Smart High-Side Power Switch

Features

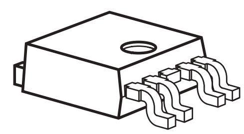
- Overload protection
- Current limitation
- Short circuit protection
- Thermal shutdown with restart
- Overvoltage protection
  (including load dump)
- Fast demagnetization of inductive loads
- Reverse battery protection
  with external resistor
- Open drain diagnostic output for overtemperature
  and short circuit
- Open load detection in OFF - State
  with external resistor
- CMOS compatible input
- Loss of GND and loss of V_{bb} protection
- ESD - Protection
- Very low standby current
- Green product (RoHS-compliant)

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	62	V
Operating voltage	$V_{bb(on)}$	6...52	V
On-state resistance	R_{ON}	200	mΩ
Nominal load current	$I_{L(ISO)}$	1.8	A

AEC Qualified

RoHS



PG-TO252-5-11

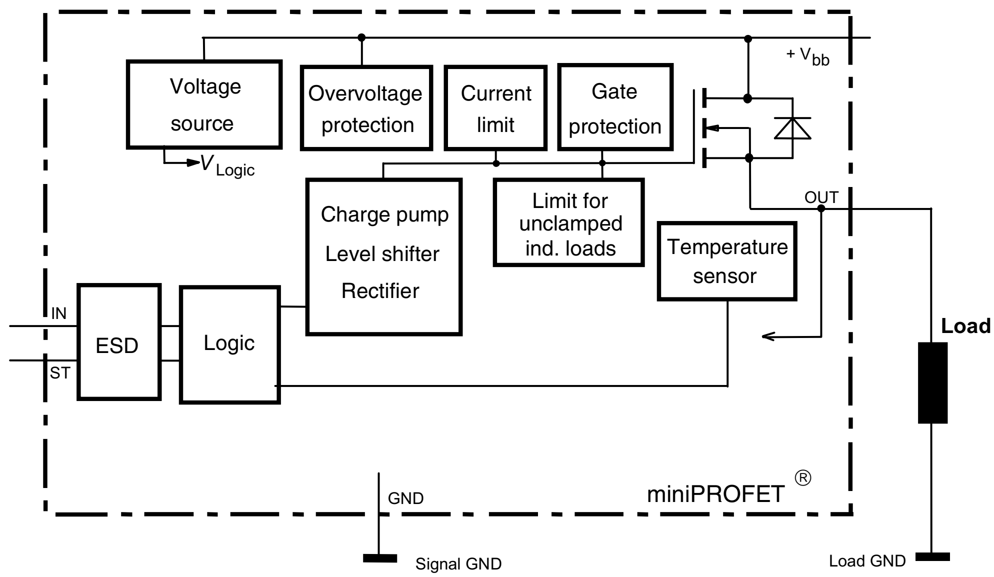
Application

- All types of resistive, inductive and capacitive loads
- µC compatible power switch for 12 V, 24 V and 42 V DC applications
- Replaces electromechanical relays and discrete circuits

General Description

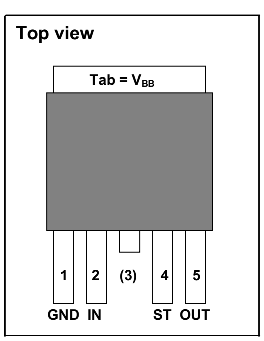
N channel vertical power FET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, monolithically integrated in Smart SIPMOS® technology.
Providing embedded protective functions.

Block Diagram



Pin	Symbol	Function
1	GND	Logic ground
2	IN	Input, activates the power switch in case of logic high signal
3	Vbb	Positive power supply voltage
4	ST	Diagnostic feedback
5	OUT	Output to the load
TAB	Vbb	Positive power supply voltage

Pin configuration



Maximum Ratings at T_j = 25°C, unless otherwise specified

Parameter	Symbol	Value	Unit
Supply voltage	V_{bb}	52	V
Supply voltage for full short circuit protection	$V_{bb(SC)}$	50	
Continuous input voltage	V_{IN}	-10 ... +16	
Load current (Short - circuit current, see page 5)	I_L	self limited	A
Current through input pin (DC)	I_{IN}	± 5	mA
Operating temperature	T_j	-40 ...+150	°C
Storage temperature	T_{stg}	-55 ... +150	
Power dissipation [1]	P_{tot}	41.6	W
Inductive load switch-off energy dissipation [1][2] single pulse, (see page 9) Tj =150 °C, I_L = 1 A	E_{AS}	150	mJ
Load dump protection [2] $V_{LoadDump}$ [3]= $V_A + V_S$ R_I=2Ω, t_d=400ms, V_{IN}= low or high, V_A=13.5V R_L = 13.5 Ω R_L = 27 Ω	$V_{Loaddump}$	 73.5 88.5	V
Electro**st**atic **d**ischarge voltage (Human Body Model) according to ANSI EOS/ESD - S5.1 - 1993 ESD STM5.1 - 1998 Input pin all other pins	V_{ESD}	 ± 1 ± 5	kV

Thermal Characteristics

junction - case:	R_{thJC}	-	-	3	K/W
Thermal resistance @ min. footprint	$R_{th(JA)}$	-	80	-	K/W
Thermal resistance @ 6 cm² cooling area [1]	$R_{th(JA)}$	-	45	60	

[1]Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for drain connection. PCB is vertical without blown air.

[2]not subject to production test, specified by design

[3]$V_{Loaddump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839 .
Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND pin, e.g. with a 150Ω resistor in GND connection. A resistor for the protection of the input is integrated.

Electrical Characteristics

Parameter and Conditions at T_j = -40...+150°C, V_{bb} = 12..42V, unless otherwise specified	Symbol	Values min.	typ.	max.	Unit
Load Switching Capabilities and Characteristics					
On-state resistance T_j = 25 °C, I_L = 1 A, V_{bb} = 9...52 V T_j = 150 °C	R_{ON}	 - -	 150 270	 200 380	mΩ
Nominal load current; Device on PCB [1)] T_C = 85 °C, V_{ON} = 0.5 V	$I_{L(ISO)}$	1.8	2.2	-	A
Turn-on time to 90% V_{OUT} R_L = 47 Ω	t_{on}	-	80	180	µs
Turn-off time to 10% V_{OUT} R_L = 47 Ω	t_{off}	-	80	200	
Slew rate on 10 to 30% V_{OUT}, R_L = 47 Ω, V_{bb} = 13.5 V	dV/dt_{on}	-	0.7	2	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 47 Ω, V_{bb} = 13.5 V	$-dV/dt_{off}$	-	0.9	2	

Operating Parameters

Operating voltage	$V_{bb(on)}$	6	-	52	V
Undervoltage shutdown of charge pump T_j = -40...+85 °C T_j = 150 °C	$V_{bb(under)}$	 - -	 - -	 4 5.5	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	4	5.5	
Standby current T_j = -40...+85 °C, V_{IN} = low T_j = +150 °C [2)], V_{IN} = low	$I_{bb(off)}$	 - -	 - -	 15 18	µA
Leakage output current (included in $I_{bb(off)}$) V_{IN} = low	$I_{L(off)}$	-	-	5	
Operating current V_{IN} = high	I_{GND}	-	0.8	2	mA

[1]Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm2 (one layer, 70µm thick) copper area for drain connection. PCB is vertical without blown air.

