

Smart Power High-Side-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
- CMOS compatible input
- Loss of GND and loss of V_{bb} protection
- ESD - Protection
- Very low standby current

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	41	V
Operating voltage	$V_{bb(on)}$	5...34	V
On-state resistance	R_{ON}	100	m Ω
Nominal load current	$I_{L(nom)}$	2	A



P-DSO-8

Application

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

General Description

N channel vertical power FET with charge pump, ground referenced CMOS compatible input, monolithically integrated in Smart SIPMOS® technology. Fully protected by embedded protection functions.

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

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

Parameter	Symbol	Value	Unit
Supply voltage	V_{bb}	40	V
Supply voltage for full short circuit protection $T_j = -40\dots+150^\circ\text{C}$	$V_{bb(SC)}$	V_{bb}	
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	μA
Operating temperature	T_j	-40 ... +150	$^\circ\text{C}$
Storage temperature	T_{stg}	-55 ... +150	
Power dissipation ¹⁾	P_{tot}	1.5	W
Inductive load switch-off energy dissipation ¹⁾²⁾ single pulse, (see page 8) $T_j=150^\circ\text{C}$, $V_{bb} = 13.5\text{ V}$, $I_L = 1\text{ A}$	E_{AS}	870	mJ
Load dump protection ²⁾ $V_{LoadDump}^{3)} = V_A + V_S$ $R_I=2\Omega$, $t_d=400\text{ms}$, $V_{IN} = \text{low or high}$, $V_A=13.5\text{V}$ $R_L = 13.5\ \Omega$	$V_{Loaddump}$	60	V
Electrostatic discharge voltage (Human Body Model) according to MIL STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993 Input pin all other pins	V_{ESD}		kV
		± 1	
		± 5	

Thermal Characteristics

Thermal resistance @ min. footprint	$R_{th(JA)}$	-	95	-	K/W
Thermal resistance @ 6 cm ² cooling area ¹⁾	$R_{th(JA)}$	-	70	83	

¹ Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6 cm² (one layer, 70 μm thick) copper area for drain connection. PCB is vertical without blown air. (see page 16)

²not tested, 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 150 Ω resistor in GND connection. A resistor for the protection of the input is integrated.

Electrical Characteristics

Parameter	Symbol	Values			Unit
		min.	typ.	max.	

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

Load Switching Capabilities and Characteristics

On-state resistance $T_j = 25^{\circ}\text{C}$, $I_L = 2\text{ A}$ $T_j = 150^{\circ}\text{C}$	R_{ON}	-	70 140	100 200	mΩ
Nominal load current; Device on PCB ¹⁾ $T_C = 85^{\circ}\text{C}$, $T_j \leq 150^{\circ}\text{C}$	$I_{L(nom)}$	2	2.4	-	A
Turn-on time to 90% V_{OUT} $R_L = 47\ \Omega$	t_{on}	-	90	170	μs
Turn-off time to 10% V_{OUT} $R_L = 47\ \Omega$	t_{off}	-	90	230	
Slew rate on 10 to 30% V_{OUT} , $R_L = 47\ \Omega$	dV/dt_{on}	-	0.8	1.7	V/μs
Slew rate off 70 to 40% V_{OUT} , $R_L = 47\ \Omega$	$-dV/dt_{off}$	-	0.8	1.7	

Operating Parameters

Operating voltage	$V_{bb(on)}$	5	-	34	V
Undervoltage shutdown of charge pump $T_j = -40...+85^{\circ}\text{C}$ $T_j = 150^{\circ}\text{C}$	$V_{bb(under)}$	- -	- -	4 5.5	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	4	5.5	V
Standby current $V_{IN} = 0\text{ V}$, $T_j = -40 \dots +85^{\circ}\text{C}$ $V_{IN} = 0\text{ V}$, $T_j = 150^{\circ}\text{C}$ ²⁾	$I_{bb(off)}$	- -	- -	10 15	μA
Leakage output current (included in $I_{bb(off)}$) $V_{IN} = 0\text{ V}$	$I_{L(off)}$	-	-	5	
Operating current $V_{IN} = 5\text{ V}$	I_{GND}	-	0.5	1.3	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. (see page 16)

²⁾ higher current due temperature sensor

Electrical Characteristics

Parameter and Conditions at $T_j = -40...+150^\circ\text{C}$, $V_{bb}=13.5\text{V}$, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	

Protection Functions

Initial peak short circuit current limit (pin 5 to 3) $T_j = -40^\circ\text{C}$, $V_{bb} = 20\text{V}$, $t_m = 150\text{ }\mu\text{s}$ $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{L(SCp)}$	- - 4	- 10 -	18 - -	A
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$	-	7	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, $I_{bb} = 4\text{ mA}$	$V_{ON(CL)}$	41	47	-	V
Overvoltage protection ¹⁾ $I_{bb} = 4\text{ mA}$	$V_{bb(AZ)}$	41	-	-	
Thermal overload trip temperature	T_{jt}	150	-	-	$^\circ\text{C}$
Thermal hysteresis	ΔT_{jt}	-	10	-	K

Reverse Battery

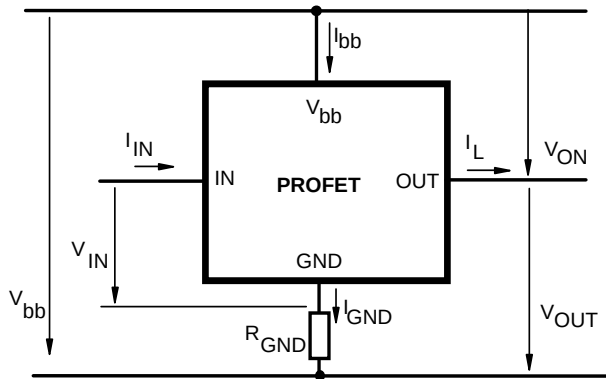
Reverse battery ²⁾	$-V_{bb}$	-	-	32	V
Drain-source diode voltage ($V_{OUT} > V_{bb}$) $T_j = 150^\circ\text{C}$	$-V_{ON}$	-	600	-	mV

¹see also $V_{ON(CL)}$ in circuit diagram on page 7

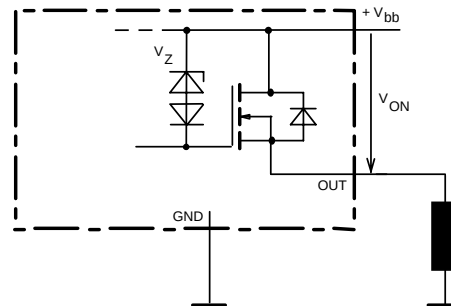
²Requires a $150\text{ }\Omega$ resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection is not active during reverse current operation! Input current has to be limited (see max. ratings page 3).

