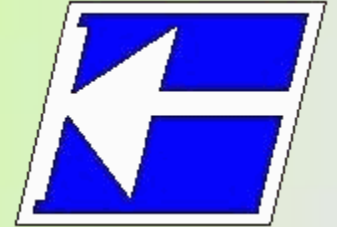


Centro Federal de Educação Tecnológica de Santa Catarina
Departamento Acadêmico de Eletrônica
Conversores Estáticos



Semicondutores Aplicados a
Conversores CC-CA
Módulos de Potência e Drivers

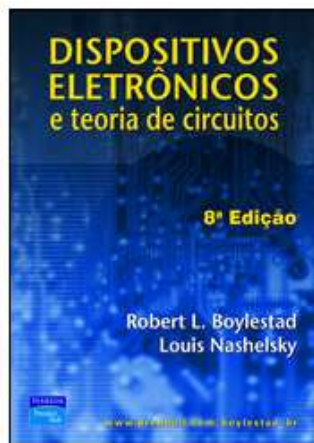
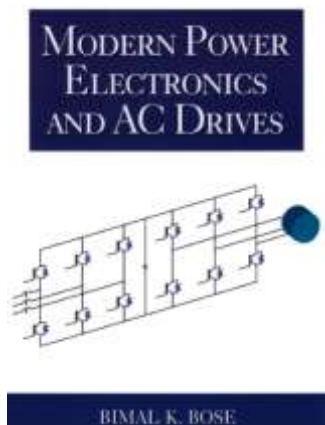
Prof. Clóvis Antônio Petry.

Florianópolis, novembro de 2008.

Bibliografia para esta aula

Capítulo 10: Inversores

1. Semicondutores aplicados aos conversores CC-CA.



www.cefetsc.edu.br/~petry

<http://www.dsce.fee.unicamp.br/~antenor/>

Nesta aula

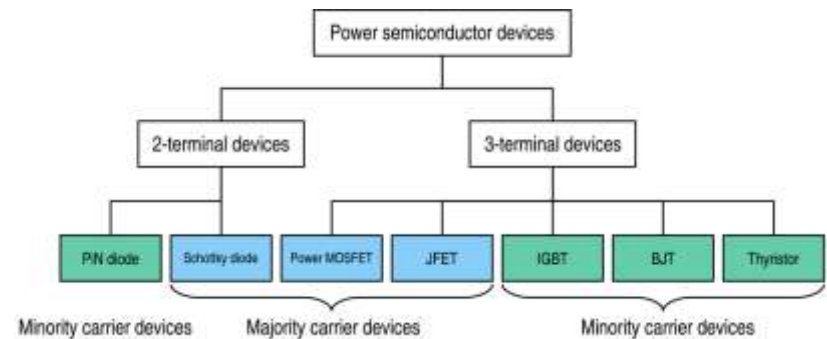
Semicondutores aplicados a conversores CC-CA:

1. Introdução;
2. MOSFET de potência;
3. IGBT;
4. Módulos de potência;
5. Driver de acionamento de MOSFET e IGBT;
6. Bootstrap.

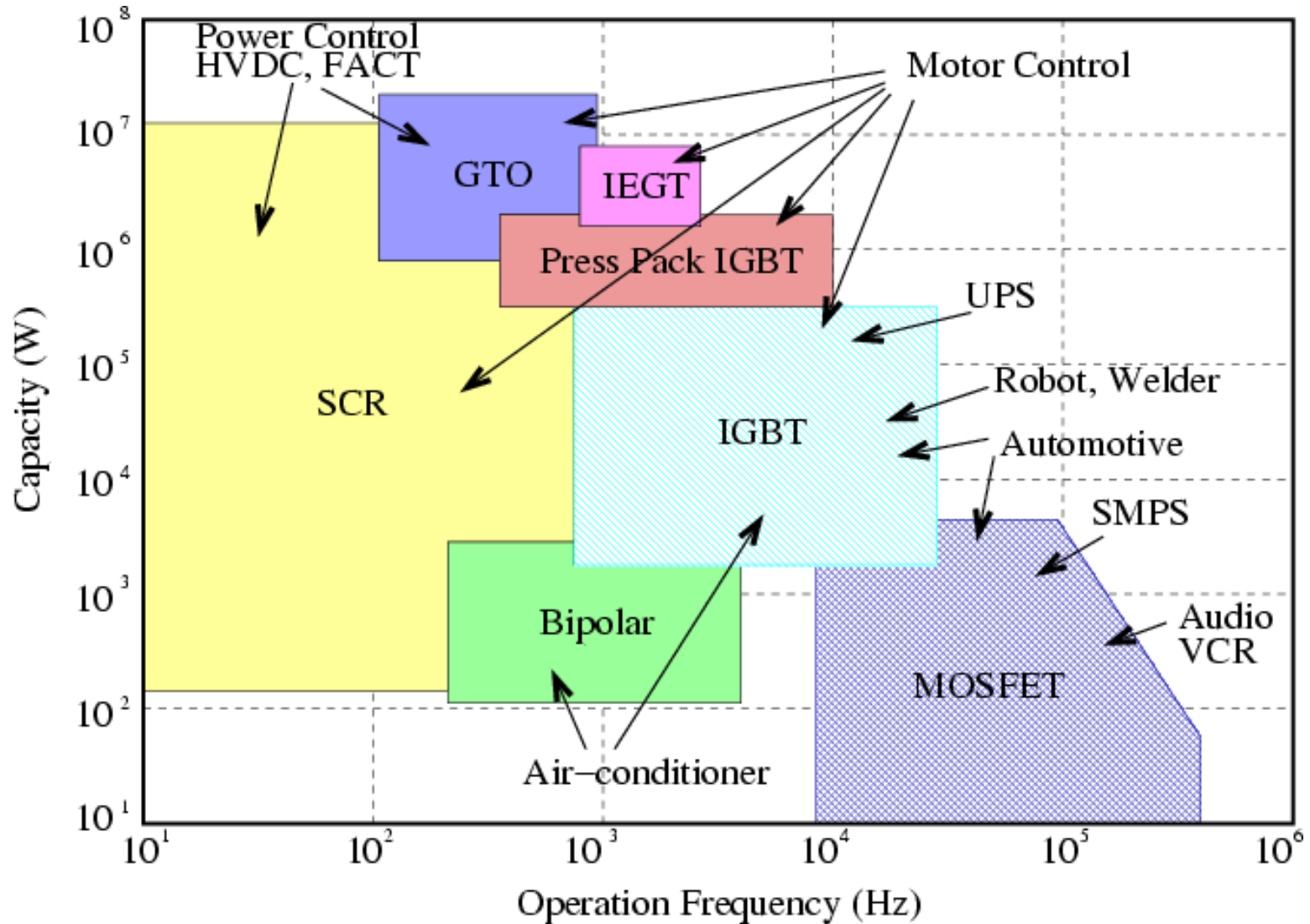
Semicondutores para eletrônica de potência

Semicondutores utilizados em eletrônica de potência:

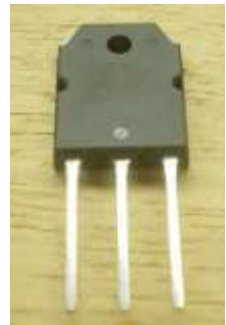
- Diode
- Thyristor or silicon-controlled rectifier (SCR)
- Triac
- Gate turn-off thyristor (GTO)
- Bipolar junction transistor (BJT or BPT)
- Power MOSFET
- Static induction transistor (SIT)
- Insulated gate bipolar transistor (IGBT)
- MOS-controlled thyristor (MCT)
- Integrated gate-commutated thyristor (IGCT)



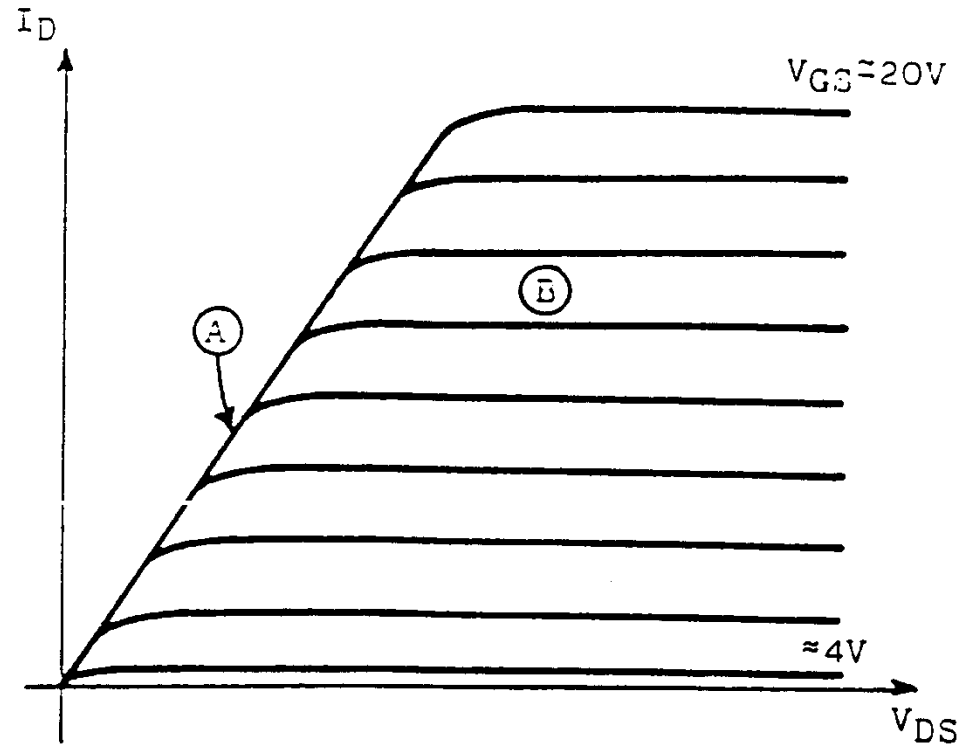
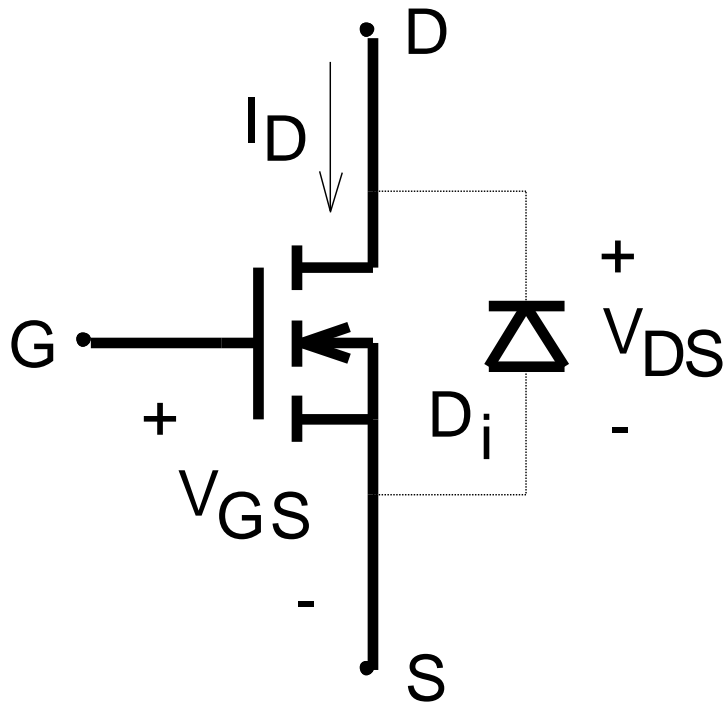
Semicondutores para eletrônica de potência



