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ISP452

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**ISP 452**

# 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
- **E**lectro**s**tatic **d**ischarge (**ESD**) protection
- Reverse battery protection[1]
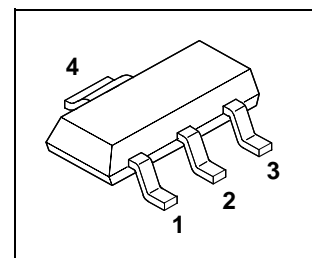
Package: PG-SOT 223

| Type | Ordering code |
|---------|---------------|
| ISP 452 | SP000219823 |

## Application
- µC 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.

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[1] With resistor $R_{GND}$=150 Ω in GND connection, resistor in series with IN connections, reverse load current limited by connected load.

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## Block diagram
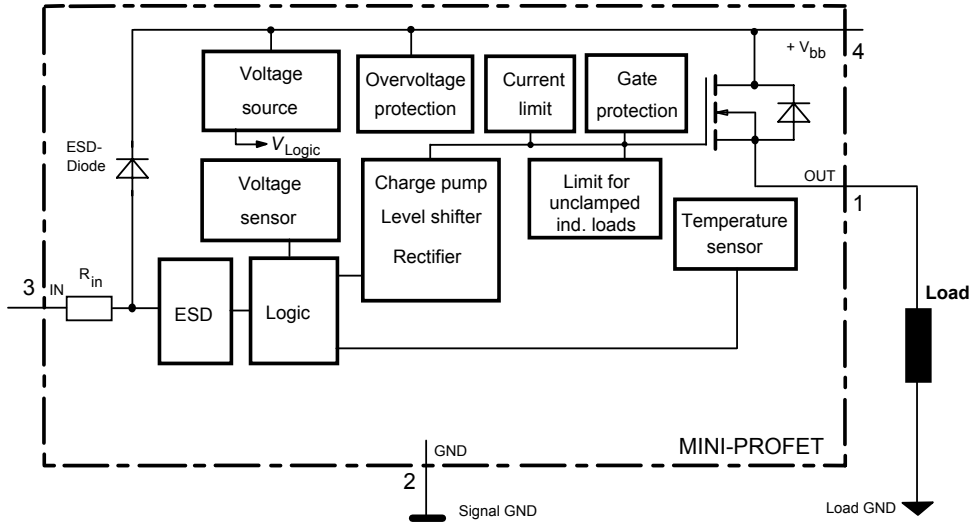


| Pin | Symbol | | Function |
|-----|--------|---|----------|
| 1 | OUT | O | Protected high-side power output |
| 2 | GND | - | Logic ground |
| 3 | IN | I | Input, activates the power switch in case of logical high signal |
| 4 | Vbb | + | Positive power supply voltage |

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**Maximum Ratings** at $T_j$ = 25 °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[2] | $V_{IN}$ | -5.0... $V_{bb}$ | V |
| Maximum input current | $I_{IN}$ | ±5 | mA |
| Inductive load switch-off energy dissipation, single pulse $I_L$ = 0.5A, $T_{j, start}$ = 150°C (not tested, specified by design) | $E_{AS}$ | 0.5 | J |
| Load dump protection[3] $V_{LoadDump} = U_A + V_s$ $R_I$=2 Ω , $t_d$=400ms, IN= low or high, $U_A$ = 13.5 V (not tested, specified by design)    $R_L$= 24 Ω    $R_L$= 80 Ω | $V_{Load\ dump}$[4] | 60 80 | V |
| Electrostatic discharge capability (ESD)[5]        PIN 3                                                                   PIN 1,2,4 | $V_{ESD}$ | ±1 ±2 | kV |
| Junction Temperature Operating temperature range Storage temperature range | $T_j$ $T_a$ $T_{stg}$ | 150 -30 ...+85 -40 ...+105 | °C |
| Max. power dissipation (DC)[6]        $T_A$ = 25 °C | $P_{tot}$ | 1.8 | W |
| Thermal resistance                    chip - soldering point:                                     chip - ambient:[6] | $R_{thJS}$ $R_{thJA}$ | 7 70 | K/W |

