



## VND5160AJ-E

### Double channel high side driver with analog current sense for automotive applications

#### Features

|                                   |            |                 |
|-----------------------------------|------------|-----------------|
| Max supply voltage                | $V_{CC}$   | 41 V            |
| Operating voltage range           | $V_{CC}$   | 4.5 to 36V      |
| Max on-state resistance (per ch.) | $R_{ON}$   | 160 m $\Omega$  |
| Current limitation (typ)          | $I_{LIMH}$ | 5 A             |
| Off state supply current          | $I_S$      | 2 $\mu A^{(1)}$ |

1. Typical value with all loads connected.

#### ■ General features

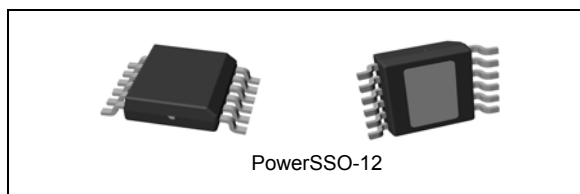
- Inrush current active management by power limitation
- Very low stand-by current
- 3.0V CMOS compatible input
- Optimized electromagnetic emission
- Very low electromagnetic susceptibility
- In compliance with the 2002/95/EC European directive

#### ■ Diagnostic functions

- Proportional load current sense
- High current sense precision for wide range currents
- Current sense disable
- Thermal shutdown indication
- Very low current sense leakage

#### ■ Protection

- Undervoltage shut-down
- Overvoltage clamp
- Load current limitation
- Self limiting of fast thermal transients
- Protection against loss of ground and loss of  $V_{CC}$
- Thermal shut down



- Reverse battery protection (see [Application schematic](#))
- Electrostatic discharge protection

#### Application

- All types of resistive, inductive and capacitive loads
- Suitable as LED driver

#### Description

The VND5160AJ-E is a monolithic device made using STMicroelectronics VIPower 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 integrates an analog current sense which delivers a current proportional to the load current (according to a known ratio) when CS\_DIS is driven low or left open. When CS\_DIS is driven high, the CURRENT SENSE pin is in a high impedance condition. Output current limitation protects the device in overload condition. In case of long overload duration, the device limits the dissipated power to safe level up to thermal shut-down intervention. Thermal shut-down with automatic restart allows the device to recover normal operation as soon as fault condition disappears.

Table 1. Device summary

| Package     | Order codes |               |
|-------------|-------------|---------------|
|             | Tube        | Tape and Reel |
| PowerSSO-12 | VND5160AJ-E | VND5160AJTR-E |

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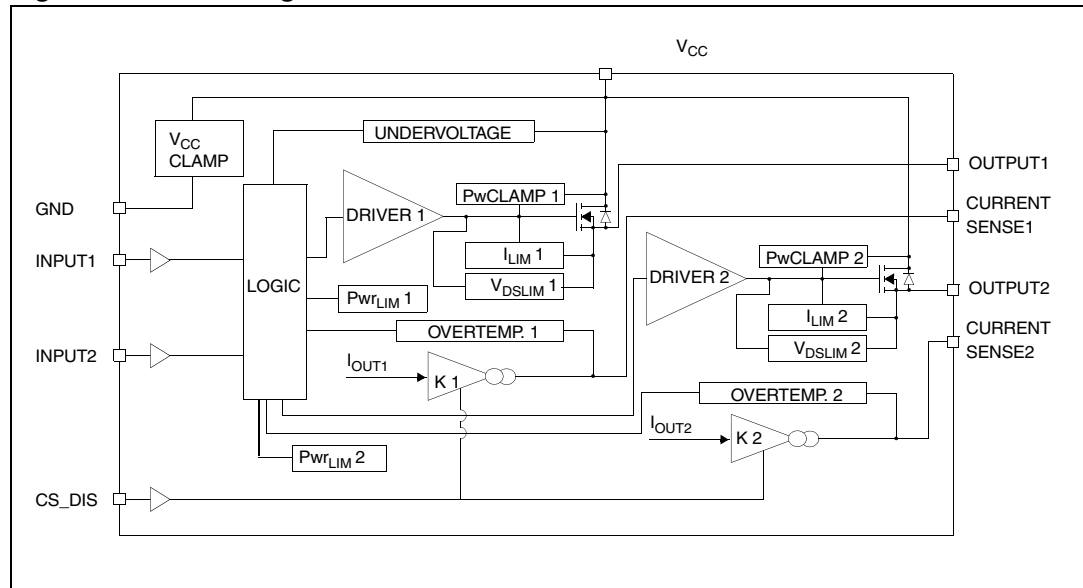
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# 1 Block diagram and pin description

