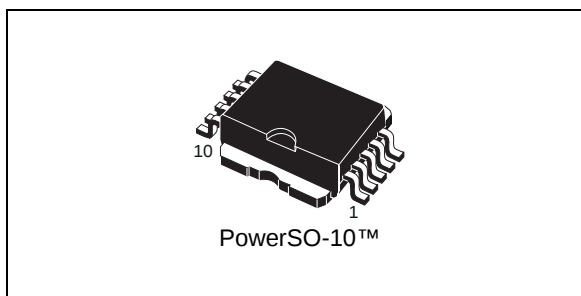


## Double channel high-side driver

### Features

| Type       | $R_{DS(on)}$ | $I_{lim}$ | $V_{CC}$ |
|------------|--------------|-----------|----------|
| VND600SP-E | 30 mΩ        | 25 A      | 36 V     |

- ECOPACK®: lead free and RoHS compliant
- Automotive Grade: compliance with AEC Guidelines
- Very low standby current
- CMOS compatible input
- Proportional load current sense
- Current sense disable
- Thermal shutdown protection and diagnosis
- Undervoltage shutdown
- Overvoltage clamp
- Load current limitation



### Description

The VND600SP-E is a monolithic device made using STMicroelectronics™ VIPower™ M0-3 technology. It is intended for driving resistive or inductive loads with one side connected to ground. Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes (see ISO7637 transient compatibility table).

This device has two channels in high-side configuration; each channel has an analog sense output on which the sensing current is proportional (according to a known ratio) to the corresponding load current.

Built-in thermal shutdown and outputs current limitation protect the chip from overtemperature and short circuit. Device turns-off in case of ground pin disconnections.

**Table 1. Device summary**

| Package     | Order codes |               |
|-------------|-------------|---------------|
|             | Tube        | Tape and reel |
| PowerSO-10™ | VND600SP-E  | VND600SPTR-E  |

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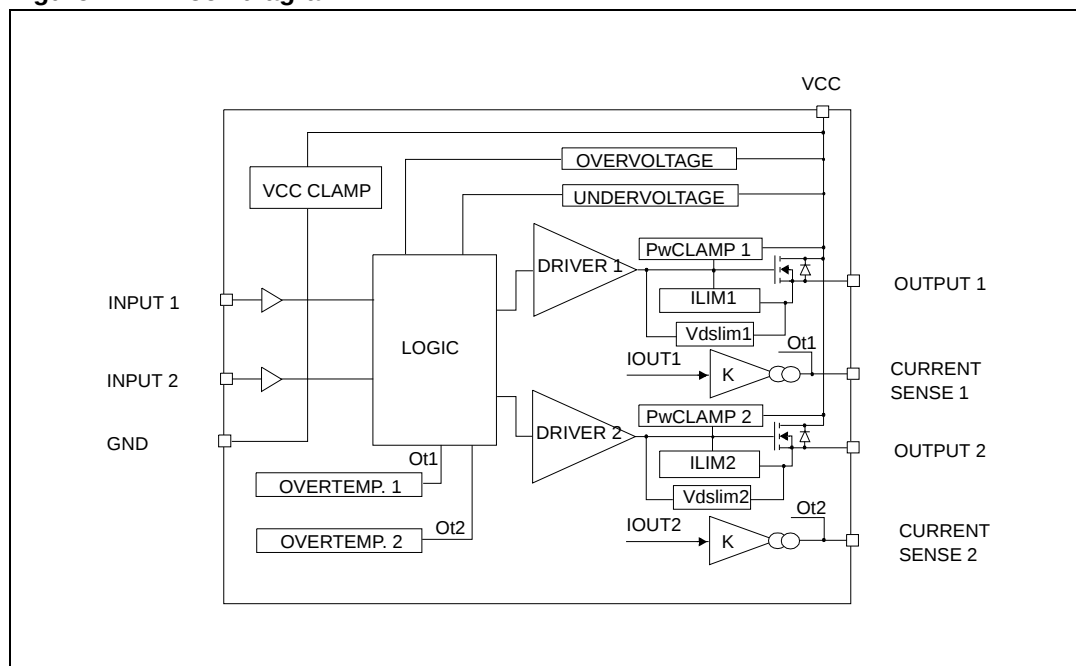
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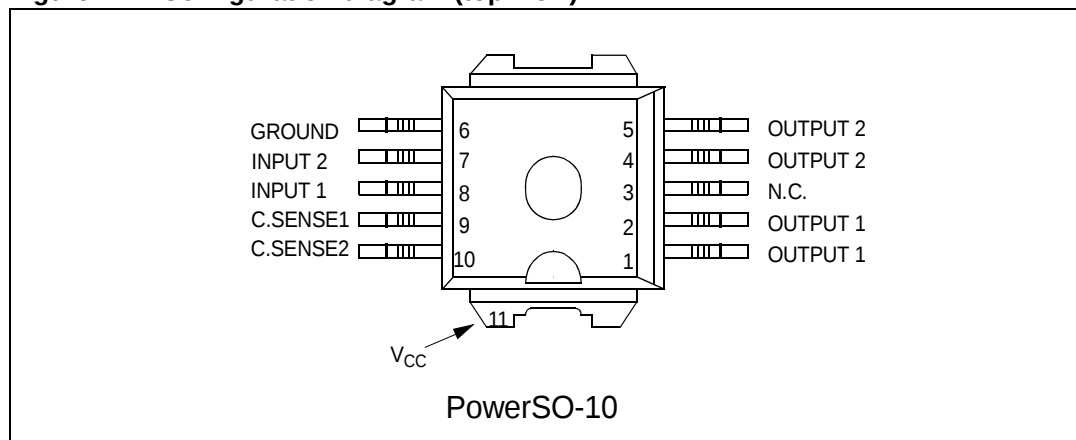
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## 1 Block diagram and pin description

**Figure 1. Block diagram**



**Figure 2. Configuration diagram (top view)**

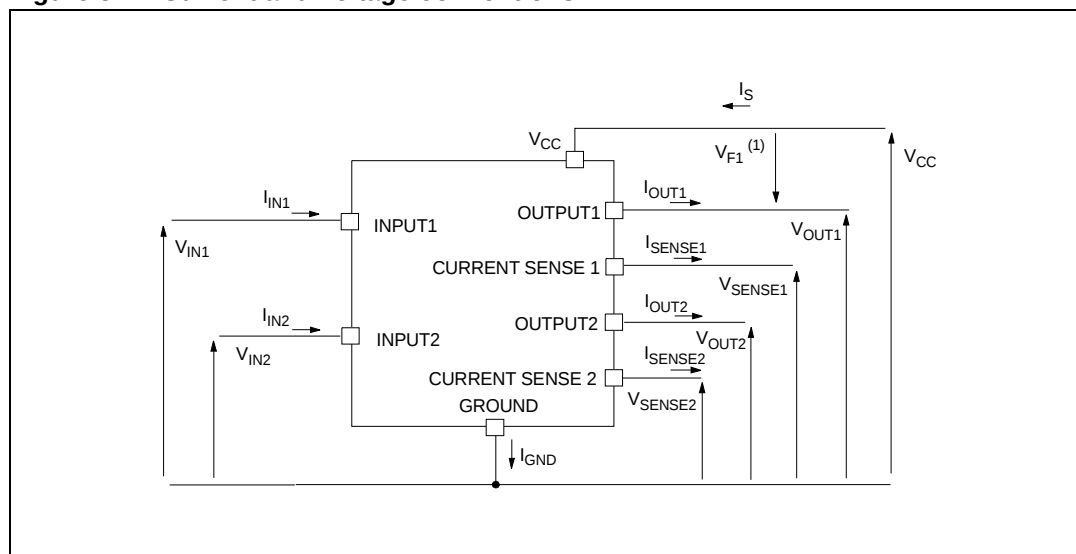


**Table 2. Suggested connections for unused and not connected pins**

| Connection / pin | Current sense                 | N.C. | Output | Input                          |
|------------------|-------------------------------|------|--------|--------------------------------|
| Floating         |                               | X    | X      | X                              |
| To ground        | Through 1 K $\Omega$ resistor | X    |        | Through 10 K $\Omega$ resistor |

## 2 Electrical specifications

**Figure 3. Current and voltage conventions**



1)  $V_{Fn} = V_{CCn} - V_{OUTn}$  during reverse battery condition

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 3](#) may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Refer also to the STMicroelectronics sure program and other relevant quality document.

