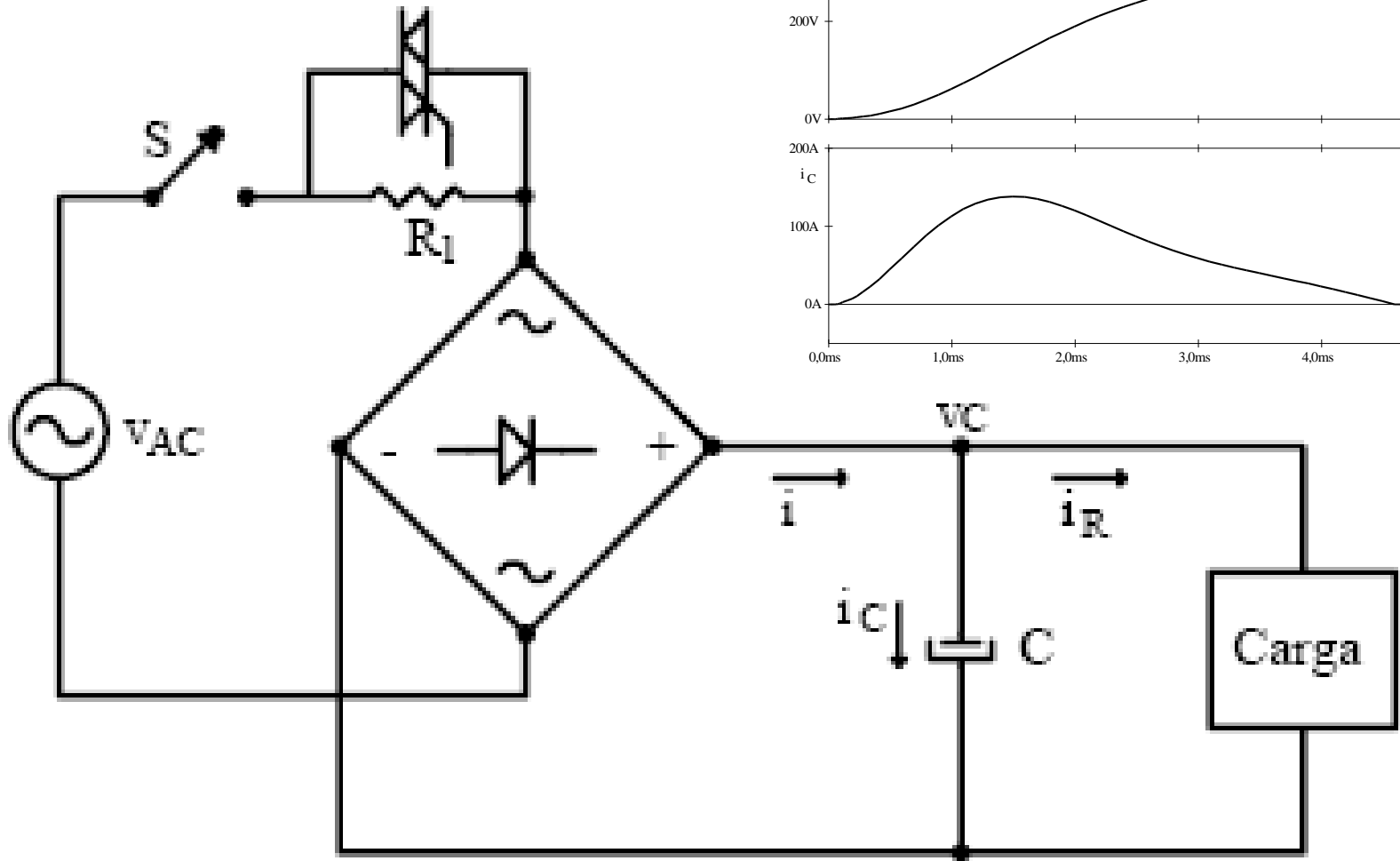


Partida do estágio de potência

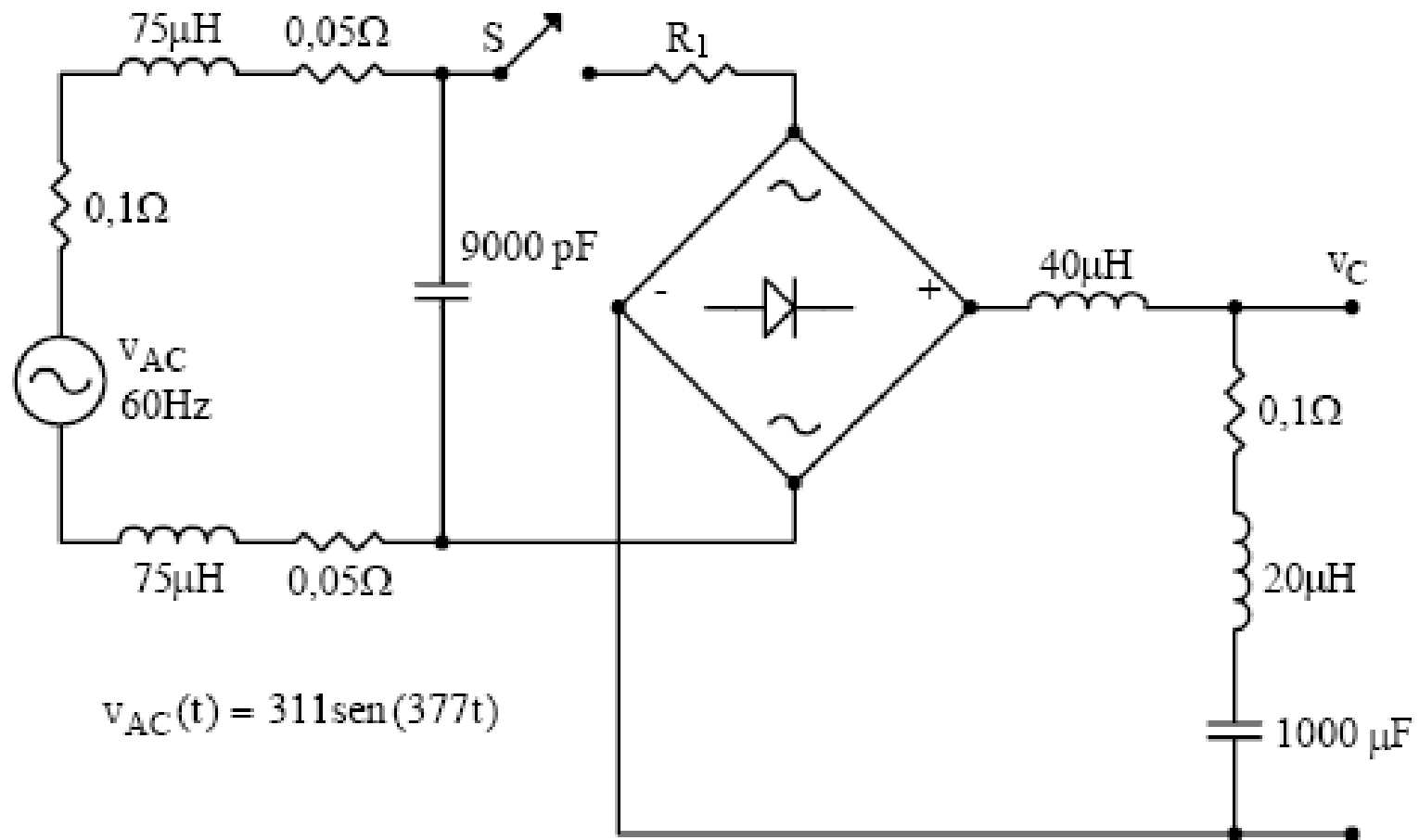
O problema:



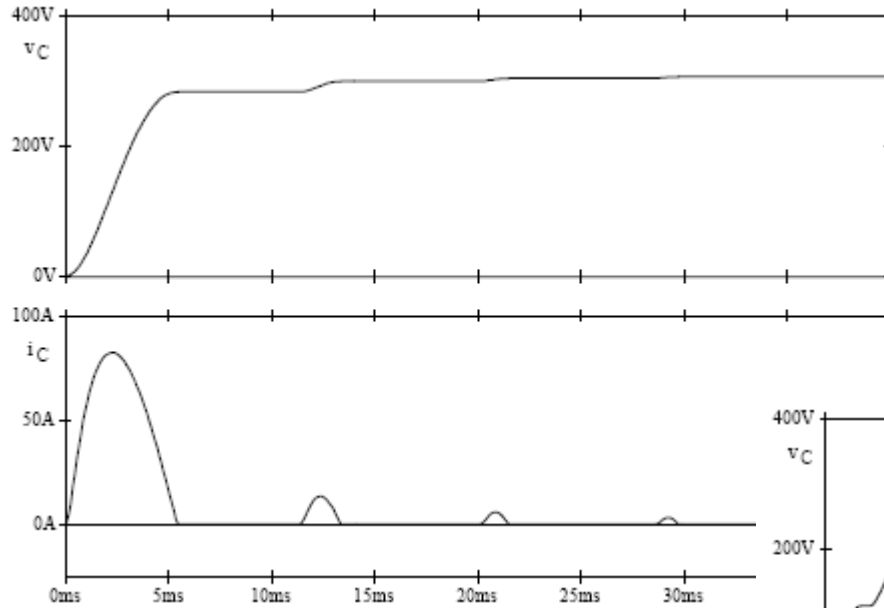
Partida do estágio de potência



Partida do estágio de potência

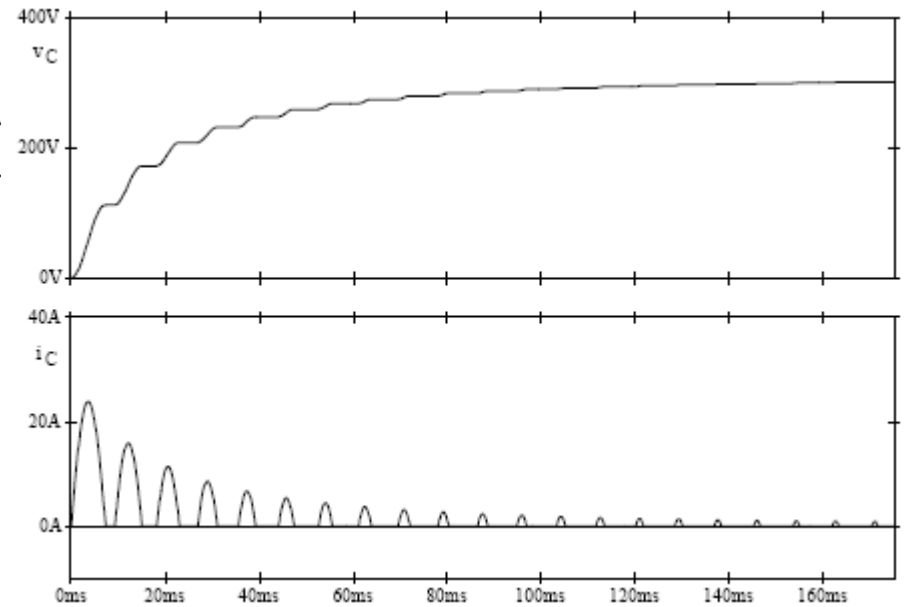


Partida do estágio de potência

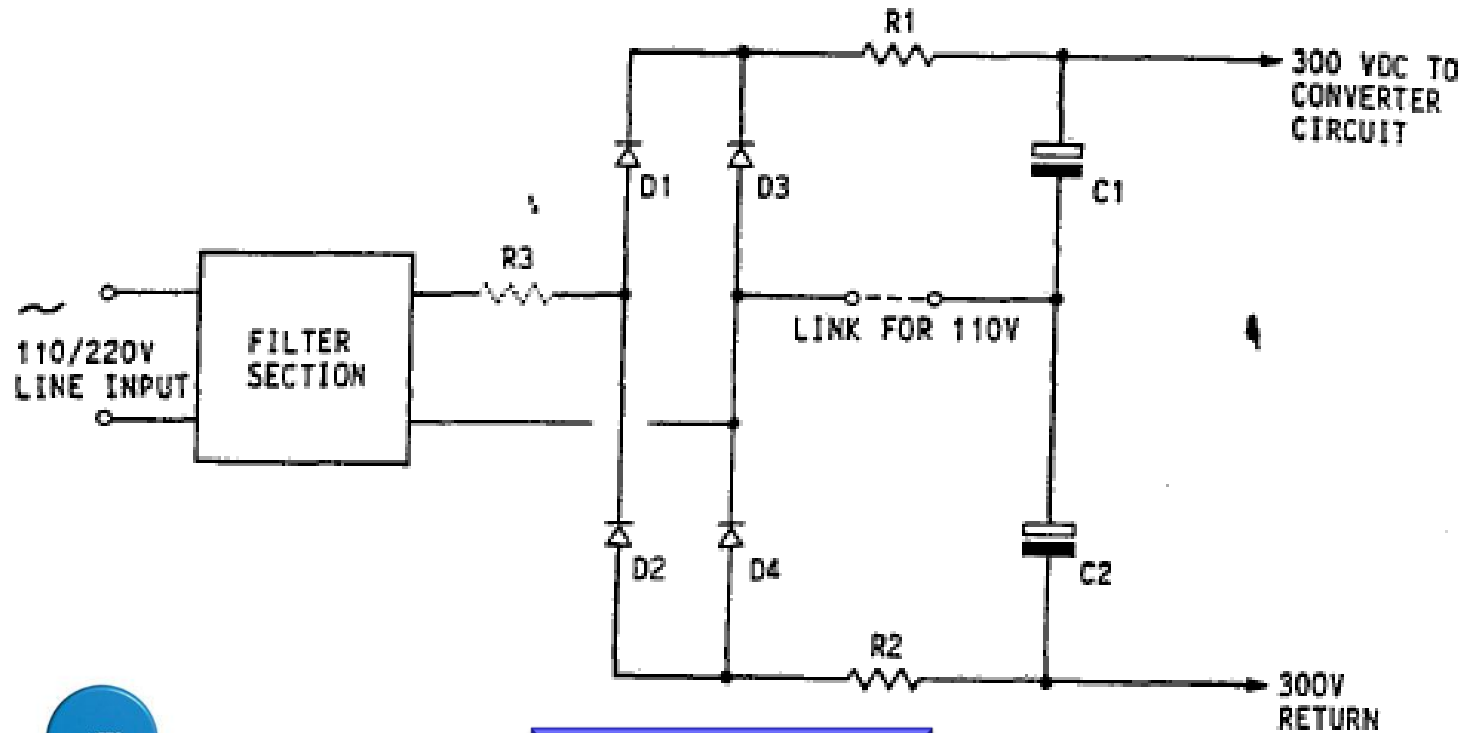


$R_1 = 1 \Omega$

$R_1 = 10 \Omega$



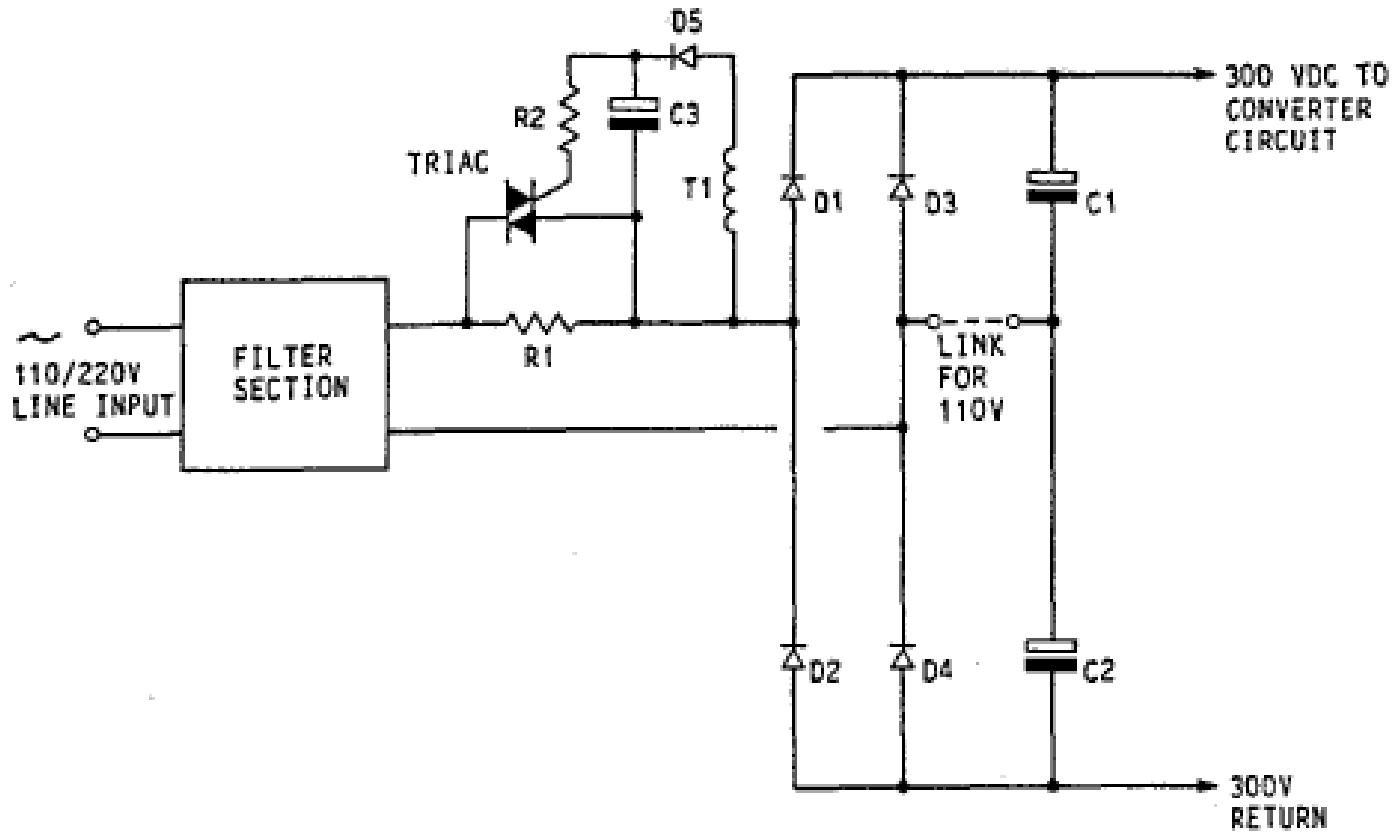
Partida do estágio de potência



Resistores série

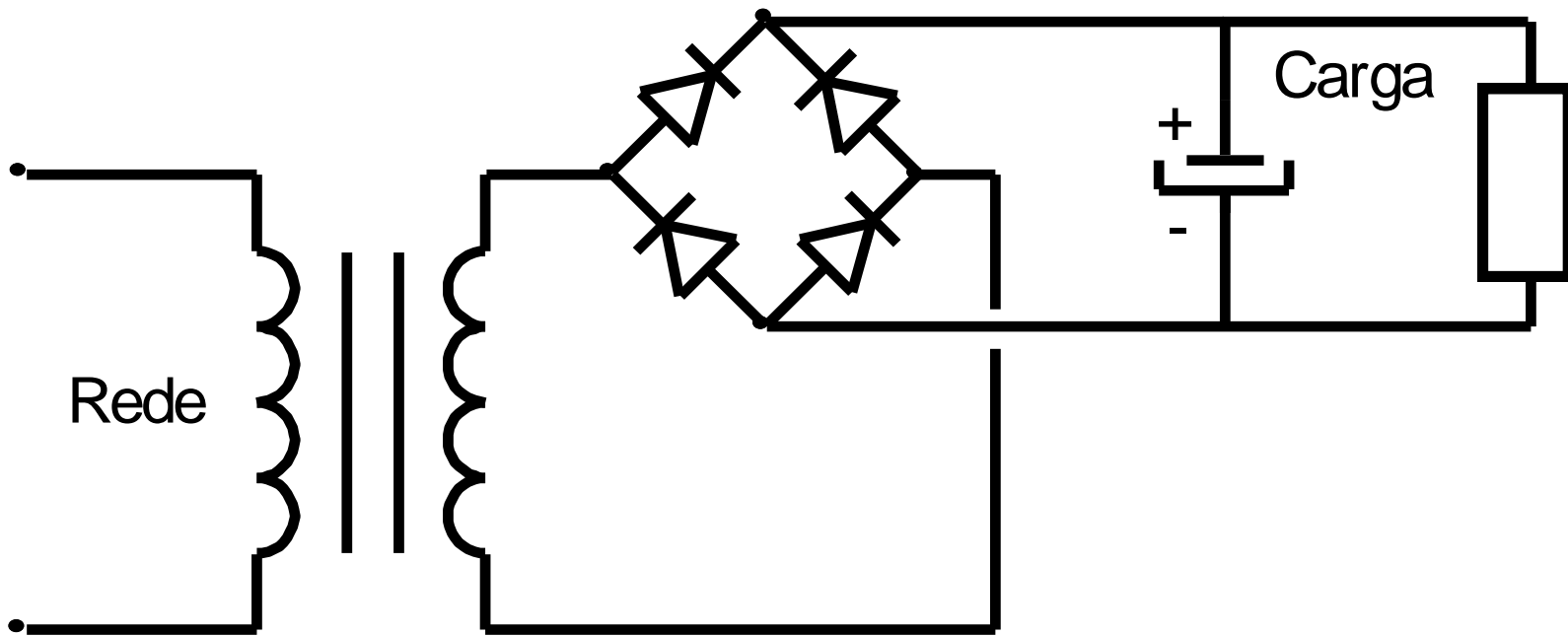


Partida do estágio de potência



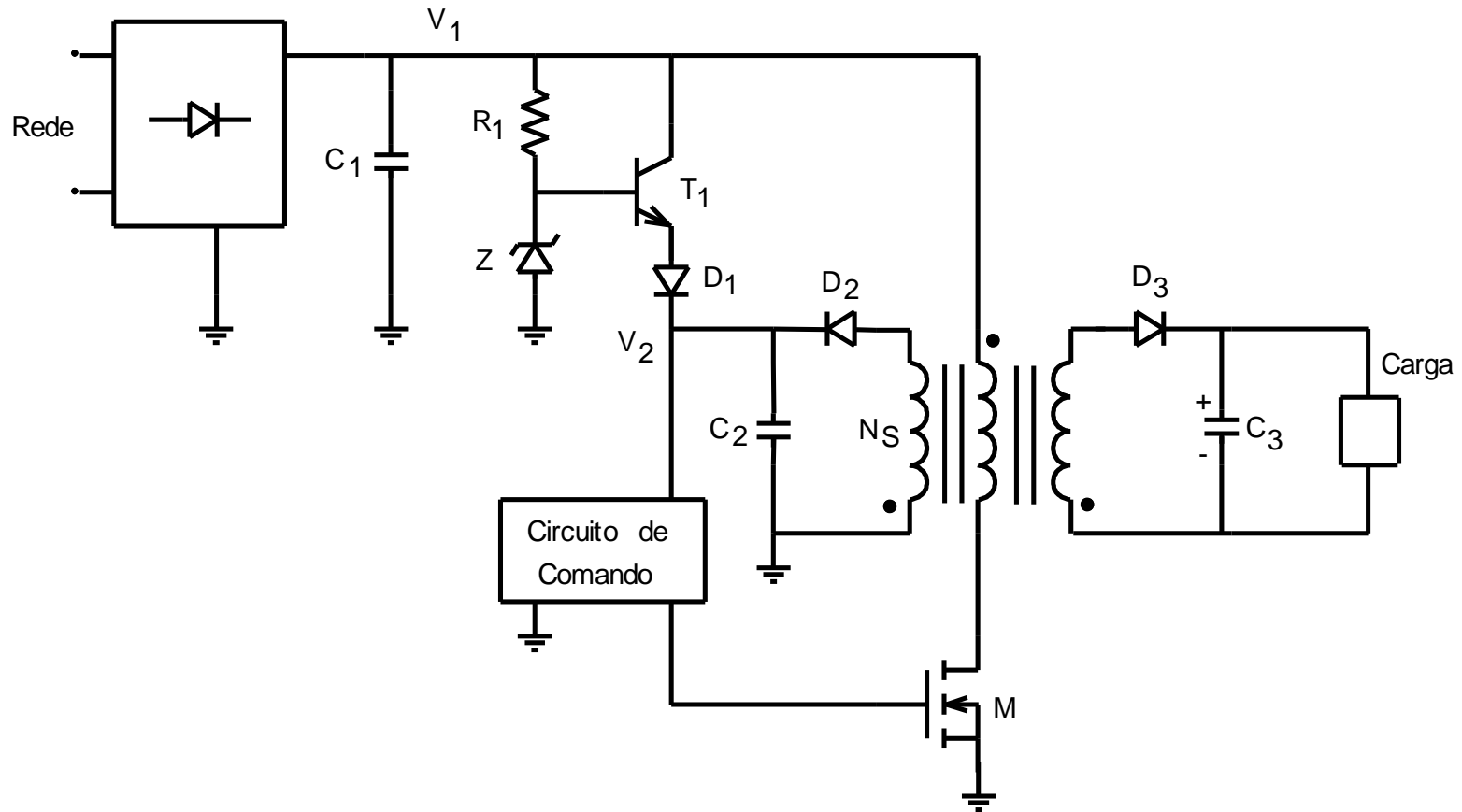
Resistores série temporariamente

Alimentação auxiliar (partida)



