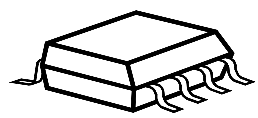
Smart Power High-Side-Switch

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
- Open load detection in OFF - State
- CMOS compatible input
- Loss of GND and loss of V_{bb} protection
- ESD - Protection
- Very low standby current
- Open drain diagnostic output

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	41	V
Operating voltage	$V_{bb(on)}$	5...34	V
On-state resistance	R_{ON}	400	mΩ
Nominal load current	$I_{L(nom)}$	0.4	A



P-DSO-8

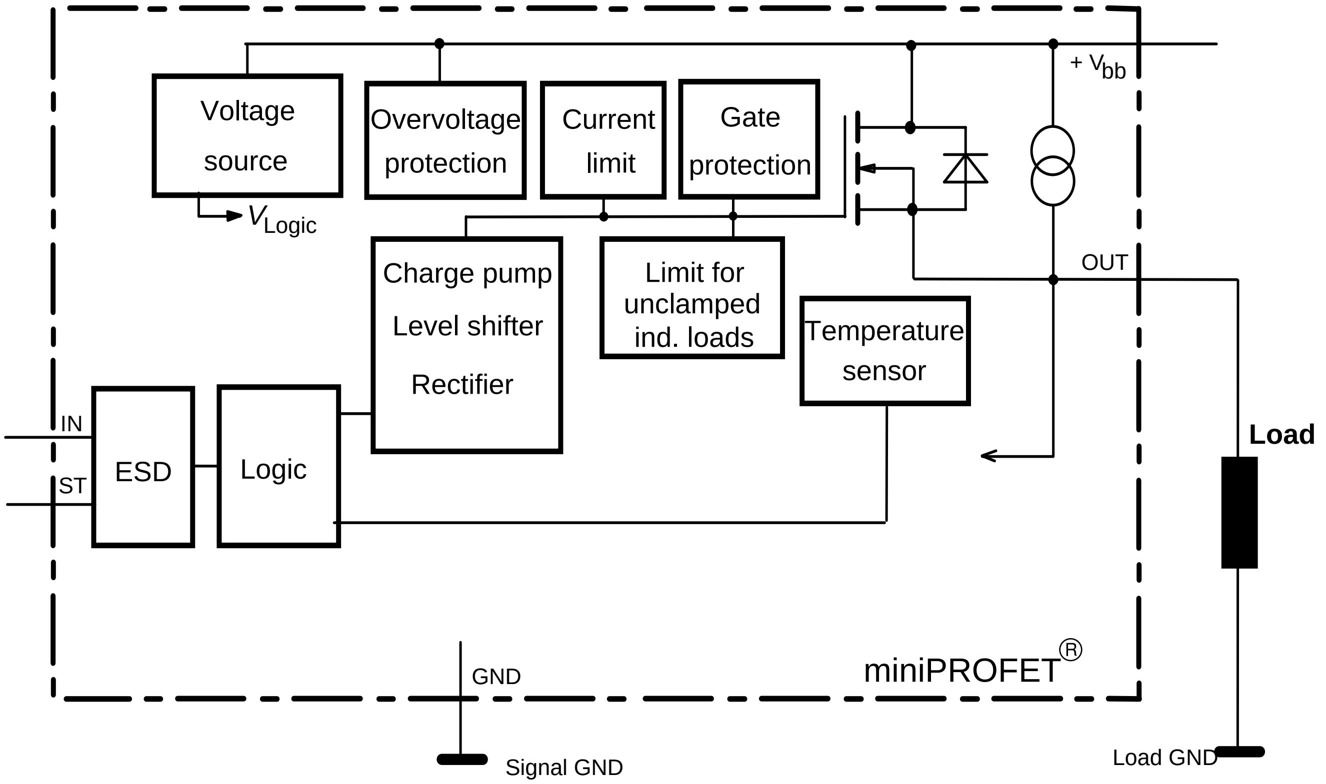
Application

- All types of resistive, inductive and capacitive loads
- µC 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 and diagnostic feedback, monolithically integrated in Smart SIPMOS ® technology.
Fully protected by embedded protection functions.

Block Diagram



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

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

Parameter	**Symbol**	**Value**	**Unit**
Supply voltage	V_{bb}	40	V
Supply voltage for full short circuit protection	$V_{bb(SC)}$	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	°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 9) Tj =150 °C, V_{bb} = 13.5 V, I_L = 0.3 A	E_{AS}	800	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 = 45 Ω	$V_{Loaddump}$	60	V
Electro**s**tatic **d**ischarge voltage (Human Body Model) according to MIL STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993	V_{ESD}		kV
Input pin		± 1	
all other pins		± 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, 70µm thick) copper area for drain connection. PCB is vertical without blown air. (see page 17)

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

Electrical Characteristics

Parameter at T_j = -40...+150°C, V_{bb}=13.5V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
Load Switching Capabilities and Characteristics					
On-state resistance T_j = 25 °C, I_L = 0.3 A T_j = 150 °C	R_{ON}	- 	250 450	400 800	mΩ
Nominal load current Device on PCB [2)1)] T_C = 85 °C, $T_j \leq$ 150 °C	$I_{L(nom)}$	0.4	-	-	A
Turn-on time to 90% V_{OUT} R_L = 47 Ω, V_{IN} = 0 to 10 V	t_{on}	-	-	140	µs
Turn-off time to 10% V_{OUT} R_L = 47 Ω, V_{IN} = 10 to 0 V	t_{off}	-	-	170	
Slew rate on 10 to 30% V_{OUT}, R_L = 47 Ω	dV/dt_{on}	-	-	2	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 47 Ω	$-dV/dt_{off}$	-	-	2	

Operating Parameters

Operating voltage	$V_{bb(on)}$	5	-	34	V
Undervoltage shutdown of charge pump	$V_{bb(under)}$	-	-	5	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	-	5.5	V
Standby current V_{IN} = 0 V	$I_{bb(off)}$	-	-	26	µA
Leakage output current (included in $I_{bb(off)}$)	$I_{L(off)}$	-	-	12	
Operating current V_{IN} = 5 V	I_{GND}	-	-	1.3	mA

1 Nominal load current is limited by current limitation (see page 5)

2 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 17)

Electrical Characteristics

Parameter and Conditions at T_j = -40...+150°C, V_{bb}=13.5V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
Protection Functions					
Initial peak short circuit current limit (pin 5 to 3)	$I_{L(SCp)}$				A
T_j = -40 °C, V_{bb} = 20 V		-	-	2	
T_j = 25 °C		-	1.2	-	
T_j = 150 °C		0.4	-	-	
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$	-	1	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_{bb} = 4 mA	$V_{ON(CL)}$	41	47	-	V
Overvoltage protection [1)] I_{bb} = 4 mA	$V_{bb(AZ)}$	41	-	-	
Thermal overload trip temperature	T_{jt}	150	-	-	°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 °C	$-V_{ON}$	-	600	-	mV

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

[2]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 and status currents has to be limited (see max. ratings page 3).

