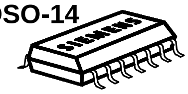
Smart High-Side Power Switch
Two Channels: 2 x 100mΩ
Status Feedback
Suitable for 42V

Product Summary
Package

Operating Voltage	$V_{bb(on)}$	5.0 ...62V	
	Active channels	one	two parallel
On-state Resistance	R_{ON}	100mΩ	50mΩ
Nominal load current	$I_{L(NOM)}$	2.9A	4.2A
Current limitation	$I_{L(SCr)}$	8A	8A

P-DSO-14



General Description

- N channel vertical power MOSFET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, monolithically integrated in Smart SIPMOS® 80V technology.
- Fully protected by embedded protection functions
- An array of resistors is integrated in order to reduce the external components

Applications

- µC compatible high-side power switch with diagnostic feedback for 12V and 24V and **42V** grounded loads
- All types of resistive, inductive and capacitive loads
- Most suitable for inductive loads
- Replaces electromechanical relays, fuses and discrete circuits

Basic Functions

- CMOS compatible input
- Improved electromagnetic compatibility (EMC)
- Fast demagnetization of inductive loads
- Stable behaviour at undervoltage
- Wide operating voltage range
- Logic ground independent from load ground
- Optimized inverscurrent capability

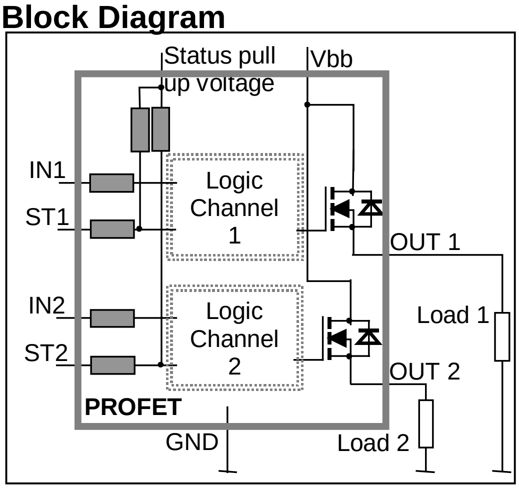
Protection Functions

- Short circuit protection
- Overload protection
- Current limitation
- Thermal shutdown
- Overvoltage protection (including load dump) with external resistor
- Reverse battery protection with external resistor
- Loss of ground and loss of V_{bb} protection
- Electrostatic discharge protection (ESD)

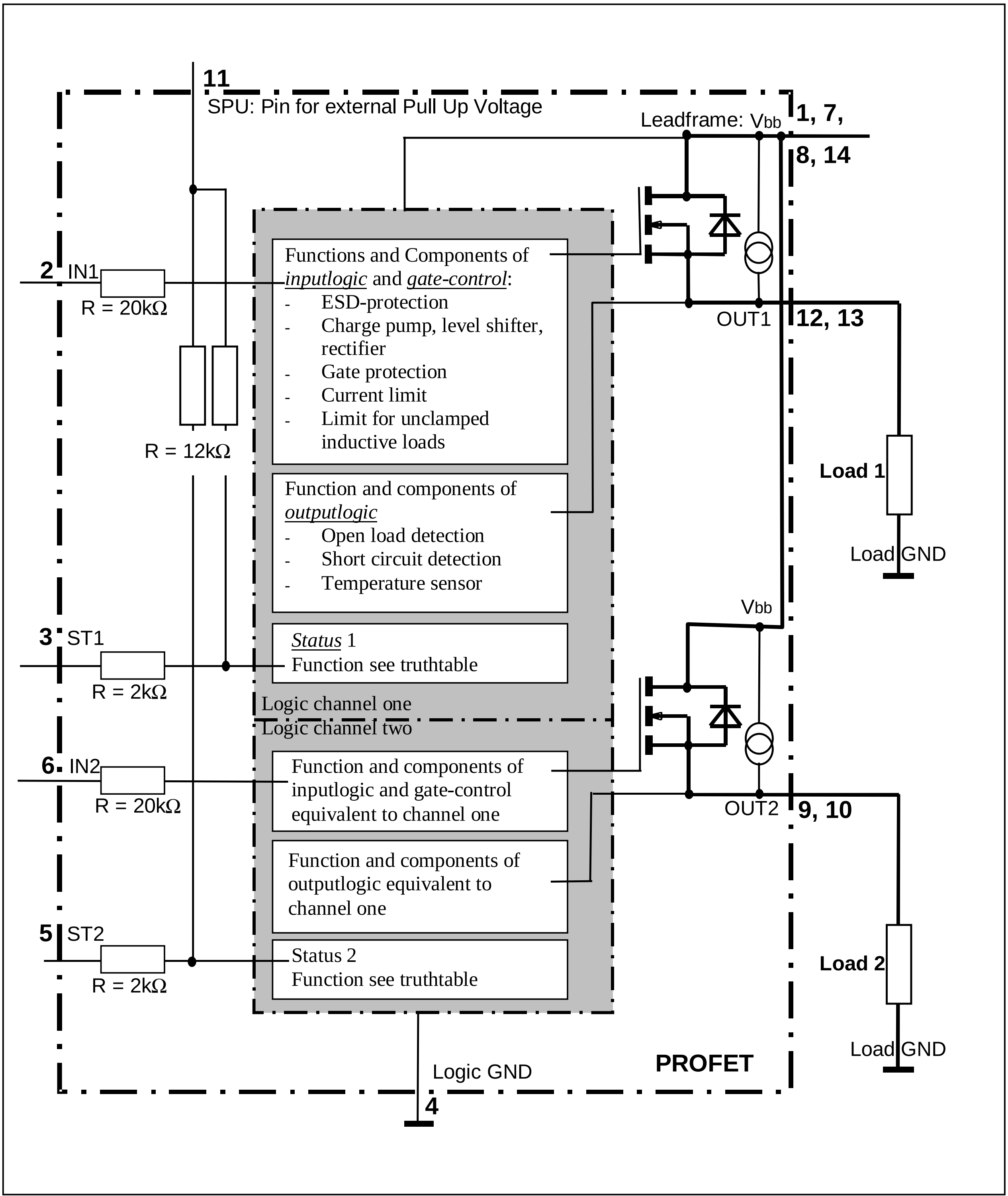
Diagnostic Function

- Diagnostic feedback with open drain output and integrated pull up resistors
- Open load detection in OFF-state
- Feedback of thermal shutdown in ON-state
- Diagnostic feedback of both channels works properly in case of inverse current