[2]higher current due temperature sensor

Electrical Characteristics

Parameter and Conditions at T_j = -40...+150°C, V_{bb} = 12..42V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
Protection Functions[1]					
Initial peak short circuit current limit (pin 3 to 5)	$I_{L(SCp)}$				A
T_j = -40 °C, V_{bb} = 20 V, t_m = 150 µs		-	-	9	
T_j = 25 °C		-	6.5	-	
T_j = 150 °C		4	-	-	
T_j = -40...+150 °C, V_{bb} > 40 V, (see page 12)		-	5[2]	-	
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$				
V_{bb} < 40V		-	6	-	
V_{bb} > 40V		-	4.5	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_{bb} = 4 mA	$V_{ON(CL)}$	59	63	-	V
Overvoltage protection [3] I_{bb} = 4 mA	$V_{bb(AZ)}$	62	-	-	
Thermal overload trip temperature	T_{jt}	150	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

Reverse Battery

Parameter and Conditions	Symbol	min.	typ.	max.	Unit
Reverse battery[4]	$-V_{bb}$	-	-	52	V
Drain-source diode voltage ($V_{OUT} > V_{bb}$) T_j = 150 °C	$-V_{ON}$	-	600	-	mV

[1] Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.

[2] not subject to production test, specified by design

[3] see also $V_{ON(CL)}$ in circuit diagram on page 8

[4] Requires a 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection is not active during reverse current operation! Input current has to be limited (see max. ratings page 3).

Electrical Characteristics

Parameter and Conditions at T_j = -40...+150°C, V_{bb} = 12..42V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
Input and Status feedback					
Input turn-on threshold voltage	$V_{IN(T+)}$	-	-	2.2	V
Input turn-off threshold voltage	$V_{IN(T-)}$	0.8	-	-	
Input threshold hysteresis	$\Delta V_{IN(T)}$	-	0.4	-	
Off state input current V_{IN} = 0.7 V	$I_{IN(off)}$	1	-	25	µA
On state input current V_{IN} = 5 V	$I_{IN(on)}$	3	-	25	
Status output (open drain), Zener limit voltage I_{ST} = 1.6 mA	$V_{ST(high)}$	5.4	6.1	-	V
Status output (open drain), ST low voltage T_j = -40...+25 °C, I_{ST} = 1.6 mA T_j = 150 °C, I_{ST} = 1.6 mA	$V_{ST(low)}$	 - -	 - -	 0.4 0.6	
Status invalid after positive input slope [1)] V_{bb} = 20 V	$t_{d(ST+)}$	-	120	160	µs
Status invalid after negative input slope [1)]	$t_{d(ST-)}$	-	250	400	
Input resistance (see page 8)	R_I	2	3.5	5	kΩ

Diagnostic Characteristics

Parameter and Conditions	Symbol	min.	typ.	max.	Unit
Short circuit detection voltage	$V_{OUT(SC)}$	-	2.8	-	V
Open load detection voltage[2)]	$V_{OUT(OL)}$	-	3	4	
Internal output pull down[3)] (see page 9 and 14) $V_{OUT(OL)}$ = 4 V	R_O	65	200	750	kΩ

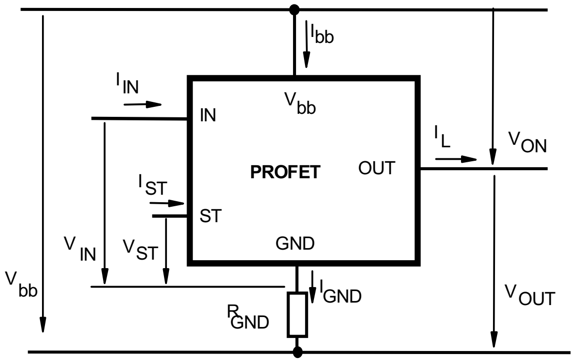
[1]no delay time after overtemperature switch off and short circuit in on-state
[2]External pull up resistor required for open load detection in off state.
[3]not subject to production test, specified by design

	Input level	Output level	Status
Normal operation	L H	L H	H H
Short circuit to GND	L H	L L *	H L
Short circuit to V_{bb} (in off-state)	L H	H H	L H
Overload	L H	L H **	H H
Overtemperature	L H	L L	H L
Open Load in off-state	L H	Z H	H (L[1]) H

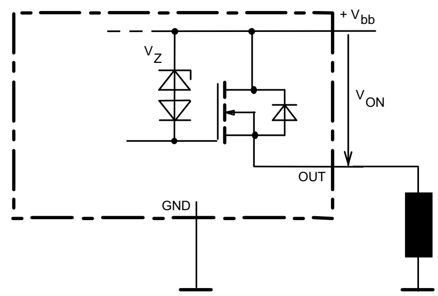
*) Out ="L": V_{OUT} < 2.8V typ.
**) Out ="H": V_{OUT} > 2.8V typ.
Z = high impedance, potential depends on external circuit

[1] with external resistor between V_{bb} and OUT

Terms

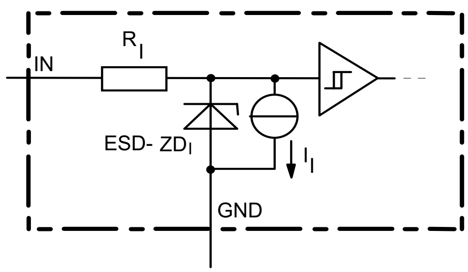


Inductive and overvoltage output clamp



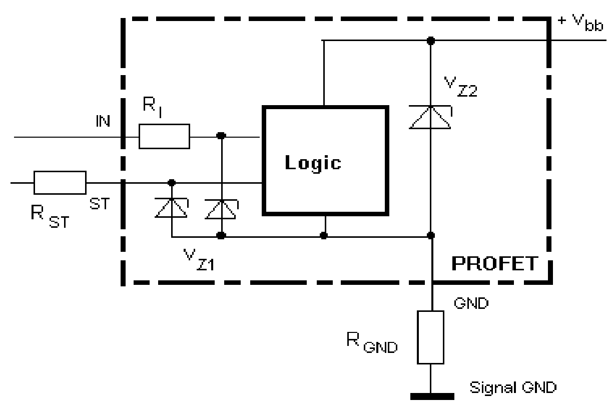
V_{ON} clamped to 59V min.

Input circuit (ESD protection)



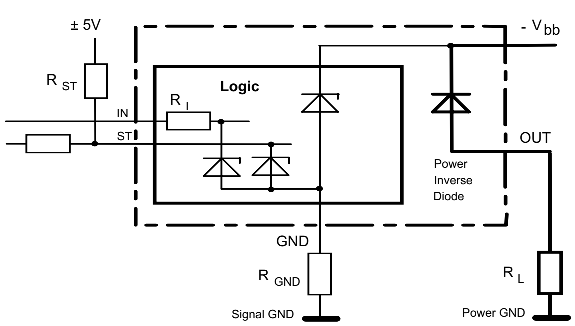
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



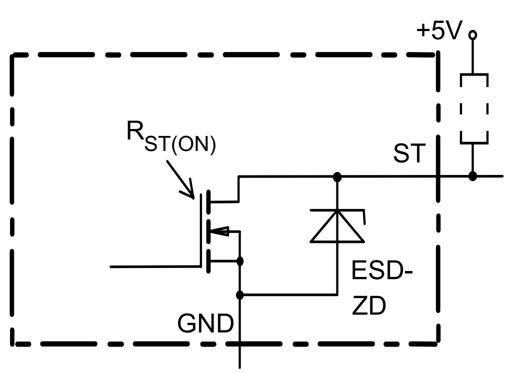
V_{Z1}=6.1V typ., V_{Z2}=$V_{bb(AZ)}$=62V min.,
R_I=3.5 kΩ typ., R_{GND}=150Ω

