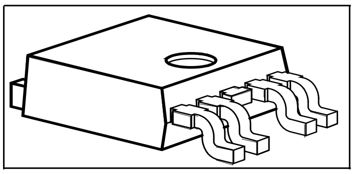
Smart Power High-Side-Switch

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	$V_{bb(AZ)}$	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



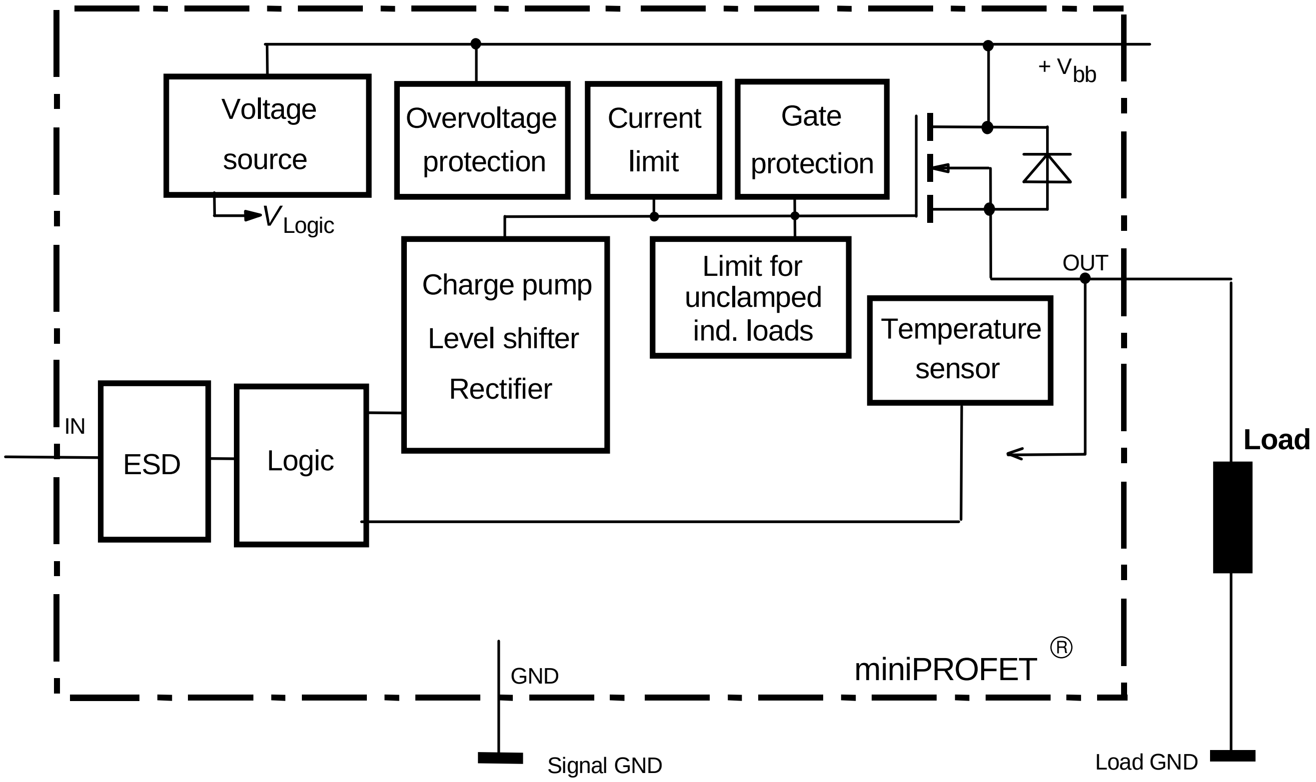
Application

- 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, 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	Vbb	Positive power supply voltage
4	NC	not connected
5	OUT	Output to the load
TAB	Vbb	Positive power supply voltage

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 8) 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**s**tatic **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 cm^2 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. (see page 16)

[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 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	R_{ON}				mΩ
T_j = 25 °C, I_L = 1 A, V_{bb} = 9...52 V		-	150	200	
T_j = 150 °C		-	270	380	
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	$V_{bb(under)}$				
T_j = -40...+85 °C		-	-	4	
T_j = 150 °C		-	-	5.5	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	4	5.5	
Standby current	$I_{bb(off)}$				µA
T_j = -40...+85 °C, V_{IN} = low		-	-	15	
T_j = +150 °C[2)] , V_{IN} = low		-	-	18	
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. (see page 16)

[2]higher current due temperature sensor

Electrical Characteristics

Parameter and Conditions	Symbol	Values			Unit
at T_j = -40...150°C, V_{bb} = 12..42V, unless otherwise specified		min.	typ.	max.	
Protection Functions					
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 11)		-	5[1]	-	
Repetitive short circuit current limit	$I_{L(SCr)}$				
$T_j = T_{jt}$ (see timing diagrams)					
V_{bb} < 40 V		-	6	-	
V_{bb} > 40 V		-	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 [2] I_{bb} = 4 mA	$V_{bb(AZ)}$	62	-	-	
Thermal overload trip temperature	T_{jt}	150	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

Reverse Battery

Reverse battery[3]	$-V_{bb}$	-	-	52	V
Drain-source diode voltage ($V_{OUT} > V_{bb}$) T_j = 150 °C	$-V_{ON}$	-	600	-	mV

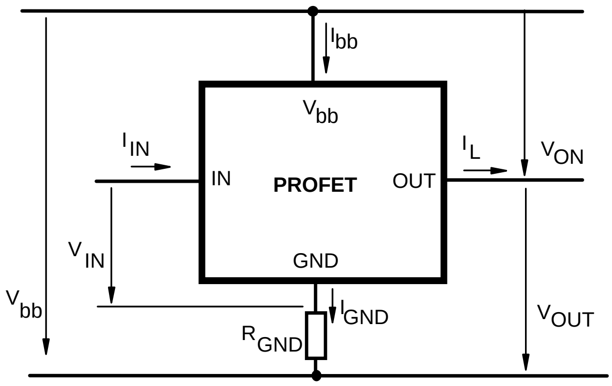
[1]not tested, specified by design

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

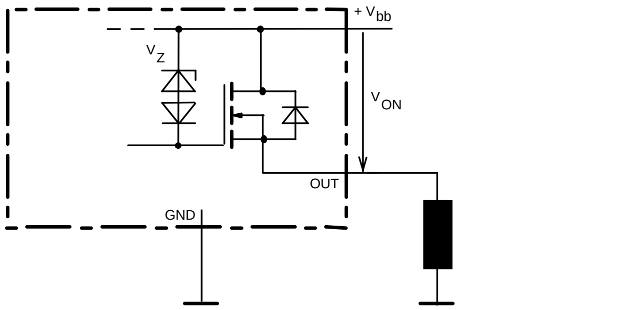
[3]Requires a 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection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