Parameter and Conditions at $T_j = -40...+150^{\circ}\text{C}$, $V_{bb}=13.5\text{V}$, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Input					
Input turn-on threshold voltage (see page 12)	$V_{\text{IN(T+)}}$	-	-	2.2	V
Input turn-off threshold voltage (see page 12)	$V_{\text{IN(T-)}}$	0.8	-	-	
Input threshold hysteresis	$\Delta V_{\text{IN(T)}}$	-	0.3	-	V
Off state input current (see page 12) $V_{\text{IN}} = 0.7 \text{ V}$	$I_{\text{IN(off)}}$	1	-	25	μA
On state input current (see page 12) $V_{\text{IN}} = 5 \text{ V}$	$I_{\text{IN(on)}}$	3	-	25	
Input resistance (see page 7)	R_{I}	1.5	3.5	5	$\text{k}\Omega$

Terms

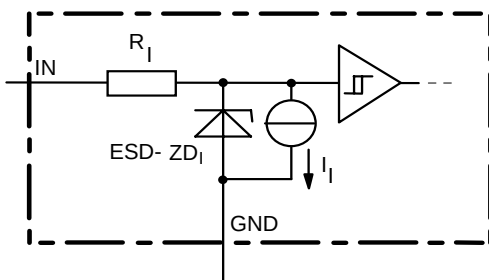


Inductive and overvoltage output clamp



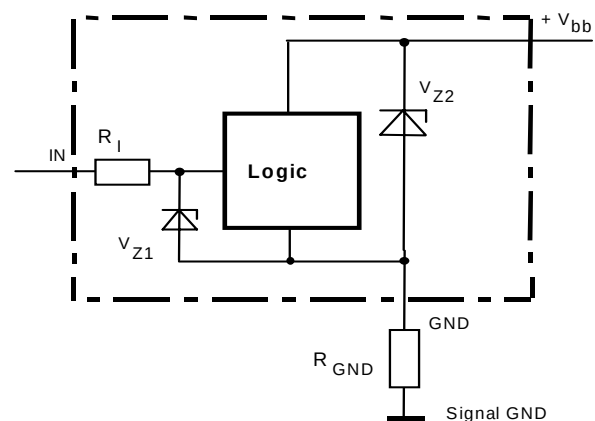
V_{ON} clamped to 47 V typ.

Input circuit (ESD protection)



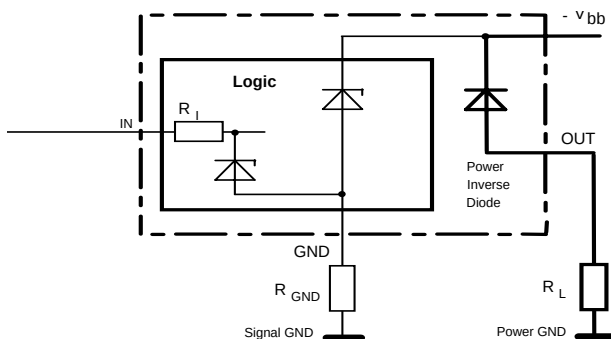
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



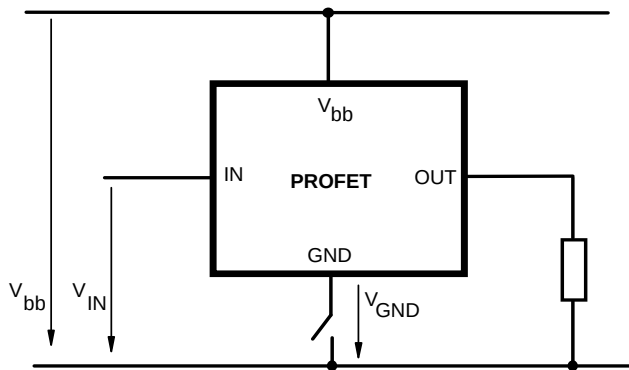
$V_{Z1}=6.1\text{V typ.}$, $V_{Z2}=V_{bb(AZ)}=47\text{V typ.}$,
 $R_I=3.5\text{ k}\Omega\text{ typ.}$, $R_{GND}=150\Omega$

Reverse battery protection

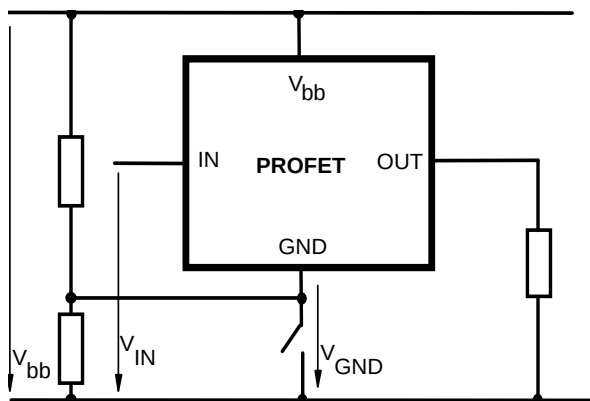


$R_{GND}=150\Omega$, $R_I=3.5\text{ k}\Omega\text{ typ.}$,
 Temperature protection is not active during inverse current

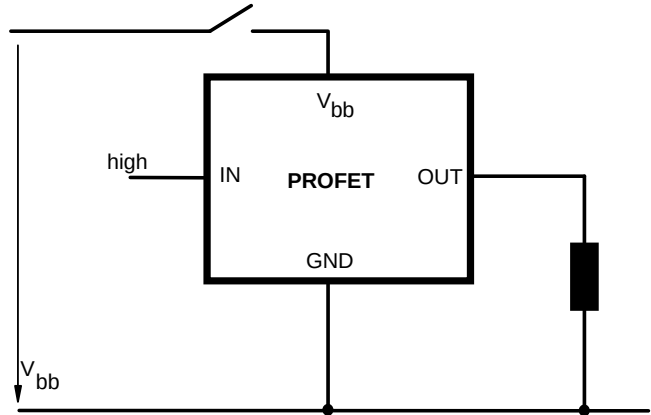
GND disconnect



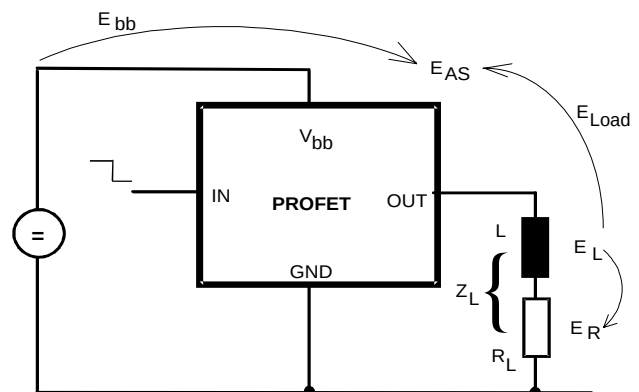
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation



