

# ISP772T

## Smart power high-side-switch for industrial applications



### Features

- Overload protection
- Current limitation
- Short circuit protection
- Thermal shutdown with restart
- ESD-protection
- Overvoltage protection (including load dump)
- Fast demagnetization of inductive loads
- Reverse battery protection with external resistor
- CMOS compatible input
- Loss of GND and loss of  $V_{bb}$  protection
- Very low standby current
- Green product (RoHS compliant)



### Potential applications

- All types of resistive, inductive and capacitive loads
- $\mu$ C compatible power switch for 12 V and 24 V DC industrial applications
- Replaces electromechanical relays and discrete circuits

### Product validation

Qualified for industrial applications according to the relevant tests of JEDEC JESD47/20/22.

### Description

**Table 1** Product summary

Parameter	Symbol	Value	Unit
Overvoltage protection	$V_{bb(AZ)}$	41	V
Operating voltage	$V_{bb(on)}$	5 to 34	V
On-state resistance	$R_{ON}$	60	m $\Omega$
Nominal load current	$I_{L(nom)}$	2.6	A
Operating temperature	$T_a$	-30 to +85	$^{\circ}$ C

N channel vertical power FET with charge pump, ground referenced CMOS compatible input, monolithically integrated with embedded protective functions.

**ISP772T**  
**Smart power high-side-switch for industrial applications**



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**Description**

<b>Type</b>	<b>Package</b>	<b>Marking</b>
ISP772T	PG-DSO-8	I772T

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Block diagram

1 Block diagram

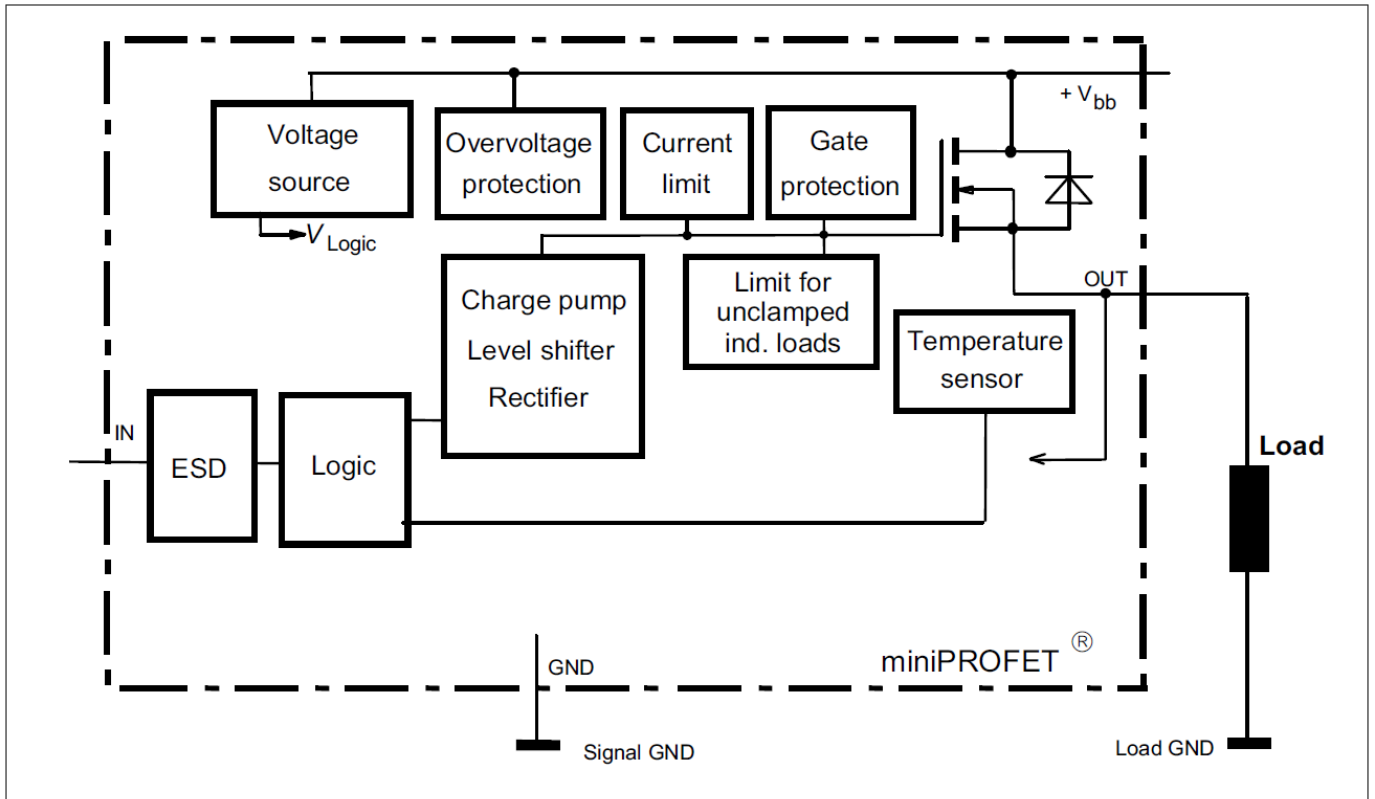
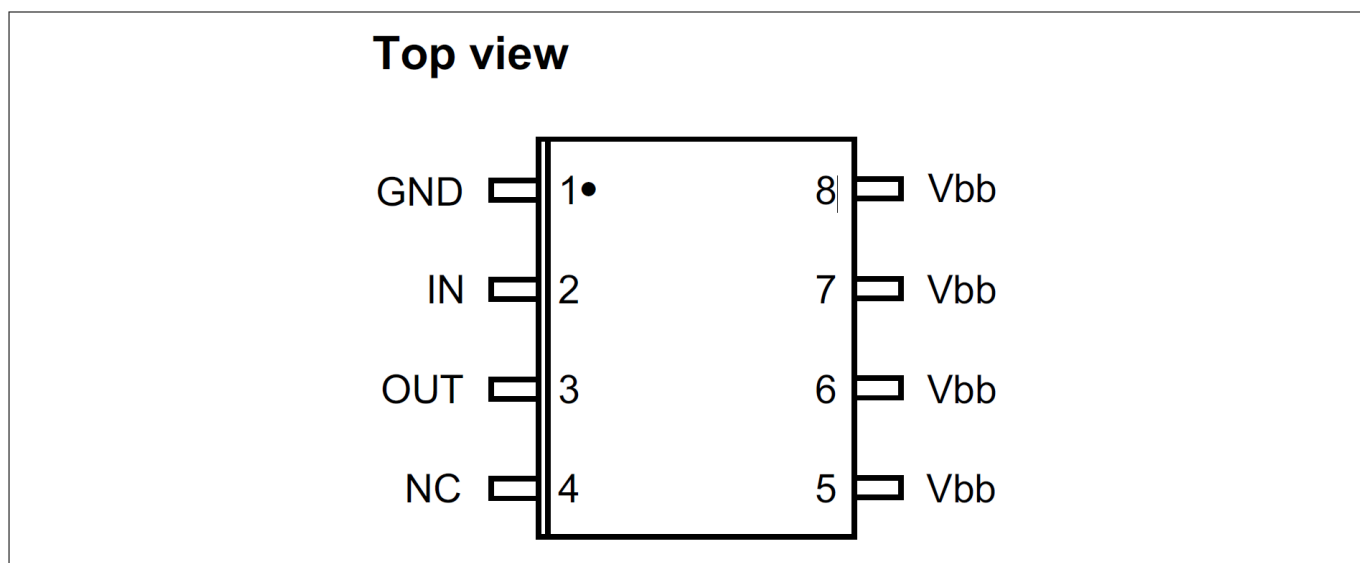