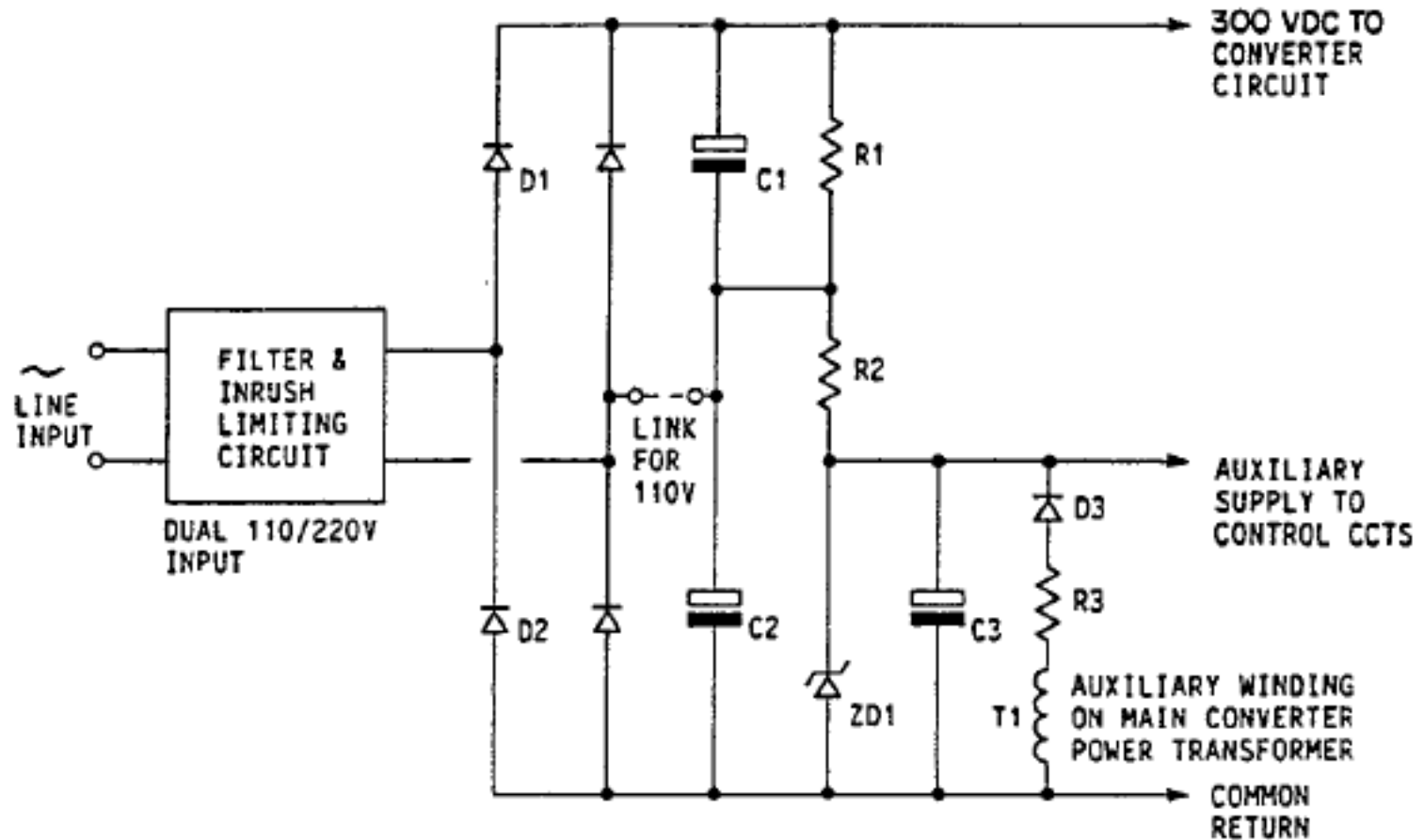
Fonte auxiliar isolada em baixa frequência

Alimentação auxiliar (partida)



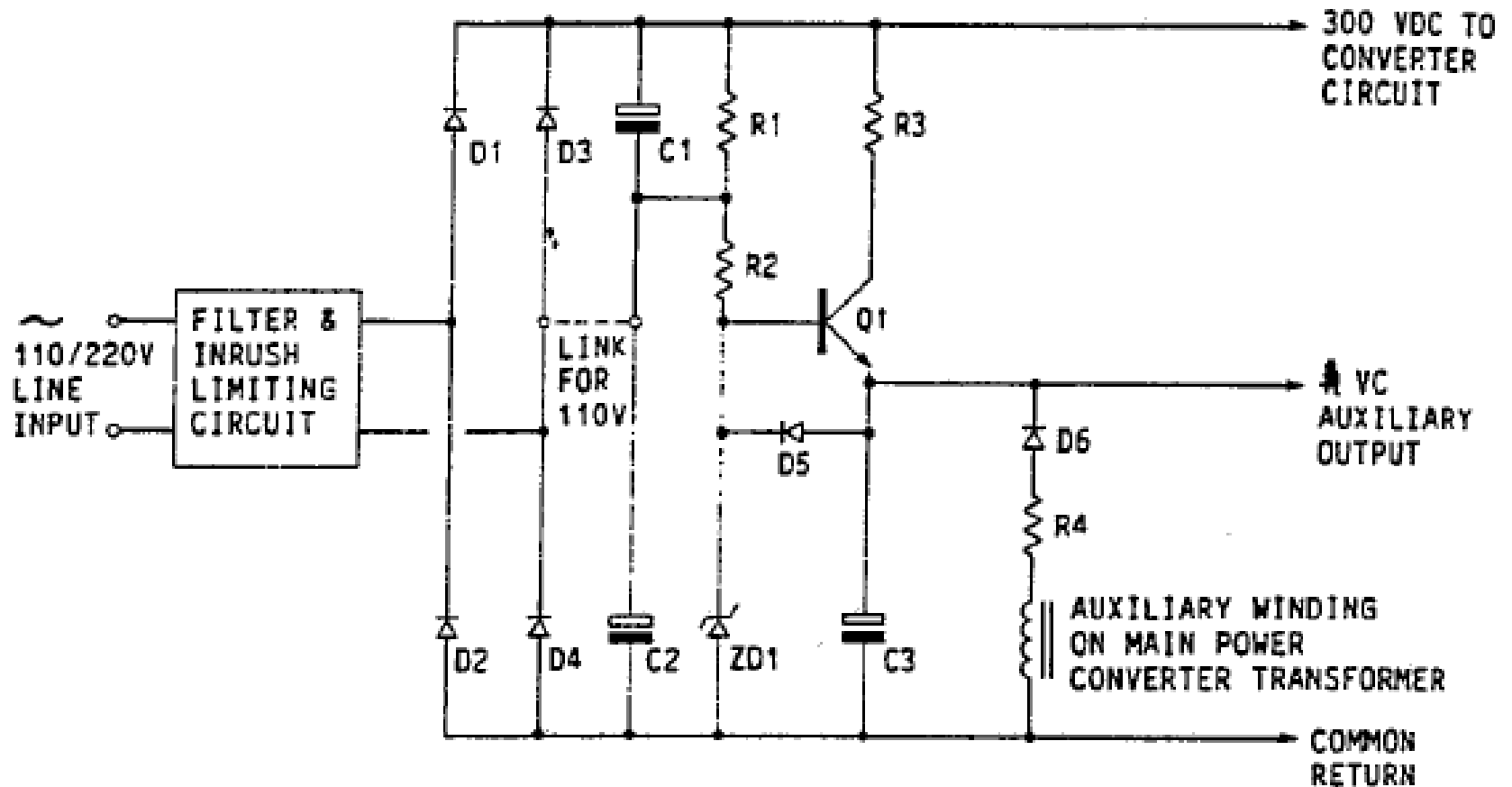
Fonte auxiliar criada a partir do estágio de potência

Alimentação auxiliar (partida)



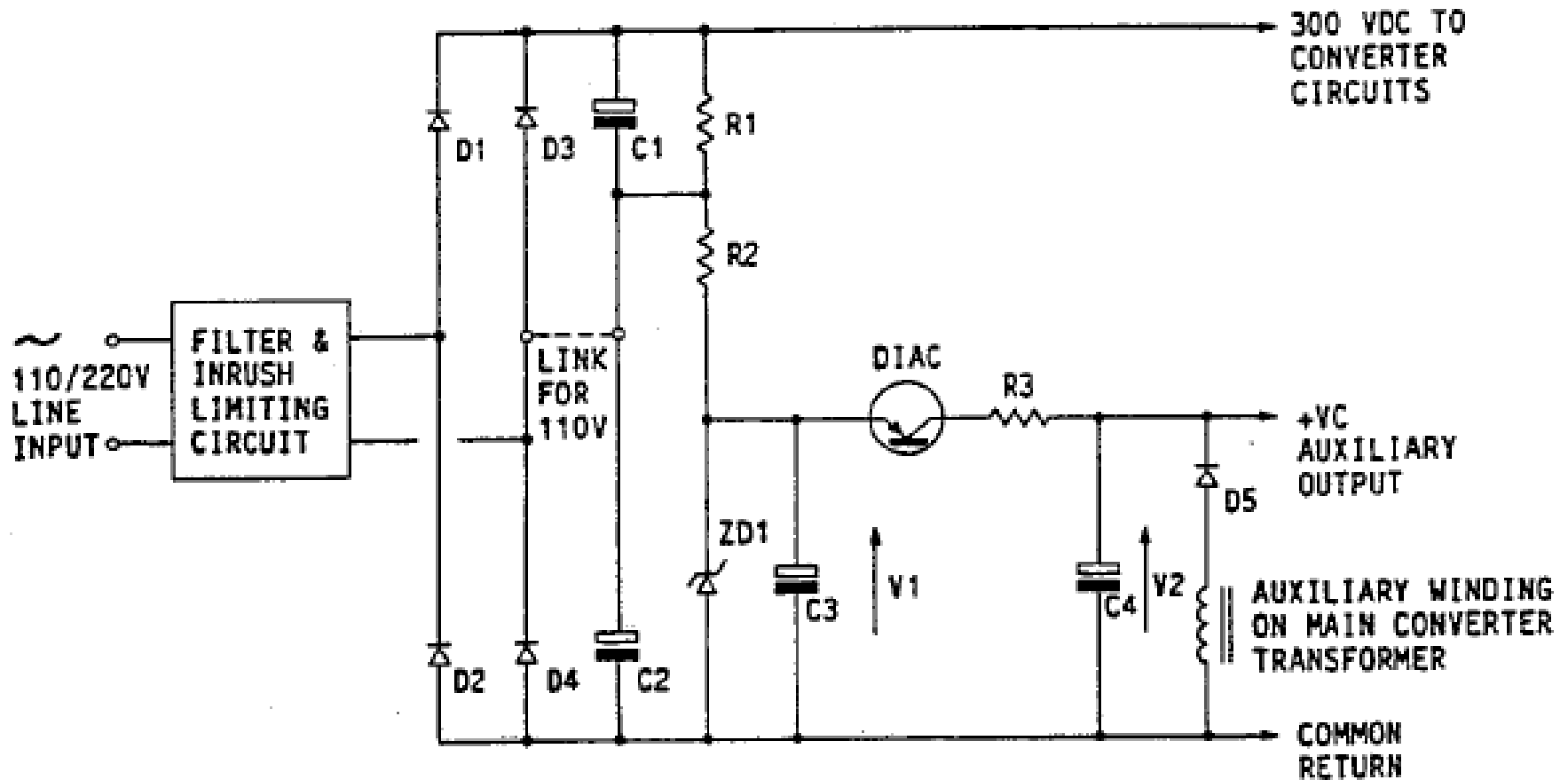
Circuito resistivo dissipativo

Alimentação auxiliar (partida)



Circuito ativo

Alimentação auxiliar (partida)



Circuito impulsivo

Fusíveis

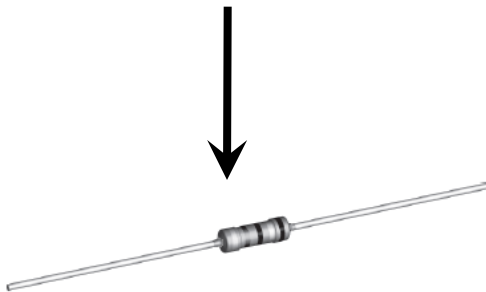
Fusíveis de ação lenta:

- Vidro;
- Areia;
- Cerâmica.

