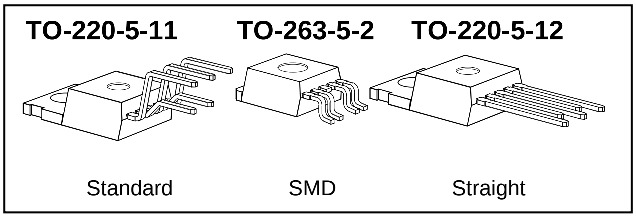
Smart Highside Power Switch
One Channel: 20mΩ

Product Summary

On-state Resistance	R_{ON}	20mΩ
Operating Voltage	$V_{bb(on)}$	4.75 ... 41V
Nominal load current	$I_{L(ISO)}$	21A
Current limitation	$I_{L(lim)}$	65A

Package



General Description

- N channel vertical power FET with charge pump, ground referenced CMOS compatible input, monolithically integrated in Smart SIPMOS® technology.
- Providing embedded protective functions.

Application

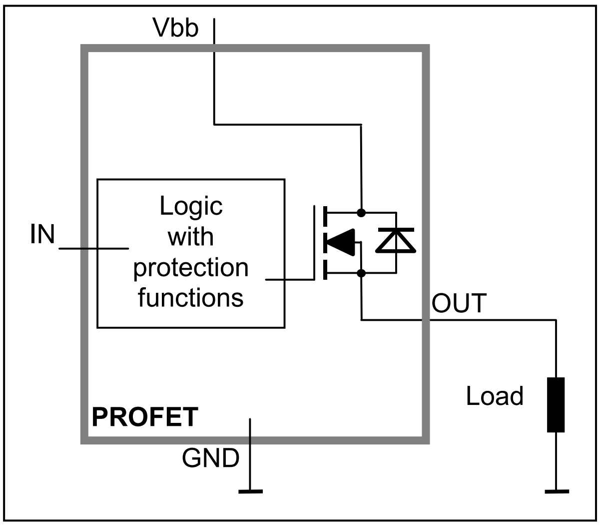
- µC compatible power switch for 5V, 12 V and 24 V DC applications
- All types of resistive, inductive and capacitve loads
- Most suitable for loads with high inrush currents, so as lamps
- Replaces electromechanical relays, fuses and discrete circuits

Basic Funktions

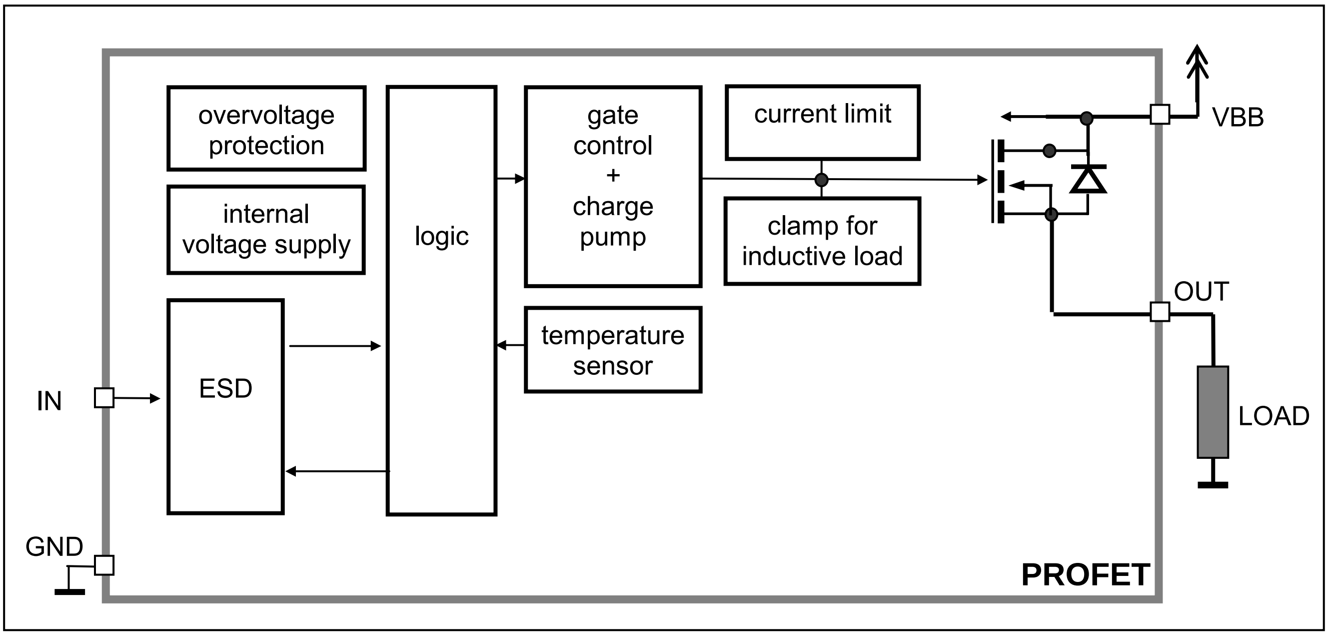
- Very low standby current
- Optimized static **e**lectro**m**agnetic **c**ompatibility (**EMC**)
- µC and CMOS compatible
- Fast demagnetization of inductive loads
- Stable behaviour at undervoltage