Reverse battery protection



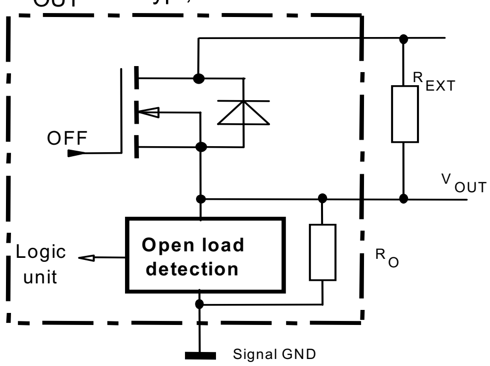
R_{GND}=150Ω, R_I=3.5kΩ typ.,
Temperature protection is not active during inverse current

Status output

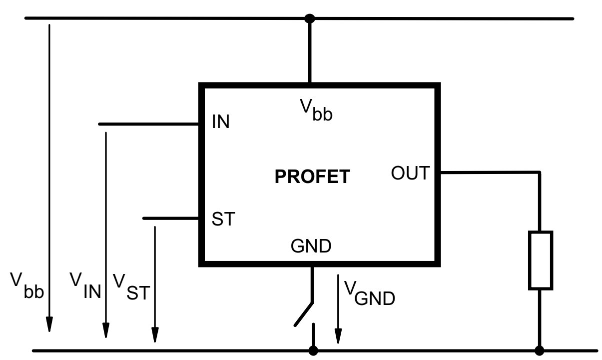


Open-load detection

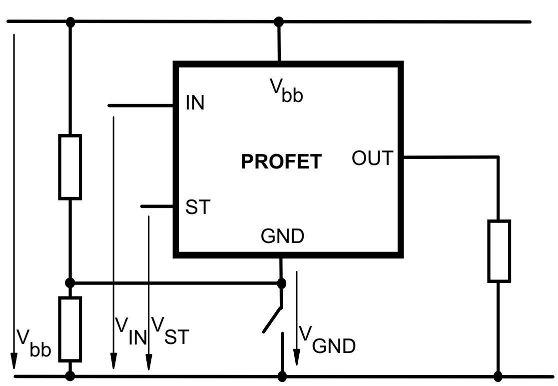
OFF-state diagnostic condition:
V_{OUT} > 3V typ.; IN=low



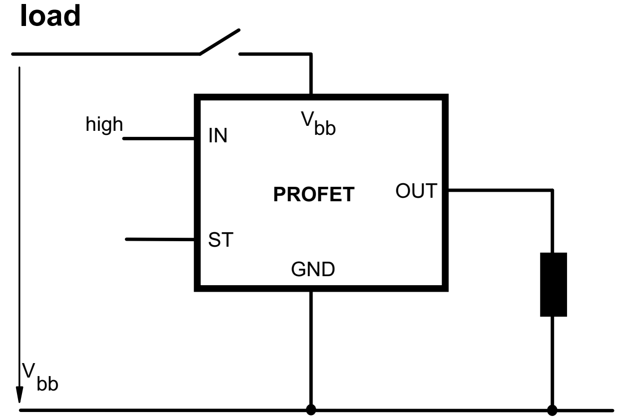
GND disconnect



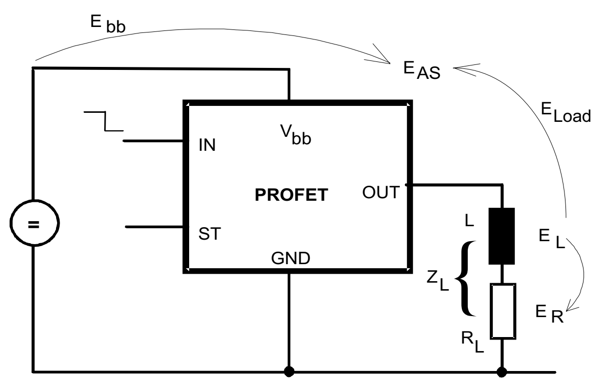
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation



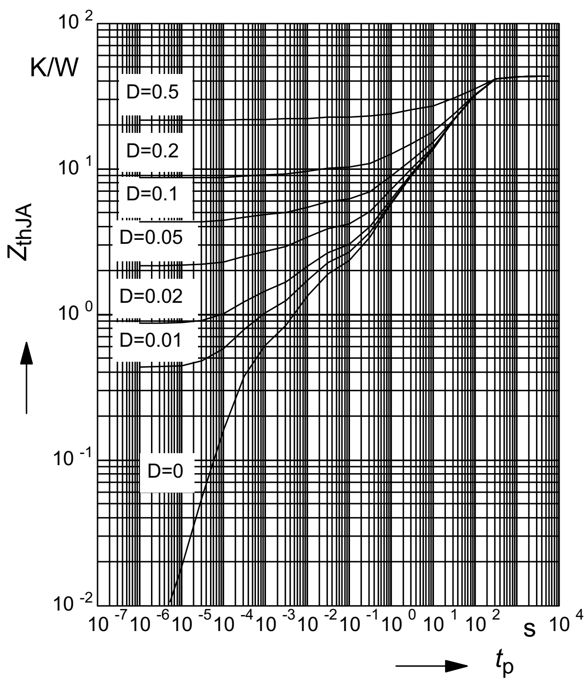
Energy stored in load inductance: $E_L = ½ * L * I_L^2$
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t)\, dt$,
with an approximate solution for $R_L > 0\Omega$:

$$E_{AS} = \frac{I_L * L}{2 * R_L} * (V_{bb} + |V_{OUT(CL)}|) * \ln\left(1 + \frac{I_L * R_L}{|V_{OUT(CL)}|}\right)$$

