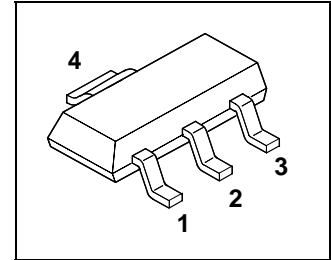


## Smart Power High-Side-Switch for Industrial Applications

### Features

- 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>



Package: PG-SOT 223

Type	Ordering code
ISP 452	SP000219823

### Application

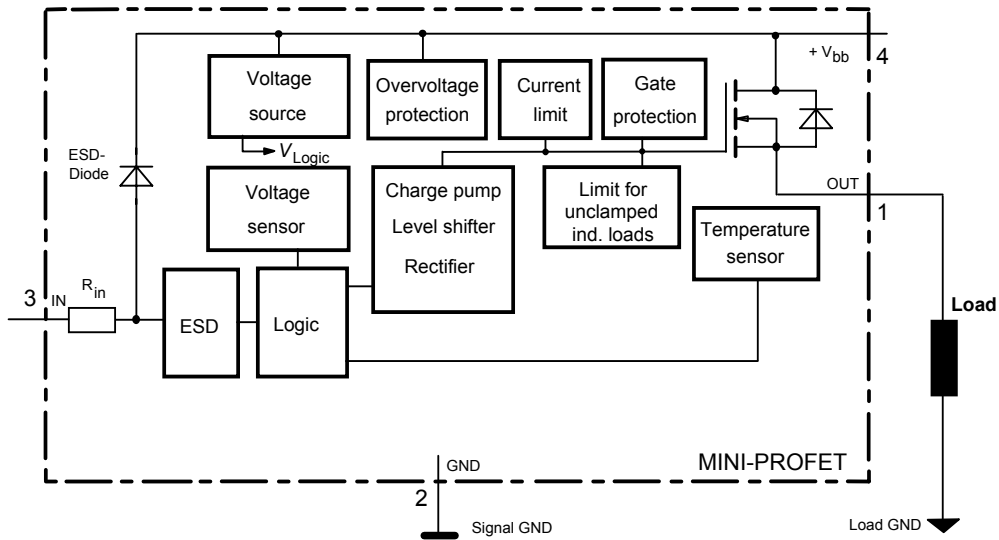
- $\mu$ C compatible power switch for 12 V DC grounded loads for industrial applications
- All types of resistive, inductive and capacitive loads
- Replaces electromechanical relays and discrete circuits

### General Description

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

<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.

Block diagram



Pin	Symbol		Function
1	OUT	O	Protected high-side power output
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  $T_j = 25\text{ °C}$  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... $V_{bb}$	V
Maximum input current	$I_{IN}$	$\pm 5$	mA
Inductive load switch-off energy dissipation, single pulse $I_L = 0.5\text{A}$ , $T_{j, start} = 150\text{°C}$ (not tested, specified by design)	$E_{AS}$	0.5	J
Load dump protection <sup>3)</sup> $V_{LoadDump} = U_A + V_S$ $R_l = 2\ \Omega$ , $t_d = 400\text{ms}$ , IN= low or high, $U_A = 13.5\text{ V}$ (not tested, specified by design) $R_L = 24\ \Omega$ $R_L = 80\ \Omega$	$V_{Load\ dump}^{4)}$	60 80	V
Electrostatic discharge capability (ESD) <sup>5)</sup> PIN 3 PIN 1,2,4	$V_{ESD}$	$\pm 1$ $\pm 2$	kV
Junction Temperature	$T_j$	150	°C
Operating temperature range	$T_a$	-30 ...+85	
Storage temperature range	$T_{stg}$	-40 ...+105	
Max. power dissipation (DC) <sup>6)</sup> $T_A = 25\text{ °C}$	$P_{tot}$	1.8	W
Thermal resistance chip - soldering point:	$R_{thJS}$	7	K/W
chip - ambient: <sup>6)</sup>	$R_{thJA}$	70	