Semicondutores para eletrônica de potência



MOSFET de potência



MOSFET de potência

Classificação das perdas:

1. Condução;

$$P_{cond} = \frac{t_{on}}{T} \cdot r_{ds(on)} \cdot i_{d(on)}^2$$

2. Comutação:

- Entrada em condução e bloqueio;

$$P_{com} = \frac{f}{2} (t_r + t_f) \cdot i_{d(on)} \cdot v_{ds(off)}$$

- Onde:

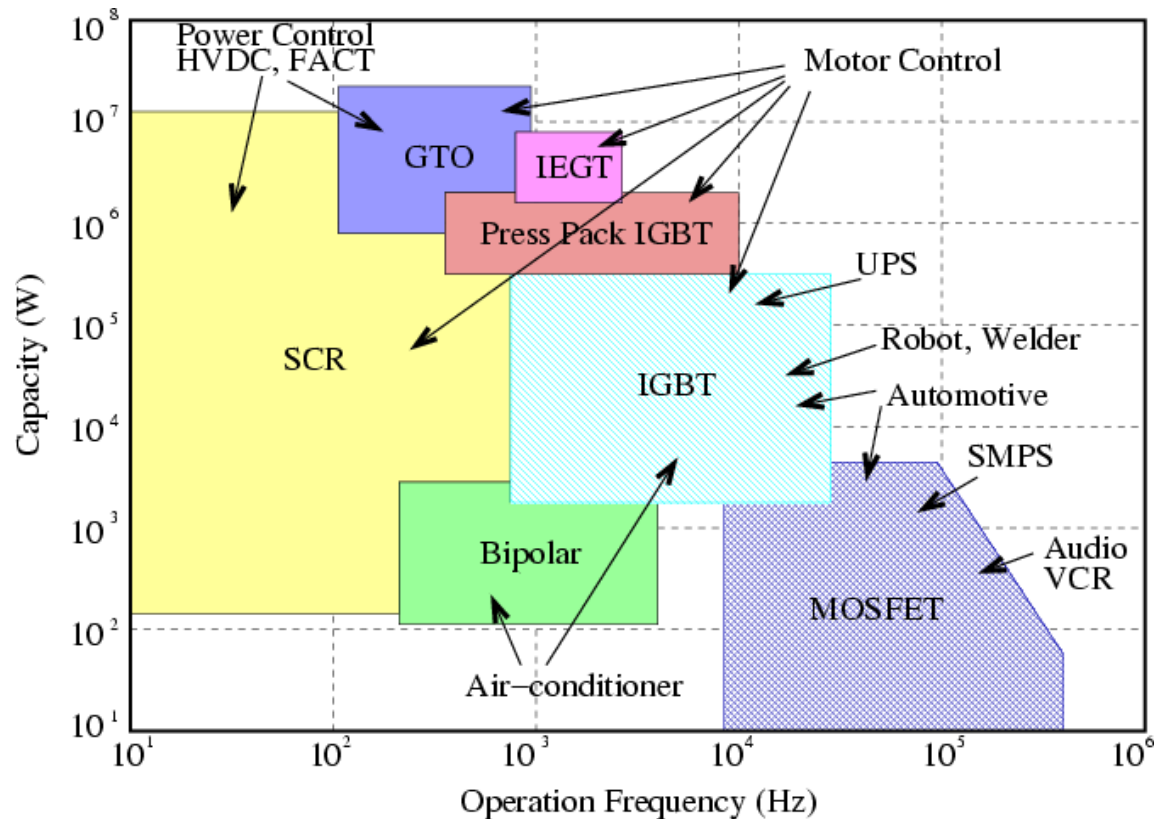
$$t_f \cong t_{on}$$

$$t_r \cong t_{off}$$

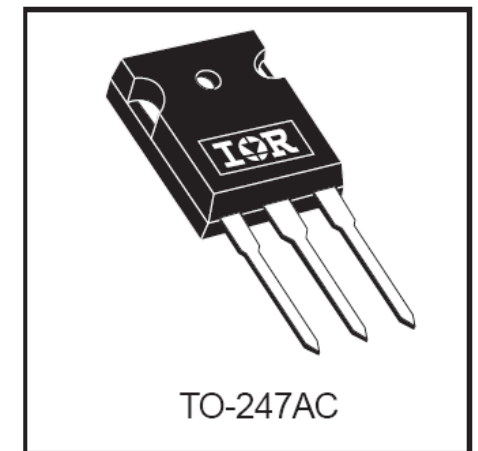
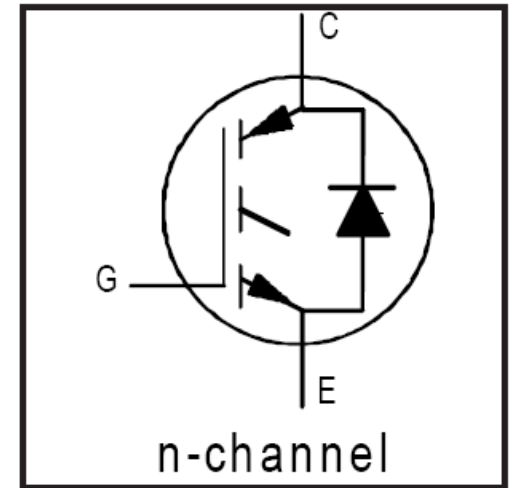
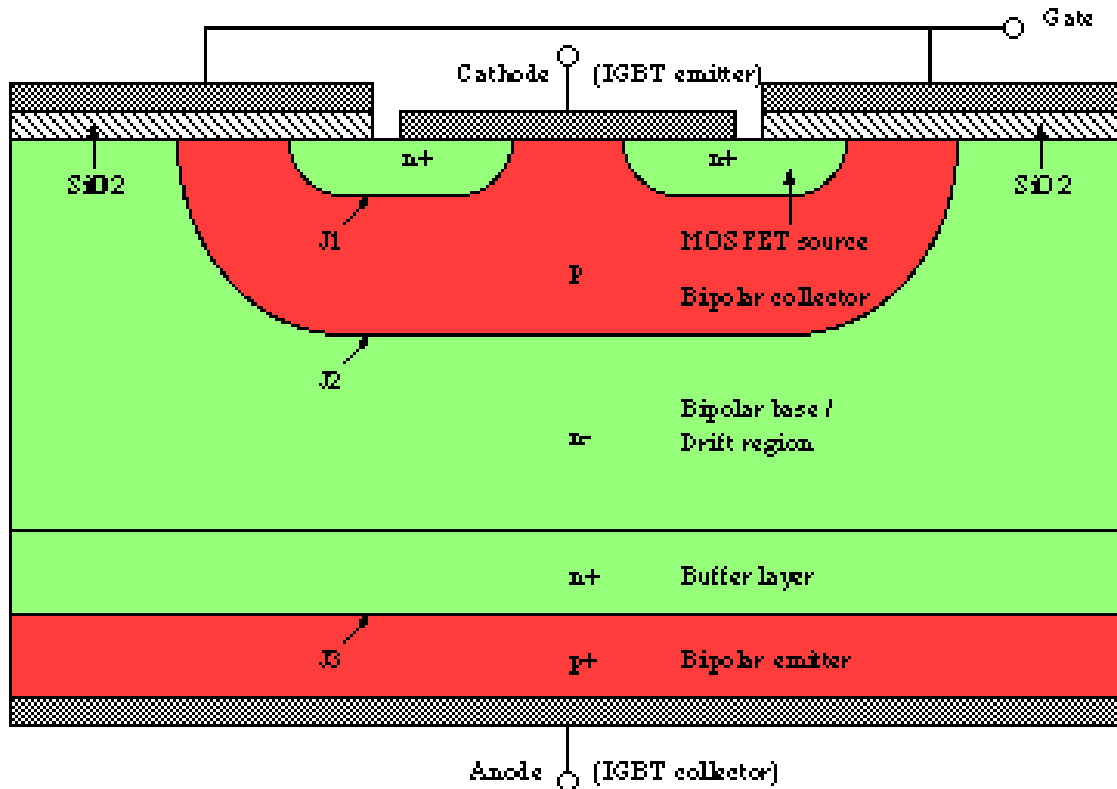
MOSFET de potência

Quando usar MOSFET:

1. Freqüências altas (acima de 50 kHz);
2. Tensões muito baixas (< 500 V);
3. Potências baixas (< 1 kW).



IGBT



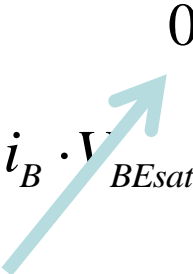
Características de BJT e MOSFET

IGBT – Insulated Gate Bipolar Transistor

IGBT

Classificação das perdas:

1. Condução;

$$P_{cond} = (i_C \cdot V_{CEsat} + i_B \cdot V_{BEsat}) \cdot t_{on} \cdot f$$


2. Comutação:

- Entrada em condução e bloqueio;

$$P_{com} = \frac{1}{2} (t_r + t_f) \cdot I \cdot E \cdot f$$

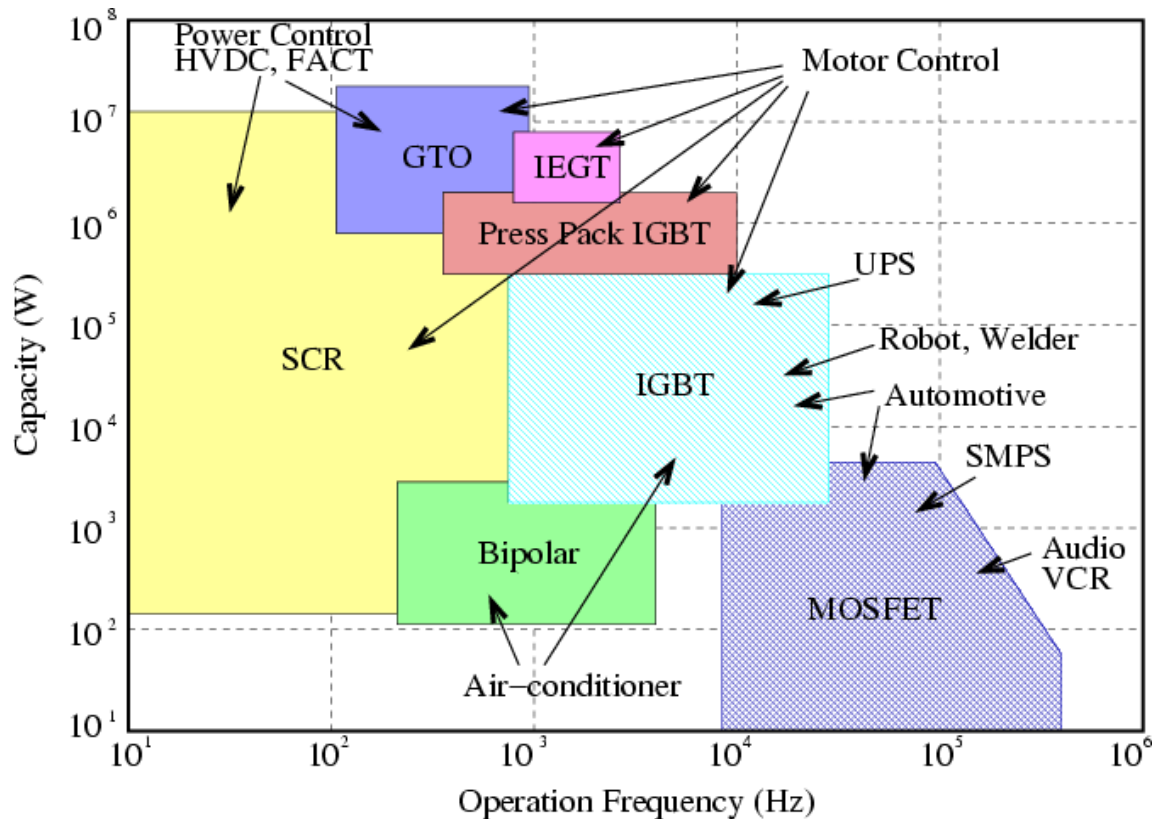
Detalhamento do cálculo de perdas



IGBT

Quando usar IGBT:

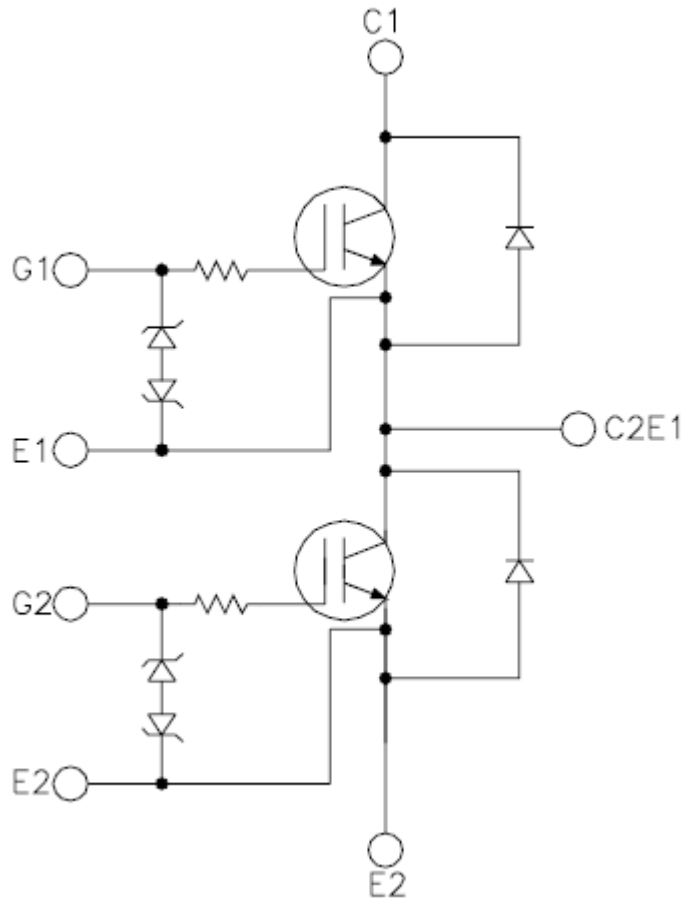
1. Freqüências baixas (menor que 50 kHz);
2. Tensões altas (> 500 V);
3. Potências altas (> 1 kW).



BJT x MOSFET x IGBT

	MOSFET	IGBT	BJT
Tipo de comando	Tensão	Tensão	Corrente
Potência do comando	Mínima	Mínima	Grande
Complexidade do comando	Simples	Simples	Média
Densidade de corrente	Elevada em baixas tensões e Baixa em altas tensões	Muito elevada	Média
Perdas de comutação	Muito baixa	Baixa para Média	Média para Alta

Módulos de potência



www.irf.com



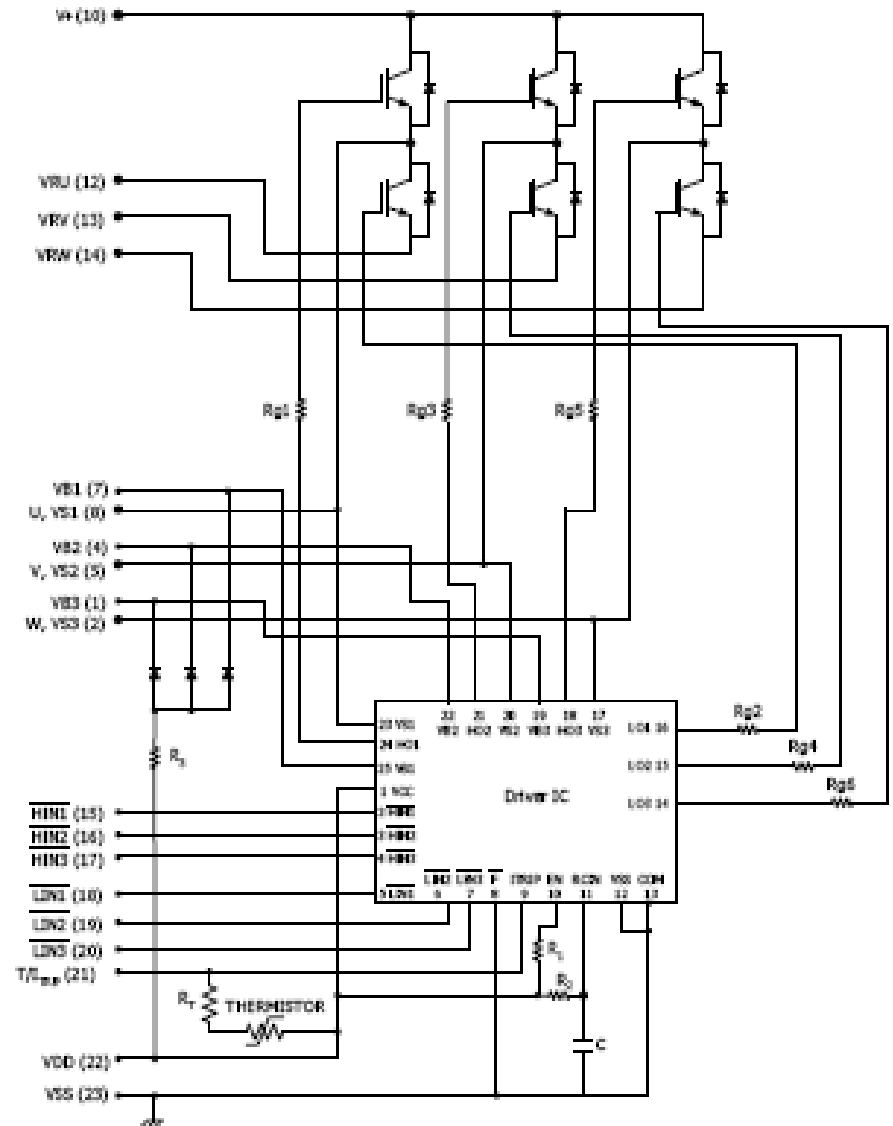
HiRel™ INT-A-Pak 2, PLASTIC HALF-BRIDGE IGBT MODULE

Product Summary





















Part Number	V_{CE}	I_C	$V_{CE(SAT)}$
G450HGBK06P2	600V	450A	1.8

Módulos de potência

IRAMS06UP60A
iMOTION™ Series
6A, 600V



Módulos de potência

IGBT	 SEMITRANS®	 SEMiX®	 SKiM™	 MiniSKiIP®	 SEMITOP®	
IPM	 MiniSKiIP®		 SKiIP® 2/3			
CIB	 MiniSKiIP®		 SEMITOP®			
MOSFET	 SEMITRANS®		 SEMITOP®			
Thyristor/Diode	 SEMiPACK®	 SEMiPACK® Fast	 SEMiSTART	 SEMiX®	 SEMITOP®	 SEMiPONT®
Bridge Rectifier	 SEMiPONT®		 SEMiX®		 SEMITOP®	



www.semikron.com.br

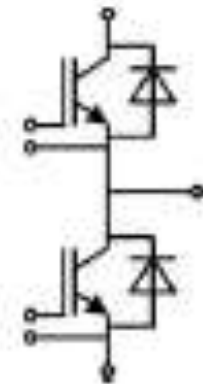


Módulos de potência

SKM 50GB063D



Absolute Maximum Ratings		$T_C = 25\text{ }^\circ\text{C}$, unless otherwise specified		
Symbol	Conditions	Values	Units	
IGBT				
V_{CES}	$T_j = 25\text{ }^\circ\text{C}$	600	V	
I_C	$T_j = 150\text{ }^\circ\text{C}$	$T_{case} = 25\text{ }^\circ\text{C}$	70	A
		$T_{case} = 75\text{ }^\circ\text{C}$	50	A
I_{CRM}	$I_{CRM} = 2 \times I_{Cnom}$	100	A	
V_{GES}		± 20	V	
t_{psc}	$V_{CC} = 300\text{ V}; V_{GE} \leq 20\text{ V}; T_j = 125\text{ }^\circ\text{C}$ $V_{CES} < 600\text{ V}$	10	μs	
Inverse Diode				
I_F	$T_j = 150\text{ }^\circ\text{C}$	$T_{case} = 25\text{ }^\circ\text{C}$	75	A
		$T_{case} = 80\text{ }^\circ\text{C}$	50	A
I_{FRM}	$I_{FRM} = 2 \times I_{Fnom}$	100	A	
I_{FSM}	$t_p = 10\text{ ms}; \text{sin.}$	$T_j = 150\text{ }^\circ\text{C}$	440	A
Module				
$I_{t(RMS)}$		200	A	
T_{vj}		- 40 ... + 150	$^\circ\text{C}$	
T_{stg}		- 40 ... + 125	$^\circ\text{C}$	
V_{isol}	AC, 1 min.	2500	V	



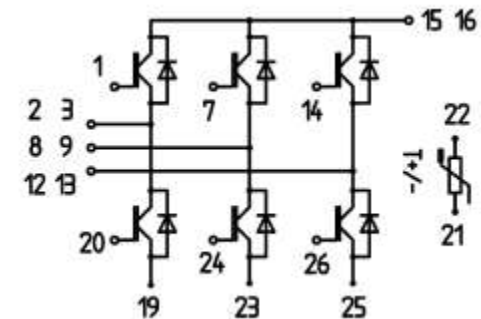
Módulos de potência

SK50GD066ET

Absolute Maximum Ratings		$T_s = 25\text{ °C}$, unless otherwise specified	
Symbol	Conditions	Values	Units
IGBT			
V_{CES}	$T_j = 25\text{ °C}$	600	V
I_C	$T_j = 175\text{ °C}$	$T_s = 25\text{ °C}$	57 A
		$T_s = 70\text{ °C}$	45 A
I_{CRM}	$I_{CRM} = 2 \times I_{Cnom}$	100	A
V_{GES}		± 20	V
t_{psc}	$V_{CC} = 360\text{ V}$; $V_{GE} \leq 20\text{ V}$; $T_j = 125\text{ °C}$ $V_{CES} < 600\text{ V}$	6	μs
Inverse Diode			
I_F	$T_j = 175\text{ °C}$	$T_s = 25\text{ °C}$	56 A
		$T_s = 70\text{ °C}$	44 A
I_{FRM}	$I_{FRM} = 2 \times I_{Fnom}$	60	A
Module			
$I_{t(RMS)}$			A
T_{vj}		-40 ... +150	$^{\circ}\text{C}$
T_{stg}		-40 ... +125	$^{\circ}\text{C}$
V_{isol}	AC, 1 min.	2500	V



