

ISP752R

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
- 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
- Very low standby current
- Green product (RoHS compliant)



Potential applications

- All types of resistive, inductive and capacitive loads
- μ C compatible power switch for 12 V, 24 V and 42 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	$V_{bb(AZ)}$	62	V
Operating voltage	$V_{bb(on)}$	6 to 52	V
On-state resistance	R_{ON}	200	m Ω
Nominal load current	$I_{L(nom)}$	1.3	A
Operating temperature	T_a	-30 to +85	°C

ISP752R

Smart power high-side-switch for industrial applications



Description

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

Type	Package	Marking
ISP752R	PG-DSO-8	I752R

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Block diagram

1 Block diagram

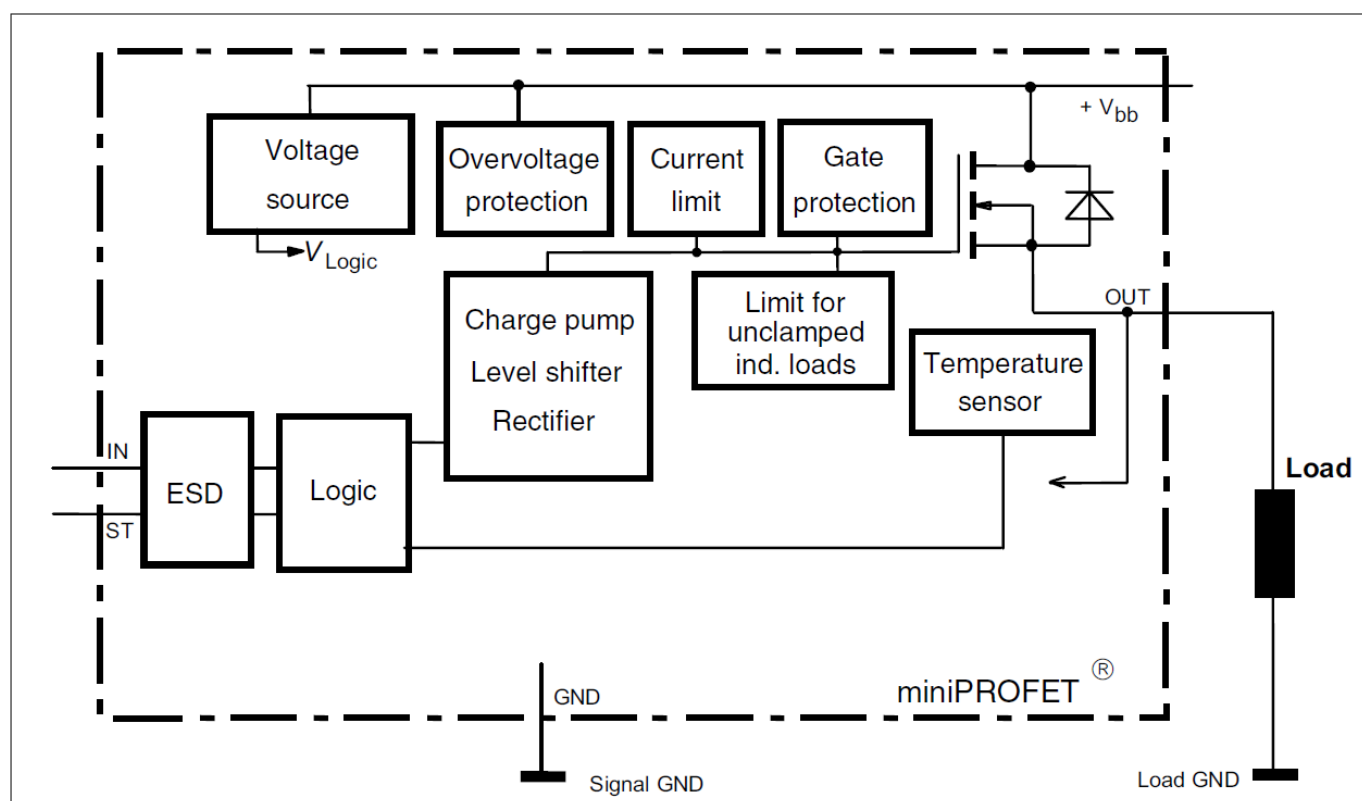


Figure 1 Block diagram

2 Pin configuration

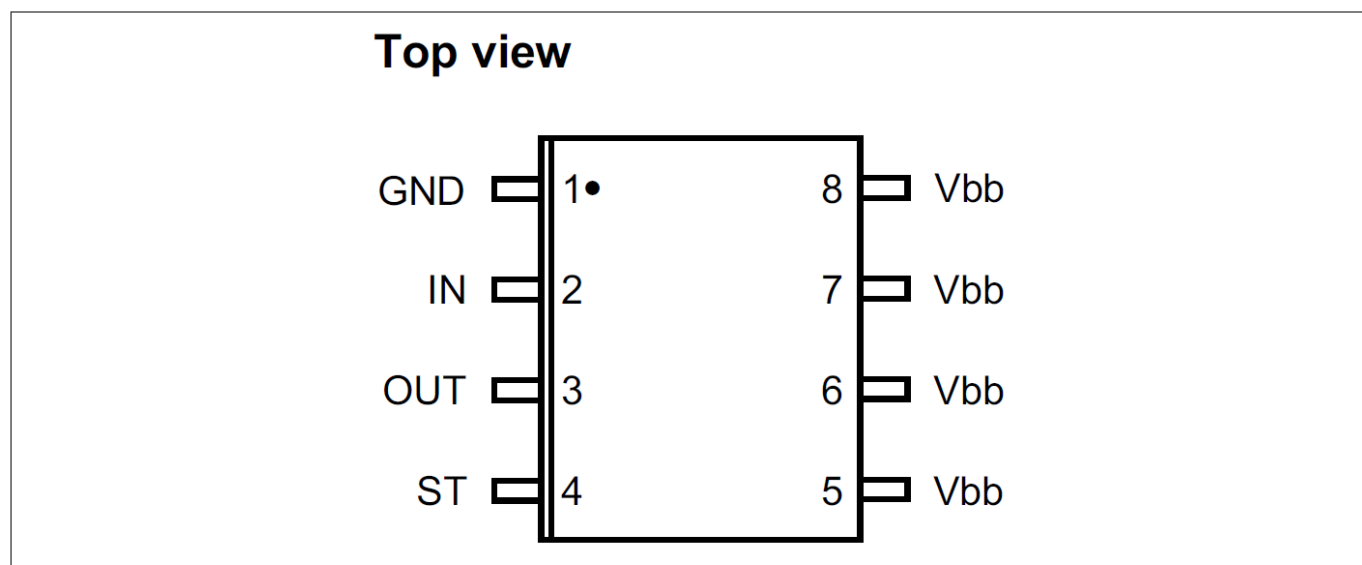


Figure 2 Pin configuration

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	ST	Diagnostic feedback
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}	52	V	–
Supply voltage for full short circuit protection	$V_{bb(SC)}$	50	V	–
Continuous input voltage	V_{IN}	-10 to +16	V	–
Load current	I_L	self limited	A	short-circuit current, see p. 12
Current through input pin (DC)	I_{IN}	± 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}	125	mJ	1) 2) single pulse $T_j = 150^\circ\text{C}$, $I_L = 1\text{ A}$ (see page 11)
Load dump protection $R_L = 13.5\ \Omega$ $R_L = 27\ \Omega$	$V_{Loaddump}$	73.5 83.5	V	2) 3) $V_{LoadDump} = V_A + V_S$, $R_I = 2\ \Omega$, $t_d = 400\text{ ms}$, $V_{IN} = \text{low or high}$, $V_A = 13.5\text{ V}$
Electrostatic Discharge Voltage (Human Body Model) OUT IN all other pins	V_{ESD}	± 6 ± 1 ± 4	kV	according to ANSI/ESDA/JEDEC JS001 (1.5 k Ω , 100 pF)