<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> Device on epoxy pcb 40 mm x 40 mm x 1.5 mm with  $6\text{ cm}^2$  copper area for  $V_{bb}$  connection



**Electrical Characteristics**

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

**Load Switching Capabilities and Characteristics**

On-state resistance (pin 4 to 1) $I_L = 0.5\text{ A}$ , $V_{in} = \text{high}$	$T_j = 25\text{ }^\circ\text{C}$ $T_j = 150\text{ }^\circ\text{C}$	$R_{ON}$	-- --	0.16 --	0.2 0.4	$\Omega$
Nominal load current (pin 4 to 1) <sup>7)</sup> ISO Standard: $V_{ON} = V_{bb} - V_{OUT} = 0.5\text{ V}$ $T_S = 85\text{ }^\circ\text{C}$		$I_{L(ISO)}$	0.7	--	--	A
Turn-on time Turn-off time $R_L = 24\text{ }\Omega$	to 90% $V_{OUT}$ to 10% $V_{OUT}$	$t_{on}$ $t_{off}$	-- --	60 60	100 150	$\mu\text{s}$
Slew rate on 10 to 30% $V_{OUT}$ , $R_L = 24\text{ }\Omega$		$dV/dt_{on}$	--	2	4	$\text{V}/\mu\text{s}$
Slew rate off 70 to 40% $V_{OUT}$ , $R_L = 24\text{ }\Omega$		$-dV/dt_{off}$	--	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  $T_j = -40\dots+150\text{ }^\circ\text{C}$		$V_{IN(T+)}$	--	--	3.5	V
Input turn-off threshold voltage  $T_j = -40\dots+150\text{ }^\circ\text{C}$		$V_{IN(T-)}$	1.5	--	--	V
Input threshold hysteresis		$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current (pin 3) $V_{IN(off)} = 1.2\text{ V}$ $T_j = -40\dots+150\text{ }^\circ\text{C}$		$I_{IN(off)}$	10	--	60	$\mu\text{A}$
On state input current (pin 3) $V_{IN(on)} = 3.0\text{ V to } V_{bb}$ $T_j = -40\dots+150\text{ }^\circ\text{C}$		$I_{IN(on)}$	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  $I_{L(SC)}$

Parameter and Conditions at $T_j = 25\text{ °C}$ , $V_{bb} = 13.5\text{V}$ unless otherwise specified	Symbol	Values			Unit	
		min	typ	max		
<b>Operating Parameters</b>						
Operating voltage <sup>8)</sup>	$T_j = -40\dots+150\text{ °C}$	$V_{bb(\text{on})}$	5.0	--	34	V
Undervoltage shutdown	$T_j = -40\dots+150\text{ °C}$	$V_{bb(\text{under})}$	3.5	--	5	V
Undervoltage restart	$T_j = -40\dots+25\text{ °C}$ $T_j = +150\text{ °C}$	$V_{bb(\text{u rst})}$	--	--	6.5 7.0	V
Undervoltage restart of charge pump see diagram page 9		$V_{bb(\text{ucp})}$	--	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	$T_j = -40\dots+150\text{ °C}$	$V_{bb(\text{over})}$	34	--	42	V
Overvoltage restart	$T_j = -40\dots+150\text{ °C}$	$V_{bb(\text{o rst})}$	33	--	--	V
Overvoltage hysteresis	$T_j = -40\dots+150\text{ °C}$	$\Delta V_{bb(\text{over})}$	--	0.7	--	V
Standby current (pin 4), $V_{in} = \text{low}$	$T_j = -40\dots+150\text{ °C}$	$I_{bb(\text{off})}$	--	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) $V_{in} = \text{low}$	$T_j = -40\dots+25\text{ °C}$ $T_j = 150\text{ °C}$	$I_{L(\text{off})}$	--	2	5 7	$\mu\text{A}$

