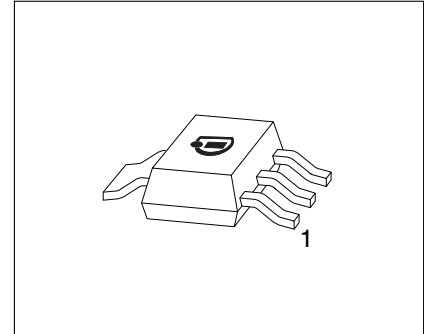




- High-side switch
- Short-circuit protection
- Input protection
- Overtemperature protection with hysteresis
- Overload protection
- Overvoltage protection
- Switching inductive load
- Clamp of negative output voltage with inductive loads
- Undervoltage shutdown
- Maximum current internally limited
- **Electrostatic discharge (ESD)** protection
- Reverse battery protection<sup>1)</sup>
- AEC qualified
- Green product (RoHS compliant)



PG-SOT-223

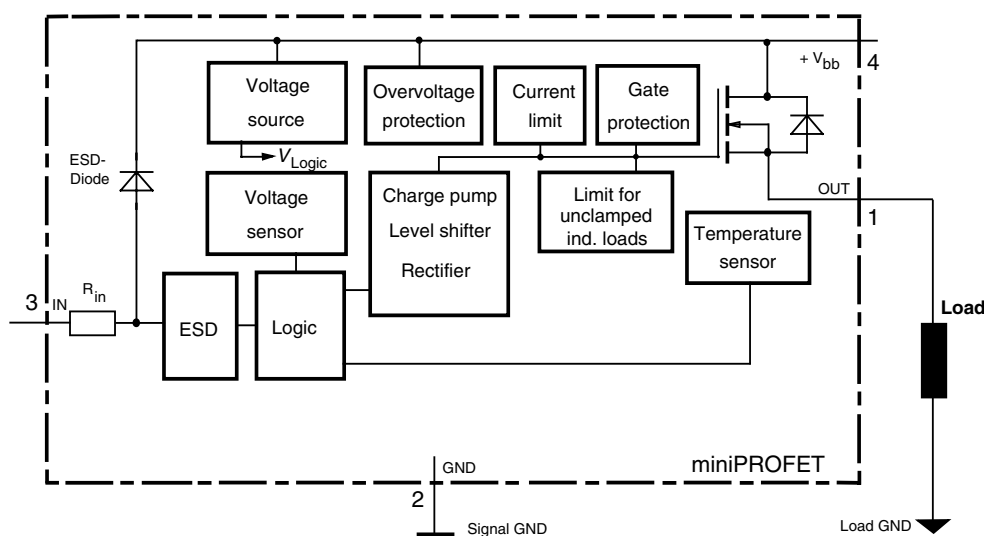
## Application

- $\mu$ C compatible power switch for 12 V DC grounded loads
- All types of resistive, inductive and capacitive loads
- 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.

## Blockdiagramm:



<sup>1)</sup> With resistor  $R_{GND}=150\ \Omega$  in GND connection, resistor in series with IN connections reverse load current limited by connected load.

Pin	Symbol	Function
1	OUT O	Output to the load
2	GND -	Logic ground
3	IN I	Input, activates the power switch in case of logical high signal
4	Vbb +	Positive power supply voltage

## Maximum Ratings at $T_j = 25^\circ\text{C}$ unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage	$V_{bb}$	40	V
Load current self-limited	$I_L$	$I_{L(SC)}$	A
Maximum input voltage <sup>2)</sup>	$V_{IN}$	$-5.0 \dots V_{bb}$	V
Maximum input current	$I_{IN}$	$\pm 5$	mA
Inductive load switch-off energy dissipation, single pulse $I_L = 0.5\text{A}$ , $T_A = 150^\circ\text{C}$ (not tested, specified by design)	$E_{AS}$	0.5	J
Load dump protection <sup>3)</sup> $V_{LoadDump} = U_A + V_S$ $R_L = 24\Omega$ $R_I = 2\Omega$ , $t_d = 400\text{ms}$ , $IN = \text{low or high}$ , $U_A = 13.5\text{V}$ $R_L = 80\Omega$ (not tested, specified by design)	$V_{Load\ dump}^{4)}$	60 80	V
Electrostatic discharge capability (ESD) <sup>5)</sup> PIN 3 PIN 1,2,4	$V_{ESD}$	$\pm 1$ $\pm 2$	kV
Operating temperature range	$T_j$	$-40 \dots +150$	$^\circ\text{C}$
Storage temperature range	$T_{stg}$	$-55 \dots +150$	$^\circ\text{C}$
Max. power dissipation (DC) <sup>6)</sup> $T_A = 25^\circ\text{C}$	$P_{tot}$	1.8	W
Thermal resistance chip - soldering point: chip - ambient: <sup>6)</sup>	$R_{thJS}$ $R_{thJA}$	7 70	K/W

