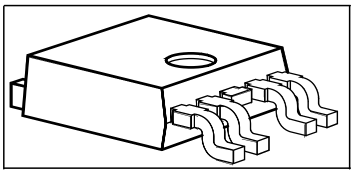
Smart Power High-Side-Switch

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



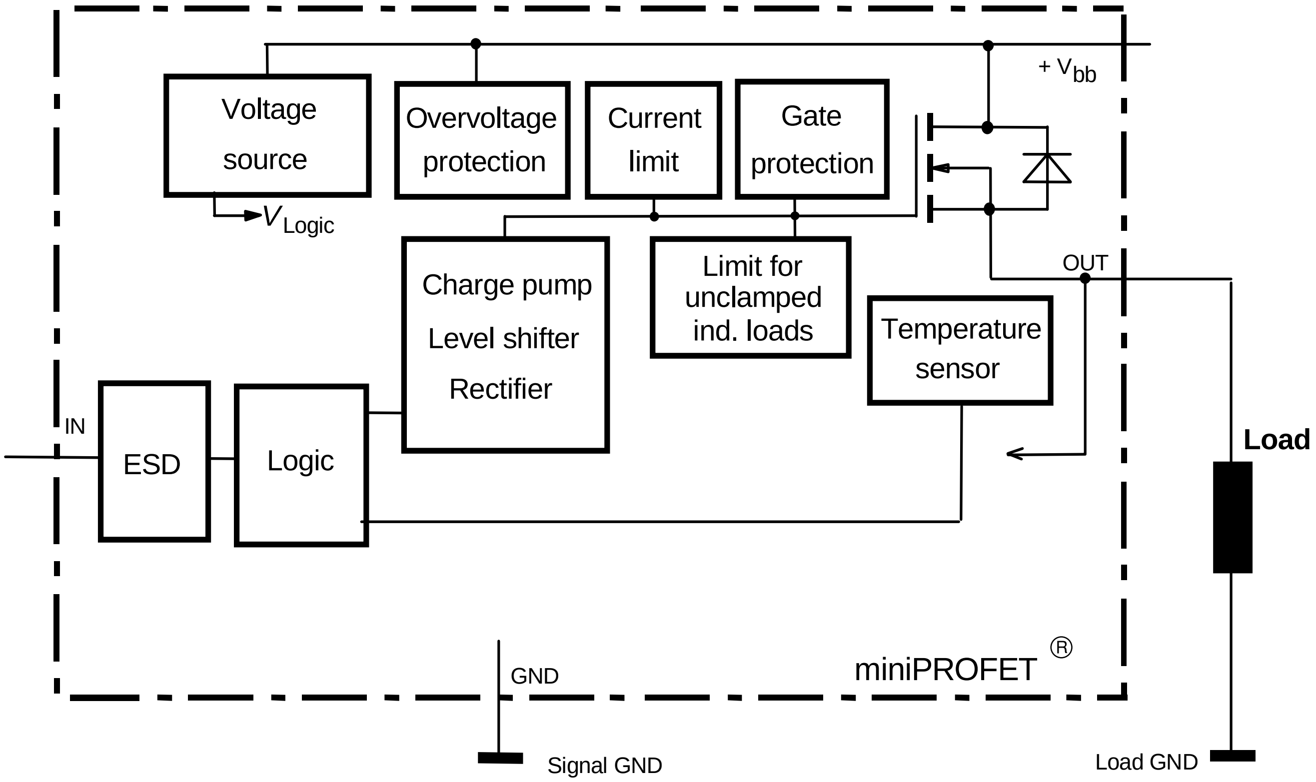
Application

- 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	$V_{Loaddump}$		V
R_L = 13.5 Ω		73.5	
R_L = 27 Ω		88.5	
Electro**s**tatic **d**ischarge voltage (Human Body Model) according to ANSI EOS/ESD - S5.1 - 1993 ESD STM5.1 - 1998	V_{ESD}		kV
Input pin		± 1	
all other pins		± 5	

Thermal Characteristics

Parameter	Symbol				Unit
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.	Values typ.	Values max.	Unit
Load Switching Capabilities and Characteristics					
On-state resistance T_j = 25 °C, I_L = 1 A, V_{bb} = 9...52 V T_j = 150 °C	R_{ON}	 - -	 150 270	 200 380	mΩ
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

Parameter	Symbol	min.	typ.	max.	Unit
Operating voltage	$V_{bb(on)}$	6	-	52	V
Undervoltage shutdown of charge pump T_j = -40...+85 °C T_j = 150 °C	$V_{bb(under)}$	 - -	 - -	 4 5.5	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	4	5.5	
Standby current T_j = -40...+85 °C, V_{IN} = low T_j = +150 °C[2)] , V_{IN} = low	$I_{bb(off)}$	 - -	 - -	 15 18	µA
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 at T_j = -40...150°C, V_{bb} = 12..42V, unless otherwise specified	Symbol	Values min.	Values typ.	Values max.	Unit
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 $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$				
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

Parameter and Conditions	Symbol	min.	typ.	max.	Unit
Reverse battery[3]	$-V_{bb}$	-	-	52	V
Drain-source diode voltage ($V_{OUT} > V_{bb}$) T_j = 150 °C	$-V_{ON}$	-	600	-	mV

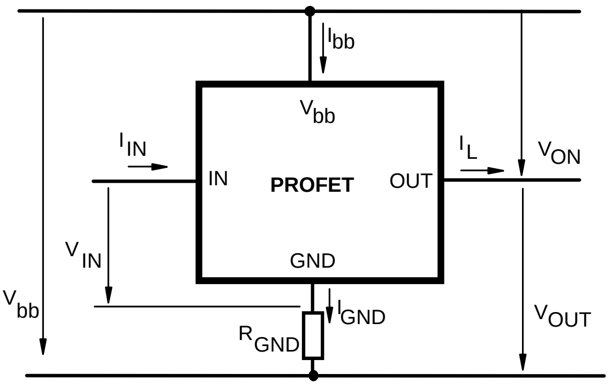
[1]not tested, specified by design

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

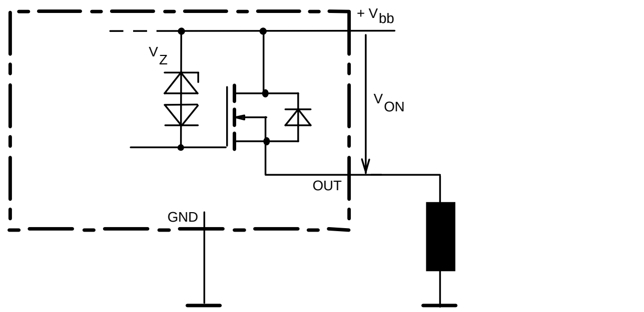
[3]Requires a 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection 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