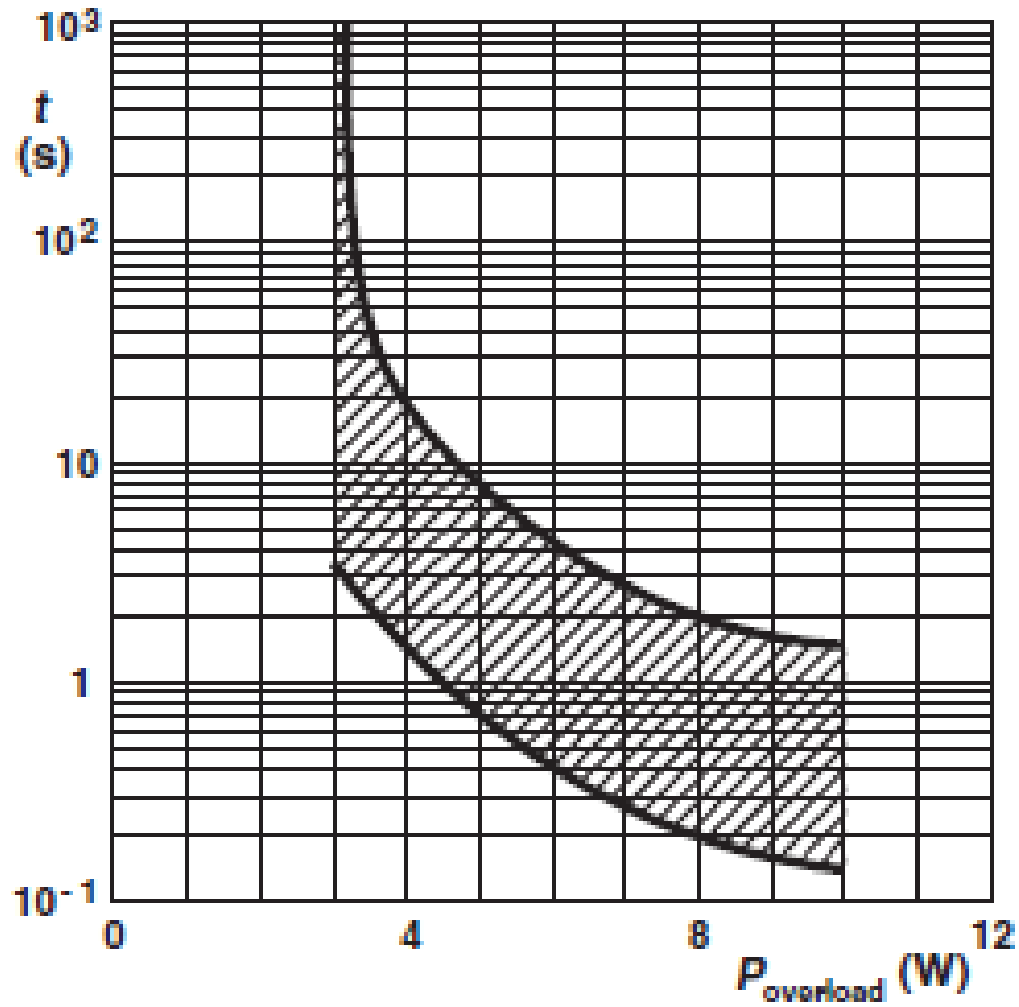
Fusíveis de ação rápida:

- Vidro;
- Areia;
- Cerâmica.

Resistores fusíveis.



Fusíveis

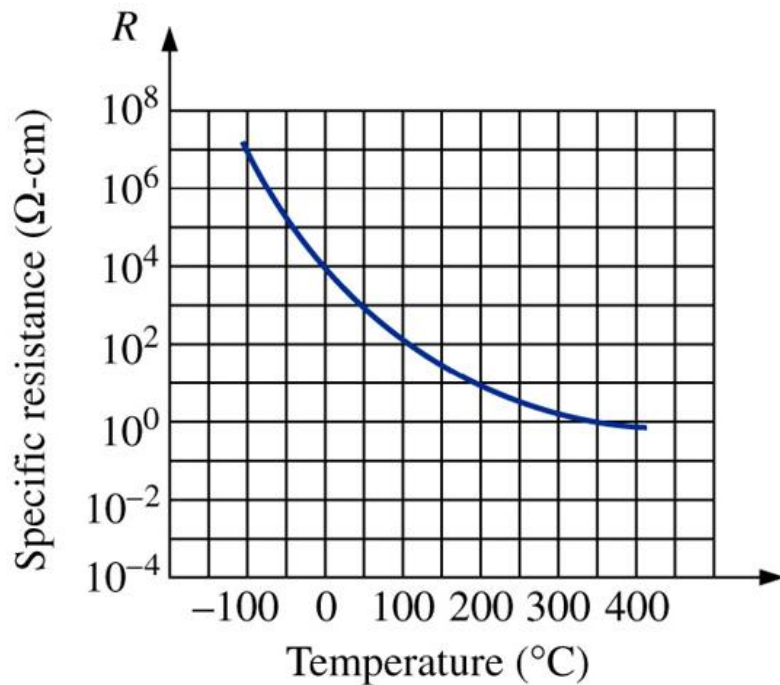


NR25 – $1 \Omega < R < 15 \Omega$

Termistores

Termistor:

- Resistor cuja resistência é sensível à variação da temperatura.

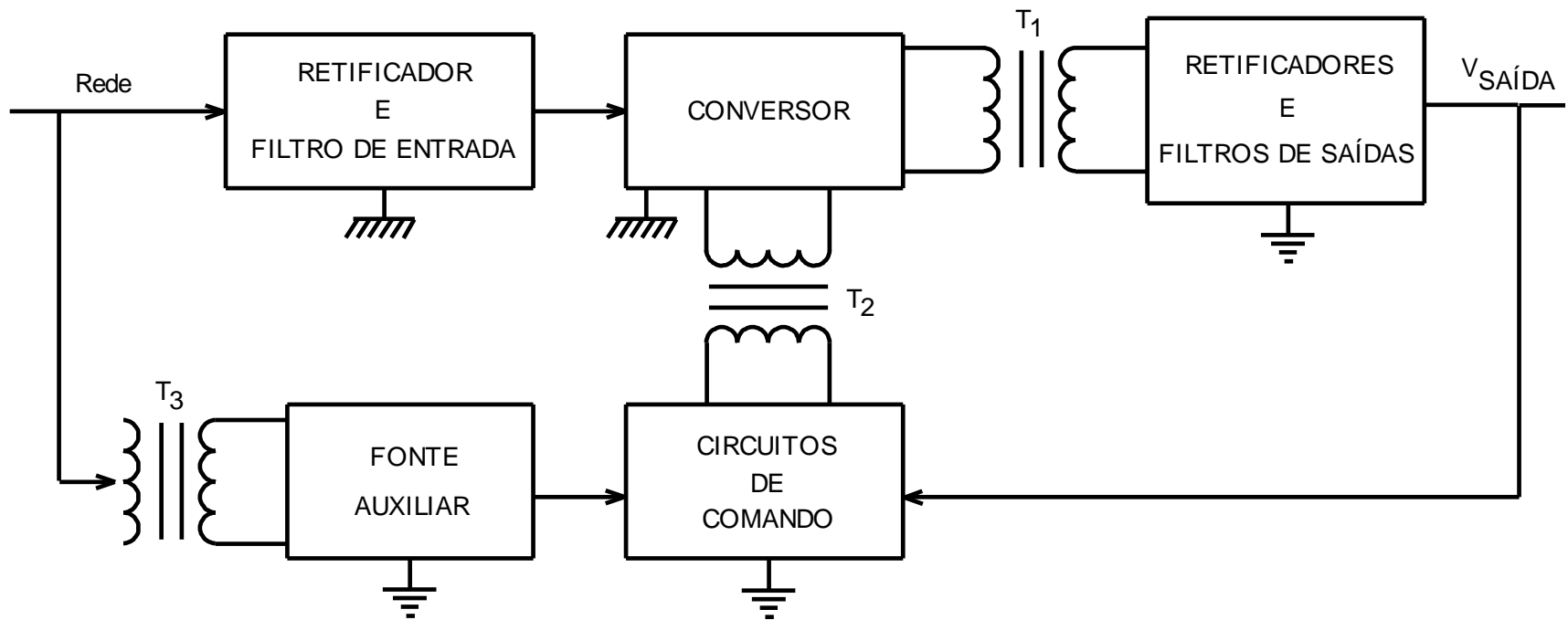


(a)

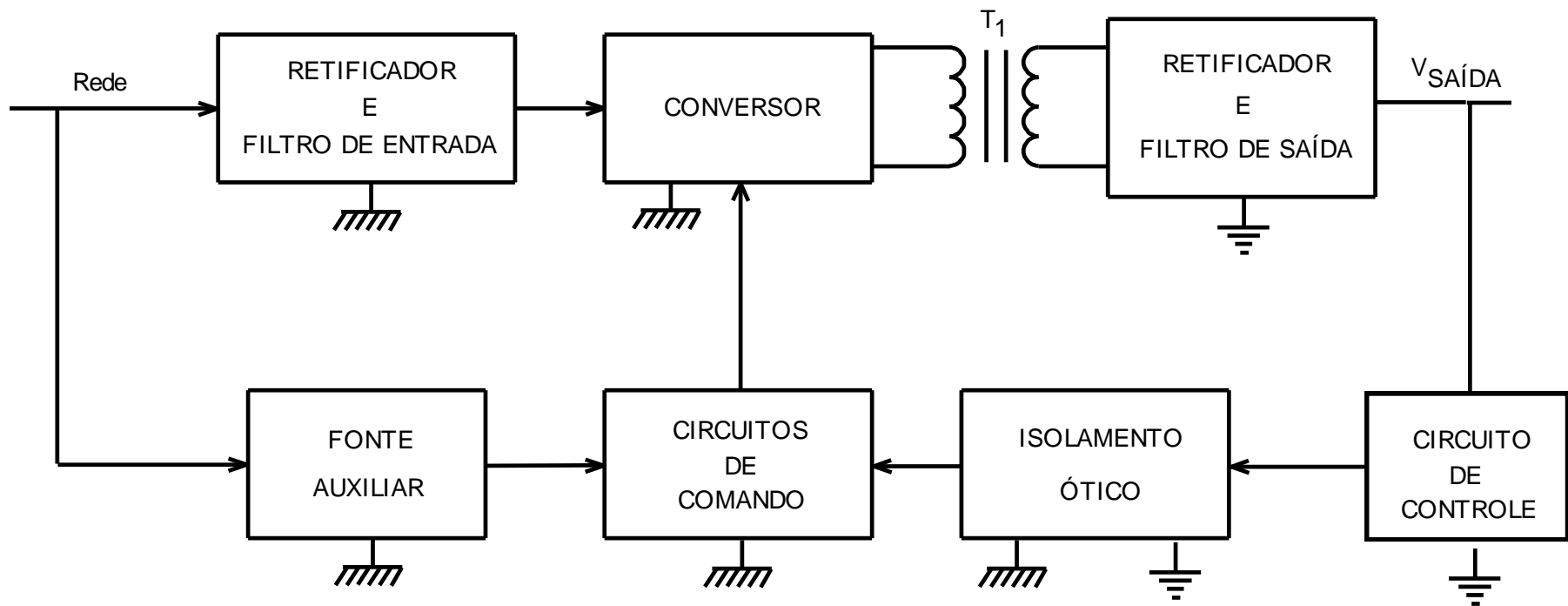


(b)