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

Parameter and Conditions at $T_j = 25\text{ °C}$ , $V_{bb} = 13.5\text{V}$ unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
<b>Protection Functions</b>					
Current limit (pin 4 to 1) $V_{bb} = 20\text{V}$	$I_{L(SC)}$	0.7	1.5	2	A
$T_j = 25\text{ °C}$					
$T_j = -40\dots+150\text{ °C}$		0.7	--	2.4	
Overvoltage protection $I_{bb}=4\text{mA}$	$V_{bb(AZ)}$	41	--	--	V
$T_j = -40\dots+150\text{ °C}$					
Output clamp (ind. load switch off) at $V_{OUT}=V_{bb}-V_{ON(CL)}$ , $I_{bb} = 4\text{mA}$	$V_{ON(CL)}$	41	47	--	V
Thermal overload trip temperature	$T_{jt}$	150	--	--	°C
Thermal hysteresis	$\Delta T_{jt}$	--	10	--	K
Inductive load switch-off energy dissipation <sup>9)</sup> $T_{j, start} = 150\text{ °C}$ , single pulse, $I_L = 0.5\text{ A}$ , $V_{bb} = 12\text{ V}$ (not tested, specified by design)	$E_{AS}$	--	--	0.5	J
Reverse battery (pin 4 to 2) <sup>10)</sup> (not tested, specified by design)	$-V_{bb}$	--	--	30	V

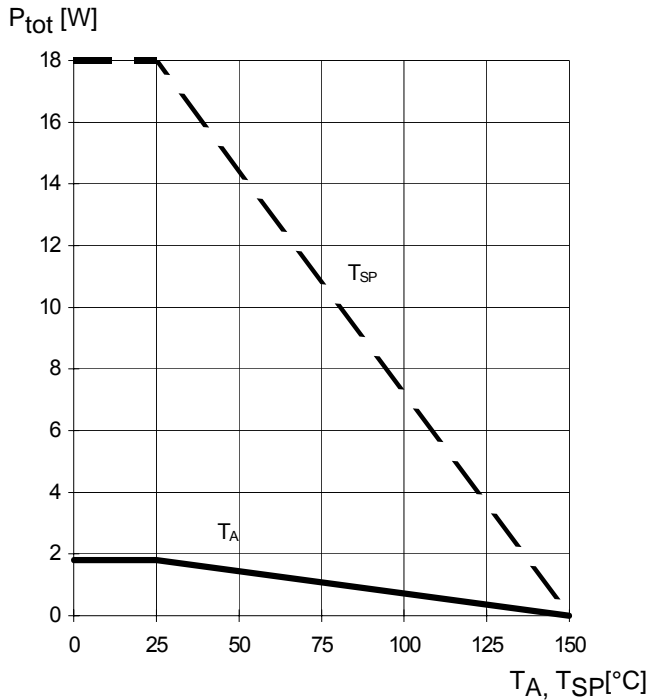
<sup>9)</sup> While demagnetizing load inductance, dissipated energy in PROFET is  $E_{AS} = \int V_{ON(CL)} * i_L(t) dt$ , approx.