**Table 3. Absolute maximum ratings**

| Symbol       | Parameter                     | Value              | Unit   |
|--------------|-------------------------------|--------------------|--------|
| $V_{CC}$     | DC supply voltage             | 41                 | V      |
| $-V_{CC}$    | Reverse supply voltage        | -0.3               | V      |
| $-I_{GND}$   | DC reverse ground pin current | -200               | mA     |
| $I_{OUT}$    | Output current                | Internally limited | A      |
| $I_R$        | Reverse output current        | -21                | A      |
| $I_{IN}$     | Input current                 | +/- 10             | mA     |
| $V_{CSENSE}$ | Current sense maximum voltage | -3<br>+15          | V<br>V |

**Table 3. Absolute maximum ratings (continued)**

| Symbol    | Parameter                                                                                                                                                                      | Value              | Unit             |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------|
| $V_{ESD}$ | Electrostatic discharge (Human Body Model:<br>$R = 1.5\text{ K}\Omega$ ; $C = 100\text{ pF}$ )                                                                                 |                    |                  |
|           | – INPUT                                                                                                                                                                        | 4000               | V                |
|           | – CURRENT SENSE                                                                                                                                                                | 2000               | V                |
|           | – OUTPUT                                                                                                                                                                       | 5000               | V                |
|           | – $V_{CC}$                                                                                                                                                                     | 5000               | V                |
| $E_{MAX}$ | Maximum switching energy<br>( $L = 0.13\text{ mH}$ ; $R_L = 0\text{ }\Omega$ ; $V_{bat} = 13.5\text{ V}$ ;<br>$T_{jstart} = 150\text{ }^\circ\text{C}$ ; $I_L = 40\text{ A}$ ) | 145                | mJ               |
| $P_{tot}$ | Power dissipation at $T_c = 25\text{ }^\circ\text{C}$                                                                                                                          | 96.1               | W                |
| $T_j$     | Junction operating temperature                                                                                                                                                 | Internally limited | $^\circ\text{C}$ |
| $T_c$     | Case operating temperature                                                                                                                                                     | -40 to 150         | $^\circ\text{C}$ |
| $T_{STG}$ | Storage temperature                                                                                                                                                            | -55 to 150         | $^\circ\text{C}$ |

## 2.2 Thermal data

**Table 4. Thermal data**

| Symbol         | Parameter                                 | Value               |                   | Unit               |
|----------------|-------------------------------------------|---------------------|-------------------|--------------------|
| $R_{thj-case}$ | Thermal resistance junction-case (max)    | 1.3                 |                   | $^\circ\text{C/W}$ |
| $R_{thj-amb}$  | Thermal resistance junction-ambient (max) | 51.3 <sup>(1)</sup> | 37 <sup>(2)</sup> | $^\circ\text{C/W}$ |

- When mounted on a standard single sided FR-4 board with  $0.5\text{ cm}^2$  of Cu (at least  $35\text{ }\mu\text{m}$  thick).
- When mounted on a standard single-sided FR-4 board with  $6\text{ cm}^2$  of Cu (at least  $35\text{ }\mu\text{m}$  thick).

## 2.3 Electrical characteristics

Values specified in this section are for  $8\text{ V} < V_{CC} < 36\text{ V}$ ;  $-40\text{ °C} < T_j < 150\text{ °C}$ , unless otherwise stated. (Per each channel).

**Table 5. Power**

| Symbol            | Parameter                | Test conditions                                                                                                    | Min. | Typ. | Max. | Unit |
|-------------------|--------------------------|--------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| $V_{CC}^{(1)}$    | Operating supply voltage |                                                                                                                    | 5.5  | 13   | 36   | V    |
| $V_{USD}^{(1)}$   | Undervoltage shutdown    |                                                                                                                    | 3    | 4    | 5.5  | V    |
| $V_{OV}^{(1)(2)}$ | Overvoltage shutdown     |                                                                                                                    | 36   |      |      | V    |
| $R_{ON}$          | On-state resistance      | $I_{OUT} = 5\text{ A}$ ; $T_j = 25\text{ °C}$                                                                      |      |      | 30   | mΩ   |
|                   |                          | $I_{OUT} = 5\text{ A}$ ; $T_j = 150\text{ °C}$                                                                     |      |      | 60   | mΩ   |
|                   |                          | $I_{OUT} = 3\text{ A}$ ; $V_{CC} = 6\text{ V}$                                                                     |      |      | 100  | mΩ   |
| $V_{clamp}$       | Clamp voltage            | $I_{CC} = 20\text{ mA}^{(2)}$                                                                                      | 41   | 48   | 55   | V    |
| $I_S^{(1)}$       | Supply current           | Off-state; $V_{CC} = 13\text{ V}$ ;<br>$V_{IN} = V_{OUT} = 0\text{ V}$                                             |      | 12   | 40   | μA   |
|                   |                          | Off-state; $V_{CC} = 13\text{ V}$ ;<br>$V_{IN} = V_{OUT} = 0\text{ V}$ ; $T_j = 25\text{ °C}$                      |      | 12   | 25   | mA   |
|                   |                          | On-state; $V_{IN} = 5\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$I_{OUT} = 0\text{ A}$ ; $R_{SENSE} = 3.9\text{ kΩ}$ |      |      | 6    | mA   |
| $I_{L(off1)}$     | Off-state output current | $V_{IN} = V_{OUT} = 0\text{ V}$                                                                                    | 0    |      | 50   | μA   |
| $I_{L(off2)}$     | Off-state output current | $V_{IN} = 0\text{ V}$ ; $V_{OUT} = 3.5\text{ V}$                                                                   | -75  |      | 0    | μA   |
| $I_{L(off3)}$     | Off-state output current | $V_{IN} = V_{OUT} = 0\text{ V}$ ;<br>$V_{CC} = 13\text{ V}$ ; $T_j = 125\text{ °C}$                                |      |      | 5    | μA   |
| $I_{L(off4)}$     | Off-state output current | $V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$T_j = 25\text{ °C}$                                 |      |      | 3    | μA   |

1. Per device.

2.  $V_{clamp}$  and  $V_{OV}$  are correlated. Typical difference is 5 V.

**Table 6. Protection<sup>(1)</sup>**

| Symbol     | Parameter                    | Test conditions                       | Min. | Typ. | Max. | Unit |
|------------|------------------------------|---------------------------------------|------|------|------|------|
| $I_{lim}$  | DC short circuit current     | $V_{CC} = 13\text{ V}$                | 25   | 40   | 70   | A    |
|            |                              | $5.5\text{ V} < V_{CC} < 36\text{ V}$ |      |      | 70   | A    |
| $T_{TSD}$  | Thermal shutdown temperature |                                       | 150  | 175  | 200  | °C   |
| $T_R$      | Thermal reset temperature    |                                       | 135  |      |      | °C   |
| $T_{HYST}$ | Thermal hysteresis           |                                       | 7    | 15   |      | °C   |

**Table 6. Protection<sup>(1)</sup> (continued)**

| Symbol             | Parameter                      | Test conditions                                                                        | Min.                 | Typ.                 | Max.                 | Unit |
|--------------------|--------------------------------|----------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|------|
| $V_{\text{demag}}$ | Turn-off output voltage clamp  | $I_{\text{OUT}} = 2 \text{ A}$ ; $V_{\text{IN}} = 0 \text{ V}$ ;<br>$L = 6 \text{ mH}$ | $V_{\text{CC}} - 41$ | $V_{\text{CC}} - 48$ | $V_{\text{CC}} - 55$ | V    |
| $V_{\text{ON}}$    | Output voltage drop limitation | $I_{\text{OUT}} = 0.5 \text{ A}$<br>$T_j = -40^\circ\text{C} \dots +150^\circ\text{C}$ |                      | 50                   |                      | mV   |

1. To ensure long term reliability under heavy overload or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device is subjected to abnormal conditions, this software must limit the duration and number of activation cycles

**Table 7.  $V_{\text{CC}}$  - output diode**

| Symbol | Parameter          | Test conditions                                               | Min | Typ | Max | Unit |
|--------|--------------------|---------------------------------------------------------------|-----|-----|-----|------|
| $V_F$  | Forward on voltage | $-I_{\text{OUT}} = 2.6 \text{ A}$ ; $T_j = 150^\circ\text{C}$ | -   | -   | 0.6 | V    |

**Table 8. Current sense  $9 \text{ V} \leq V_{\text{CC}} \leq 16 \text{ V}$** 

| Symbol                | Parameter                                                | Test conditions                                                                                                                                                                                  | Min          | Typ          | Max          | Unit |
|-----------------------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|--------------|------|
| $K_1$                 | $I_{\text{OUT}}/I_{\text{SENSE}}$                        | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 0.5 \text{ A}$ ;<br>$V_{\text{SENSE}} = 0.5 \text{ V}$ ; other channels open;<br>$T_j = -40^\circ\text{C} \dots 150^\circ\text{C}$                       | 3300         | 4400         | 6000         |      |
| $dK_1/K_1$            | Current sense ratio drift                                | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 0.5 \text{ A}$ ;<br>$V_{\text{SENSE}} = 0.5 \text{ V}$ ; other channels open;<br>$T_j = -40^\circ\text{C} \dots 150^\circ\text{C}$                       | -10          |              | +10          | %    |
| $K_2$                 | $I_{\text{OUT}}/I_{\text{SENSE}}$                        | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 5 \text{ A}$ ; $V_{\text{SENSE}} = 4 \text{ V}$ ;<br>other channels open; $T_j = -40^\circ\text{C}$<br>$T_j = 25^\circ\text{C} \dots 150^\circ\text{C}$  | 4200<br>4400 | 4900<br>4900 | 6000<br>5750 |      |
| $dK_2/K_2$            | Current sense ratio drift                                | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 5 \text{ A}$ ; $V_{\text{SENSE}} = 4 \text{ V}$ ;<br>other channels open;<br>$T_j = -40^\circ\text{C} \dots 150^\circ\text{C}$                           | -6           |              | +6           | %    |
| $K_3$                 | $I_{\text{OUT}}/I_{\text{SENSE}}$                        | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 15 \text{ A}$ ; $V_{\text{SENSE}} = 4 \text{ V}$ ;<br>other channels open; $T_j = -40^\circ\text{C}$<br>$T_j = 25^\circ\text{C} \dots 150^\circ\text{C}$ | 4200<br>4400 | 4900<br>4900 | 5500<br>5250 |      |
| $dK_3/K_3$            | Current sense ratio drift                                | $I_{\text{OUT1}}$ or $I_{\text{OUT2}} = 15 \text{ A}$ ; $V_{\text{SENSE}} = 4 \text{ V}$ ;<br>other channels open;<br>$T_j = -40^\circ\text{C} \dots 150^\circ\text{C}$                          | -6           |              | +6           | %    |
| $V_{\text{SENSE1,2}}$ | Max analog sense output voltage                          | $V_{\text{CC}} = 5.5 \text{ V}$ ; $I_{\text{OUT1,2}} = 2.5 \text{ A}$ ;<br>$R_{\text{SENSE}} = 10 \text{ k}\Omega$                                                                               | 2            |              |              | V    |
|                       |                                                          | $V_{\text{CC}} > 8 \text{ V}$ ; $I_{\text{OUT1,2}} = 5 \text{ A}$ ;<br>$R_{\text{SENSE}} = 10 \text{ k}\Omega$                                                                                   | 4            |              |              | V    |
| $V_{\text{SENSEH}}$   | Analog sense output voltage in overtemperature condition | $V_{\text{CC}} = 13 \text{ V}$ ; $R_{\text{SENSE}} = 3.9 \text{ k}\Omega$                                                                                                                        |              | 5.5          |              | V    |