Necessidade de Isolamento

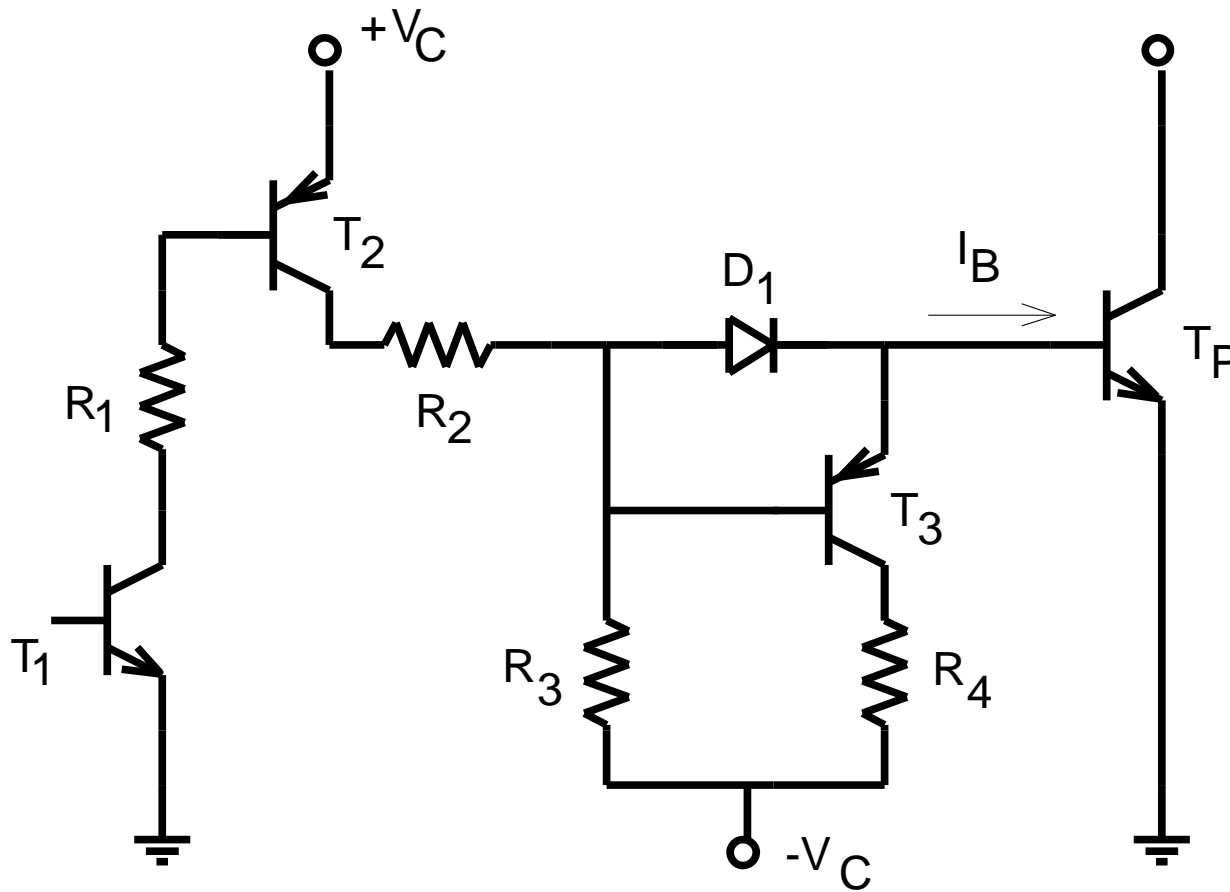


Isolamento do sinal de comando



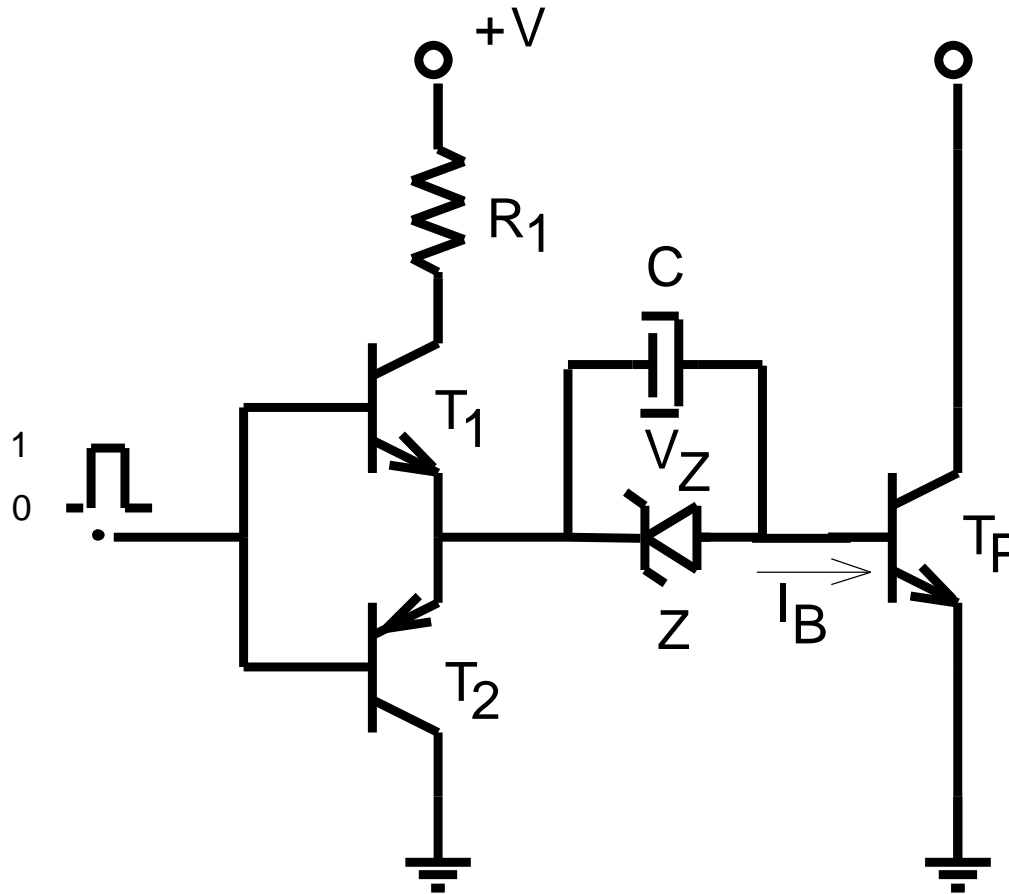
Isolamento do sinal de realimentação

Acionamento dos interruptores - BJT



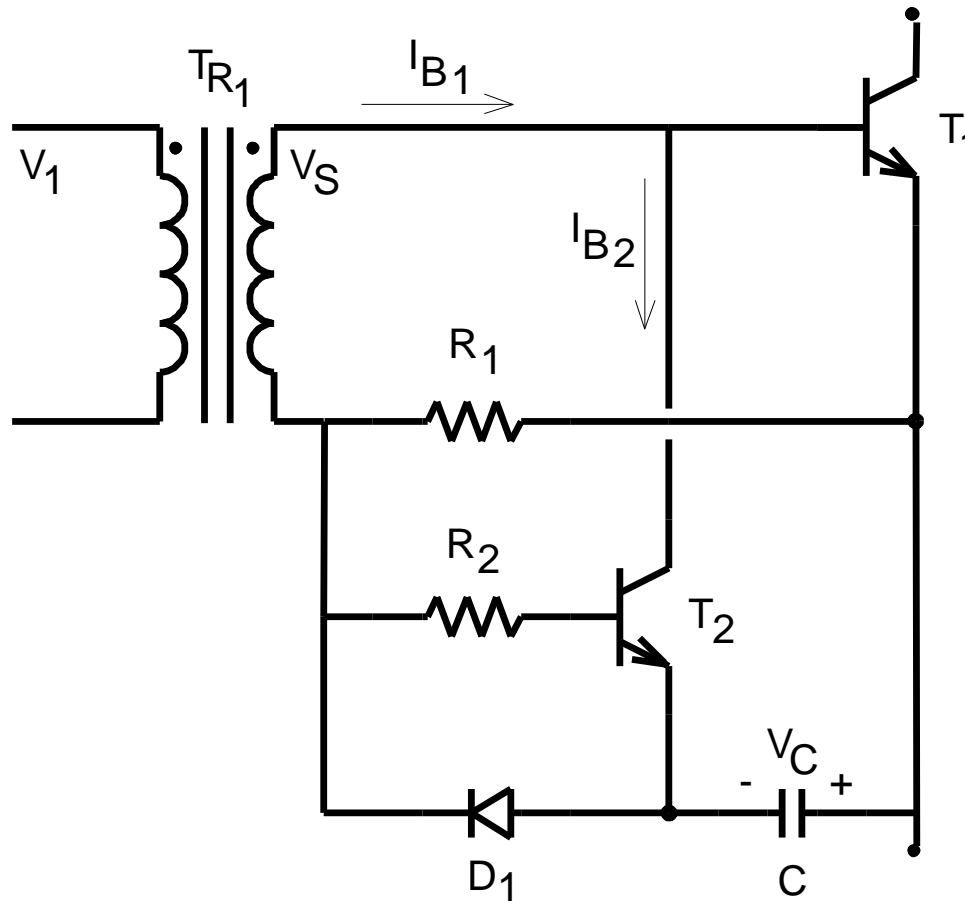
Comando de base com fonte negativa

Acionamento dos interruptores - BJT



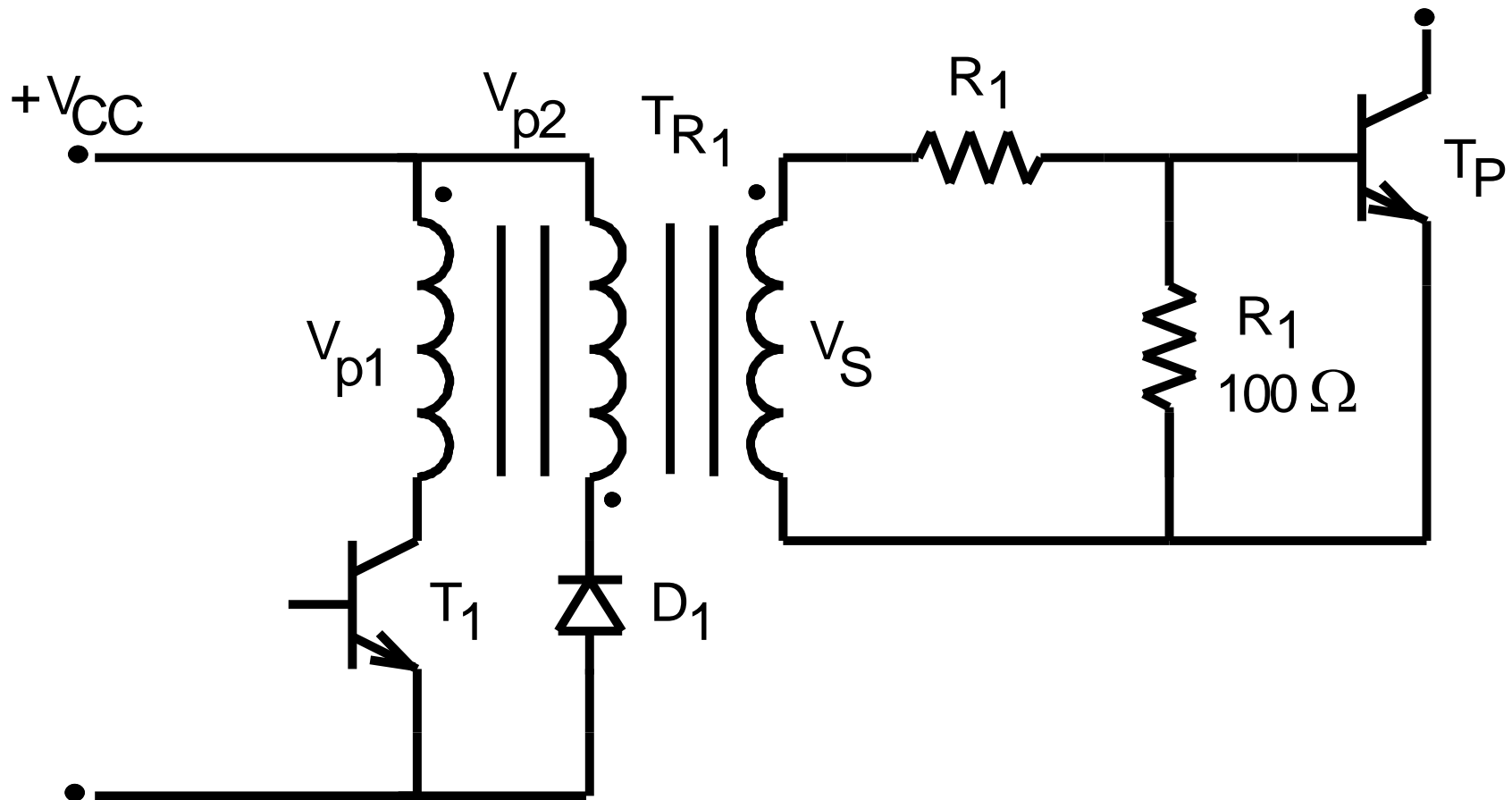
Comando de base sem fonte negativa