Energy stored in load inductance: $E_L = \frac{1}{2} * L * I_L^2$

While demagnetizing load inductance,

the energy dissipated in PROFET is

$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t) dt,$$

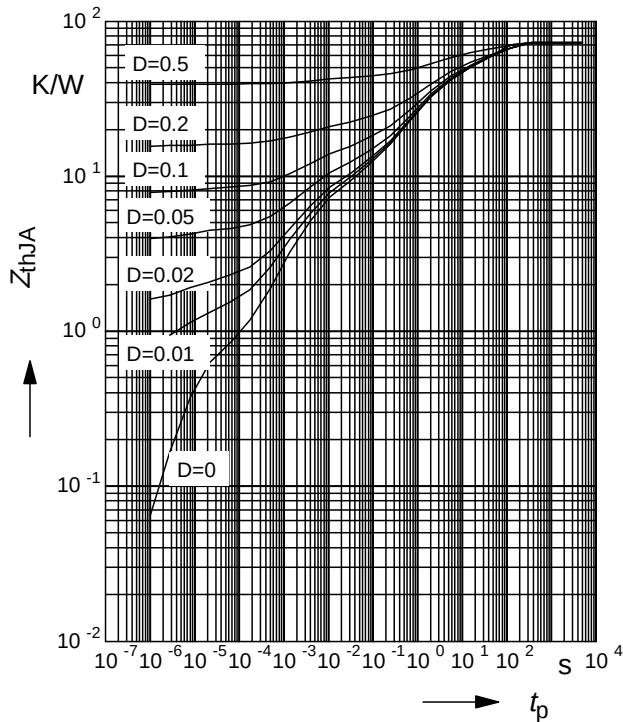
with an approximate solution for $R_L > 0\Omega$:

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

Typ. transient thermal impedance

$Z_{thJA}=f(t_p)$ @ 6cm² heatsink area

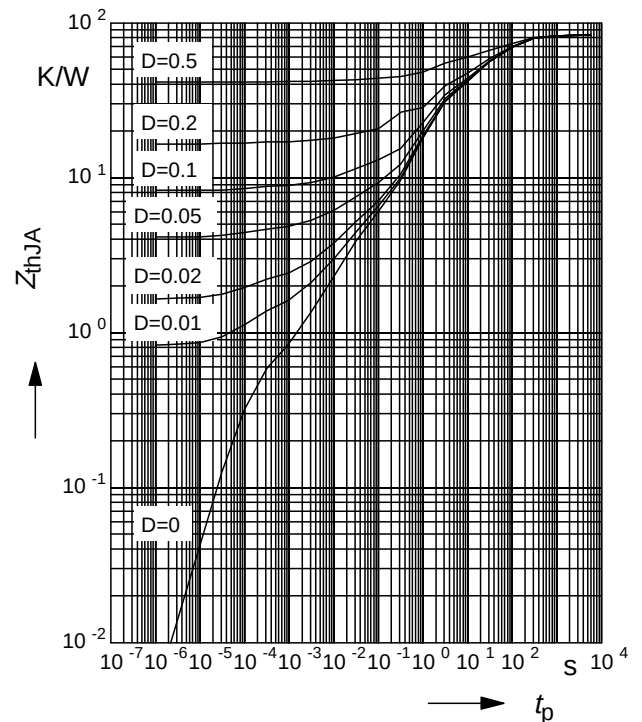
Parameter: $D=t_p/T$



Typ. transient thermal impedance

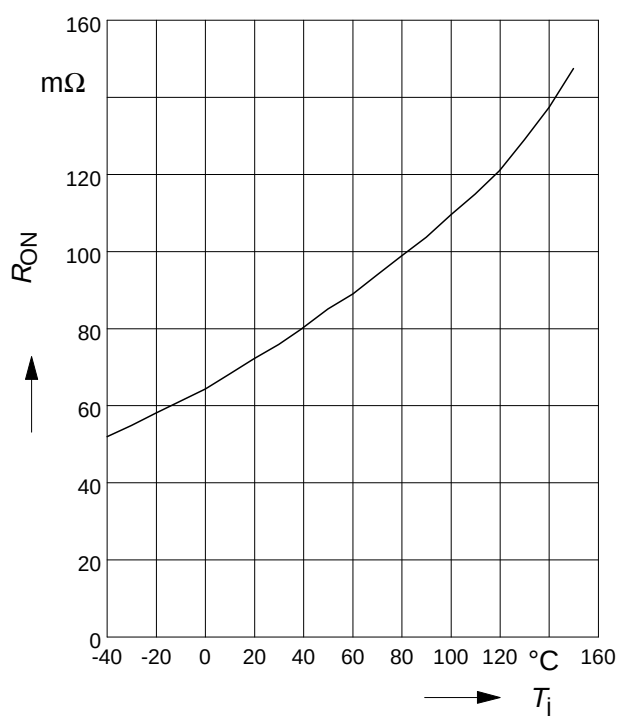
$Z_{thJA}=f(t_p)$ @ min. footprint

Parameter: $D=t_p/T$



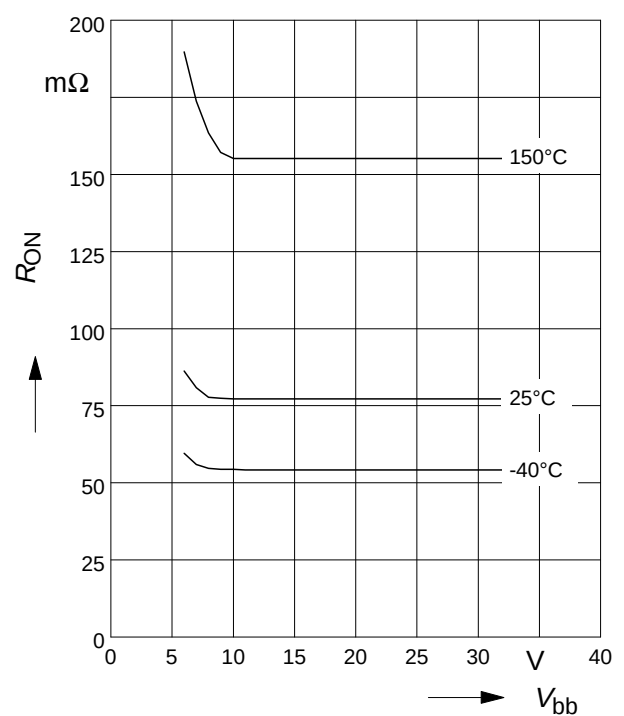
Typ. on-state resistance

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



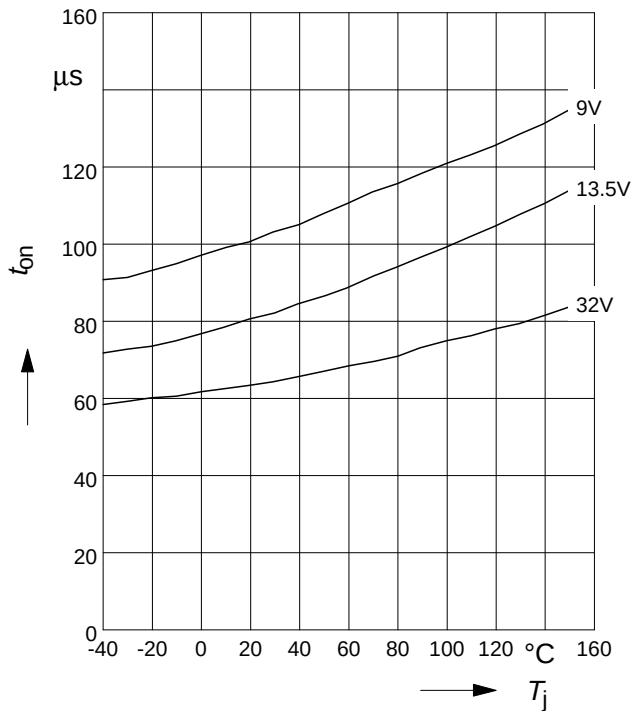
Typ. on-state resistance

$R_{ON} = f(V_{bb})$; $I_L = 0.5A$; $V_{in} = \text{high}$



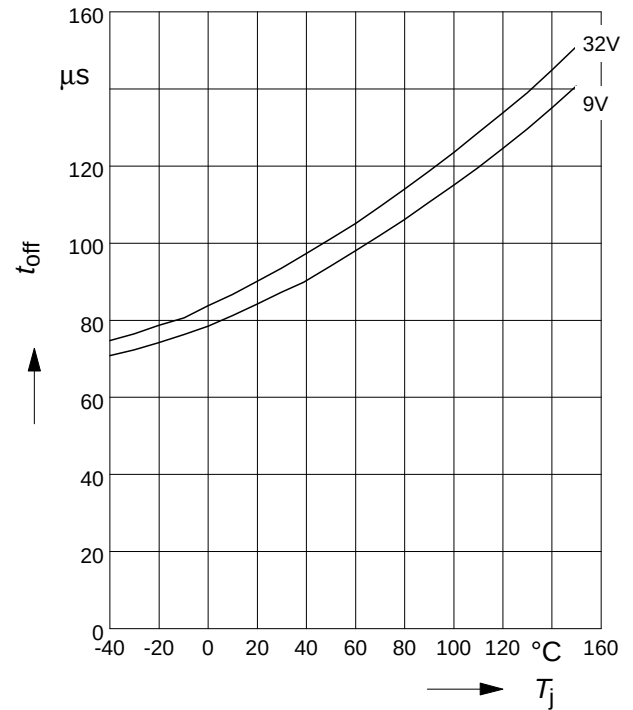
Typ. turn on time