Protection Functions

- Short circuit protection
- Current limitation
- Overload protection
- Thermal shutdown
- Overvoltage protection (including load dump) with external GND-resistor
- Reverse battery protection with external GND-resistor
- Loss of ground and loss of V_{bb} protection
- **E**lectro**s**tatic **d**ischarge (**ESD**) protection



Functional diagram

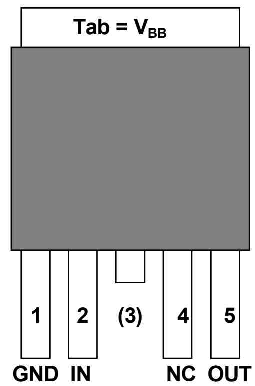


Pin Definitions and Functions

Pin	Symbol	Function
1	GND	**Logic ground**
2	IN	**Input**, activates the power switch in case of logical high signal
3	V_{bb}	**Positive power supply voltage** The tab is shorted to pin 3
4	N.C.	**Not connected**
5	OUT	**Output** to the load
Tab	V_{bb}	**Positive power supply voltage** The tab is shorted to pin 3

Pin configuration

(top view)



Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 4)	V_{bb}	43	V
Supply voltage for full short circuit protection $T_{j\ Start}$=-40 ...+150°C	V_{bb}	34	V
Load dump protection[1] $V_{LoadDump} = V_A + V_s$, V_A = 13.5 V R_I[2]= 2 Ω, R_L= 0,5 Ω, t_d= 200 ms, IN= low or high	$V_{Load\ dump}$[3]	60	V
Load current (Short-circuit current, see page 5)	I_L	self-limited	A
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC) ; TC≤25°C	P_{tot}	125	W
Maximal switchable inductance, single pulse V_{bb} = 12V, $T_{j,start}$ = 150°C, T_C = 150°C const. (see diagram, p.8) $I_{L(ISO)}$ = 21 A, RL= 0 Ω: E[4]$_{AS}$=0.7J:	Z_L	2.1	mH
Electrostatic discharge capability (ESD) IN: (Human Body Model) Out to all other pins shorted: acc. MIL-STD883D, method 3015.7 and ESD assn. std. S5.1-1993; R=1.5kΩ; C=100pF	V_{ESD}	1.0 8.0	kV
Input voltage (DC)	V_{IN}	-10 ... +16	V
Current through input pin (DC) see internal circuit diagrams page 7	I_{IN}	±2.0	mA

Thermal resistance chip - case:	R_{thJC}	≤ 1	K/W
junction - ambient (free air):	R_{thJA}	≤ 75	
SMD version, device on pcb[5]:		≤ 33	

1) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND pin, e.g. with a 150 Ω resistor in the GND connection. A resistor for the protection of the input is integrated.