[2]   At $V_{IN}$ > $V_{bb}$, the input current is not allowed to exceed ±5 mA.
[3]   Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND pin, e.g. with a 150 Ω resistor in the GND connection. A resistor for the protection of the input is integrated.
[4]   $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839
[5]   HBM according to MIL-STD 883D, Methode 3015.7
[6]   Device on epoxy pcb 40 mm x 40 mm x 1.5 mm with 6 cm$^2$ copper area for $V_{bb}$ connection

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## Electrical Characteristics

| Parameter and Conditions | Symbol | Values | | | Unit |
|---|---|---|---|---|---|
| at $T_j$ = 25 °C, $V_{bb}$ = 13.5V unless otherwise specified | | min | typ | max | |

### Load Switching Capabilities and Characteristics

| Parameter and Conditions | | Symbol | min | typ | max | Unit |
|---|---|---|---|---|---|---|
| On-state resistance (pin 4 to 1) $I_L$ = 0.5 A, $V_{in}$ = high | $T_j$ = 25°C | $R_{ON}$ | -- | 0.16 | 0.2 | $\Omega$ |
| | $T_j$ = 150°C | | -- | -- | 0.4 | |
| Nominal load current (pin 4 to 1)[7] ISO Standard: $V_{ON}$ = $V_{bb}$ - $V_{OUT}$ = 0.5 V $T_S$ = 85 °C | | $I_{L(ISO)}$ | 0.7 | -- | -- | A |
| Turn-on time | to 90% $V_{OUT}$ | $t_{on}$ | -- | 60 | 100 | µs |
| Turn-off time $R_L$ = 24 $\Omega$ | to 10% $V_{OUT}$ | $t_{off}$ | -- | 60 | 150 | |
| Slew rate on 10 to 30% $V_{OUT}$, $R_L$ = 24 $\Omega$ | | d$V$/dt$_{on}$ | -- | 2 | 4 | V/µs |
| Slew rate off 70 to 40% $V_{OUT}$, $R_L$ = 24 $\Omega$ | | -d$V$/dt$_{off}$ | -- | 2 | 4 | V/µs |

### Input

| Parameter and Conditions | | Symbol | min | typ | max | Unit |
|---|---|---|---|---|---|---|
| Allowable input voltage range, (pin 3 to 2) | | $V_{IN}$ | -3.0 | -- | $V_{bb}$ | V |
| Input turn-on threshold voltage | $T_j$ = -40...+150°C | $V_{IN(T+)}$ | -- | -- | 3.5 | V |
| Input turn-off threshold voltage | $T_j$ = -40...+150°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 V | $T_j$ = -40...+150°C | $I_{IN(off)}$ | 10 | -- | 60 | µA |
| On state input current (pin 3) $V_{IN(on)}$ = 3.0 V to $V_{bb}$ | $T_j$ = -40...+150°C | $I_{IN(on)}$ | 10 | -- | 100 | µA |
| Input resistance | | $R_{IN}$ | 1.5 | 2.8 | 3.5 | k$\Omega$ |

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[7] $I_{L(ISO)}$ is limited by current limitation, see $I_{L(SC)}$