Electrical Characteristics

Parameter at T_j = -40...+150°C, V_{bb}=13.5V, unless otherwise specified	Symbol	Values min.	typ.	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	$\Delta V_{IN(T)}$	-	0.3	-	
Off state input current V_{IN} = 0.7 V	$I_{IN(off)}$	1	-	30	µA
On state input current V_{IN} = 5 V	$I_{IN(on)}$	1	-	30	
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 input slope [1]	$t_{d(ST)}$	-	300	600	µs
Input resistance (see page 8)	R_I	1.5	3.5	5	kΩ

Diagnostic Characteristics

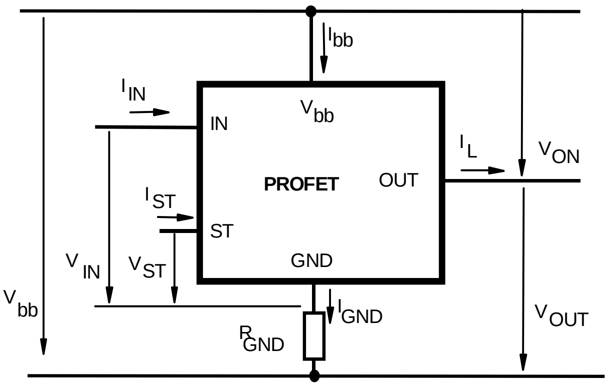
Short circuit detection voltage	$V_{OUT(SC)}$	-	2.8	-	V
Openload detection voltage	$V_{OUT(OL)}$	-	3	-	
Openload detection current included in standby current $I_{bb(off)}$	$I_{L(OL)}$	-	5	-	µA

[1] No delay time after overtemperature switch off and short circuit in on-state

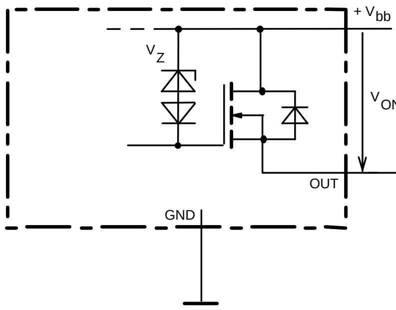
	Input level	Output level	Status
Normal operation	L H	L H	L L
Short circuit to GND	L H	L L *	L H
Short circuit to V_{bb} (in off-state)	L H	H H	H L
Overload	L H	L H **	L L
Overtemperature	L H	L L	L H
Open Load in off-state	L H	H H	H L

*) Out ="L": V_{OUT} < 2V typ.
**) Out ="H": V_{OUT} > 2V typ.

Terms

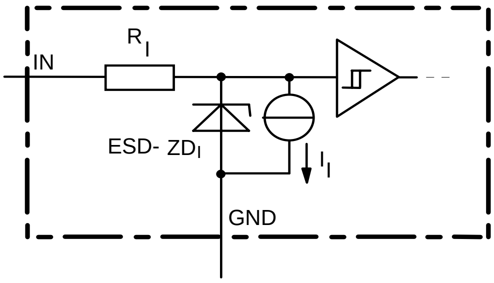


Inductive and overvoltage output clamp



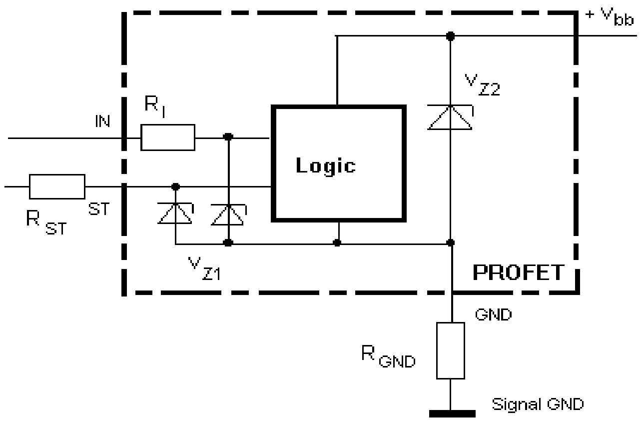
V_{ON} clamped to 47 V typ.

Input circuit (ESD protection)



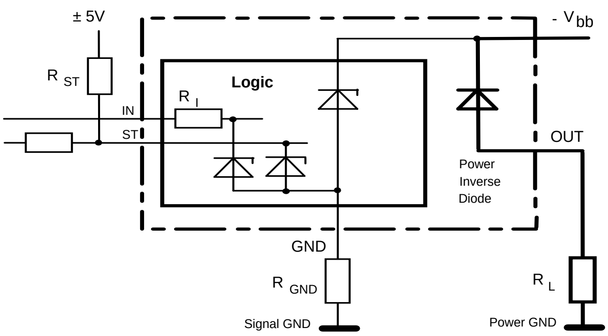
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



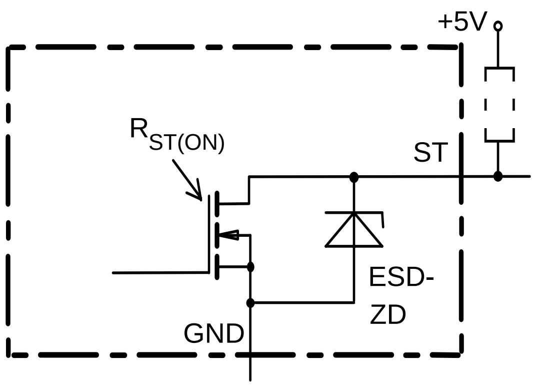
V_{Z1}=6.1V typ., V_{Z2}=$V_{bb(AZ)}$=47V typ.,
R_I=3.5 kΩ typ., R_{GND}=150Ω

Reverse battery protection



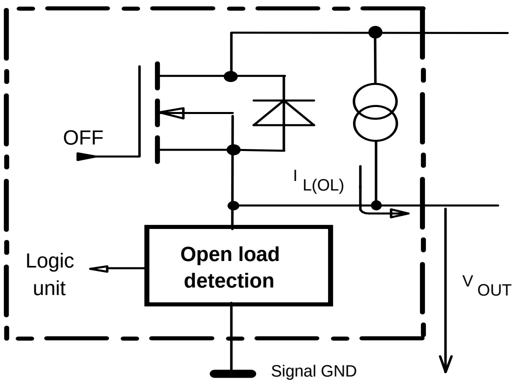
R_{GND}=150Ω, R_I=3.5kΩ typ.,
Temperature protection is not active during inverse current

Status output

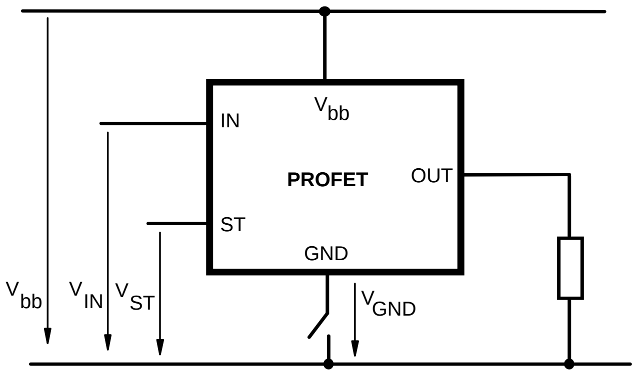


Open-load detection

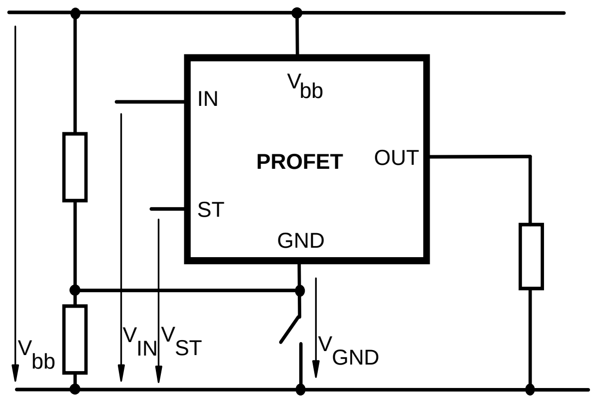
OFF-state diagnostic condition:
V_{OUT} > 3V typ.; IN=low



