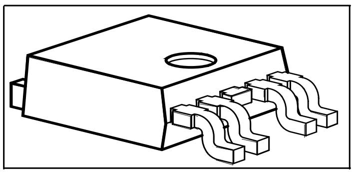
Smart Power High-Side-Switch

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	$V_{bb(AZ)}$	60	V
Operating voltage	$V_{bb(on)}$	5...34	V
On-state resistance	R_{ON}	200	mΩ
Nominal load current	$I_{L(ISO)}$	1.8	A



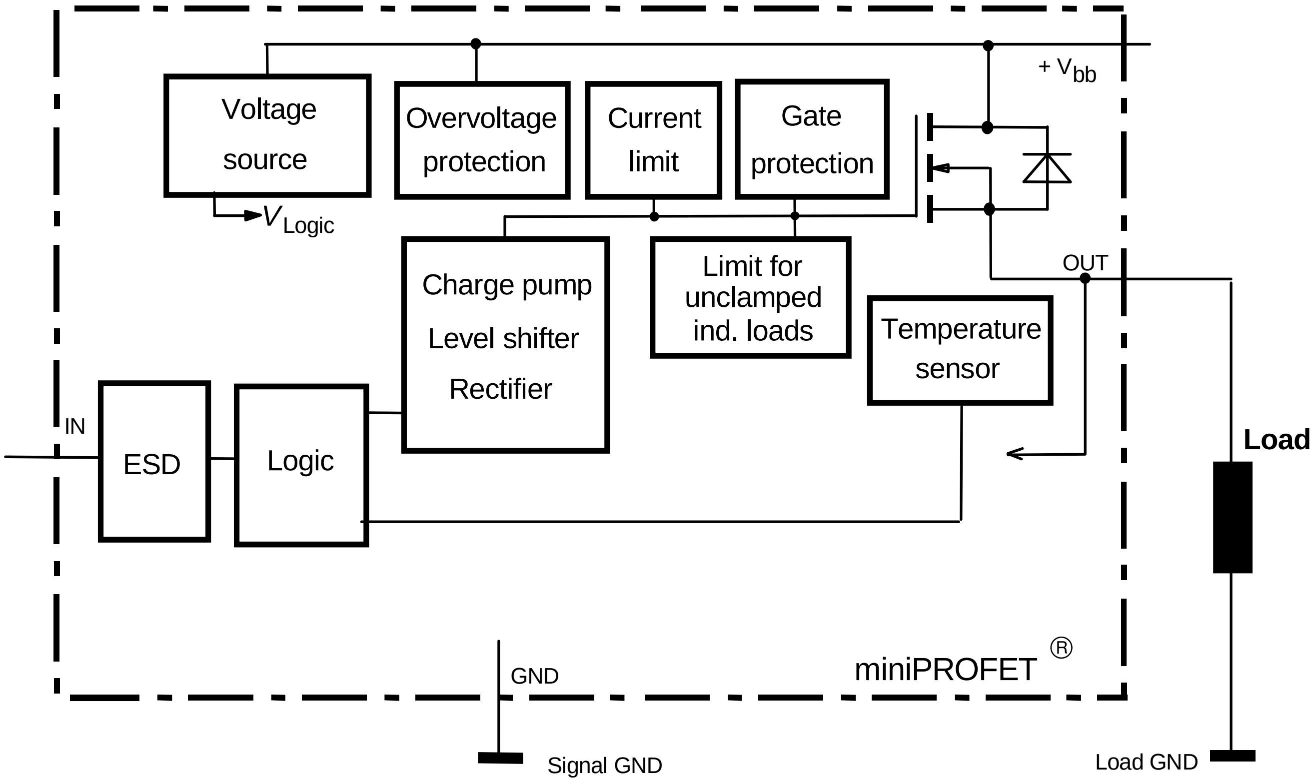
Application

- All types of resistive, inductive and capacitive loads
- µC compatible power switch for 12 V 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.