<sup>2)</sup> At  $V_{IN} > V_{bb}$ , the input current is not allowed to exceed  $\pm 5\text{ mA}$ .

<sup>3)</sup> Supply voltages higher than  $V_{bb(AZ)}$  require an external current limit for the GND pin, e.g. with a  $150\ \Omega$  resistor in the GND connection. A resistor for the protection of the input is integrated.

<sup>4)</sup>  $V_{Load\ dump}$  is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

<sup>5)</sup> HBM according to MIL-STD 883D, Methode 3015.7

<sup>6)</sup> BSP 452 on epoxy pcb  $40\text{ mm} \times 40\text{ mm} \times 1.5\text{ mm}$  with  $6\text{ cm}^2$  copper area for  $V_{bb}$  connection



## Electrical Characteristics

Parameter and Conditions at $T_j = 25^\circ\text{C}$ , $V_{bb} = 13.5\text{V}$ unless otherwise specified	Symbol	Values			Unit
		min	typ	max	

## Load Switching Capabilities and Characteristics

On-state resistance (pin 4 to 1) $I_L = 0.5\text{ A}$ , $V_{in} = \text{high}$ $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$R_{ON}$	-- --	0.16 --	0.2 0.4	$\Omega$
Nominal load current (pin 4 to 1) <sup>7)</sup> ISO Standard: $V_{ON} = V_{bb} - V_{OUT} = 0.5\text{ V}$ $T_s = 85^\circ\text{C}$	$I_{L(ISO)}$	0.7	--	--	A
Turn-on time to 90% $V_{OUT}$ $R_L = 24\ \Omega$	$t_{on}$	--	60	100	$\mu\text{s}$
Turn-off time to 10% $V_{OUT}$ $R_L = 24\ \Omega$	$t_{off}$	--	60	150	$\mu\text{s}$
Slew rate on 10 to 30% $V_{OUT}$ , $R_L = 24\ \Omega$	$dV/dt_{on}$	--	2	4	$\text{V}/\mu\text{s}$
Slew rate off 70 to 40% $V_{OUT}$ , $R_L = 24\ \Omega$	$-dV/dt_{off}$	--	2	4	$\text{V}/\mu\text{s}$

## Input

Allowable input voltage range, (pin 3 to 2)	$V_{IN}$	-3.0	--	$V_{bb}$	V
Input turn-on threshold voltage  $T_j = -40\dots+150^\circ\text{C}$	$V_{IN(T+)}$	--	--	3.5	V
Input turn-off threshold voltage  $T_j = -40\dots+150^\circ\text{C}$	$V_{IN(T-)}$	1.5	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current (pin 3) $V_{IN(off)} = 1.2\text{ V}$ $T_j = -40\dots+150^\circ\text{C}$	$I_{IN(off)}$	10	--	60	$\mu\text{A}$
On state input current (pin 3) $V_{IN(on)} = 3.0\text{ V to } V_{bb}$ $T_j = -40\dots+150^\circ\text{C}$	$I_{IN(on)}$	10	--	100	$\mu\text{A}$
Input resistance	$R_{IN}$	1.5	2.8	3.5	$\text{k}\Omega$

<sup>7)</sup>  $I_{L(ISO)}$  is limited by current limitation, see  $I_{L(SC)}$ , next page