**Table 8. Current sense 9 V ≤ V<sub>CC</sub> ≤ 16 V (continued)**

| Symbol               | Parameter                                                  | Test conditions                                                                  | Min | Typ | Max | Unit |
|----------------------|------------------------------------------------------------|----------------------------------------------------------------------------------|-----|-----|-----|------|
| R <sub>VSENSEH</sub> | Analog sense output impedance in overtemperature condition | V <sub>CC</sub> = 13 V; T <sub>j</sub> > T <sub>TSD</sub> ;<br>All channels open |     | 400 |     | Ω    |
| t <sub>DSENSE</sub>  | Current sense delay response                               | to 90% I <sub>SENSE</sub> <sup>(1)</sup>                                         |     |     | 500 | μs   |

1. Current sense signal delay after positive input slope.

**Table 9. Switching (V<sub>CC</sub> = 13 V)**

| Symbol                                 | Parameter              | Test conditions                                        | Min | Typ                       | Max | Unit |
|----------------------------------------|------------------------|--------------------------------------------------------|-----|---------------------------|-----|------|
| t <sub>d(on)</sub>                     | Turn-on delay time     | R <sub>L</sub> = 2.6 Ω (see <a href="#">Figure 4</a> ) | -   | 30                        | -   | μs   |
| t <sub>d(off)</sub>                    | Turn-on delay time     | R <sub>L</sub> = 2.6 Ω (see <a href="#">Figure 4</a> ) | -   | 30                        | -   | μs   |
| (dV <sub>OUT</sub> /dt) <sub>on</sub>  | Turn-on voltage slope  | R <sub>L</sub> = 2.6 Ω (see <a href="#">Figure 4</a> ) | -   | <a href="#">Figure 15</a> | -   | V/μs |
| (dV <sub>OUT</sub> /dt) <sub>off</sub> | Turn-off voltage slope | R <sub>L</sub> = 2.6 Ω (see <a href="#">Figure 4</a> ) | -   | <a href="#">Figure 16</a> | -   | V/μs |

**Table 10. Logic input (channel 1, 2)**

| Symbol               | Parameter                | Test conditions          | Min  | Typ  | Max  | Unit |
|----------------------|--------------------------|--------------------------|------|------|------|------|
| V <sub>IL</sub>      | Input low level voltage  |                          |      |      | 1.25 | V    |
| I <sub>IL</sub>      | Low level input current  | V <sub>IN</sub> = 1.25 V | 1    |      |      | μA   |
| V <sub>IH</sub>      | Input high level voltage |                          | 3.25 |      |      | V    |
| I <sub>IH</sub>      | High level input current | V <sub>IN</sub> = 3.25 V |      |      | 10   | μA   |
| V <sub>I(hyst)</sub> | Input hysteresis voltage |                          | 0.5  |      |      | V    |
| V <sub>ICL</sub>     | Input clamp voltage      | I <sub>IN</sub> = 1 mA   | 6    | 6.8  | 8    | V    |
|                      |                          | I <sub>IN</sub> = -1 mA  |      | -0.7 |      | V    |

Figure 4. Switching characteristics (resistive load  $R_L = 2.6 \Omega$ )

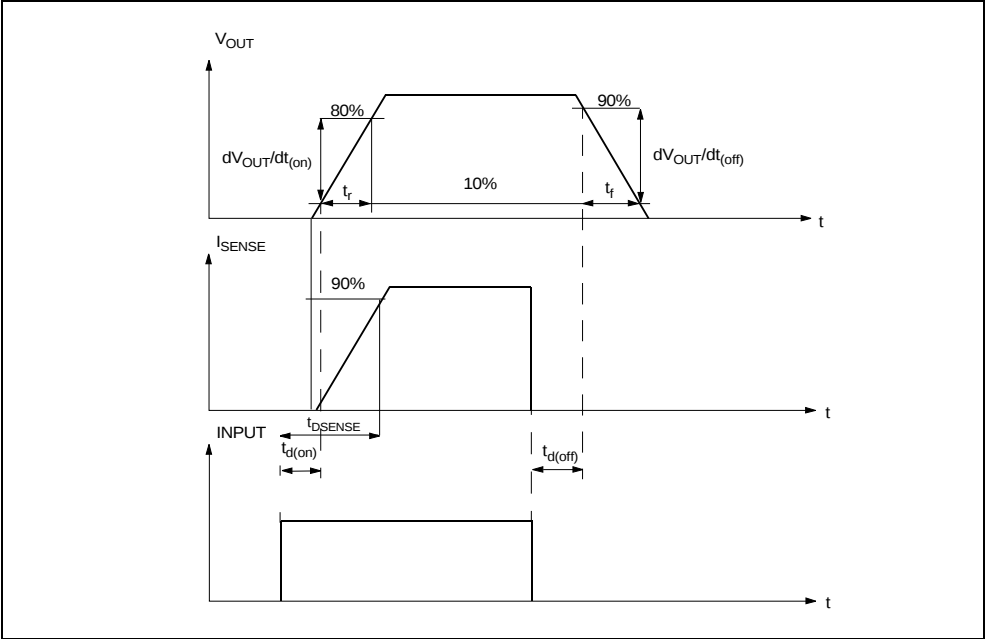
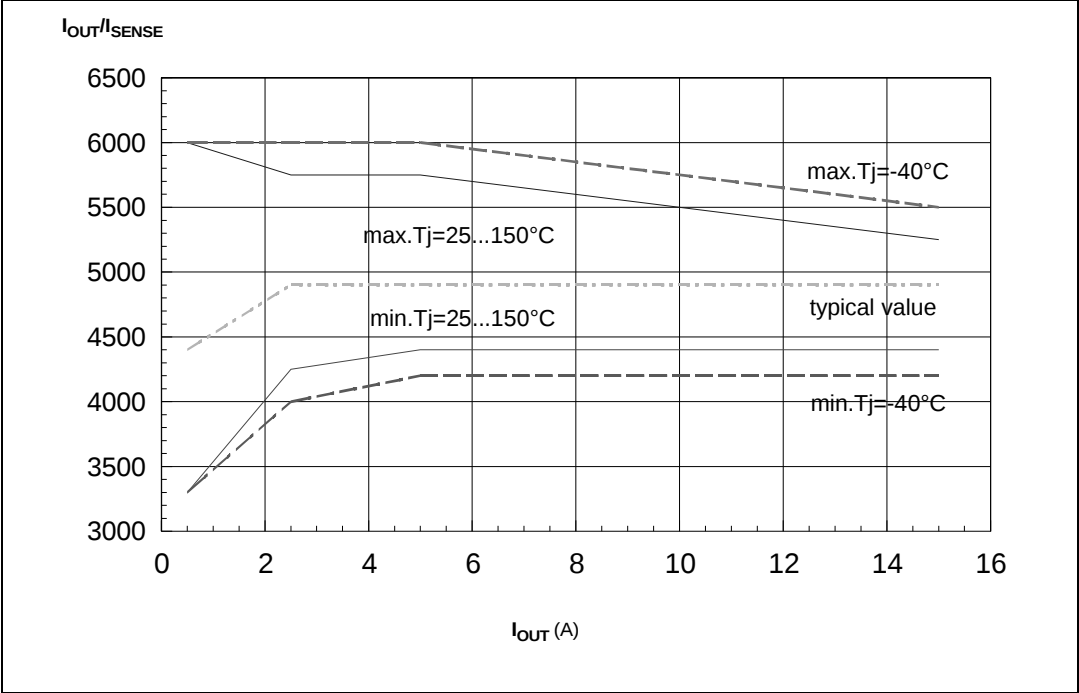


Figure 5.  $I_{OUT}/I_{SENSE}$  versus  $I_{OUT}$



**Table 11. Truth table (per each channel)**

| Conditions                    | Input | Output | Sense                          |
|-------------------------------|-------|--------|--------------------------------|
| Normal operation              | L     | L      | 0                              |
|                               | H     | H      | Nominal                        |
| Overtemperature               | L     | L      | 0                              |
|                               | H     | L      | $V_{SENSEH}$                   |
| Undervoltage                  | L     | L      | 0                              |
|                               | H     | L      | 0                              |
| Overvoltage                   | L     | L      | 0                              |
|                               | H     | L      | 0                              |
| Short circuit to GND          | L     | L      | 0                              |
|                               | H     | L      | $(T_J < T_{TSD})$ 0            |
|                               | H     | L      | $(T_J > T_{TSD})$ $V_{SENSEH}$ |
| Short circuit to $V_{CC}$     | L     | H      | 0                              |
|                               | H     | H      | < Nominal                      |
| Negative output voltage clamp | L     | L      | 0                              |