Typ. transient thermal impedance

Z_{thJA}=f(t_p) @ 6cm² heatsink area

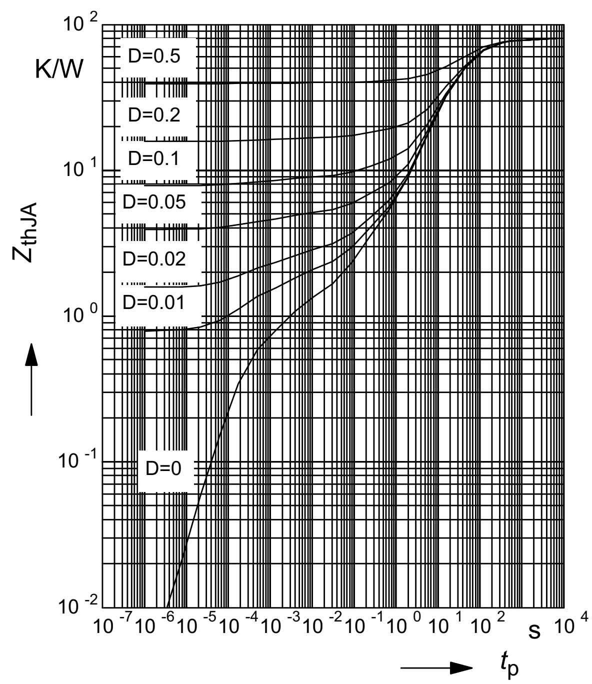
Parameter: $D=t_p/T$



Typ. transient thermal impedance

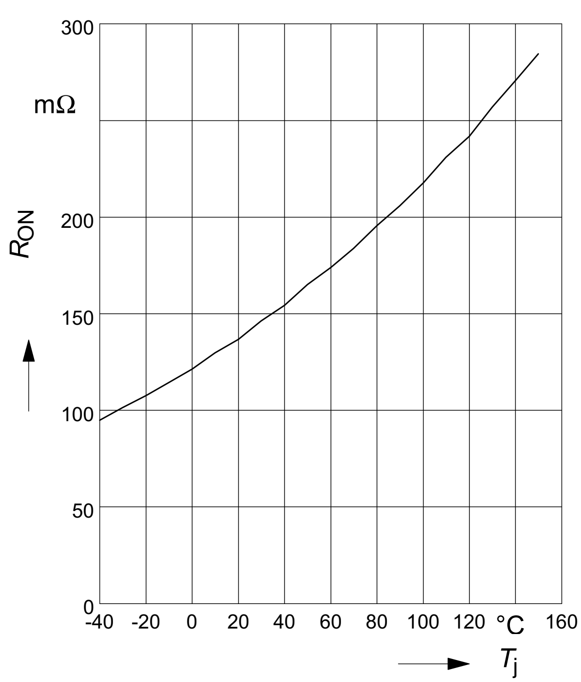
Z_{thJA}=f(t_p) @ min. footprint

Parameter: $D=t_p/T$



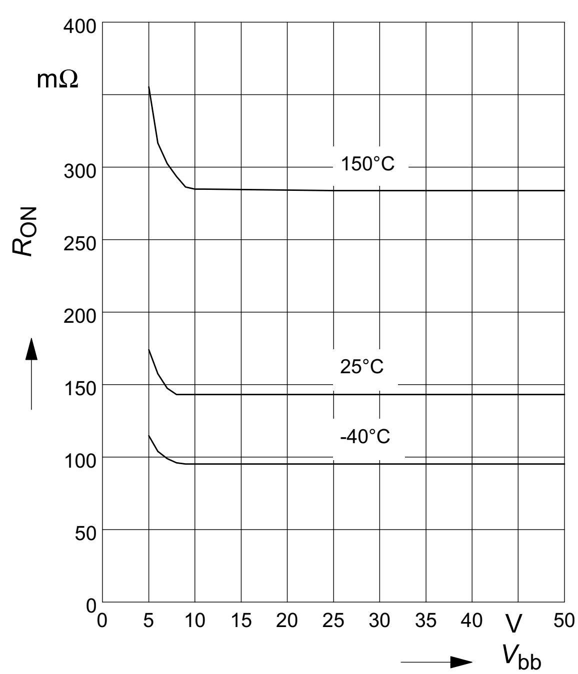
Typ. on-state resistance

R_{ON} = f(T_j) ; V_{bb} = 13.5V ; V_{in} = high



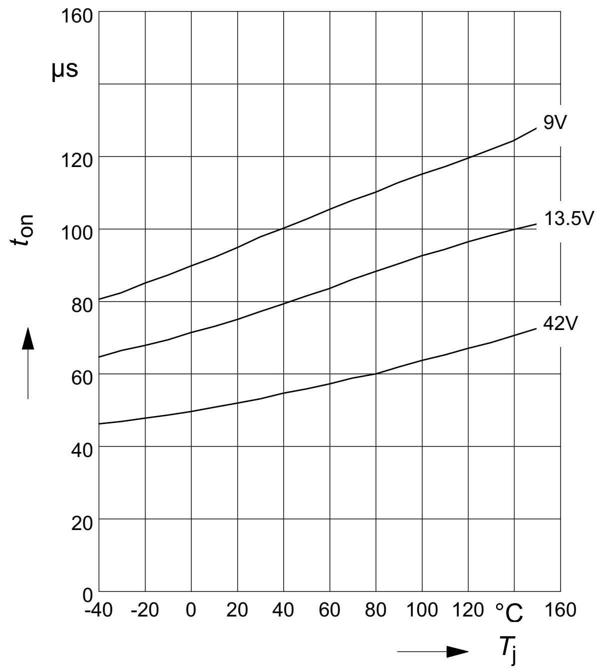
Typ. on-state resistance

R_{ON} = f(V_{bb}); I_L = 1 A ; V_{in} = high



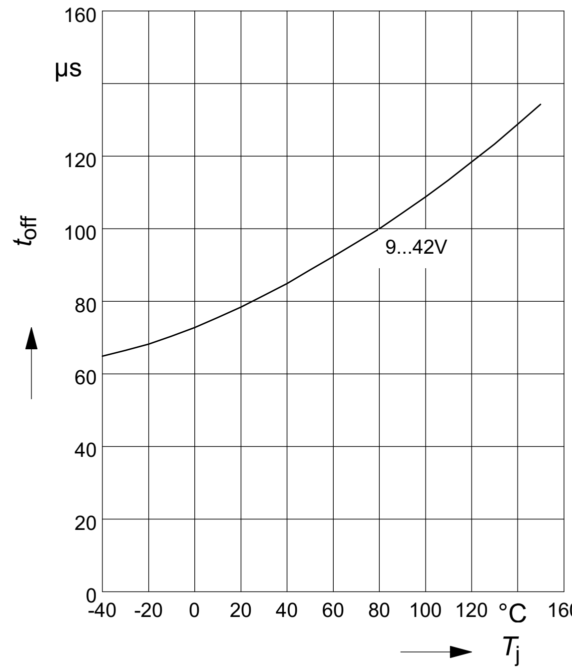
Typ. turn on time

t_{on} = f(T_j); R_L = 47Ω