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

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

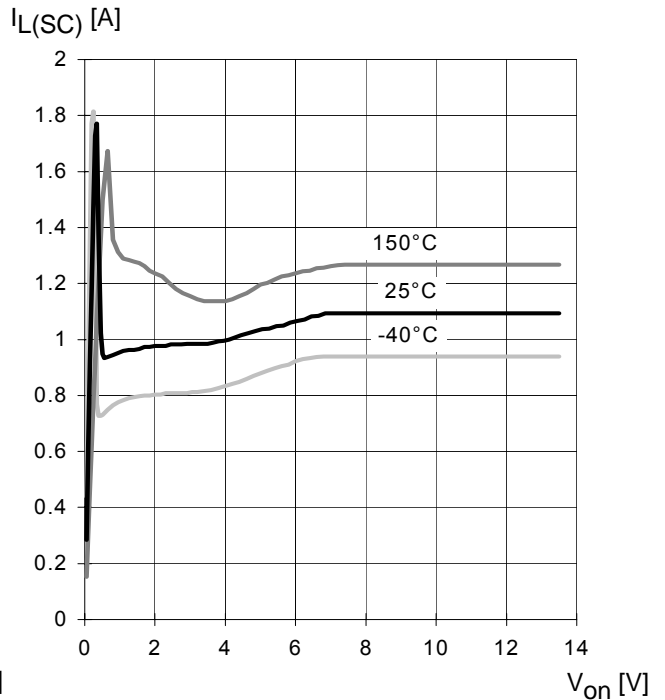
**Max. allowable power dissipation**

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



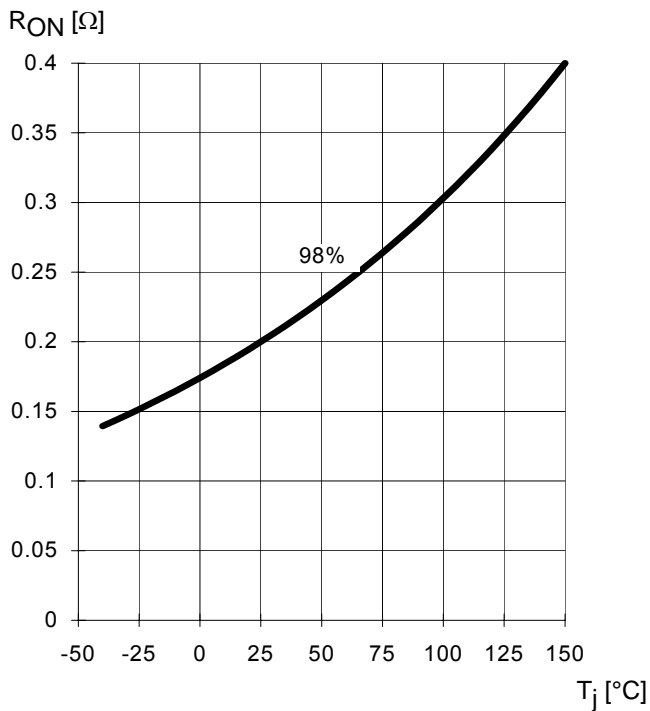
**Current limit characteristic**

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



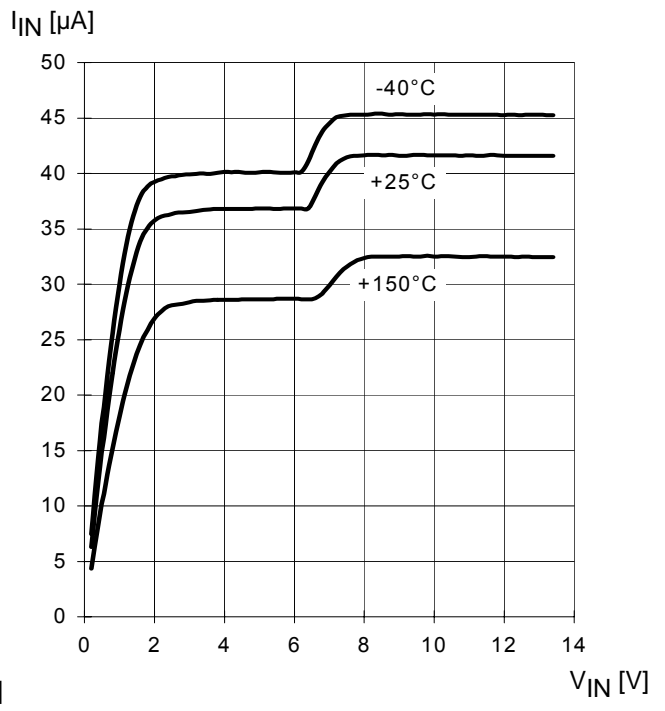
**On state resistance (Vbb-pin to OUT-pin)**