**Table 12. Electrical transient requirements on V<sub>CC</sub> pin (part 1)**

| ISO T/R 7637/1<br>test pulse | Test levels |         |         |         | Delays and<br>impedance  |
|------------------------------|-------------|---------|---------|---------|--------------------------|
|                              | I           | II      | III     | IV      |                          |
| 1                            | -25 V       | -50 V   | -75 V   | -100 V  | 2 ms, 10 $\Omega$        |
| 2                            | +25 V       | +50 V   | +75 V   | +100 V  | 0.2 ms, 10 $\Omega$      |
| 3a                           | -25 V       | -50 V   | -100 V  | -150 V  | 0.1 $\mu$ s, 50 $\Omega$ |
| 3b                           | +25 V       | +50 V   | +75 V   | +100 V  | 0.1 $\mu$ s, 50 $\Omega$ |
| 4                            | -4 V        | -5 V    | -6 V    | -7 V    | 100 ms, 0.01 $\Omega$    |
| 5                            | +26.5 V     | +46.5 V | +66.5 V | +86.5 V | 400 ms, 2 $\Omega$       |

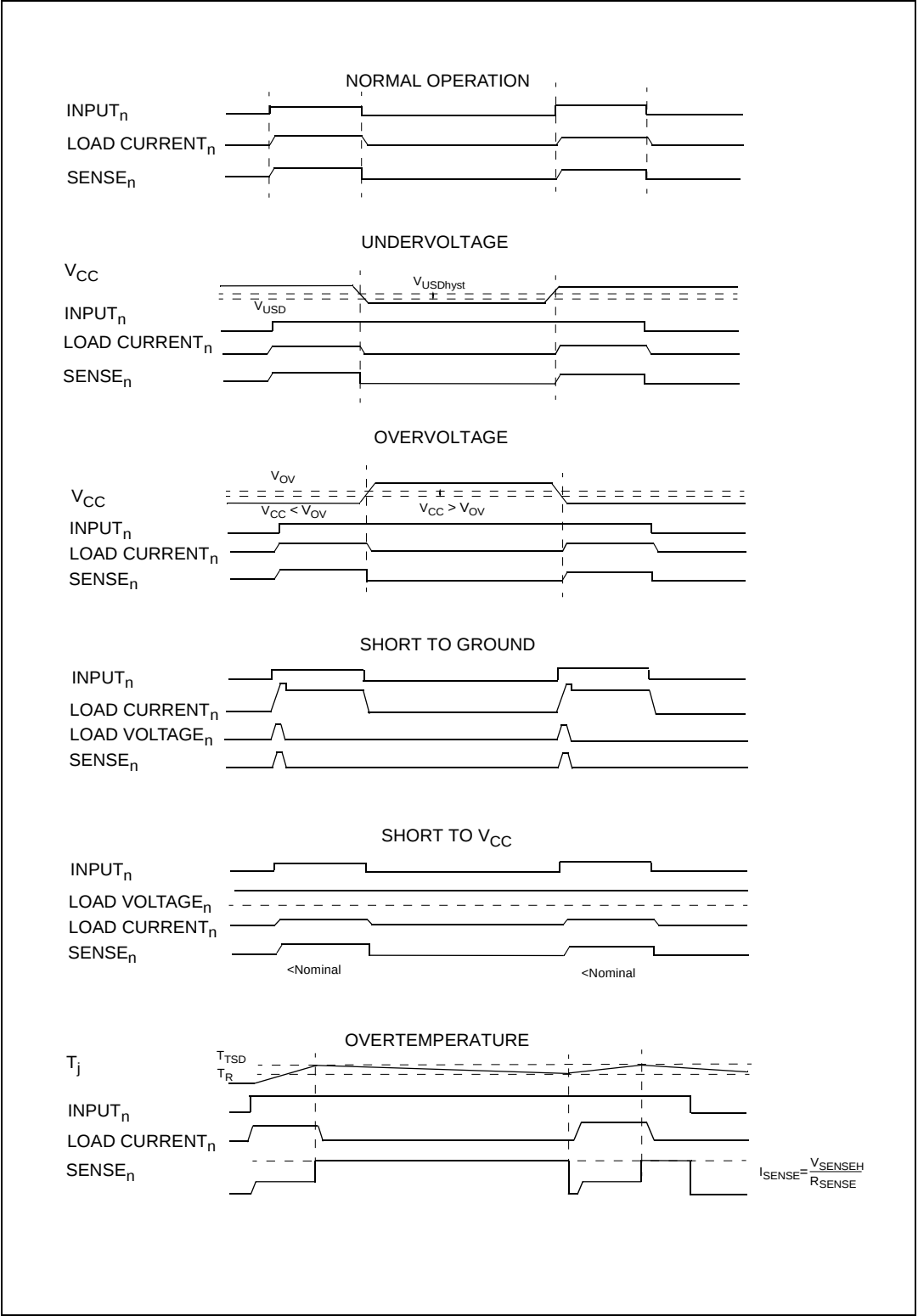
**Table 13. Electrical transient requirements on V<sub>CC</sub> pin (part 2)**

| ISO T/R 7637/1<br>Test pulse | Test levels results |    |     |    |
|------------------------------|---------------------|----|-----|----|
|                              | I                   | II | III | IV |
| 1                            | C                   | C  | C   | C  |
| 2                            | C                   | C  | C   | C  |
| 3a                           | C                   | C  | C   | C  |
| 3b                           | C                   | C  | C   | C  |
| 4                            | C                   | C  | C   | C  |
| 5                            | C                   | E  | E   | E  |

**Table 14. Electrical transient requirements on V<sub>CC</sub> pin (part 3)**

| Class | Contents                                                                                                                                                                |
|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C     | All functions of the device are performed as designed after exposure to disturbance.                                                                                    |
| E     | One or more functions of the device is not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device. |

