Smart Highside Power Switch

Reversave™

- Reverse battery protection by self turn on of power MOSFET

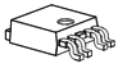
Features

- Short circuit protection with latch
- Current limitation
- Overload protection
- Thermal shutdown with restart
- Overvoltage protection (including load dump)
- Loss of ground protection
- Loss of V_{bb} protection (with external diode for charged inductive loads)
- Very low standby current
- Fast demagnetisation of inductive loads
- **E**lectro**s**tatic **d**ischarge (**ESD**) protection
- Optimized static **e**lectro**m**agnetic **c**ompatibility (**EMC**)

Product Summary			
Operating voltage	$V_{bb(on)}$	5.5 ... 38	V
On-state resistance	R_{ON}	10	mΩ
Nominal current	$I_{L(nom)}$	8	A
Load current (ISO)	$I_{L(ISO)}$	33	A
Current limitation	$I_{L12(SC)}$	75	A

Package

TO-252-5-1
(DPAK 5 pin; less than half the size as TO 220 SMD)



Diagnostic Function

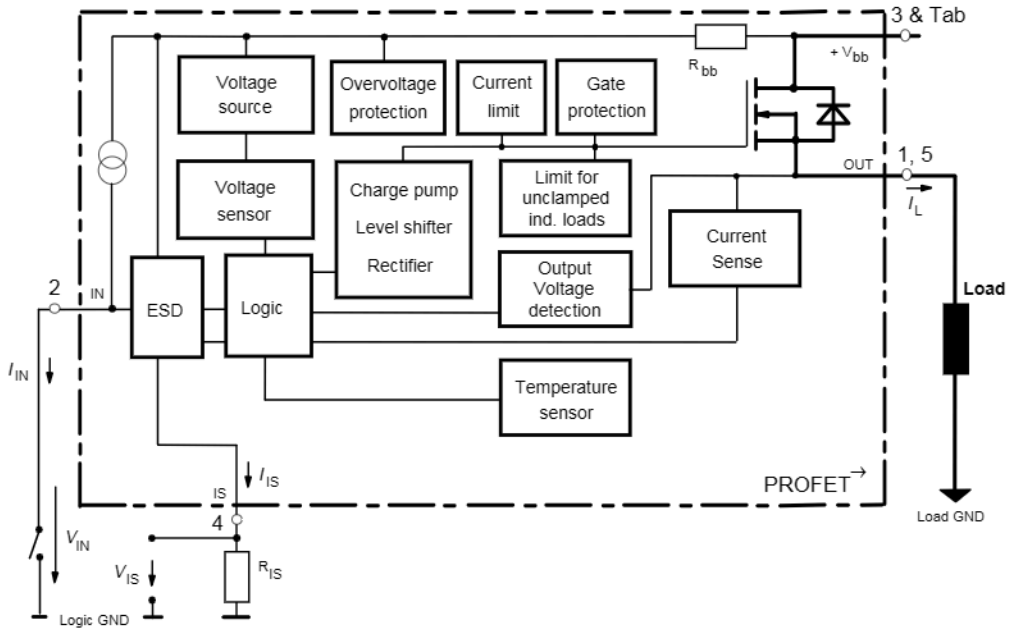
- Proportional load current sense (with defined fault signal in case of overload operation, overtemperature shutdown and/or short circuit shutdown)

Application

- Power switch with current sense diagnostic feedback for 12V and 24 V DC grounded loads
- All types of resistive, inductive and capacitive loads
- Replaces electromechanical relays, fuses and discrete circuits

General Description

N channel vertical power FET with charge pump, current controlled input and diagnostic feedback with load current sense, integrated in Smart SIPMOS→ chip on chip technology. Providing embedded protective functions.



Pin	Symbol		Function
1	OUT	O	**Output;** output to the load; pin 1 and 5 must be externally shorted* .
2	IN	I	**Input;** activates the power switch if shorted to ground.
Tab/(3)	Vbb	+	**Supply Voltage;** positive power supply voltage; tab and pin3 are internally shorted.
4	IS	S	**Sense Output;** Diagnostic feedback; provides at normal operation a sense current proportional to the load current; in case of overload, overtemperature and/or short circuit a defined current is provided (see Truth Table on page 8)
5	OUT	O	**Output;** output to the load; pin 1 and 5 must be externally shorted* .