Block Diagram



Functional diagram

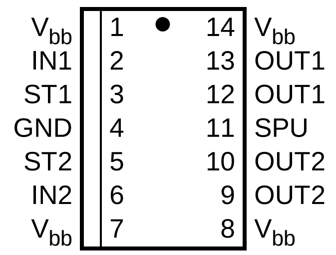


Pin Definitions and Functions

Pin	Symbol	Function
1,7, 8,14,	V_{bb}	**Positive power supply voltage**. Design the wiring for the simultaneous max. short circuit currents from channel 1 to 2 and also for low thermal resistance
2	IN1	**Input 1,2** activates channel 1,2 in case of logic high signal
6	IN2	
12,13	OUT1	**Output 1,2** protected high-side power output of channel 1,2. Design the wiring for the max. short circuit current; both outputpins have to be connected in parallel for operation according this spec.
9,10	OUT2	
3	ST1	**Diagnostic feedback 1,2** of channel 1,2 open drain
5	ST2	
4	GND	**Logic Ground**
11	SPU	Connection for **external pull up voltage** source for the open drain status output. Pull up resistors are integrated.

Pin configuration

(top view)



Maximum Ratings at T_j = 25°C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 6)	V_{bb}	62	V
Supply voltage for full short circuit protection $T_{j,start}$ = -40 ...+150°C	V_{bb}	50	V
Load current (Short-circuit current, see page 7)	I_L	self-limited	A
Load dump protection[1] $V_{LoadDump} = V_A + V_s$, V_A = 27 V R_I[2] = 8 Ω, t_d = 200 ms; IN = low or high, each channel loaded with R_L = 20 Ω,	$V_{Load\,dump}$[3]	70	V
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC)[4] (all channels active) T_a = 25°C: T_a = 85°C:	P_{tot}	3.0 1.6	W
Maximal switchable inductance, single pulse V_{bb} = 12V, $T_{j,start}$ = 150°C[4], I_L = 2.5 A, E_{AS} = 110 mJ, 0 Ω one channel: I_L = 3.5 A, E_{AS} = 278 mJ, 0 Ω two parallel channels: see diagrams on page 12	Z_L	23.0 30.0	mH
Electrostatic discharge capability (ESD): (Human Body Model) acc. MIL-STD883D, method 3015.7 and ESD assn. std. S5.1-1993 R=1.5kΩ; C=100pF	V_{ESD}	1.0	kV
Input voltage (DC)	V_{IN}	±42	V
Current through input pin (DC) Current through status pin (DC)	I_{IN} I_{ST}	±2.0 ±2.0	mA
Status pull up voltage	V_{SPU}	±42	V

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1) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND and status pins (a 150Ω resistor for the GND connection is recommended.

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) 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. See page 15

Thermal Characteristics

Parameter and Conditions		Symbol	Values			Unit
			min	typ	Max	
Thermal resistance						
junction - soldering point[4),5)]	each channel:	R_{thjs}	--	--	25	K/W
junction - ambient[4)]	one channel active:	R_{thja}	--	45	--	
	all channels active:		--	41	--	

Electrical Characteristics

Parameter and Conditions, each of the two channels at T_j = -40...+150°C, V_{bb} = 24 V unless otherwise specified		Symbol	Values			Unit
			min	typ	Max	

Load Switching Capabilities and Characteristics

On-state resistance (V_{bb} to OUT); I_L = 2 A, V_{bb} ≥ 7V						
each channel,	T_j = 25°C:	R_{ON}	--	90	100	mΩ
	T_j = 150°C:		--	170	200	
two parallel channels,	T_j = 25°C:		--	45	50	
see diagram, page 12						

5) Soldering point: Upper side of solder edge of device pin 15. See page 15

Parameter and Conditions, each of the two channels at T_j = -40...+150°C, V_{bb} = 24 V unless otherwise specified	**Symbol**	**Values**			**Unit**
		min	typ	Max	
Nominal load current one channel active: two parallel channels active: Device on PCB[6]), T_a = 85°C, $T_j \le$ 150°C	$I_{L(NOM)}$	2.5 4.0	2.9 4.2	-- --	A
Output current while GND disconnected or pulled up; V_{bb} = 30 V, V_{IN} = 0, see diagram page 11; (not tested specified by design)	$I_{L(GNDhigh)}$	--	--	1.0	mA
Turn-on time[7]) IN ⎍ to 90% V_{OUT}: Turn-off time IN ⎍ to 10% V_{OUT}: R_L = 12 Ω	t_{on} t_{off}	-- --	-- --	55 80	µs
Slew rate on[7]) 10 to 30% V_{OUT}, R_L = 12 Ω:	dV/dt_{on}	1.9	--	5	V/µs
Slew rate off[7]) 70 to 40% V_{OUT}, R_L = 12 Ω:	$-dV/dt_{off}$	1.5	--	6.5	V/µs