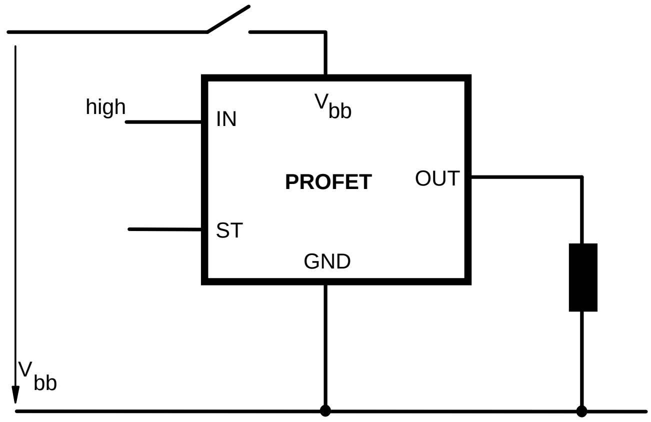
GND disconnect



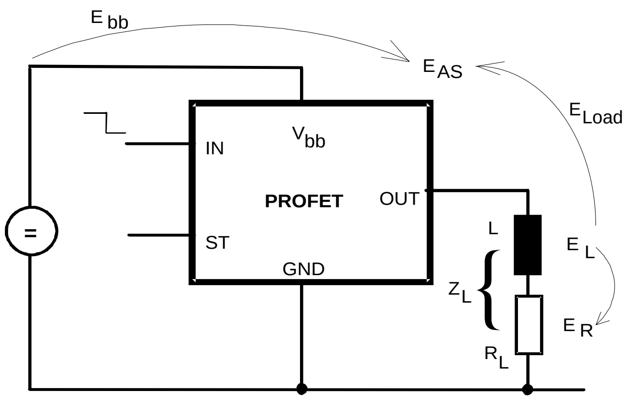
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation



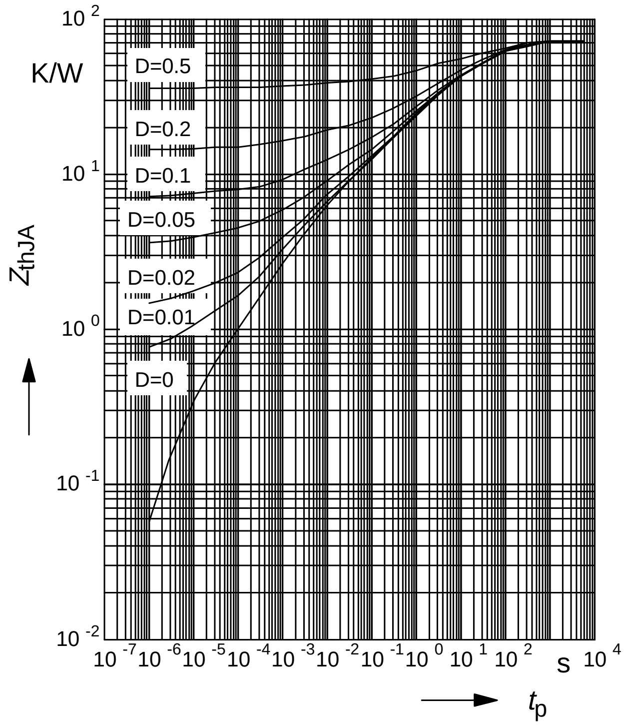
Energy stored in load inductance: $E_L = ½ * L * I_L^2$
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t)\, dt$,
with an approximate solution for R_L > 0Ω:

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

Typ. transient thermal impedance

Z_{thJA}=f(t_p) @ 6cm² heatsink area

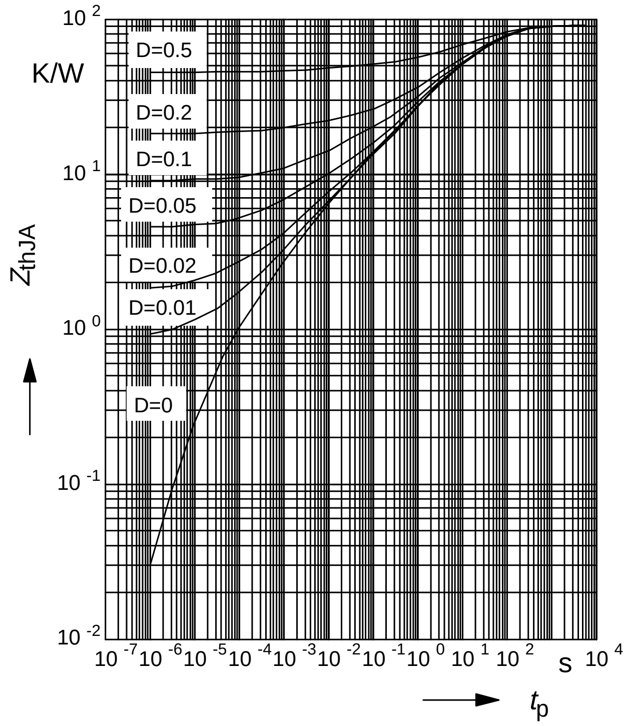
Parameter: D=t_p/T



Typ. transient thermal impedance

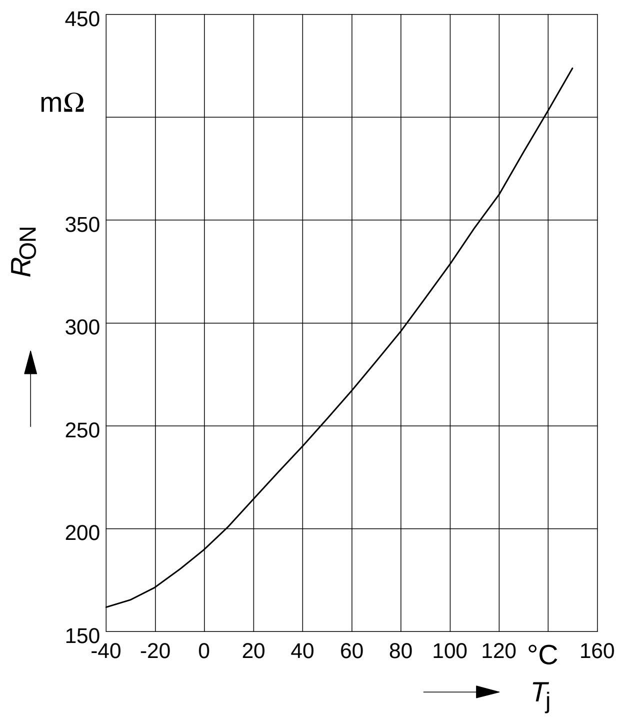
Z_{thJA}=f(t_p) @ minimal footprint

Parameter: D=t_p/T



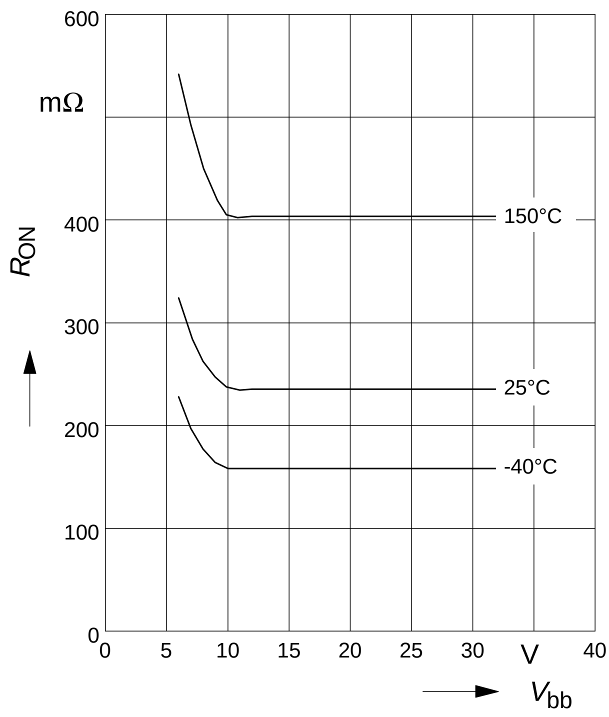
Typ. on-state resistance

R_{ON} **= f(T_j)** ; V_{bb} = 13,5V ; V_{in} = high



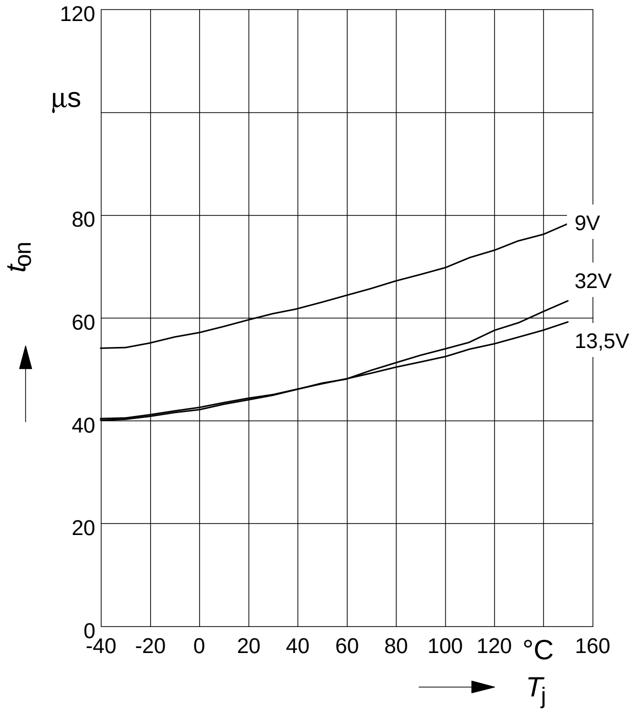
Typ. on-state resistance

R_{ON} **= f(V_{bb})**; I_L = 0.3A ; V_{in} = high



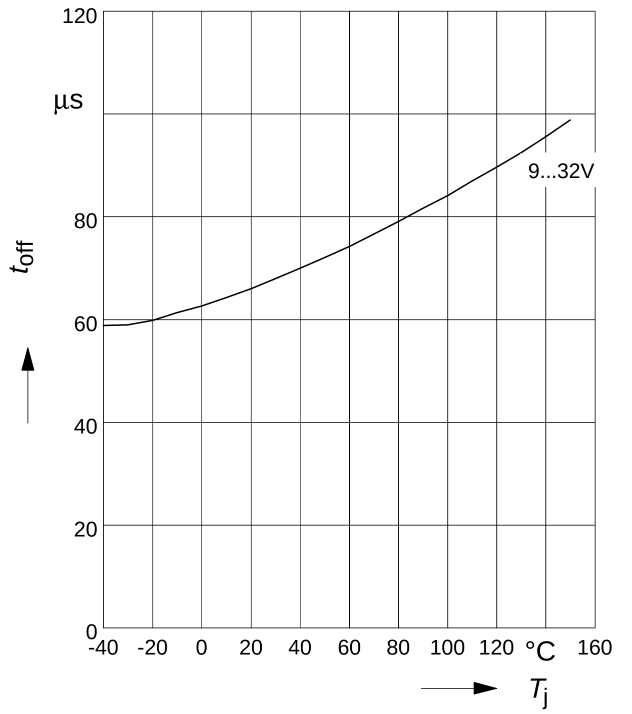
Typ. turn on time

t_{on} **= f(**T_j**)**; R_L = 47Ω