2) R_I = internal resistance of the load dump test pulse generator

3) $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

4) E_{AS} is the maximum inductive switch off energy

5) Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

Electrical Characteristics

Parameter and Conditions at T_j =-40...+150°C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	

Load Switching Capabilities and Characteristics

On-state resistance (V_{bb} (pin3) to OUT (pin5)); I_L = 2 A V_{bb}≥7V: T_j=25 °C: T_j=150 °C: see diagram page 9	R_{ON}	--	15 28	20 37	mΩ
Nominal load current (pin 3 to 5) 'ISO 10483-1, 6.7:V_{ON}=0.5V, T_C=85°C	$I_{L(ISO)}$	17	21	--	A
Output current (pin 5) while GND disconnected or GND pulled up[6], V_{bb}=30 V, V_{IN}= 0, see diagram page 7	$I_{L(GNDhigh)}$	--	--	2	mA
Turn-on time IN ⌐ to 90% V_{OUT}: Turn-off time IN ¬ to 10% V_{OUT}: R_L = 12 Ω,	t_{on} t_{off}	40 40	90 110	200 250	µs
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω,	dV/dt_{on}	0.1	--	1	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω,	$-dV/dt_{off}$	0.1	--	1	V/µs

Operating Parameters

Operating voltage T_j =-40°C T_j =+25°C T_j =+105°C[6] T_j =+150°C	$V_{bb(on)}$	4.75 4.75 4.75 5.0	-- -- -- --	41 43 43 43	V
Overvoltage protection[7] T_j =-40°C: I_{bb} = 40 mA T_j =+25...+150°C:	$V_{bb(AZ)}$	41 43	-- 47	-- 52	V
Standby current (pin 3) [8] T_j=-40...+25°C: T_j=+105°C[6]: V_{IN}=0 see diagram page 9 T_j=+150°C:	$I_{bb(off)}$	-- -- --	5 -- --	10 10 25	µA
Off-State output current (included in $I_{bb(off)}$) V_{IN}=0	$I_{L(off)}$	--	1.5	10	µA
Operating current (Pin 1)[9], V_{IN}=5 V,	I_{GND}	--	2	4	mA

6) not subject to production test, specified by design

7) see also $V_{ON(CL)}$ in table of protection functions and circuit diagram page 7

8) Measured with load, typ. 40 µA without load.

9) Add I_{IN}, if V_{IN}>5.5 V

Parameter and Conditions at T_j =-40...+150°C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	Values typ	Values max	Unit
Protection Functions[10]					
Current limit (pin 3 to 5) (see timing diagrams, page 9) T_j =-40°C: T_j =25°C: T_j =+150°C:	$I_{L(lim)}$	-- -- 40	-- 65 --	85 -- --	A
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams, page 10)	$I_{L(SCr)}$	--	55	--	A
Thermal shutdown time[11][12] $T_{j,start}$ =25°C: (see timing diagram on page 10)	$T_{off(SC)}$	--	14	--	ms
Output clamp (inductive load switch off) ;T_j =-40°C: at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_L= 40 mA T_j=25..150°C:	$V_{ON(CL)}$	41 43	-- 47	-- 52	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Reverse battery (pin 3 to 1) [13]	$-V_{bb}$	--	--	32	V
Reverse battery voltage drop ($V_{OUT} > V_{bb}$) I_L = -2A T_j =+150°C:	$-V_{ON(rev)}$	--	540	--	mV

[10] 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.

[11] not subject to production test, specified by design

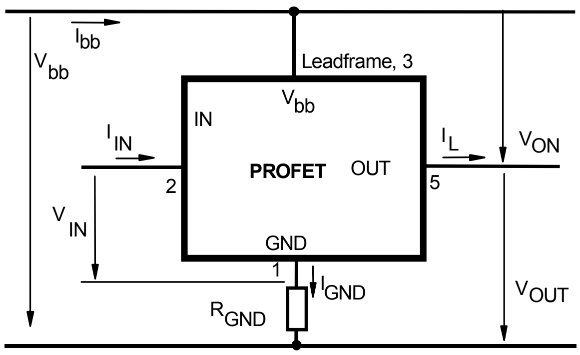
[12] Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

[13] Requires 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Note that the power dissipation is higher compared to normal operating conditions due to the voltage drop across the intrinsic drain-source diode. The temperature protection is not active during reverse current operation! Input and Status currents have to be limited (see max. ratings page 1 and circuit page 7).