Figure 1 Block diagram

Pin configuration

## 2 Pin configuration



**Figure 2** Pin configuration

Pin	Symbol	Function
1	GND	Logic ground
2	IN	Input, activates the power switch in case of logic high signal
3	OUT	Output to the load
4	NC	not connected
5	Vbb	Positive power supply voltage
6	Vbb	Positive power supply voltage
7	Vbb	Positive power supply voltage
8	Vbb	Positive power supply voltage

General product characteristics

### 3 General product characteristics

#### 3.1 Absolute maximum ratings

**Table 2** Maximum ratings

$T_j = 25^\circ\text{C}$ , unless otherwise specified

Parameter	Symbol	Value	Unit	Note or condition
Supply voltage	$V_{bb}$	40	V	–
Supply voltage for full short circuit protection	$V_{bb(SC)}$	36	V	$T_j = -40^\circ\text{C}$ to $+150^\circ\text{C}$
Continuous input voltage	$V_{IN}$	-10 to +16	V	–
Load current	$I_L$	self limited	A	(short-circuit current, see p. 10)
Current through input pin (DC)	$I_{IN}$	$\pm 5$	mA	–
Junction temperature	$T_j$	150	$^\circ\text{C}$	–
Operating temperature	$T_a$	-30 to +85	$^\circ\text{C}$	–
Storage temperature	$T_{stg}$	-40 to +105	$^\circ\text{C}$	–
Power dissipation	$P_{tot}$	1.5	W	1)
Inductive load switch-off energy dissipation	$E_{AS}$	900	mJ	1) 2) single pulse, $T_j = 150^\circ\text{C}$ , $V_{bb} = 13.5\text{ V}$ , $I_L = 1.5\text{ A}$ (see page 9)
Load dump protection $R_L = 9\ \Omega$	$V_{LoadDump}$	63	V	2) 3) $V_{LoadDump} = V_A + V_S$ $R_l = 2\ \Omega$ , $t_d = 400\text{ ms}$ , $V_{IN} = \text{low or high}$ , $V_A = 13.5\text{ V}$
Electrostatic Discharge Voltage (Human Body Model) OUT IN all other pins	$V_{ESD}$	$\pm 6$ $\pm 1$ $\pm 4$	kV	according to ANSI/ESDA/JEDEC JS001 (1.5 k $\Omega$ , 100 pF)

1 Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70  $\mu\text{m}$  thick) copper area for drain connection. PCB is vertical without blown air. (see page 19)

2 Not subject to production test, specified by design

3  $V_{LoadDump}$  is set up 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 150  $\Omega$  resistor in GND connection. A resistor for the protection of the input is integrated.

**General product characteristics**

**3.2 Thermal resistance**

**Table 3 Thermal resistance**

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Thermal resistance minimum footprint 6 cm <sup>2</sup> cooling area <sup>4)</sup>	R <sub>th(JA)</sub>	–	95	–	K/W	–
		–	70	83		

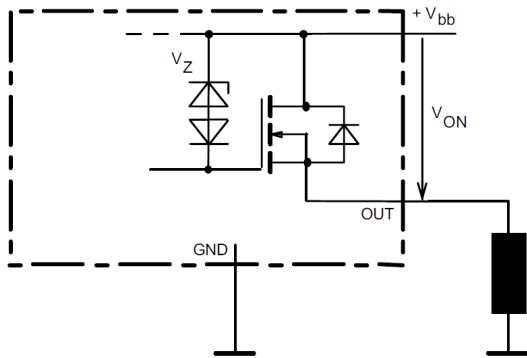
<sup>4</sup> Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air. (see page [19](#))

Functional description and electrical characteristics

## 4 Functional description and electrical characteristics

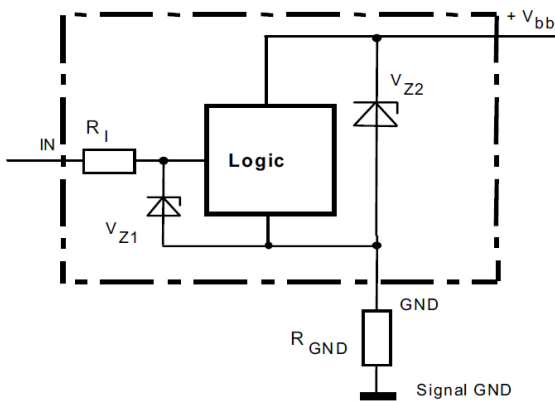
### 4.1 Functional description

#### Inductive and overvoltage output clamp



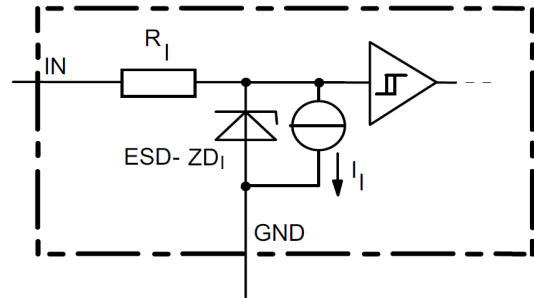
$V_{ON}$  clamped to 47 V typ.

#### Overvoltage protection of logic part



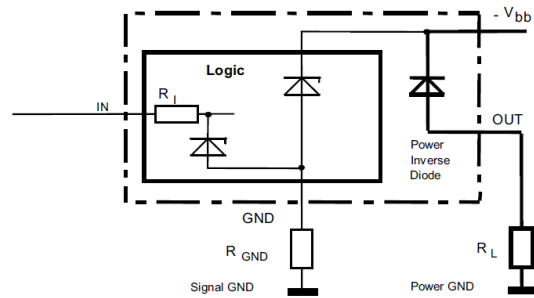
$V_{Z1} = 6.1 \text{ V typ.}$ ,  $V_{Z2} = V_{bb(AZ)} = 47 \text{ V typ.}$ ,  $R_1 = 3.5 \text{ k}\Omega \text{ typ.}$ ,  $R_{GND} = 150 \Omega$

#### Input circuit (ESD protection)



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

#### Reverse battery protection

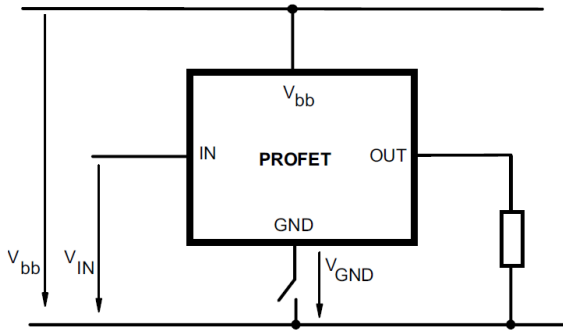


$R_{GND} = 150 \Omega$ ,  $R_1 = 3.5 \text{ k}\Omega \text{ typ.}$ , temperature protection is not active during inverse current