Figure 6. Waveforms



## 2.4 Electrical characteristics curves

Figure 7. Off-state output current

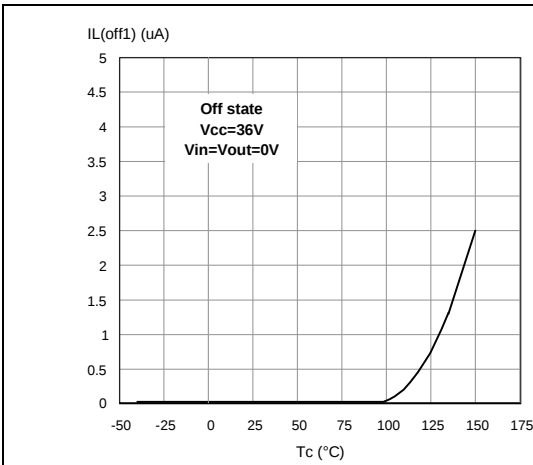


Figure 8. High level input current

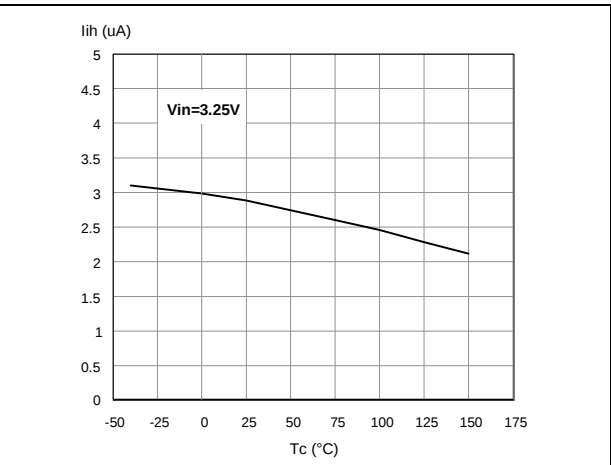


Figure 9. Input low level

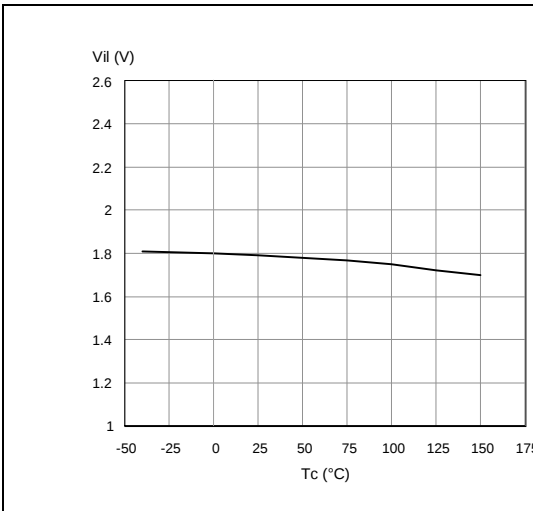


Figure 10. Input high level

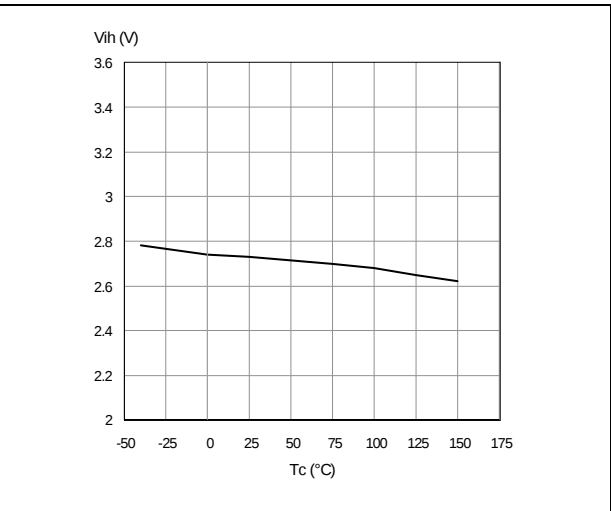


Figure 11. Input clamp voltage

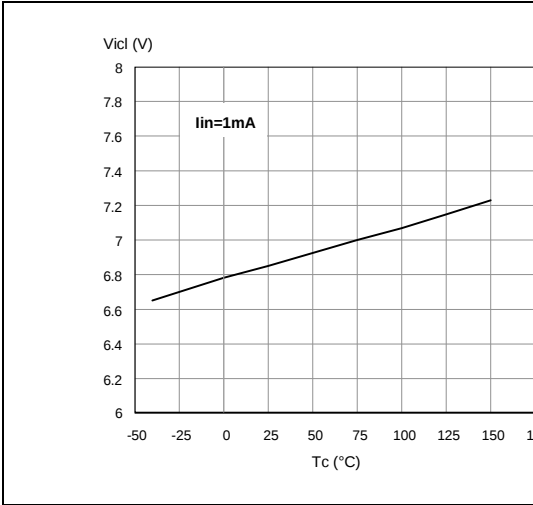


Figure 12. Input hysteresis voltage

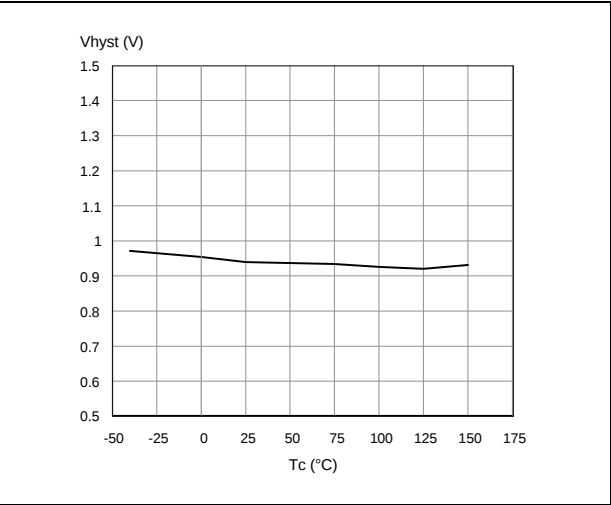


Figure 13. Overvoltage shutdown

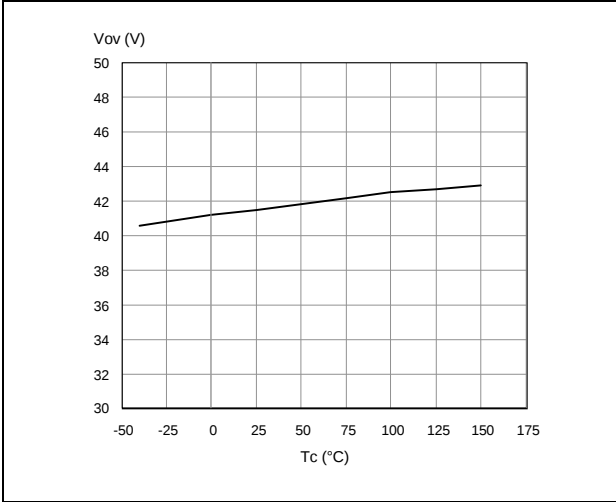


Figure 14.  $I_{LIM}$  vs  $T_{case}$

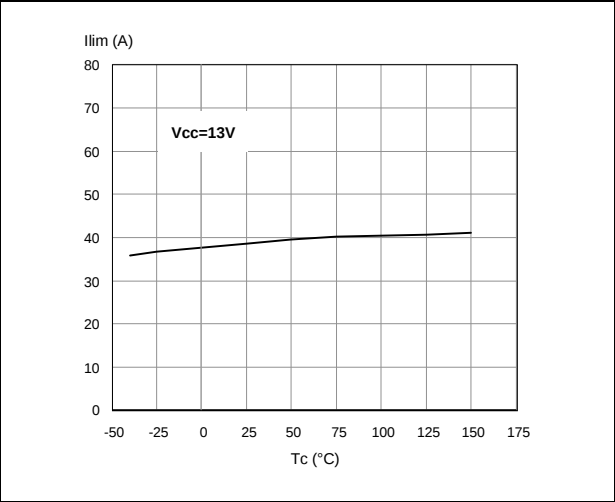


Figure 15. Turn-on voltage slope

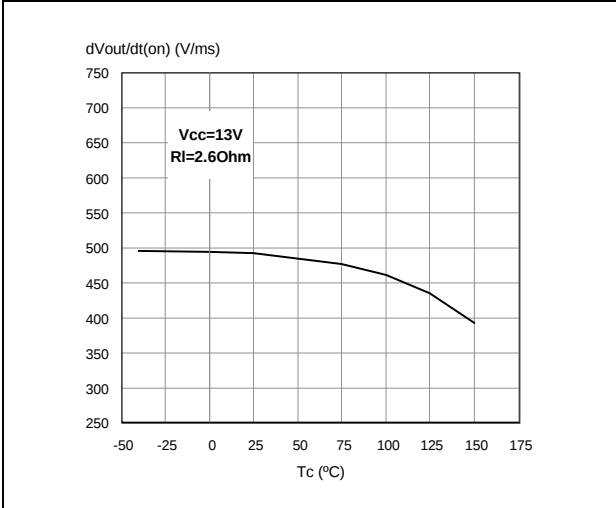


Figure 16. Turn-off voltage slope

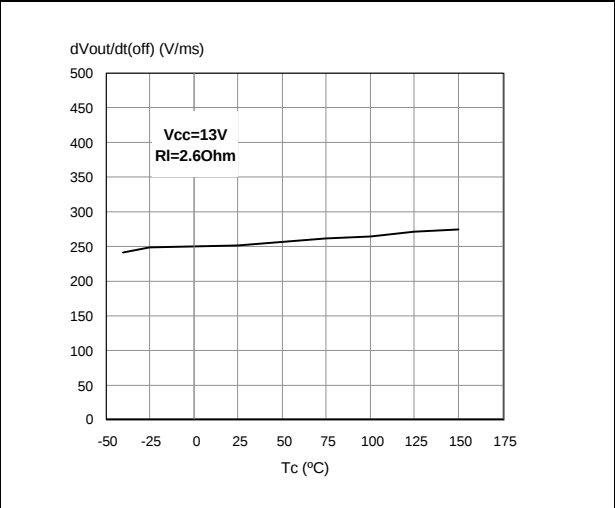


Figure 17. On-state resistance vs  $T_{case}$

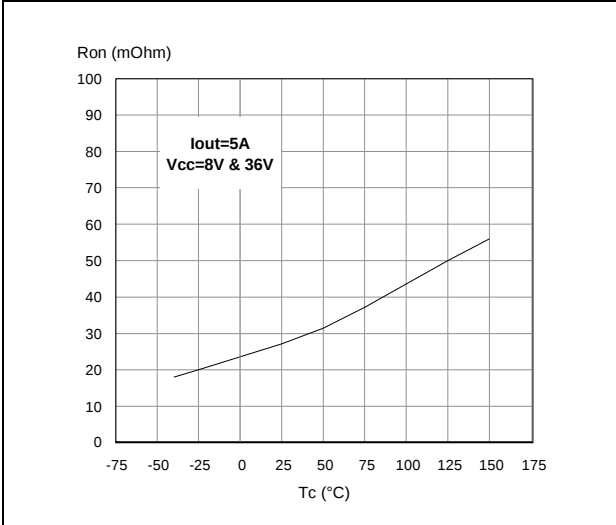
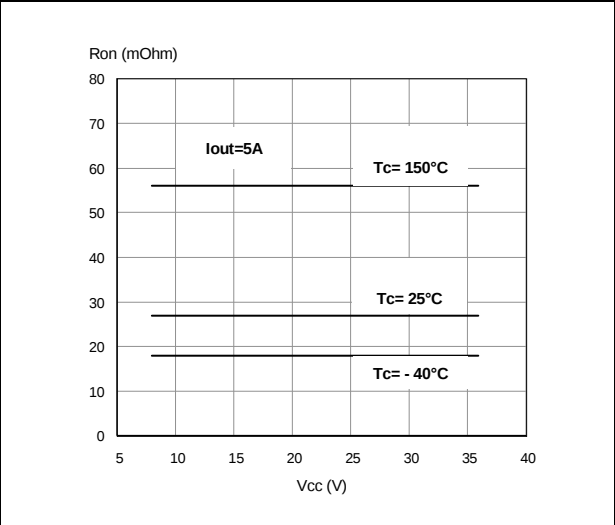
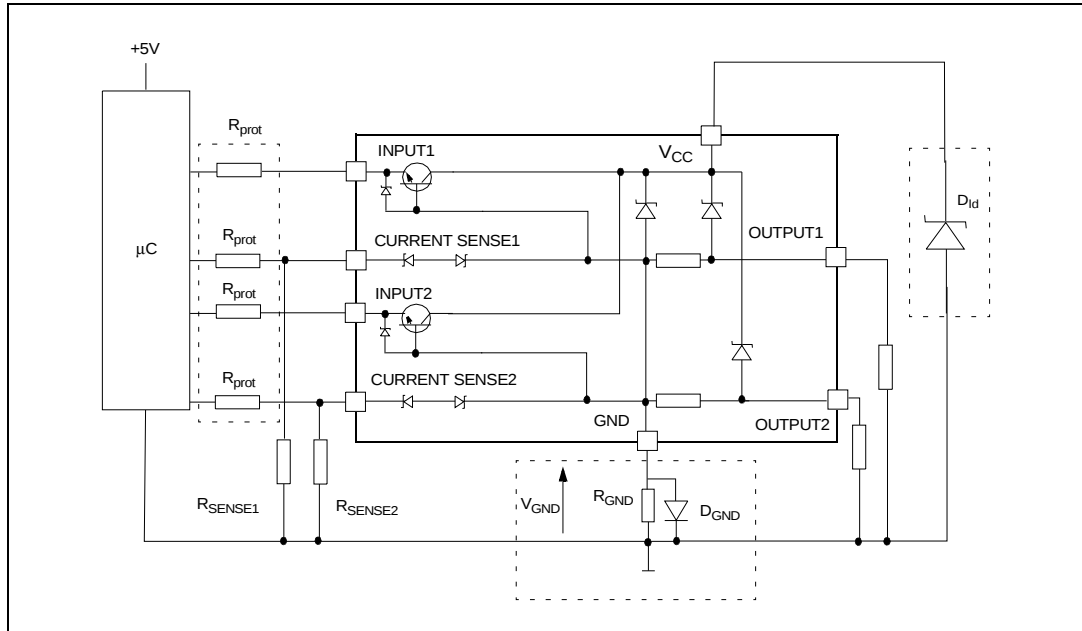


Figure 18. On-state resistance vs  $V_{CC}$



### 3 Application information

Figure 19. Application schematic



#### 3.1 GND protection network against reverse battery

##### 3.1.1 Solution 1: resistor in the ground line ( $R_{GND}$ only)

This can be used with any type of load.