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| Parameter and Conditions | Symbol | Values | | | Unit |
|---|---|---|---|---|---|
| at $T_j$ = 25 °C, $V_{bb}$ = 13.5V unless otherwise specified | | min | typ | max | |
| **Operating Parameters** | | | | | |
| Operating voltage[8]  $T_j$ =-40...+150°C | $V_{bb(on)}$ | 5.0 | -- | 34 | V |
| Undervoltage shutdown  $T_j$ =-40...+150°C | $V_{bb(under)}$ | 3.5 | -- | 5 | V |
| Undervoltage restart  $T_j$ =-40...+25°C  $T_j$ =+150°C | $V_{bb(u\,rst)}$ | -- | -- | 6.5  7.0 | V |
| Undervoltage restart of charge pumpe  see diagram page 9 | $V_{bb(ucp)}$ | -- | 5.6 | 7 | V |
| Undervoltage hysteresis  $\Delta V_{bb(under)} = V_{bb(u\,rst)} - V_{bb(under)}$ | $\Delta V_{bb(under)}$ | -- | 0.3 | -- | V |
| Overvoltage shutdown  $T_j$ =-40...+150°C | $V_{bb(over)}$ | 34 | -- | 42 | V |
| Overvoltage restart  $T_j$ =-40...+150°C | $V_{bb(o\,rst)}$ | 33 | -- | -- | V |
| Overvoltage hysteresis  $T_j$ =-40...+150°C | $\Delta V_{bb(over)}$ | -- | 0.7 | -- | V |
| Standby current (pin 4), $V_{in}$ = low  $T_j$ =-40...+150°C | $I_{bb(off)}$ | -- | 10 | 25 | µA |
| Operating current (pin 2), $V_{in}$ = 5 V | $I_{GND}$ | -- | 1 | 1.6 | mA |
| Leakage current (pin 1) $V_{in}$ = low  $T_j$ =-40...+25°C  $T_j$ =150°C | $I_{L(off)}$ | -- | 2 | 5  7 | µA |

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[8]  At supply voltage increase up to $V_{bb}$= 5.6 V typ without charge pump, $V_{OUT} \approx V_{bb}$ - 2 V

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

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

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

[10]  Requires 150 Ω resistor in GND connection. Reverse load current (through intrinsic drain-source diode) has to be limited by the connected load.
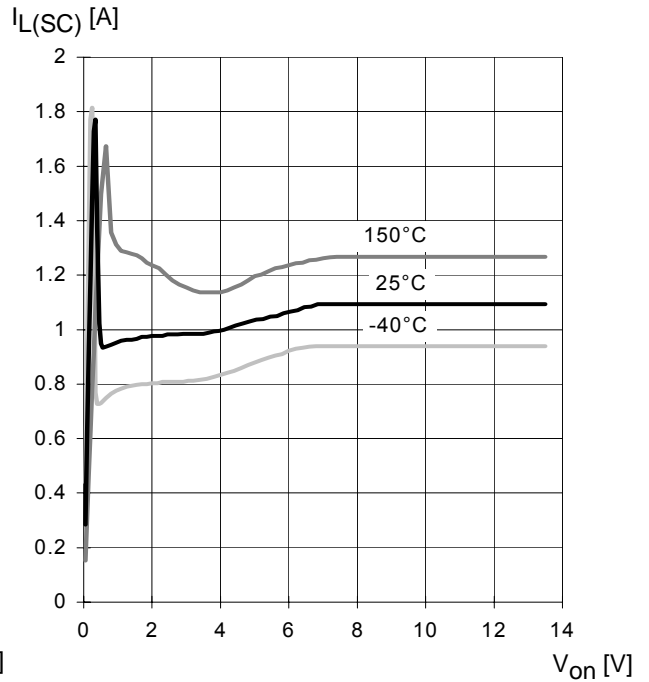
**ISP 452**
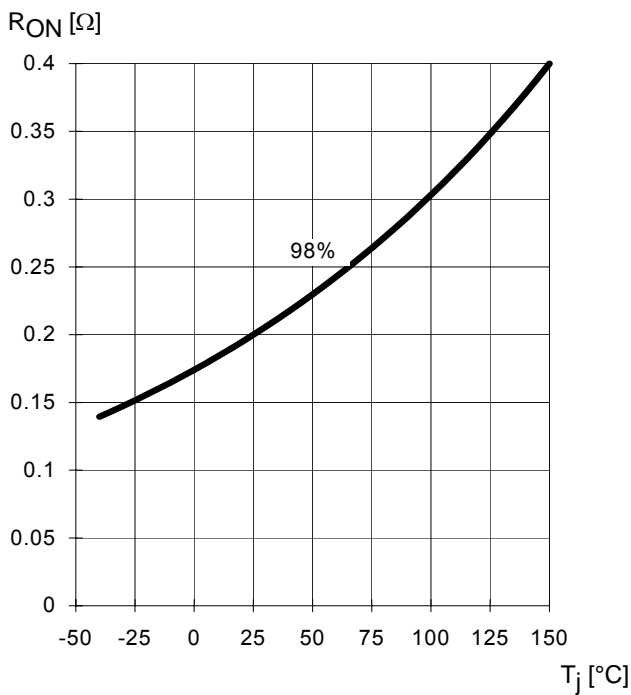
**Max. allowable power dissipation**
$P_{tot} = f (T_A, T_{SP})$