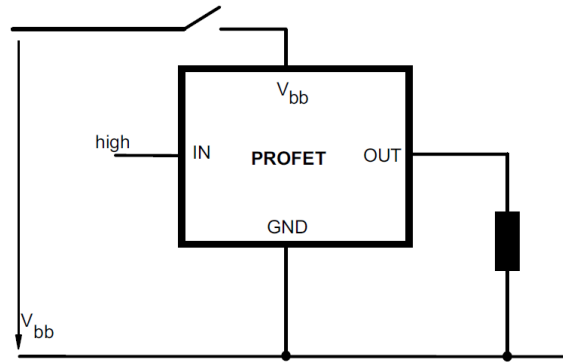


**Functional description and electrical characteristics**

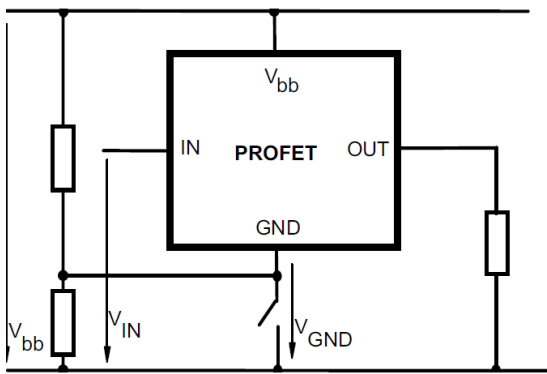
**GND disconnect**



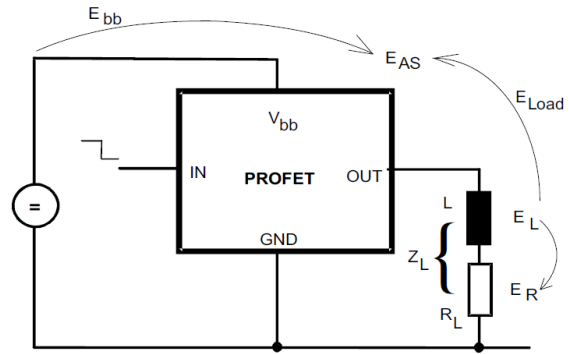
**V<sub>bb</sub> disconnect with charged inductive load**



**GND disconnect with GND pull up**



**Inductive load switch-off energy dissipation**



Energy stored in load inductance:

$$E_L = 1/2 \times L \times I_L^2$$

While demagnetizing load inductance, the energy dissipated in PROFET is

$$E_{AS} = E_{bb} + E_L - E_R = V_{ON(CL)} \times I_L(t) dt$$

with an approximate solution for  $R_L > 0 \Omega$ :

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

Functional description and electrical characteristics

4.2 Electrical characteristics

**Table 4** Electrical characteristics

$T_j = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ,  $V_{bb} = 13.5\text{ V}$ , unless otherwise specified

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
<b>Load switching capabilities and characteristics</b>						
On-state resistance $T_j = 25^\circ\text{C}$ , $I_L = 2\text{ A}$ , $V_{bb} = 9\text{ V}$ to $40\text{ V}$ $T_j = 150^\circ\text{C}$	$R_{ON}$	–	50 95	60 120	mΩ	–
Nominal load current; Device on PCB	$I_{L(nom)}$	2.6	3.1	–	A	<sup>5)</sup> $T_C = 85^\circ\text{C}$ , $T_j \leq 150^\circ\text{C}$
Turn-on time to 90% $V_{OUT}$	$t_{on}$	–	90	180	μs	$R_L = 47\ \Omega$
Turn-off time to 10% $V_{OUT}$	$t_{off}$	–	110	230	μs	$R_L = 47\ \Omega$
Slew rate on 10% to 30% $V_{OUT}$	$dV/dt_{on}$	–	0.7	1.5	V/μs	$R_L = 47\ \Omega$
Slew rate off 70% to 40% $V_{OUT}$	$-dV/dt_{off}$	–	0.7	1.5	V/μs	$R_L = 47\ \Omega$
<b>Operating parameters</b>						
Operating voltage	$V_{bb(on)}$	5	–	34	V	–
Undervoltage shutdown of charge pump $T_j = -40^\circ\text{C}$ to $+85^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$V_{bb(under)}$	–	–	4 5.5	V	–
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	–	4	5.5	V	–
Standby current $T_j = -40^\circ\text{C}$ to $+85^\circ\text{C}$ , $V_{IN} = 0\text{ V}$ $T_j = 150^\circ\text{C}$ <sup>6)</sup> , $V_{IN} = 0\text{ V}$	$I_{bb(off)}$	–	–	10 15	μA	–
Leakage output current	$I_{L(off)}$	–	–	5	μA	included in $I_{bb(off)}$ , $V_{IN} = 0\text{ V}$
Operating current	$I_{GND}$	–	0.8	1.5	mA	$V_{IN} = 5\text{ V}$
<b>Protection functions</b> <sup>7)</sup>						
Initial peak short circuit current limit (pin 5 to 3) $T_j = -40^\circ\text{C}$ , $V_{bb} = 20\text{ V}$ , $t_m = 150\ \mu\text{s}$ $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{L(SCp)}$	–	–	28 – –	A	–

<sup>5)</sup> Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air. (see page 19)

<sup>6)</sup> Higher current due temperature sensor

<sup>7)</sup> 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.

**Functional description and electrical characteristics**

**Table 4 Electrical characteristics (continued)**

$T_j = -40^\circ\text{C}$  to  $+150^\circ\text{C}$ ,  $V_{bb} = 13.5\text{ V}$ , unless otherwise specified

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
Repetitive short circuit current limit	$I_{L(\text{SCR})}$	-	12	-	A	$T_j = T_{jt}$ (see <a href="#">Timing diagrams</a> )
Output clamp (inductive load switch off)	$V_{\text{ON}(\text{CL})}$	41	47	-	V	$V_{\text{OUT}} = V_{bb} - V_{\text{ON}(\text{CL})}$ , $I_{bb} = 4\text{ mA}$
Overvoltage protection	$V_{bb(\text{AZ})}$	41	-	-	V	<sup>8)</sup> , $I_{bb} = 4\text{ mA}$
Thermal overload trip temperature	$T_{jt}$	150	-	-	$^\circ\text{C}$	-
Thermal hysteresis	$\Delta T_{jt}$	-	10	-	K	-

**Reverse battery**

Reverse battery	$-V_{bb}$	-	-	32	V	<sup>9)</sup>
Drain-source diode voltage	$-V_{\text{ON}}$	-	600	-	mV	$V_{\text{OUT}} > V_{bb}$ $T_j = 150^\circ\text{C}$

**Input**

Input turn-on threshold voltage	$V_{\text{IN}(\text{T}+)}$	-	-	2.2	V	(see page <a href="#">15</a> )
Input turn-off threshold voltage	$V_{\text{IN}(\text{T}-)}$	0.8	-	-	V	(see page <a href="#">15</a> )
Input threshold hysteresis	$\Delta V_{\text{IN}(\text{T})}$	-	0.3	-	V	-
Off state input current	$I_{\text{IN}(\text{off})}$	1	-	25	$\mu\text{A}$	$V_{\text{IN}} = 0.7\text{ V}$ (see page <a href="#">15</a> )
On state input current	$I_{\text{IN}(\text{on})}$	3	-	25	$\mu\text{A}$	$V_{\text{IN}} = 5\text{ V}$ (see page <a href="#">15</a> )
Input resistance	$R_I$	1.5	3.5	5	$\text{k}\Omega$	(see page <a href="#">8</a> )

<sup>8</sup> See also  $V_{\text{ON}(\text{CL})}$  in circuit diagram on page [8](#)