Operating Parameters

Operating voltage	$V_{bb(on)}$	6.0	--	62	V
Undervoltage restart of charge pump T_j =-40...+25°C: T_j =+150°C:	$V_{bb(ucp)}$	-- --	4 --	5.5 7	V
Overvoltage protection[8]) I_{bb} = 40 mA	$V_{bb(AZ)}$	62	67	75	V
Standby current[9]) T_j =-40°C...+25°C: T_j =+125°C (not tested, specified by design): V_{IN} = 0; see diagram page 10 T_j =+150°C:	$I_{bb(off)}$	-- -- --	13 25	23 23 35	µA
Off-State output current (included in $I_{bb(off)}$) V_{IN} = 0; each channel	$I_{L(off)}$	--	3	--	µA
Operating current [10]), V_{IN} = 5V, one channel on: all channels on:	I_{GND}	-- --	1.0 2.0	1.5 3.0	mA

6) 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. See page 15

7) See timing diagram on page 13.

8) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND; a 150Ω resistor is recommended. See also $V_{ON(CL)}$ in table of protection functions and circuit diagram on page 10.

9) Measured with load; for the whole device; all channels off

10) Add I_{ST}, if I_{ST} > 0

Parameter and Conditions, each of the two channels at T_j = -40...+150°C, V_{bb} = 24 V unless otherwise specified	Symbol	Values			Unit
		min	typ	Max	
Protection Functions					
Current limit, (see timing diagrams, page 13) T_j =-40°C: / T_j =25°C: / T_j =+150°C:	$I_{L(lim)}$	-- / -- / 5	10 / 9 / 8	12 / -- / --	A
Repetitive short circuit current limit, $T_j = T_{jt}$ each channel / two parallel channels (see timing diagrams, page 13; not tested specified by design)	$I_{L(SCr)}$	-- / --	8 / 8	-- / --	A
Initial short circuit shutdown time $T_{j,start}$ =25°C: (see timing diagrams on page 13)	$t_{off(SC)}$	--	2	--	ms
Output clamp (inductive load switch off)[11] at $V_{ON(CL)} = V_{bb} - V_{OUT}$, I_L= 40 mA	$V_{ON(CL)}$	62	67	75	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Reverse Battery					
Reverse battery voltage [12]	$-V_{bb}$	--	--	24	V
Drain-source diode voltage ($V_{out} > V_{bb}$) I_L = -3.0 A, T_j = +150°C	$-V_{ON}$	--	650	--	mV
Inverse current					
GND current in case of 3A inverse current [13] Specified by design	$I_{GND(inv\ cur)}$	--	--	15	mA

11) If channels are connected in parallel, output clamp is usually accomplished by the channel with the lowest $V_{ON(CL)}$

12) 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 have to be limited (see max. ratings page 4 and circuit page 10).

13) In case of an inverse current of 3A the both status outputs must not be disturbed.
The neighbour channel can be switched normally; not all paramters lay within the range of the spec
Please note, that in case of an inverse current no protection function is active. The power dissipation is higher compared to normal operation in forward mode due to the voltage drop across the drain-source diode (as it is with reverse polaritiy). If this mode lasts for a too long time the device can be destroyed.

Parameter and Conditions, each of the two channels at T_j = -40...+150°C, V_{bb} = 24 V unless otherwise specified	**Symbol**	**Values**			**Unit**
		min	typ	Max	
Diagnostic Characteristics					
Open load detection current	$I_{L(off)}$	--	3	--	µA
Open load detection voltage	$V_{OUT(OL)}$	2.0	2.85	3.7	V
Short circuit detection voltage V_{bb}(pin 1,7,8,14) to OUT1 (pin 12,13) resp. V_{bb}(pin 1,7,8,14) to OUT2 (pin 9,10)	$V_{ON(SC)}$	--	4.0	--	V
Input and Status Feedback[14]					
Integrated resistors; T_j =25°C: (see circuit page 2) Input	R_I	--	20	--	kΩ
Status	R_{ST}	--	2	--	kΩ
Status pull up	$R_{pull\ up}$	--	12	--	kΩ
Input turn-on threshold voltage	$V_{IN(T+)}$	1.2	--	2.2	V
Input turn-off threshold voltage	$V_{IN(T-)}$	1.0	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.25	--	V
Off state input current V_{IN} = 0.4 V:	$I_{IN(off)}$	1	--	15	µA
On state input current V_{IN} = 5 V:	$I_{IN(on)}$	10	25	50	µA
Status output (open drain)					
Zener limit voltage	$V_{ST(high)}$	5.4	6.1	--	V
ST low voltage V_{SPU} = 5V:	$V_{ST(low)}$	--	--	0.4	

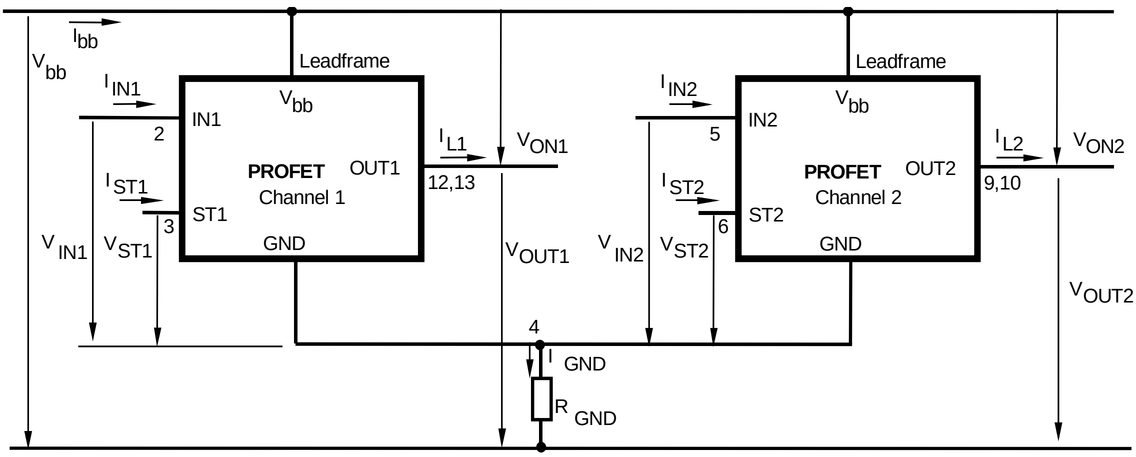
[14] If a ground resistor R_{GND} is used, add the voltage drop across these resistors.