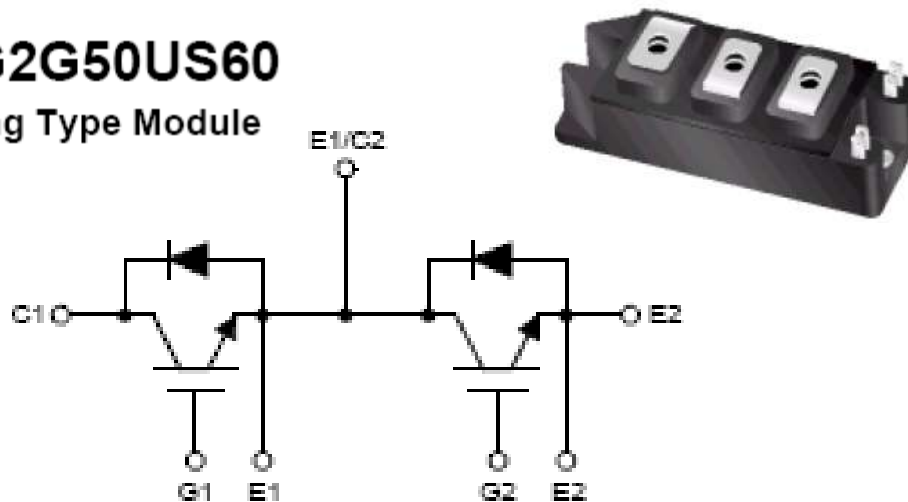
SEMISTOP® 3



www.semikron.com.br

Módulos de potência

FMG2G50US60 Molding Type Module



www.fairchildsemi.com

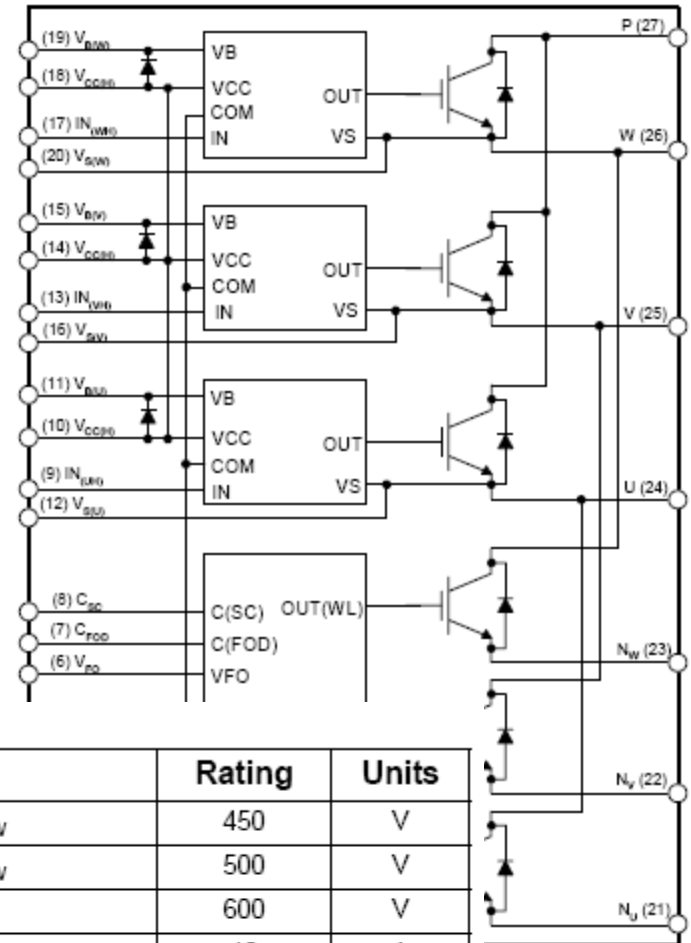
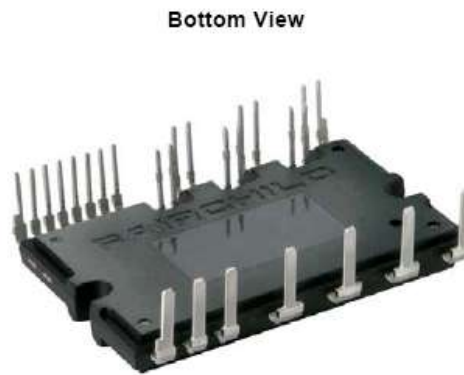
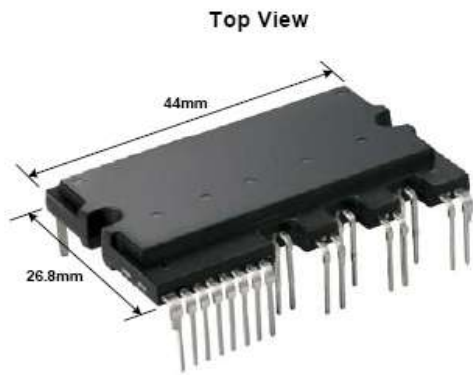


Absolute Maximum Ratings T_C = 25°C unless otherwise noted

Symbol	Description	FMG2G50US60	Units
V _{CES}	Collector-Emitter Voltage	600	V
V _{GES}	Gate-Emitter Voltage	± 20	V
I _C	Collector Current @ T _C = 25°C	50	A
I _{CM(1)}	Pulsed Collector Current	100	A
I _F	Diode Continuous Forward Current @ T _C = 100°C	50	A
I _{FM}	Diode Maximum Forward Current	100	A
T _{SC}	Short Circuit Withstand Time @ T _C = 100°C	10	us
P _D	Maximum Power Dissipation @ T _C = 25°C	250	W
T _J	Operating Junction Temperature	-40 to +150	°C
T _{stg}	Storage Temperature Range	-40 to +125	°C
V _{iso}	Isolation Voltage @ AC 1minute	2500	V
Mounting Torque	Power Terminals Screw : M5	2.0	N.m
	Mounting Screw : M5	2.0	N.m

Módulos de potência

FSBF10CH60BT Smart Power Module



Inverter Part

Symbol	Parameter	Conditions	Rating	Units
V_{FN}	Supply Voltage	Applied between P- N_U , N_V , N_W	450	V
$V_{FN(Surge)}$	Supply Voltage (Surge)	Applied between P- N_U , N_V , N_W	500	V
V_{CES}	Collector-emitter Voltage		600	V
$\pm I_C$	Each IGBT Collector Current	$T_C = 25^\circ\text{C}$	10	A
$\pm I_{CP}$	Each IGBT Collector Current (Peak)	$T_C = 25^\circ\text{C}$, Under 1ms Pulse Width	20	A
P_C	Collector Dissipation	$T_C = 25^\circ\text{C}$ per One Chip	20	W
$T_{J(Power\ chips)}$	Operating Junction Temperature	(Note 1)	-40 ~ 150	$^\circ\text{C}$

Driver ou Drive

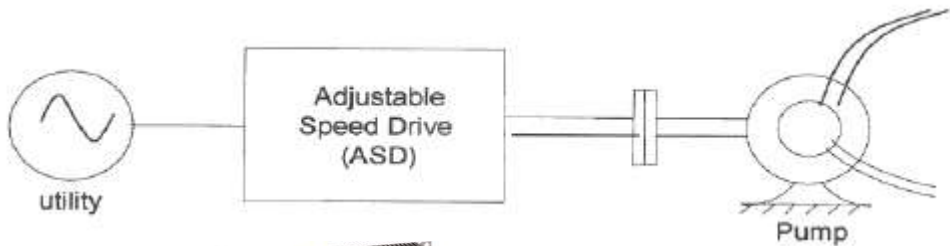
Drive



Driver

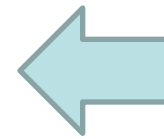
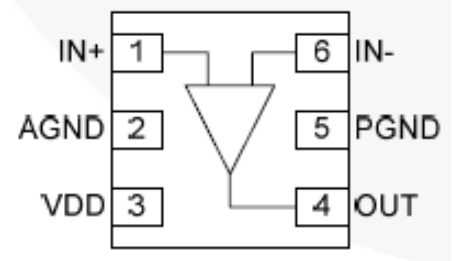
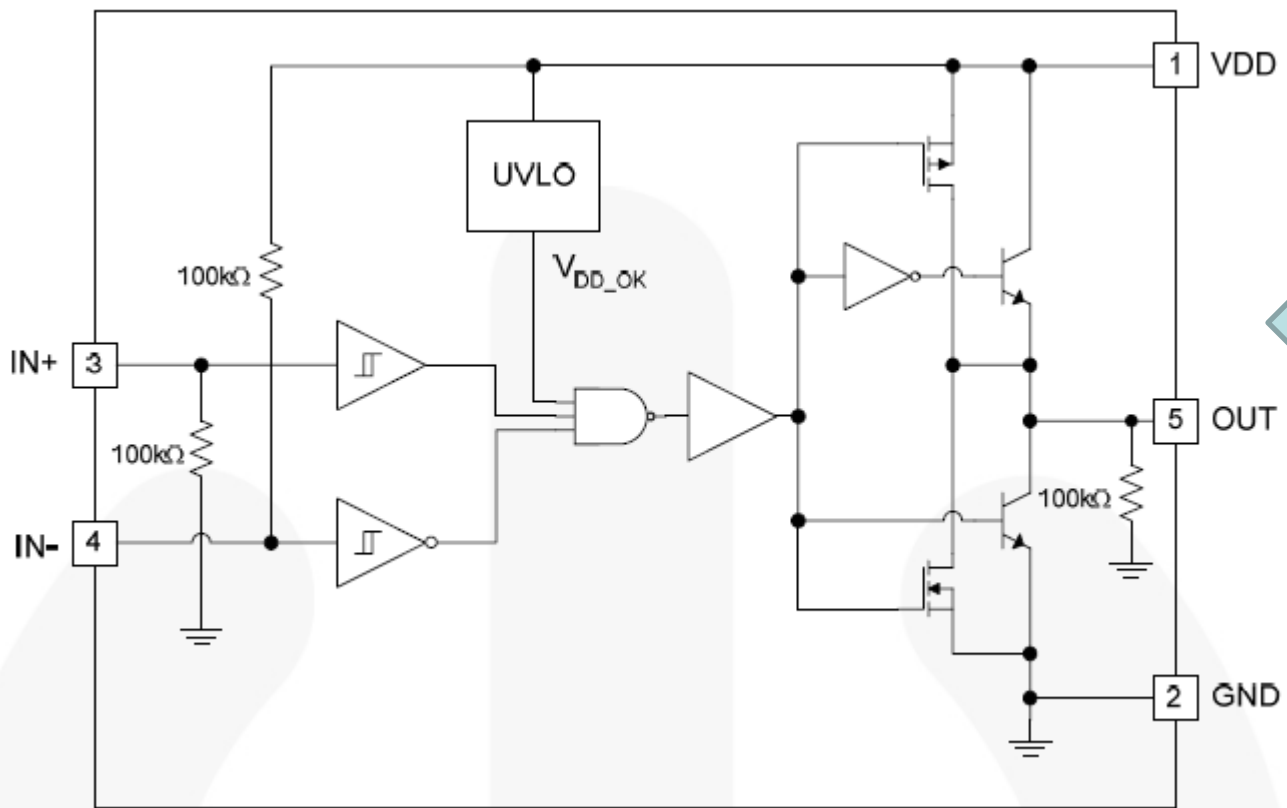
Para acionamento de motores

Para acionamento de semicondutores



Driver

FAN3100 Single 2A High-Speed, Low-Side Gate Driver



PWM??