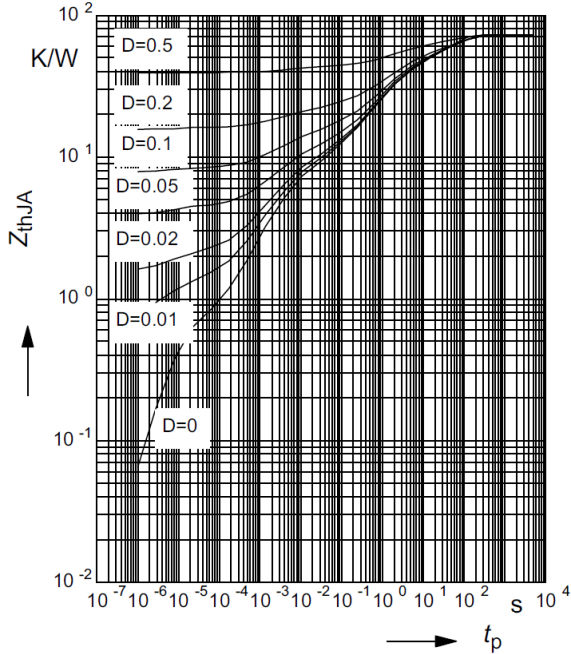
<sup>9</sup> Requires a  $150\ \Omega$  resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection is not active during reverse current operation! Input current has to be limited (see [Absolute maximum ratings](#) on page [6](#)).

Functional description and electrical characteristics

4.3 Typical performance characteristics

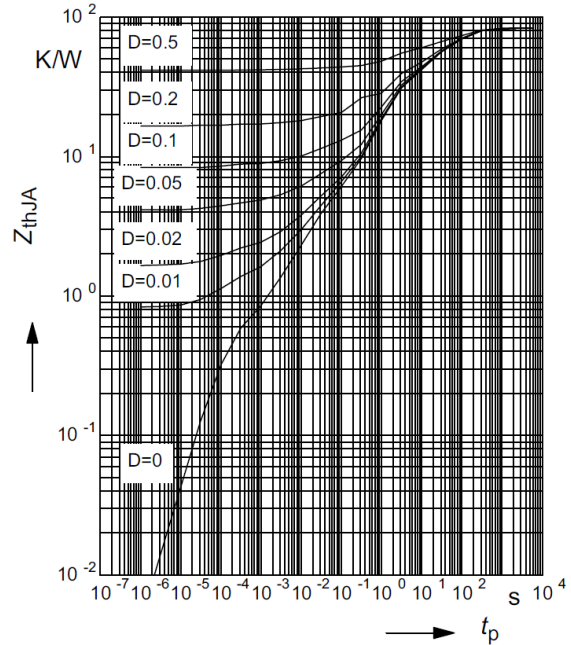
Typ. transient thermal impedance  $Z_{thJA} = f(t_p)$   
@ 6 cm<sup>2</sup> heatsink area

Parameter:  $D = t_p/T$



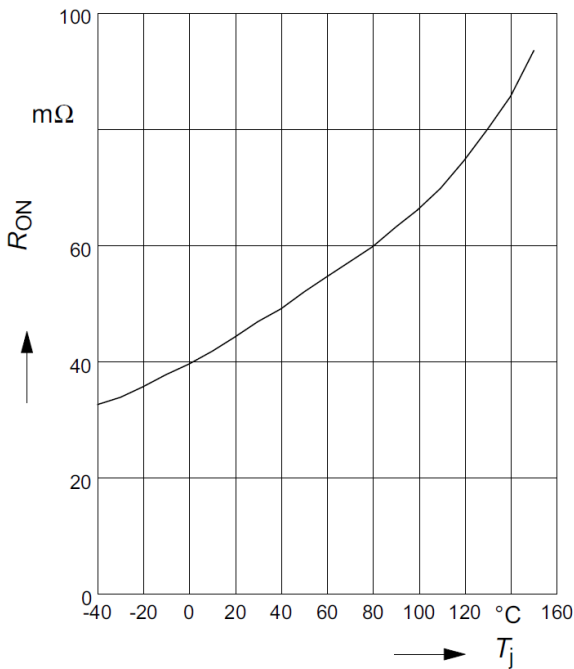
Typ. transient thermal impedance  $Z_{thJA} = f(t_p)$   
@ minimum footprint

Parameter:  $D = t_p/T$



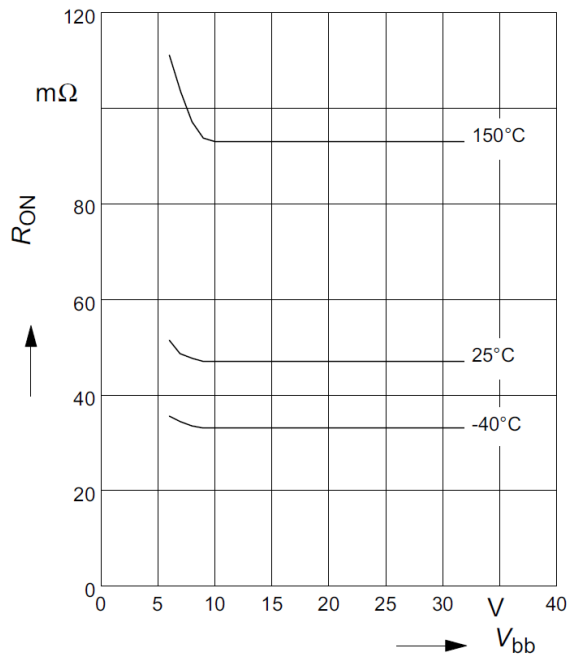
Typ. on-state resistance  $R_{ON} = f(T_j)$

$V_{bb} = 13.5\text{ V}$ ;  $V_{IN} = \text{high}$



Typ. on-state resistance  $R_{ON} = f(V_{bb})$

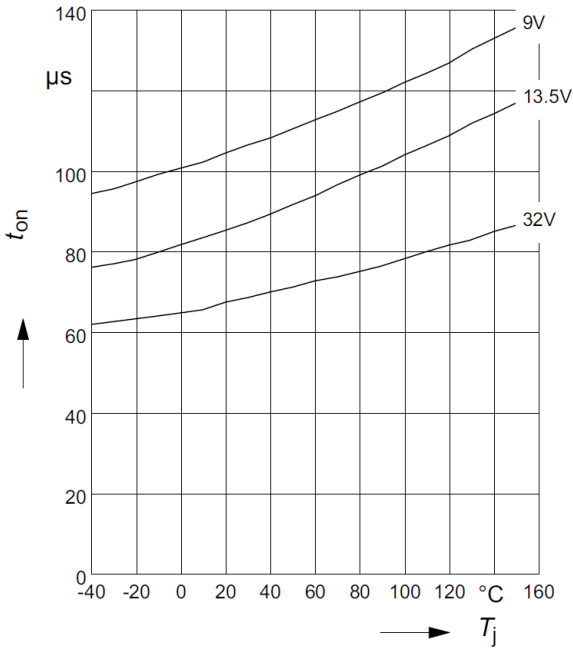
$I_L = 0.5\text{ A}$ ;  $V_{IN} = \text{high}$