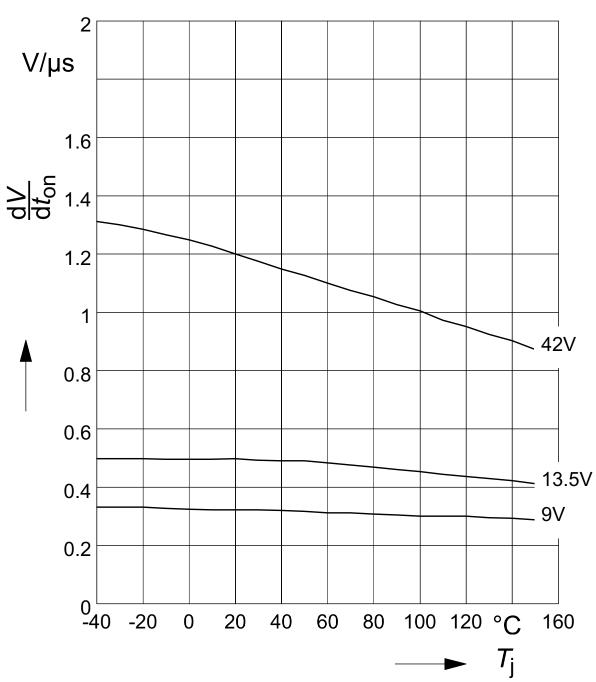
Typ. turn off time

t_{off} = f(T_j); R_L = 47Ω



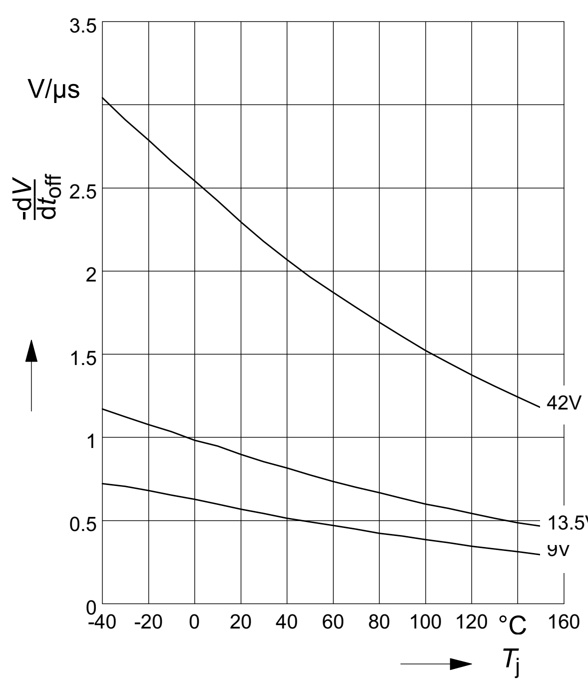
Typ. slew rate on

dV/dt_{on} = f(T_j) ; R_L = 47 Ω



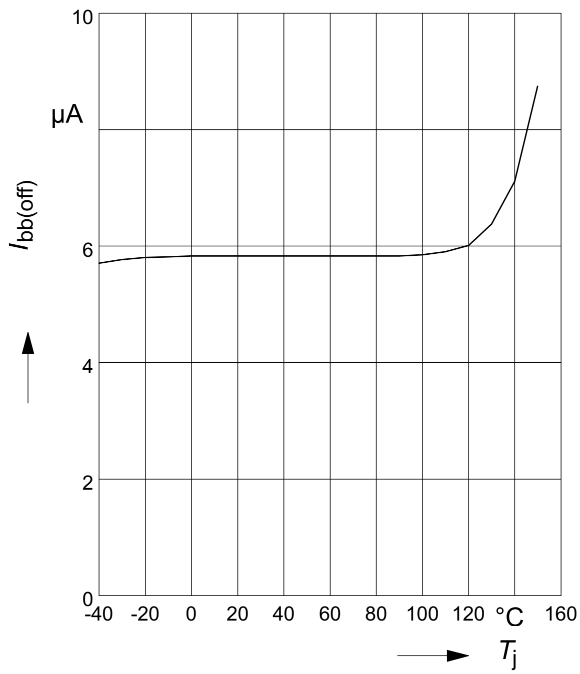
Typ. slew rate off

dV/dt_{off} = f(T_j); R_L = 47 Ω



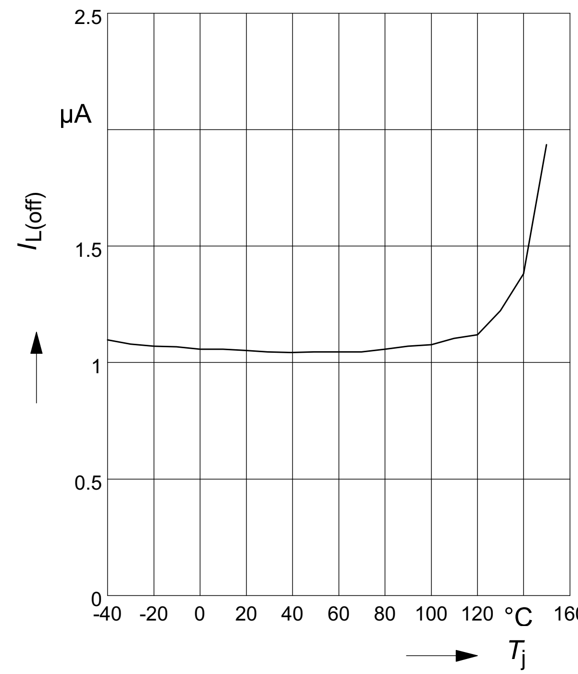
Typ. standby current

$I_{bb(off)} = f(T_j)$; V_{bb} = 42V ; V_{IN} = low



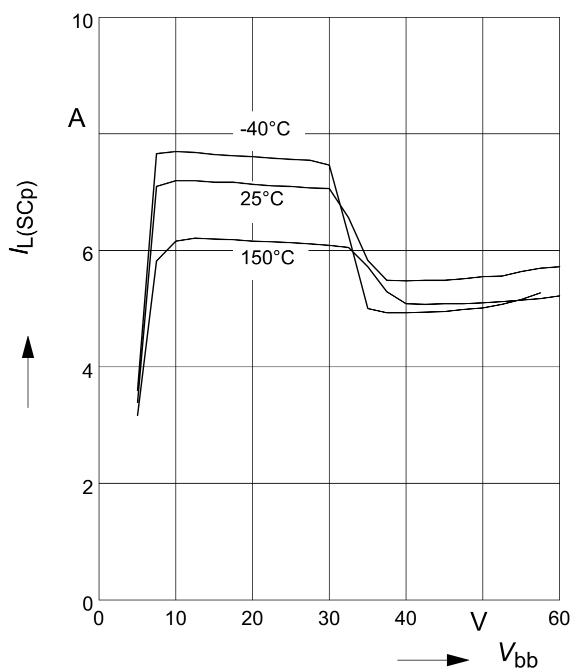
Typ. leakage current

$I_{L(off)} = f(T_j)$; V_{bb} = 42V ; V_{IN} = low



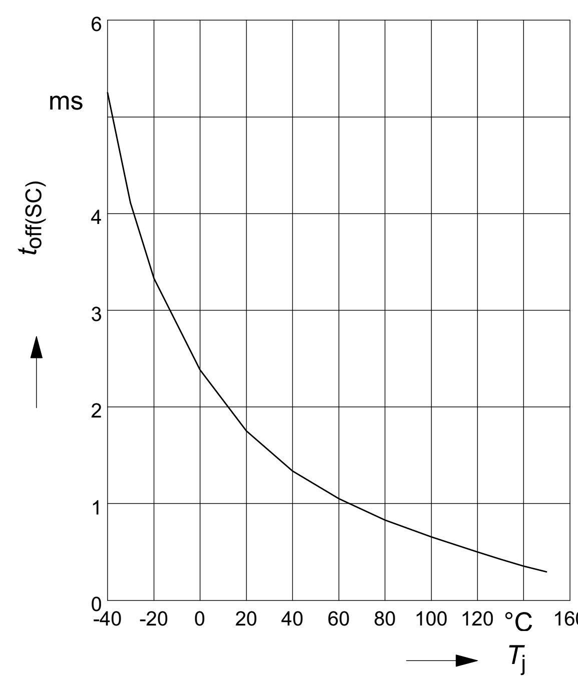
Typ. initial peak short circuit current limit