Driver






SEMIDRIVER™

Type	Number of Channels	V _{CE} max. V	Gate voltage V	Output peak current A	Output charge μ C	Switching frequency kHz	Isolation voltage kV	dv/dt max. kV/ μ s
SKYPER™ Driver Core								
SKYPER \square 32 (R)	2	1700	+15 / -7	15	2,5	50	4	50
SKYPER \square 32PRO (R)	2	1700	+15 / -7	15	6,3	50	4	50
SKHI-DRIVER PCB-mountable								
SKHI \square 21A (R)	2	1200	+15 / 0	8	4	50	2,5	50
SKHI \square 22 \square A \square / \square B (R)	2	1200	+15 / -7	8	4			
SKHI \square 22 \square A / B H4 (R)	2	1700	+15 / -7	8	4			
SKHI \square 24 (R)	2	1700	+15 / -8	15	5			
SKHI \square 61 (R)	6	900	+15 / -6,5	2	1			
SKHI \square 71 (R)	7	900	+15 / -6,5	2	1			
SKHI-DRIVER Plug-and-Play								
SKHI \square 10/12 (R)	1	1200	+15 / -8	8	9,6			
SKHI \square 10/17 (R)	1	1700	+15 / -8	8	9,6			
SKHI \square 23/12 (R)	2	1200	+15 / -8	8	4,8			
SKHI \square 23/17 (R)	2	1700	+15 / -8	8	4,8			
SKHI \square 26W, \square SKHI \square 26F *	2	1600	+15 / -8	8	10			
SKHI \square 27W *	2	1700	+15 / -8	30	30	10	4	75
SKHI \square 01 (R)	3	-	-	-	-	-	2,5	-

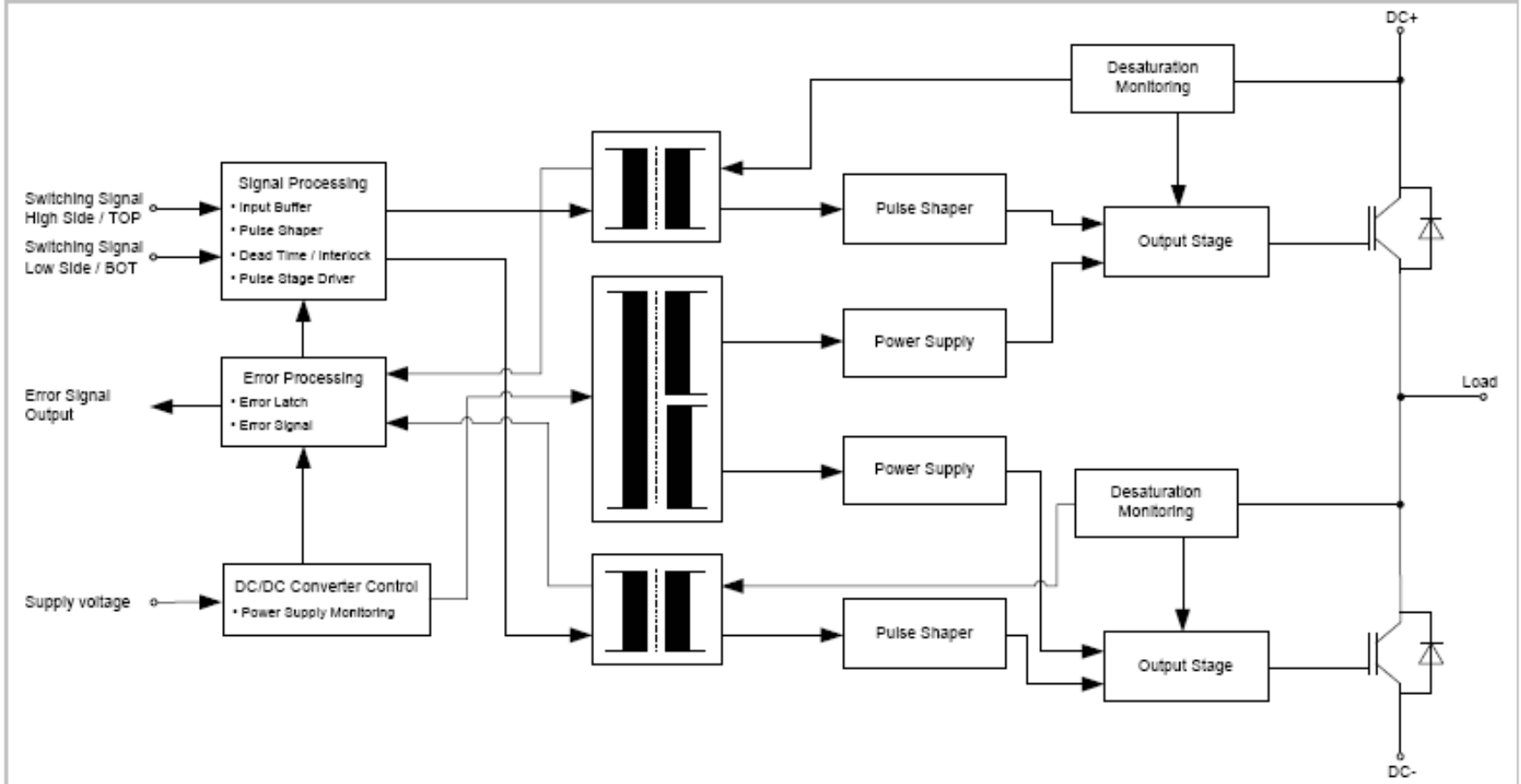


Driver

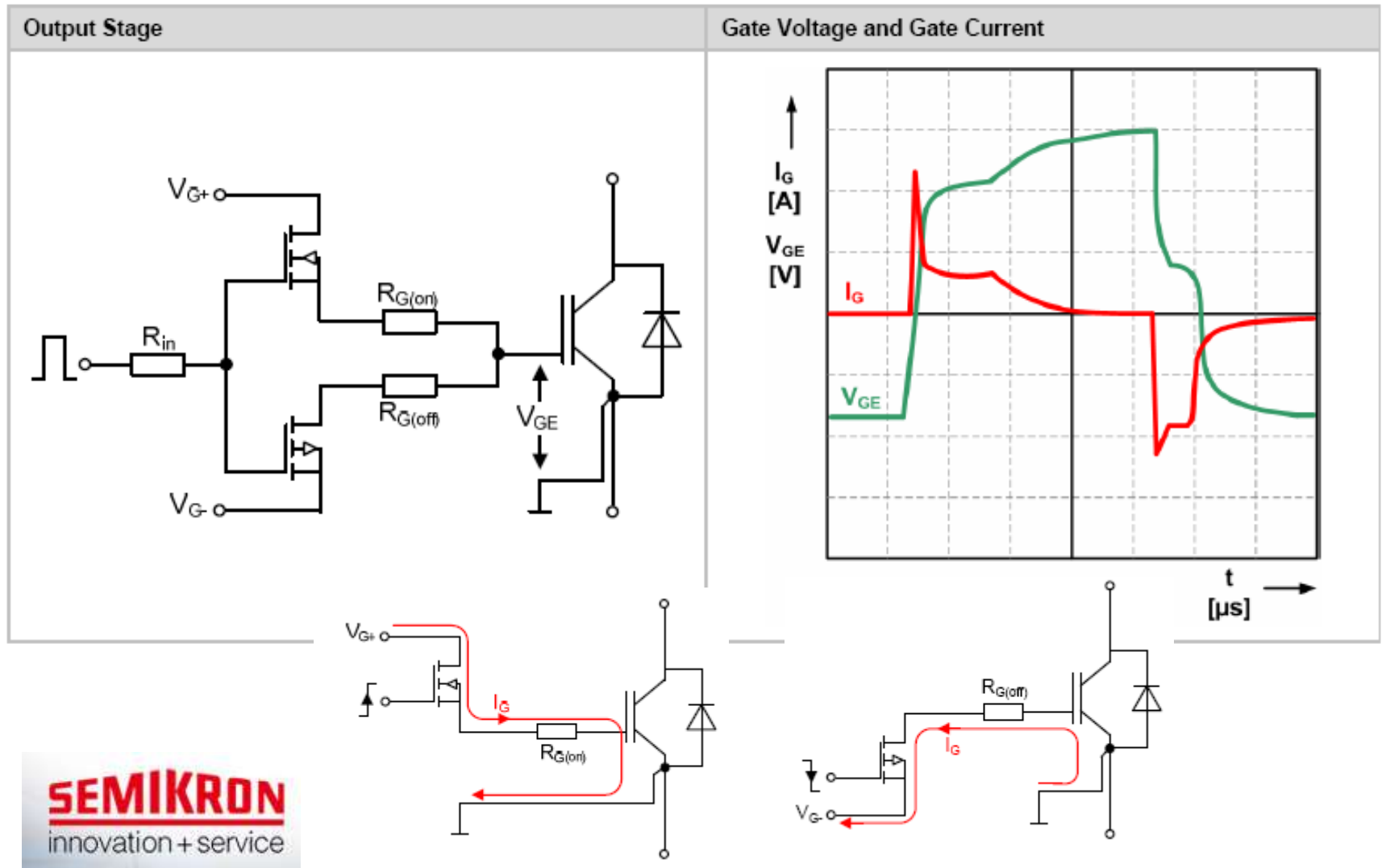
SKYPER® Driver Core	SKHI-DRIVER PCB-mountable	SKHI-DRIVER Plug-and-Play
 <p>Magnetic Transformer Secondary Side</p> <p>Primary Side</p>	 <p>Primary Side Magnetic Transformer</p> <p>Secondary Side</p>	 <p>Primary Side Magnetic Transformer Plug Connectors to IGBT</p> <p>Plug Connector to Controller Secondary Side</p>
<ul style="list-style-type: none"> ▪ Core technology ▪ PCB mountable driver ▪ Pins for PCB soldering & plug connection 	<ul style="list-style-type: none"> ▪ Hybrid technology ▪ PCB mountable driver ▪ Pins for PCB soldering ▪ Capsule housing 	<ul style="list-style-type: none"> ▪ SMT technology ▪ Complete driver solution ▪ Connectors for controller and IGBT connection ▪ Integrated turn-on and turn-off gate resistors