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



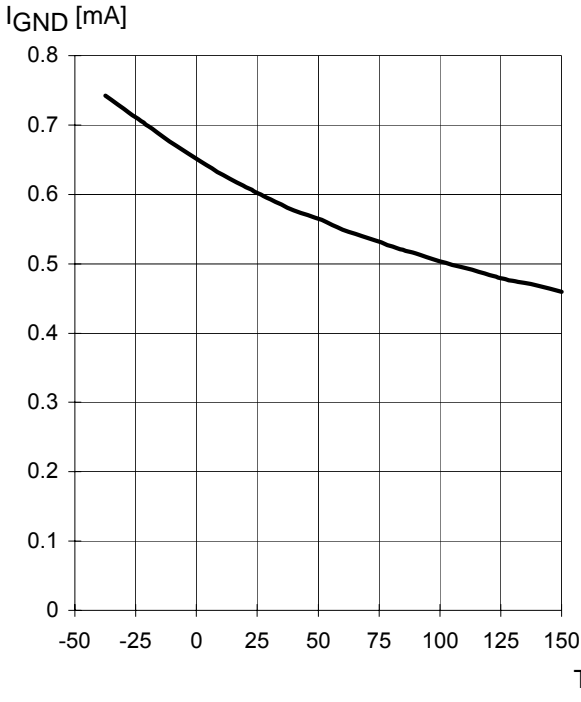
**Typ. input current**

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



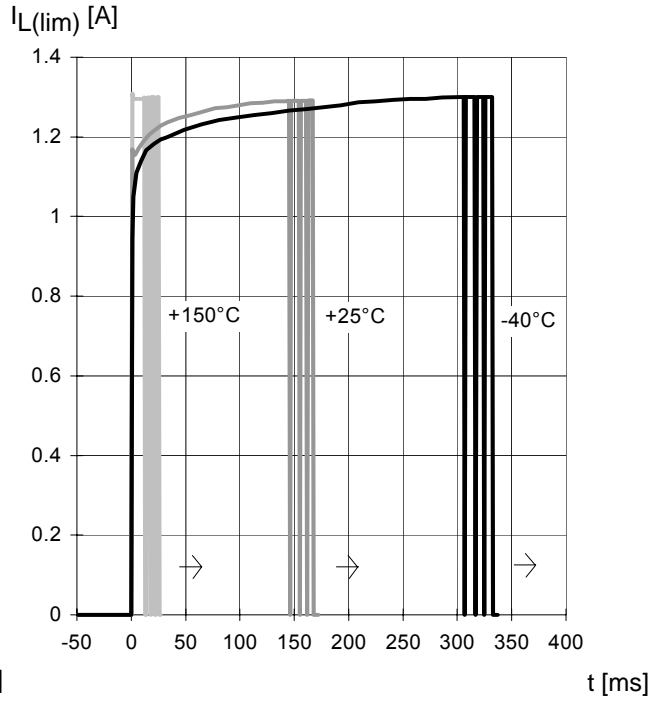
**Typ. operating current**

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



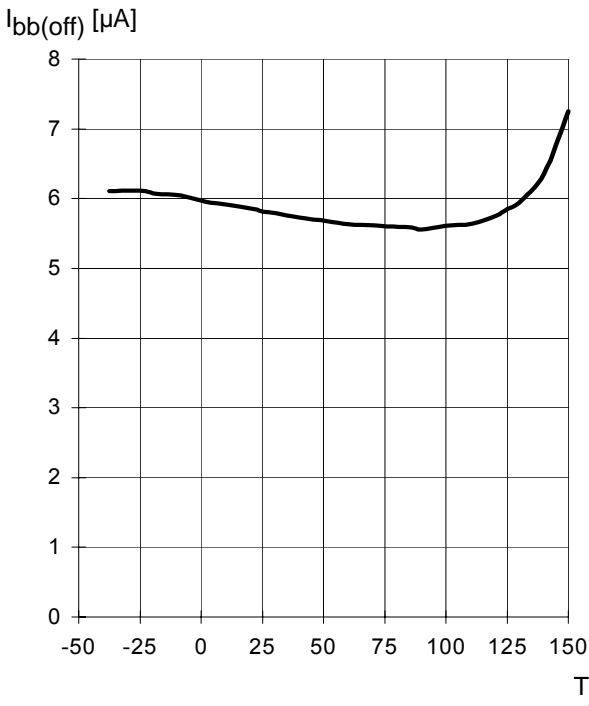
**Typ. overload current**

$I_{L(lim)} = f(t)$ ;  $V_{bb} = 13.5\text{ V}$ , no heatsink, Param.:  $T_{jstart}$