¹ Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air (see page [22](#))

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 Ω 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 ² cooling area ⁴⁾	$R_{th(JA)}$	–	95 70	– 83	K/W	–

⁴ Device on 50 mm × 50 mm × 1.5 mm epoxy PCB FR4 with 6 cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air (see page 22)

4 Functional description and electrical characteristics

4.1 Functional description

	Input level	Output level	Status
Normal operation	L	L	H
	H	H	H
Short circuit to GND	L	L	H
	H	L ⁵⁾	L
Short circuit to V_{bb} (in off-state)	L	H	L
	H	H	H
Overload	L	L	H
	H	H ⁶⁾	H
Overtemperature	L	L	H
	H	L	L
Open load in off-state	L	Z ⁷⁾	H (L ⁸⁾)
	H	H	H

⁵ Out = "L": $V_{OUT} < 2.8 \text{ V typ.}$

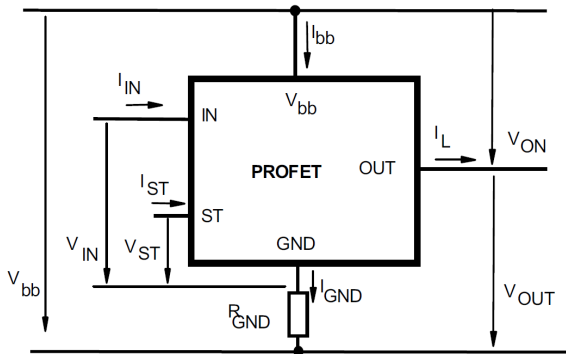
⁶ Out = "H": $V_{OUT} > 2.8 \text{ V typ.}$

⁷ Z = high impedance, potential depends on external circuit

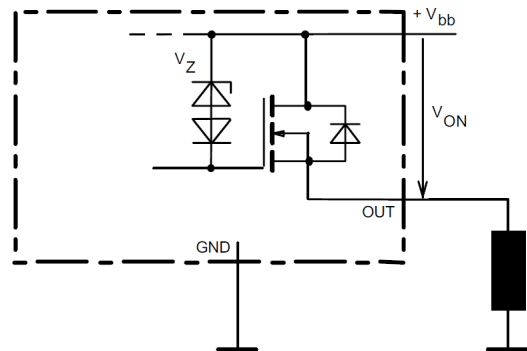
⁸ with external resistor between V_{bb} and OUT

Functional description and electrical characteristics

Terms

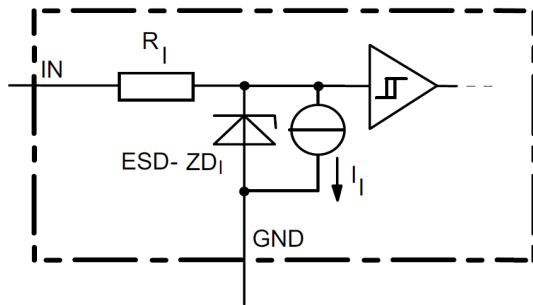


Inductive and overvoltage output clamp



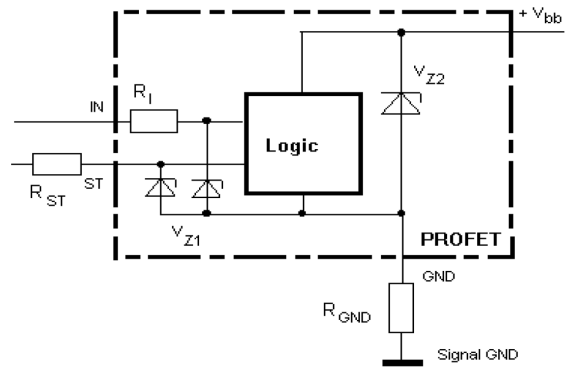
V_{ON} clamped to 59 V min.

Input circuit (ESD protection)



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

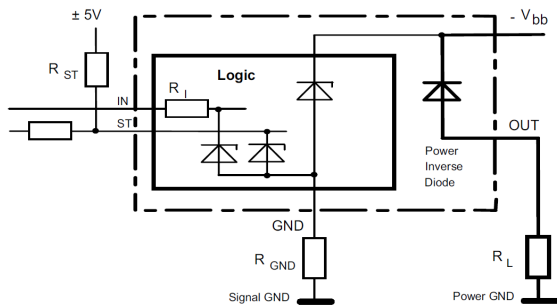
Overvoltage protection of logic part



$V_{Z1} = 6.1 \text{ V typ.}$, $V_{Z2} = V_{bb(AZ)} = 62 \text{ V min.}$,
 $R_I = 3.5 \text{ k}\Omega \text{ typ.}$, $R_{GND} = 150 \Omega$

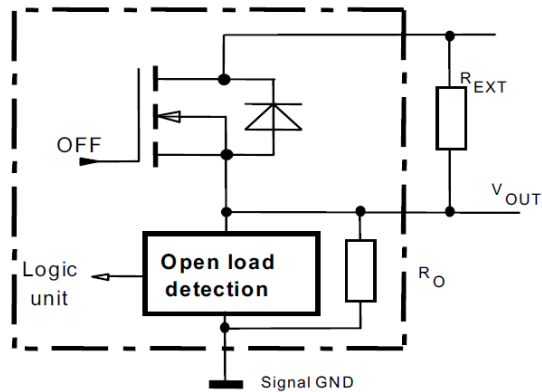
Functional description and electrical characteristics

Reverse battery protection



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

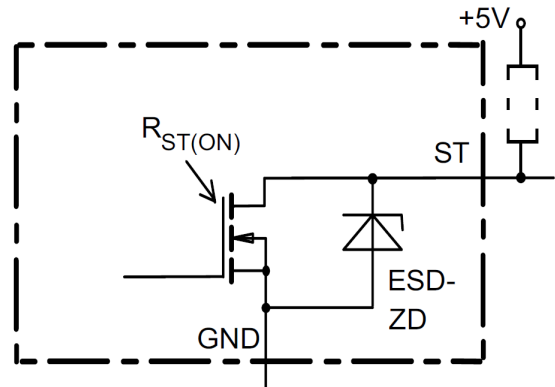
Open-load detection



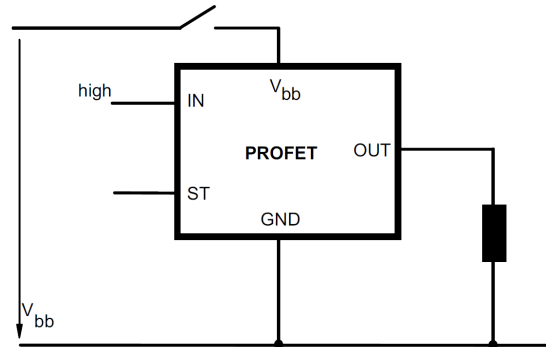
OFF-state diagnostic condition:

$V_{OUT} > 3 \text{ V}$ typ.; IN = low

Status output

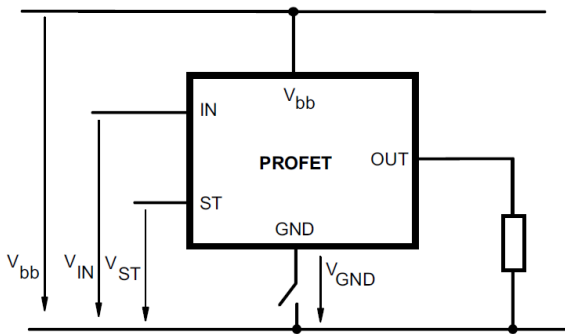


V_{bb} disconnect with charged inductive load

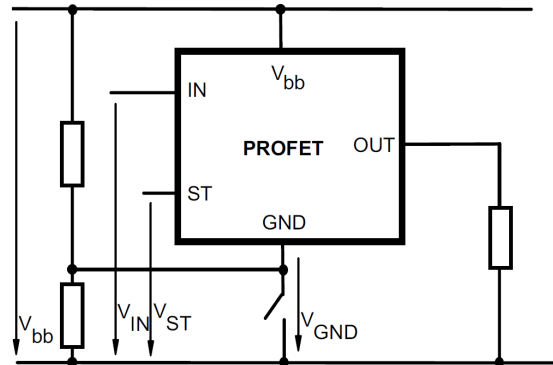


Functional description and electrical characteristics

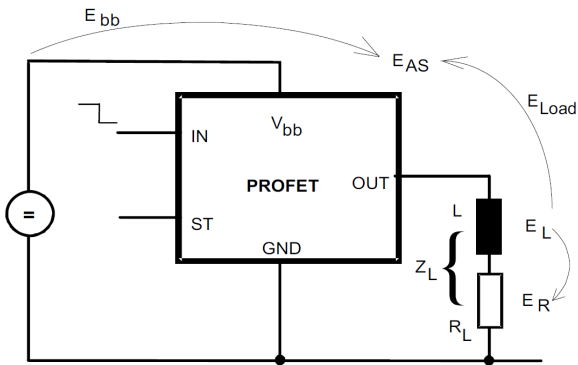
GND disconnect



GND disconnect with GND pull up



Inductive load switch-off energy dissipation



Energy stored in load inductance:

$$E_L = \frac{1}{2} \times L \times I_L^2$$

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

at $T_j = -40^\circ\text{C}$ to $+150^\circ\text{C}$, $V_{bb} = 12\text{ V}$ to 42 V , unless otherwise specified

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		

Load switching capabilities and characteristics

On-state resistance $T_j = 25^\circ\text{C}$, $I_L = 1\text{ A}$, $V_{bb} = 9\text{ V}$ to 52 V $T_j = 150^\circ\text{C}$	R_{ON}	–	150	200	mΩ	–
		–	270	380		
Nominal load current	$I_{L(nom)}$	1.3	1.7	–	A	Device on PCB ⁹⁾ $T_C = 85^\circ\text{C}$, $T_j \leq 150^\circ\text{C}$
Turn-on time to 90% V_{OUT}	t_{on}	–	80	180	μs	$R_L = 47\ \Omega$
Turn-off time to 10% V_{OUT}	t_{off}	–	80	200	μs	$R_L = 47\ \Omega$
Slew rate on 10% to 30% V_{OUT}	dV/dt_{on}	–	0.7	2	V/μs	$R_L = 47\ \Omega$, $V_{bb} = 13.5\text{ V}$
Slew rate off 70% to 40% V_{OUT}	$-dV/dt_{off}$	–	0.9	2	V/μs	$R_L = 47\ \Omega$, $V_{bb} = 13.5\text{ V}$

Operating parameters

Operating voltage	$V_{bb(on)}$	6	–	52	V	–
Undervoltage shutoff charge pump $T_j = -40^\circ\text{C}$ to $+85^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$V_{bb(under)}$	–	–	4	V	–
		–	–	5.5		
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	–	4	5.5	V	–
Standby current $T_j = -40^\circ\text{C}$ to $+85^\circ\text{C}$, $V_{IN} = \text{low}$ $T_j = 150^\circ\text{C}$ ¹⁰⁾ , $V_{IN} = \text{low}$	$I_{bb(off)}$	–	–	15	μA	–
		–	–	18		
Leakage output current (included in $I_{bb(off)}$)	$I_{L(off)}$	–	–	5	μA	$V_{IN} = \text{low}$
Operating current	I_{GND}	–	0.8	2	mA	$V_{IN} = \text{high}$

Protection functions ¹¹⁾

Initial peak short circuit current limit $T_j = -40^\circ\text{C}$, $V_{bb} = 20\text{ V}$, $t_m = 150\ \mu\text{s}$ $T_j = 25^\circ\text{C}$	$I_{L(SCp)}$	–	–	9	A	(pin 5 to 3)
		–	6.5	–		–

⁹⁾ Device on $50\text{ mm} \times 50\text{ mm} \times 1.5\text{ mm}$ epoxy PCB FR4 with 6 cm^2 (one layer, $70\ \mu\text{m}$ thick) copper area for drain connection. PCB is vertical without blown air (see page 22)

¹⁰⁾ Higher current due temperature sensor

¹¹⁾ 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)

at $T_j = -40^\circ\text{C}$ to $+150^\circ\text{C}$, $V_{bb} = 12\text{ V}$ to 42 V , unless otherwise specified

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
$T_j = 150^\circ\text{C}$		4	–	–		–
$T_j = -40^\circ\text{C}$ to $+150^\circ\text{C}$, $V_{bb} > 40\text{ V}$ (see p. 17)		–	5 ¹²⁾	–		–
Repetitive short circuit current limit, $T_j = T_{jt}$	$I_{L(SCr)}$				A	(see Timing diagrams)
$V_{bb} < 40\text{ V}$		–	6	–		
$V_{bb} > 40\text{ V}$		–	4.5	–		
Output clamp (inductive load switch off)	$V_{ON(CL)}$	59	63	–	V	$V_{OUT} = V_{bb} - V_{ON(CL)}$, $I_{bb} = 4\text{ mA}$
Overvoltage protection	$V_{bb(AZ)}$	62	–	–	V	13) $I_{bb} = 4\text{ mA}$
Thermal overload trip temperature	T_{jt}	150	–	–	$^\circ\text{C}$	–
Thermal hysteresis	ΔT_{jt}	–	10	–	K	–
Reverse battery						
Reverse battery	$-V_{bb}$	–	–	52	V	14)
Drain-source diode voltage ($V_{OUT} > V_{bb}$)	$-V_{ON}$	–	600	–	mV	$T_j = 150^\circ\text{C}$
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	–	–	V	–
Input threshold hysteresis	$\Delta V_{IN(T)}$	–	0.4	–	V	–
Off state input current $V_{IN} = 0.7\text{ V}$	$I_{IN(off)}$	1	–	25	μA	–
On state input current	$I_{IN(on)}$	3	–	25	μA	$V_{IN} = 5\text{ V}$
Status output (open drain), Zener limit voltage	$V_{ST(high)}$	5.4	6.1	–	V	$I_{ST} = 1.6\text{ mA}$
Status output (open drain), ST low voltage	$V_{ST(low)}$				V	–
$T_j = -40^\circ\text{C}$ to $+25^\circ\text{C}$, $I_{ST} = 1.6\text{ mA}$		–	–	0.4		
$T_j = 150^\circ\text{C}$, $I_{ST} = 1.6\text{ mA}$		–	–	0.6		
Status invalid after positive input slope	$t_{d(ST+)}$	–	120	160	μs	15)

¹² Not subject to production test, specified by design

¹³ see also $V_{ON(CL)}$ in circuit diagram on page 9

¹⁴ 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

Functional description and electrical characteristics

Table 4 **Electrical characteristics (continued)**

at $T_j = -40^{\circ}\text{C}$ to $+150^{\circ}\text{C}$, $V_{bb} = 12\text{ V}$ to 42 V , unless otherwise specified

Parameter	Symbol	Values			Unit	Note or condition
		Min.	Typ.	Max.		
						$V_{bb} = 20\text{ V}$
Status invalid after negative input slope ¹⁵⁾	$t_{d(\text{ST-})}$	–	250	400	μs	–
Input resistance	R_I	2	3.5	5	$\text{k}\Omega$	see page 9

Diagnostic characteristics

Short circuit detection voltage	$V_{\text{OUT(SC)}}$	–	2.8	–	V	–
Open load detection voltage	$V_{\text{OUT(OL)}}$	–	3	4	V	¹⁶⁾
Internal output pull down	R_O	–	200	–	$\text{k}\Omega$	¹⁷⁾ $V_{\text{OUT(OL)}} = 4\text{ V}$ (see page 10 and page 19)

during reverse current operation! Input current has to be limited (see **Absolute maximum ratings** on page 6).