Truth Table

Channel 1	Input 1	Output 1	Status 1
Channel 2	Input 2	Output 2	Status 2
	level	level	BTS 723
Normal operation	**L** **H**	**L** **H**	**L** **H**
Open load	**L** **H**	**V_{OUT} > 2.7V** **H**	**H** **H**
Short circuit to GND	**L** **H**	**L** **L**	**L** **L**
Short circuit to V_{bb}	**L** **H**	**H** **H**	**H** **H**
Overtem-perature	**L** **H**	**L** **L**	**L** **L**

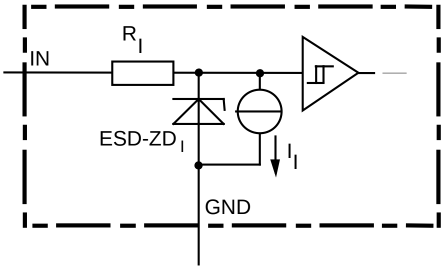
Parallel switching of channel 1 and 2 is easily possible by connecting the inputs and outputs in parallel. In this mode it is recommended to use only one status.

Terms



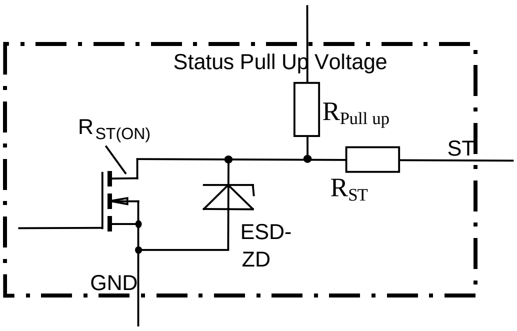
Leadframe (V_{bb}) is connected to pin **1,7,8,14**
External R_{GND} optional; a single resistor $R_{GND} = 150\Omega$ for reverse battery protection up to the max. operating voltage.

Input circuit (ESD protection), IN1 or IN2



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

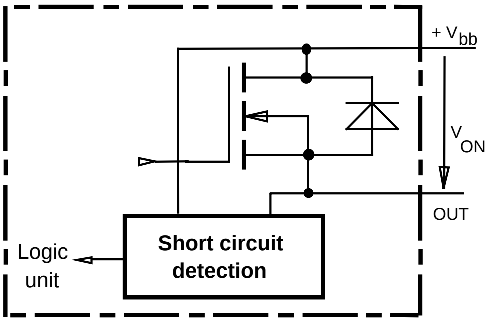
Status output, ST1 or ST2



ESD-Zener diode: 6.1 V typ., $R_{ST(ON)}$ < 250 Ω,
R_{ST} = 2 kΩ typ., $R_{pull\ up}$ = 12 kΩ typ.
The use of ESD zener diodes as voltage clamp at DC conditions is not recommended

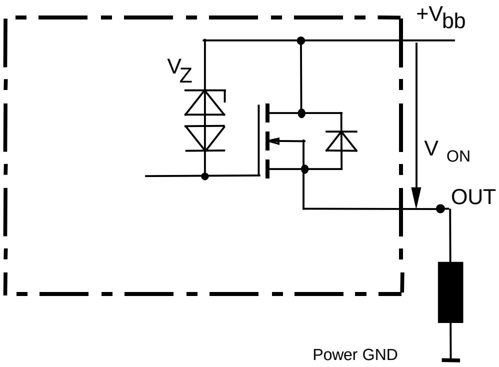
Short Circuit detection

Fault Signal at ST-Pin: V_{ON} > 4.0 V typ, no switch off by the PROFET itself, external switch off recommended!



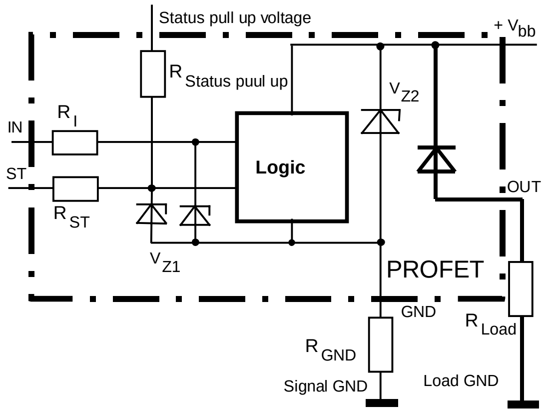
Inductive and overvoltage output clamp,

OUT1 or OUT2



V_{ON} clamped to $V_{ON(CL)}$ = 67 V typ.