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}	40	V
Supply voltage for full short circuit protection	$V_{bb(SC)}$	tbd	
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}	41.6	W
Inductive load switch-off energy dissipation[1)2)] single pulse, (see page 8) Tj =150 °C	E_{AS}	tbd	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	$V_{Loaddump}$	tbd	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 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	-	
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 11)

[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 = 25 °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 T_j = 150 °C	R_{ON}	 - 	 tbd tbd	 200 400	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}	t_{on}	-	80	tbd	µs
Turn-off time to 10% V_{OUT}	t_{off}	-	80	tbd	µs
Slew rate on 10 to 30% V_{OUT},	dV/dt_{on}	-	1	tbd	V/µs
Slew rate off 70 to 40% V_{OUT},	$-dV/dt_{off}$	-	1	tbd	

Operating Parameters

Parameter	Symbol	min.	typ.	max.	Unit
Operating voltage T_j = -40...+150 °C	$V_{bb(on)}$	5	-	34	V
Undervoltage shutdown of charge pump	$V_{bb(under)}$	-	-	tbd	
Undervoltage restart of charge pump	$V_{bb(u\ cp)}$	-	-	tbd	V
Standby current V_{IN} = 0 V, T_j = -40 ... +85 °C V_{IN} = 0 V, T_j = 150°C [2]	$I_{bb(off)}$	 - -	 - -	 10 15	µA
Leakage output current (included in $I_{bb(off)}$) V_{IN} = 0 V	$I_{L(off)}$	-	-	tbd	
Operating current V_{IN} = 5 V	I_{GND}	-	1	tbd	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 11)

[2] higher current due temperature sensor

Electrical Characteristics

Parameter and Conditions at T_j = 25 °C, V_{bb}=13.5V, unless otherwise specified	**Symbol**	**Values** min.	typ.	max.	**Unit**
Protection Functions					
Initial peak short circuit current limit (pin 3 to 5)	$I_{L(SCp)}$				A
T_j = -40 °C, V_{bb} = tbd V, t_m = tbd µs		-	-	tbd	
T_j = 25 °C		-	7.5	-	
T_j = 150 °C		tbd	-	-	
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams)	$I_{L(SCr)}$	-	tbd	-	
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$,	$V_{ON(CL)}$	60	tbd	-	V
Overvoltage protection [1] T_j = -40...+150 °C	$V_{bb(AZ)}$	60	-	-	
Thermal overload trip temperature	T_{jt}	150	-	-	°C
Thermal hysteresis	ΔT_{jt}	-	10	-	K

Reverse Battery

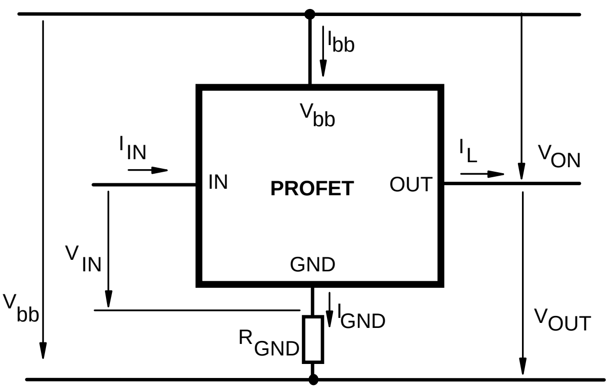
Reverse battery[2]	$-V_{bb}$	-	-	tbd	V
Drain-source diode voltage ($V_{OUT} > V_{bb}$) T_j = 150 °C	$-V_{ON}$	-	tbd	-	mV

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

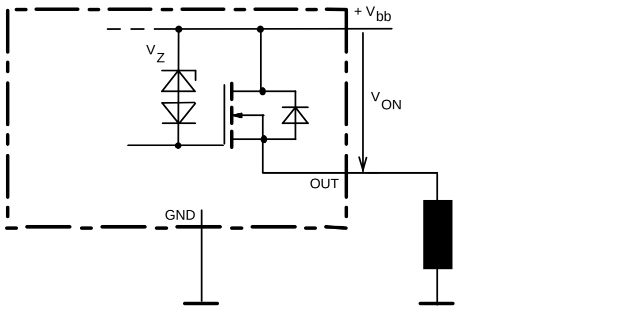
[2] Requires a 150 Ω resistor in GND connection. The reverse load current through the intrinsic drain-source diode has to be limited by the connected load. Power dissipation is higher compared to normal operating conditions due to the voltage drop across the drain-source diode. The temperature protection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