Parameter and Conditions at T_j = -40...150°C, V_{bb} = 12..42V, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Input					
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	
Input resistance (see page 7)	R_I	2	3.5	5	kΩ

Terms

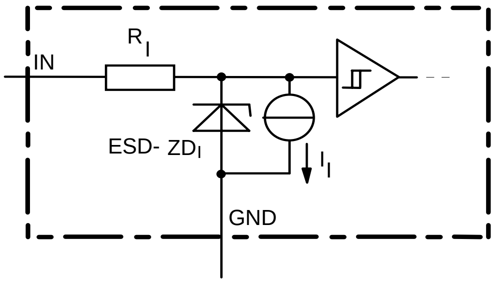


Inductive and overvoltage output clamp



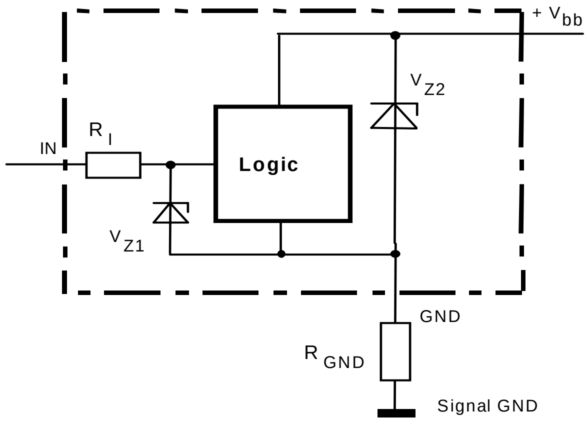
V_{ON} clamped to 59V min.

Input circuit (ESD protection)



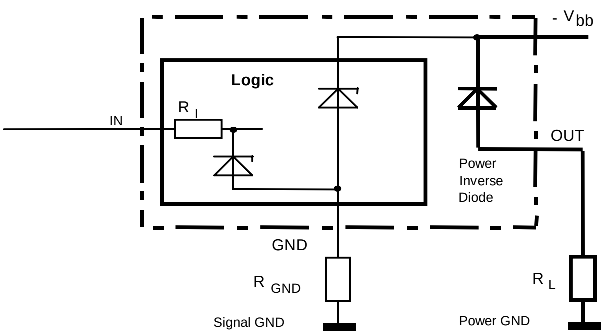
The use of ESD zener diodes as voltage clamp
at DC conditions is not recommended

Overvoltage protection of logic part



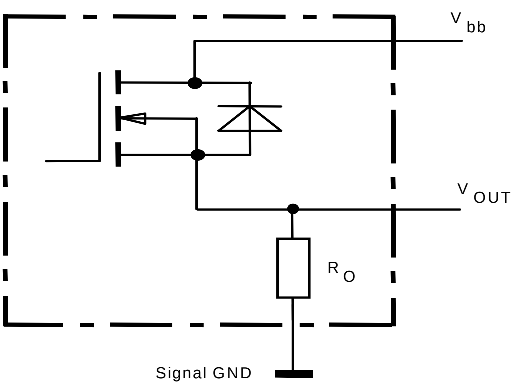
V_{Z1}=6.1V typ., V_{Z2}=$V_{bb(AZ)}$=62V min.,
R_I=3.5 kΩ typ., R_{GND}=150Ω

Reverse battery protection



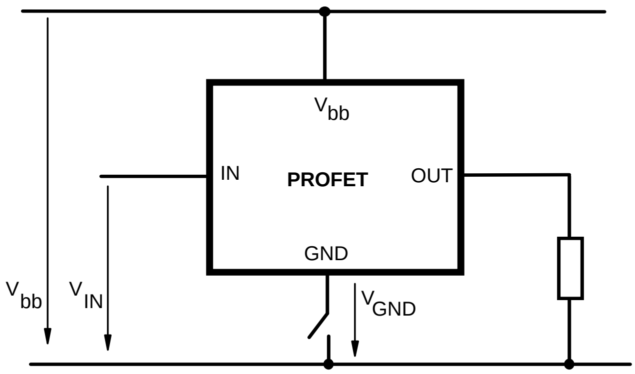
R_{GND}=150Ω, R_I=3.5kΩ typ.,
Temperature protection is not active during inverse current

Internal output pull down

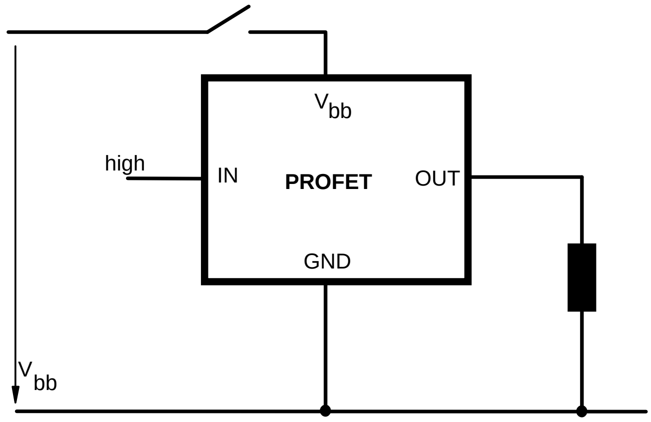


R_O = 200 kΩ typ.