$$t_{on} = f(T_j); R_L = 47\Omega$$



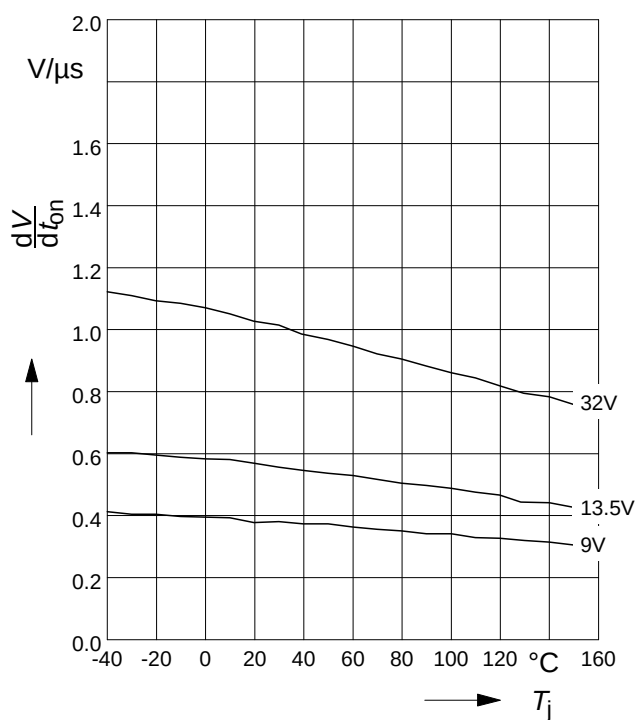
Typ. turn off time

$$t_{off} = f(T_j); R_L = 47\Omega$$



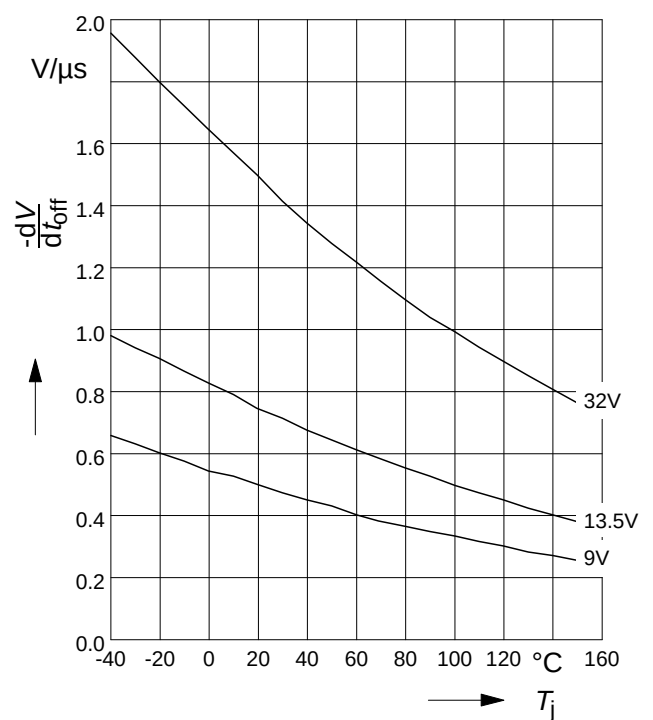
Typ. slew rate on

$$dV/dt_{on} = f(T_j); R_L = 47\Omega$$



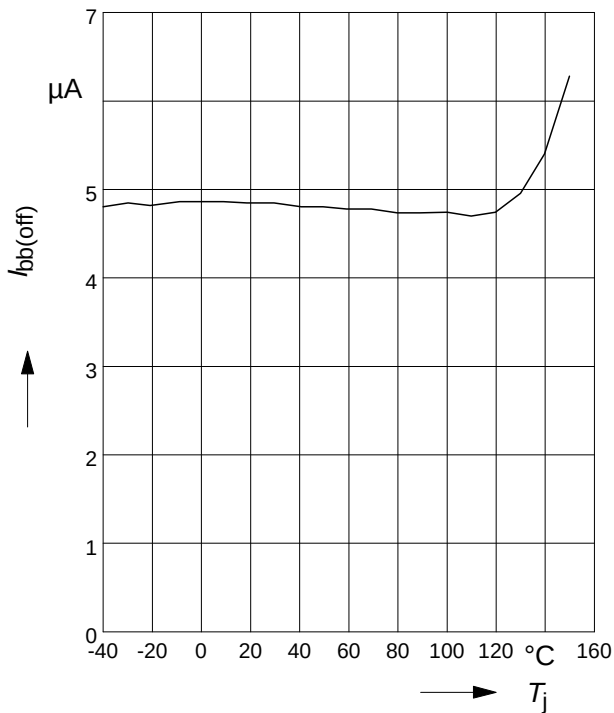
Typ. slew rate off

$$dV/dt_{off} = f(T_j); R_L = 47\Omega$$



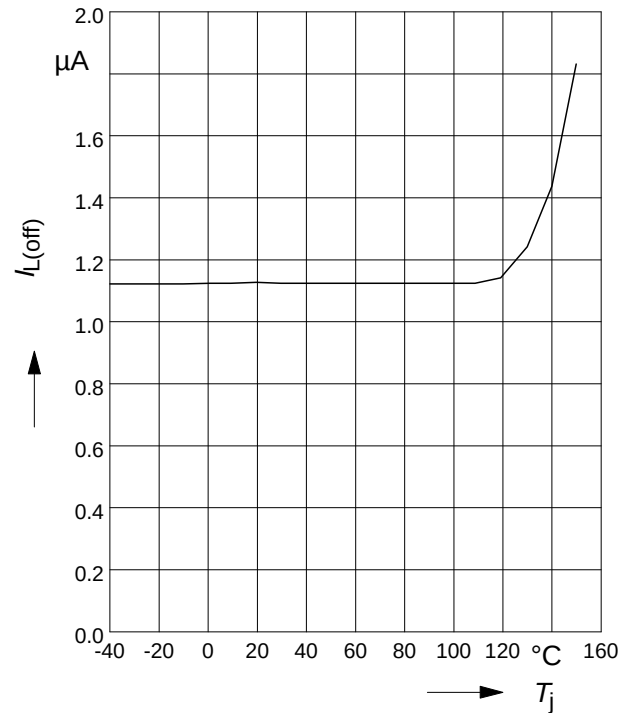
Typ. standby current

$$I_{bb(off)} = f(T_j) ; V_{bb} = 32V ; V_{IN} = low$$



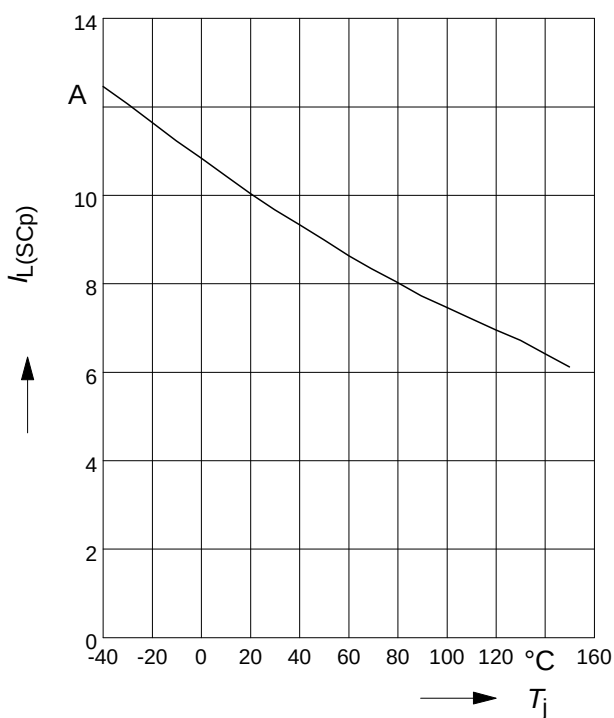
Typ. leakage current

$$I_{L(off)} = f(T_j) ; V_{bb} = 32V ; V_{IN} = low$$



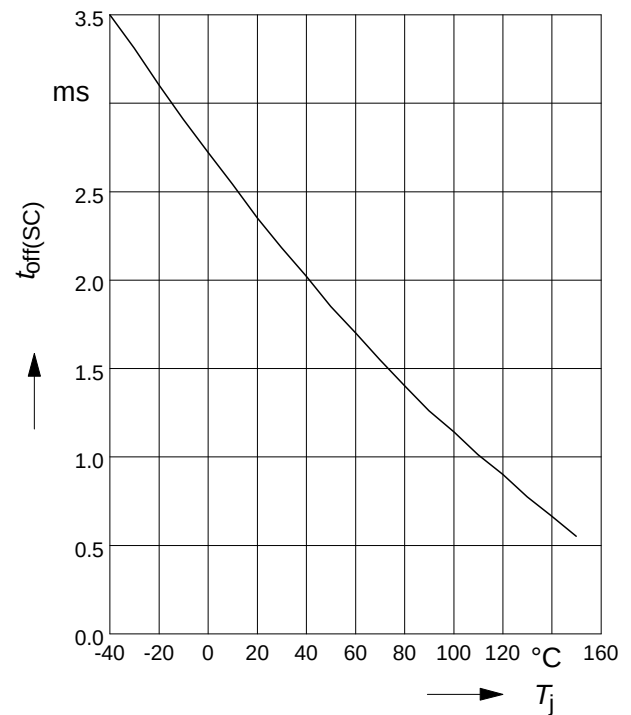
Typ. initial peak short circuit current limit