$P_{tot}$ [W]
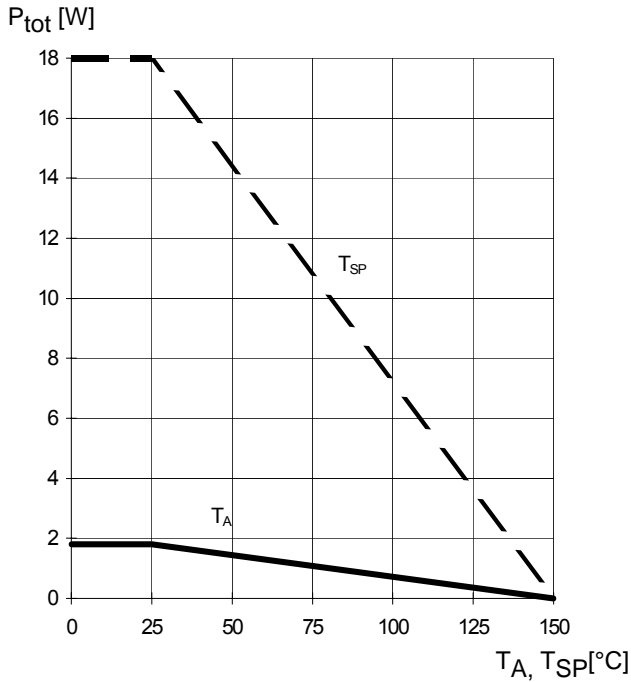
**Current limit characteristic**
$I_{L(SC)} = f (V_{on})$; ($V_{on}$ see terms schematic below)
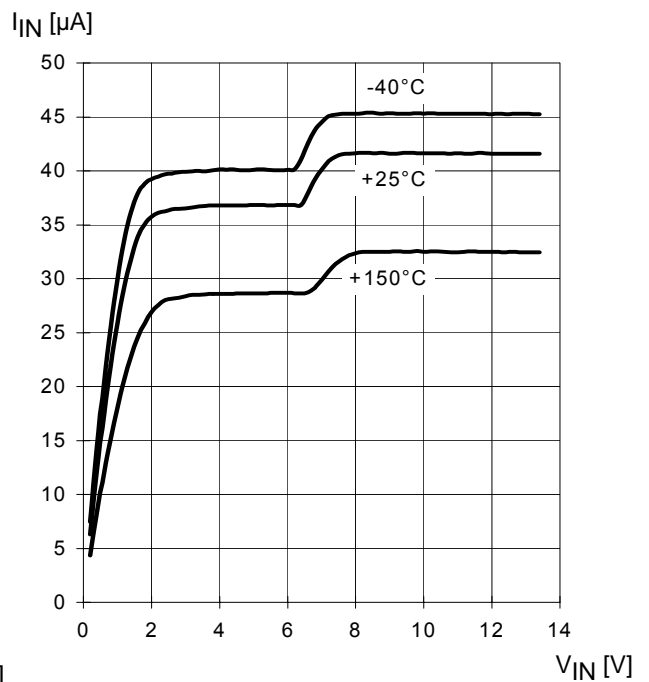
$I_{L(SC)}$ [A]