Parameter and Conditions at $T_j = 25^\circ\text{C}$ , $V_{bb} = 13.5\text{V}$ unless otherwise specified	Symbol	Values			Unit	
		min	typ	max		
<b>Operating Parameters</b>						
Operating voltage <sup>8)</sup>	$T_j = -40\dots+150^\circ\text{C}$	$V_{bb(\text{on})}$	5.0	--	34	V
Undervoltage shutdown	$T_j = -40\dots+150^\circ\text{C}$	$V_{bb(\text{under})}$	3.5	--	5	V
Undervoltage restart	$T_i = -40\dots+25^\circ\text{C}$ $T_j = +150^\circ\text{C}$	$V_{bb(\text{u rst})}$	--	--	6.5 7.0	V
Undervoltage restart of charge pump see diagram page 7		$V_{bb(\text{ucp})}$	--	5.6	7	V
Undervoltage hysteresis $\Delta V_{bb(\text{under})} = V_{bb(\text{u rst})} - V_{bb(\text{under})}$		$\Delta V_{bb(\text{under})}$	--	0.3	--	V
Overvoltage shutdown	$T_j = -40\dots+150^\circ\text{C}$	$V_{bb(\text{over})}$	34	--	42	V
Overvoltage restart	$T_j = -40\dots+150^\circ\text{C}$	$V_{bb(\text{o rst})}$	33	--	--	V
Overvoltage hysteresis	$T_j = -40\dots+150^\circ\text{C}$	$\Delta V_{bb(\text{over})}$	--	0.7	--	V
Standby current (pin 4), $V_{in} = \text{low}$	$T_j = -40\dots+150^\circ\text{C}$	$I_{bb(\text{off})}$	--	10	25	$\mu\text{A}$
Operating current (pin 2), $V_{in} = 5\text{ V}$		$I_{\text{GND}}$	--	1	1.6	mA
leakage current (pin 1) $V_{in} = \text{low}$	$T_j = -40\dots+25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{\text{L}(\text{off})}$	--	2	5 7	$\mu\text{A}$

## Protection Functions

Current limit (pin 4 to 1)	$T_j = 25^\circ\text{C}$	$I_{L(\text{SC})}$	0.7	1.5	2	A
$V_{bb} = 20\text{V}$	$T_j = -40\dots+150^\circ\text{C}$		0.7	--	2.4	
Overvoltage protection $I_{bb}=4\text{mA}$	$T_j = -40\dots+150^\circ\text{C}$	$V_{bb(\text{AZ})}$	41	--	--	V
Output clamp (ind. load switch off) at $V_{\text{OUT}}=V_{bb}-V_{\text{ON}(\text{CL})}$ , $I_{bb} = 4\text{mA}$		$V_{\text{ON}(\text{CL})}$	41	47	--	V
Thermal overload trip temperature		$T_{jt}$	150	--	--	$^\circ\text{C}$
Thermal hysteresis		$\Delta T_{jt}$	--	10	--	K
Inductive load switch-off energy dissipation <sup>9)</sup> $T_{j \text{ Start}} = 150^\circ\text{C}$ , single pulse, $I_L = 0.5\text{A}$ , $V_{bb} = 12\text{V}$ (not tested, specified by design)		$E_{\text{AS}}$	--	--	0.5	J
Reverse battery (pin 4 to 2) <sup>10)</sup> (not tested, specified by design)		$-V_{bb}$	--	--	30	V

<sup>8)</sup> At supply voltage increase up to  $V_{bb}=5.6\text{V}$  typ without charge pump,  $V_{\text{OUT}} \approx V_{bb} - 2\text{V}$

<sup>9)</sup> While demagnetizing load inductance, dissipated energy in PROFET is  $E_{\text{AS}} = \int V_{\text{ON}(\text{CL})} \cdot i_L(t) dt$ , approx.

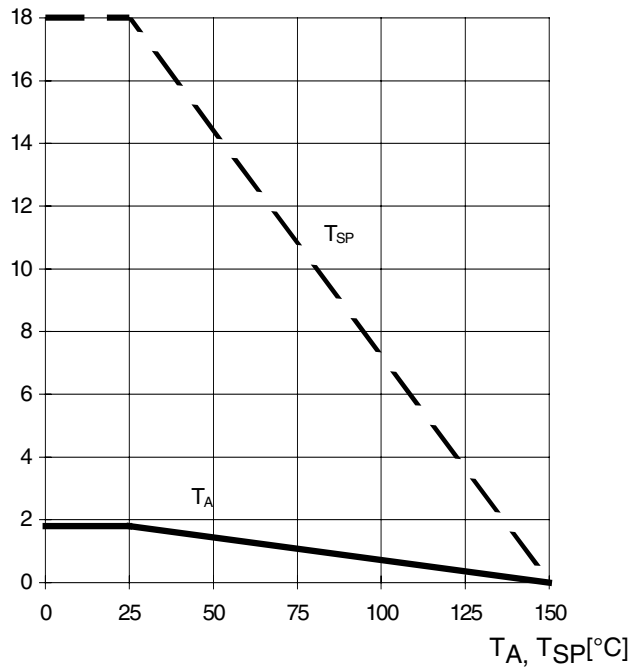
$$E_{\text{AS}} = \frac{1}{2} \cdot L \cdot I_L^2 \cdot \left( \frac{V_{\text{ON}(\text{CL})}}{V_{\text{ON}(\text{CL})} - V_{bb}} \right)$$