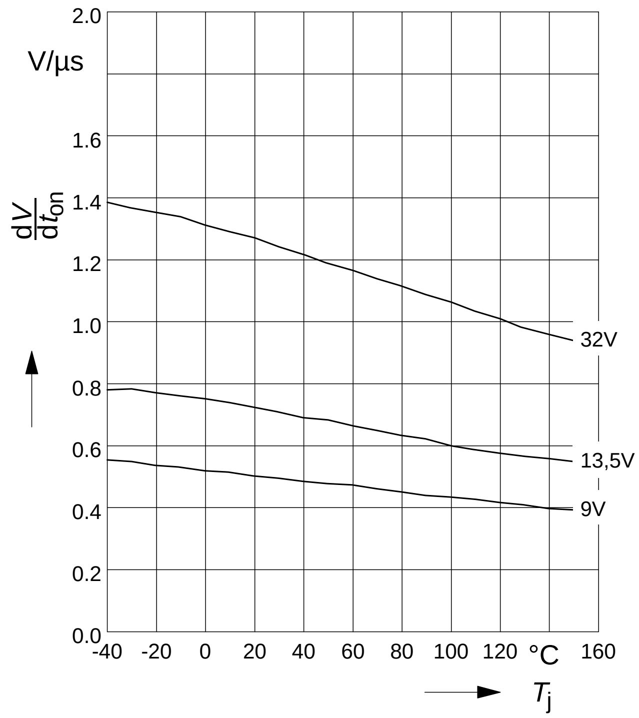
Typ. turn off time

t_{off} **= f(**T_j**)**; R_L = 47Ω



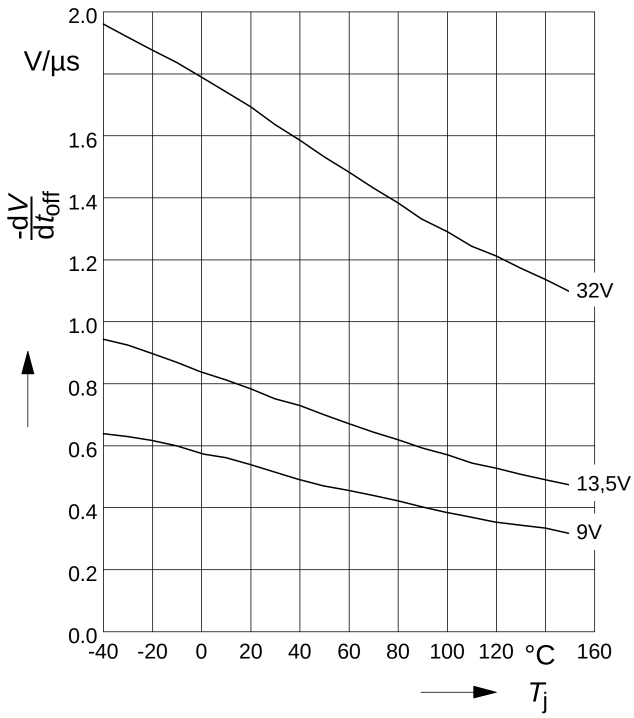
Typ. slew rate on

dV/dt_{on} **= f(**T_j**)** ; R_L = 47 Ω



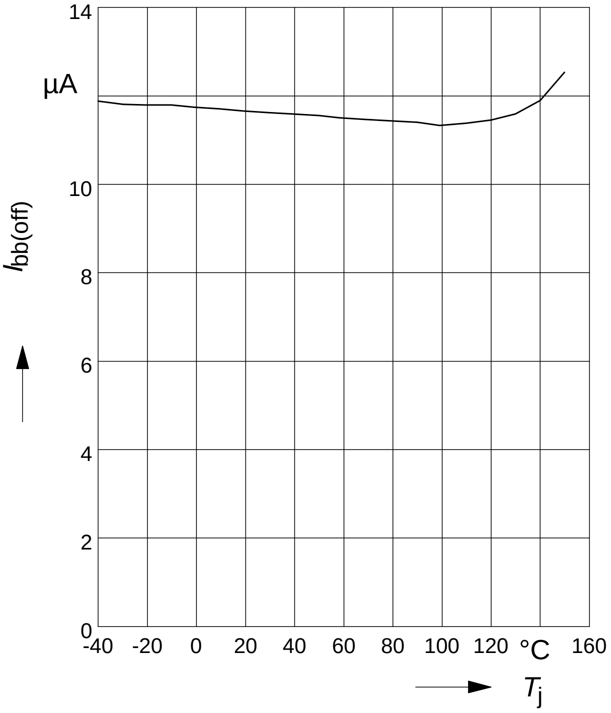
Typ. slew rate off

dV/dt_{off} **= f(**T_j**)**; R_L = 47 Ω



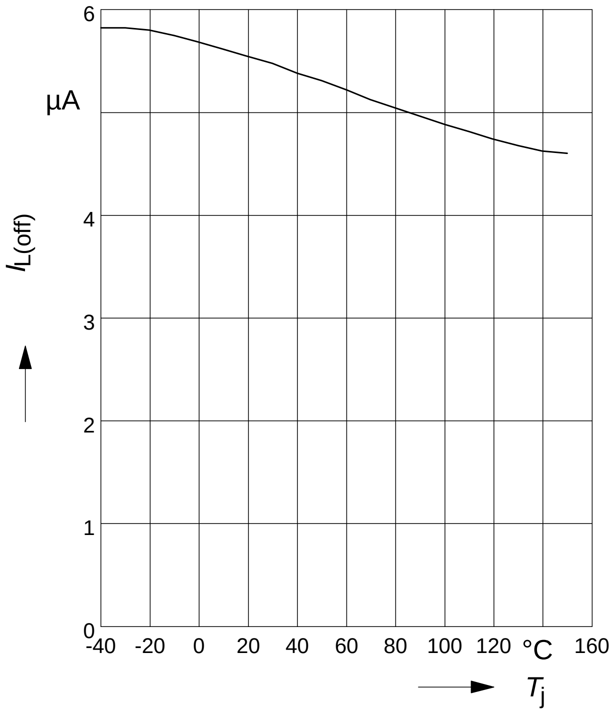
Typ. standby current

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



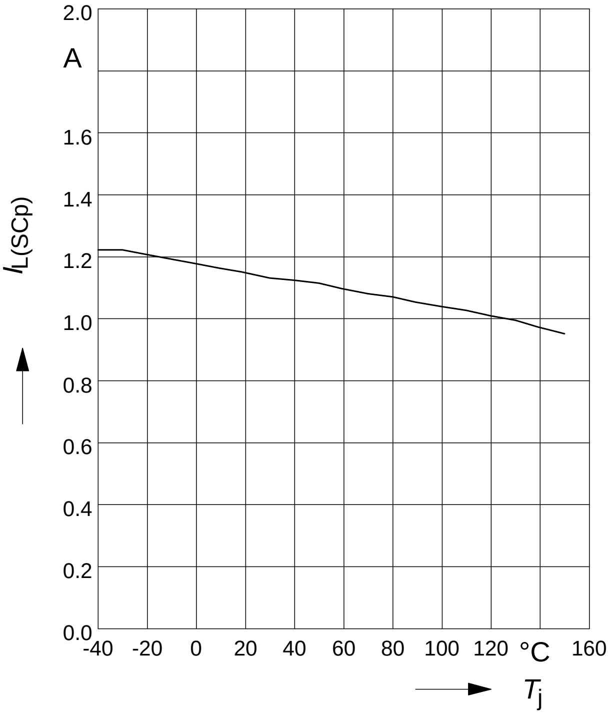
Typ. leakage current

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



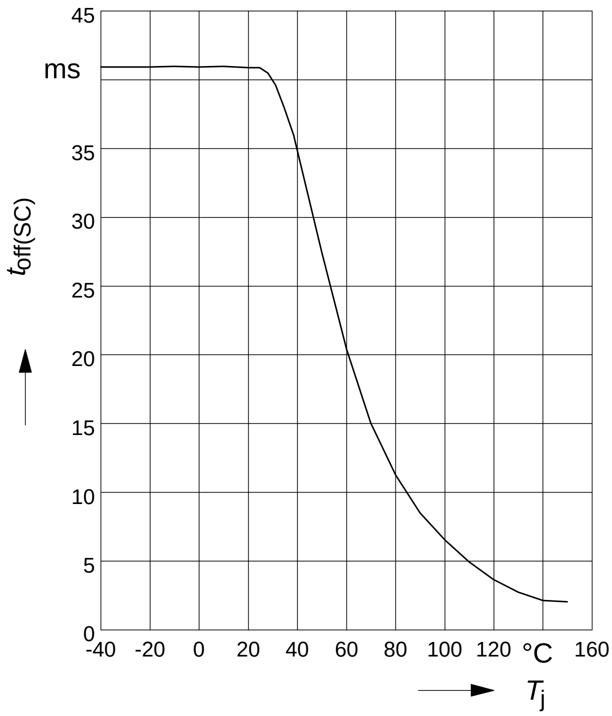
Typ. initial peak short circuit current limit