*) Not shorting all outputs will considerably increase the on-state resistance, reduce the peak current capability and decrease the current sense accuracy

Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 4)	V_{bb}	38	V
Supply voltage for full short circuit protection [1]	V_{bb}	30	V
Load dump protection $V_{LoadDump} = U_A + V_s$, U_A = 13.5 V R_I= 2 Ω, R_L= 1.5 Ω, t_d= 400 ms, IN= low or high	$V_{Load\ dump}$ [2]	45	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)	P_{tot}	59	W
Inductive load switch-off energy dissipation [3] single pulse I_L = 20 A, V_{bb}= 12V T_j=150 °C:	E_{AS}	0.3	J
Electrostatic discharge capability (ESD) (Human Body Model) acc. ESD assn. std. S5.1-1993; R=1.5kΩ; C=100pF	V_{ESD}	3.0	kV
Current through input pin (DC) Current through current sense pin (DC) see internal circuit diagrams page 9	I_{IN} I_{IS}	+15, -120 +15, -120	mA
Input voltage slew rate V_{bb} ≤ 16V : V_{bb} > 16V [4]:	dV_{bIN} / dt	self-limited 20	V/∝s

1) Short circuit is defined as a combination of remaining resistances and inductances. See schematic on page11.

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

3) See also diagram on page 11.

4) See also on page 8. Slew rate limitation can be achieved by means of using a series resistor R_{IN} in the input path. This resistor is also required for reverse operation. See also page 10.

Thermal Characteristics

Parameter and Conditions	Symbol	Values	Unit

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at T_j= 25, V_{bb} = 12 V unless otherwise specified			

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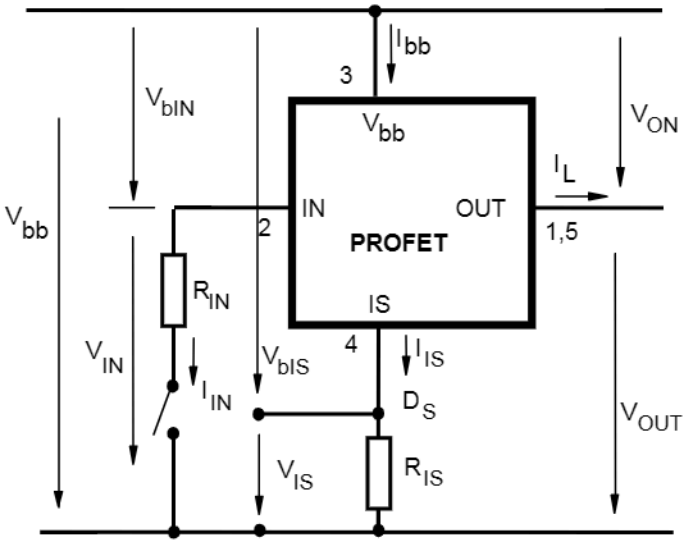
Truth Table

	Input Current level	Output level	Current Sense IIS
Normal operation	**L** **H**	**L** **H**	**≈0 ($I_{IS(LL)}$)** **nominal**
Overload [19]	**L** **H**	**L** **H**	**≈0 ($I_{IS(LL)}$)** **$I_{IS,fault}$**
Short circuit to GND [20]	**L** **H**	**L** **L**	**≈0 ($I_{IS(LL)}$)** **$I_{IS,fault}$**
Overtemperature	**L** **H**	**L** **L**	**≈0 ($I_{IS(LL)}$)** **$I_{IS,fault}$**
Short circuit to Vbb	**L** **H**	**H** **H**	**≈0 ($I_{IS(LL)}$)** **<nominal** [21]
Open load	**L** **H**	**Z** **H**	**≈0 ($I_{IS(LL)}$)** **≈0 ($I_{IS(LH)}$)**

L = "Low" Level
H = "High" Level

Z = high impedance, potential depends on external circuit

Terms



Two or more devices can easily be connected in parallel to increase load current capability.

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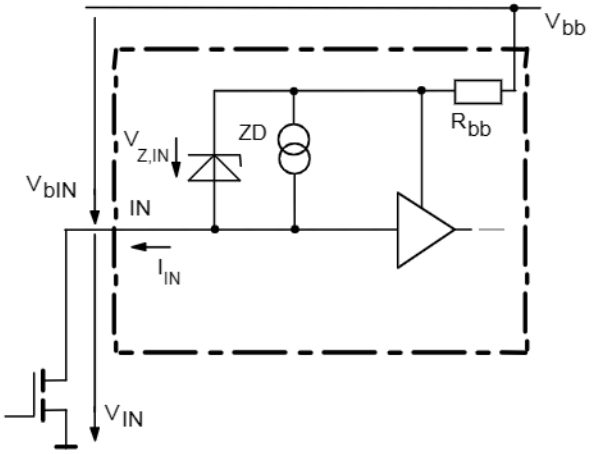
19) Overload is detected at the following condition: 1V (typ.) < V_{ON} < 3.5V (typ.) . See also page 11.
20) Short Circuit is detected at the following condition: V_{ON} > 3.5V (typ.) . See also page 11.
21) Low ohmic short to V_{bb} may reduce the output current I_L and therefore also the sense current I_{IS}.