**On state resistance (Vbb-pin to OUT-pin)**
$R_{ON} = f (Tj)$; $V_{bb} = 13.5$ V; $I_L = 0.5$ A

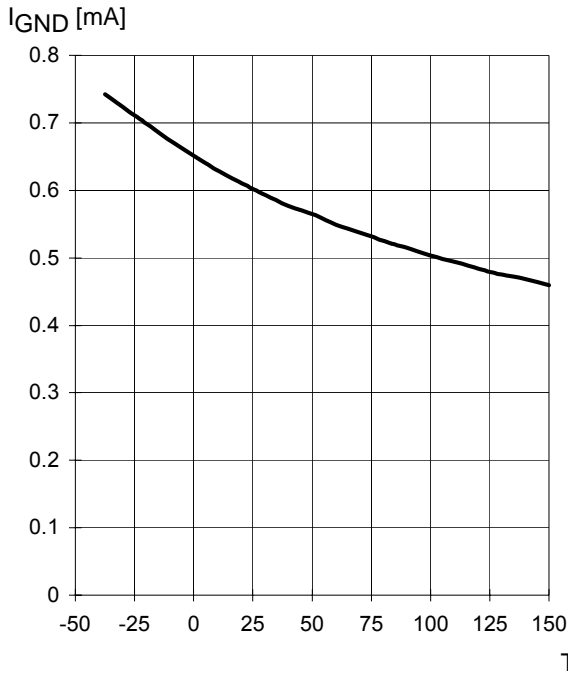$R_{ON}$ [Ω]

**Typ. input current**
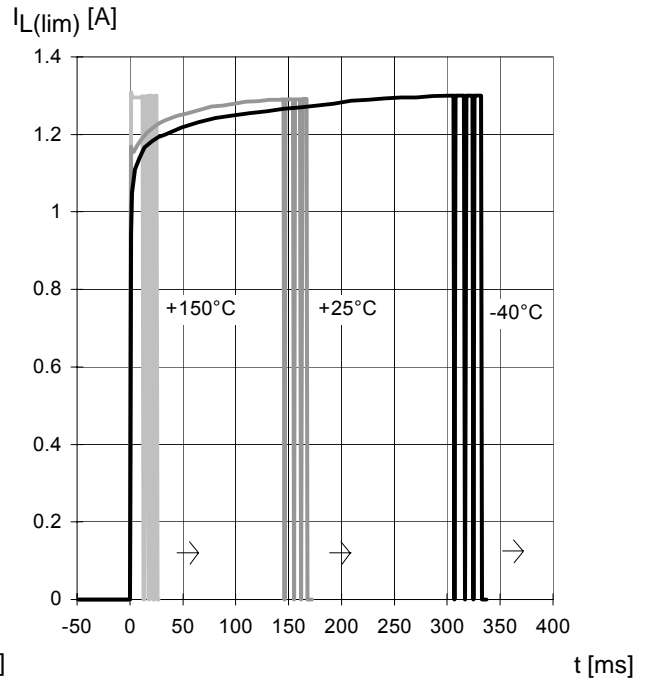$I_{IN} = f (V_{IN})$; $V_{bb} = 13.5$ V

$I_{IN}$ [µA]

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**Typ. operating current**
$I_{GND} = f (T_j)$; $V_{bb}$ = 13.5 V; $V_{IN}$ = high

$I_{GND}$ [mA]



$T_j$ [°C]

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

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



+150°C    +25°C    -40°C

t [ms]

**Typ. standby current**
$I_{bb(off)} = f (T_j)$; $V_{bb}$ = 13.5 V; $V_{IN}$ = low

$I_{bb(off)}$ [µA]



$T_j$ [°C]
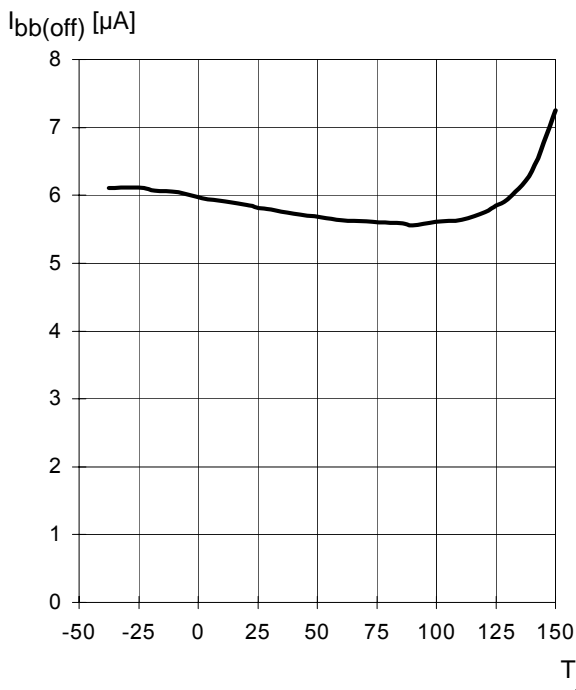
**Short circuit current**
$I_{L(SC)} = f (T_j)$; $V_{bb}$ = 13.5 V