$I_{L(SCp)} = f(V_{bb})$



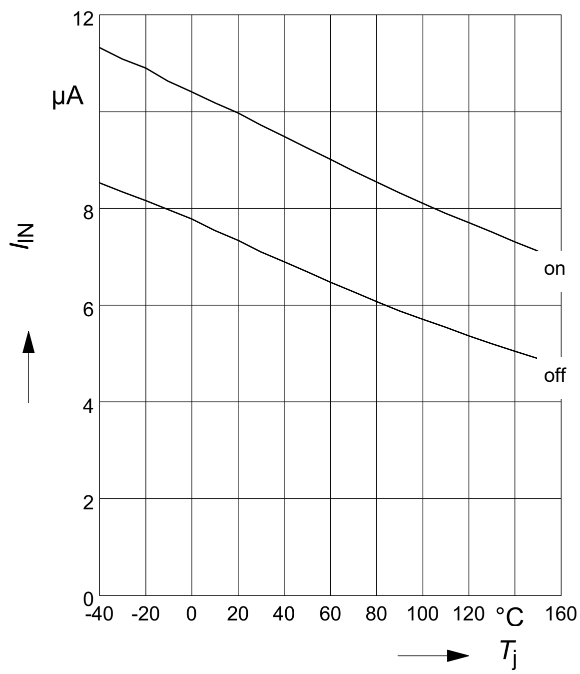
Typ. initial short circuit shutdown time

$t_{off(SC)} = f(T_{j,start})$; V_{bb} = 20V



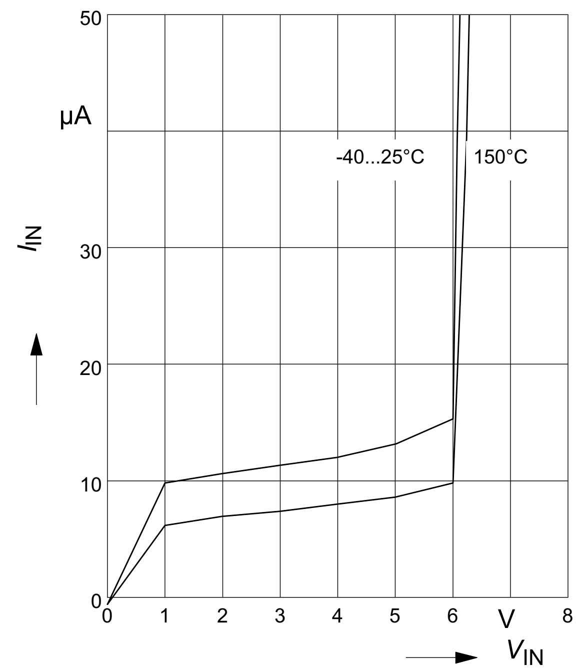
Typ. input current

$I_{IN(on/off)} = f(T_j)$; V_{bb} = 13.5V; V_{IN} = low/high
$V_{INlow} \leq 0.7V$; V_{INhigh} = 5V



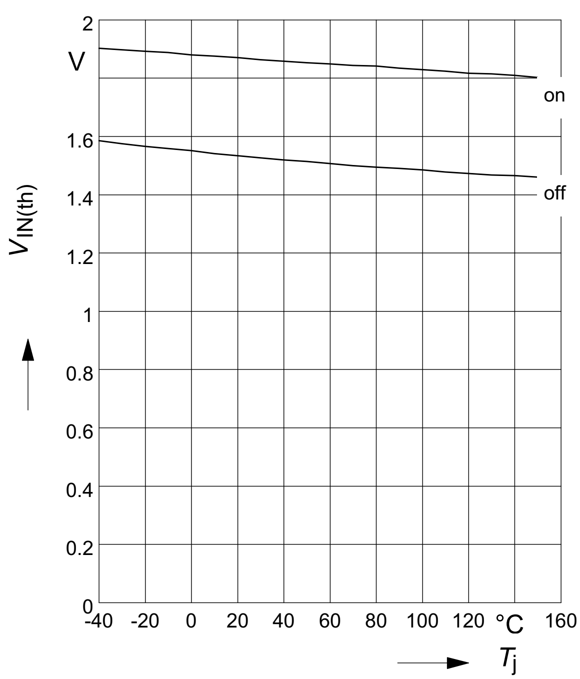
Typ. input current

$I_{IN} = f(V_{IN})$; V_{bb} = 13.5V



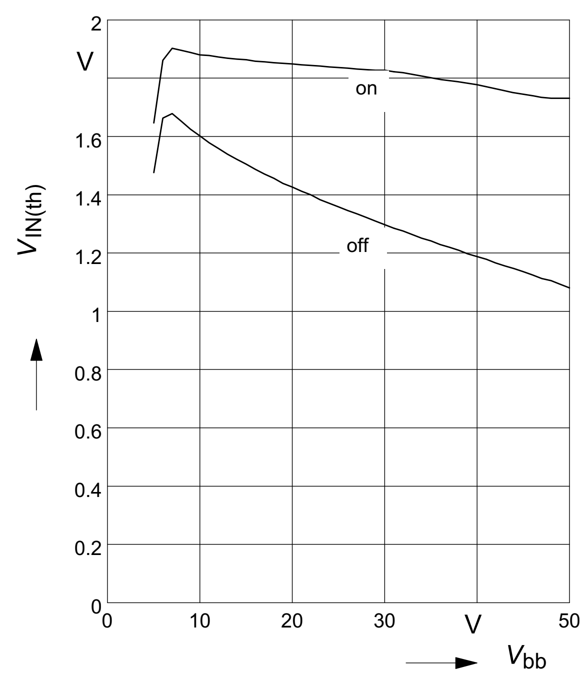
Typ. input threshold voltage

$V_{IN(th)} = f(T_j)$; V_{bb} = 13.5V



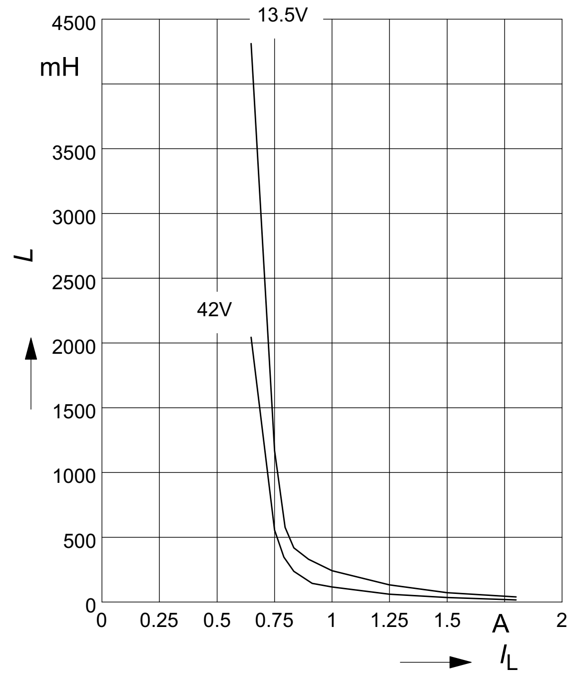
Typ. input threshold voltage

$V_{IN(th)} = f(V_{bb})$; T_j = 25°C



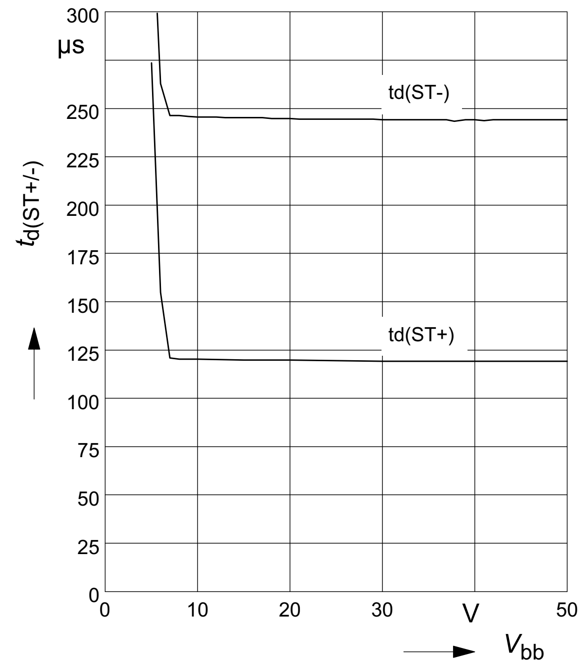
Maximum allowable load inductance for a single switch off