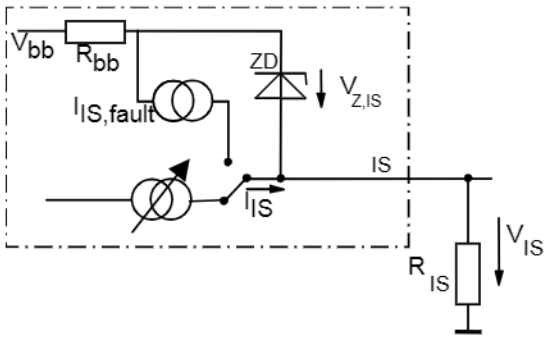
Input circuit (ESD protection)



ESD-Zener diode: 67 V typ., max 15 mA;

Current sense output

Normal operation

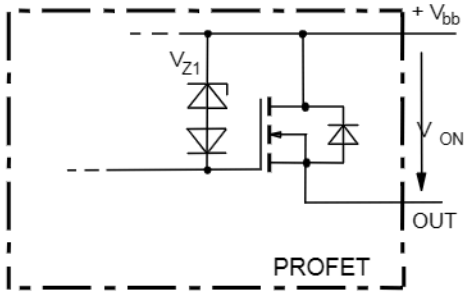


$V_{Z,IS}$ = 67 V (typ.), R_{IS} = 1 kΩ nominal (or 1 kΩ /n, if n devices are connected in parallel). $I_S = I_L/k_{ilis}$ can be only driven by the internal circuit as long as V_{out} - V_{IS} > 5V. Therefore R_{IS} should be less than

$$\frac{V_{bb} - 5V}{7.5mA}.$$

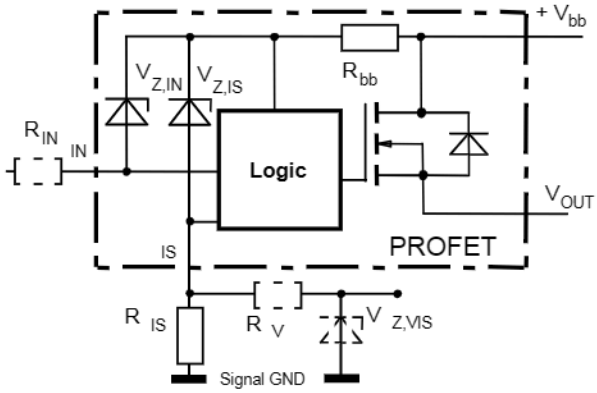
Note: *For large values of R_{IS} the voltage V_{IS} can reach almost V_{bb}. See also overvoltage protection.*
If you don't use the current sense output in your application, you can leave it open.

Inductive and overvoltage output clamp



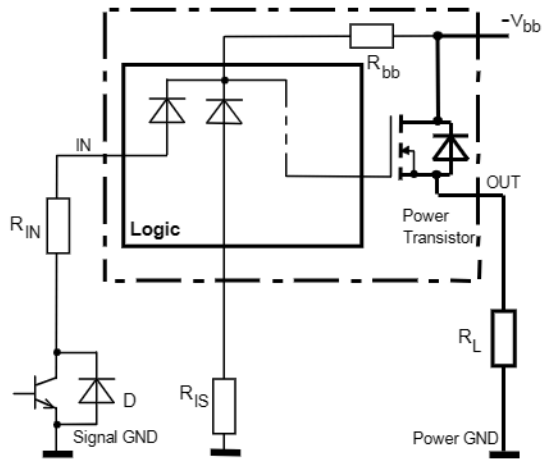
V_{ON} is clamped to $V_{ON(Cl)}$ = 42 V typ

Overvoltage protection of logic part



R_{bb} = 100 Ω typ., $V_{Z,IN}$ = $V_{Z,IS}$ = 67 V typ., R_{IS} = 1 kΩ nominal. Note that when overvoltage exceeds 67 V typ. a voltage above 5V can occur between IS and GND, if R_V, $V_{Z,VIS}$ are not used.

Reversave™ (Reverse battery protection)

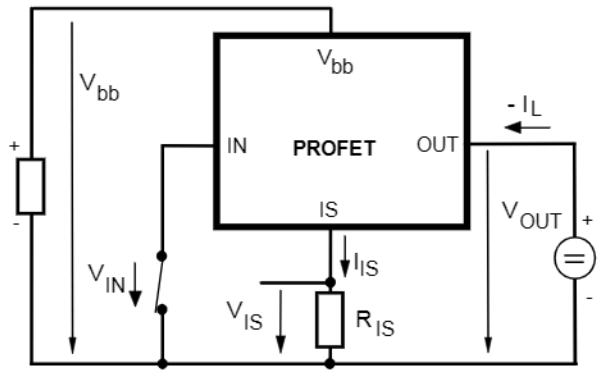


R_{IS} typ. 1 kΩ. Add R_{IN} for reverse battery protection in applications with V_{bb} above 16V;

recommended value: $\frac{1}{R_{IN}} + \frac{1}{R_{IS}} = \frac{0.08A}{|V_{bb}| - 12V}$

To minimise power dissipation at reverse battery operation, the overall current into the IN and IS pin should be about 80mA. The current can be provided by using a small signal diode D in parallel to the input switch, by using a MOSFET input switch or by proper adjusting the current through R_{IS}.
Since the current via R_{bb} generates additional heat in the device, this has to be taken into account in the overall thermal consideration.