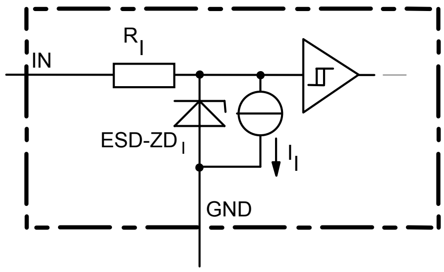
Parameter and Conditions at T_j =-40...+150°C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	Values typ	Values max	Unit
Input[14]					
Input resistance see circuit page 7	R_I	2.5	3.8	6.5	kΩ
Input turn-on threshold voltage	$V_{IN(T+)}$	1.2	--	2.2	V
Input turn-off threshold voltage	$V_{IN(T-)}$	0.8	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.3	--	V
Off state input current (pin 2) V_{IN} = 0.4 V:	$I_{IN(off)}$	1	--	15	µA
On state input current (pin 2) V_{IN} = 5 V:	$I_{IN(on)}$	4.5	12	24	µA

14) If a ground resistor R_{GND} is used, add the voltage drop across this resistor.

Terms

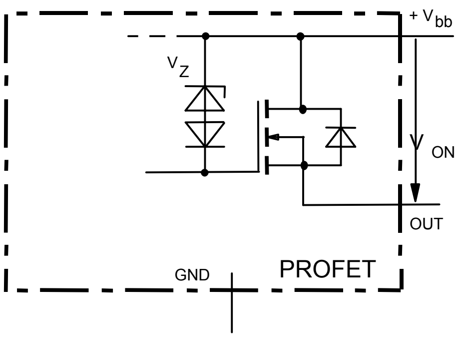


Input circuit (ESD protection)



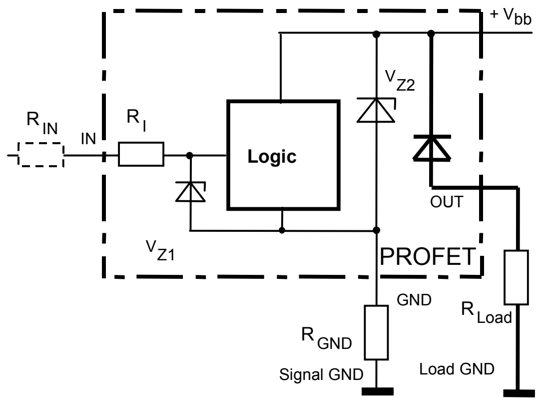
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended.

Inductive and overvoltage output clamp



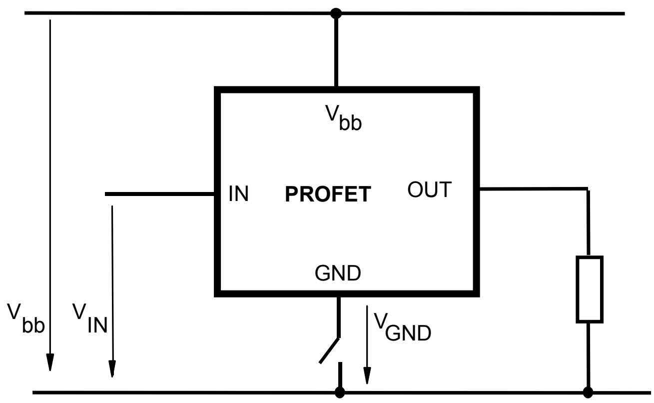
V_{ON} clamped to 47 V typ.

Overvolt. and reverse batt. protection



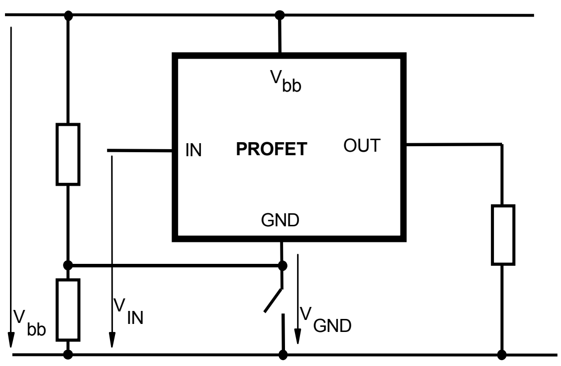
V_{Z1} = 6.1 V typ., V_{Z2} = 47 V typ., R_{GND} = 150 Ω, R_I= 3.5 kΩ typ.
In case of reverse battery the load current has to be limited by the load. Temperature protection is not active

GND disconnect



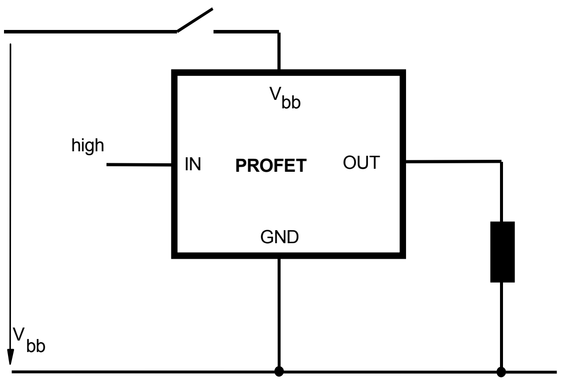
Any kind of load. In case of Input=high is $V_{OUT} \approx V_{IN} - V_{IN(T+)}$.