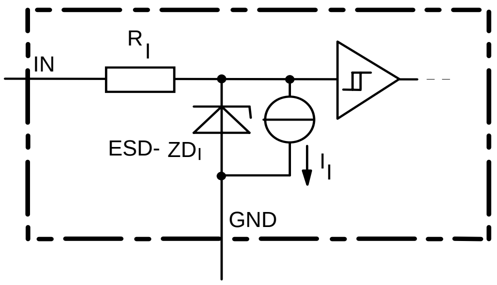


Inductive and overvoltage output clamp



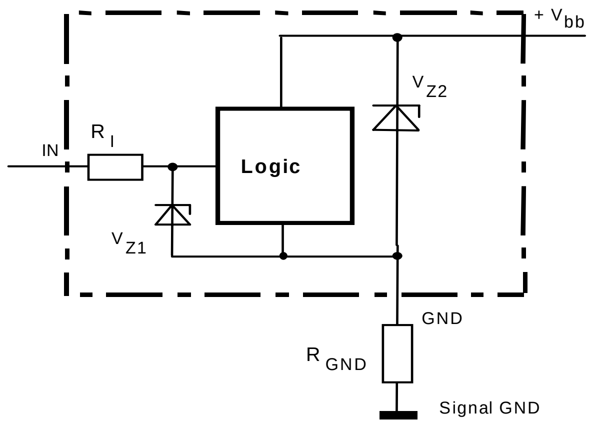
V_{ON} clamped to 59V min.

Input circuit (ESD protection)



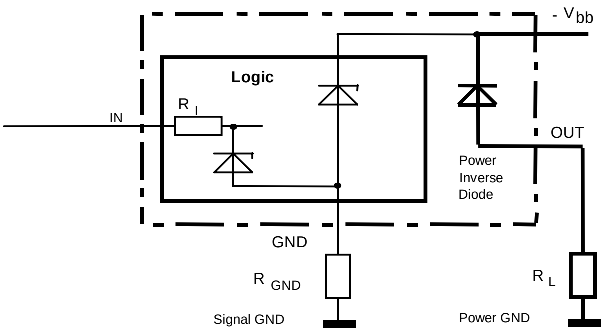
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



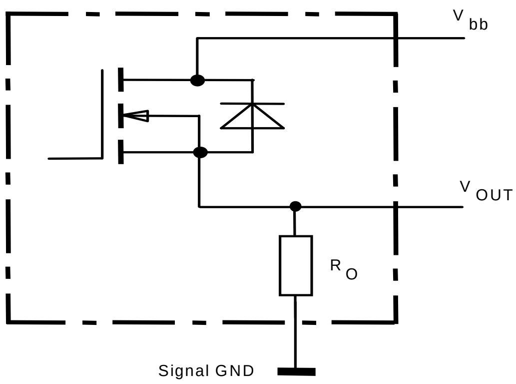
V_{Z1}=6.1V typ., V_{Z2}=$V_{bb(AZ)}$=62V min., R_I=3.5 kΩ typ., R_{GND}=150Ω

Reverse battery protection



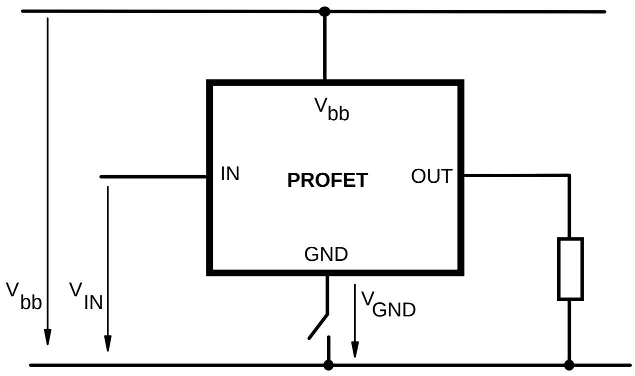
R_{GND}=150Ω, R_I=3.5kΩ typ.,
Temperature protection is not active during inverse current

Internal output pull down

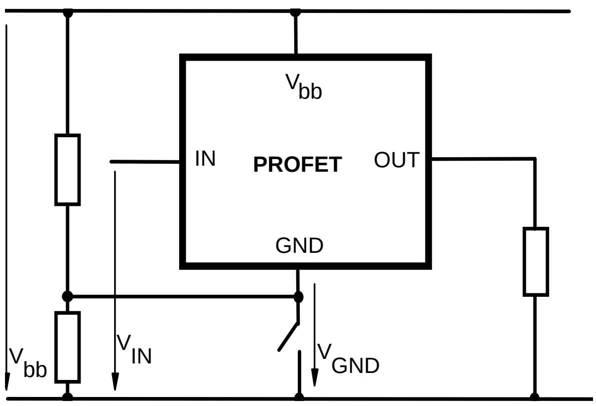


R_O = 200 kΩ typ.