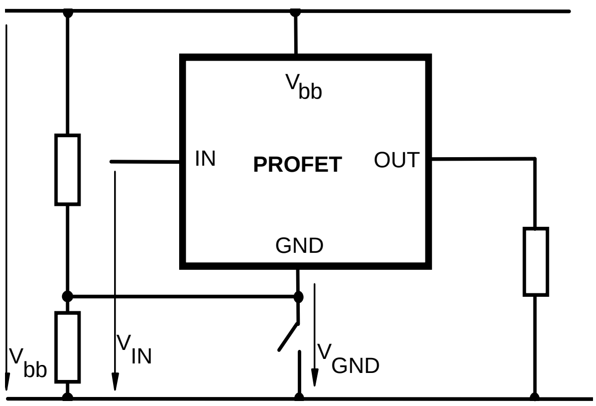
GND disconnect



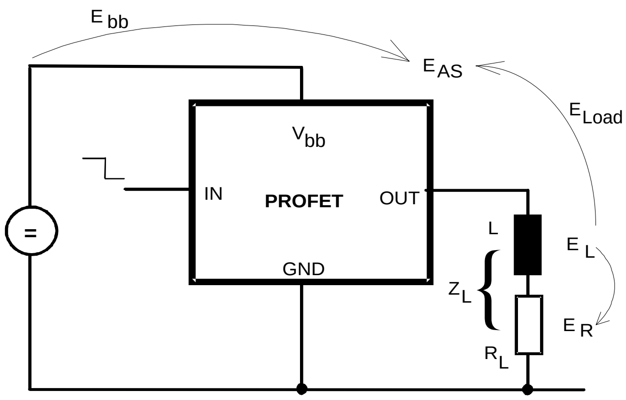
Vbb disconnect with charged inductive load



GND disconnect with GND pull up



Inductive Load switch-off energy dissipation



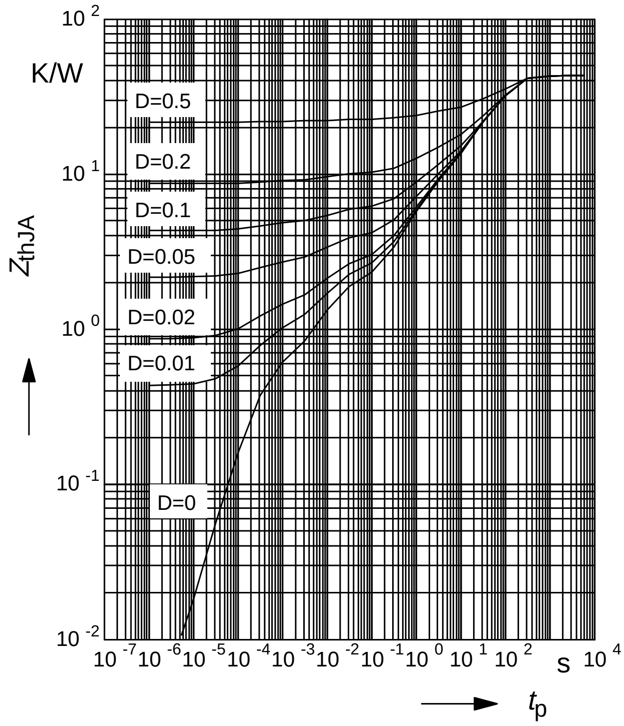
Energy stored in load inductance: $E_L = ½ * L * I_L^2$
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t)\, dt$,
with an approximate solution for $R_L > 0\Omega$:

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

Typ. transient thermal impedance

Z_{thJA}=f(t_p) @ 6cm^2 heatsink area

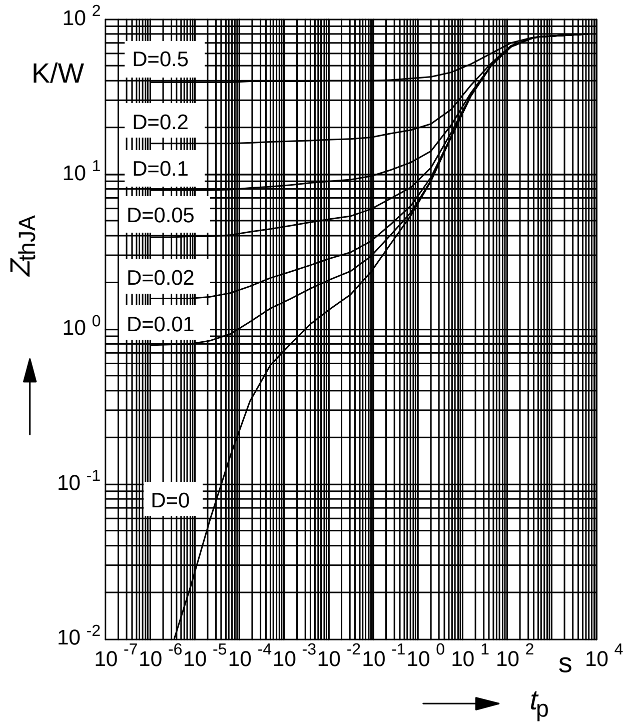
Parameter: D=t_p/T



Typ. transient thermal impedance

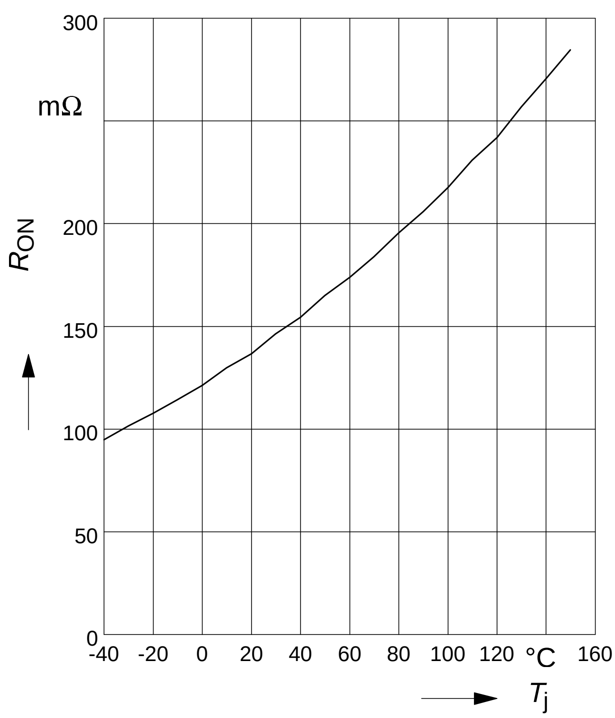
Z_{thJA}=f(t_p) @ min. footprint

Parameter: D=t_p/T



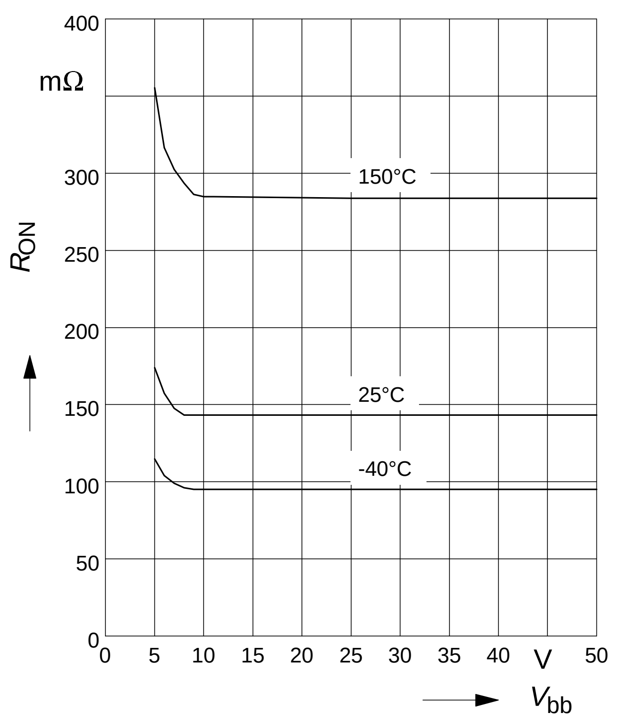
Typ. on-state resistance

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



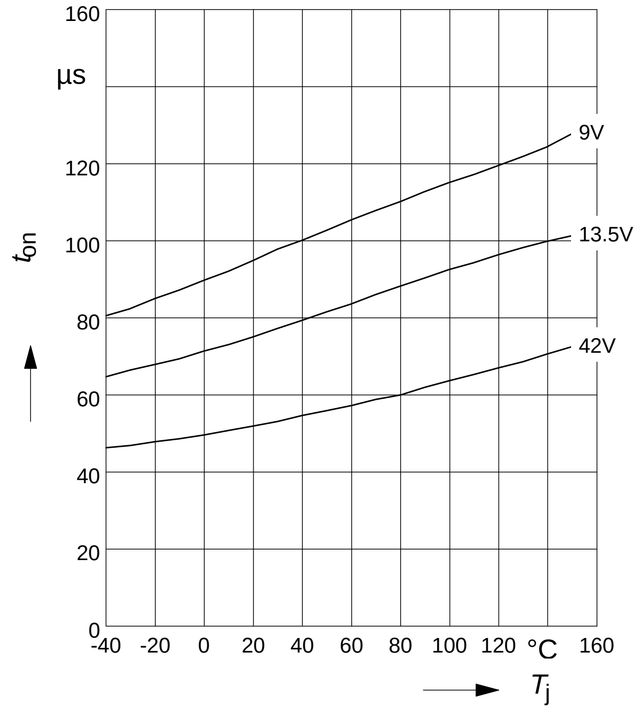
Typ. on-state resistance

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



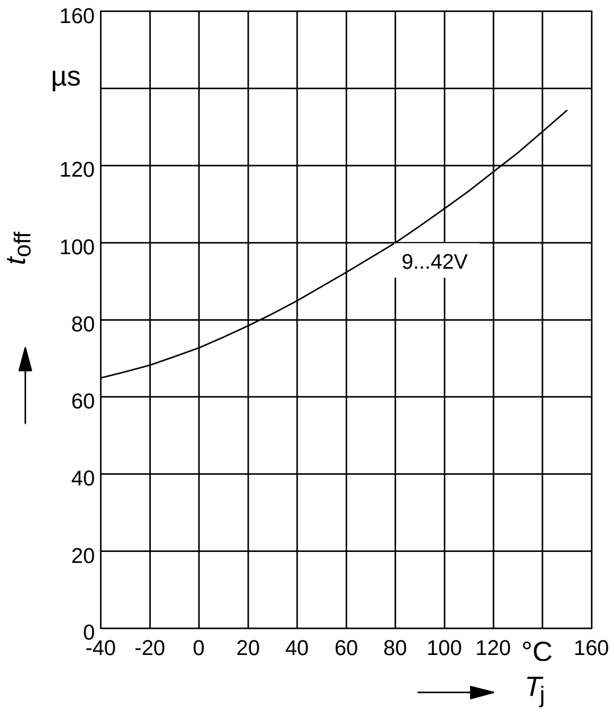
Typ. turn on time

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