L **= f(*I*$_L$)**; T_{jstart}=150°C, R_L=0Ω



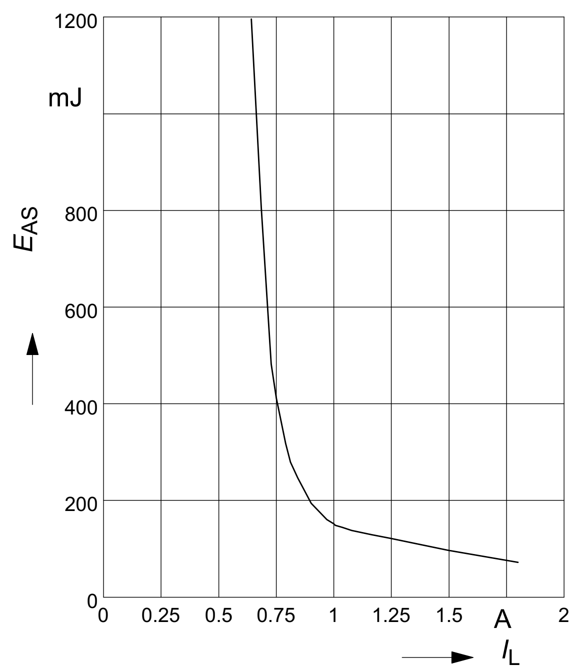
Typ. status delay time

$t_{d(ST+/-)}$ **= f(*V*$_{bb}$)**; T_j = 25°C



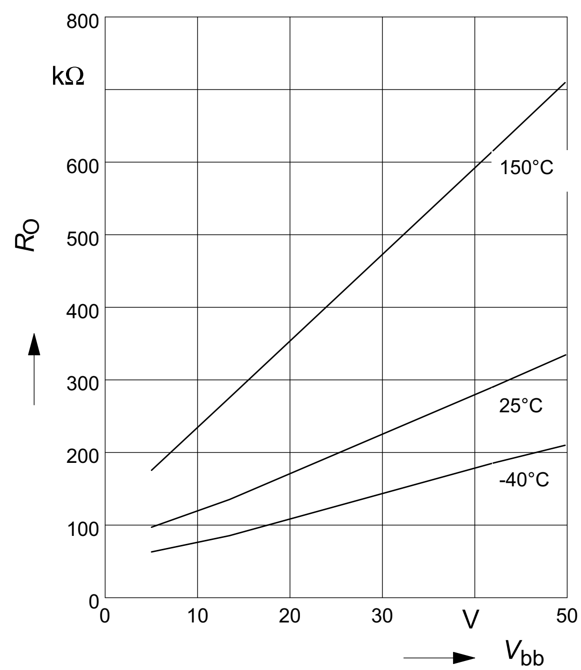
Maximum allowable inductive switch-off energy, single pulse

E_{AS} **= f(*I*$_L$)**; T_{jstart} = 150°C, V_{bb} = 13.5V



Typ. internal output pull down

R_O **= f(*V*$_{bb}$)**



Timing diagrams

Figure 1a: Vbb turn on:

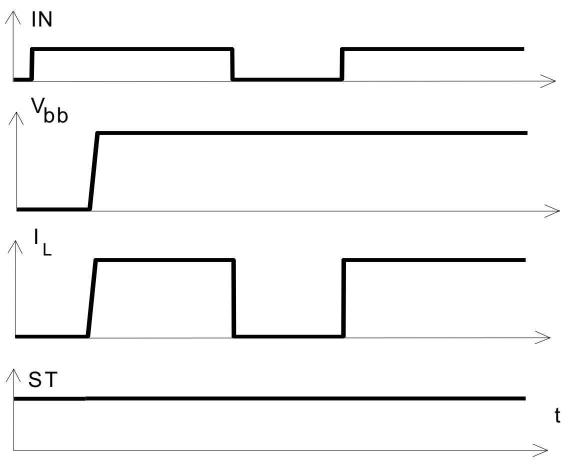


Figure 2b: Switching a lamp,

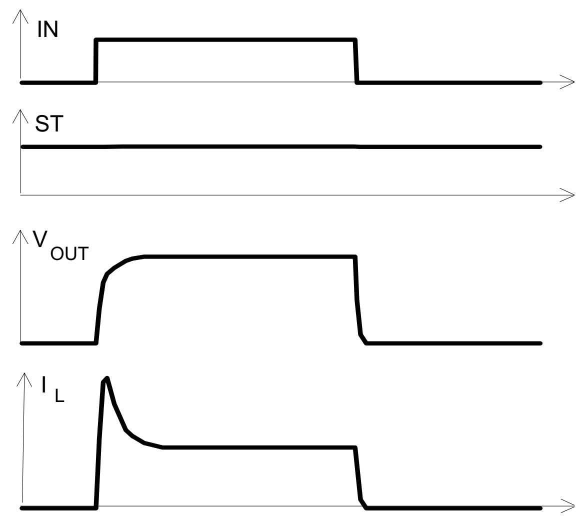


Figure 2a: Switching a resistive load,
turn-on/off time and slew rate definition

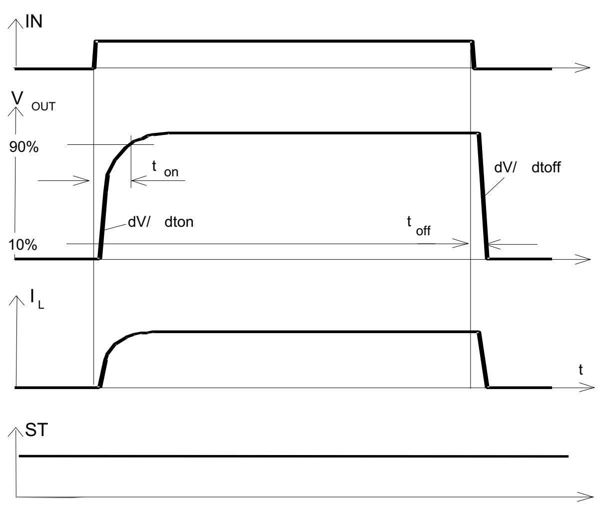


Figure 2c: Switching an inductive load

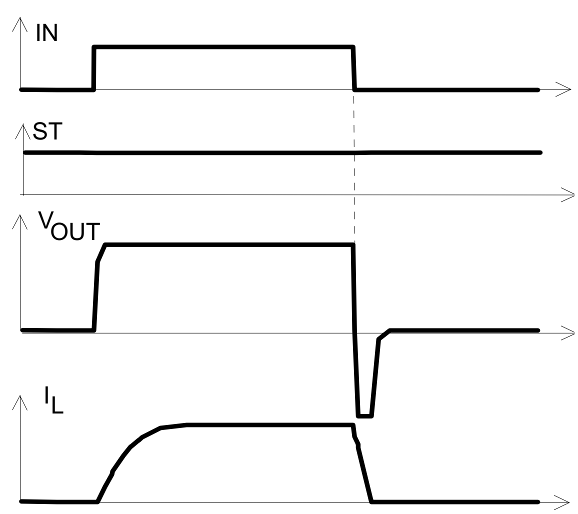
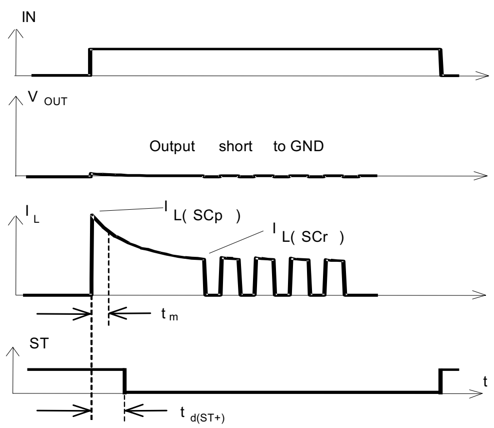


Figure 3a: Turn on into short circuit, shut down by overtemperature, restart by cooling



Heating up of the chip may require several milliseconds, depending on external conditions.