GND disconnect with GND pull up



Any kind of load. If $V_{GND} > V_{IN} - V_{IN(T+)}$ device stays off

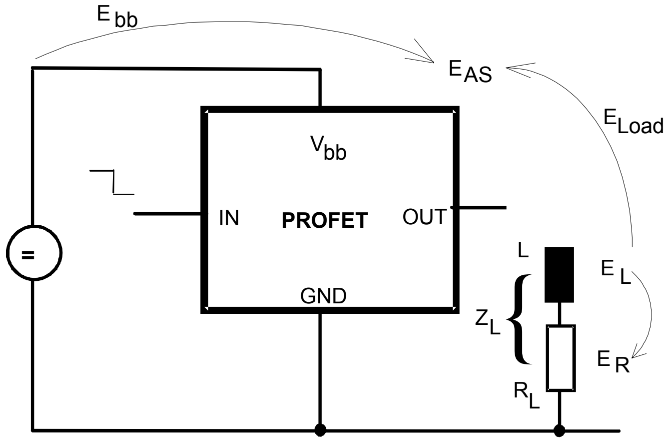
V_{bb} disconnect with charged inductive load



For inductive load currents up to the limits defined by Z_L (max. ratings and diagram on page 8) each switch is protected against loss of V_{bb}.

Consider at your PCB layout that in the case of Vbb dis-connection with energized inductive load all the load current flows through the GND connection.

Inductive load switch-off energy dissipation



Energy stored in load inductance:

$$E_L = \tfrac{1}{2} \cdot L \cdot I_L^2$$

While demagnetizing load inductance, the energy dissipated in PROFET is

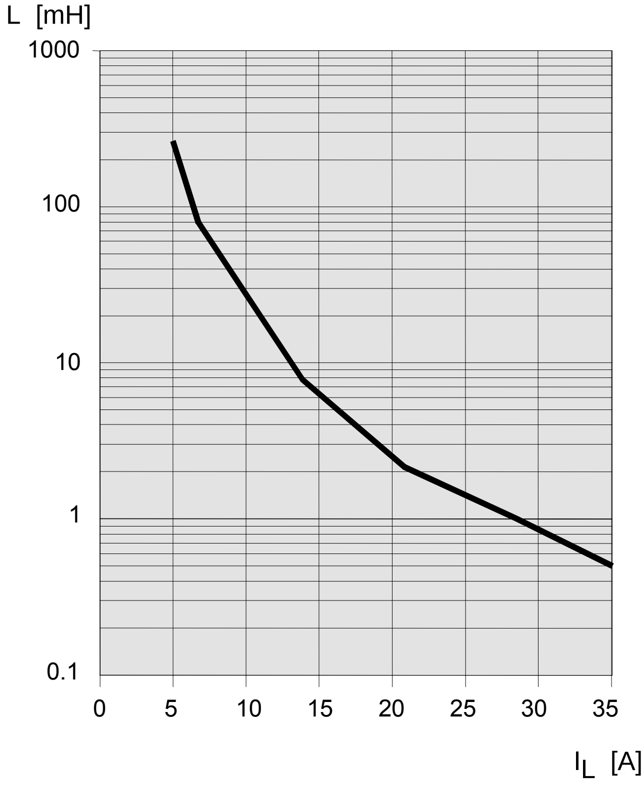
$$E_{AS} = E_{bb} + E_L - E_R = V_{ON(CL)} \cdot i_L(t)\ dt,$$