<sup>10)</sup> Requires  $150\Omega$  resistor in GND connection. Reverse load current (through intrinsic drain-source diode) is normally limited by the connected load.

## Max. allowable power dissipation

$$P_{\text{tot}} = f(T_A, T_{\text{SP}})$$

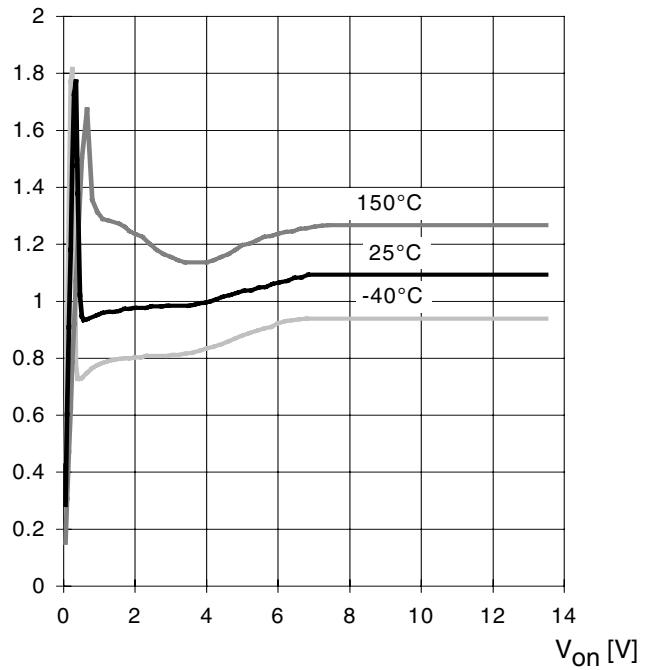
$P_{\text{tot}}$  [W]



## Current limit characteristic

$$I_{\text{L(SC)}} = f(V_{\text{on}}); (V_{\text{on}} \text{ see testcircuit})$$

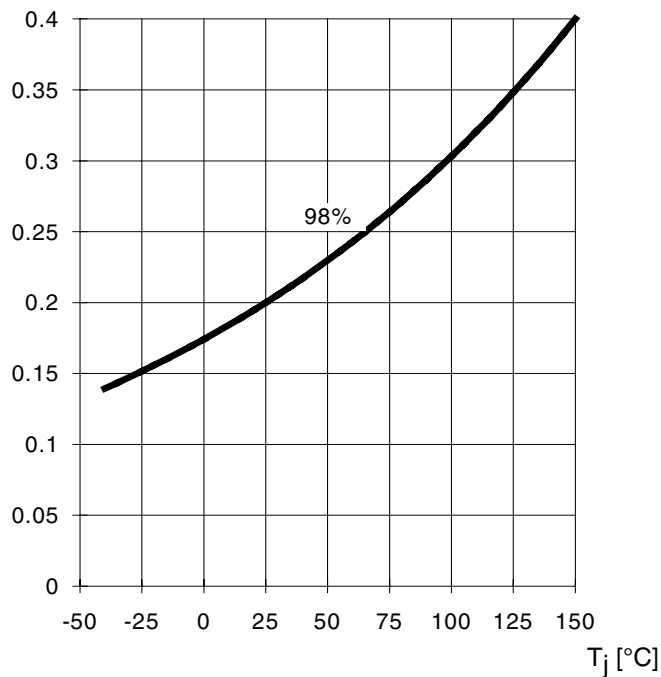
$I_{\text{L(SC)}}$  [A]



## On state resistance (Vbb-pin to OUT-pin)

$$R_{\text{ON}} = f(T_j); V_{\text{bb}} = 13.5 \text{ V}; I_{\text{L}} = 0.5 \text{ A}$$