The following is an indication on how to dimension the  $R_{GND}$  resistor.

1.  $R_{GND} \leq 600 \text{ mV} / I_{S(on)max}$
2.  $R_{GND} \geq (-V_{CC}) / (-I_{GND})$

where  $-I_{GND}$  is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device's datasheet.

Power dissipation in  $R_{GND}$  (when  $V_{CC} < 0$ : during reverse battery situations) is:

$$P_D = (-V_{CC})^2 / R_{GND}$$

This resistor can be shared amongst several different HSDs. Please note that the value of this resistor should be calculated with formula (1) where  $I_{S(on)max}$  becomes the sum of the maximum on-state currents of the different devices.

Please note that if the microprocessor ground is not shared by the device ground then the  $R_{GND}$  produces a shift ( $I_{S(on)max} * R_{GND}$ ) in the input thresholds and the status output values. This shift varies depending on how many devices are ON in the case of several high-side drivers sharing the same  $R_{GND}$ .

If the calculated power dissipation leads to a large resistor or several devices have to share the same resistor then ST suggests to utilize solution 2 (see [Section 3.1.2](#)).

### 3.1.2 Solution 2: diode ( $D_{GND}$ ) in the ground line

A resistor ( $R_{GND} = 1\text{ k}\Omega$ ) should be inserted in parallel to  $D_{GND}$  if the device drives an inductive load.

This small signal diode can be safely shared amongst several different HSDs. Also in this case, the presence of the ground network produces a shift ( $\sim 600\text{ mV}$ ) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift does not vary if more than one HSD shares the same diode/resistor network.

Series resistor in INPUT and STATUS lines are also required to prevent that, during battery voltage transient, the current exceeds the absolute maximum rating.

Safest configuration for unused INPUT and STATUS pin is to leave them unconnected, while unused SENSE pin has to be connected to ground pin.

## 3.2 Load dump protection

$D_{ld}$  is necessary (Voltage Transient Suppressor) if the load dump peak voltage exceeds the  $V_{CC}$  max DC rating. The same applies if the device is subject to transients on the  $V_{CC}$  line that are greater than the ones shown in [Table 12](#).

## 3.3 MCU I/Os protection

If a ground protection network is used and negative transient are present on the  $V_{CC}$  line, the control pins are pulled negative. ST suggests to insert a resistor ( $R_{prot}$ ) in line to prevent the microcontroller I/Os pins to latch-up.

The value of these resistors is a compromise between the leakage current of microcontroller and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of microcontroller I/Os.

$$-V_{CCpeak}/I_{latchup} \leq R_{prot} \leq (V_{OH\mu C} - V_{IH} - V_{GND}) / I_{IHmax}$$

Calculation example:

For  $V_{CCpeak} = -100\text{ V}$  and  $I_{latchup} \geq 20\text{ mA}$ ;  $V_{OH\mu C} \geq 4.5\text{ V}$

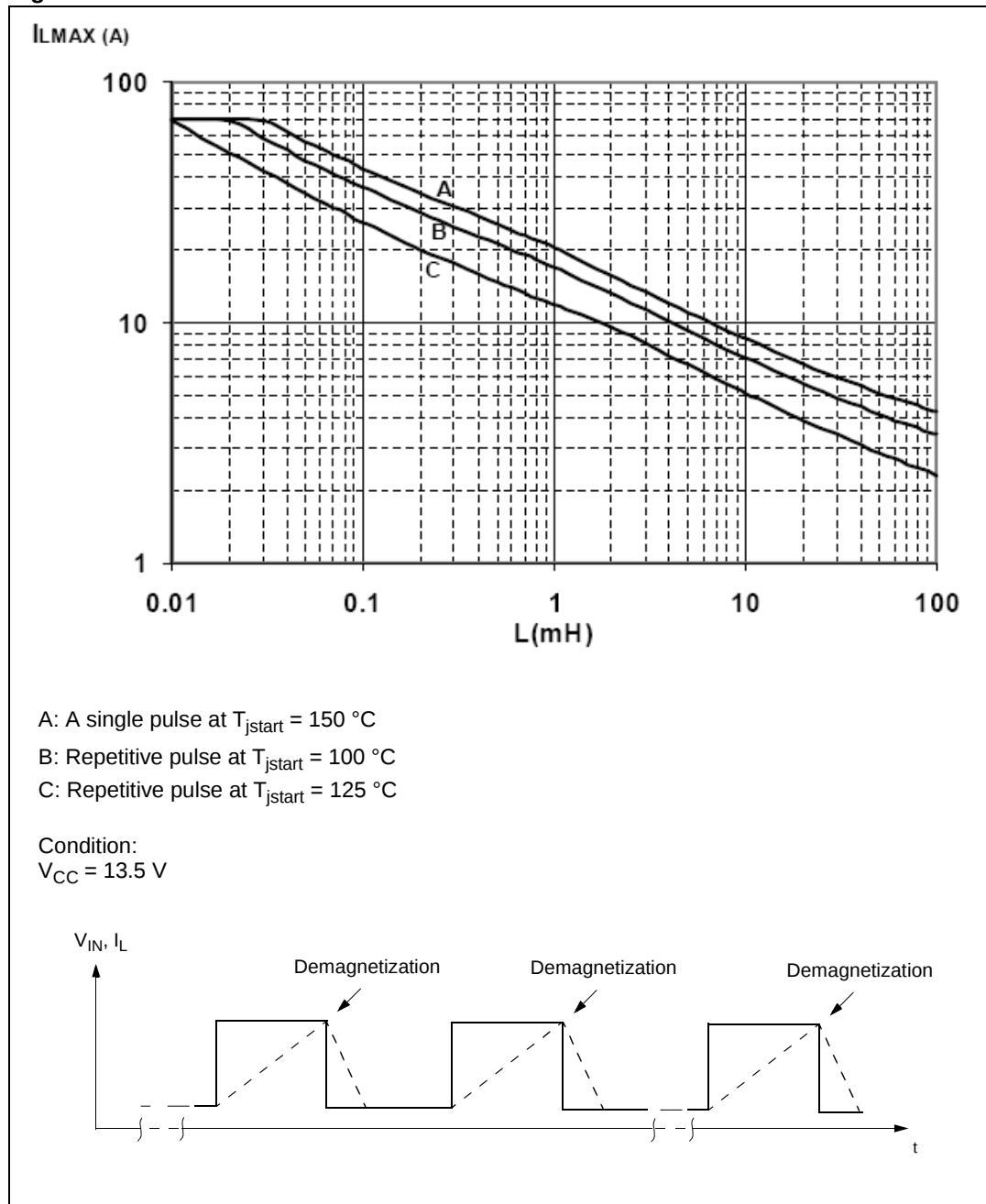
$$5\text{ k}\Omega \leq R_{prot} \leq 65\text{ k}\Omega.$$

Recommended values:

$$R_{prot} = 10\text{ k}\Omega.$$

### 3.4 PowerSO-10 maximum demagnetization energy ( $V_{CC} = 13.5\text{ V}$ )

Figure 20. Maximum turn-off current versus load inductance<sup>(1)</sup>

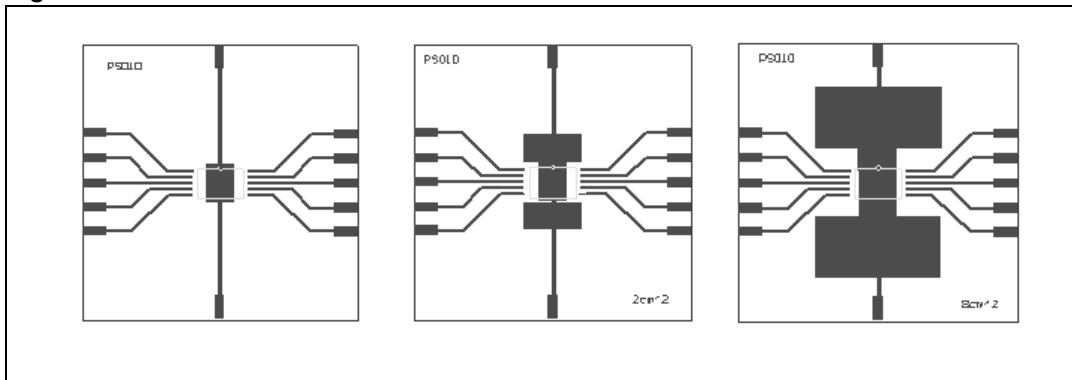


1. Values are generated with  $R_L = 0\text{ }\Omega$   
 In case of repetitive pulses,  $T_{jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves B and C.

## 4 Package and PCB thermal data

### 4.1 PowerSO-10 thermal data

Figure 21. PowerSO-10 PC board<sup>(1)</sup>



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area= 58 mm x 58 mm, PCB thickness=2 mm, Cu thickness = 35  $\mu$ m, Copper areas: from minimum pad lay-out to 8 cm<sup>2</sup>).