**Functional description and electrical characteristics**

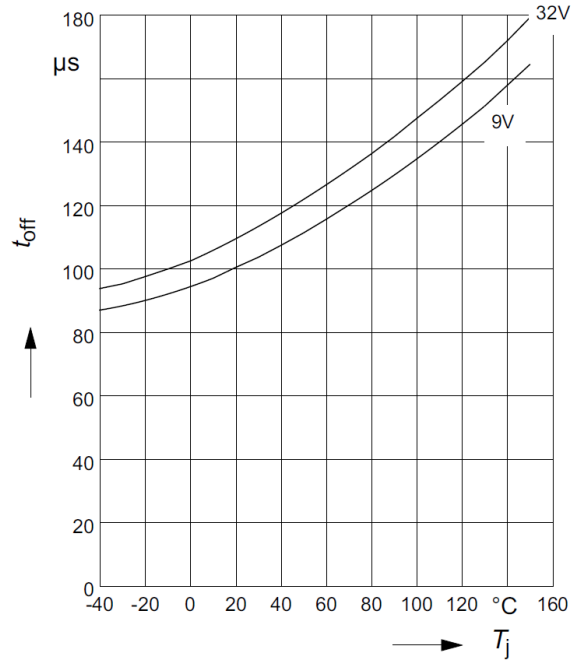
**Typ. turn-on time  $t_{on} = f(T_j)$**

$R_L = 47 \Omega$



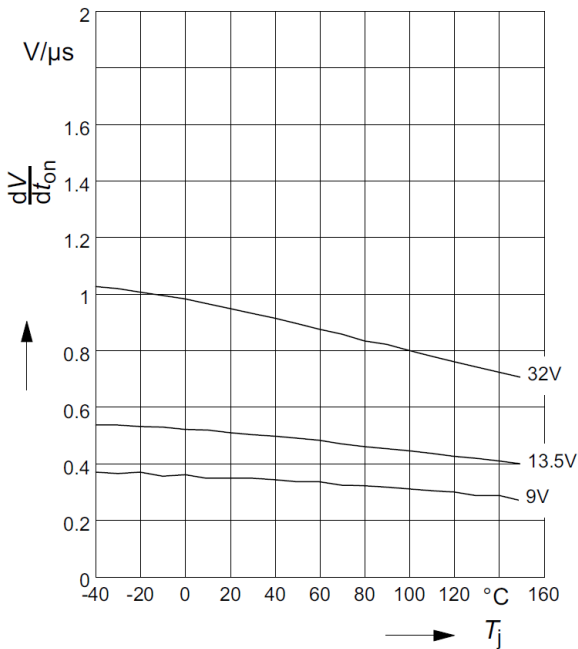
**Typ. turn-off time  $t_{off} = f(T_j)$**

$R_L = 47 \Omega$



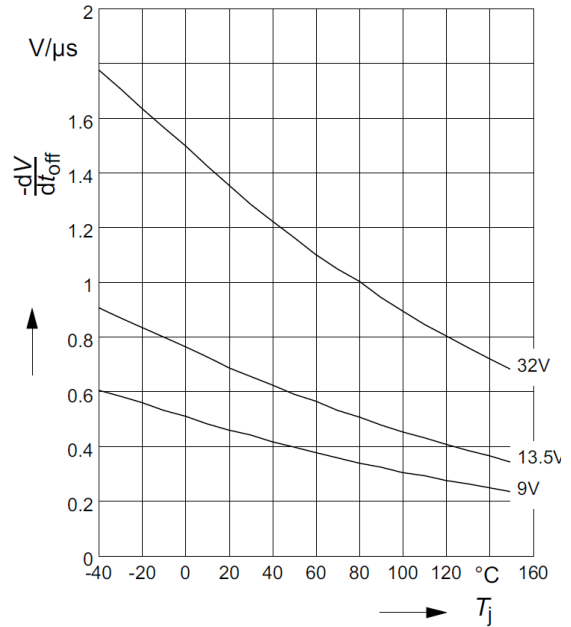
**Typ. slew rate on  $dV/dt_{on} = f(T_j)$**

$R_L = 47 \Omega$



**Typ. slew rate off  $dV/dt_{off} = f(T_j)$**

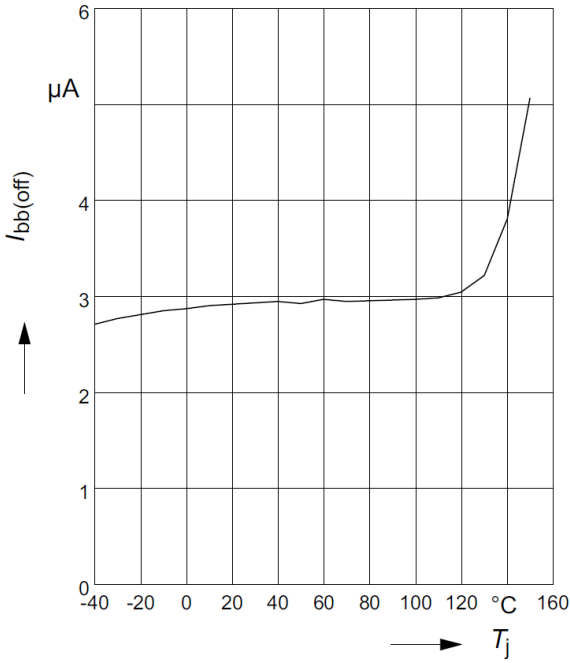
$R_L = 47 \Omega$



**Functional description and electrical characteristics**

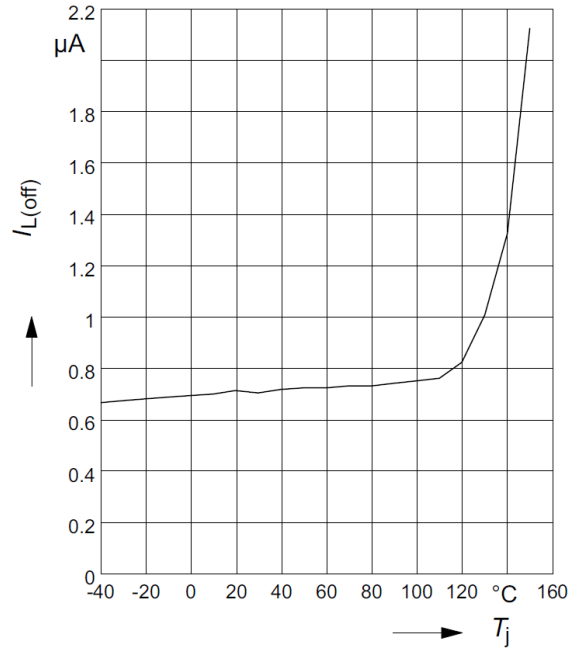
**Typ. standby current  $I_{bb(off)} = f(T_j)$**

$V_{bb} = 32\text{ V}; V_{IN} = \text{low}$



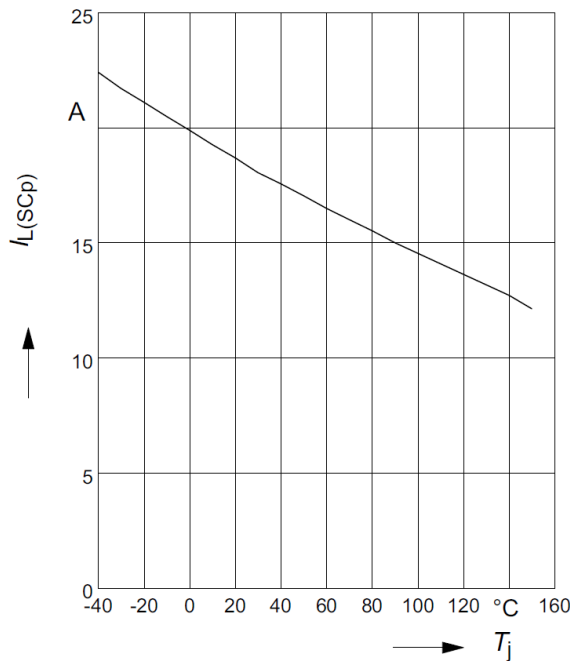
**Typ. leakage current  $I_{L(off)} = f(T_j)$**