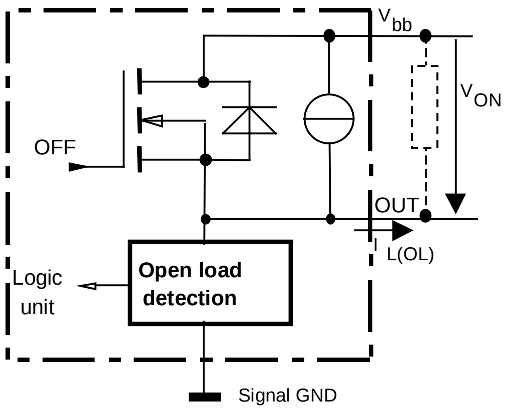
Overvolt. and reverse batt. protection



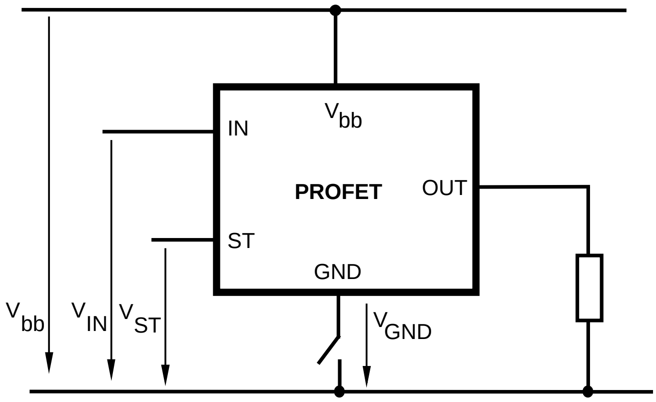
V_{Z1} = 6.1 V typ., V_{Z2} = 67 V typ., R_{GND} = 150 Ω,
R_I = 2 kΩ typ., R_{ST} = 20 kΩ typ., $R_{pull\ up}$ = 12 kΩ typ
In case of reverse battery the load current has to be limited by the load. Temperature protection is not active

Open-load detection, OUT1 or OUT2

OFF-state diagnostic condition:
Open load, if V_{OUT} > 2.7 V typ. (IN low)
$I_{L(OL)}$ typ. 2µA
An external resitor can be used to increase the open load detection current

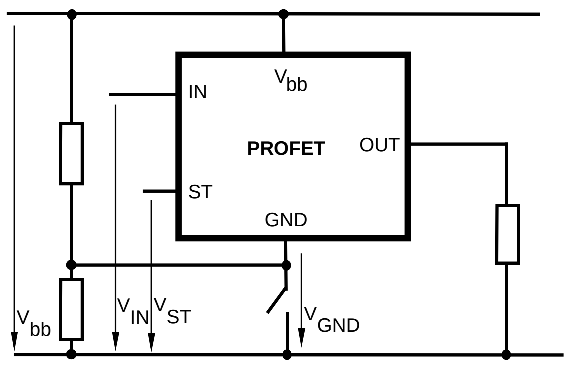


GND disconnect



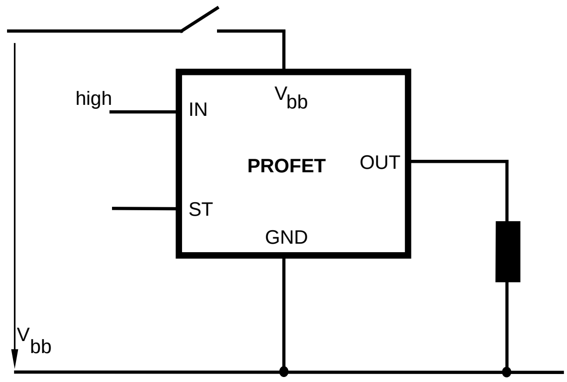
Any kind of load.
Due to $V_{GND} > 0$, no V_{ST} = low signal available.

GND disconnect with GND pull up



Any kind of load. If $V_{GND} > V_{IN} - V_{IN(T+)}$ device stays off
Due to $V_{GND} > 0$, no V_{ST} = low signal available.

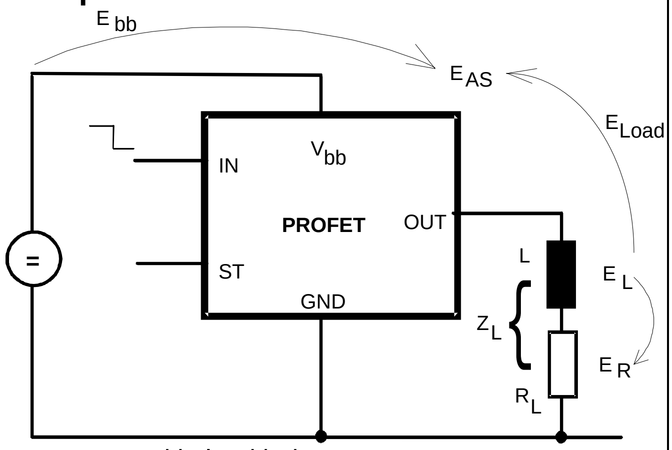
V_{bb} disconnect with energized inductive load



For inductive load currents up to the limits defined by Z_L (max. ratings and diagram on page 12) each switch is protected against loss of V_{bb}.

Consider at your PCB layout that in the case of Vbb disconnection 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

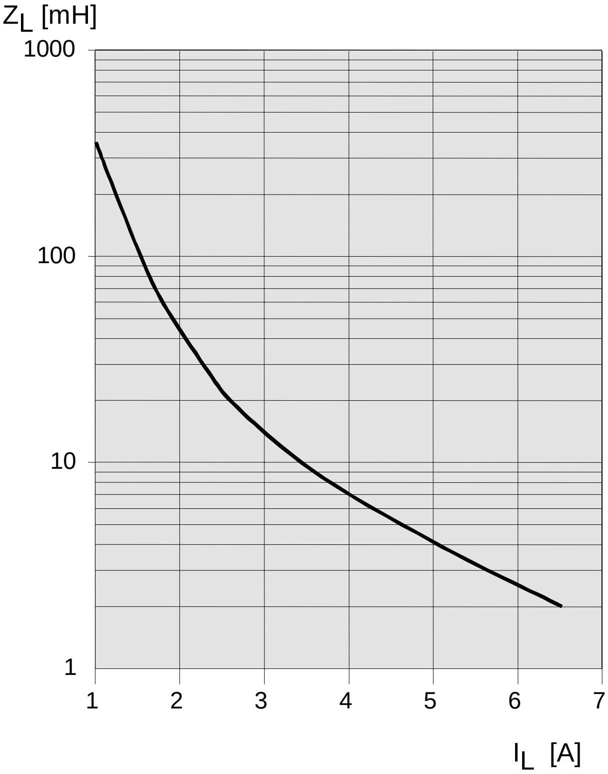
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} \cdot i_L(t)\, dt,$$