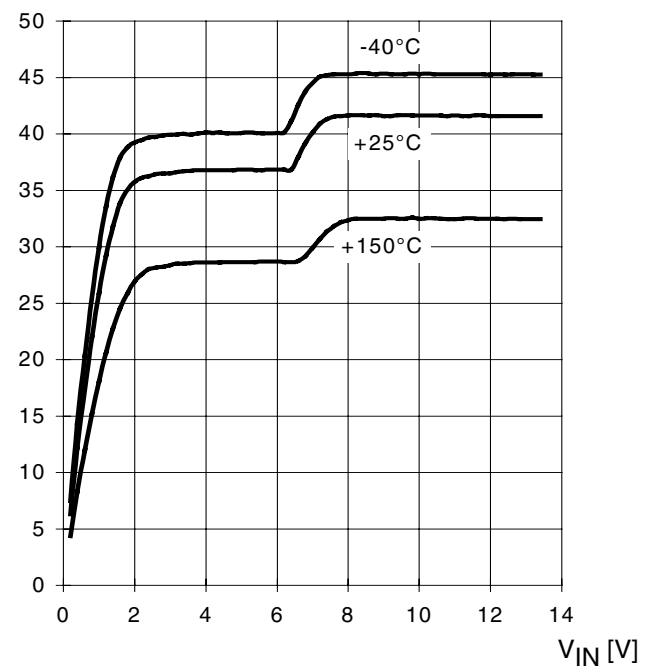
$R_{\text{ON}}$  [ $\Omega$ ]



## Typ. input current

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

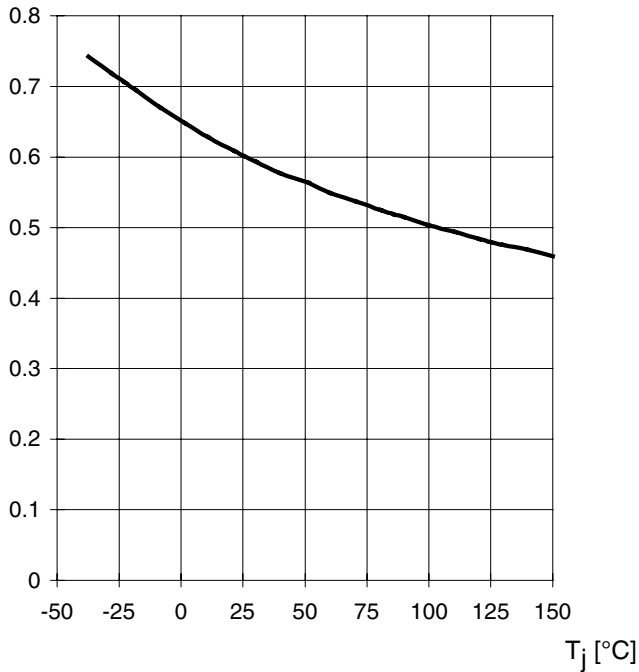
$I_{\text{IN}}$  [ $\mu\text{A}$ ]



## Typ. operating current

$I_{GND} = f(T_j)$ ;  $V_{bb} = 13,5 \text{ V}$ ;  $V_{IN} = \text{high}$

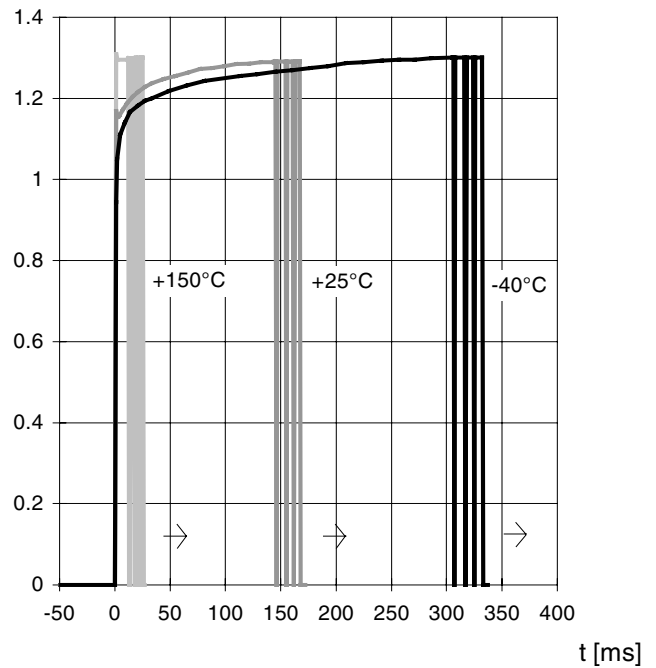
$I_{GND} [\text{mA}]$



## Typ. overload current

$I_{L(lim)} = f(t)$ ;  $V_{bb} = 13,5 \text{ V}$ , no heatsink, Param.:  $T_{jstart}$