$V_{bb} = 32\text{ V}; V_{IN} = \text{low}$



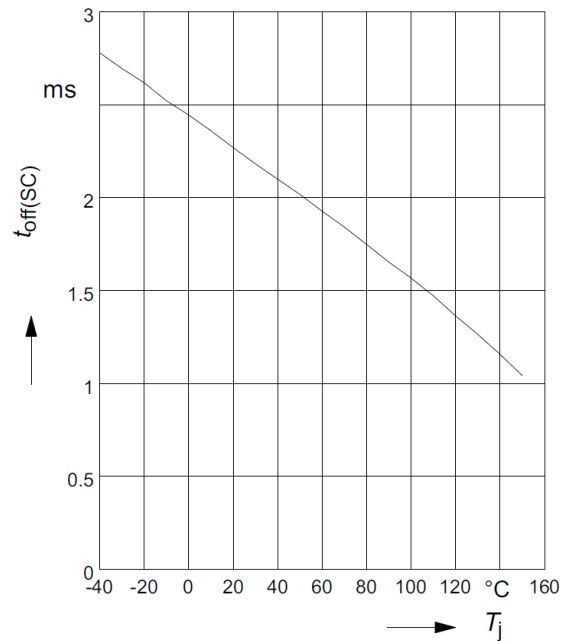
**Typ. initial peak short circuit current limit  $I_{L(SCp)} = f(T_j)$**

$V_{bb} = 20\text{ V}$



**Typ. initial short circuit shutdown time  $t_{off(SC)} = f(T_j, \text{start})$**

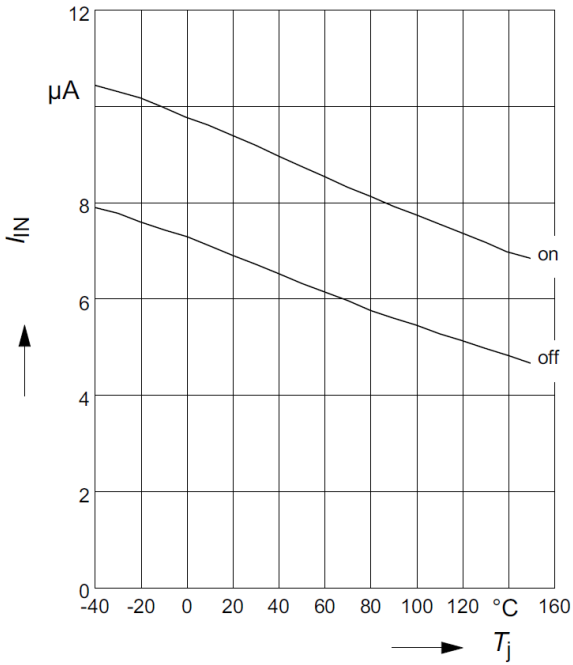
$V_{bb} = 20\text{ V}$



**Functional description and electrical characteristics**

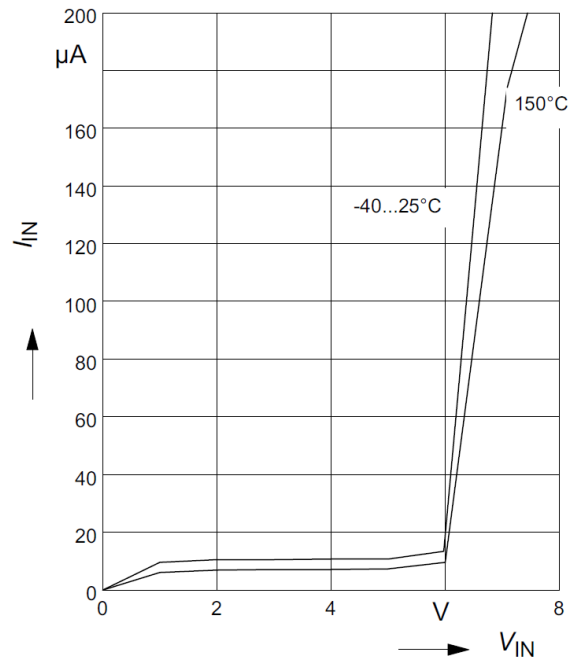
**Typ. input current  $I_{IN(on/off)} = f(T_j)$**

$V_{bb} = 13.5\text{ V}$ ;  $V_{IN} = \text{low/high}$ ;  $V_{INlow} \leq 0.7\text{ V}$ ;  $V_{INhigh} = 5\text{ V}$



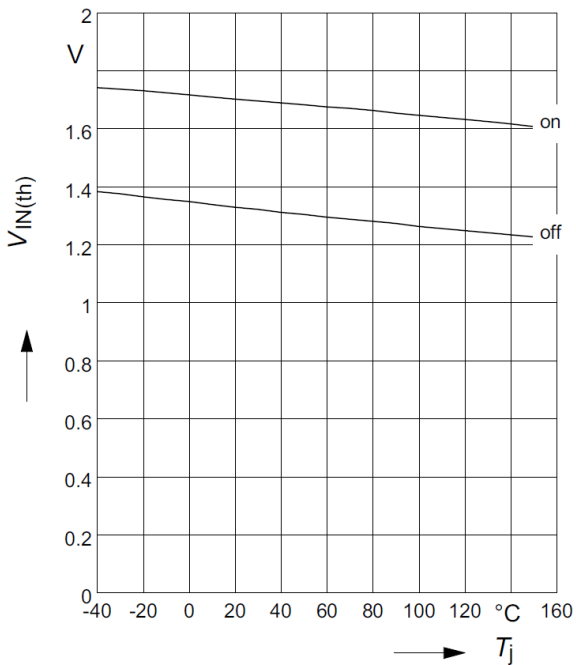
**Typ. input current  $I_{IN} = f(V_{IN})$**

$V_{bb} = 13.5\text{ V}$



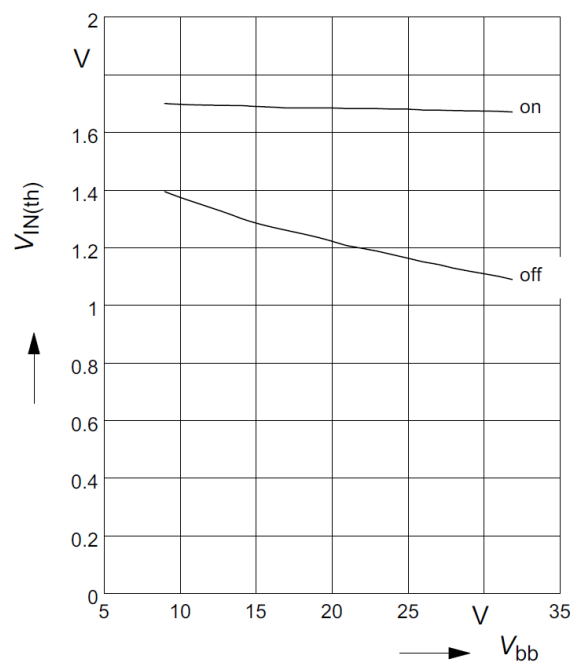
**Typ. input threshold voltage  $V_{IN(th)} = f(T_j)$**