Driver

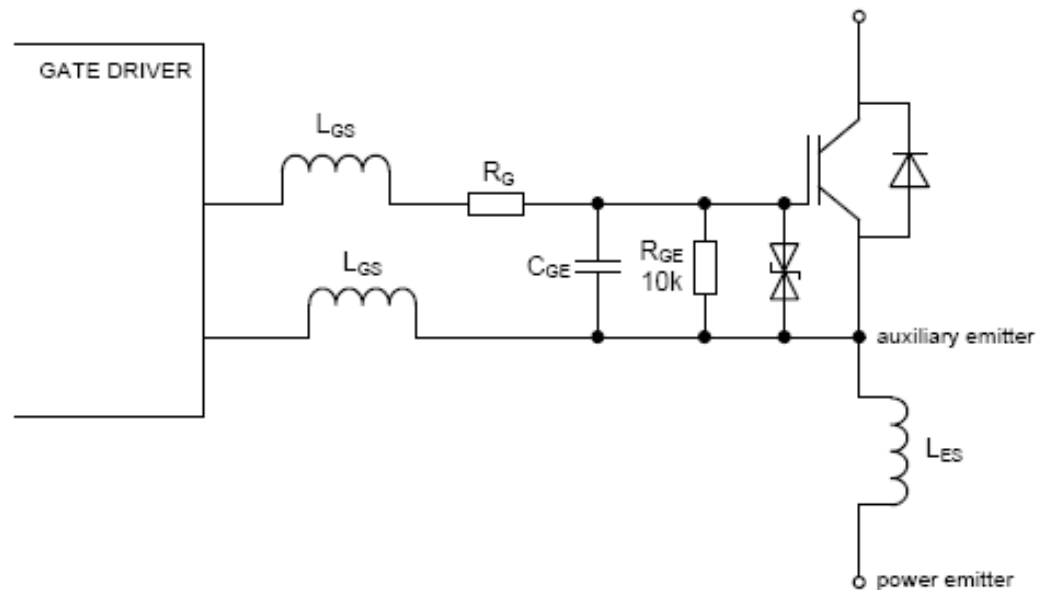
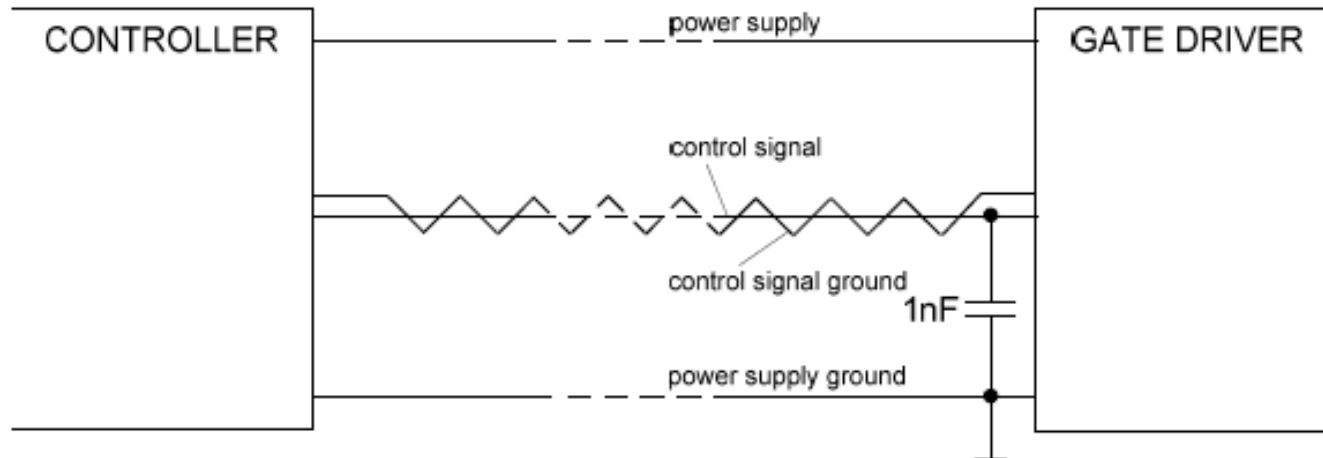
Typical Block Diagram



Driver



Driver



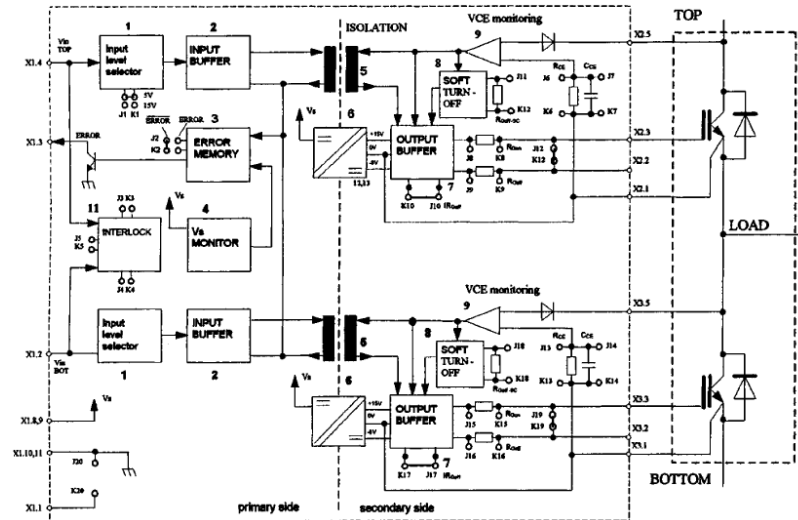
Driver



SEMIDRIVER™

Medium Power Double IGBT Driver

SKHI 23/12 (R)



Absolute Maximum Ratings		$T_a = 25\text{ }^\circ\text{C}$, unless otherwise specified	
Symbol	Conditions	Values	Units
V_S	Supply voltage primary	18	V
V_{iH}	Input signal voltage (HIGH) (for 15 V and 5 V input level)	$V_S + 0,3$	V
$I_{out,PEAK}$	Output peak current	± 8	A
$I_{out,AV}$	Output average current	± 50	mA
V_{CE}	Collector emitter voltage sense	1200	V
dv/dt	Rate of rise and fall of voltage (secondary to primary side)	75	kV/ μ s
$V_{isol IO}$	Isolation test volt. IN-OUT (2 sec. AC)	2500	V
$R_{Gon min}$	minimal R_{Gon}	2,7	Ω
$R_{Goff min}$	minimal R_{Goff}	2,7	Ω
$Q_{out/pulse}$	charge per pulse	4,8	μ C
T_{op}	Operating temperature	- 25 ... + 85	$^\circ$ C
T_{stg}	Storage temperature	- 25 ... + 85	$^\circ$ C

Driver



SEMIDRIVER™

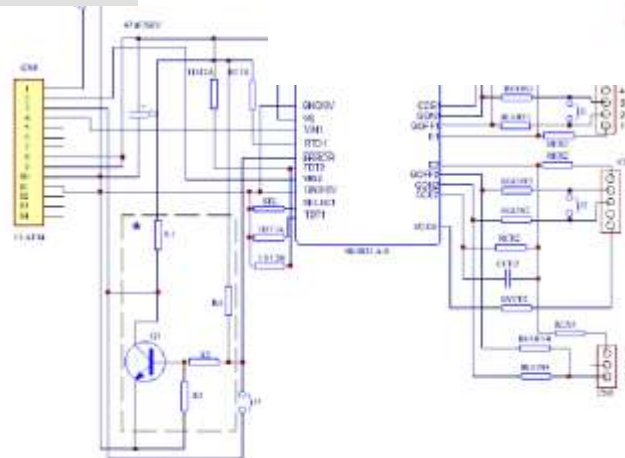
Hybrid Dual MOSFET
Driver

SKHI 21A (R)