Figure 22.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

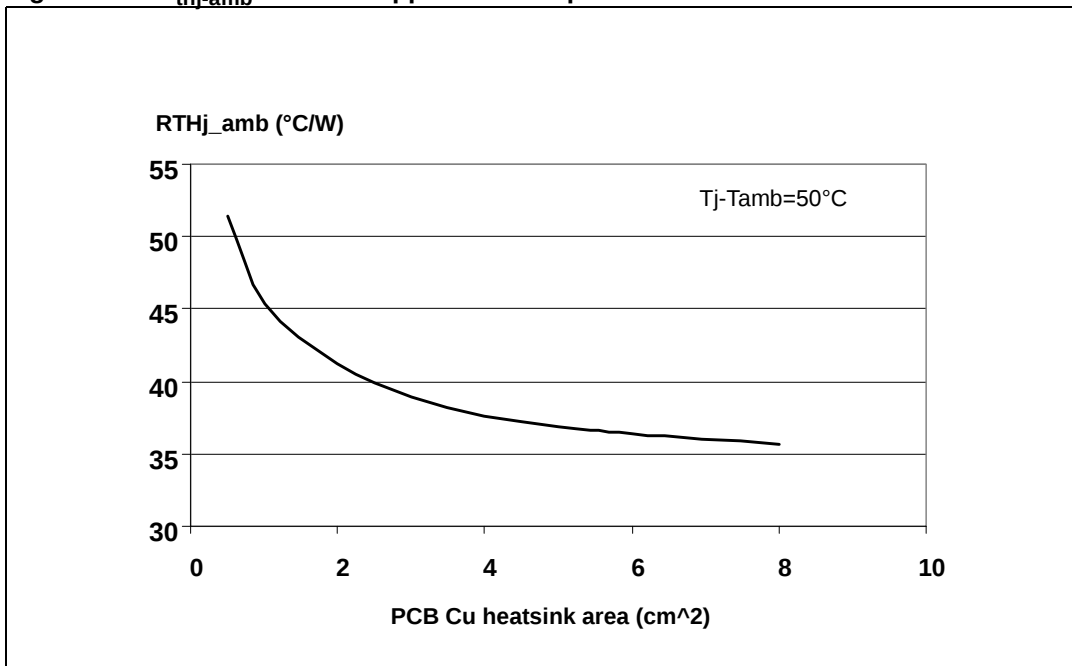
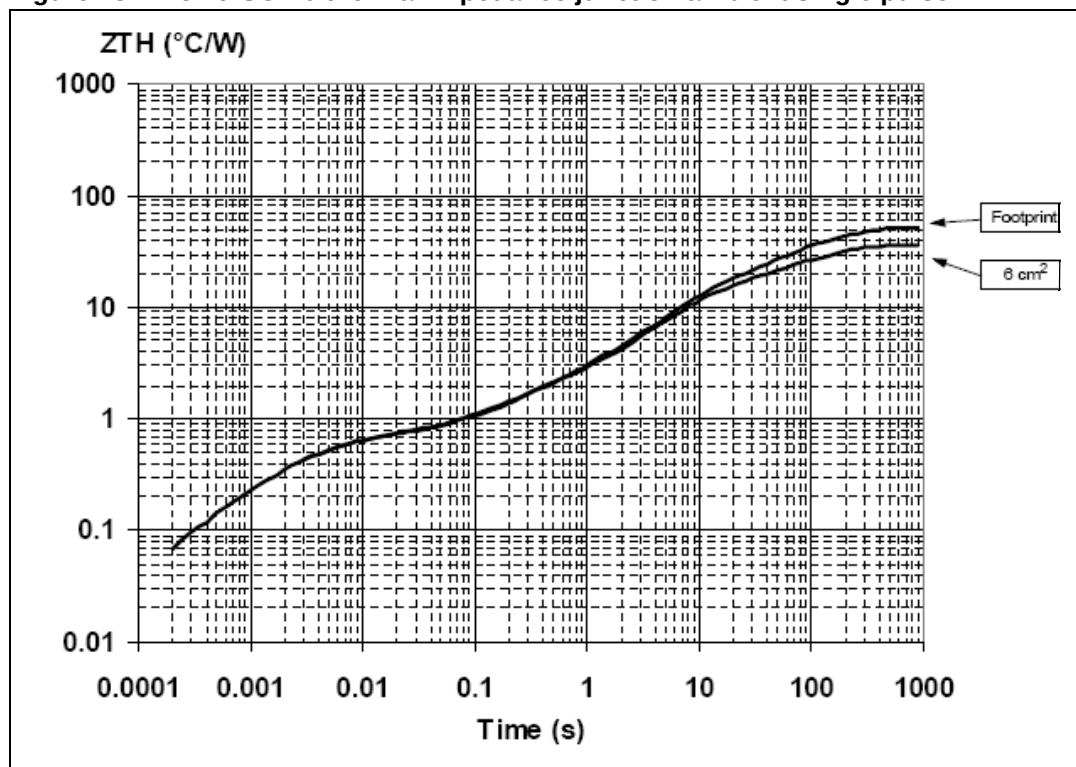


Figure 23. PowerSO-10 thermal impedance junction ambient single pulse



Equation 1: pulse calculation formula

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

$$\text{where } \delta = t_p / T$$

Figure 24. Thermal fitting model of a double channel HSD in PowerSO-10

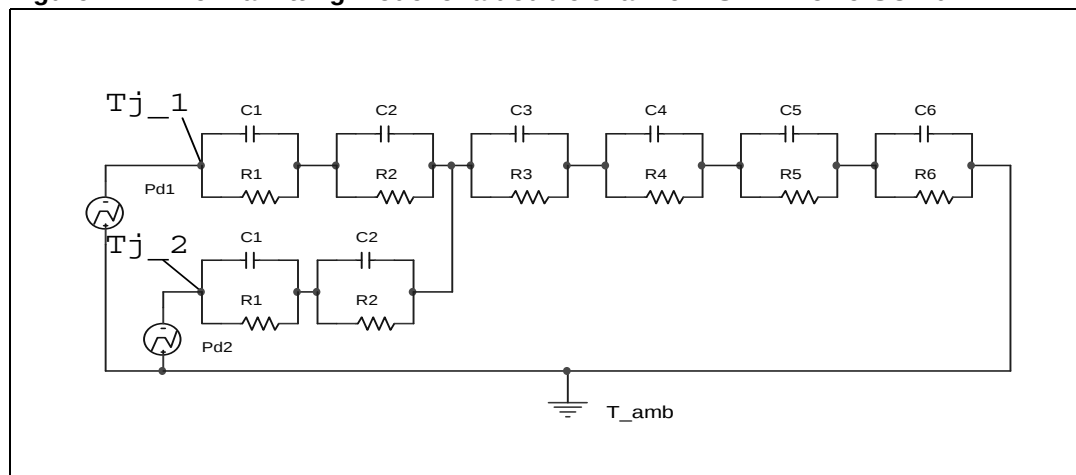


Table 15. Thermal parameter

| Area/island (cm <sup>2</sup> ) | Footprint | 6  |
|--------------------------------|-----------|----|
| R1 (°C/ W)                     | 0.05      |    |
| R2 (°C/ W)                     | 0.3       |    |
| R3 (°C/ W)                     | 0.3       |    |
| R4 (°C/ W)                     | 0.8       |    |
| R5 (°C/ W)                     | 12        |    |
| R6 (°C/ W)                     | 37        | 22 |
| C1 (W.s/ °C)                   | 0.001     |    |
| C2 (W.s /°C)                   | 5.00E-03  |    |
| C3 (W.s/ °C)                   | 0.02      |    |
| C4 (W.s/ °C)                   | 0.3       |    |
| C5 (W.s/ °C)                   | 0.75      |    |
| C6 (W.s/ °C)                   | 3         | 5  |

## 5 Package and packing information

### 5.1 ECOPACK® packages

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 5.2 PowerSO-10 mechanical data