Acionamento dos interruptores - BJT



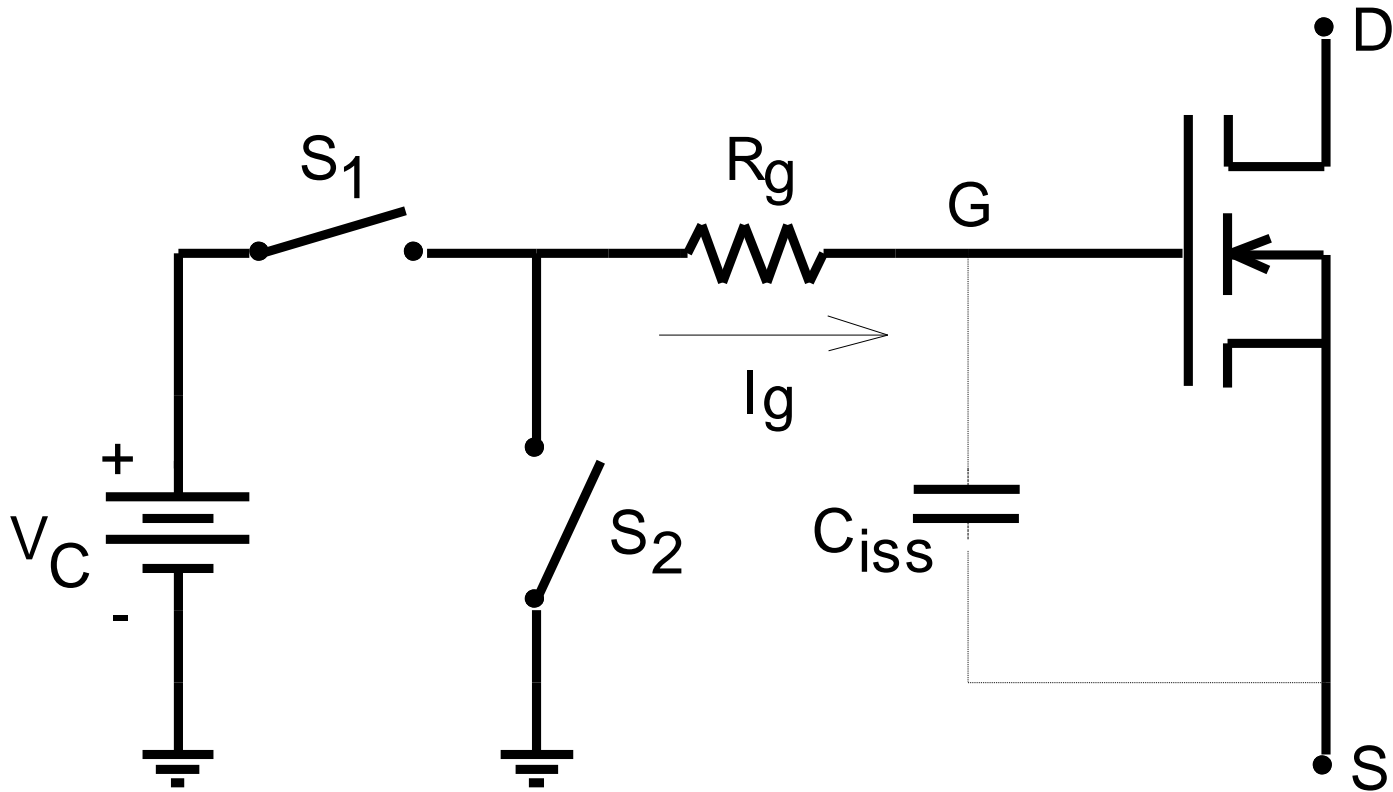
Comando de base isolado

Acionamento dos interruptores - BJT



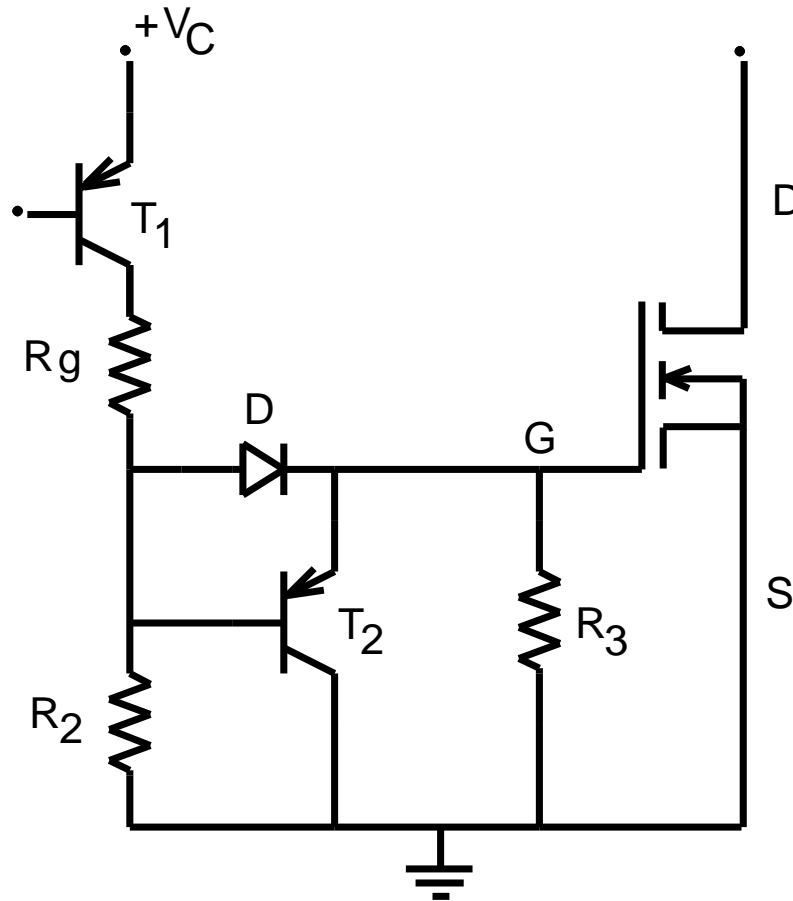
Comando de base isolado

Acionamento dos interruptores - MOSFET



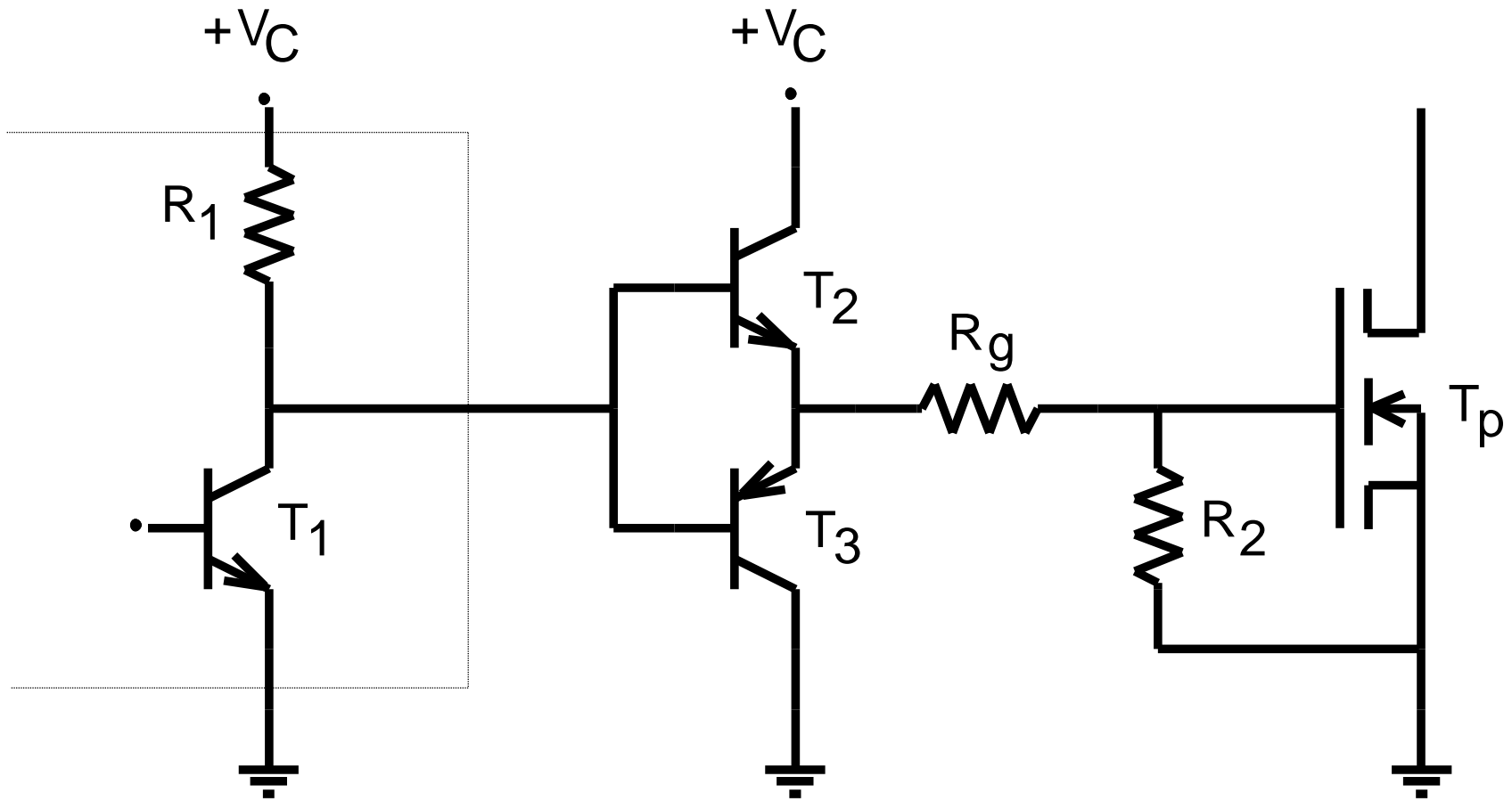
Circuito de gatilho de um MOSFET

Acionamento dos interruptores - MOSFET



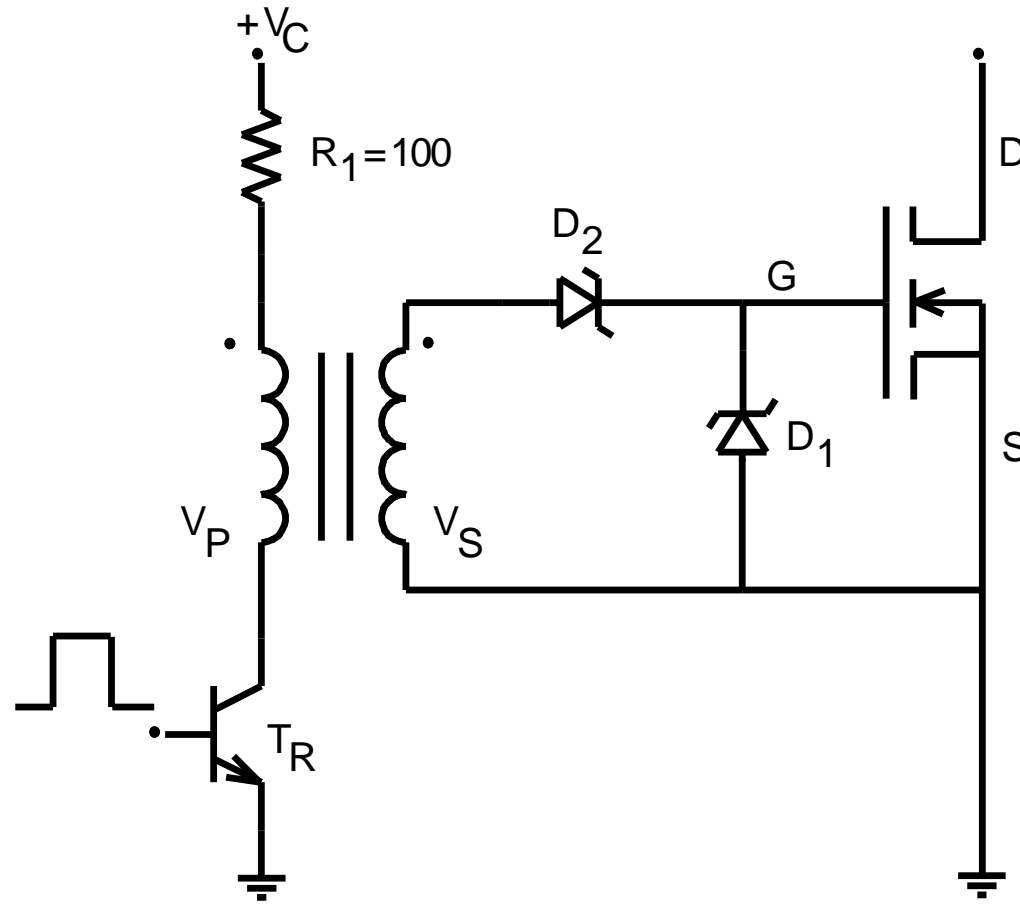
Circuito de comando de gatilho não-isolado