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



Typ. initial short circuit shutdown time

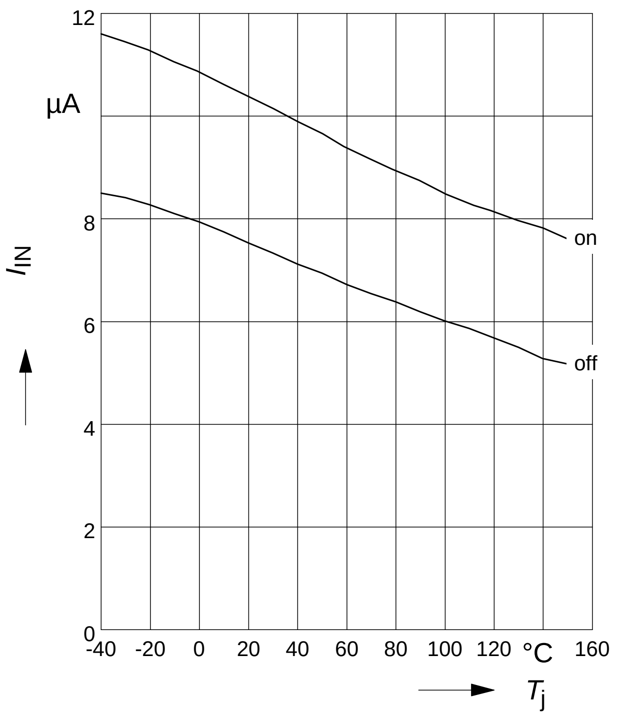
$t_{off(SC)} = f(T_{j,start})$; V_{bb} = 20V



Typ. input current

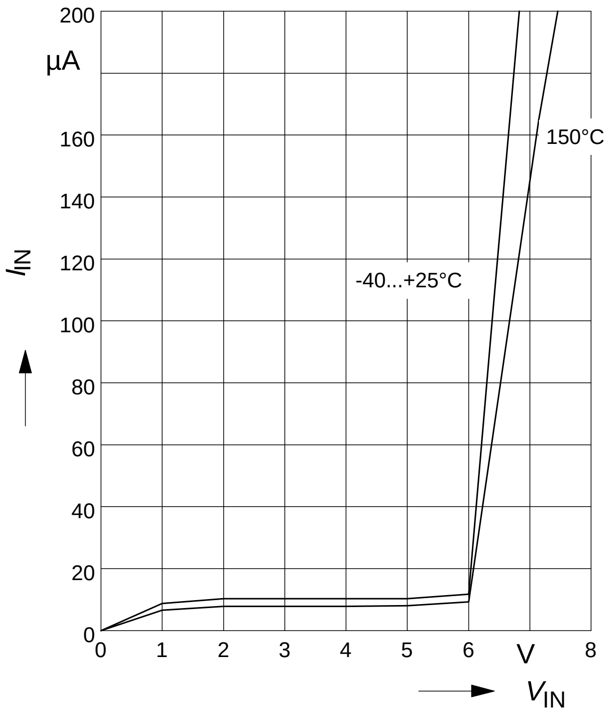
$I_{IN(on/off)}$ = f(T_j); V_{bb} = 13,5V; V_{IN} = low/high