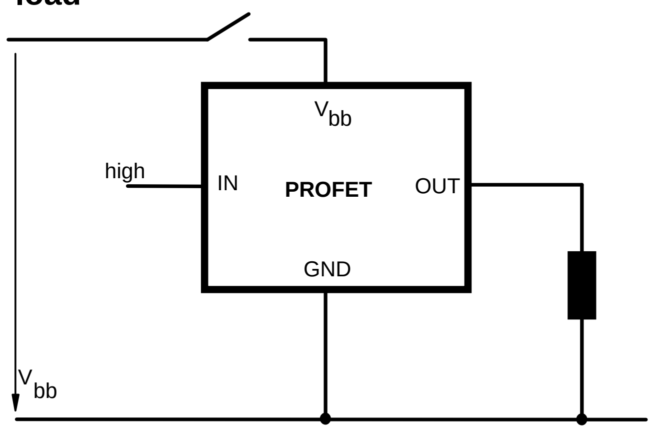
GND disconnect



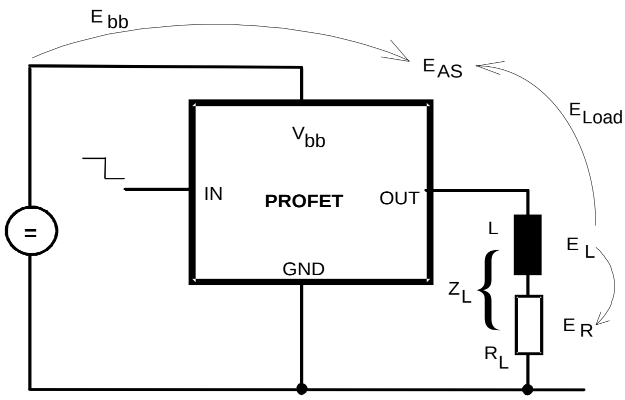
GND disconnect with GND pull up



V_{bb} disconnect with charged inductive load



Inductive Load switch-off energy dissipation



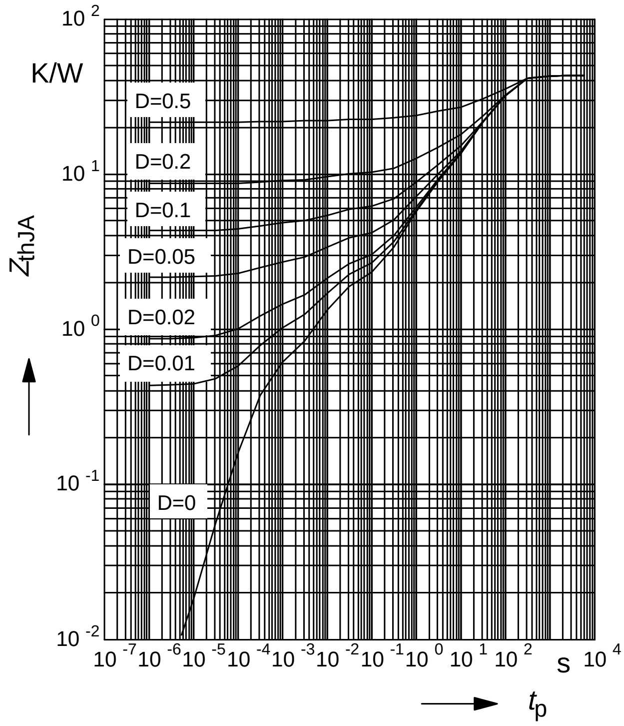
Energy stored in load inductance: $E_L = ½ * L * I_L^2$
While demagnetizing load inductance,
the enérgy dissipated in PROFET is
$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} * i_L(t)\,dt$,
with an approximate solution for $R_L > 0\Omega$:

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

Typ. transient thermal impedance

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

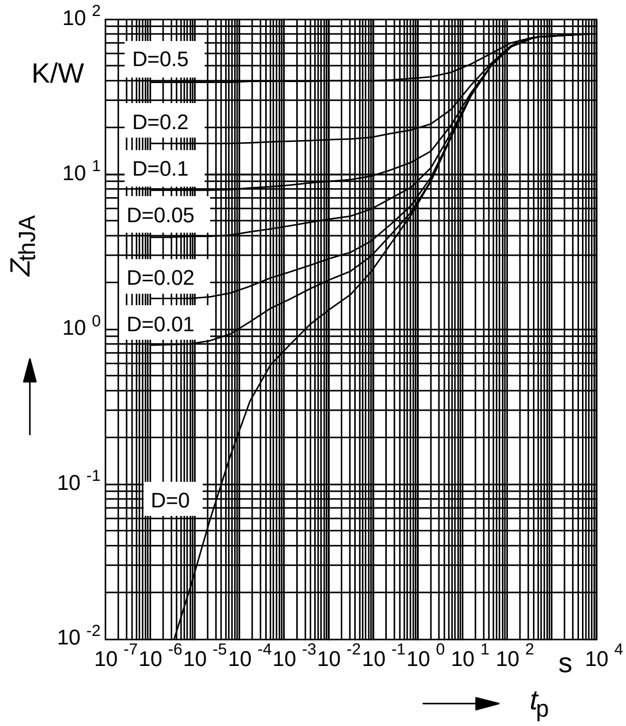
Parameter: $D=t_p/T$



Typ. transient thermal impedance

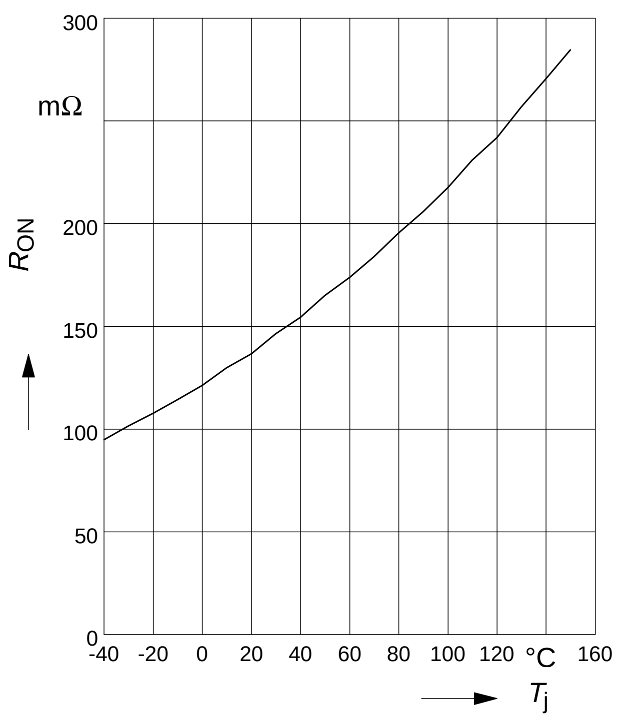
Z_{thJA}=f(t_p) @ min. footprint

Parameter: $D=t_p/T$



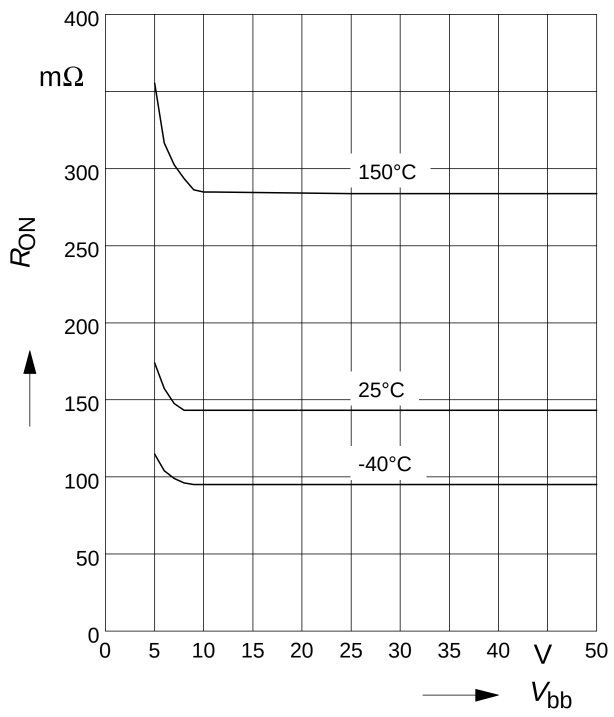
Typ. on-state resistance

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



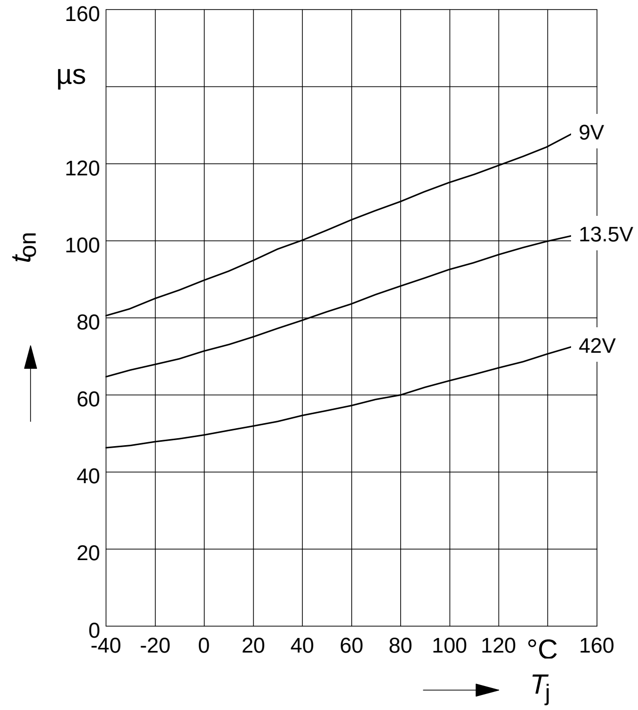
Typ. on-state resistance

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

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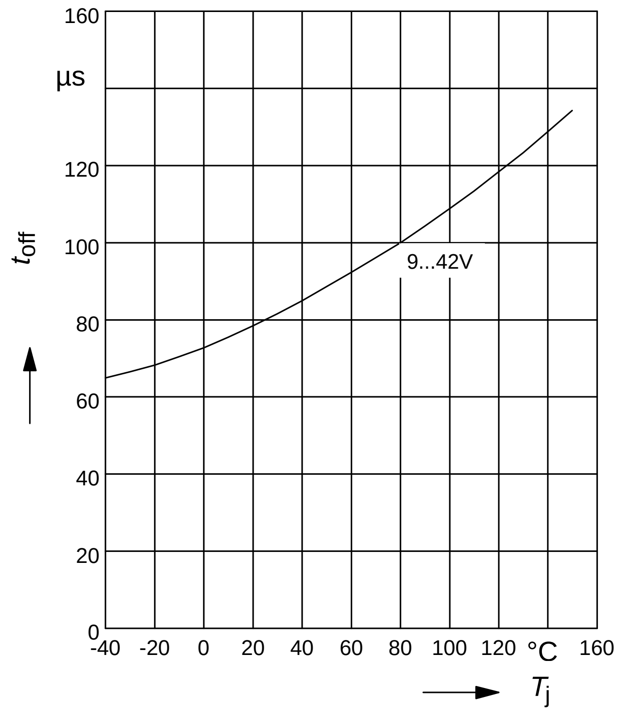
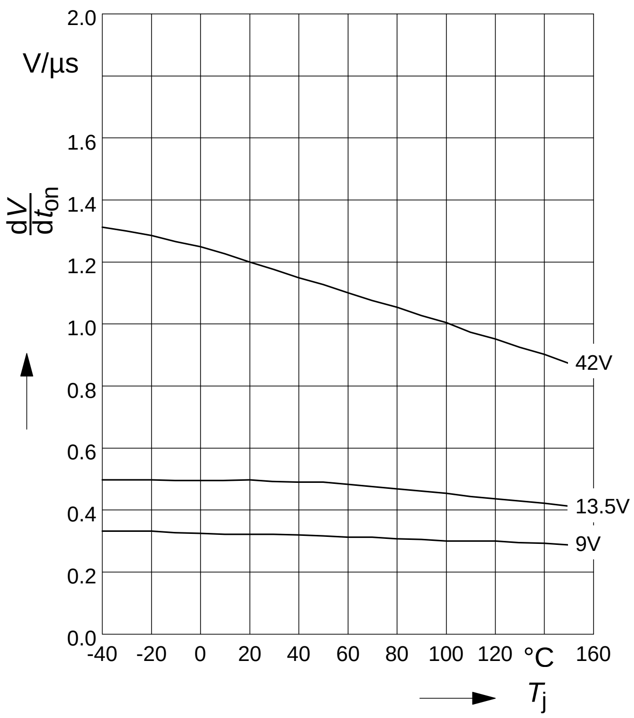