Acionamento dos interruptores - MOSFET



Circuito de comando de gatilho

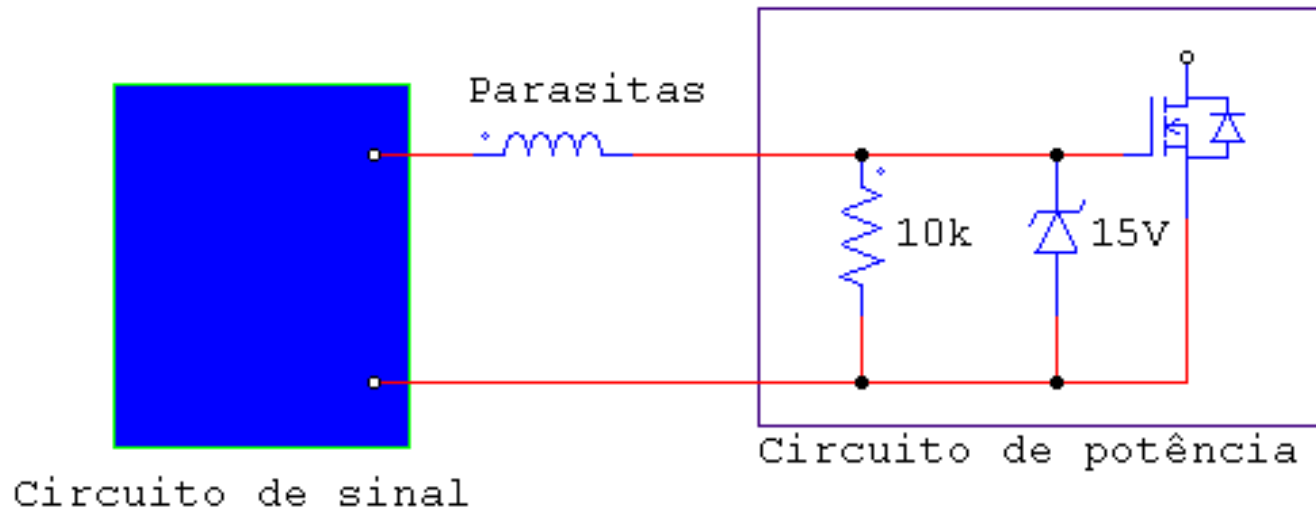
Acionamento dos interruptores - MOSFET



Circuito de gatilho isolado

Proteção do gatilho de MOSFETs

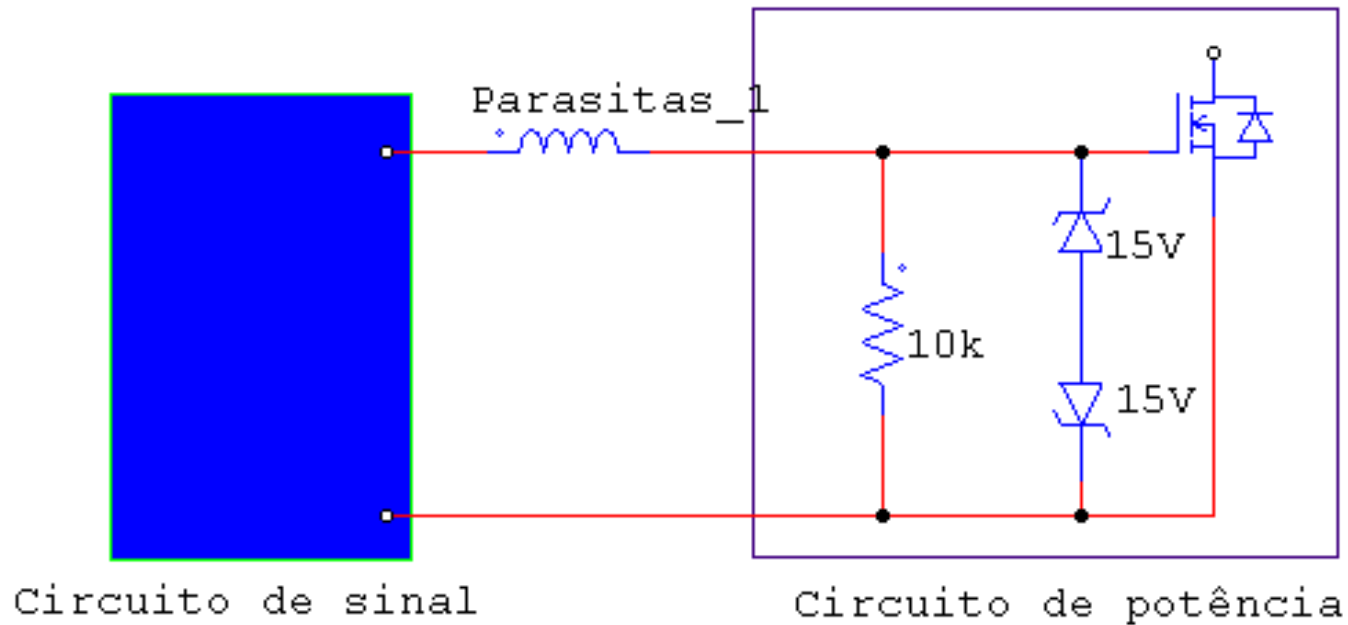
Posicionar o mais próximo possível do MOSFET:



Para circuito com tensão de gatilho apenas positiva.

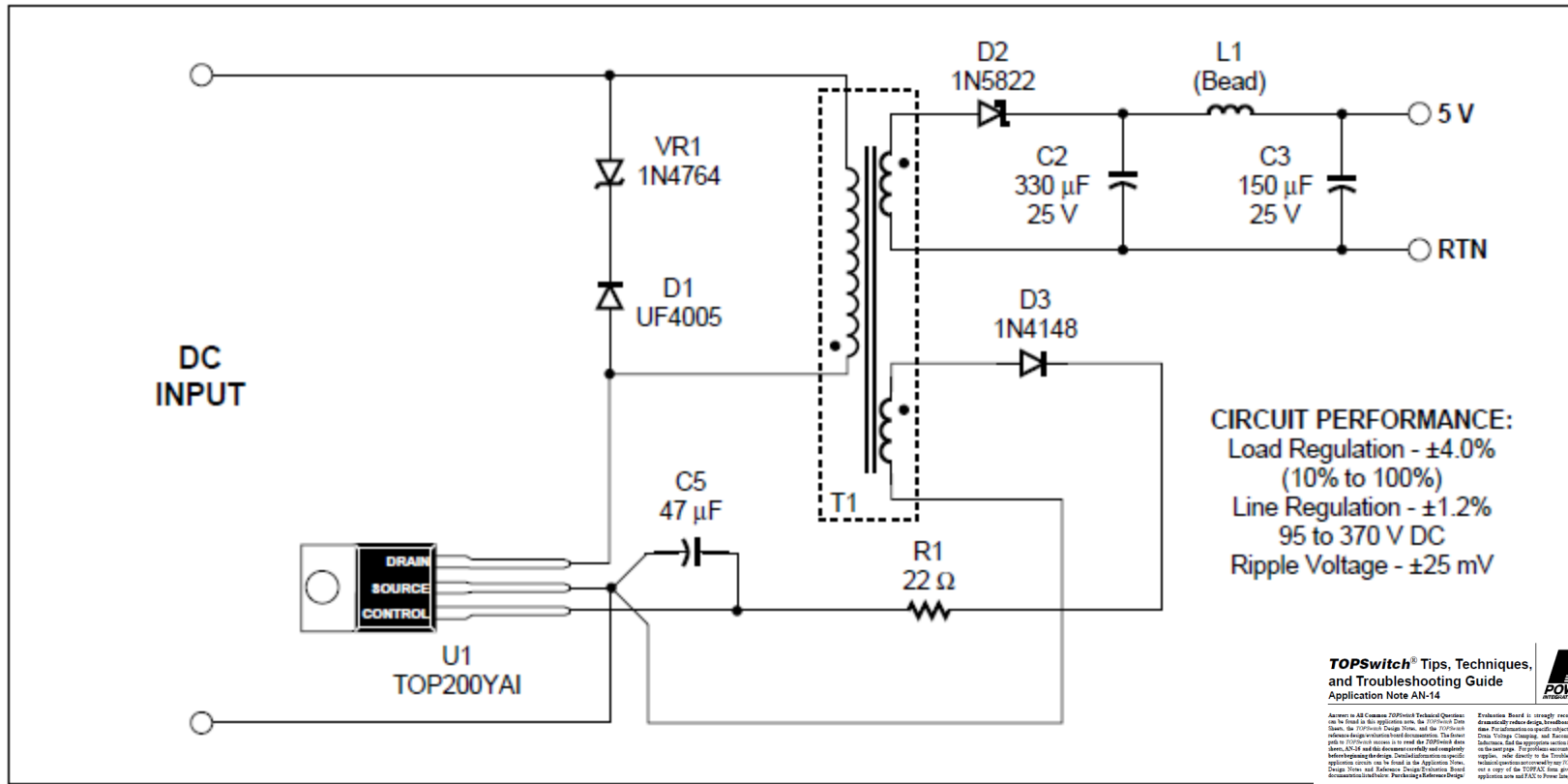
Proteção do gatilho de MOSFETs

Posicionar o mais próximo possível do MOSFET:



Para circuito com tensão de gatilho positiva e negativa.

PCB e layout



TOPSwitch® Tips, Techniques, and Troubleshooting Guide
 Application Note AN-14



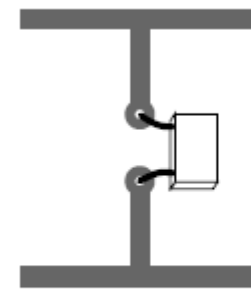
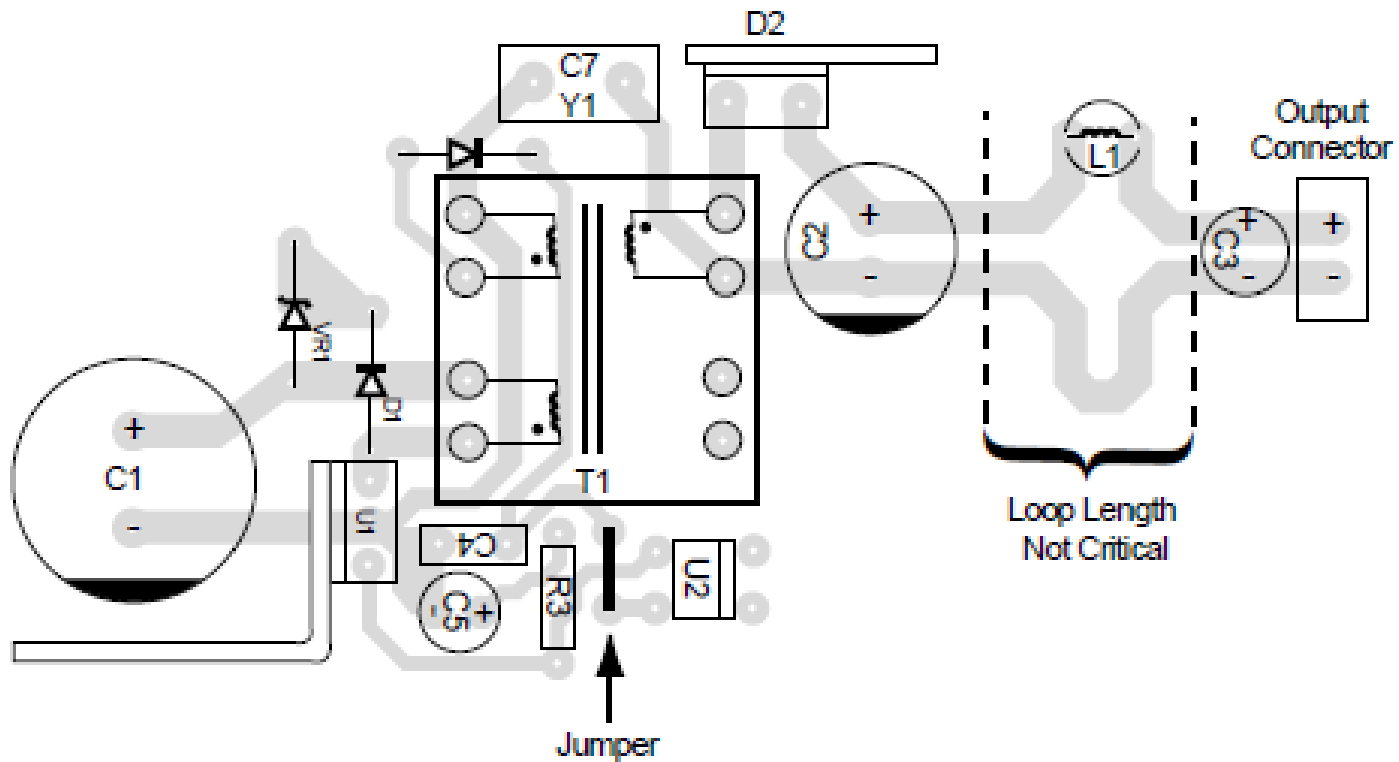
Access to All Common TOPSwitch Technical Questions can be found in the application note, the TOPSwitch Clinic Sheet, the TOPSwitch Design Store, and the TOPSwitch Reference Design Evaluation Board. The Reference Design Store provides access to real life TOPSwitch design cases, AN-14 and the Reference Design and Reference Design Evaluation Board. Detailed information on specific applications can be found in the Application Store, Design Store and Reference Design Evaluation Board documentation including: Troubleshooting Reference Design