V_{INlow} ≤ 0,7V; V_{INhigh} = 5V



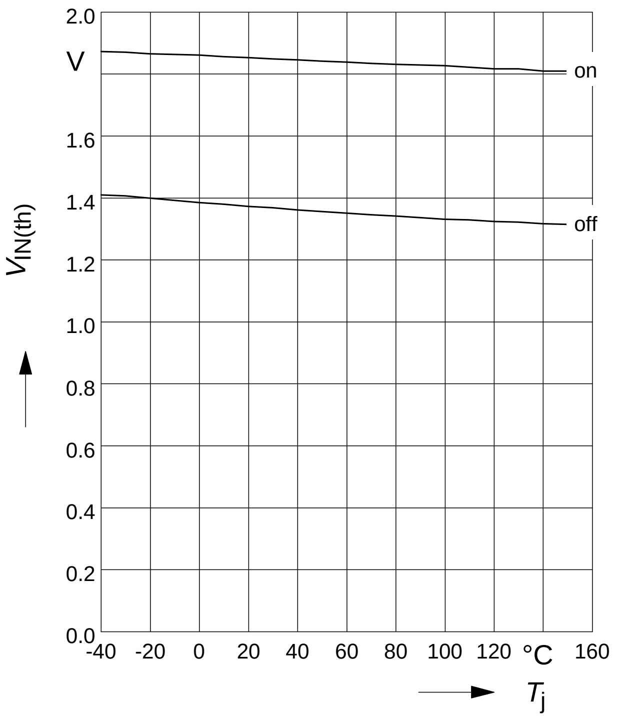
Typ. input current

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



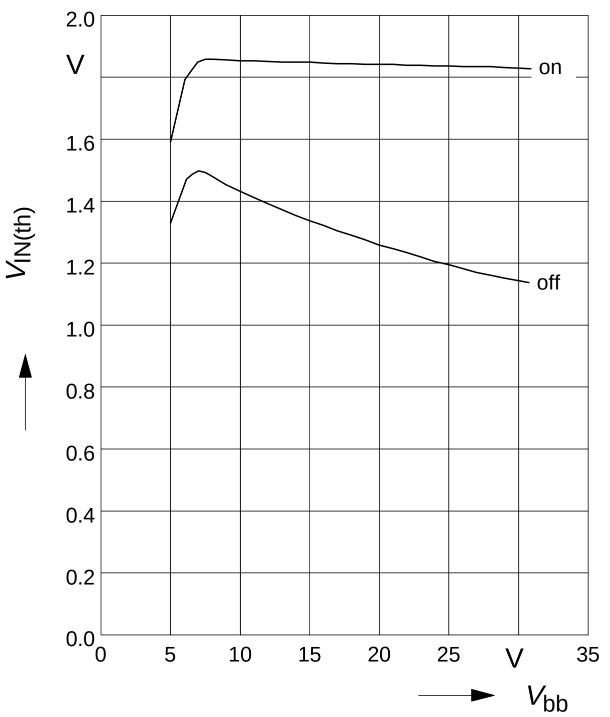
Typ. input threshold voltage

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



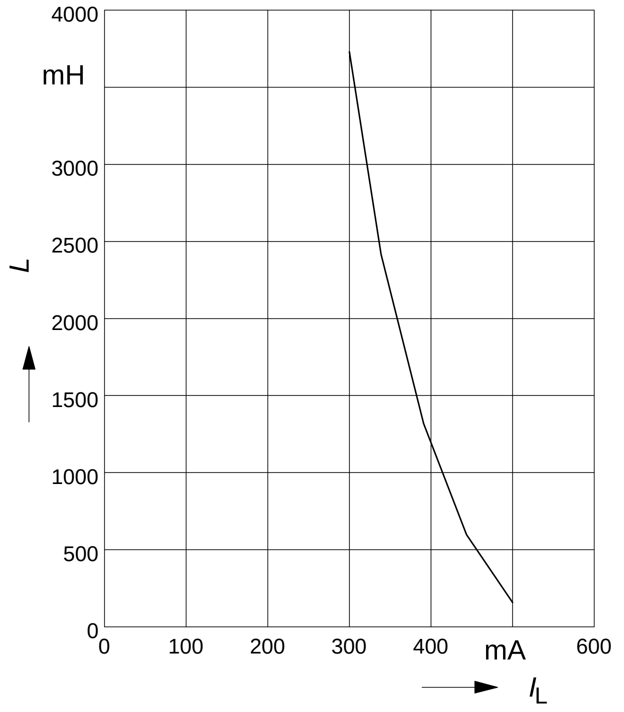
Typ. input threshold voltage

$V_{IN(th)}$ = f(V_{bb}) ; T_j = 25°C



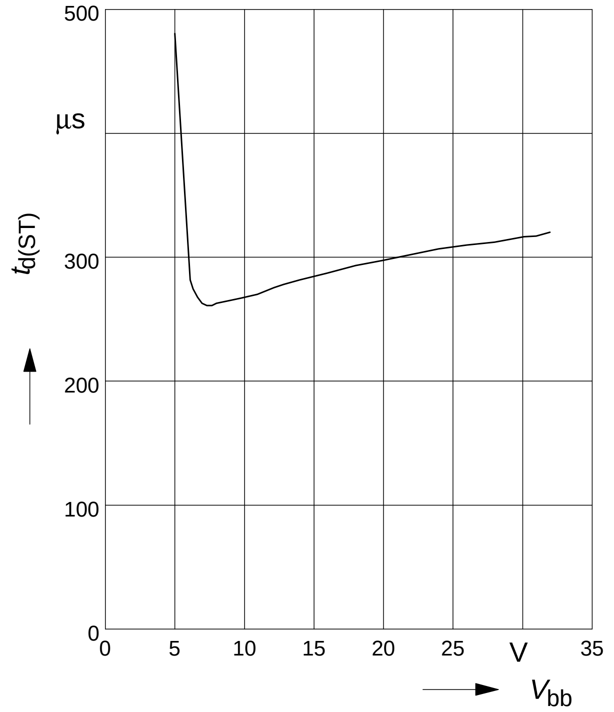
Maximum allowable load inductance for a single switch off

$L = f(I_L)$; T_{jstart}=150°C, V_{bb}=13.5V, R_L=0Ω



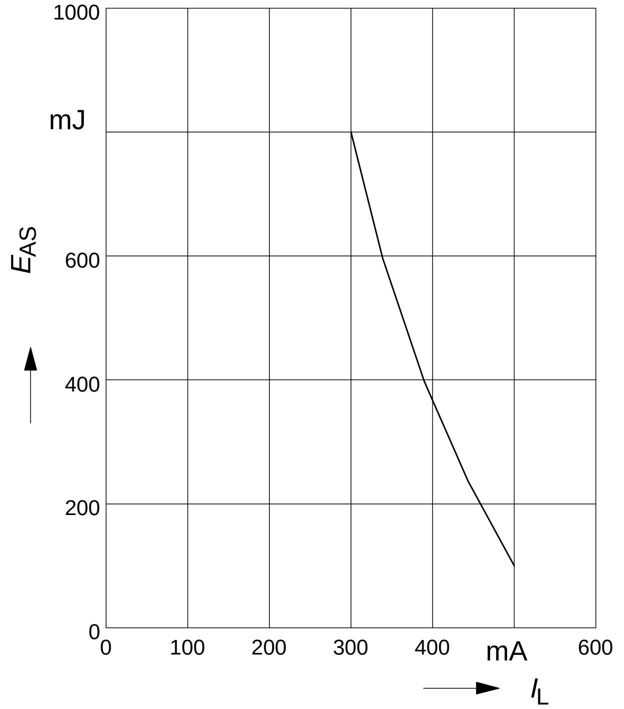
Typ. status delay time

$t_{d(ST)} = f(V_{bb})$; T_j = 25°C



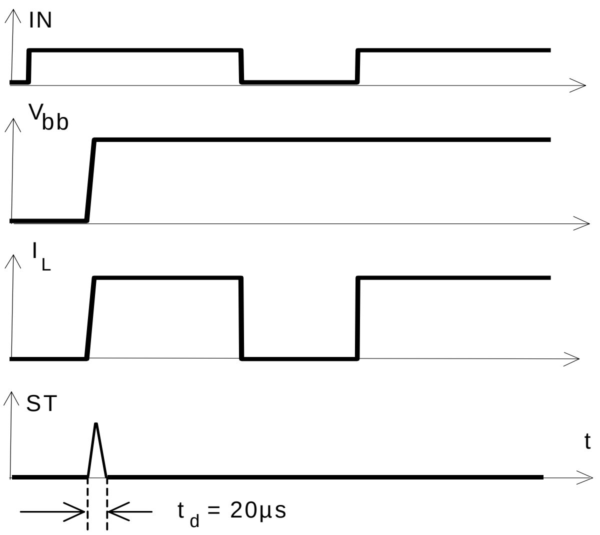
Maximum allowable inductive switch-off energy, single pulse

$E_{AS} = f(I_L)$; T_{jstart} = 150°C, V_{bb} = 13,5V



Timing diagrams

Figure 1a: Vbb turn on:



Invalid status during t_d

Figure 2b: Switching a lamp,

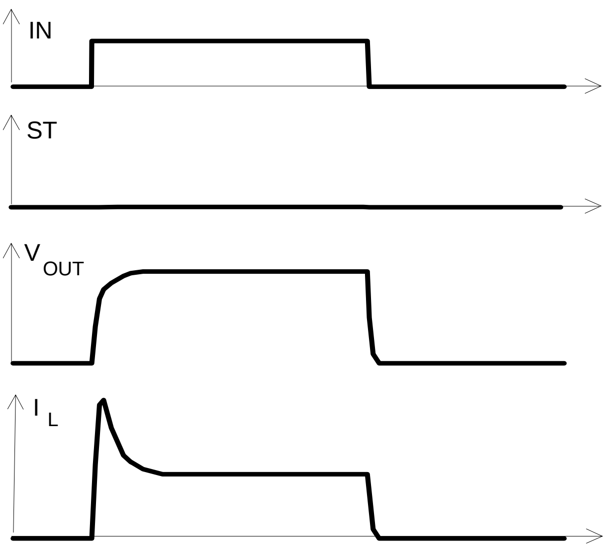


Figure 2a: Switching a resistive load, turn-on/off time and slew rate definition

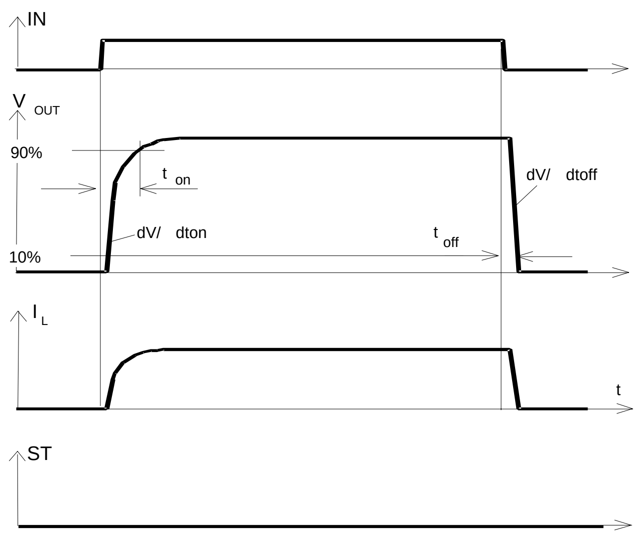


Figure 2c: Switching an inductive load

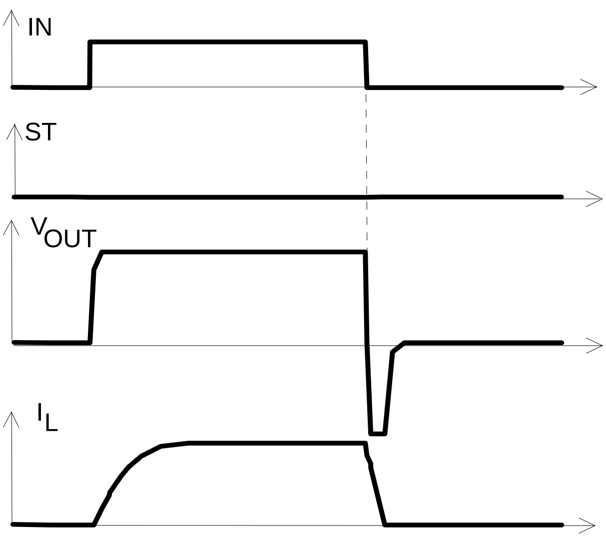
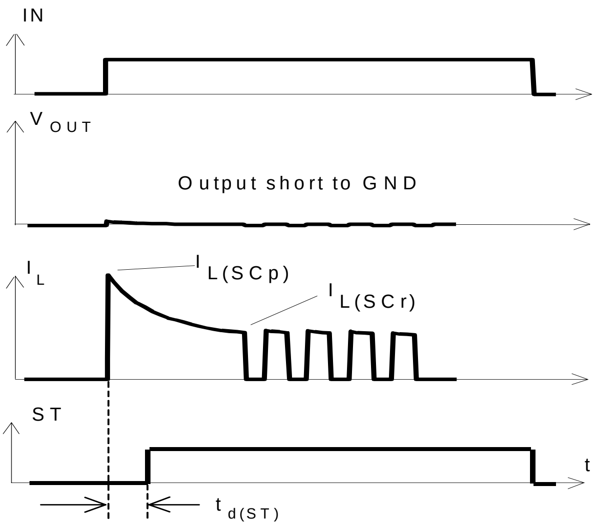


Figure 3a: Turn on into short circuit,
shut down by overtemperature, restart by cooling



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

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

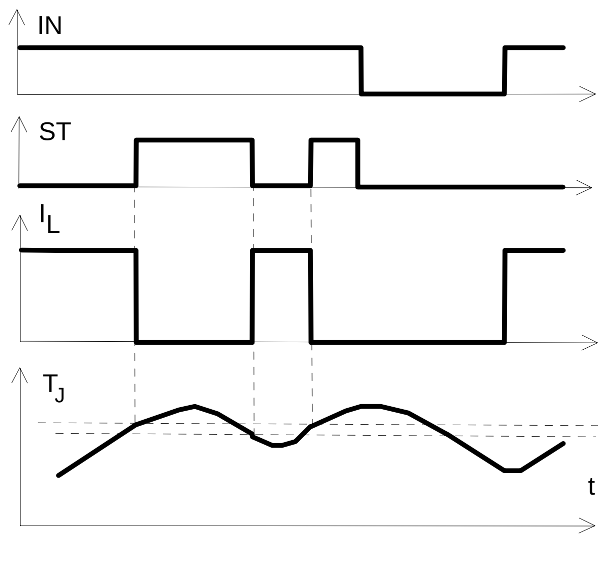


Figure 3b: Short circuit in on-state
shut down by overtemperature, restart by cooling

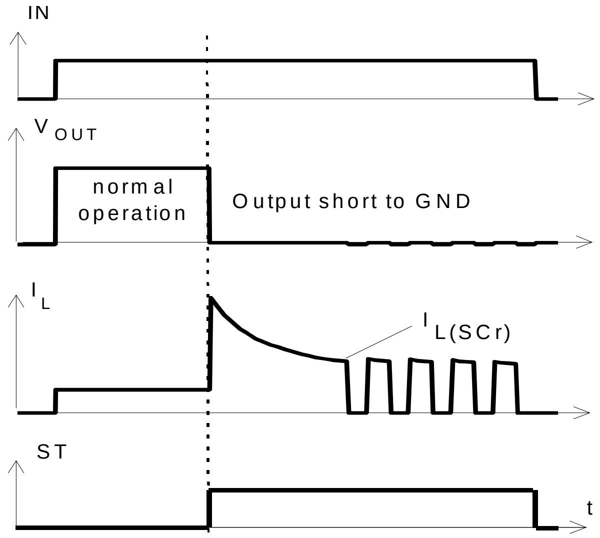
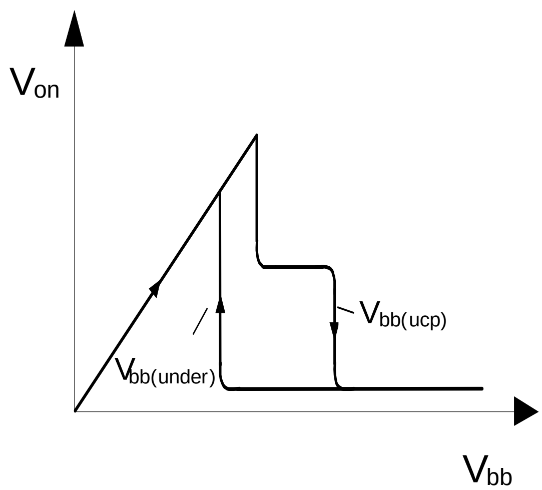


Figure 5: Undervoltage restart of charge pump

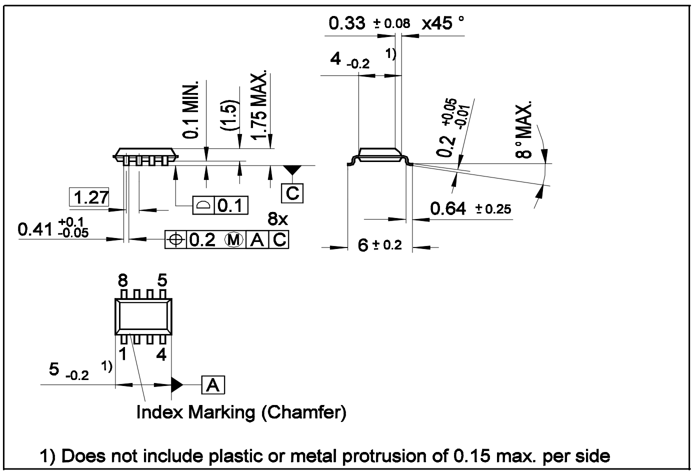


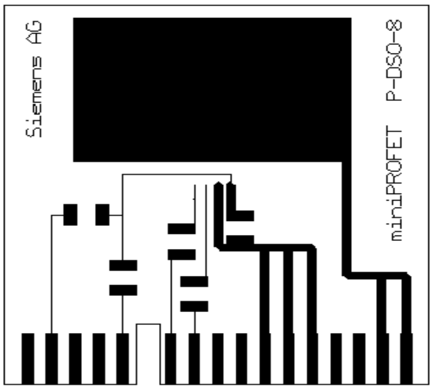
Package and ordering code

all dimensions in mm

Ordering code:

	Q67060-S7304-A2





Printed circuit board (FR4, 1.5mm thick, one layer 70µm, $6cm^2$ 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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