Figure 25. PowerSO-10 package dimensions

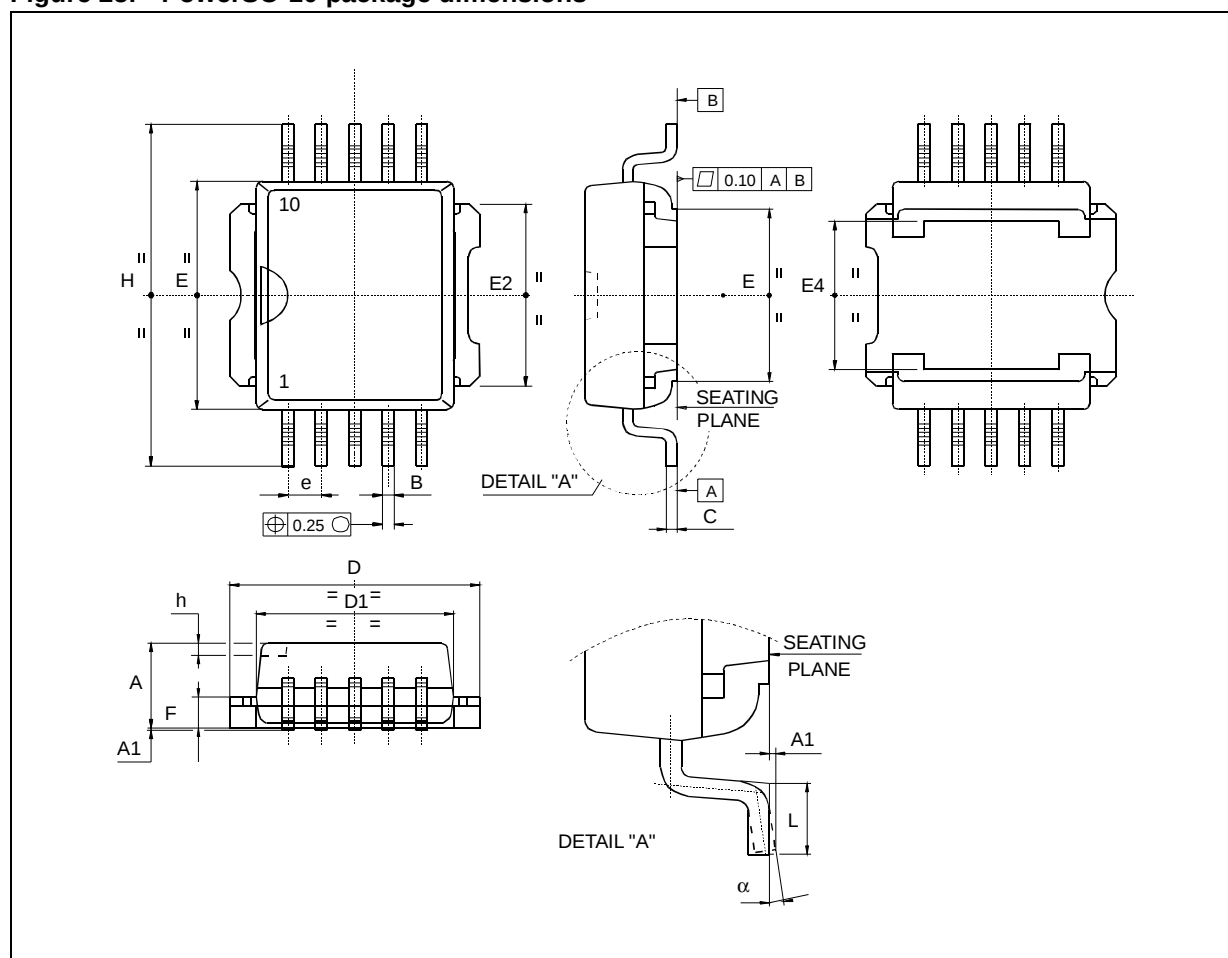


Table 16. PowerSO-10 mechanical data

| Dim.              | Millimeters |      |       |
|-------------------|-------------|------|-------|
|                   | Min.        | Typ. | Max.  |
| A                 | 3.35        |      | 3.65  |
| A <sup>(1)</sup>  | 3.4         |      | 3.6   |
| A1                | 0           |      | 0.10  |
| B                 | 0.40        |      | 0.60  |
| B <sup>(1)</sup>  | 0.37        |      | 0.53  |
| C                 | 0.35        |      | 0.55  |
| C <sup>(1)</sup>  | 0.23        |      | 0.32  |
| D                 | 9.40        |      | 9.60  |
| D1                | 7.40        |      | 7.60  |
| E                 | 9.30        |      | 9.50  |
| E2                | 7.20        |      | 7.60  |
| E2 <sup>(1)</sup> | 7.30        |      | 7.50  |
| E4                | 5.90        |      | 6.10  |
| E4 <sup>(1)</sup> | 5.90        |      | 6.30  |
| e                 |             | 1.27 |       |
| F                 | 1.25        |      | 1.35  |
| F <sup>(1)</sup>  | 1.20        |      | 1.40  |
| H                 | 13.80       |      | 14.40 |
| H <sup>(1)</sup>  | 13.85       |      | 14.35 |
| h                 |             | 0.50 |       |
| L                 | 1.20        |      | 1.80  |
| L <sup>(1)</sup>  | 0.80        |      | 1.10  |
| a                 | 0°          |      | 8°    |
| α <sup>(1)</sup>  | 2°          |      | 8°    |

1. Muar only POA P013P.

### 5.3 PowerSO-10 packing information

Figure 26. PowerSO-10 suggested pad layout and tube shipment (no suffix)

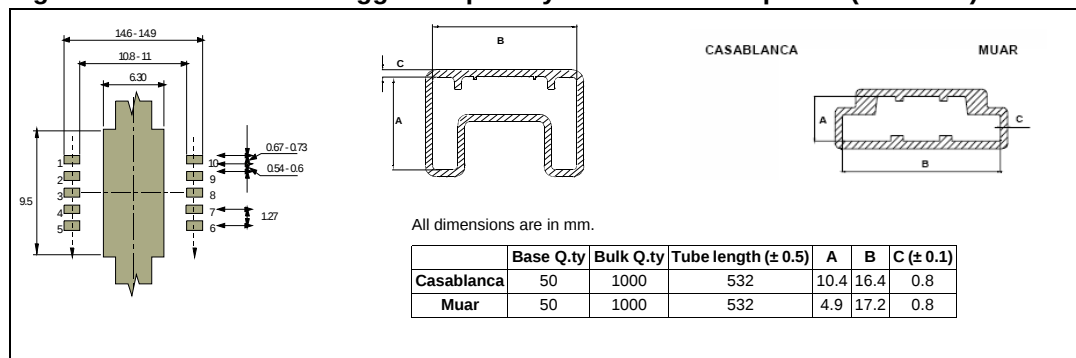
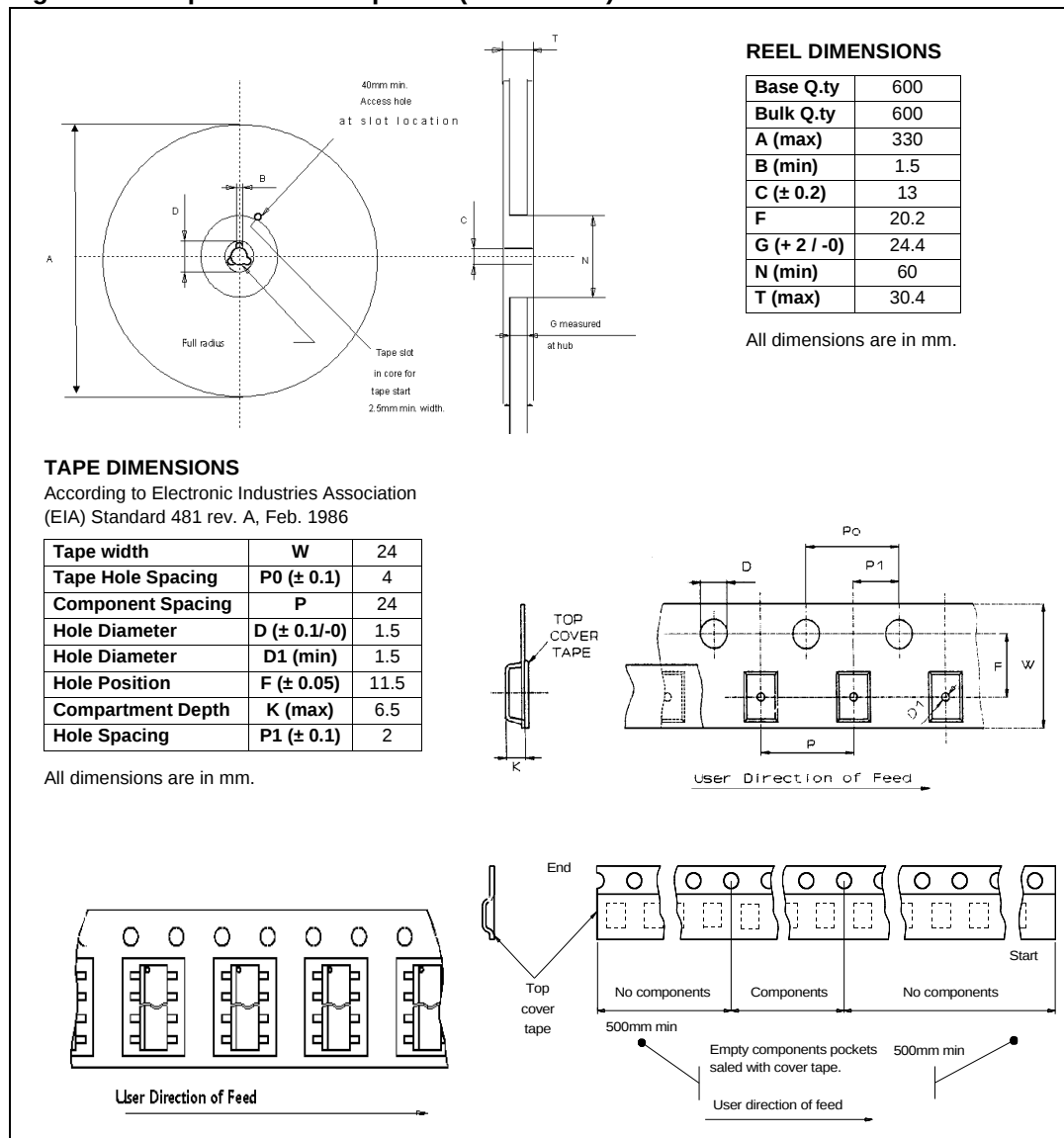


Figure 27. Tape and reel shipment (suffix “TR”)



## 6 Revision history

**Table 17. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                              |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 01-Oct-2004 | 1        | Initial release.                                                                                                                                                                                     |
| 28-Jun-2010 | 2        | Changed <a href="#">Features</a> list.<br>Reformatted entire document. No content change.                                                                                                            |
| 11-Feb-2011 | 3        | Updated <a href="#">Features</a> list.<br>Updated following tables:<br>– <a href="#">Table 5: Power</a><br>– <a href="#">Table 8: Current sense 9 V <math>\leq</math> VCC <math>\leq</math> 16 V</a> |
| 19-Sep-2013 | 4        | Updated Disclaimer.                                                                                                                                                                                  |

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