¹⁵⁾ No delay time after overtemperature switch off and short circuit in on-state

¹⁶⁾ External pull up resistor required for open load detection in off state

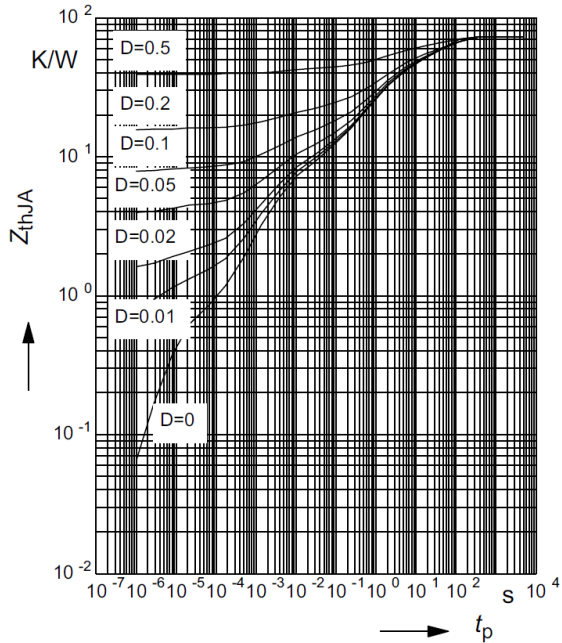
¹⁷⁾ Not subject to production test, specified by design

Functional description and electrical characteristics

4.3 Typical performance characteristics

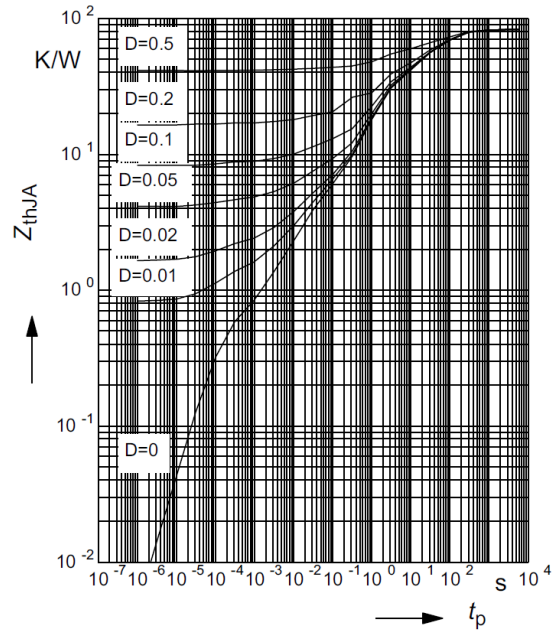
Typ. transient thermal impedance $Z_{thJA} = f(t_p)$
@ 6 cm² heatsink area

$$D = t_p / T$$



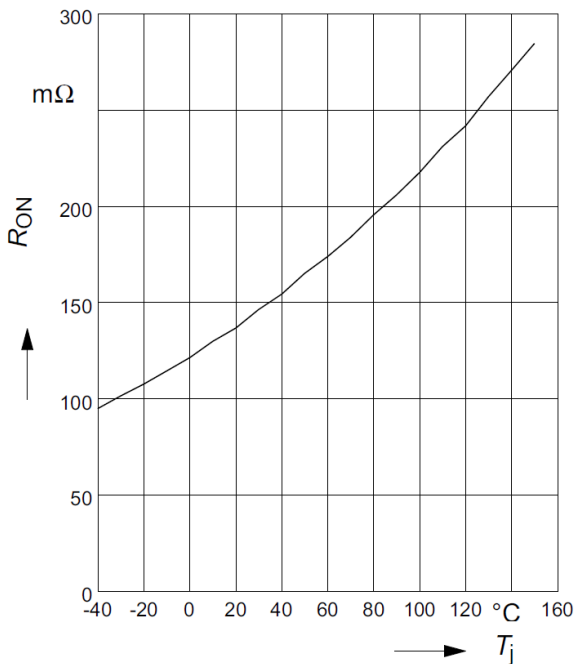
Typ. transient thermal impedance $Z_{thJA} = f(t_p)$
@ minimum footprint

$$D = t_p / T$$



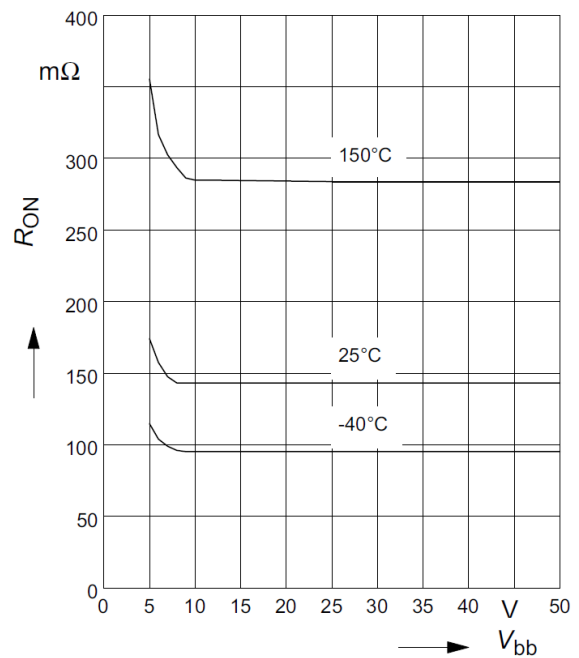
Typ. on-state resistance $R_{ON} = f(T_j)$

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



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

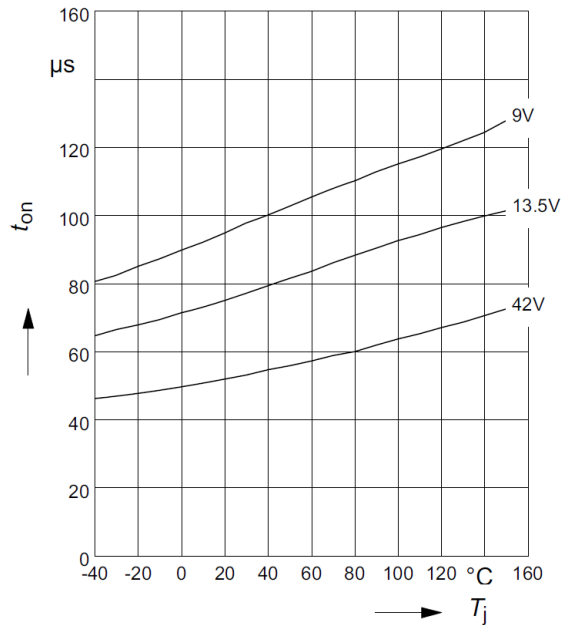
$I_L = 1 \text{ A}$; $V_{IN} = \text{high}$