Inverse load current operation

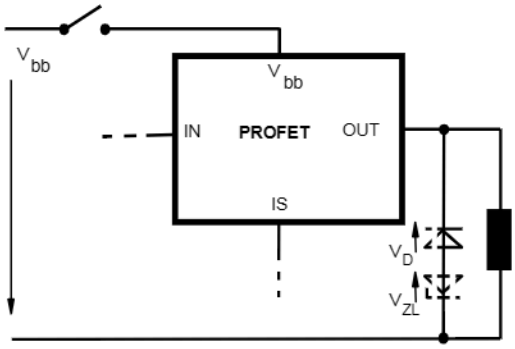


The device can be operated in inverse load current mode (V_{OUT} > V_{bb} > 0V). The current sense feature is not available during this kind of operation (I_{IS} = 0). In case of inverse operation the intrinsic drain source diode is eventually conducting resulting in considerably increased power dissipation.
The transition from inverse to forward mode can result in a delayed switch on.
Note: *Temperature protection during inverse load current operation is not possible!*

V_{bb} disconnect with energised inductive load

Provide a current path with load current capability by using a diode, a Z-diode, or a varistor. (V_{ZL}+V_D<39 V if R_{IN} = 0). For higher clamp voltages currents at IN and IS have to be limited to 120 mA.

Version a:

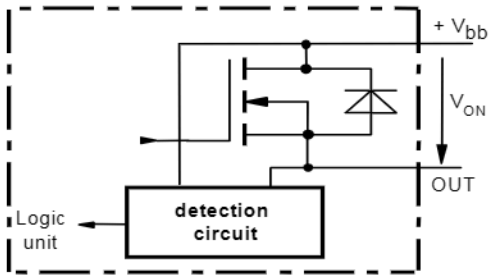


Short circuit detection

Fault Condition: $V_{ON} > V_{ON(SC)}$ (3.5 V typ.) and t> $t_{d(SC)}$ (typ.650 µs).

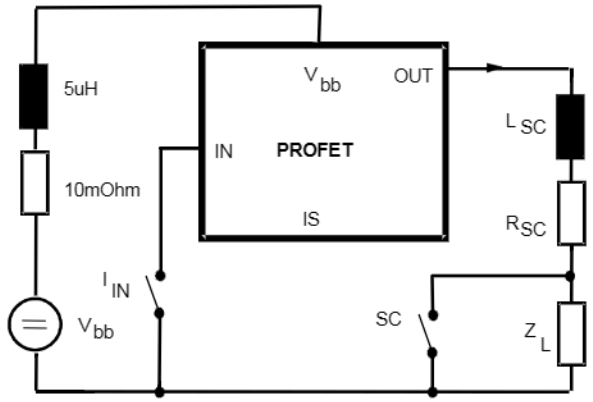
Overload detection

Fault Condition: $V_{ON} > 1$ V typ.

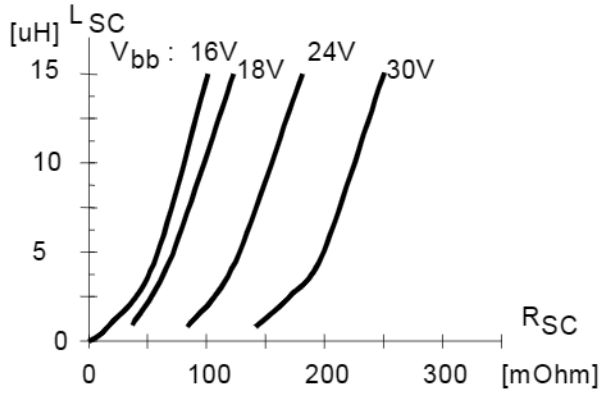


Short circuit

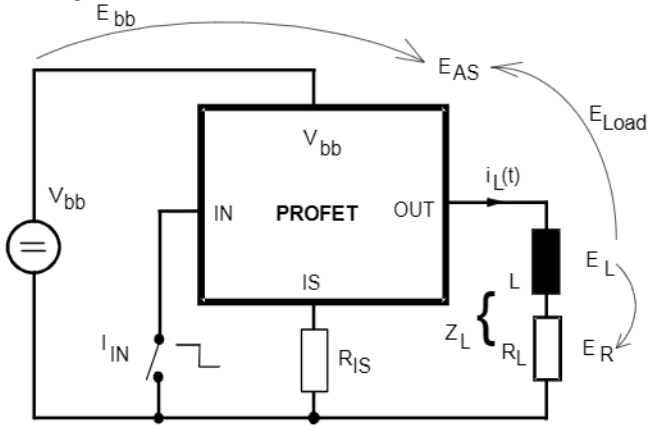
Short circuit is a combination of primary and secondary impedance's and a resistance's.