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



$T_j$ [°C]

**ISP 452**
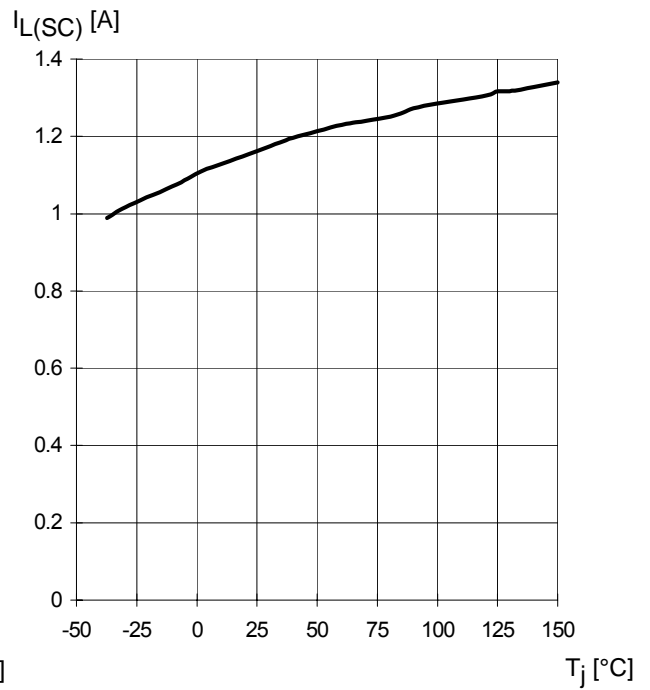
**Typ. input turn on voltage threshold**
$V_{IN(T+)} = f(T_j)$;

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



$T_j$ [°C]
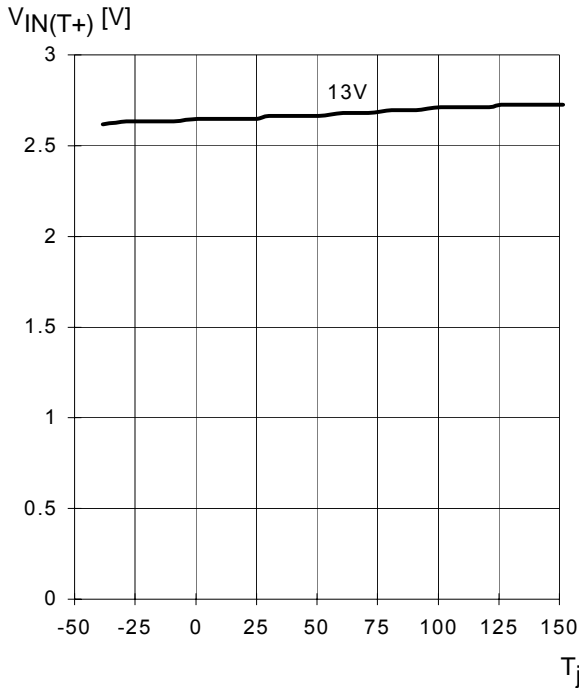
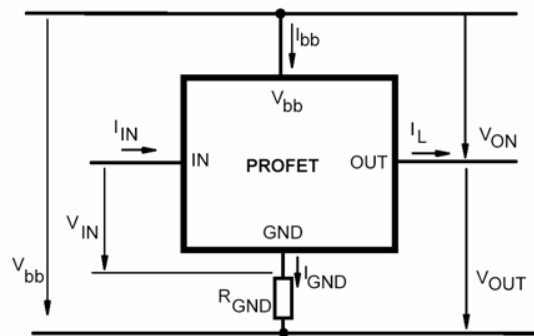**Figure 6: Undervoltage restart of charge pump**