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

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

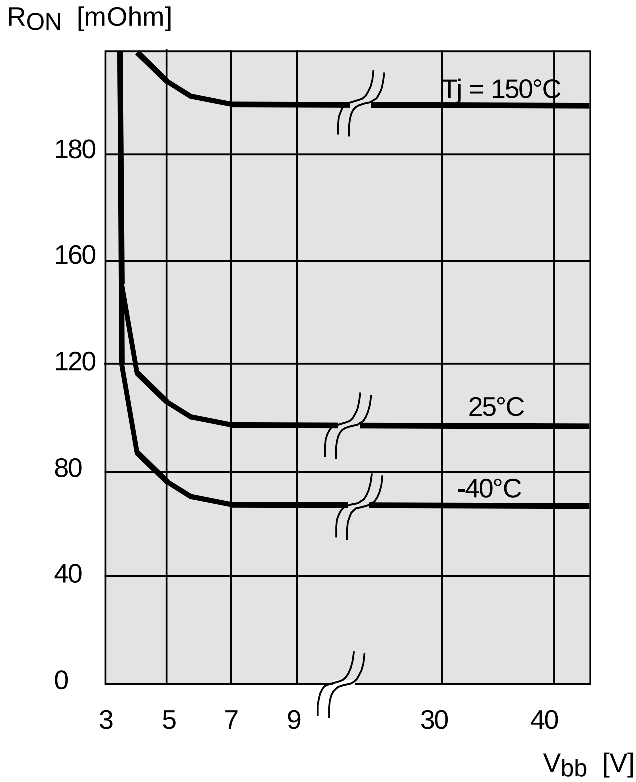
Maximum allowable load inductance for a single switch off (one channel)[4)]

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



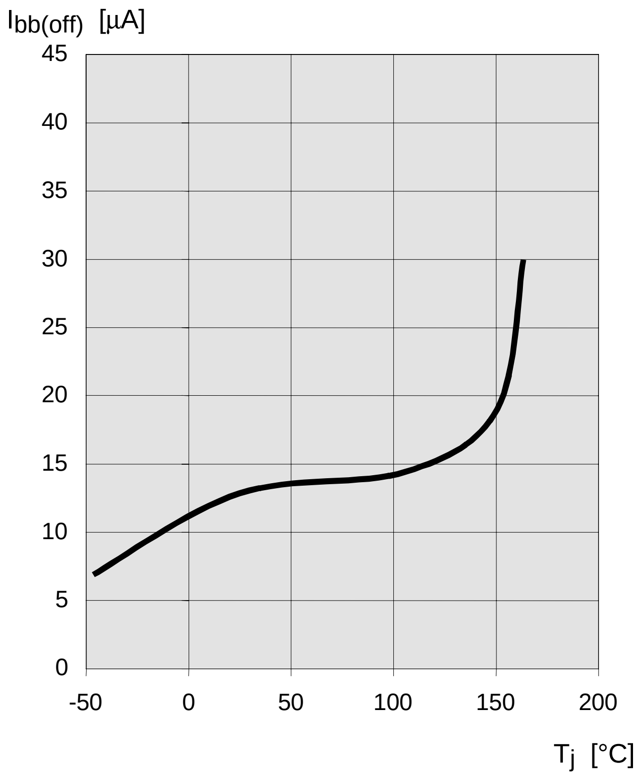
Typ. on-state resistance

R_ON = f (V_bb, T_j); $I_L = 2\,A$, IN = high



Typ. standby current

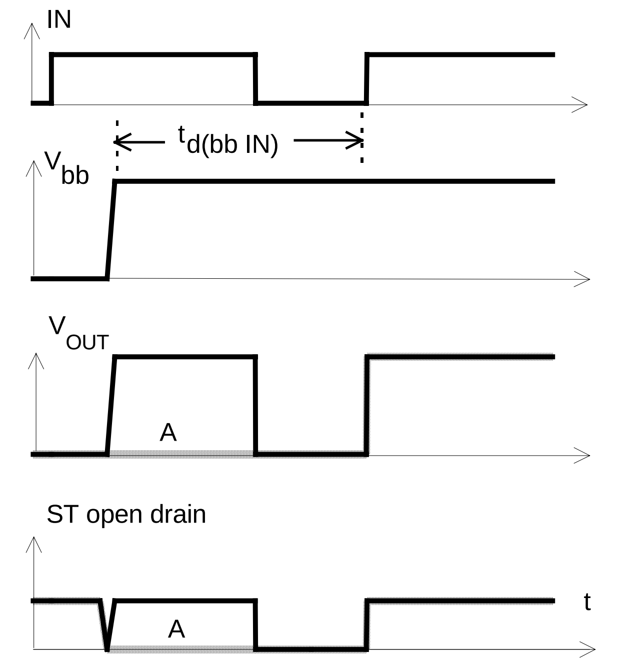
I_bb(off) = f (T_j); V_{bb} = 9...34 V, IN1,2,3,4 = low