$$I_{L(SCp)} = f(T_j) ; V_{bb} = 20V$$



Typ. initial short circuit shutdown time

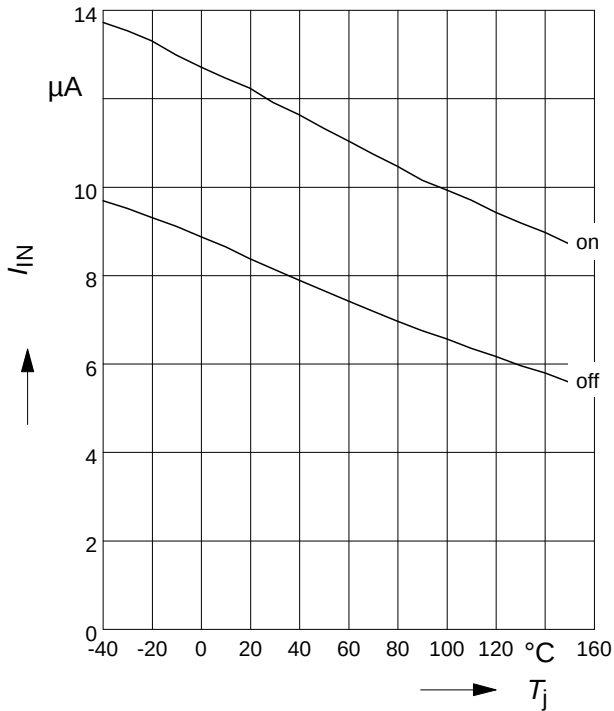
$$t_{off(SC)} = f(T_{j,start}) ; V_{bb} = 20V$$



Typ. input current

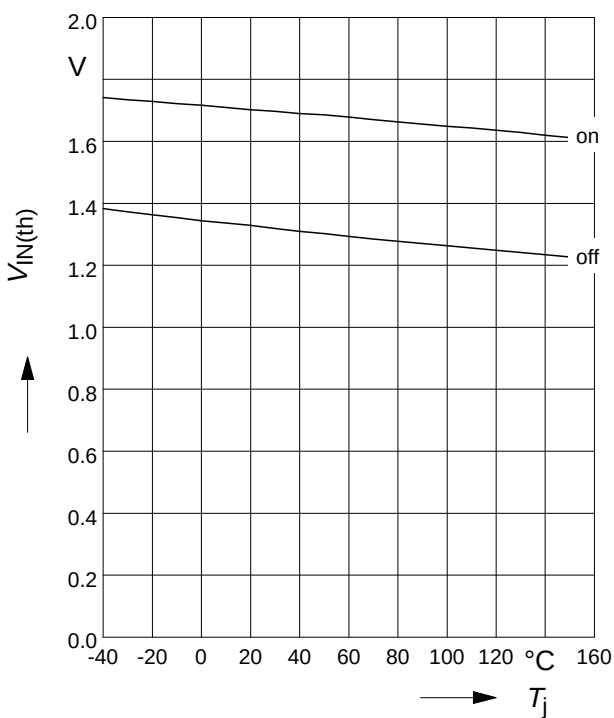
$I_{IN(on/off)} = f(T_j)$; $V_{bb} = 13,5V$; $V_{IN} = \text{low/high}$