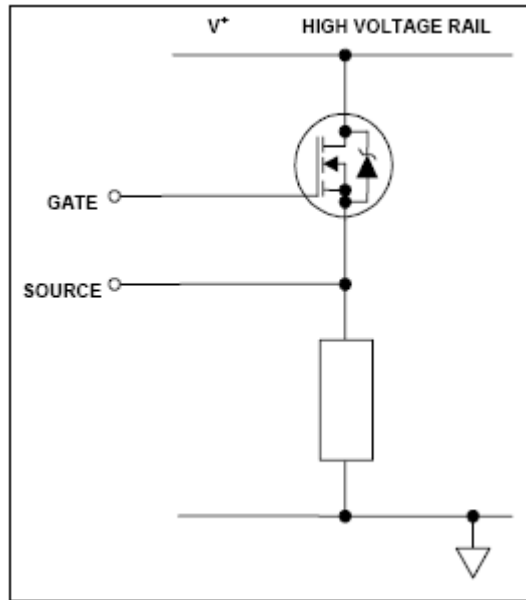


Printed Circuit Board
for SKHI 21A and
SKHI 22A/B drivers

SKPC 22/2

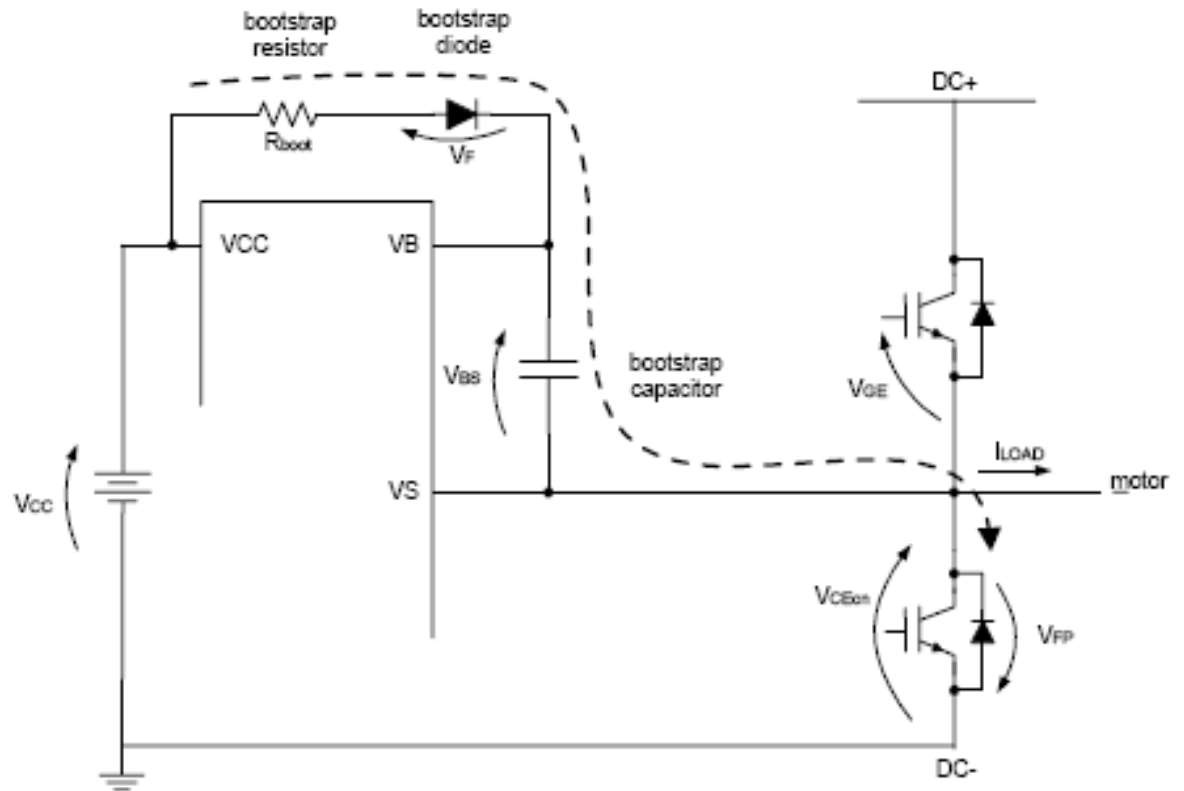


Bootstrap

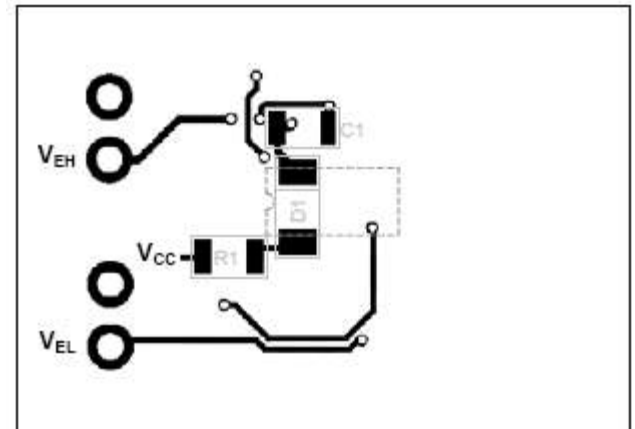
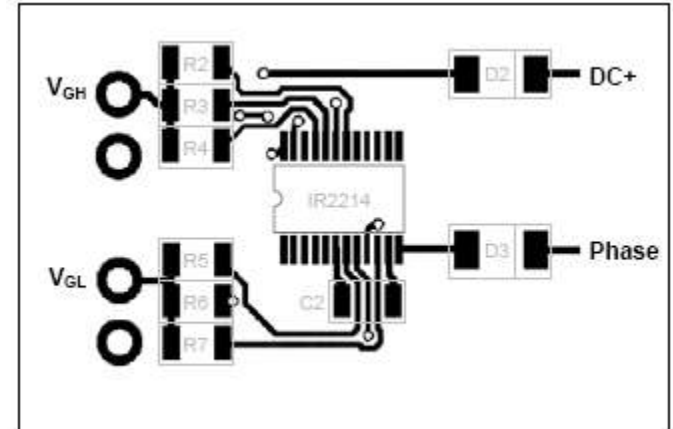
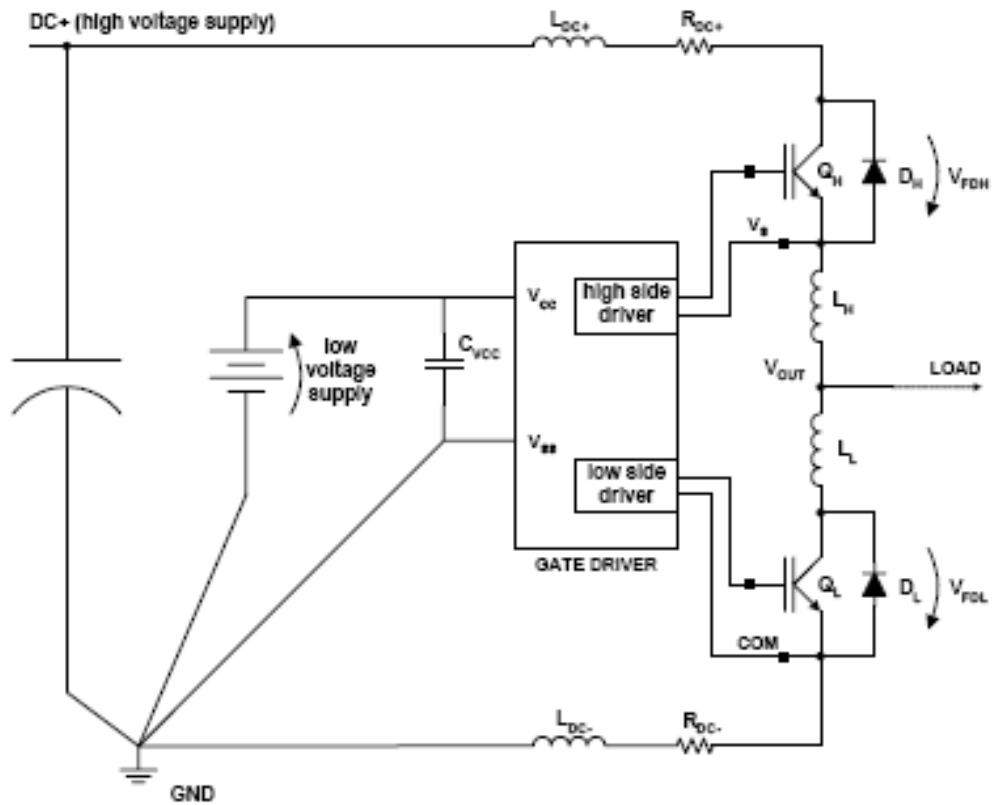


Problema

Princípio do Bootstrap



Bootstrap



Bootstrap

IR2111(S) & (PbF) HALF-BRIDGE DRIVER

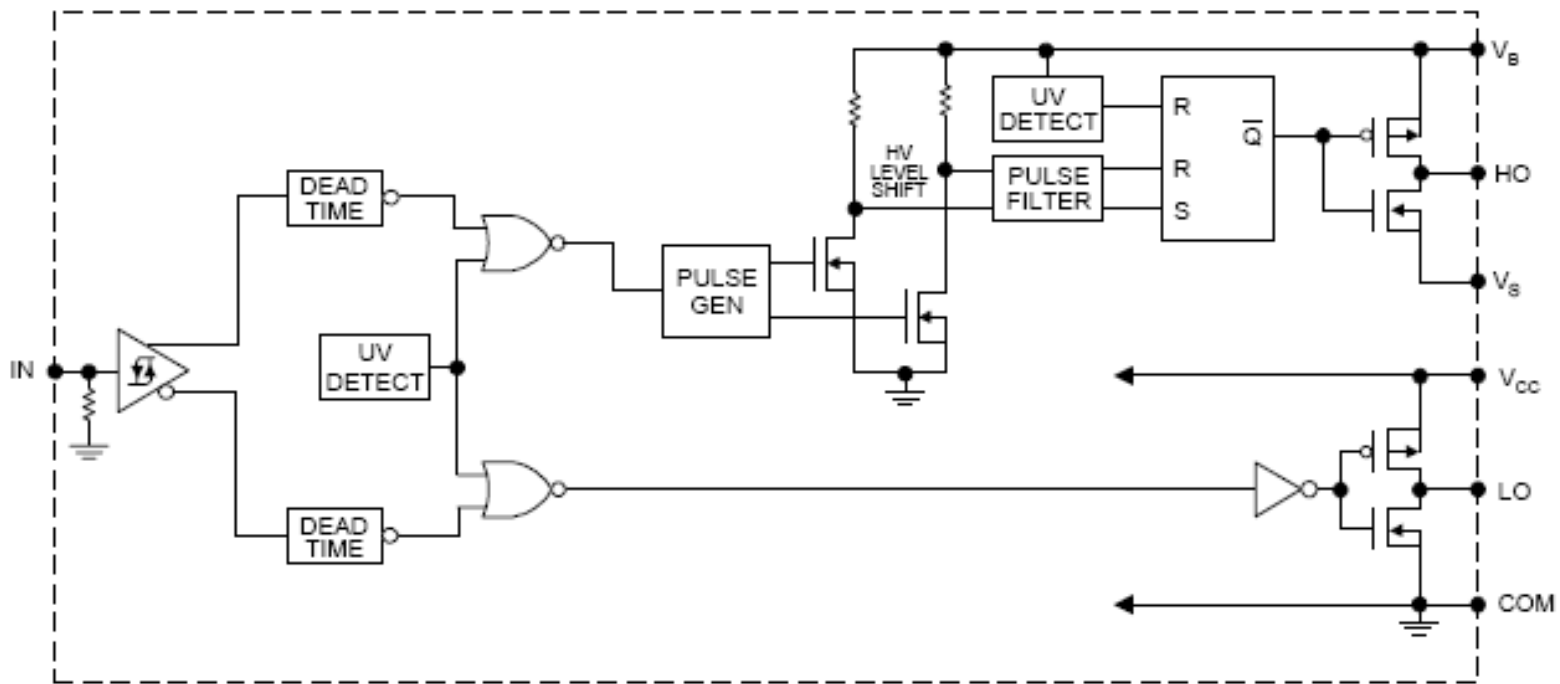
V_{OFFSET}	600V max.
$I_{O+/-}$	200 mA / 420 mA
V_{OUT}	10 - 20V
$t_{on/off}$ (typ.)	750 & 150 ns
Deadtime (typ.)	650 ns