Functional description and electrical characteristics

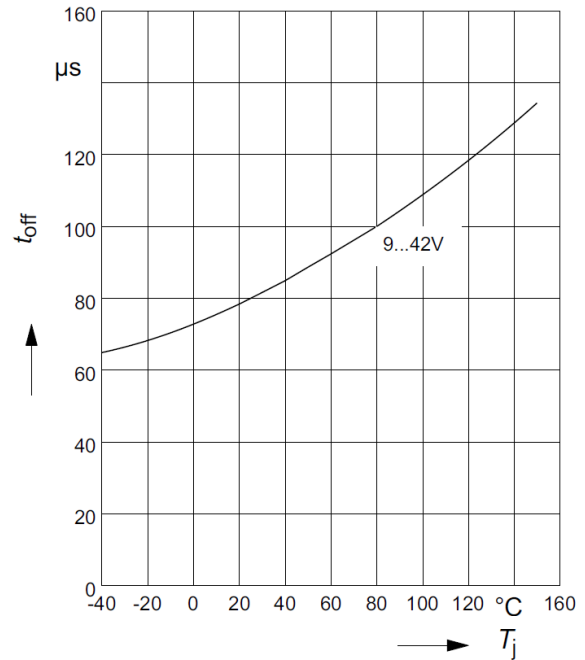
Typ. turn-on time $t_{on} = f(T_j)$

$R_L = 47 \Omega$



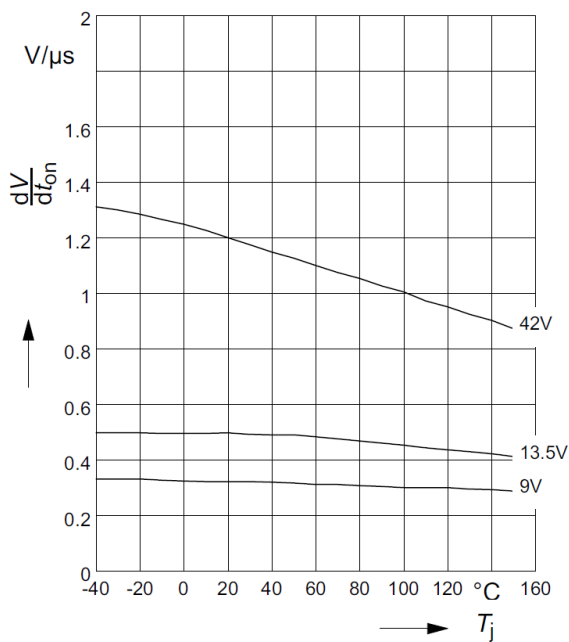
Typ. turn-off time $t_{off} = f(T_j)$

$R_L = 47 \Omega$



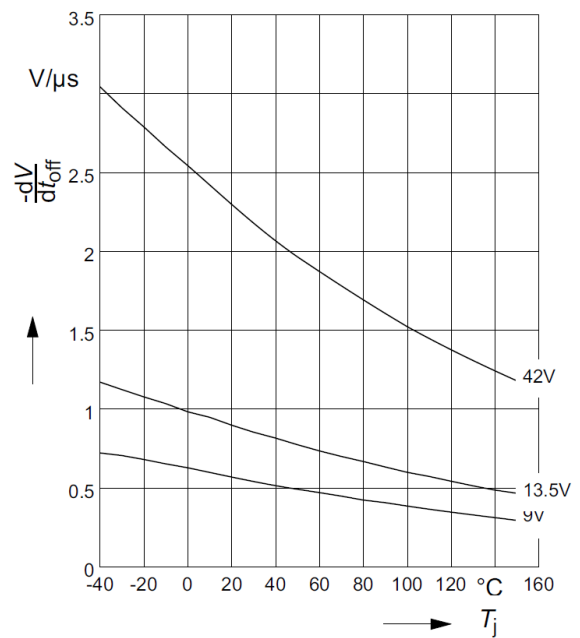
Typ. slew rate on $dV/dt_{on} = f(T_j)$

$R_L = 47 \Omega$



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

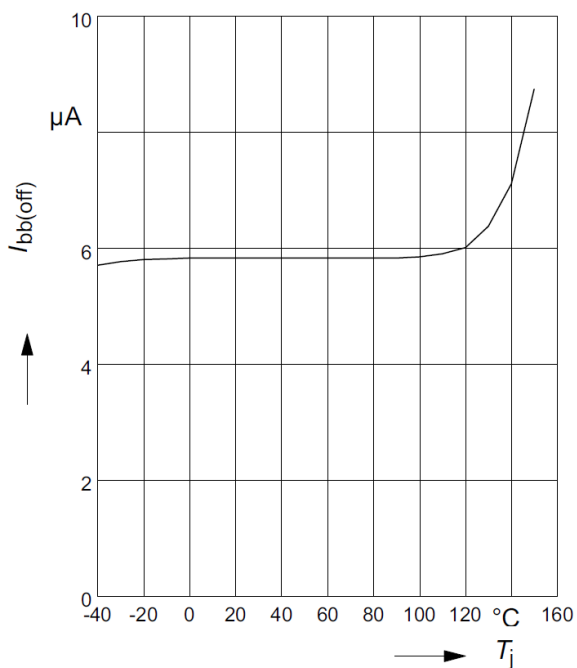
$R_L = 47 \Omega$



Functional description and electrical characteristics

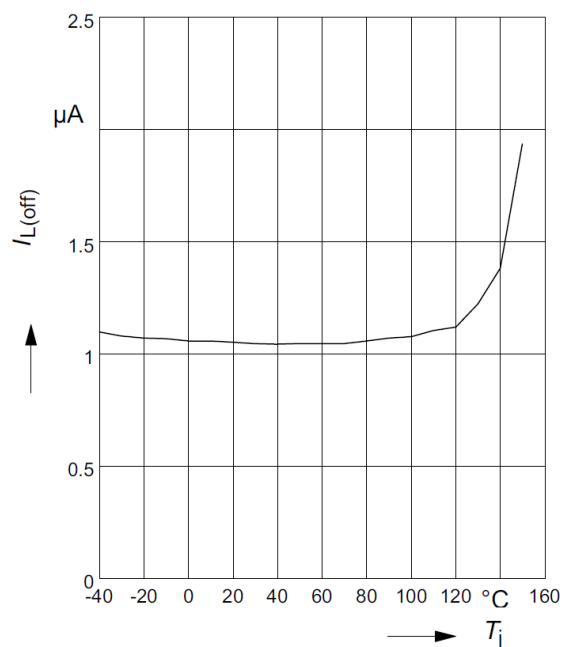
Typ. standby current $I_{bb(off)} = f(T_j)$