Allowable combinations of minimum, secondary resistance for full protection at given secondary inductance and supply voltage for single short circuit event:



Inductive load switch-off energy dissipation

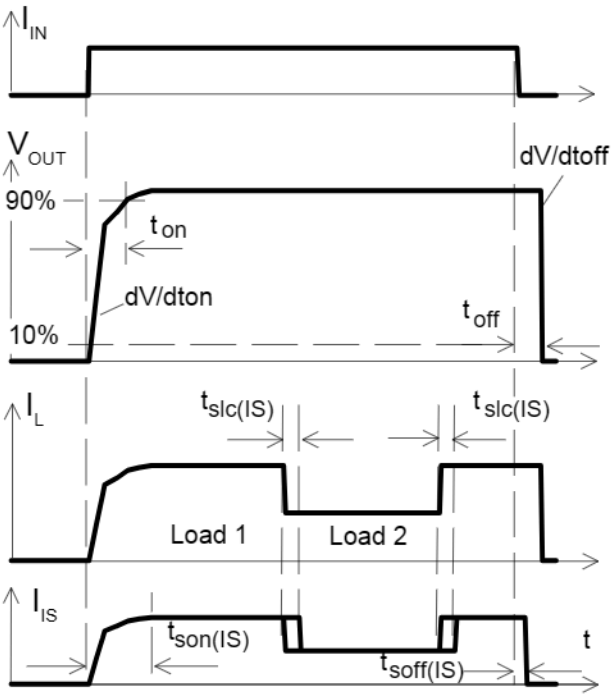


Energy stored in load inductance:

$$E_L = {}^1/_2$$

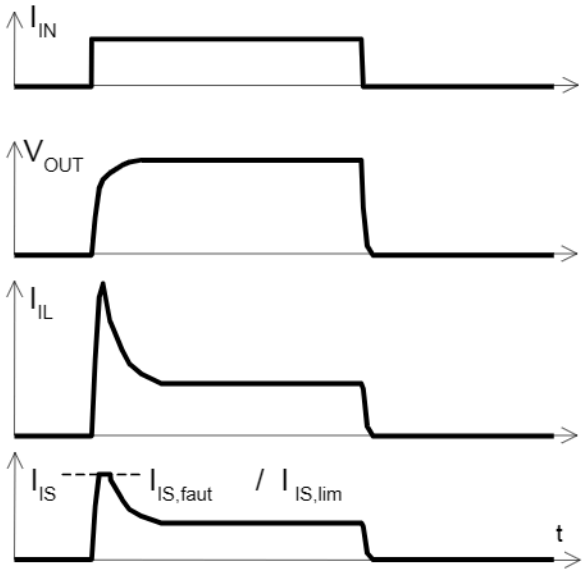
Timing diagrams

Figure 1a: Switching a resistive load, change of load current in on-condition:



The sense signal is not valid during a settling time after turn-on/off and after change of load current.

Figure 2a: Switching motors and lamps:



As long as $V_{bIS} < V_{Z,IS}$ the sense current will never exceed $I_{IS,fault}$ and/or $I_{IS,lim}$.

Figure 2b: Switching an inductive load:

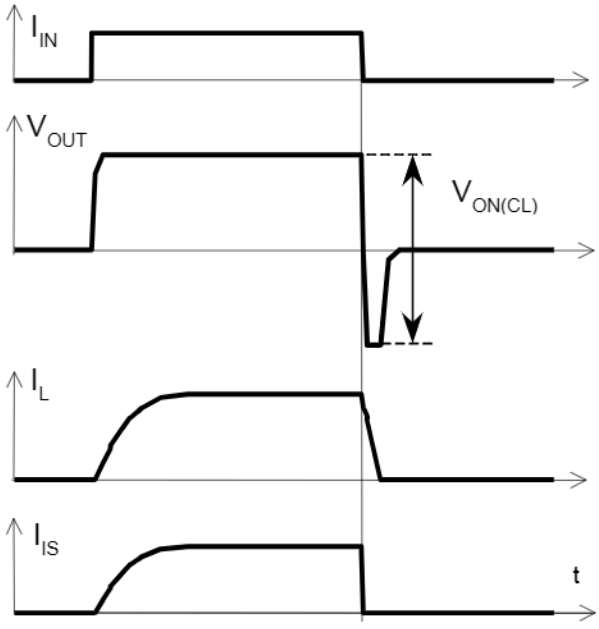
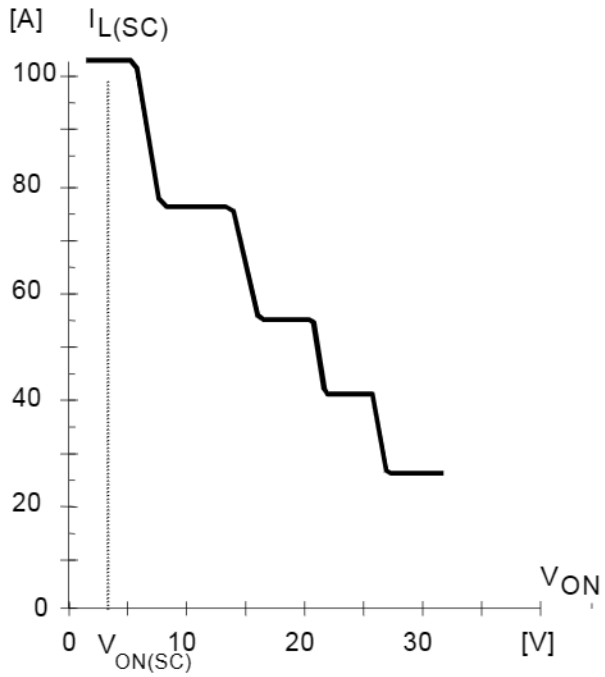
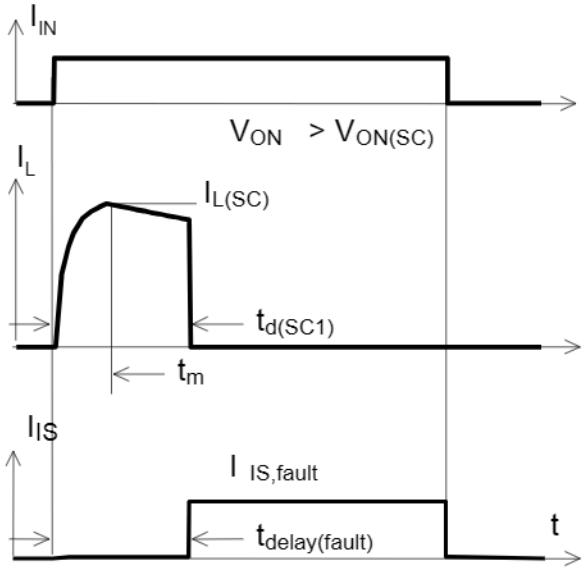


Figure 3a: Typ. current limitation characteristic



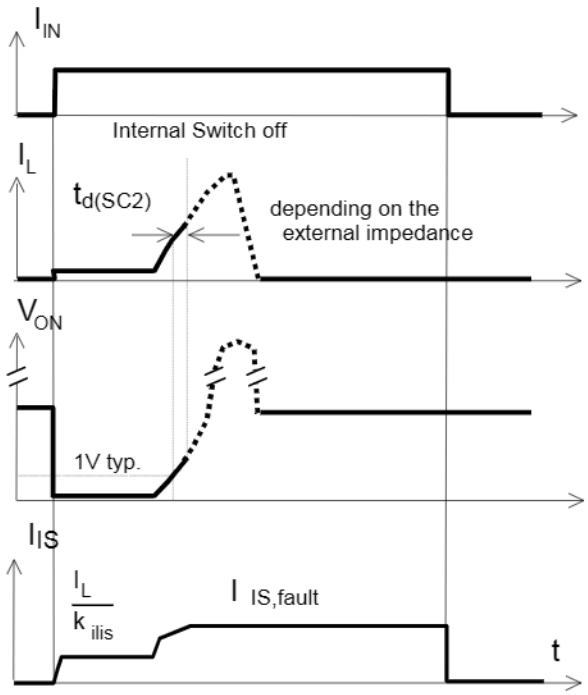
In case of $V_{ON} > V_{ON(SC)}$ (typ. 4 V) the device will be switched off by internal short circuit detection.

Figure 3b: Short circuit type one:
shut down by short circuit detection, reset by $I_{IN} = 0$.



Shut down remains latched until next reset via input.

Figure 3c: Short circuit type two:
shut down by short circuit detection, reset by $I_{IN} = 0$.



Shut down remains latched until next reset via input.