Figure 4: Overtemperature:
Reset if $T_j < T_{jt}$

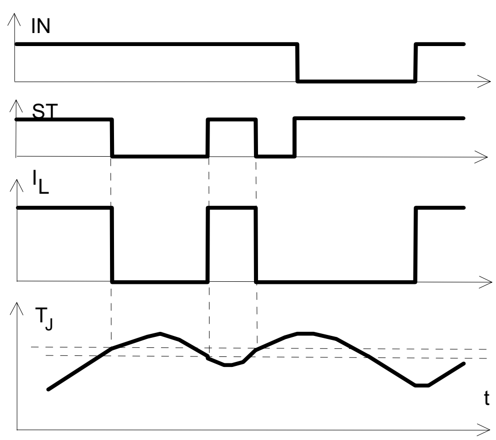


Figure 3b: Short circuit in on-state shut down by overtemperature, restart by cooling

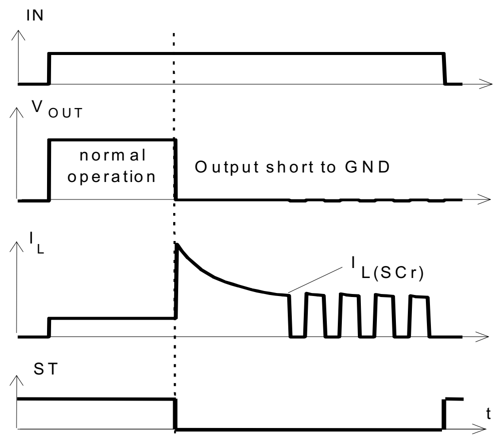


Figure 5: Undervoltage restart of charge pump

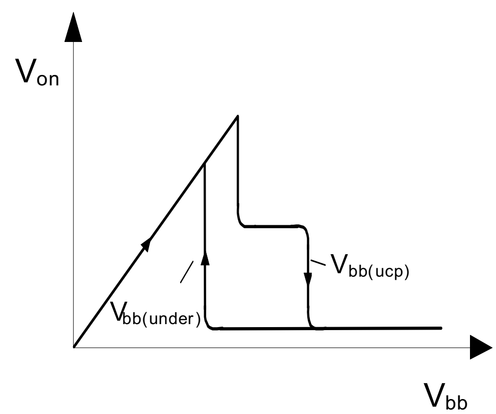
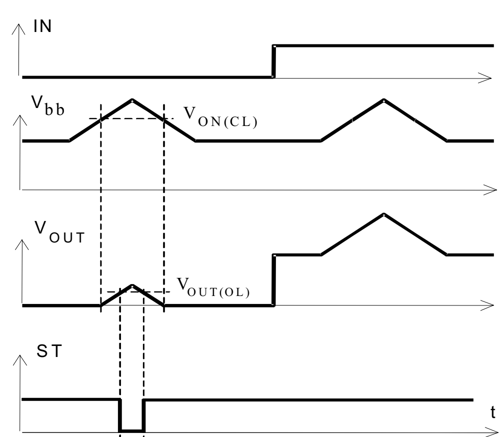
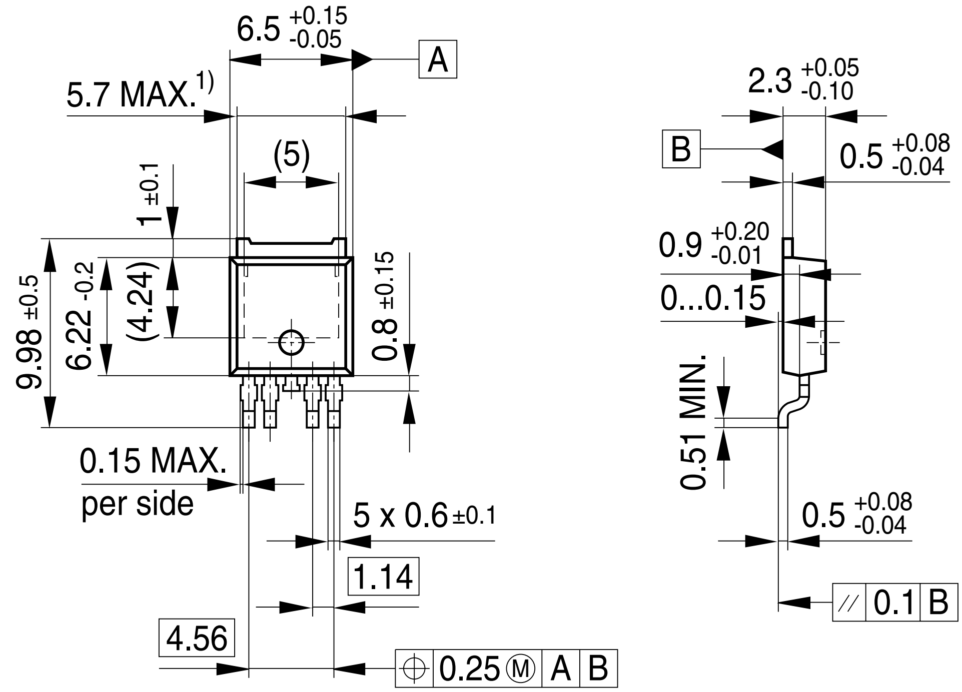


Figure 7: Overvoltage



Package Outlines



1) Includes mold flashes on each side.
All metal surfaces tin plated, except area of cut.

Figure 1 **PG-TO252-5-11** (Plastic Dual Small Outline Package) (RoHS-compliant)

Green Product

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Please specify the package needed (e.g. green package) when placing an order.

You can find all of our packages, sorts of packing and others in our Infineon Internet Page "Products": **http://www.infineon.com/products**.

Dimensions in mm

Revision History

Version	Date	Changes
V1.0	2004-01-27	initial version
V1.1	2007-01-15	AEC icon added RoHS icon added Green product (RoHS-compliant) added to the feature list Package information updated to green Green explanation added

Edition 2007-01-15

Published by
Infineon Technologies AG
81726 Munich, Germany

Legal Disclaimer

The information given in this document shall in no event be regarded as a guarantee of conditions or characteristics ("Beschaffenheitsgarantie"). With respect to any examples or hints given herein, any typical values stated herein and/or any information regarding the application of the device, Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind, including without limitation warranties of non-infringement of intellectual property rights of any third party.

Information

For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office (**www.infineon.com**).

Warnings

Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office.

Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.