$V_{bb} = 42 \text{ V}$; $V_{IN} = \text{low}$

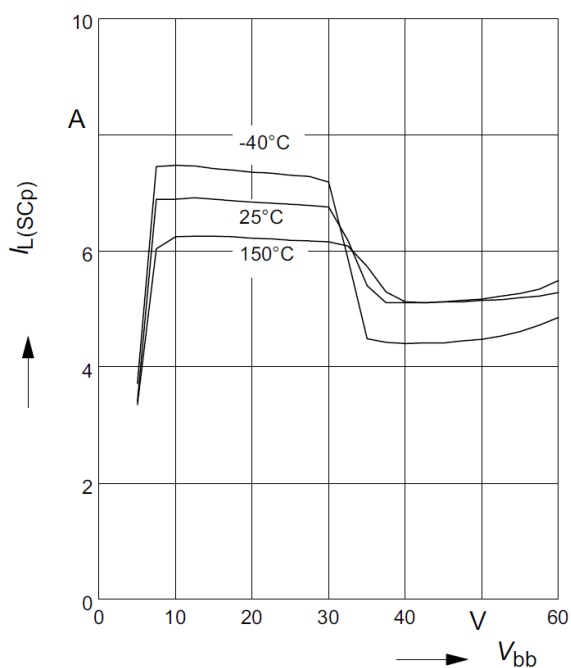


Typ. leakage current $I_{L(off)} = f(T_j)$

$V_{bb} = 42 \text{ V}$; $V_{IN} = \text{low}$

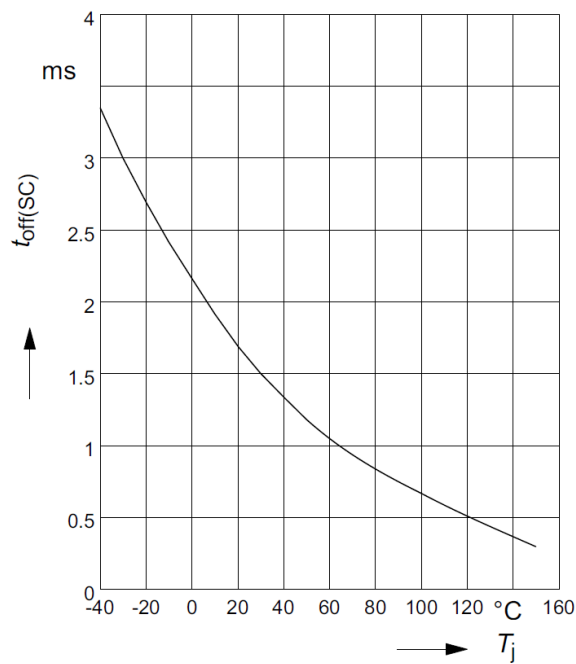


Typ. initial peak short circuit current limit $I_{L(SCP)} = f(V_{bb})$



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

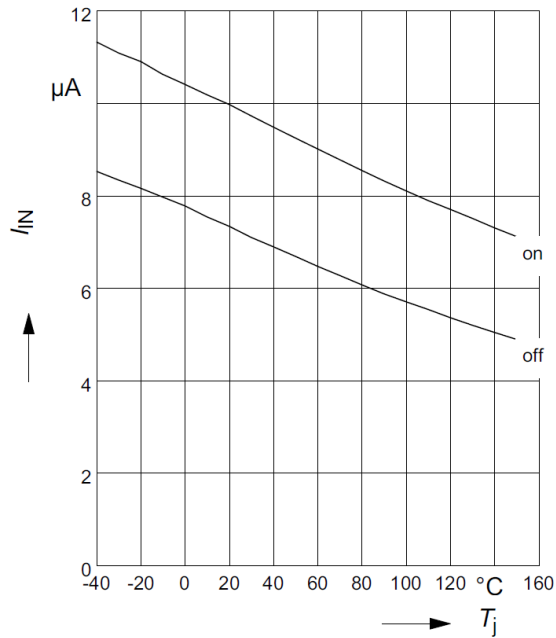
$V_{bb} = 20 \text{ V}$



Functional description and electrical characteristics

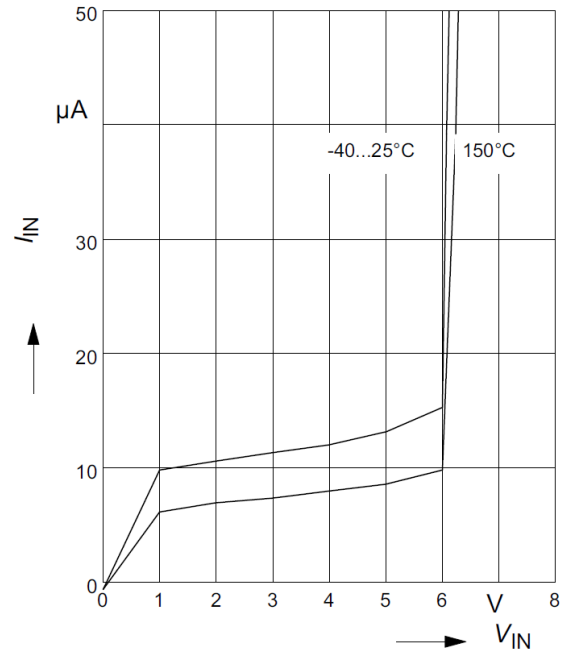
Typ. input current $I_{IN(on/off)} = f(T_j)$

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



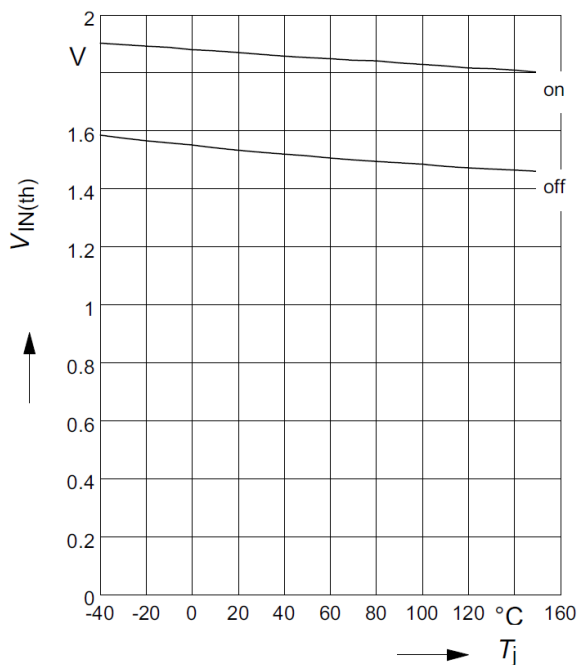
Typ. input current $I_{IN} = f(V_{IN})$

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



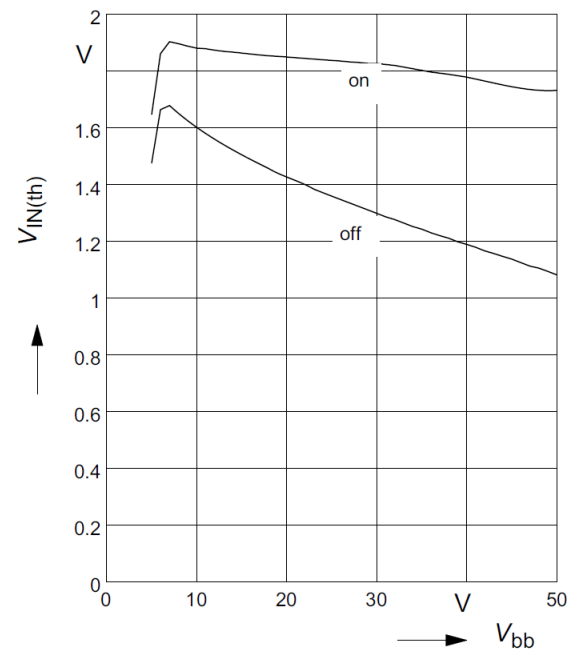
Typ. input threshold voltage $V_{IN(th)} = f(T_j)$

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



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

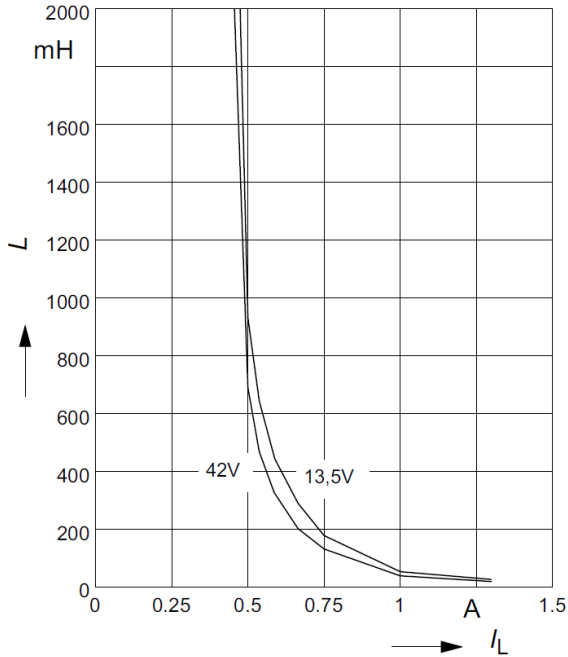
$T_j = 25^\circ\text{C}$



Functional description and electrical characteristics

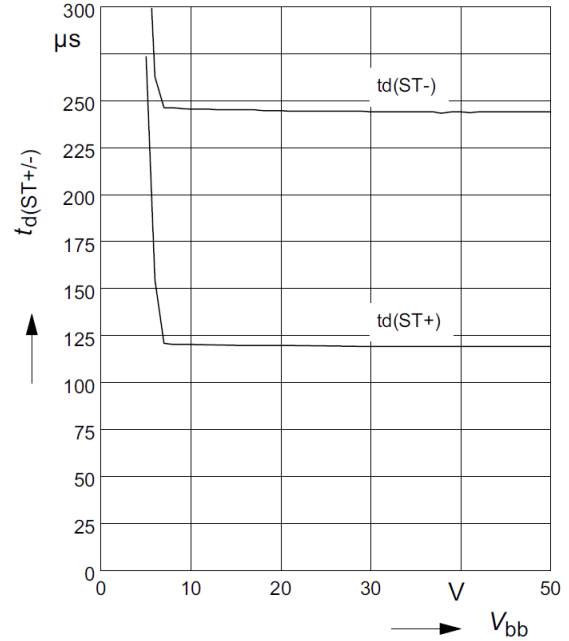
Maximum allowable load inductance for a single switch off $L = f(I_L)$