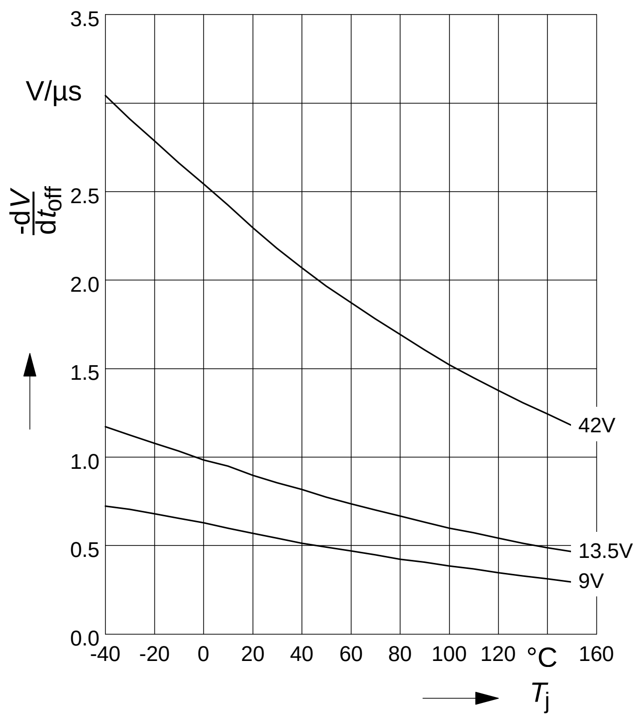
Typ. slew rate on

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



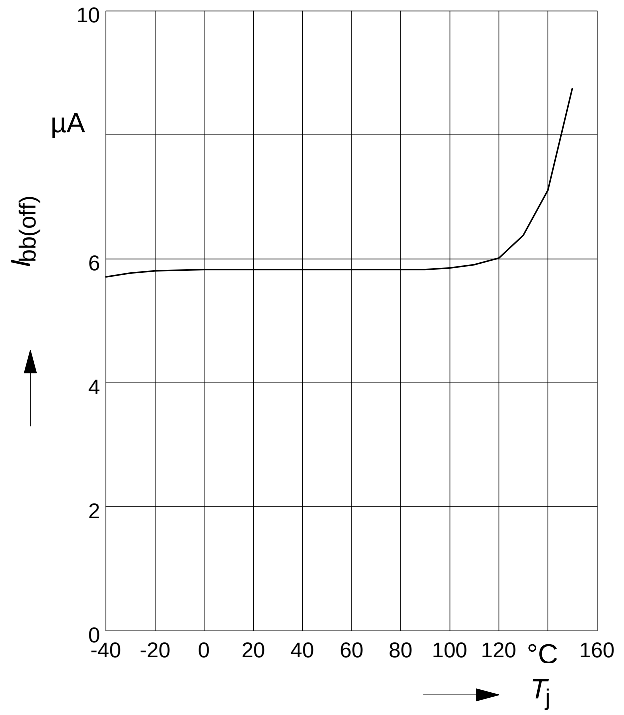
Typ. slew rate off

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



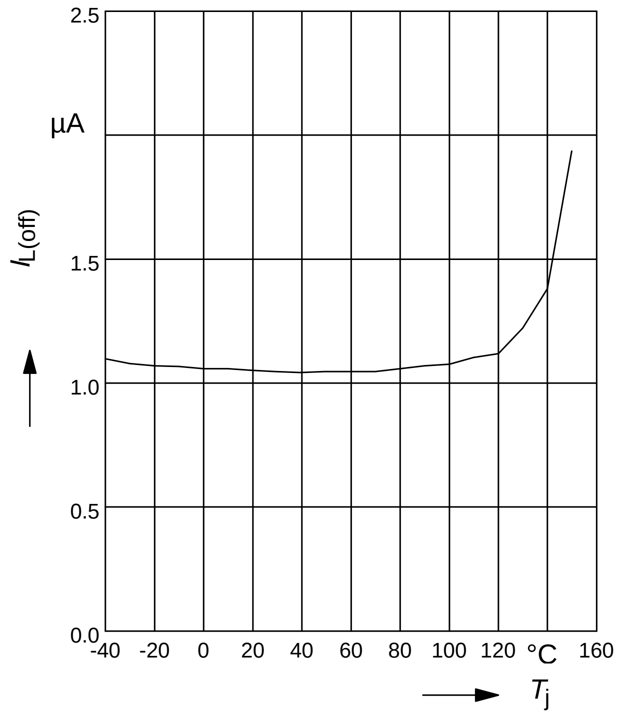
Typ. standby current

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



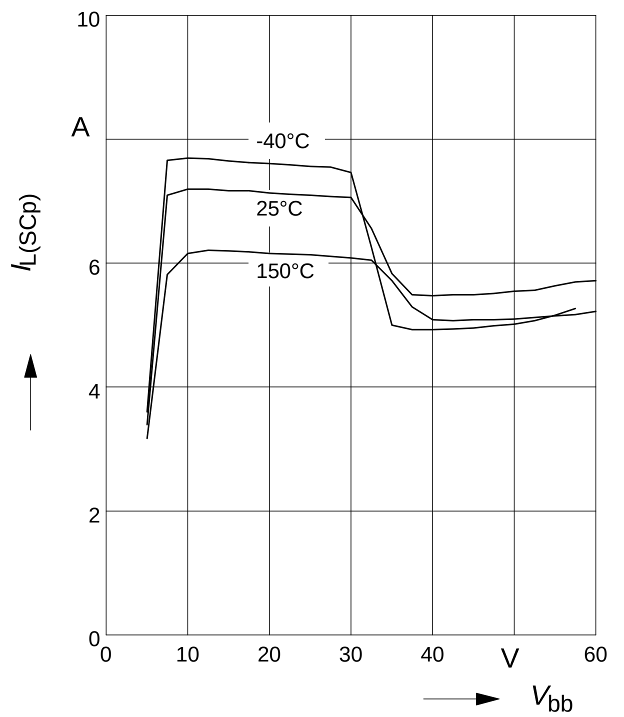
Typ. leakage current

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



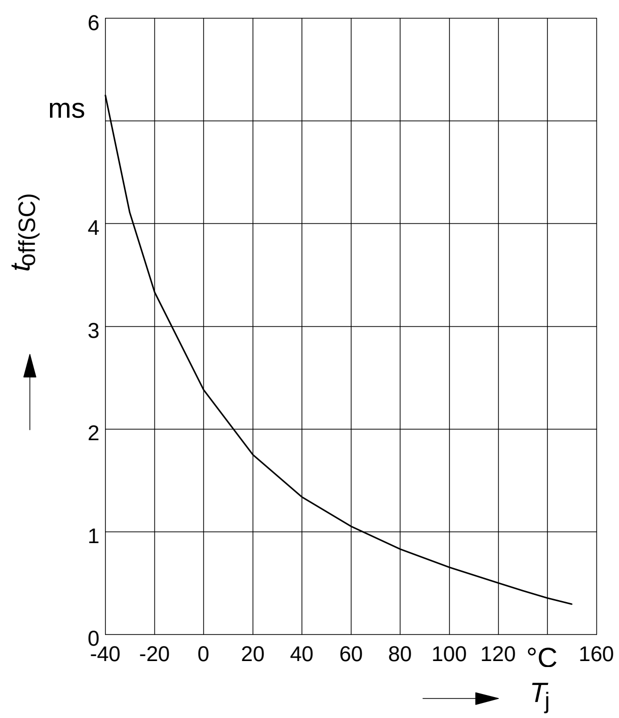
Typ. initial peak short circuit current limit