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

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

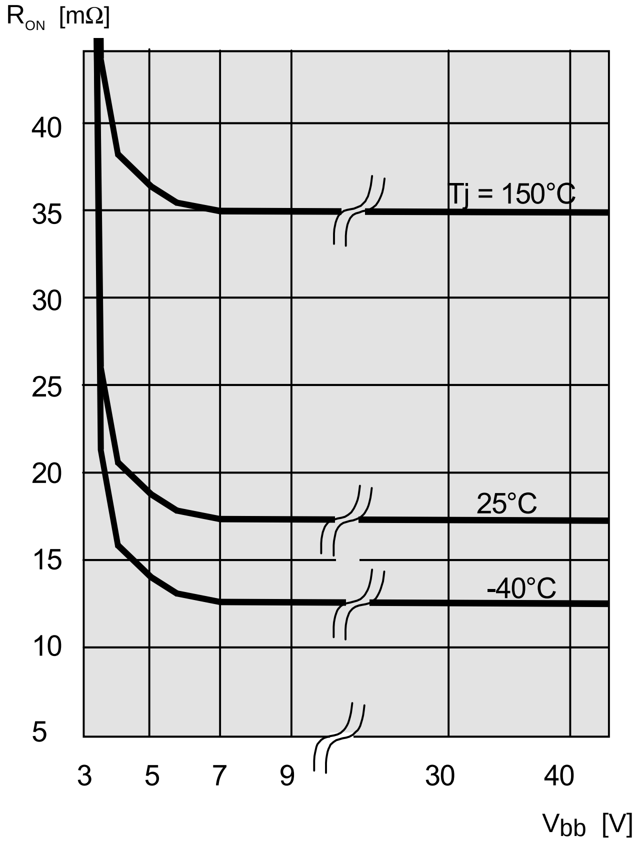
Maximum allowable load inductance for a single switch off

$L = f(I_L)$; $T_{j,start} = 150°C$, $V_{bb} = 12\,V$, $R_L = 0\,\Omega$



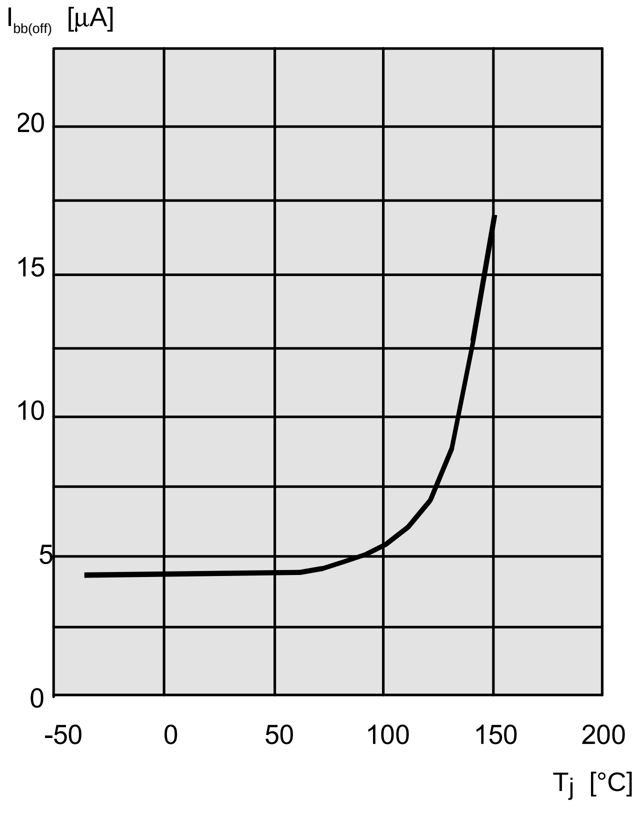
Typ. on-state resistance

$R_{ON} = f(V_{bb}, T_j)$; I_L = 2 A, IN = high



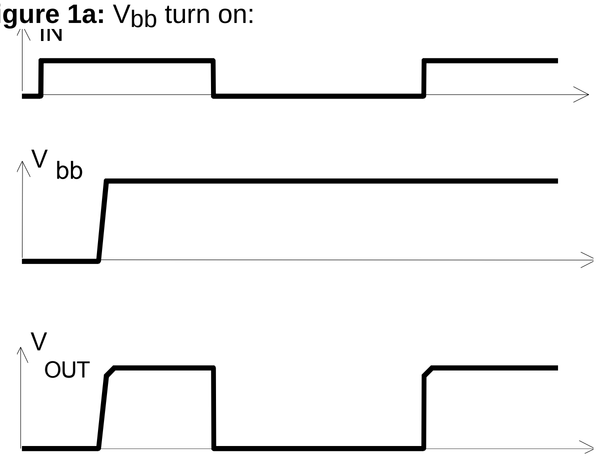
Typ. standby current

$I_{bb(off)} = f(T_j)$; V_{bb} = 9...34 V, IN1,2 = low



Timing diagrams

Figure 1a: V_{bb} turn on:



proper turn on under all conditions

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

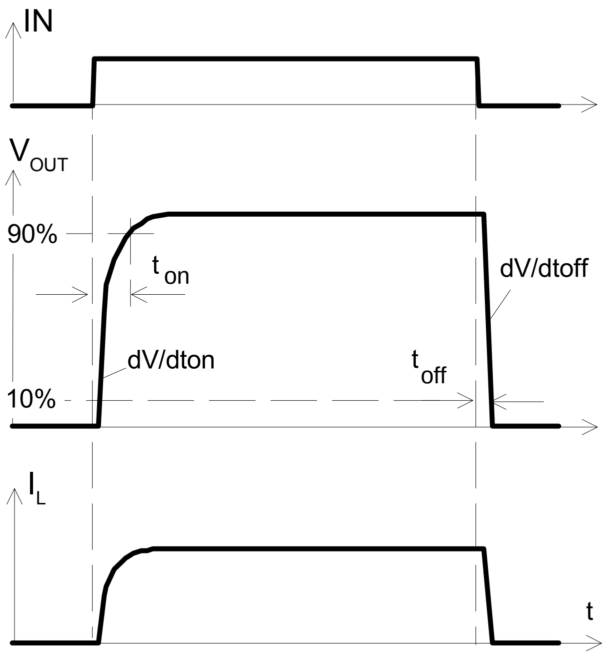


Figure 2b: Switching a lamp,

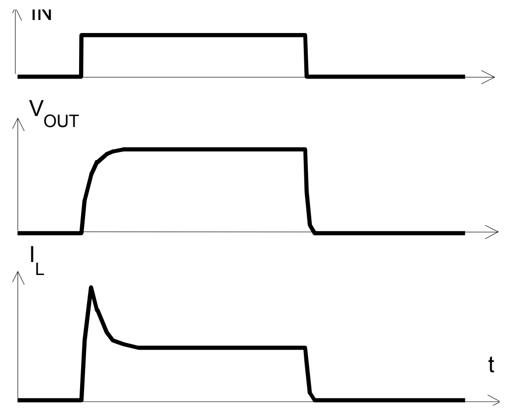
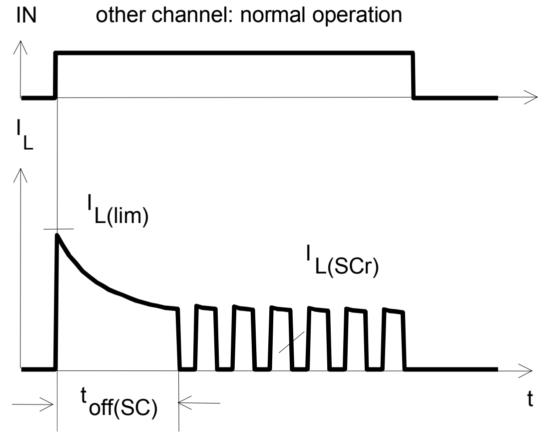
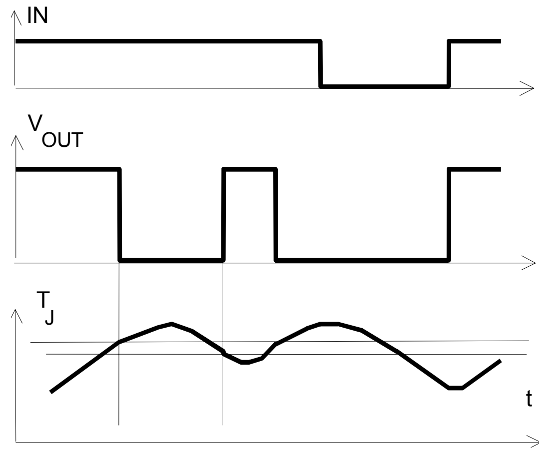