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

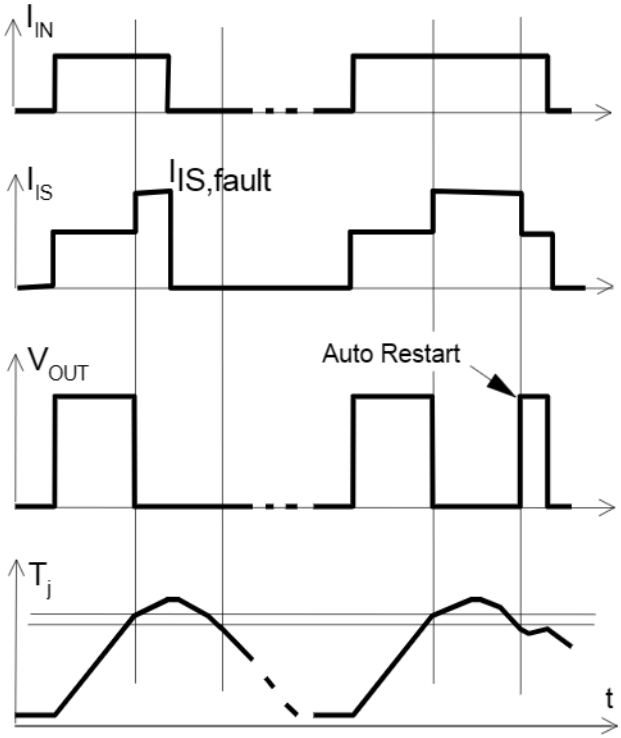


Figure 4b: Overload
$T_j < T_{jt}$

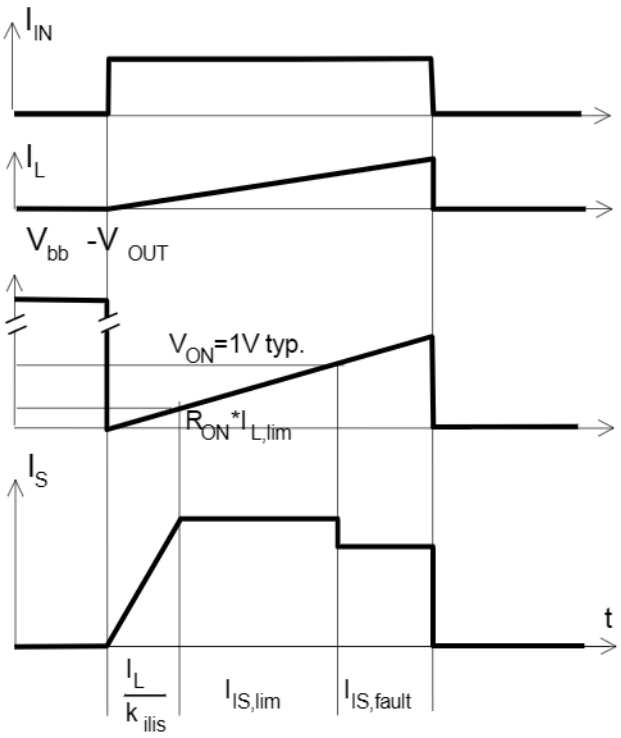


Figure 5a: Undervoltage restart of charge pump, overvoltage clamp

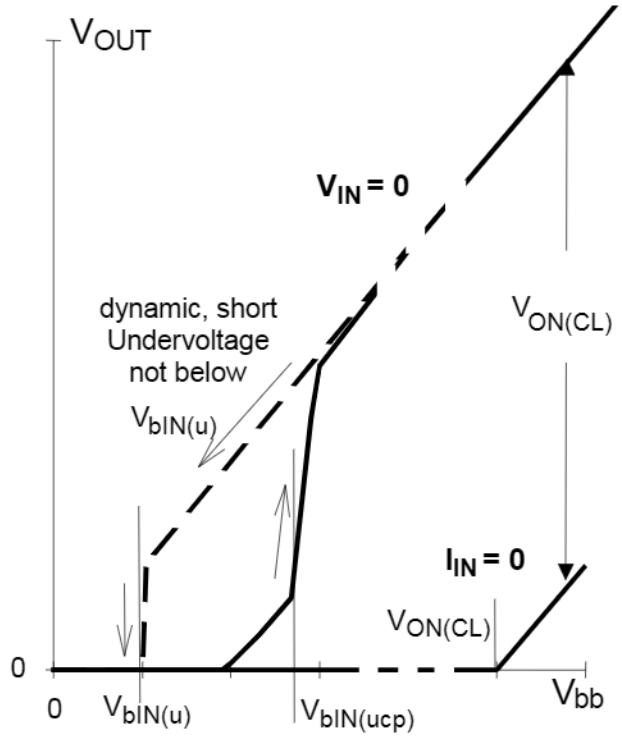


Figure 6a: Current sense versus load current:

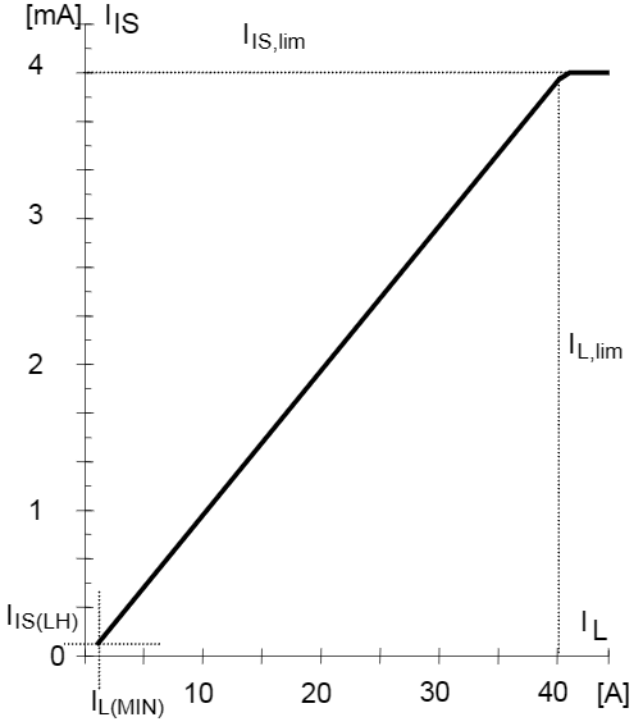
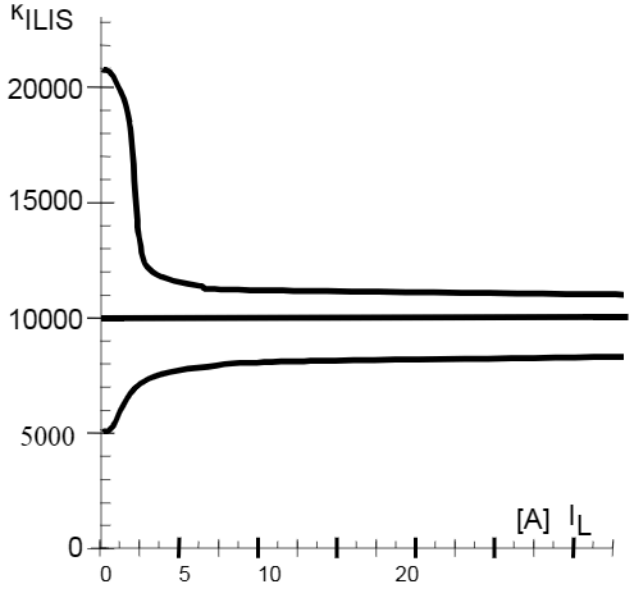
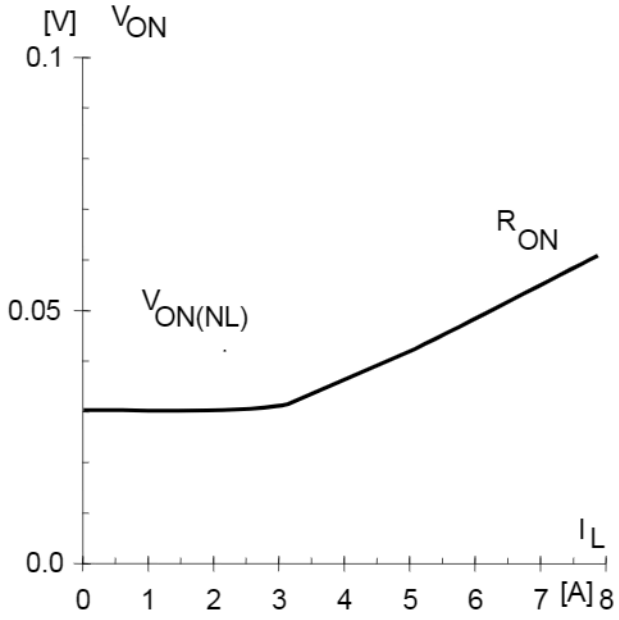


Figure 6b: Current sense ratio[22]:



22 This range for the current sense ratio refers to all devices. The accuracy of the k_{ILIS} can be raised by means of calibration the value of k_{ILIS} for every single device.

Figure 7a: Output voltage drop versus load current:

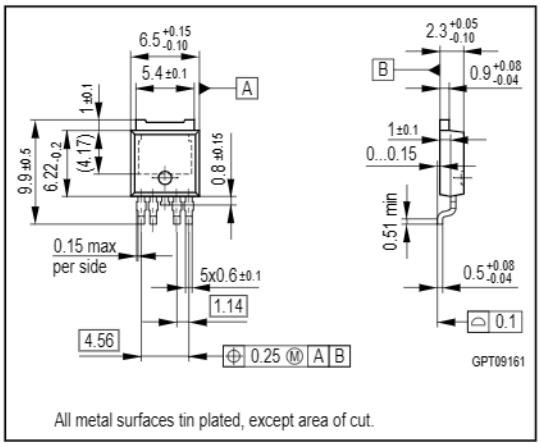


Package and Ordering Code

All dimensions in mm

D-Pak-5 Pin: TO-252-5-1

Sales Code	BTS6143D
Ordering code	Q67060-S7411-A803



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