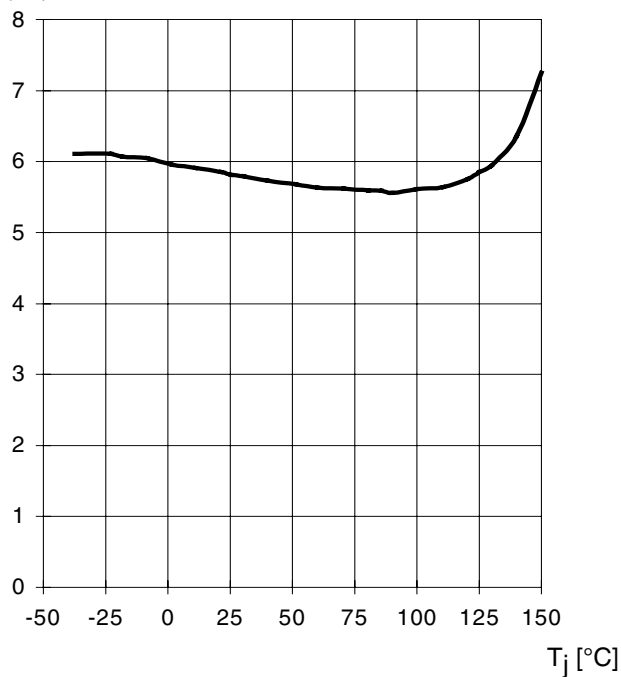
$I_{L(lim)} [\text{A}]$



## Typ. standby current

$I_{bb(off)} = f(T_j)$ ;  $V_{bb} = 13,5 \text{ V}$ ;  $V_{IN} = \text{low}$

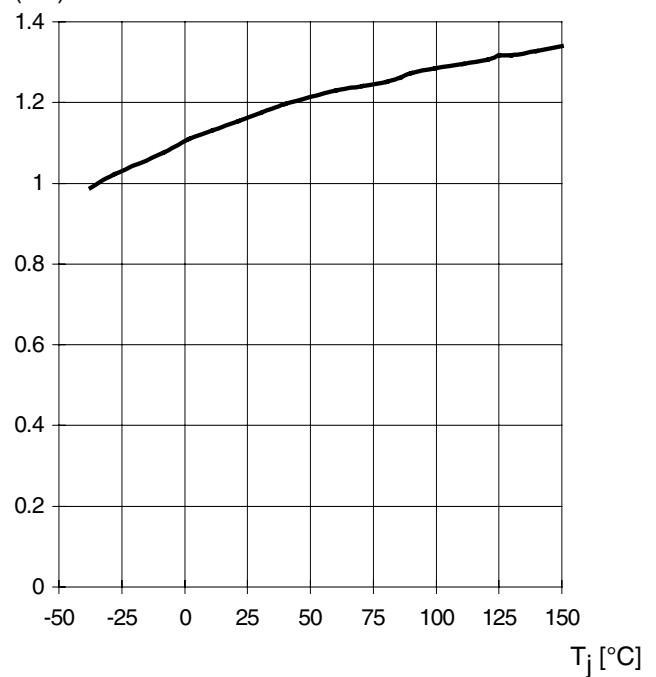
$I_{bb(off)} [\mu\text{A}]$



## Short circuit current

$I_{L(SC)} = f(T_j)$ ;  $V_{bb} = 13,5 \text{ V}$