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



Typ. initial short circuit shutdown time

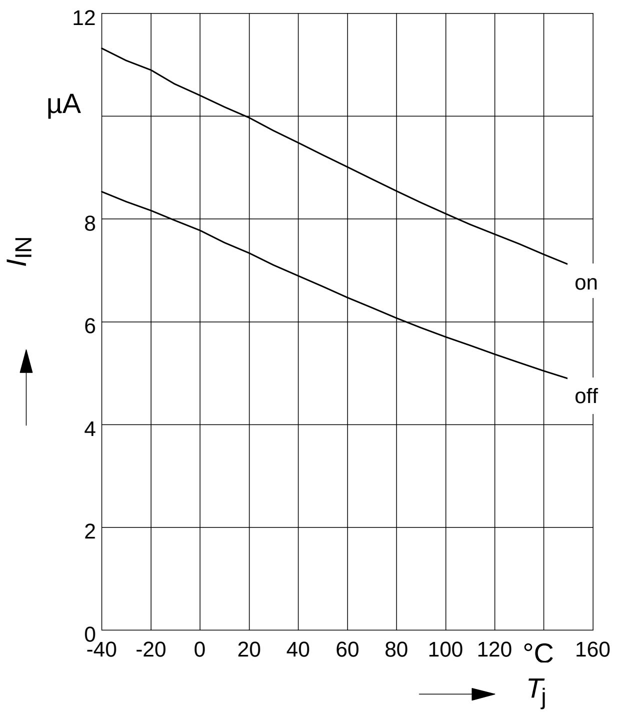
$t_{off(SC)} = f(T_{j,start})$; V_{bb} = 20V



Typ. input current

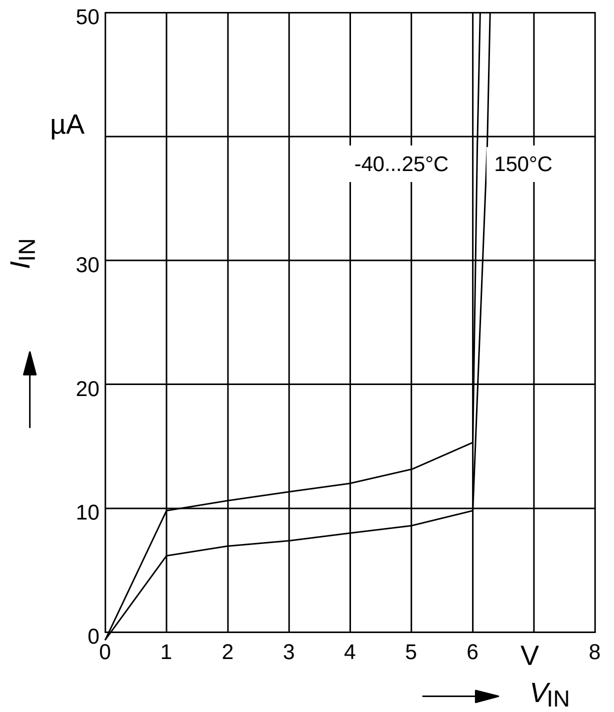
$I_{IN(on/off)} = f(T_j)$; V_{bb} = 13,5V; V_{IN} = low/high