Figure 3a: Short circuit
shut down by overtemperature, reset by cooling



Heating up may require several milliseconds, depending on external conditions

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

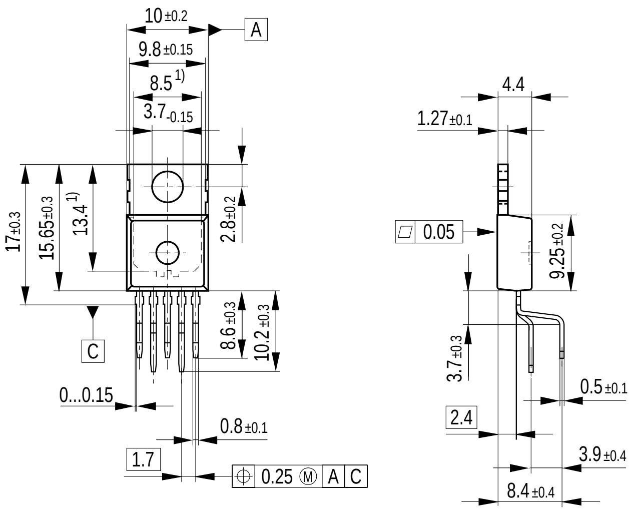


Package and Ordering Code

All dimensions in mm

Standard (=staggered): P-TO220-5-11

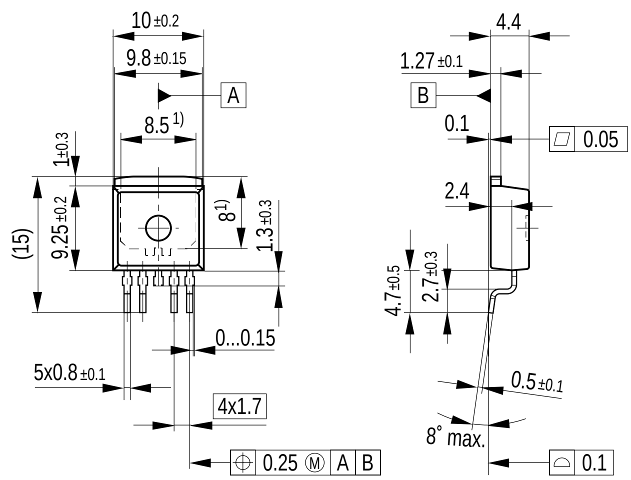
Sales code	BTS441T
Ordering code:	Q67060-S6112-A2



1) Typical
All metal surfaces tin plated, except area of cut.

SMD: P-TO263-5-2 (tape&reel)

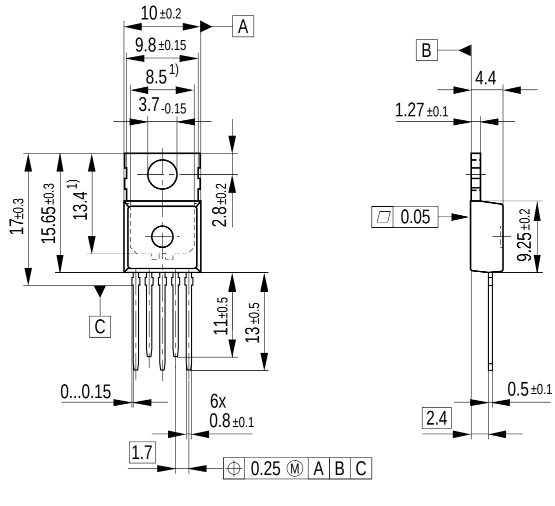
Sales code	BTS441T G
Ordering code:	Q67060-S6112-A3



1) Typical
All metal surfaces tin plated, except area of cut.

Straight: P-TO220-5-12

Sales code	BTS441T S
Ordering code:	Q67060-S6112-A4



Typical
1) All metal surfaces tin plated, except area of cut.

Published by Infineon Technoligies AG,
St.-Martin-Strasse 53, D-81669 München

Attention please!
The information herein is given to describe certain components and shall not be considered as a guarantee of characteristics.
Terms of delivery and rights to technical change reserved.
We hereby disclaim any and all warranties, including but not limited to warranties of non-infringement, regarding circuits, descriptions and charts stated herein.

Information
For further information on technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies Office in Germany or our Infineon Technologies Representatives worldwide (see address ist).

Warnings
Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office.

Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.