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



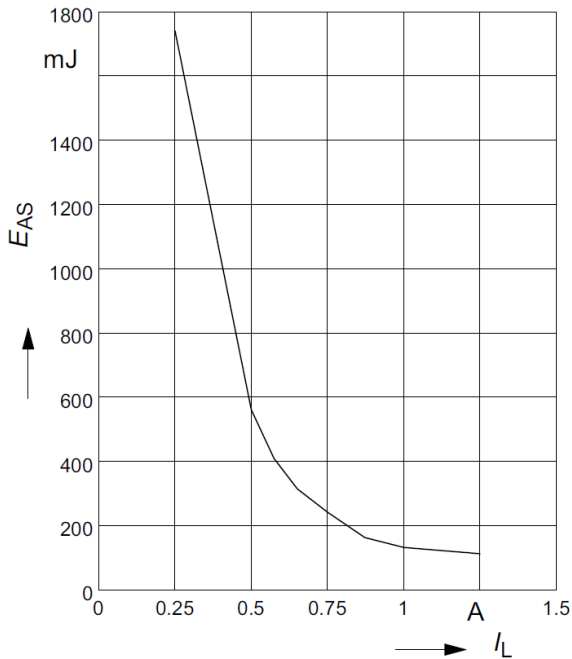
Typ. status delay time $t_{d(ST)} = f(V_{bb})$