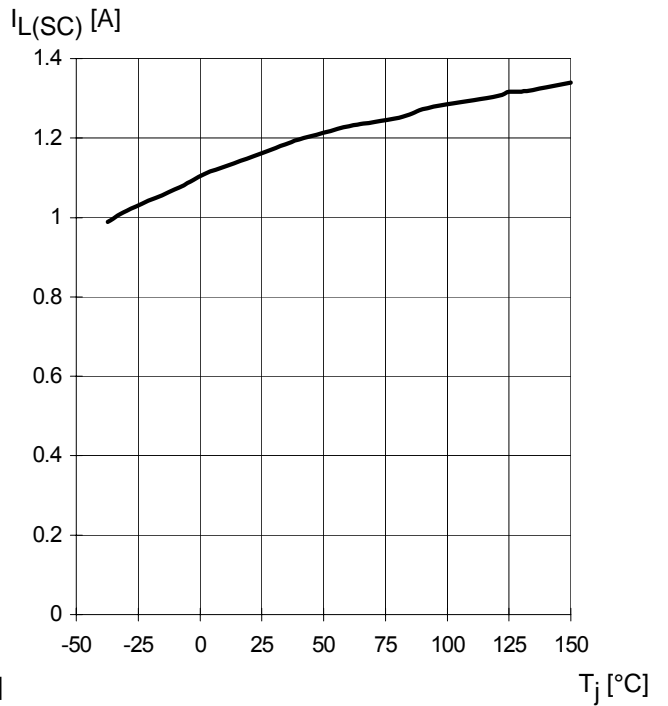
**Typ. standby current**

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



**Short circuit current**

$I_{L(SC)} = f(T_j)$ ;  $V_{bb} = 13.5\text{ V}$





Typ. input turn on voltage threshold

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

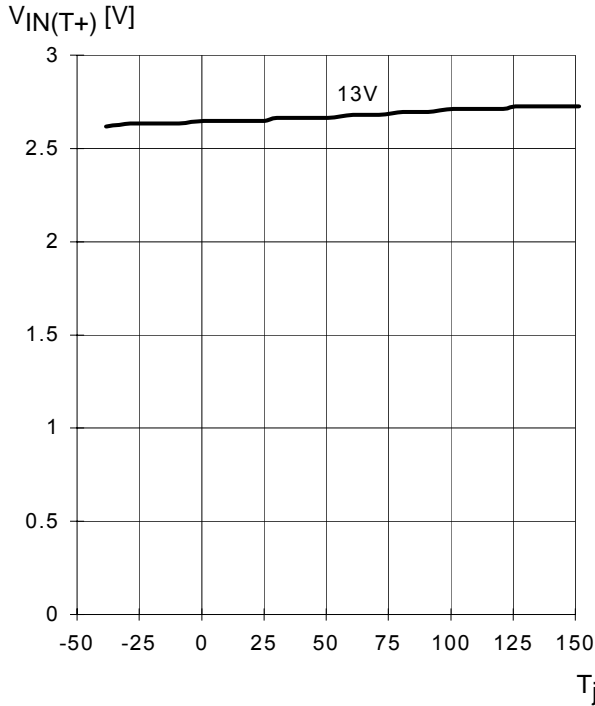
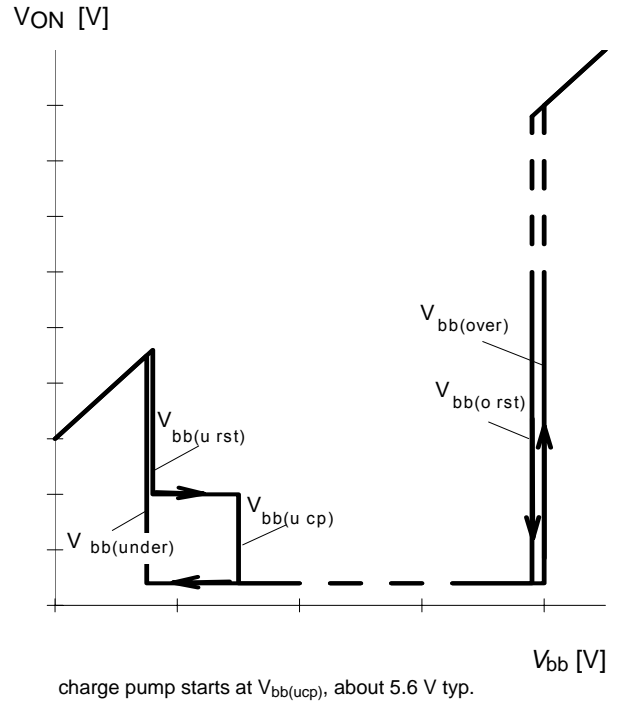