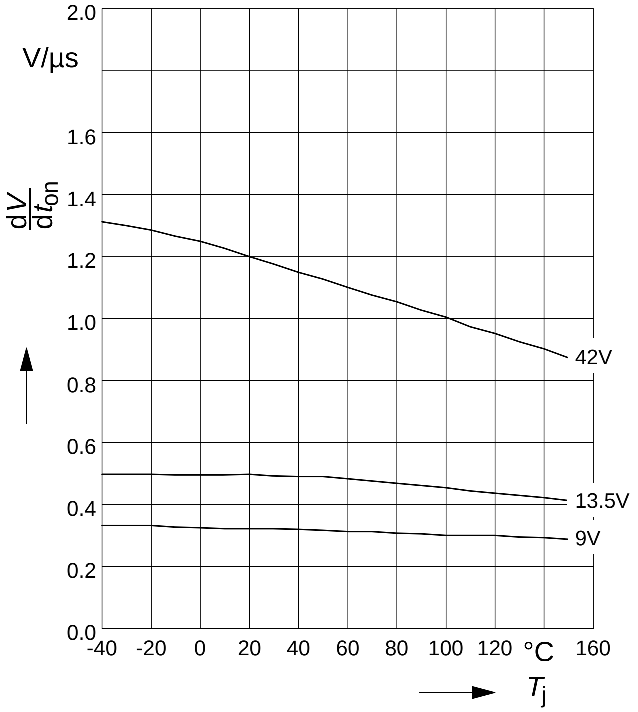
Typ. turn off time

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



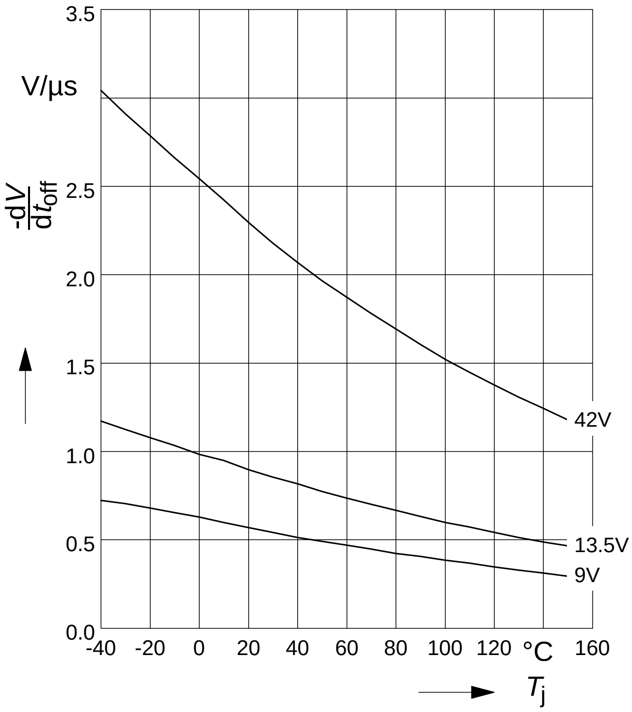
Typ. slew rate on

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



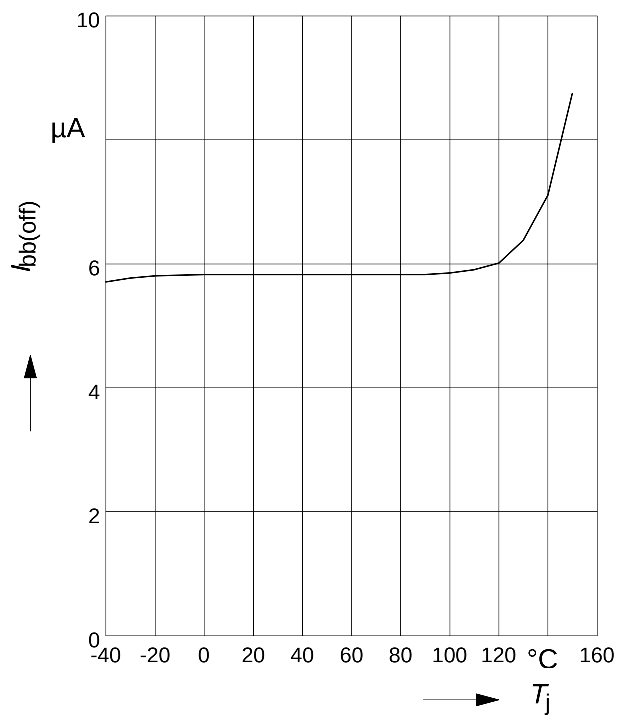
Typ. slew rate off

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



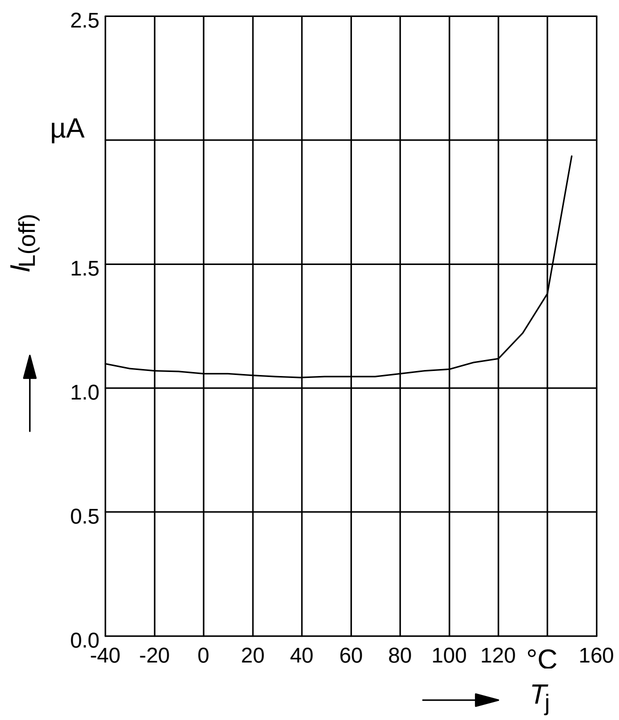
Typ. standby current

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



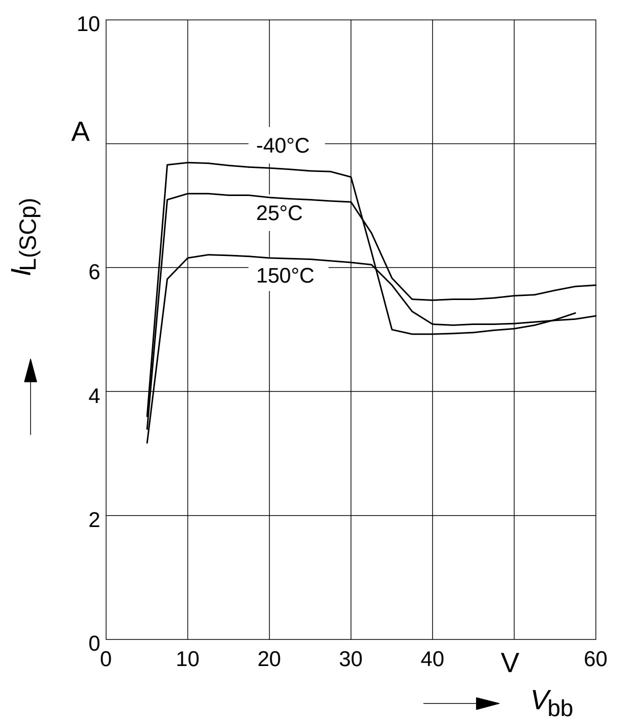
Typ. leakage current

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



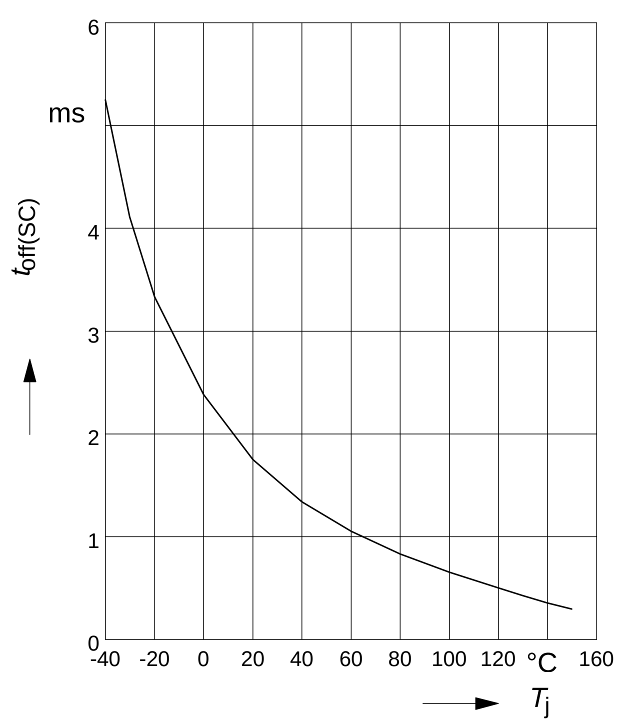
Typ. initial peak short circuit current limit