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

Terms

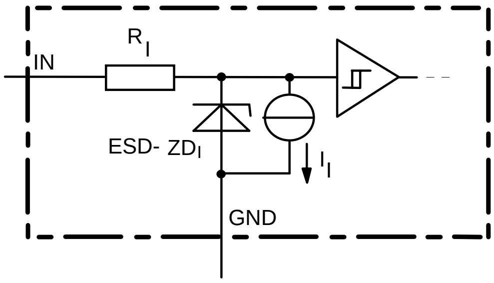


Inductive and overvoltage output clamp



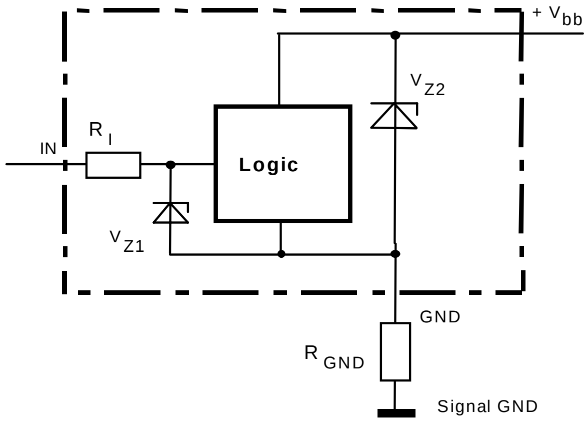
V_{ON} clamped to tbd V typ.

Input circuit (ESD protection)



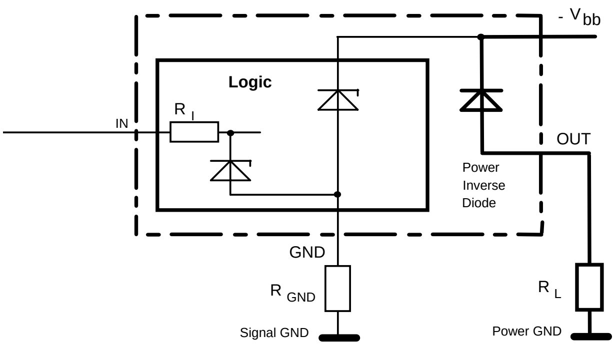
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

Overvoltage protection of logic part



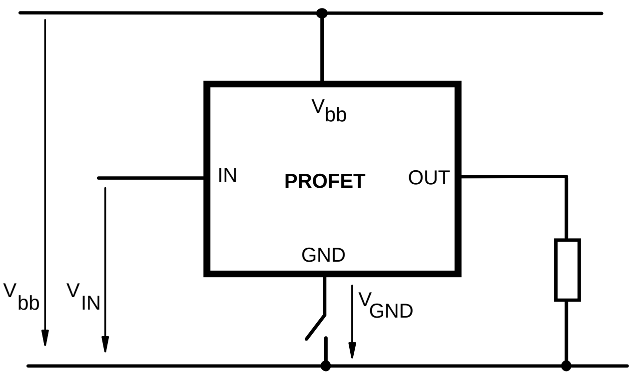
V_{Z1}=6.1V typ., V_{Z2}=$V_{bb(AZ)}$=tbd V typ.,
R_I=3.5 kΩ typ., R_{GND}=150Ω