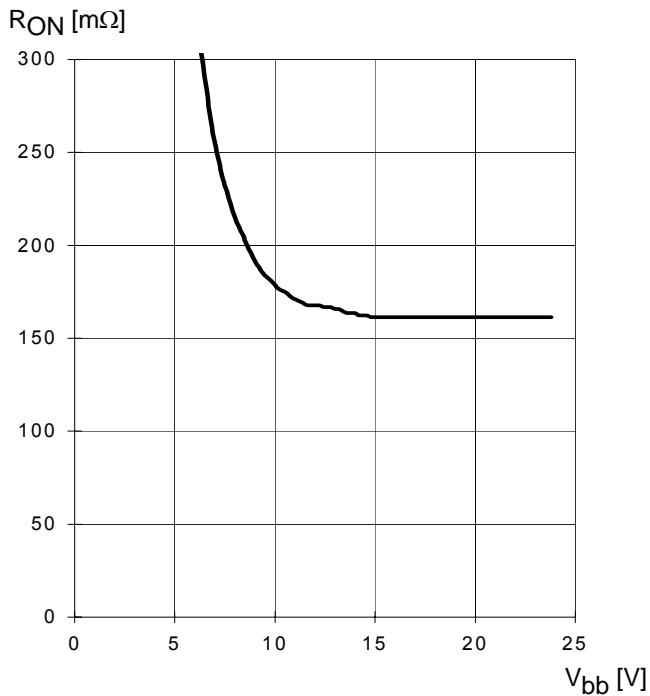


Figure 6: Undervoltage restart of charge pump

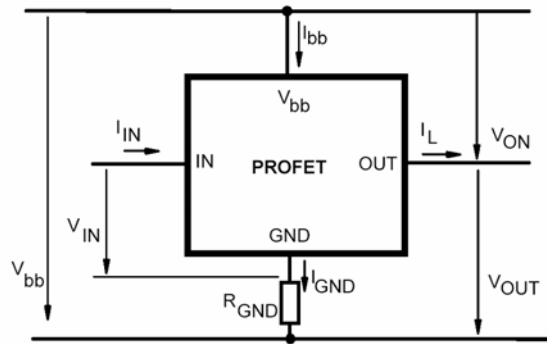


Typ. on-state resistance (Vbb-Pin to Out-Pin)

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



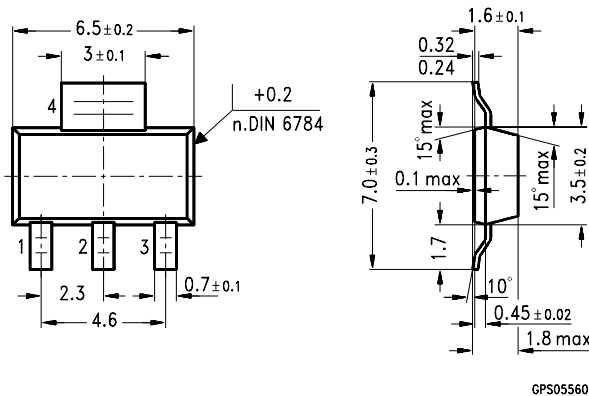
Terms



**Package:**

all dimensions in mm.

PG-SOT 223:



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