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



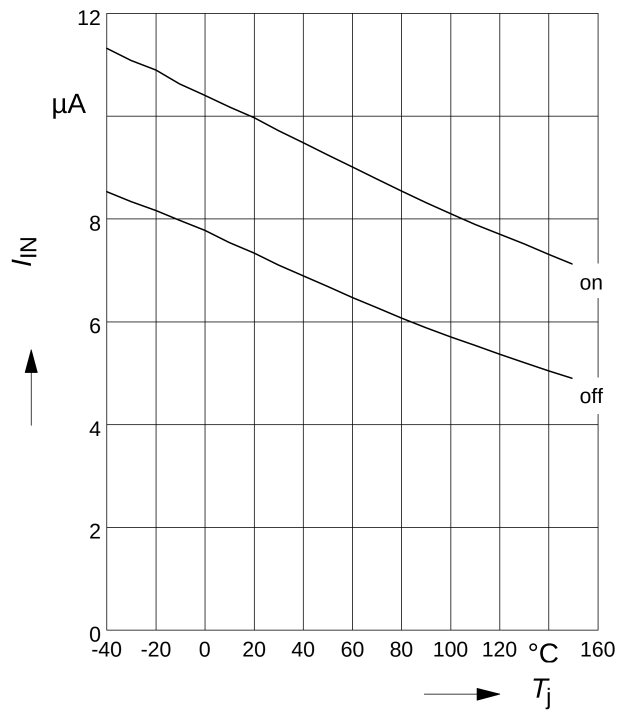
Typ. initial short circuit shutdown time

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



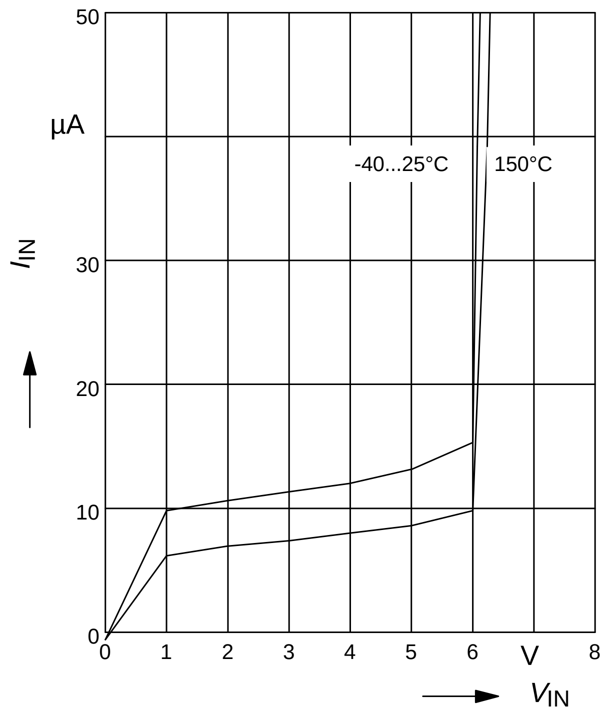
Typ. input current

$I_{IN(on/off)} = f(T_j)$; V_{bb} = 13,5V; V_{IN} = low/high
$V_{INlow} \leq$ 0,7V; V_{INhigh} = 5V