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

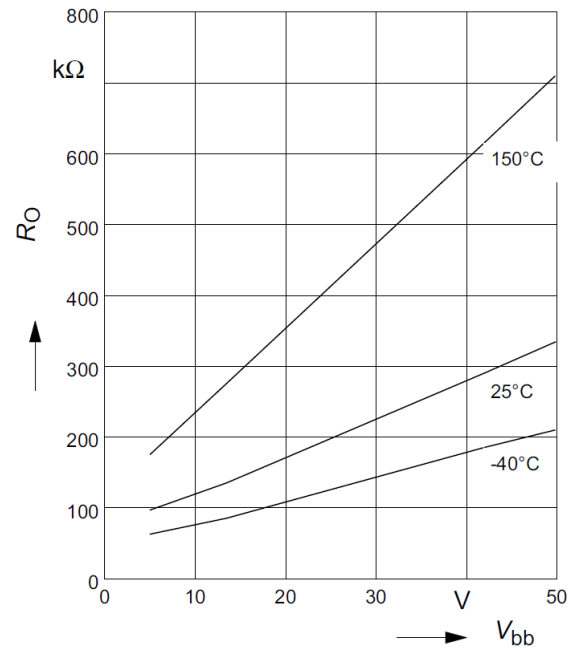


Maximum allowable inductive switch-off energy, single pulse $E_{AS} = f(I_L)$

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

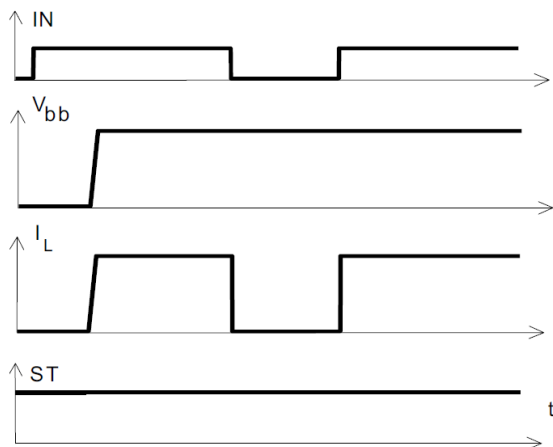


Typ. internal output pull down $R_O = f(V_{bb})$

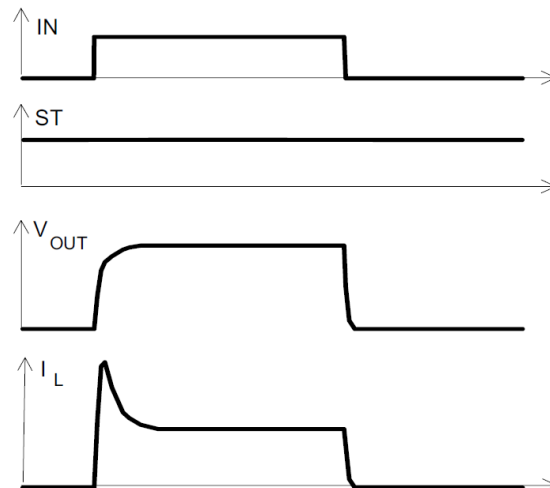


4.4 Timing diagrams

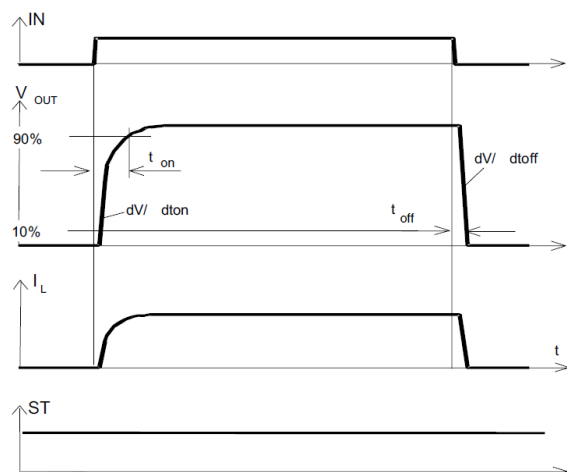
V_{bb} turn on



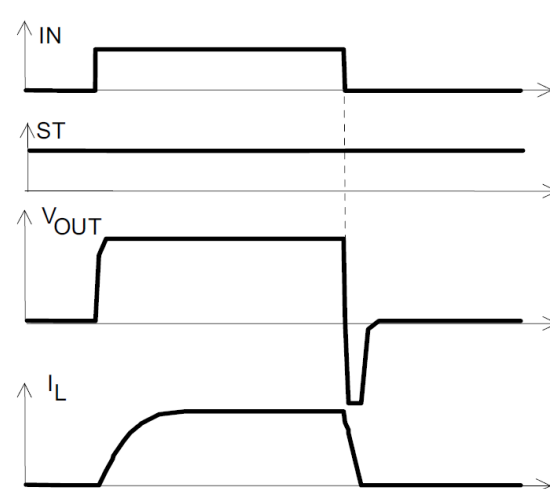
Switching a lamp



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

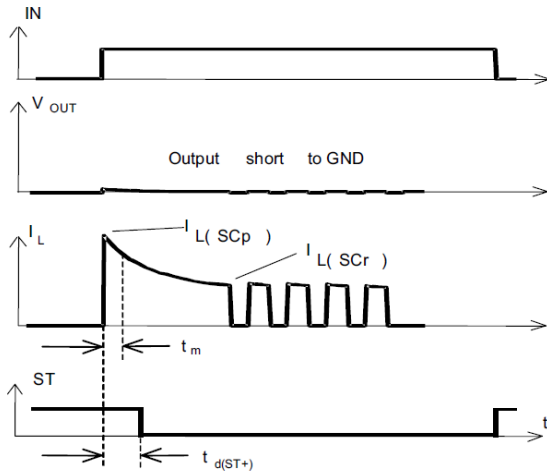


Switching an inductive load



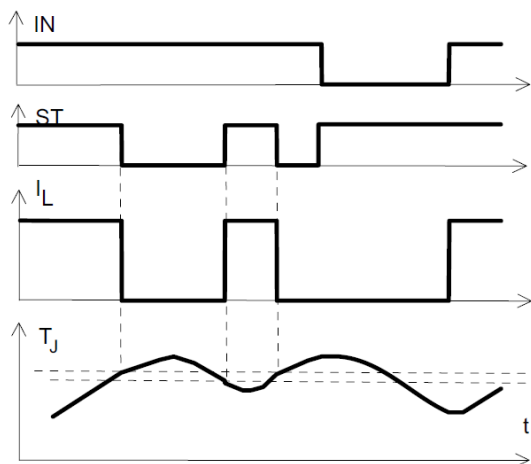
Functional description and electrical characteristics

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

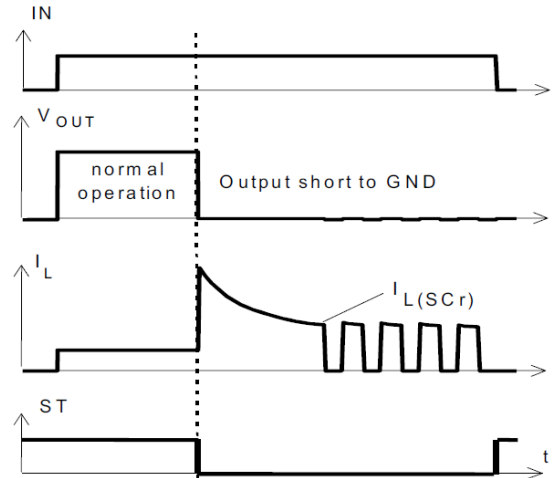


Heating up of the chip may require several milliseconds, depending on external conditions.

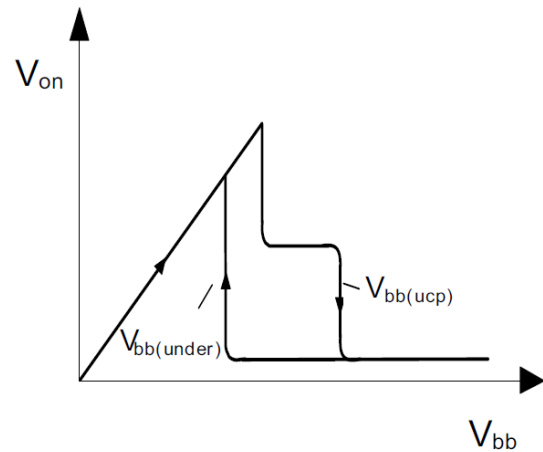
Overtemperature: Reset if $T_j < T_{jt}$



Short circuit in on-state shut down by overtemperature, restart by cooling



Undervoltage restart of charge pump



5 Package information

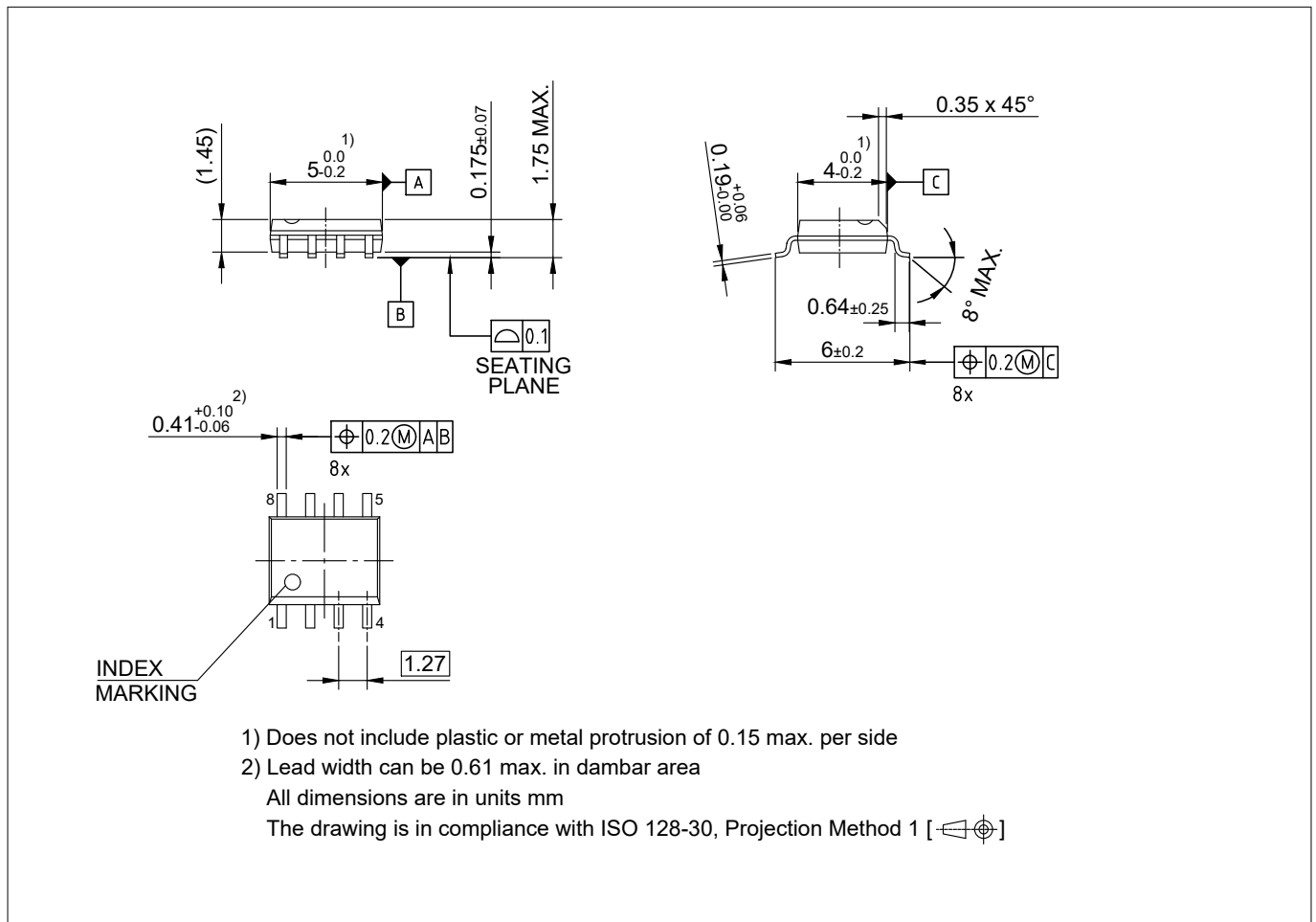


Figure 3 PG-DSO-8

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.

Revision history

6 Revision history

Document version	Date of release	Description of changes
1.2	2019-07-25	Datasheet updated: • ESD ratings for HBM updated according to ANSI/ESDA/JEDEC JS001 • Editorial changes
1.1	2008-09-26	All pages: • Added new Infineon logo • Initial version of RoHS-compliant derivate of the ISP752R Page 1 and 17: • Added RoHS compliance statement and Green product feature • Package changed to RoHS compliant version Page 18: Added Revision history Page 19: Update of disclaimer

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Edition 2019-07-25

Published by

Infineon Technologies AG
81726 Munich, Germany

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Document reference
IFX-Z8F64610014

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