8-Lead PDIP

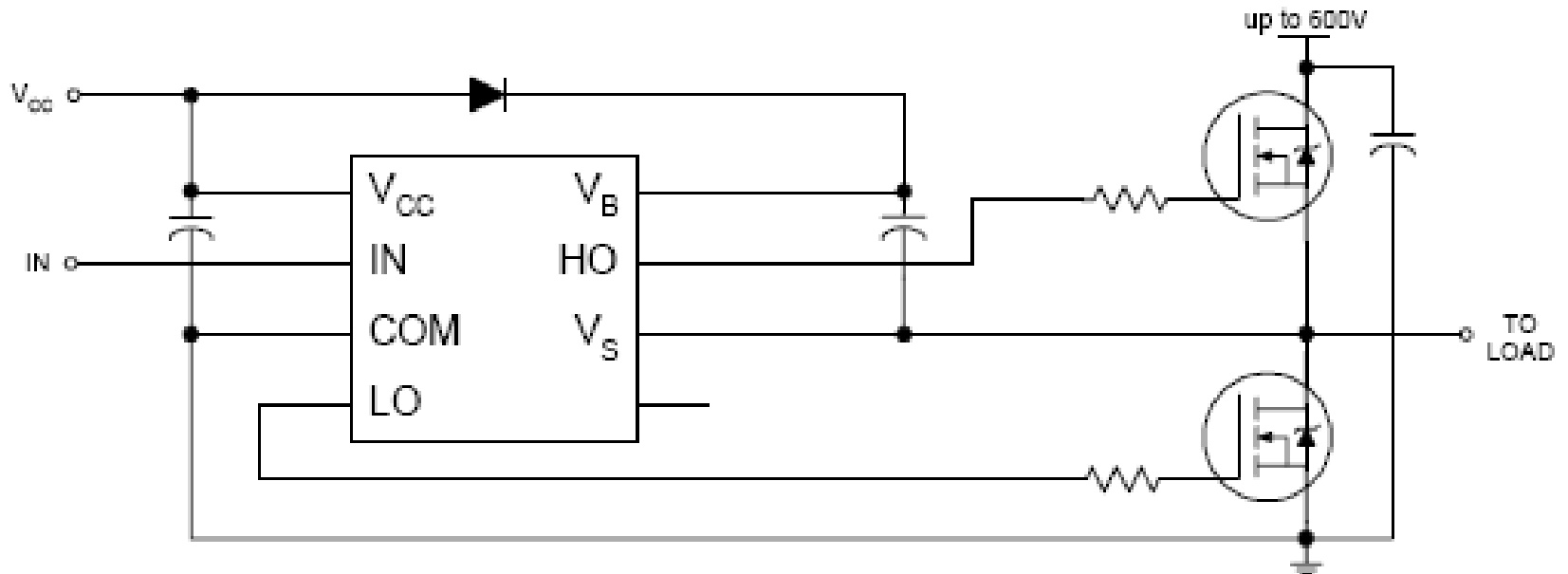


8-Lead SOIC



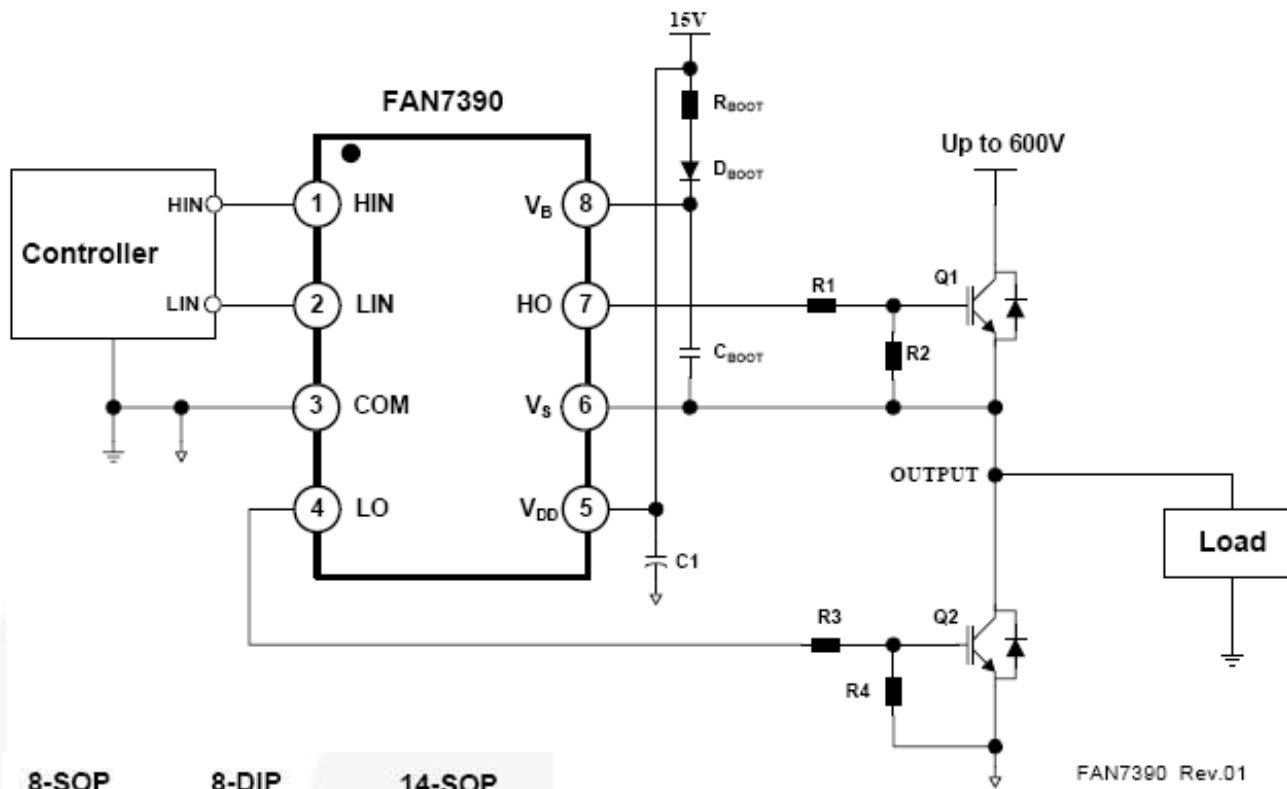
Bootstrap

IR2111(S) & (PbF) HALF-BRIDGE DRIVER



Bootstrap

FAN7390 High-Current, High & Low-Side, Gate-Drive IC



8-SOP



8-DIP



14-SOP

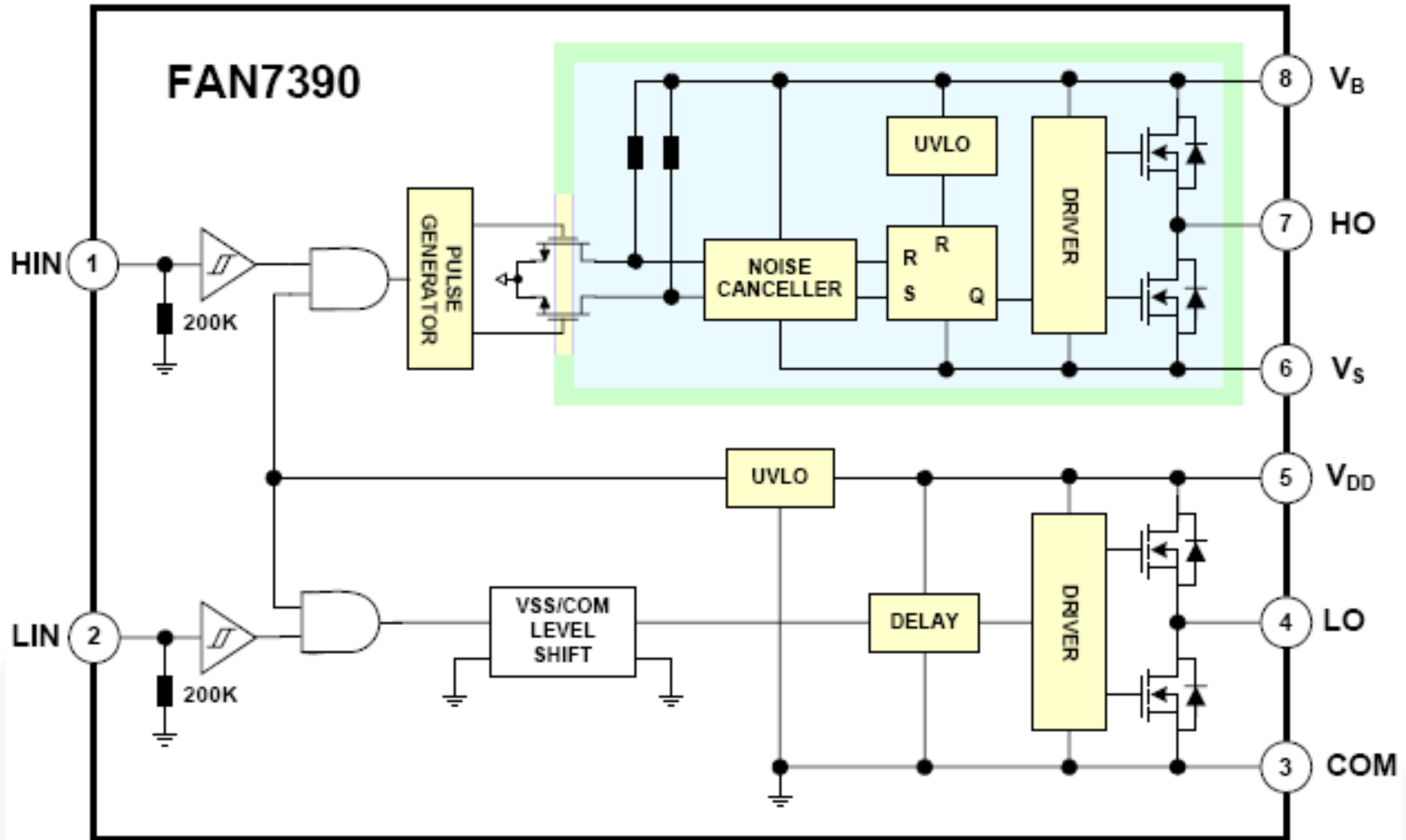


FAN7390 Rev.01



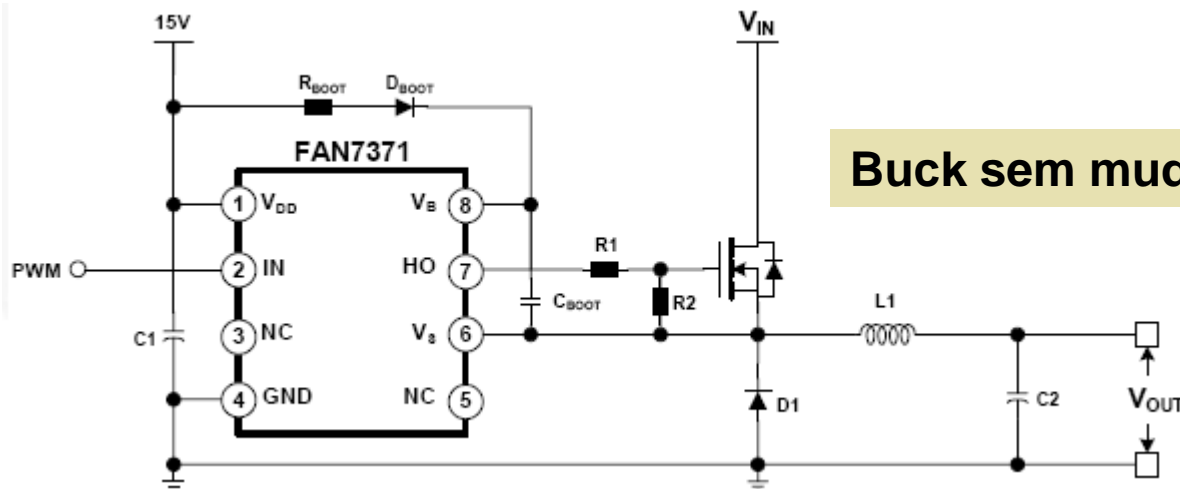
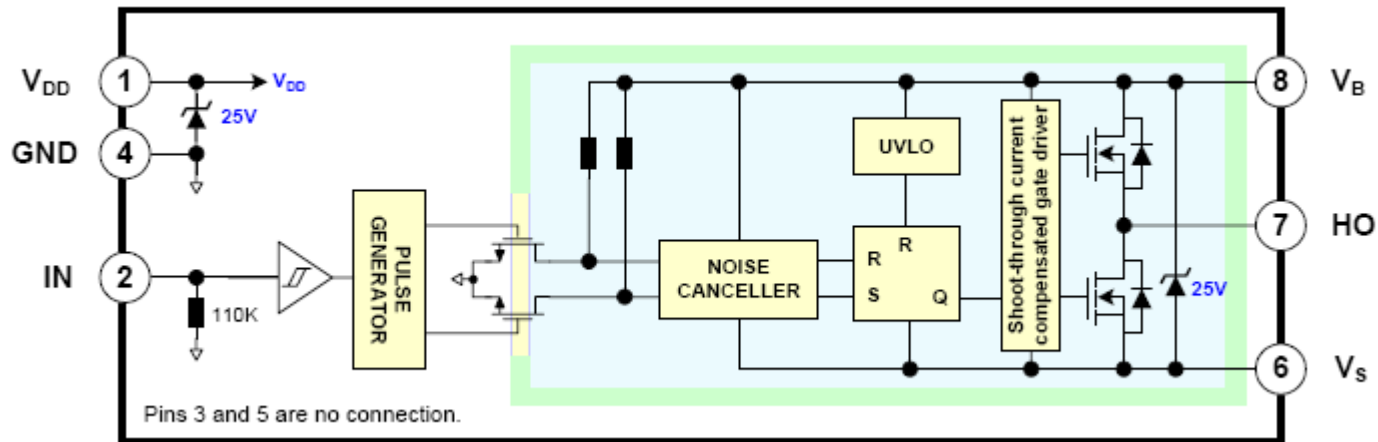
www.fairchildsemi.com

Bootstrap



Bootstrap

FAN7371 High-Current High-Side Gate Drive IC



Buck sem mudar chave de posição



Próxima aula

Capítulo 10: Inversores

1. Conversores CC-CA monofásicos.