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



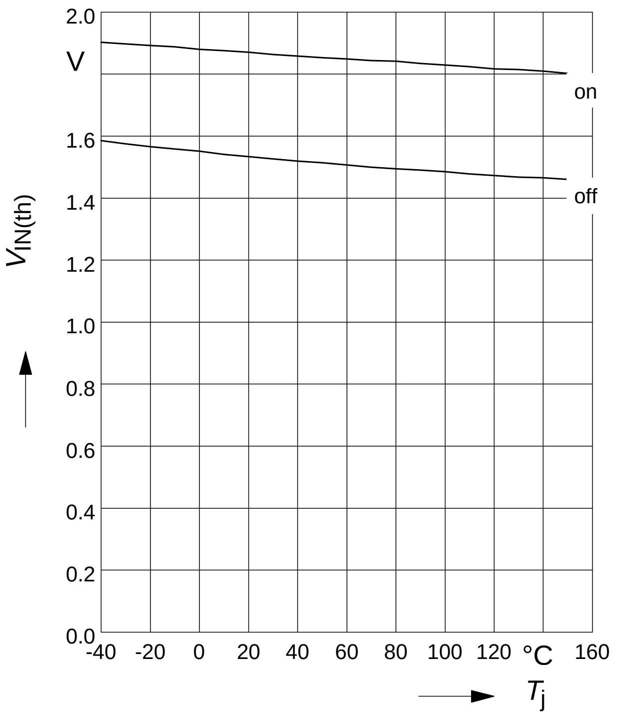
Typ. input current

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



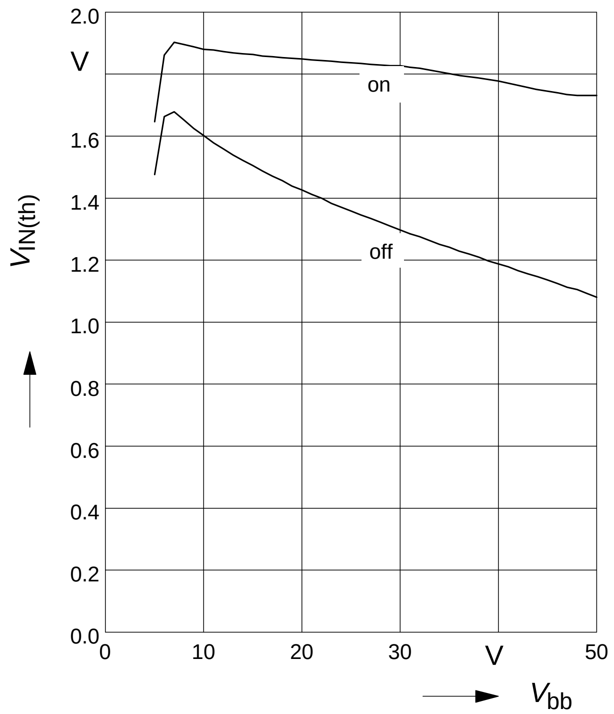
Typ. input threshold voltage

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



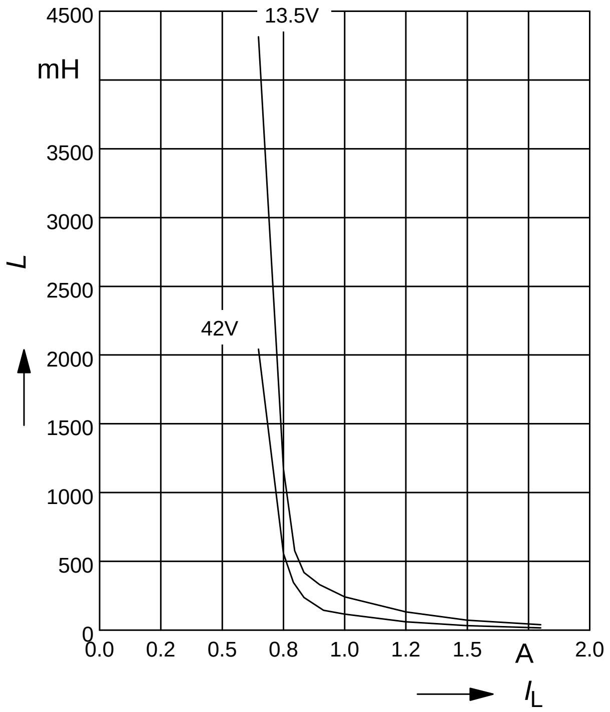
Typ. input threshold voltage

$V_{IN(th)} = f(V_{bb})$; T_j = 25°C



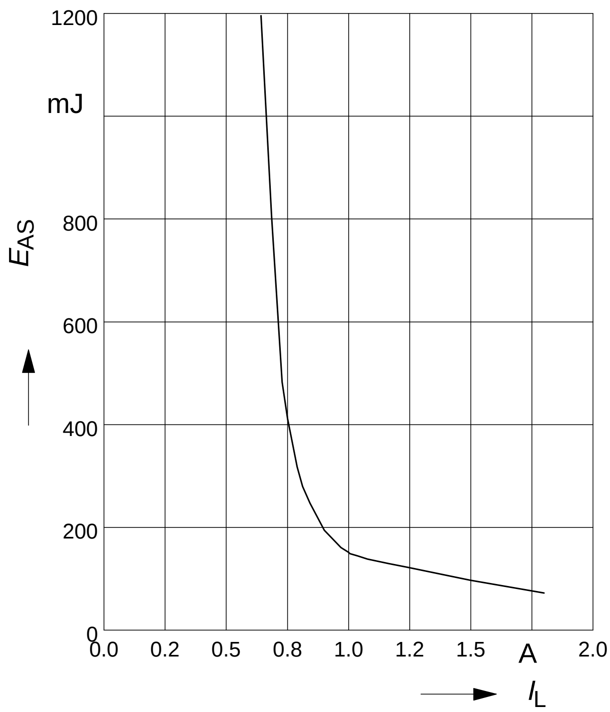
Maximum allowable load inductance for a single switch off

$L = f(I_L)$; 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:

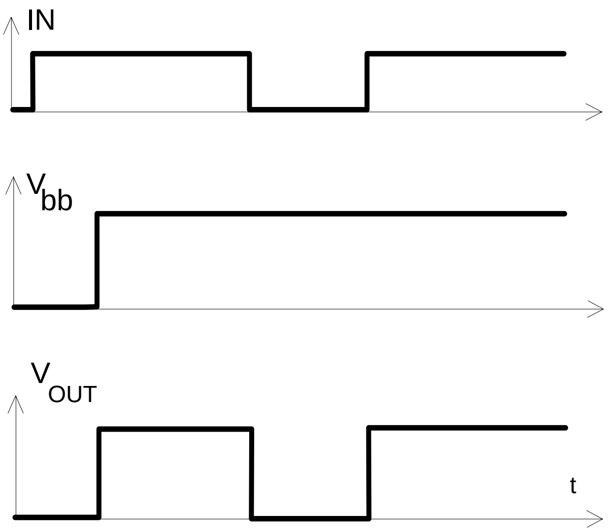


Figure 2b: Switching a lamp,

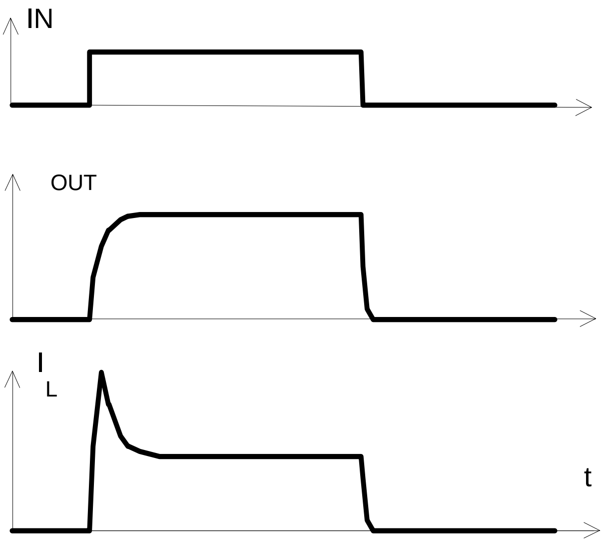


Figure 2a: Switching a resistive load,
turn-on/off time and slew rate definition

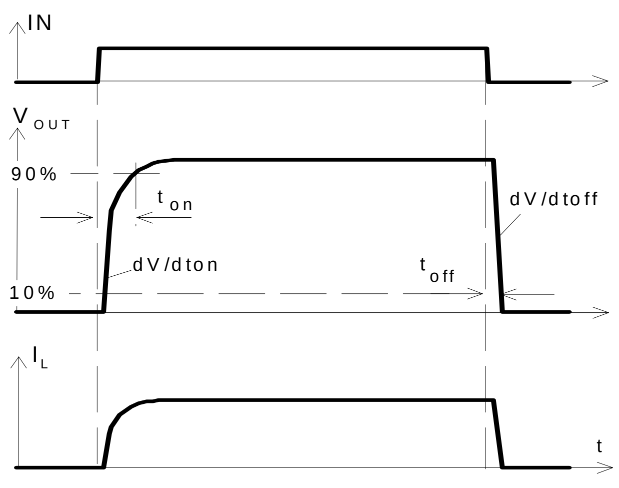


Figure 2c: Switching an inductive load

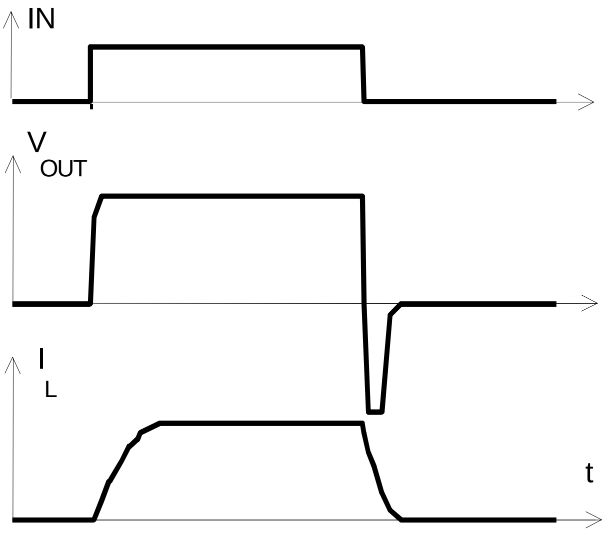
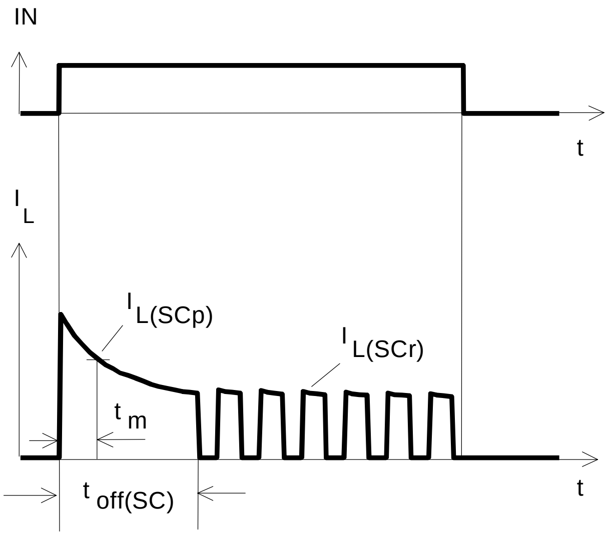


Figure 3a: Turn on into short circuit, shut down by overtemperature, restart by cooling



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

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

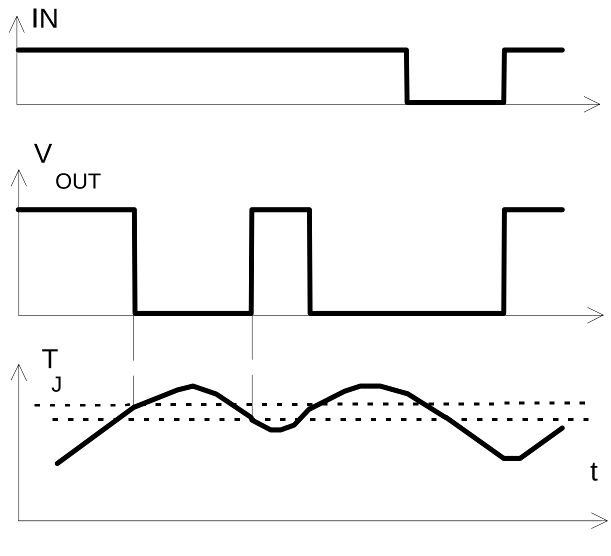
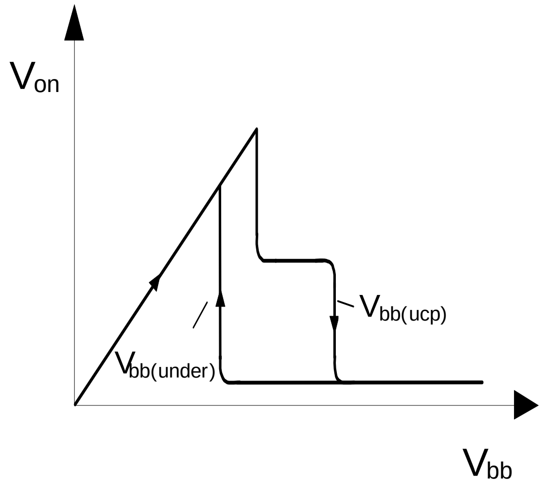


Figure 5: Undervoltage restart of charge pump

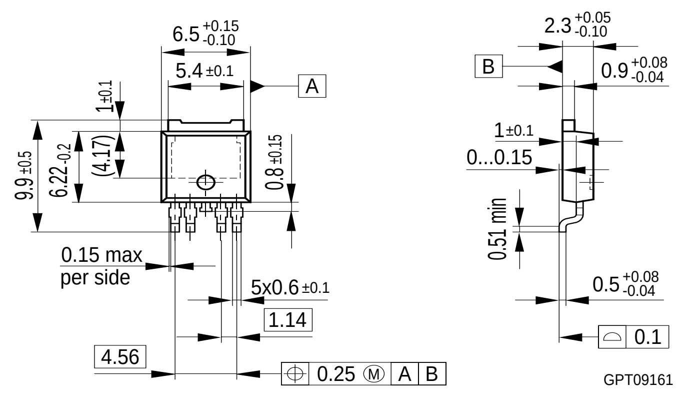


Package and ordering code

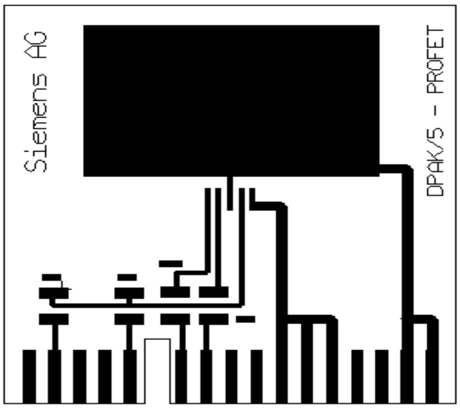
all dimensions in mm

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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