Reverse battery protection

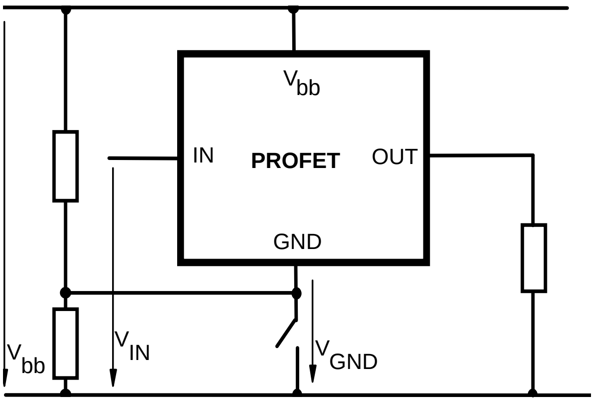


R_{GND}=150Ω, R_I=3.5kΩ typ.,
Temperature protection is not active during inverse current

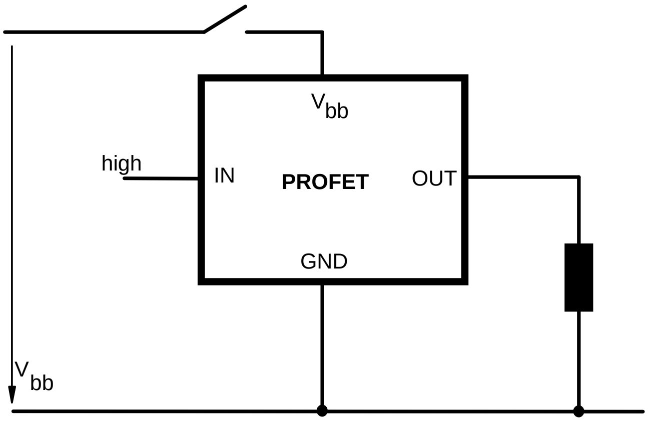
GND disconnect



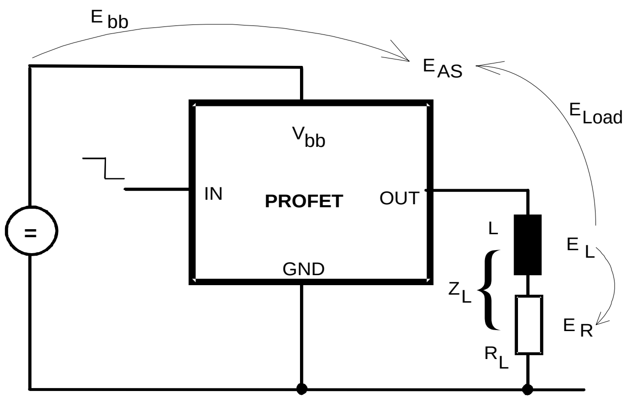
GND disconnect with GND pull up



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 $R_L > 0\Omega$:

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

Timing diagrams

Figure 1a: Vbb turn on:

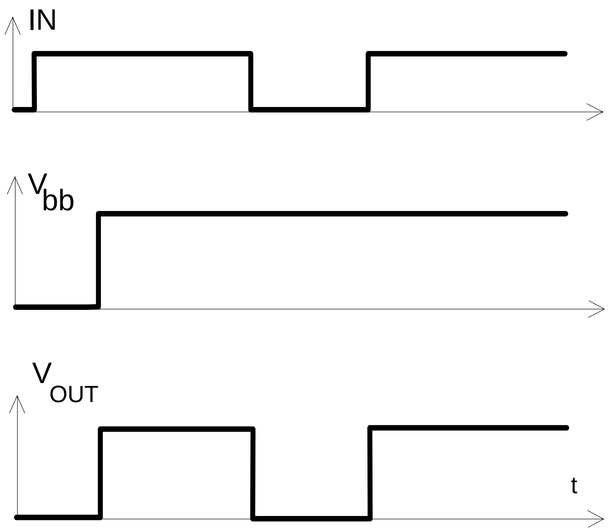


Figure 2a: Switching a resistive load,
turn-on/off time and slew rate definition

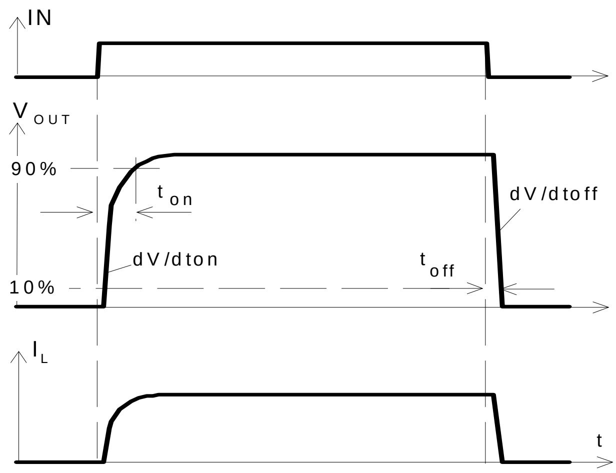


Figure 2b: Switching a lamp,

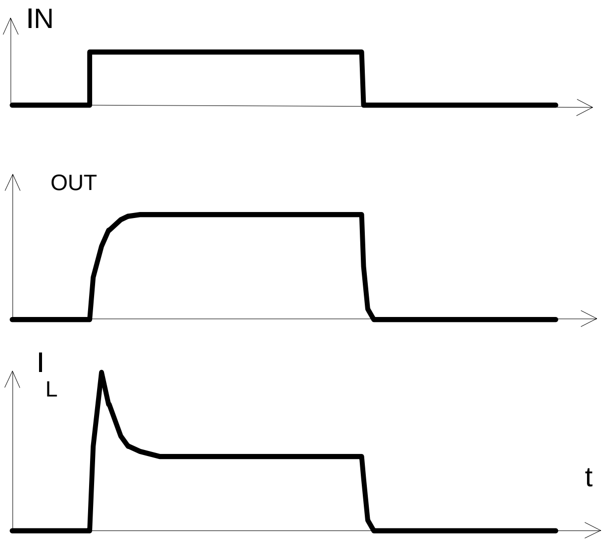


Figure 2c: Switching an inductive load

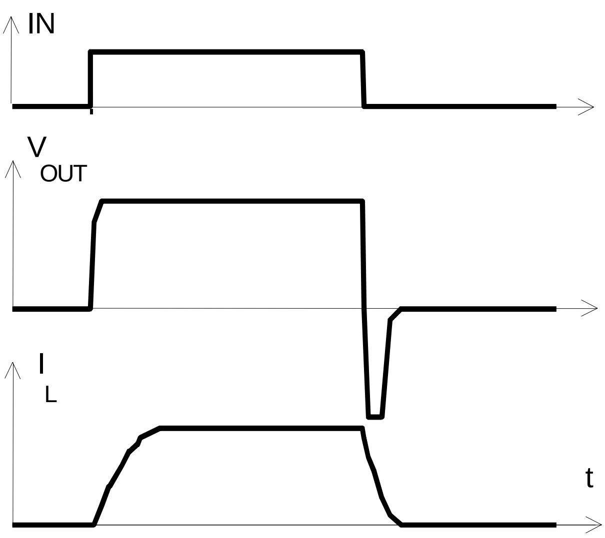
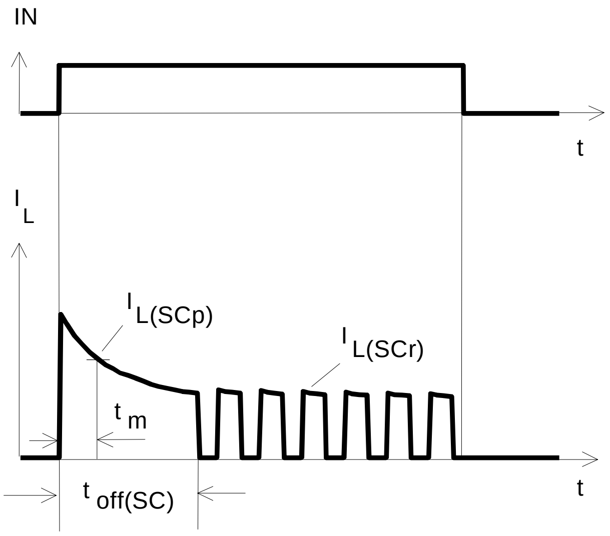