$V_{INlow} \leq 0,7V$; $V_{INhigh} = 5V$



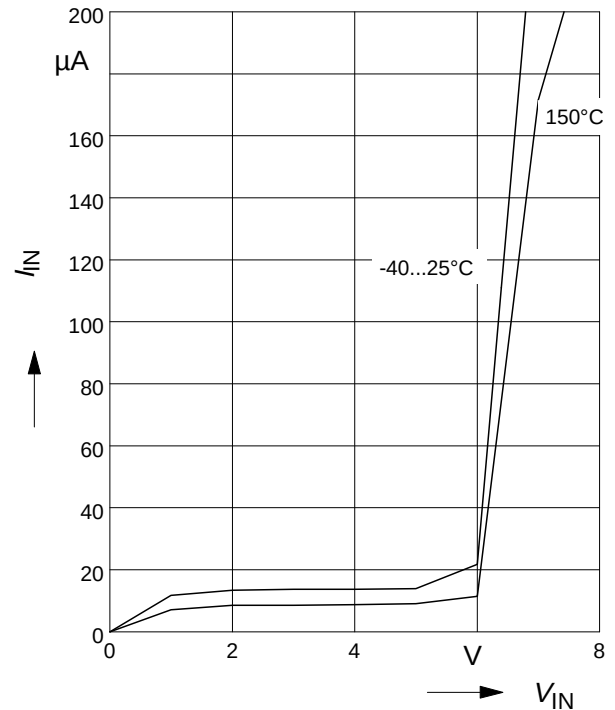
Typ. input threshold voltage

$V_{IN(th)} = f(T_j)$; $V_{bb} = 13,5V$



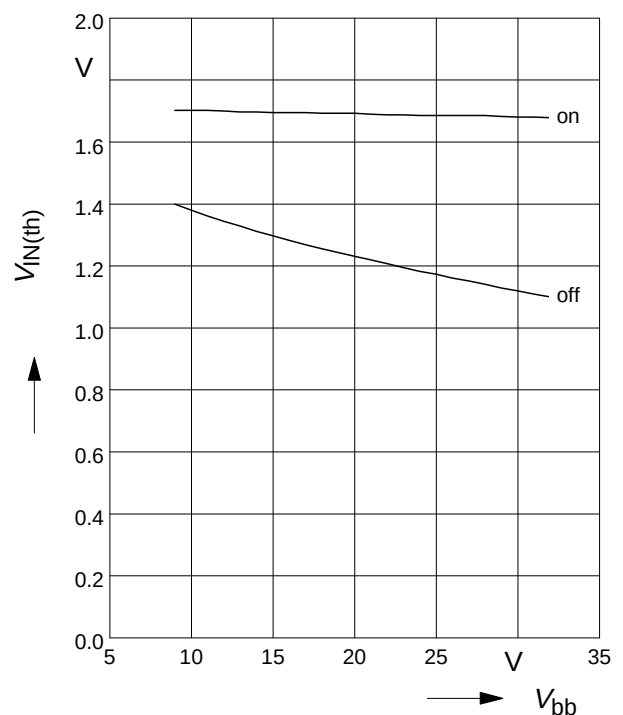
Typ. input current

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



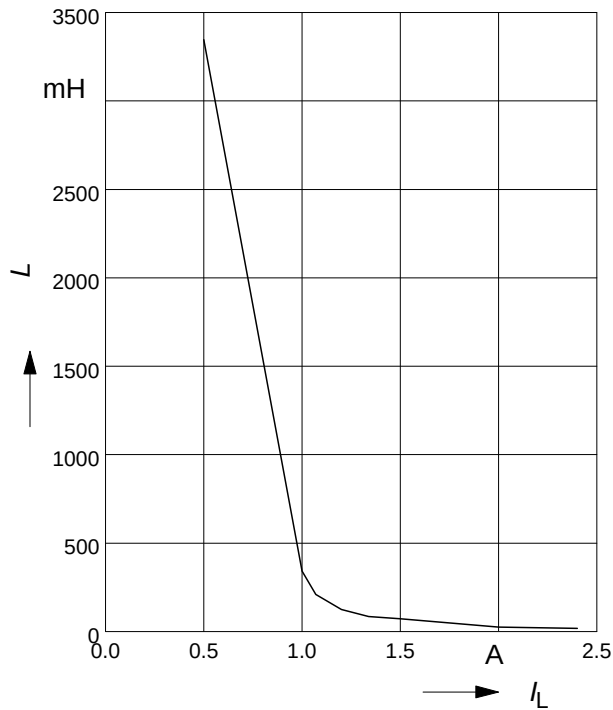
Typ. input threshold voltage

$V_{IN(th)} = f(V_{bb})$; $T_j = 25°C$



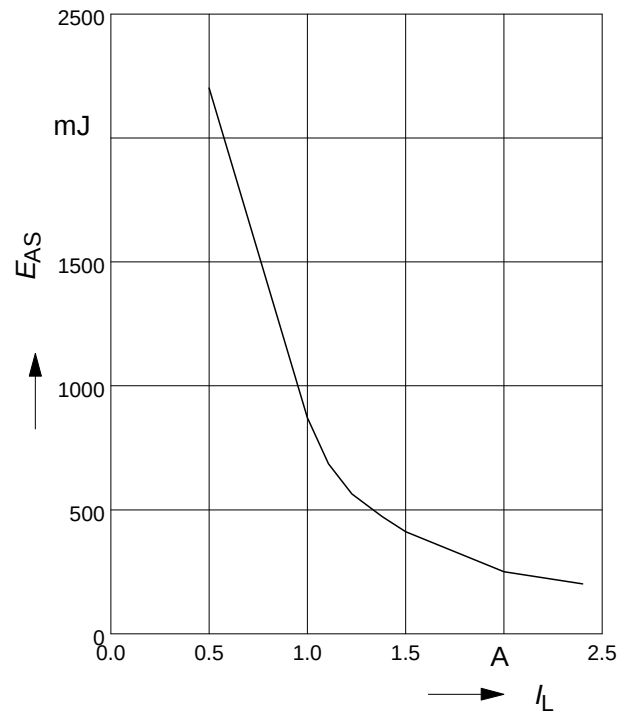
Maximum allowable load inductance for a single switch off

$L = f(I_L)$; $T_{jstart}=150^{\circ}\text{C}$, $V_{bb}=13.5\text{V}$, $R_L=0\Omega$



Maximum allowable inductive switch-off energy, single pulse

$E_{AS} = f(I_L)$; $T_{jstart} = 150^{\circ}\text{C}$, $V_{bb} = 13.5\text{V}$



Timing diagrams

Figure 1a: V_{bb} turn on:

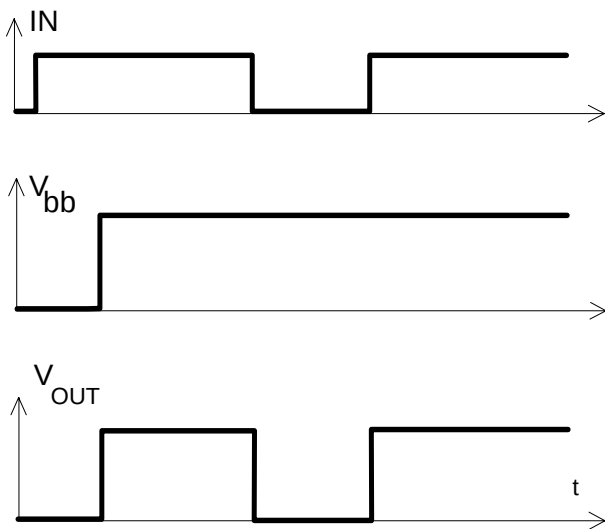


Figure 2b: Switching a lamp,

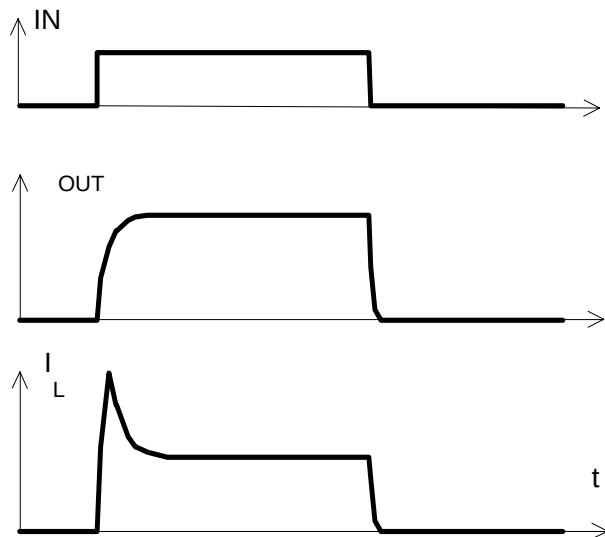


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

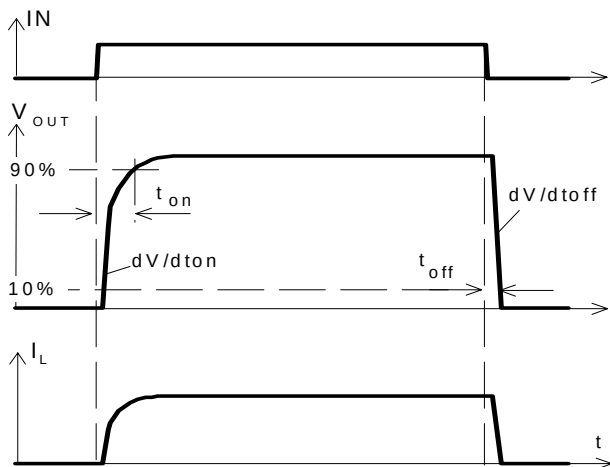


Figure 2c: Switching an inductive load

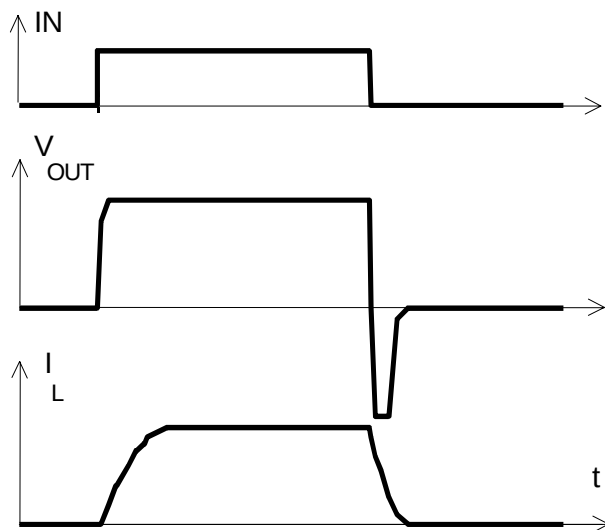
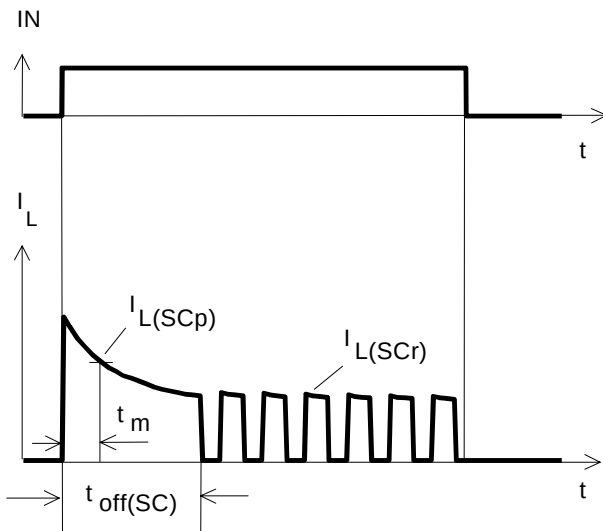


Figure 3a: Turn on into short circuit, shut down by overtemperature, restart by cooling



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

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

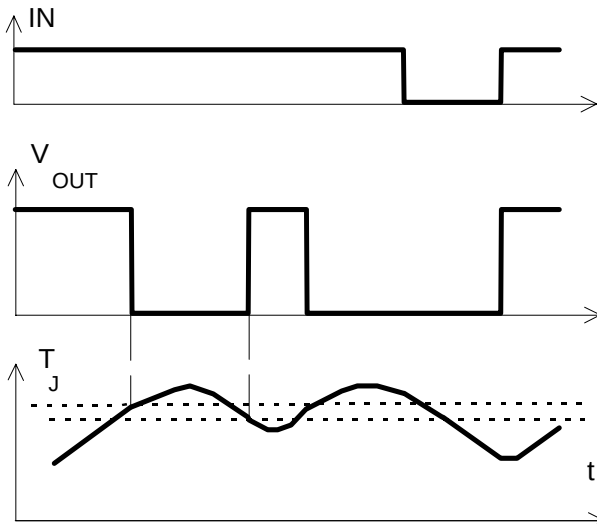
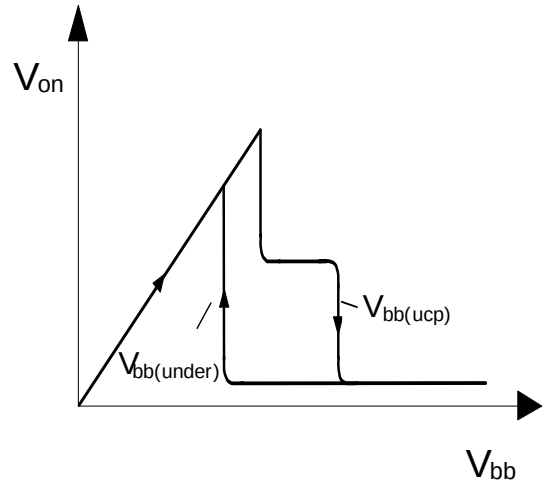


Figure 5: Undervoltage restart of charge pump

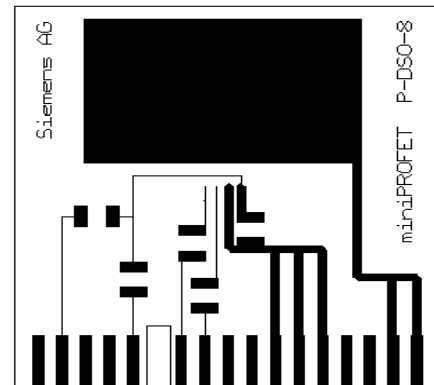
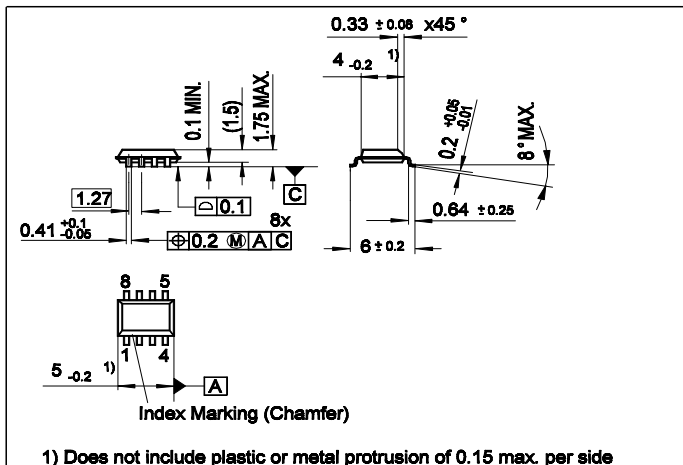


Package and ordering code

all dimensions in mm

Ordering code:

Q67060-S7301-A2



Printed circuit board (FR4, 1.5mm thick, one layer 70µm, 6cm² active heatsink area) as a reference for max. power dissipation P_{tot} nominal load current $I_{L(nom)}$ and thermal resistance R_{thja}

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