Timing diagrams

All channels are symmetric and consequently the diagrams are valid for channel 1 and channel 2

Figure 1a: V_{bb} turn on, :



in case of too early V_{IN}=high the device may not turn on (curve A)
$t_{d(bb\ IN)}$ approx. 150 µs

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

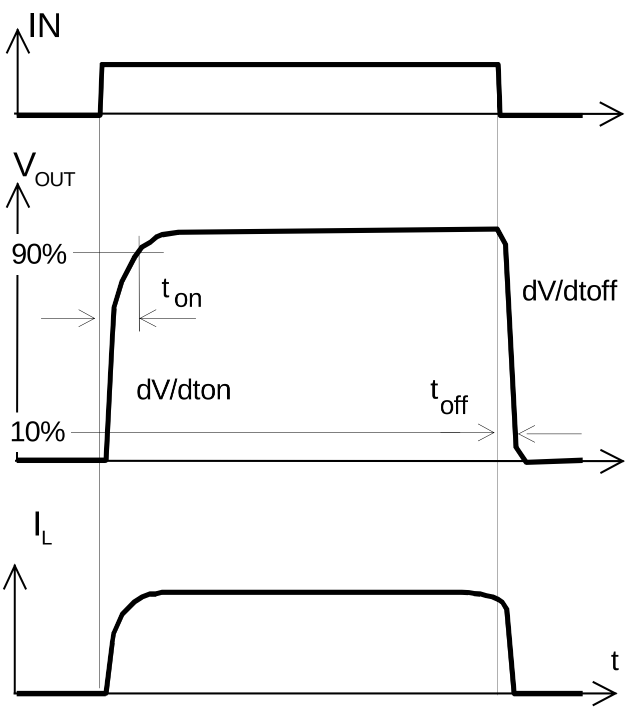


Figure 2b: Switching an inductive load

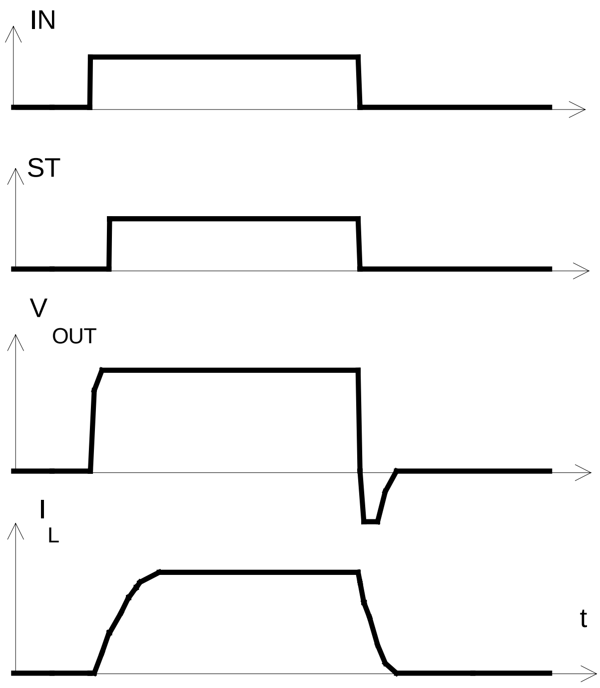
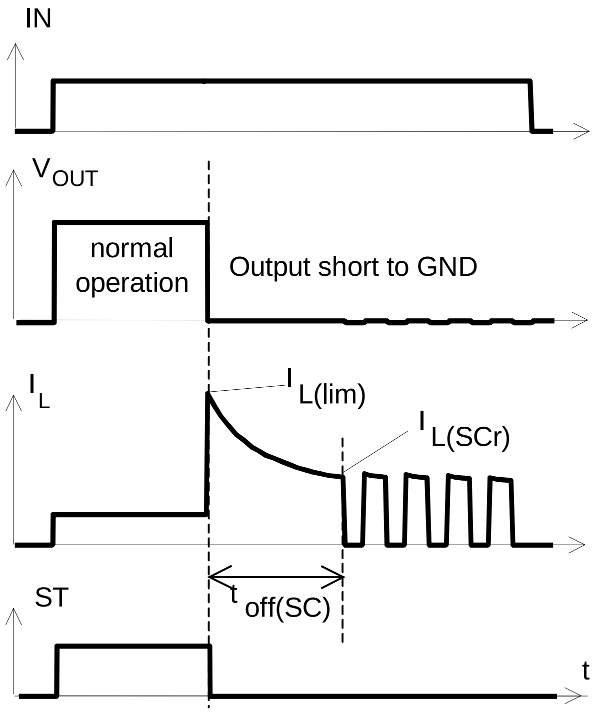


Figure 3a: Short circuit:
shut down by overtempertature, reset by cooling



Heating up requires several milliseconds, depending on external conditions. External shutdown in response to status fault signal recommended.