$I_{L(SC)} [\text{A}]$



Typ. input turn on voltage threshold

$$V_{IN(T+)} = f(T_j);$$

$V_{IN(T+)} [V]$

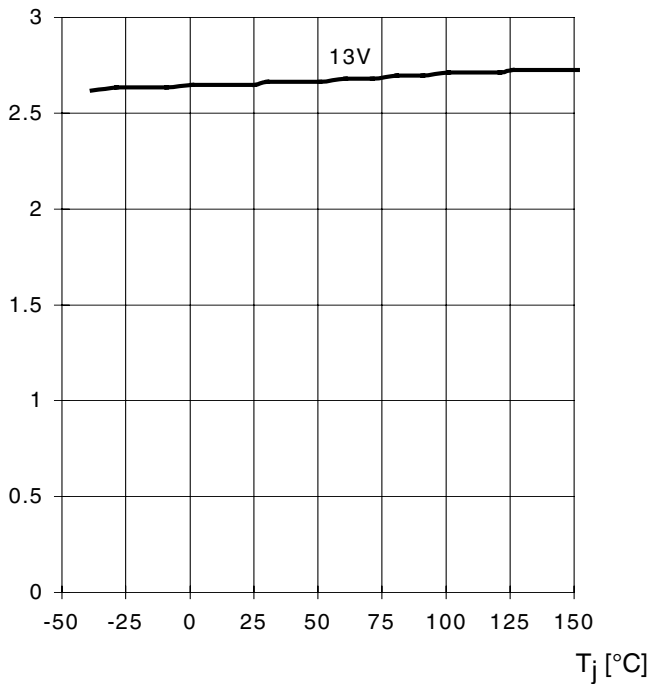
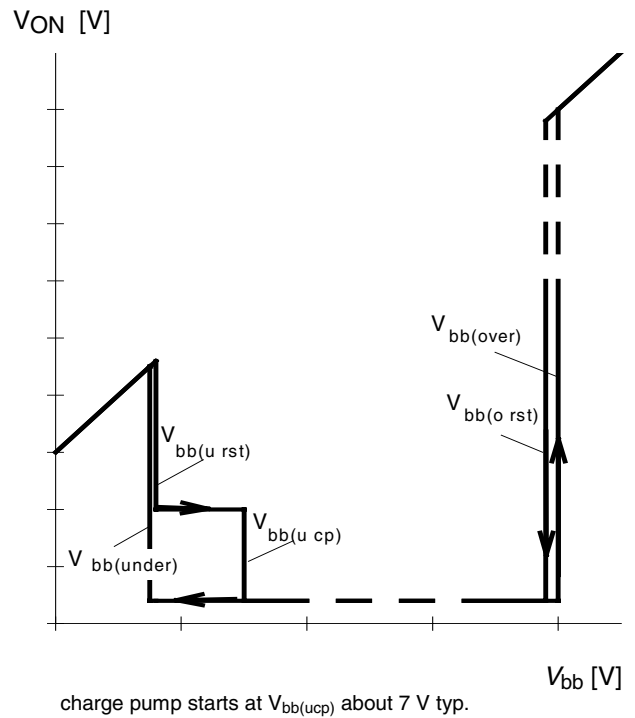


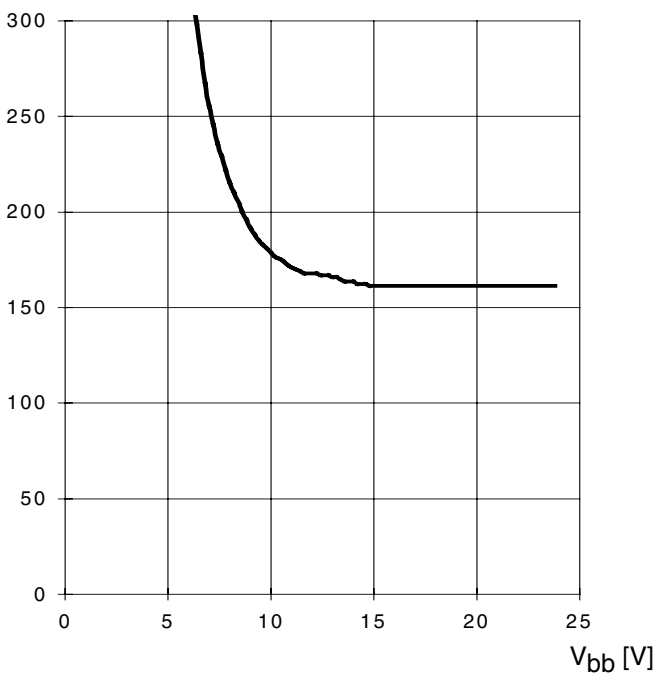
Figure 6: Undervoltage restart of charge pump