$V_{bb} = 13.5\text{ V}$



**Typ. input threshold voltage  $V_{IN(th)} = f(V_{bb})$**

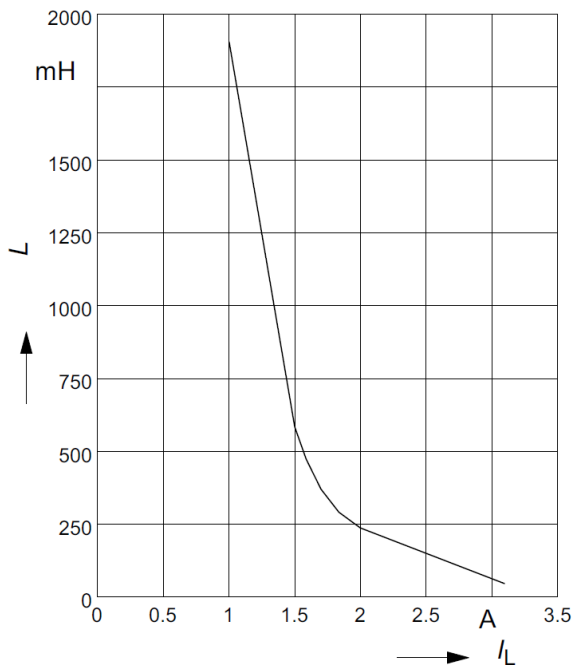
$T_j = 25^{\circ}\text{C}$



**Functional description and electrical characteristics**

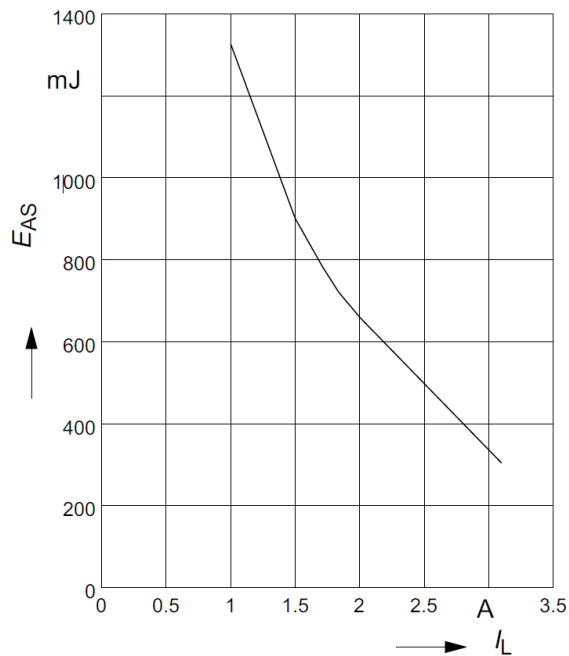
**Maximum allowable load inductance for a single switch off  $L = f(I_L)$**

$T_{jstart} = 150^{\circ}\text{C}$ ,  $V_{bb} = 13.5\text{ V}$ ,  $R_L = 0\ \Omega$



**Maximum allowable inductive switch off energy, single pulse  $E_{AS} = f(I_L)$**

$T_{jstart} = 150^{\circ}\text{C}$ ,  $V_{bb} = 13.5\text{ V}$

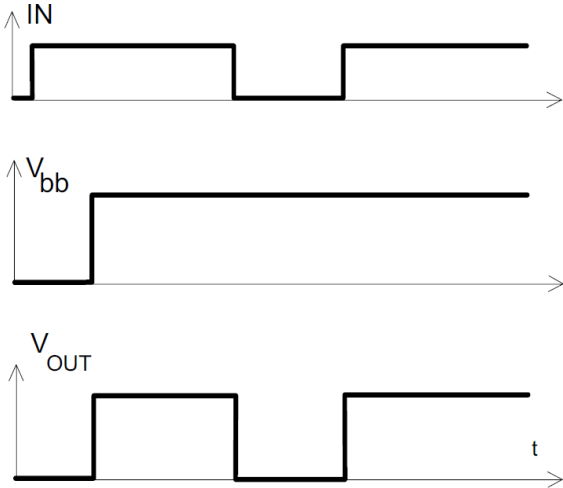




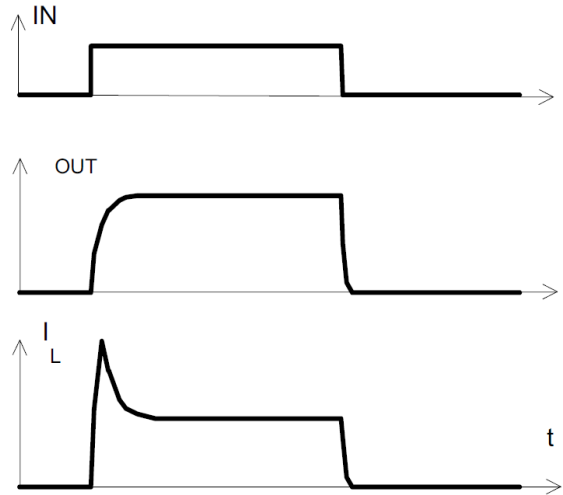
**Functional description and electrical characteristics**