$V_{ON}$ [V]



charge pump starts at $V_{bb(ucp)}$, about 5.6 V typ.
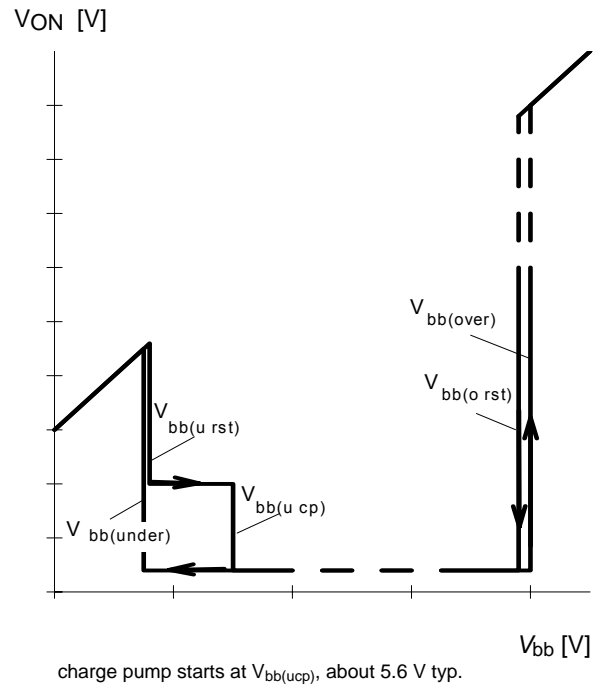
**Typ. on-state resistance (Vbb-Pin to Out-Pin)**
$R_{ON} = f(V_{bb}, I_L)$; $I_L$=0.5A, $T_j$ = 25°C

$R_{ON}$ [mΩ]



$V_{bb}$ [V]

**Terms**

2006-03-01

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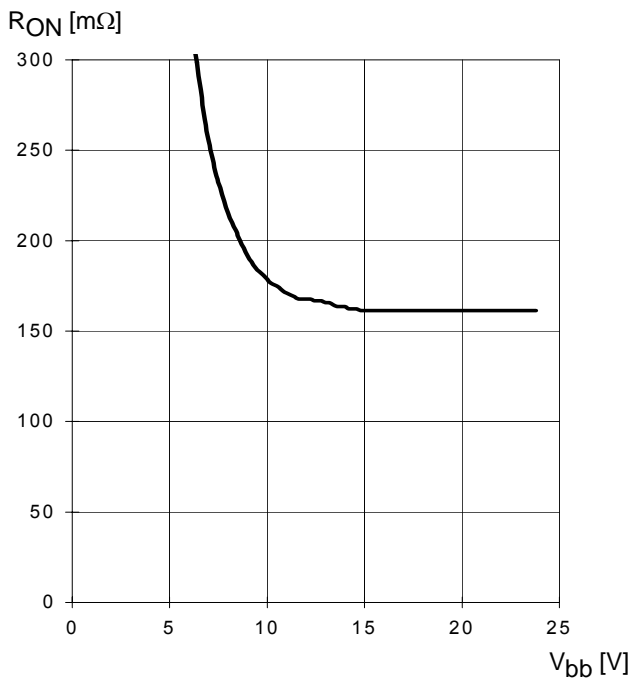
## Package:

all dimensions in mm.

PG-SOT 223:
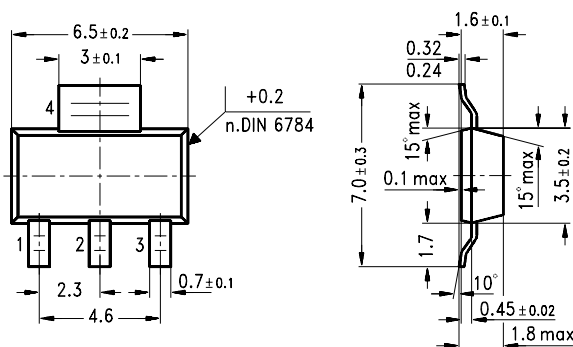


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