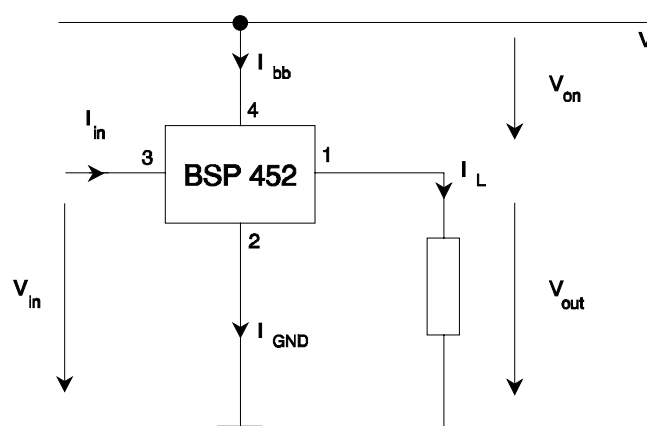
Typ. on-state resistance (Vbb-Pin to Out-Pin)

$$R_{ON} = f(V_{bb}, I_L); I_L = 0.5A, T_j = 25^{\circ}C$$

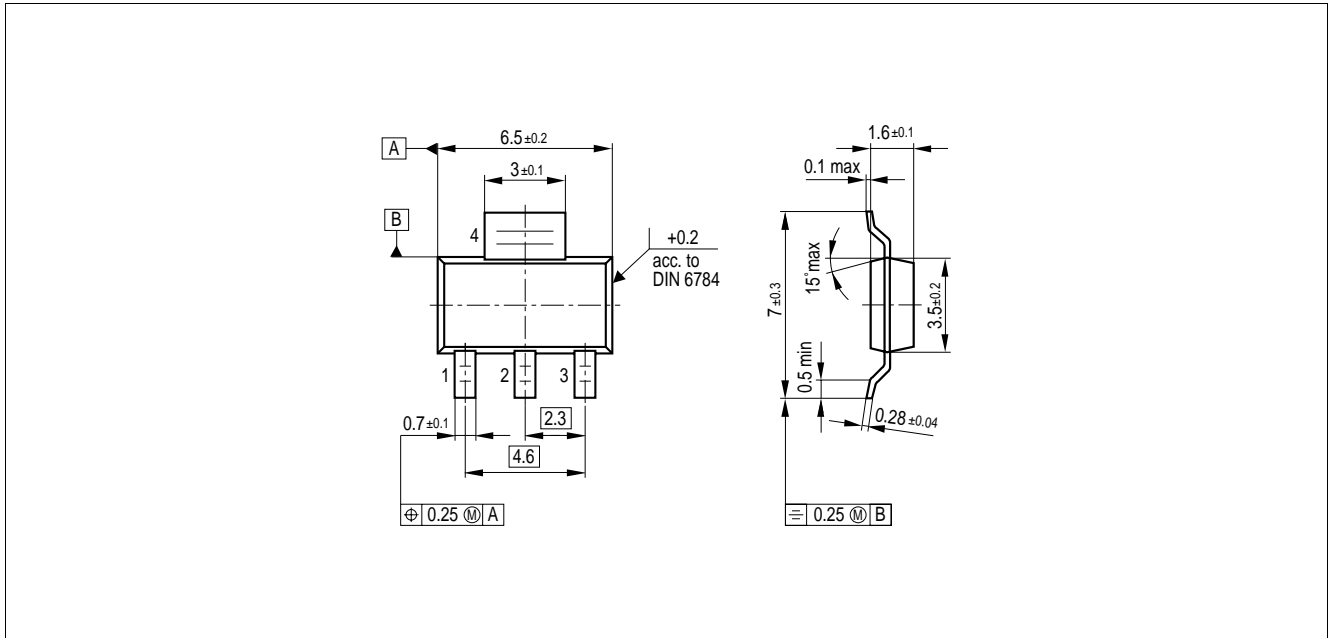
$R_{ON} [m\Omega]$



Test circuit



## Package Outlines



**Figure 1** PG-SOT-223 (Plastic Dual Small Outline Package) (RoHS-compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

Please specify the package needed (e.g. green package) when placing an order

## Revision History

Version	Date	Changes
1.0	2007-05-25	Creation of the green datasheet. First page : Adding the green logo and the AEC qualified Adding the bullet AEC qualified and the RoHS compliant features Package page Modification of the package to be green.

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