- Other Design/Application Notes**
- AD-11: TOPSwitch Power Supply Design Techniques for EMI and Safety
 - AD-12: TOPSwitch Flyback Design Methodology
 - AD-13: Flyback Transformer Design for TOPSwitch Power Supplies
 - AD-14: TOPSwitch Flyback Troubleshooting Construction Guide for TOPSwitch
 - AD-15: TOPSwitch Flyback Power Supply Efficiency
 - AD-16: Thermal Implications Techniques for TOPSwitch Power Supplies
 - DS-1: Power Factor Correction Using TOPSwitch
 - DS-2: Single Bus Supplies Using the TOP200
 - DS-3: A Low-Cost, Low-Power Cost TOPSwitch Supply
 - DS-4: Shielded Flyback Supplies Using TOPSwitch
 - DS-5: Constant Current Constant Power Regulation Circuit for TOPSwitch
 - DS-6: TOPSwitch Power Supply for Ethernet PLS-11 Power Line Transceiver
 - DS-7: DC to DC Converter Using TOPSwitch for Telecom and Cellular Applications

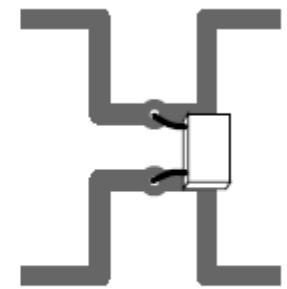
AN 14

- Reference Design/Evaluation Board Documentation**
- RD00: TOP200 Reference Design Board
 115 to 370 VAC Input, 500 mA, 5V Output (Replaces AD-1)
 - RD01: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD02: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD03: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD04: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD05: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD06: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD07: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD08: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD09: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD10: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD11: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD12: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD13: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD14: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD15: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD16: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD17: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD18: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD19: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output
 - RD20: TOP200 Reference Design Board
 115 to 370 VAC Input, 1.0 A Output

PCB e layout

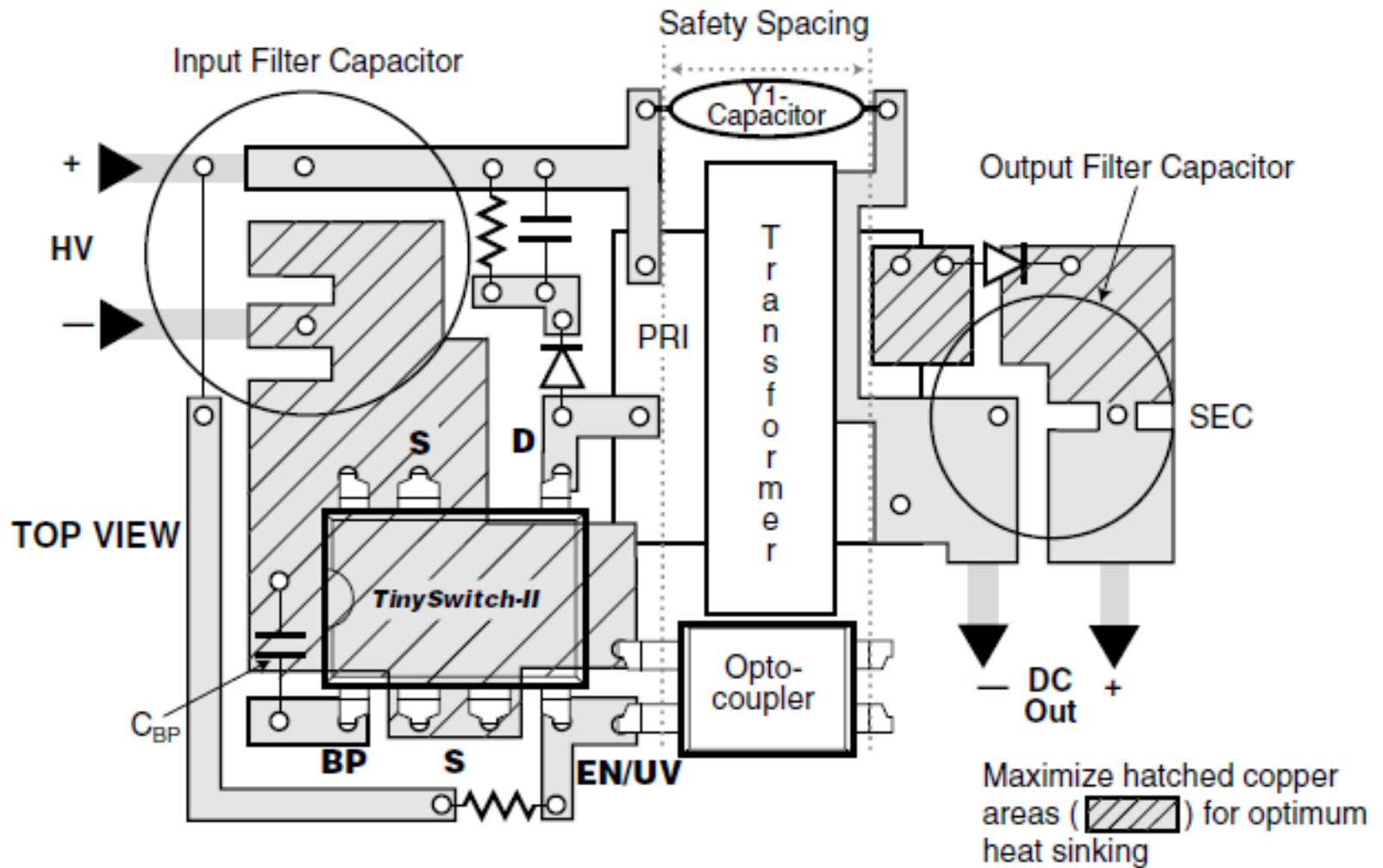


(a)
WRONG



(b)
RIGHT

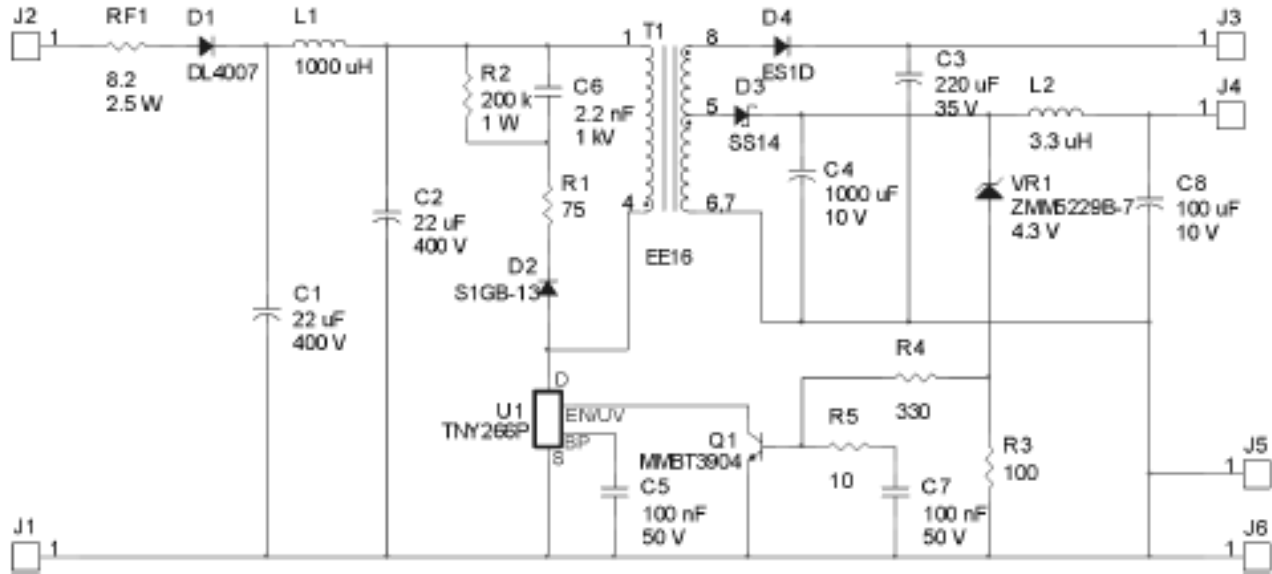
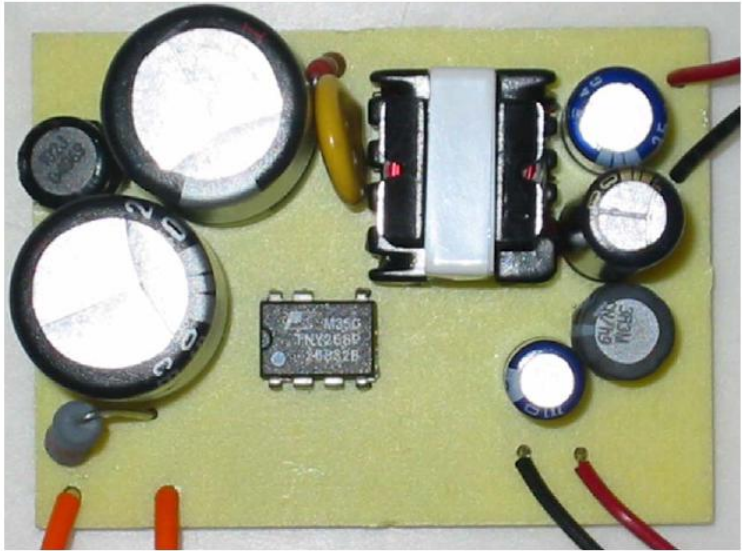
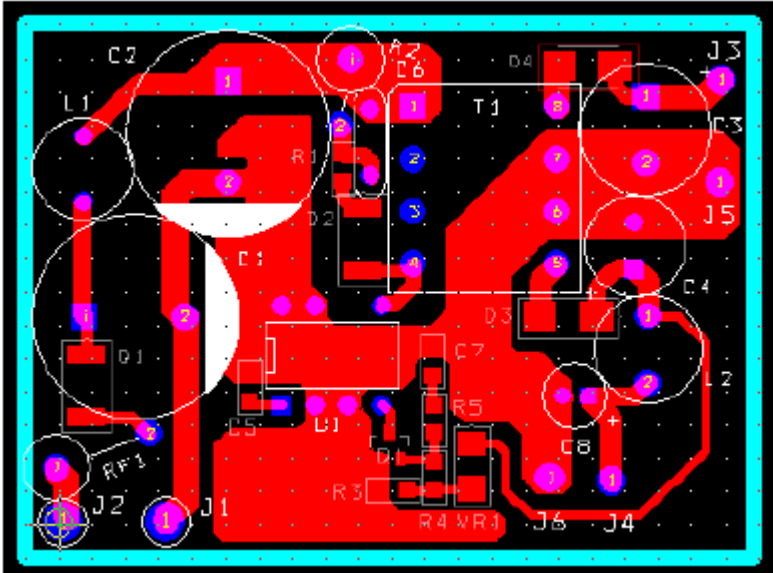
PCB e layout



PCB e layout

Description	Symbol	Min	Typ	Max	Units	Comment	
Input							
Voltage	V_{IN}	90		265	VAC	2 Wire – no P.E.	
Frequency	f_{LINE}	47	50/60	64	Hz		
No-load Input Power (230 VAC)				0.7	W		
Output							
Output Voltage 1	V_{OUT1}		5		V	± 5% 20 MHz bandwidth	
Output Ripple Voltage 1	$V_{RIPPLE1}$		50		mV		
Output Current 1	I_{OUT1}		500		mA		
Output Voltage 2	V_{OUT1}		24		V	± 15% 20 MHz bandwidth	
Output Ripple Voltage 2	$V_{RIPPLE1}$		200		mV		
Output Current 2	I_{OUT1}		200		mA		
Output Power	P_{OUT}		7.3		W		
Efficiency	η	80			%	Measured at P_{OUT} (7.3 W), 25 °C	
Environmental							
Conducted EMI		Meets CISPR22B / EN55022B					
Safety		Designed to meet IEC950, UL1950 Class II					
Surge		4			kV	1.2/50 μ s surge, IEC 1000-4-5, Series Impedance: Differential Mode: 2 Ω Common Mode: 12 Ω	
Surge		3			kV	100 kHz ring wave, 500 A short circuit current, differential and common mode	
Ambient Temperature	T_{AMB}	0		70	°C	Free convection, sea level	

PCB e layout



<http://www.powerint.com/>

Próxima aula

Parte 3 – Fontes chaveadas:

1. Projeto de uma fonte chaveada.