Figure 3a: Turn on into short circuit,
shut down by overtemperature, restart by cooling



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

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

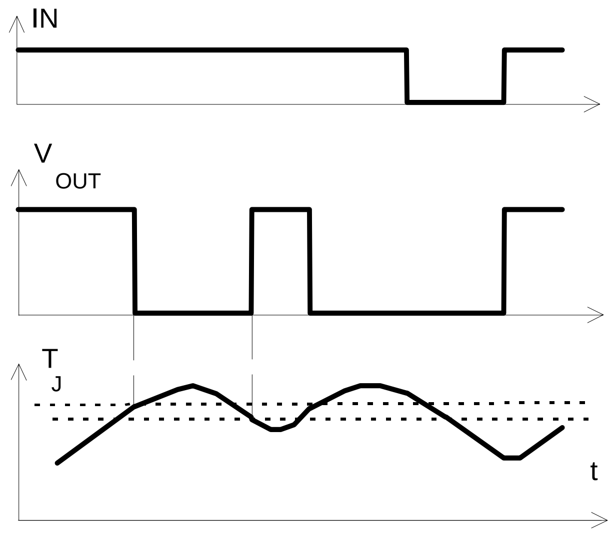
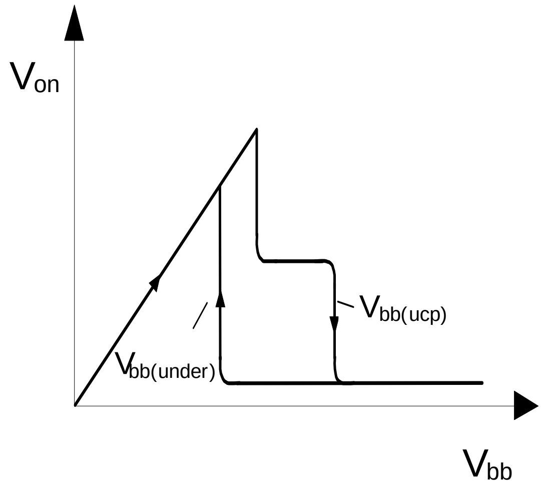


Figure 5: Undervoltage restart of charge pump

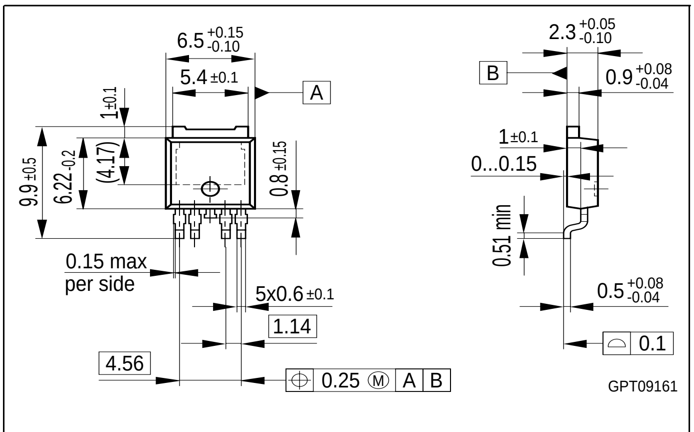


Package and ordering code

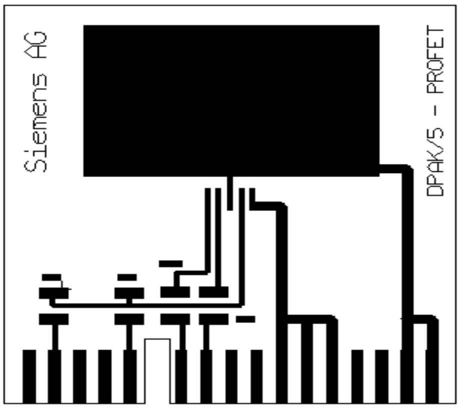
all dimensions in mm

Ordering code:

	XXX



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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