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

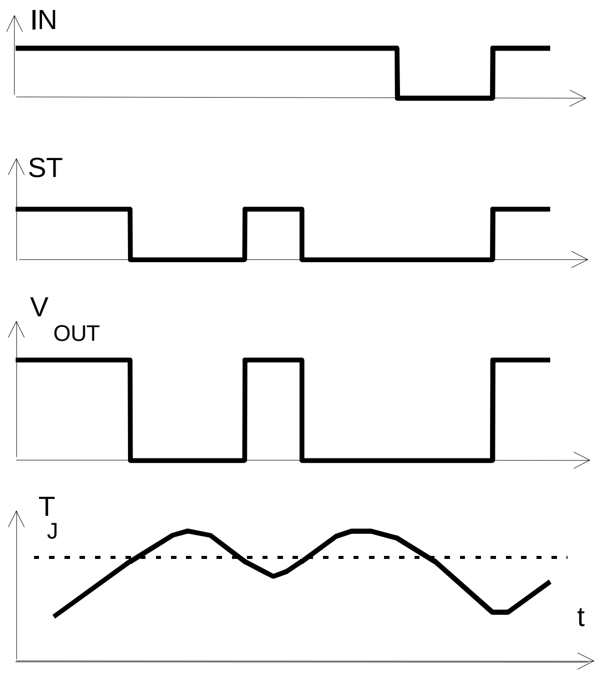
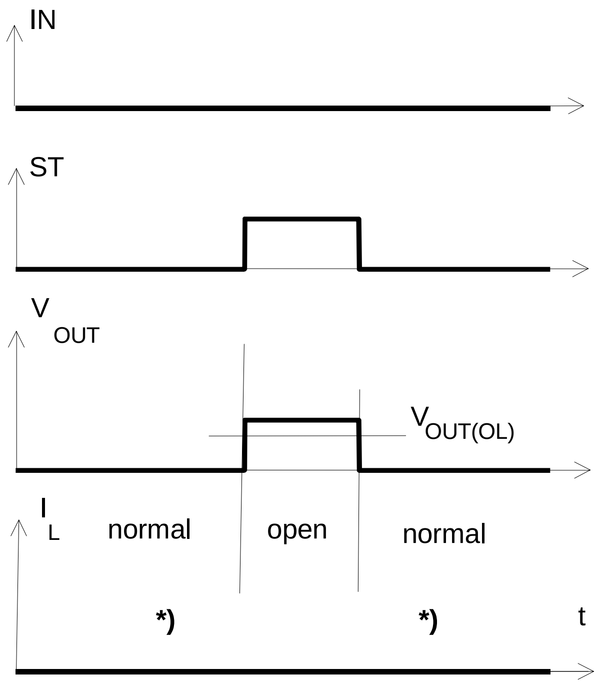
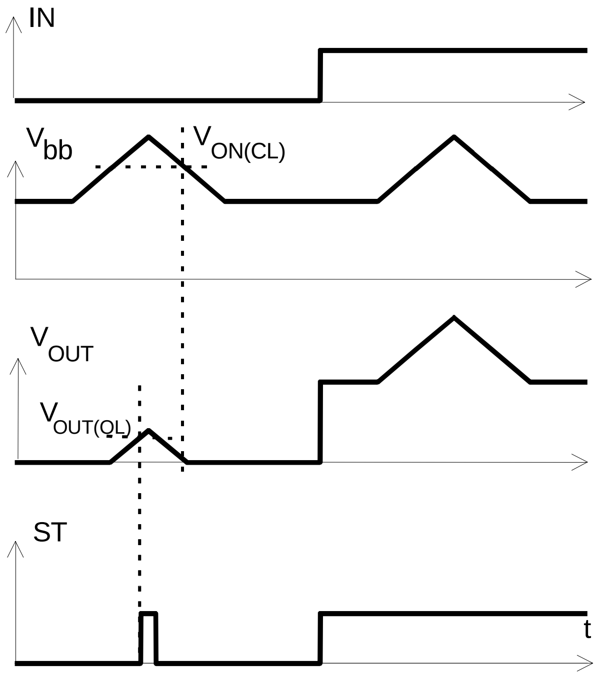


Figure 5a: Open load, : detection in OFF-state, open load occurs in off-state



*) I_L = 2 µA typ. V_{OUT} > 2.7V

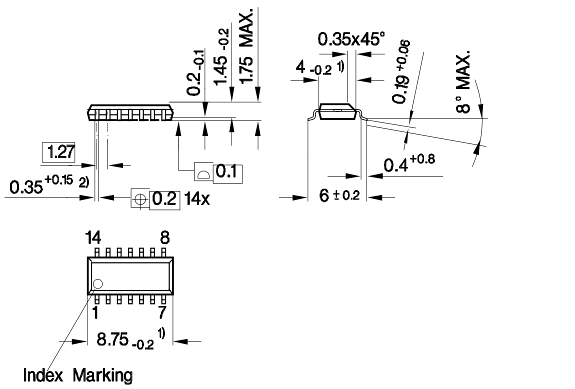
Figure 6: Overvoltage, no shutdown:



Package and Ordering Code

Standard: P-DSO-14-9

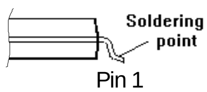
Sales Code	BTS 723 GW
Ordering Code	tbd

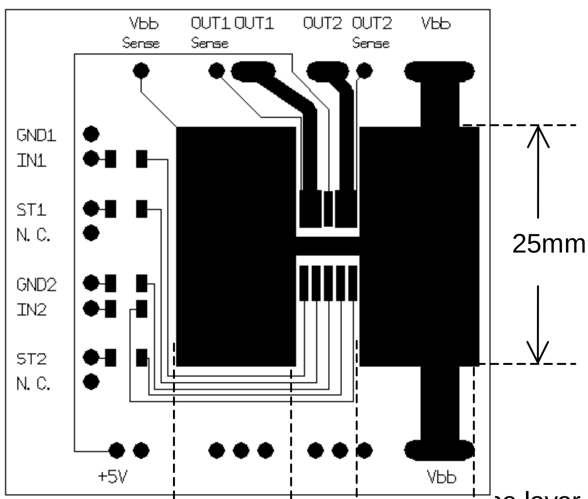


1) Does not include plastic or metal protrusion of 0.15 max. per side
2) Lead width can be 0.61 max. in dambar area

All dimensions in millimetres

Definition of soldering point with temperature T_S: upper side of solder edge of device pin 1.





Printed circuit board (FR4, 1.5mm thick, one layer 70µm, 6cm² 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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