**4.4 Timing diagrams**

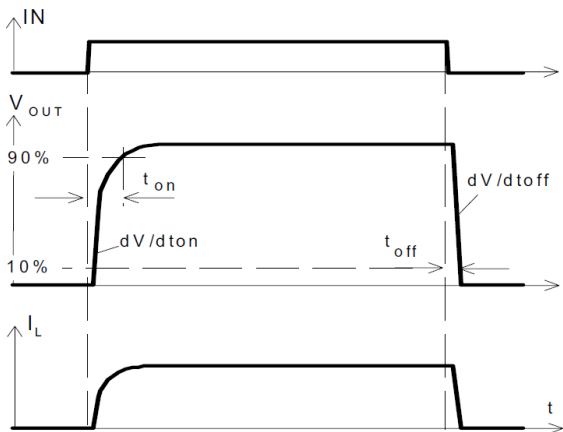
**$V_{bb}$  turn on**



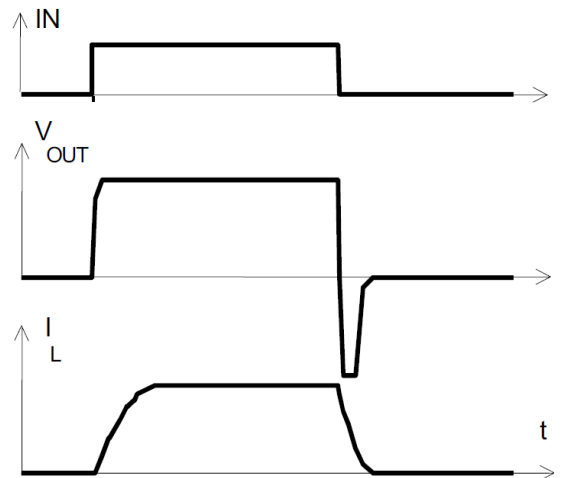
**Switching a lamp**



**Switching a resistive load, turn-on/off time and slew rate definition**

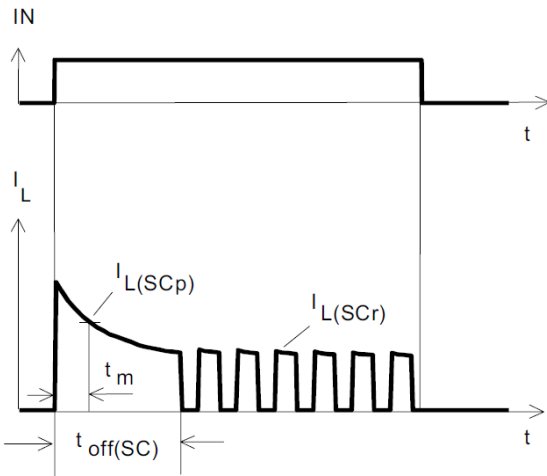


**Switching an inductive load**

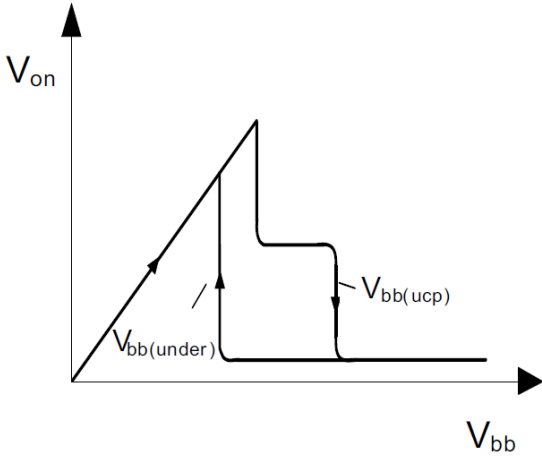


**Functional description and electrical characteristics**

**Turn on into short circuit, shut down by overtemperature, restart by cooling**

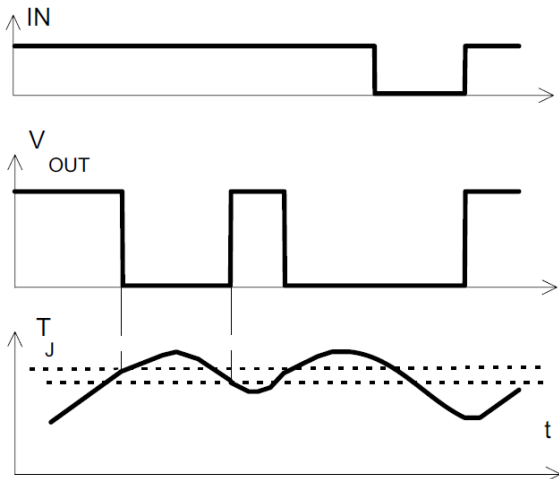


**Undervoltage restart of charge pump**



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

**Overtemperature: Reset if  $T_j < T_{jt}$**



Package information

5 Package information

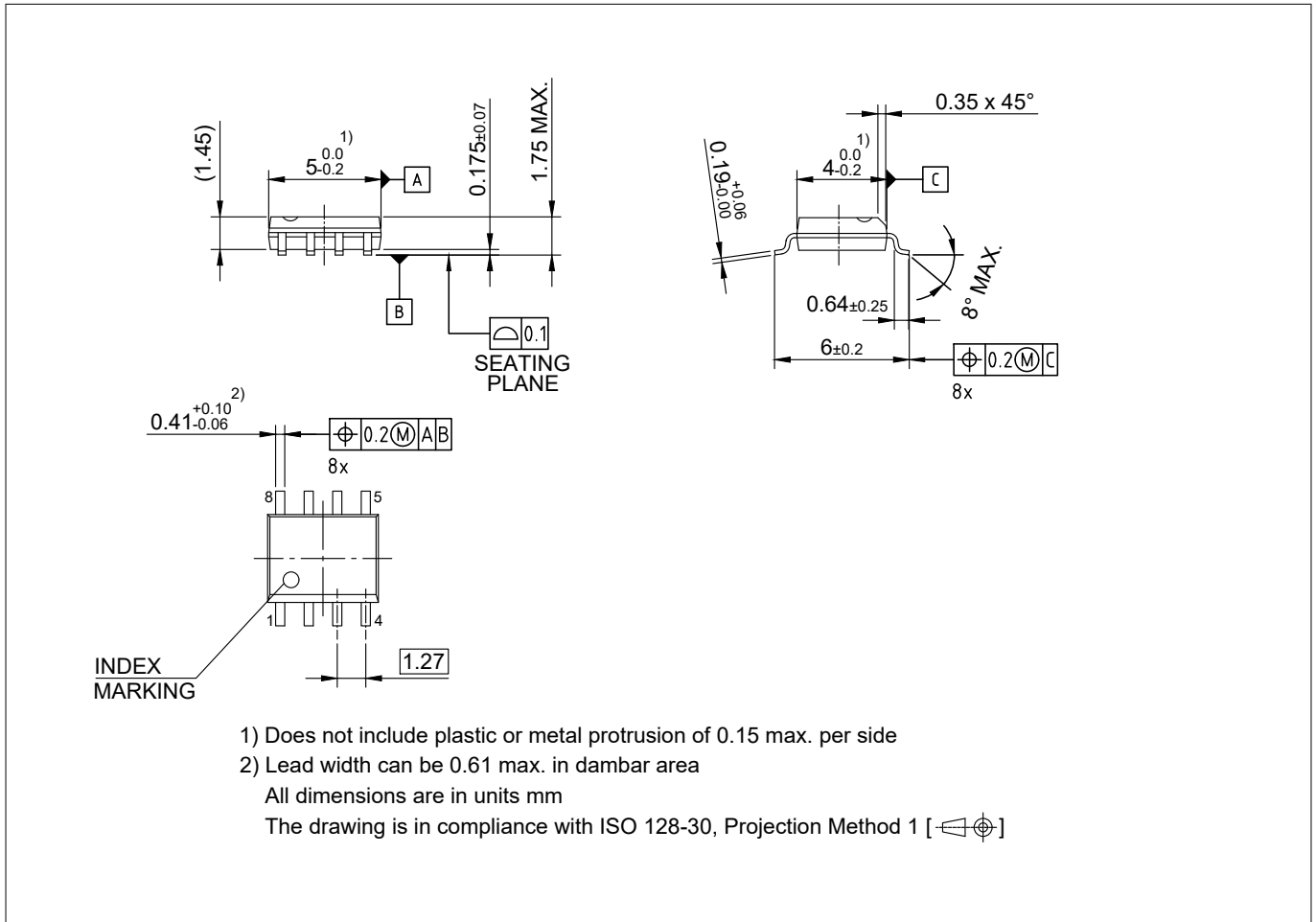


Figure 3 PG-DSO-8

Green Product (RoHS compliant)

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 (Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Information on alternative packages

Please visit [www.infineon.com/packages](http://www.infineon.com/packages).

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Revision history

## 6 Revision history

Document version	Date of release	Description of changes
1.2	2019-07-25	Datasheet updated: <ul style="list-style-type: none"><li>• ESD ratings for HBM updated according to ANSI/ESDA/JEDEC JS-001</li><li>• Figures updated in chapter 4 (functional description)</li><li>• Editorial changes</li></ul>
1.1	2008-09-29	All pages: <ul style="list-style-type: none"><li>• Added new Infineon logo</li><li>• Initial version of RoHS-compliant derivate of the ISP772T</li></ul> Page 1 and 17: <ul style="list-style-type: none"><li>• Added RoHS compliance statement and Green product feature</li><li>• Package changed to RoHS compliant version</li></ul> Page 18: Added Revision history Page 19: Update of disclaimer

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