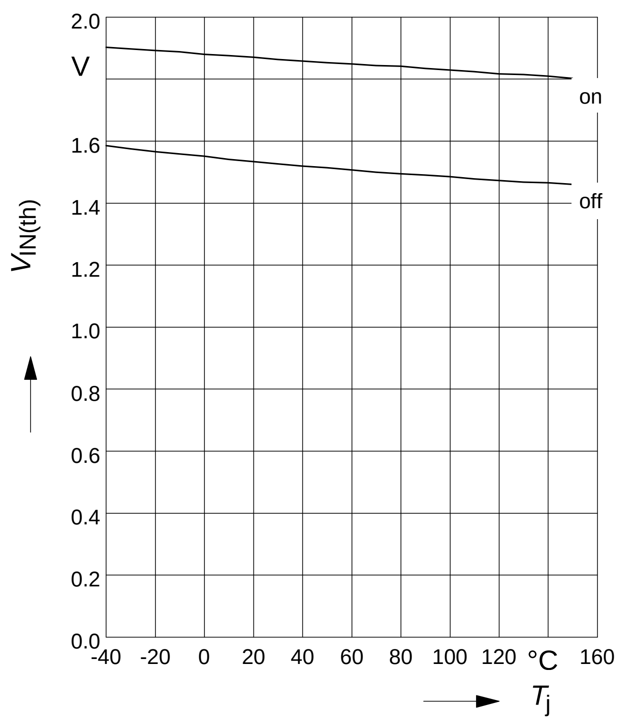
Typ. input current

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



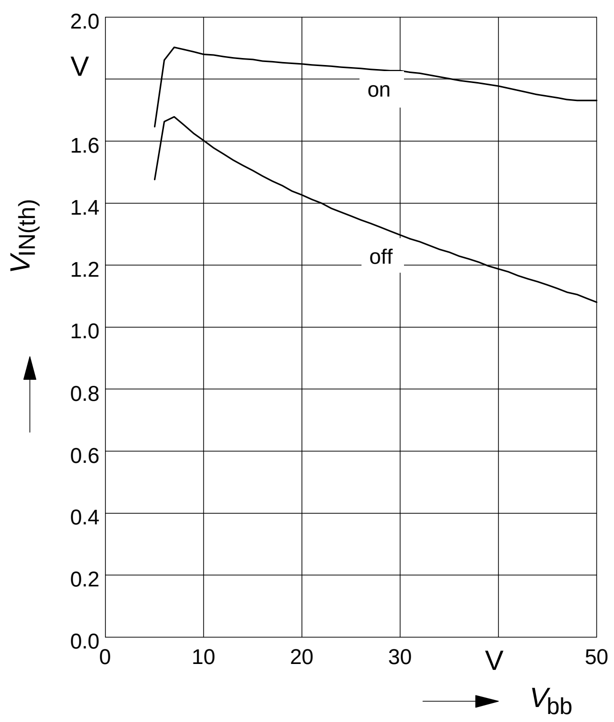
Typ. input threshold voltage

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



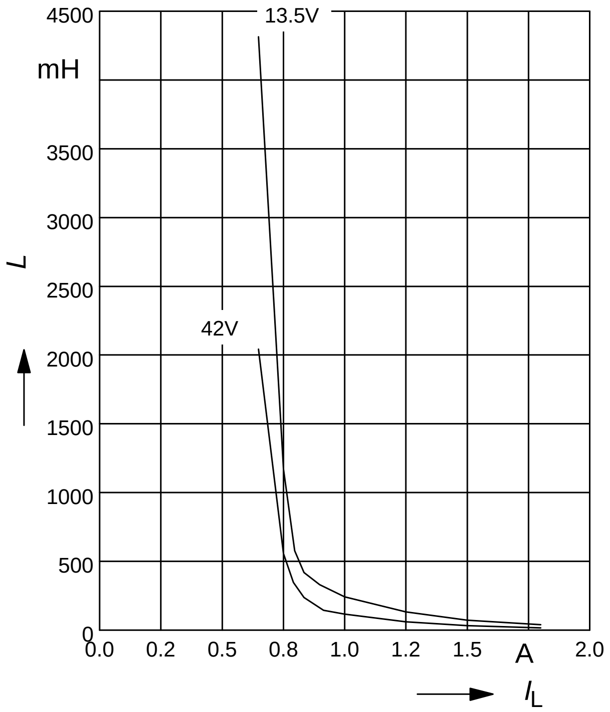
Typ. input threshold voltage

$V_{IN(th)} = f(V_{bb})$; T_j = 25°C



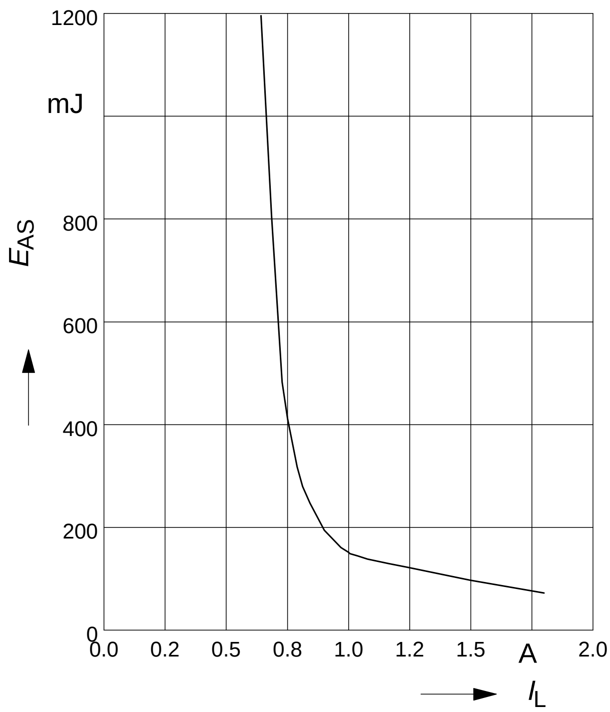
Maximum allowable load inductance for a single switch off

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



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:

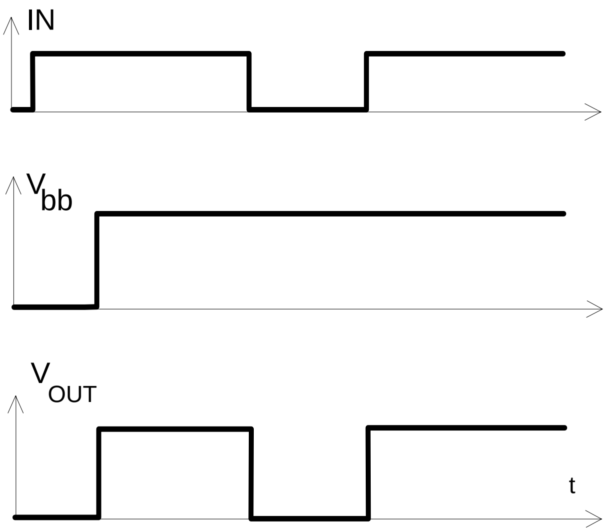


Figure 2b: Switching a lamp,

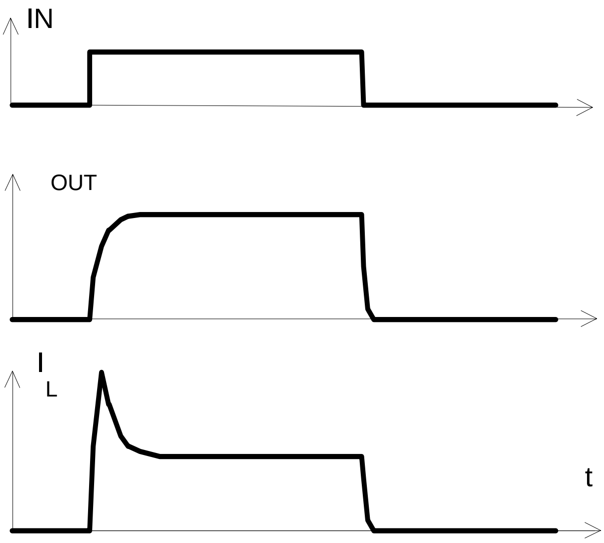


Figure 2a: Switching a resistive load,
turn-on/off time and slew rate definition

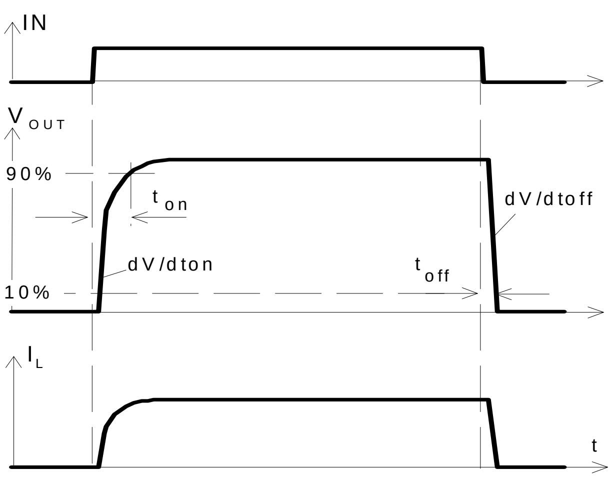


Figure 2c: Switching an inductive load

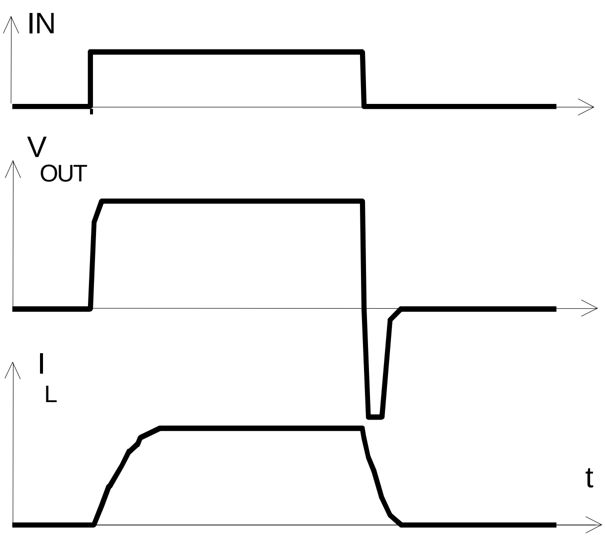
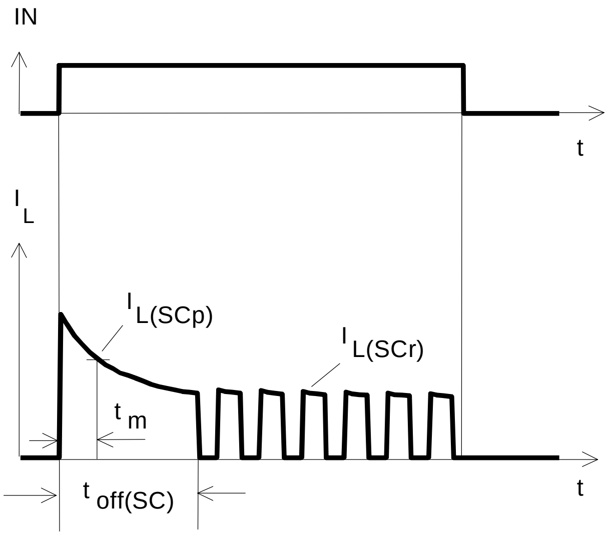


Figure 3a: Turn on into short circuit,
shut down by overtemperature, restart by cooling



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

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

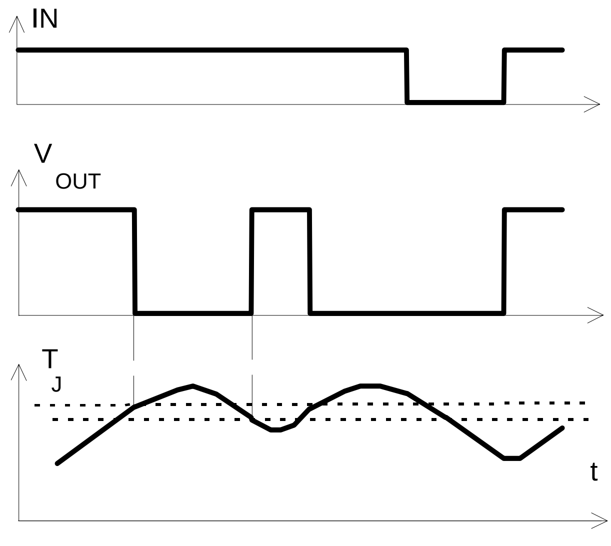
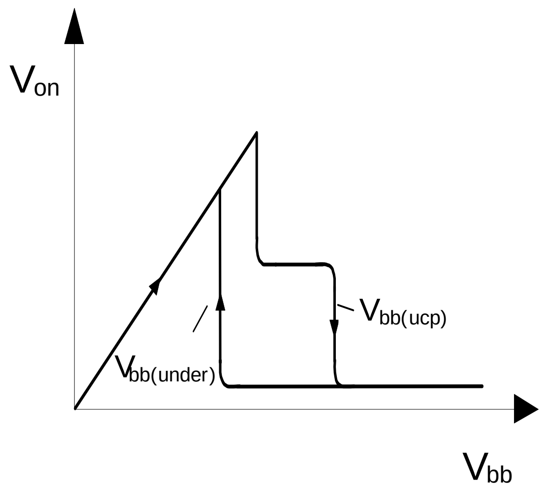


Figure 5: Undervoltage restart of charge pump

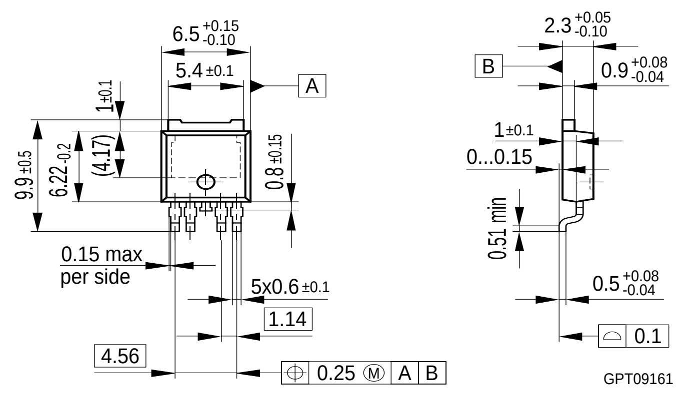


Package and ordering code

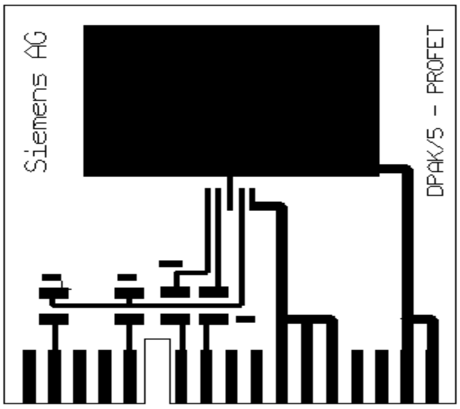
all dimensions in mm

Ordering code:

	Q67060-S7406



All metal surfaces tin plated, except area of cut.



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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