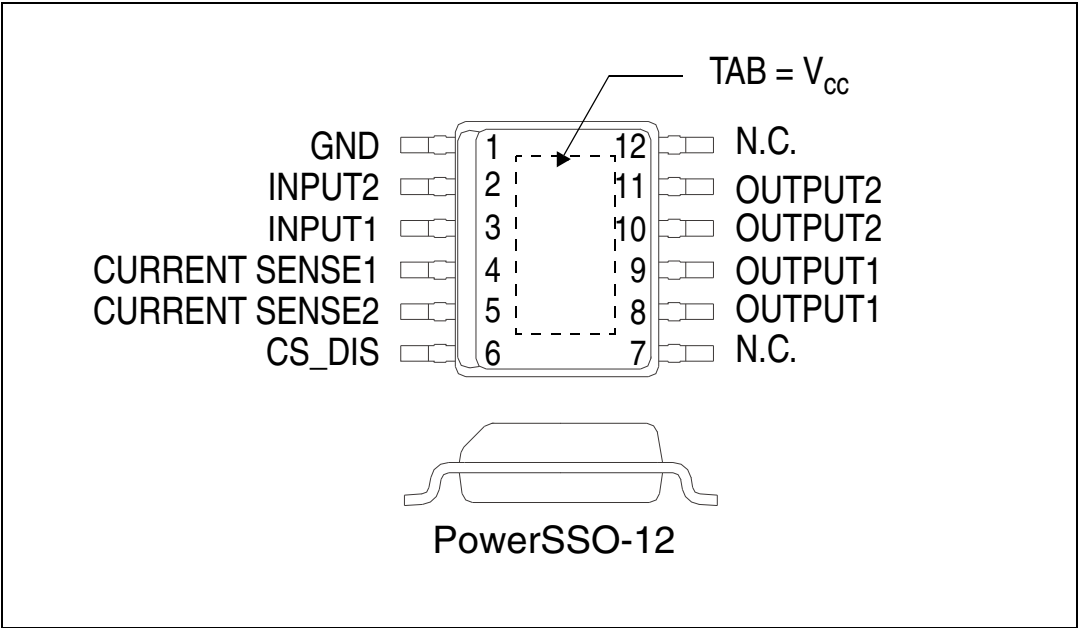
**Figure 1. Block diagram**



**Table 2. Pin function**

| Name                       | Function                                                                                     |
|----------------------------|----------------------------------------------------------------------------------------------|
| V <sub>CC</sub>            | Battery connection.                                                                          |
| OUTPUT <sub>n</sub>        | Power output.                                                                                |
| GND                        | Ground connection. Must be reverse battery protected by an external diode/resistor network.  |
| INPUT <sub>n</sub>         | Voltage controlled input pin with hysteresis, CMOS compatible. Controls output switch state. |
| CURRENT SENSE <sub>n</sub> | Analog current sense pin, delivers a current proportional to the load current.               |
| CS_DIS                     | Active high CMOS compatible pin, to disable the current sense pin.                           |

Figure 2. Configuration diagram (top view)



**Note:** The above pin configuration reflects the changes notified with PCN-APG-BOD/07/2886. The new pinout is backward compatible with existing PCB layouts where pins #7 and 12 are connected to Vcc. For new PCB designs, these pins should be left unconnected.

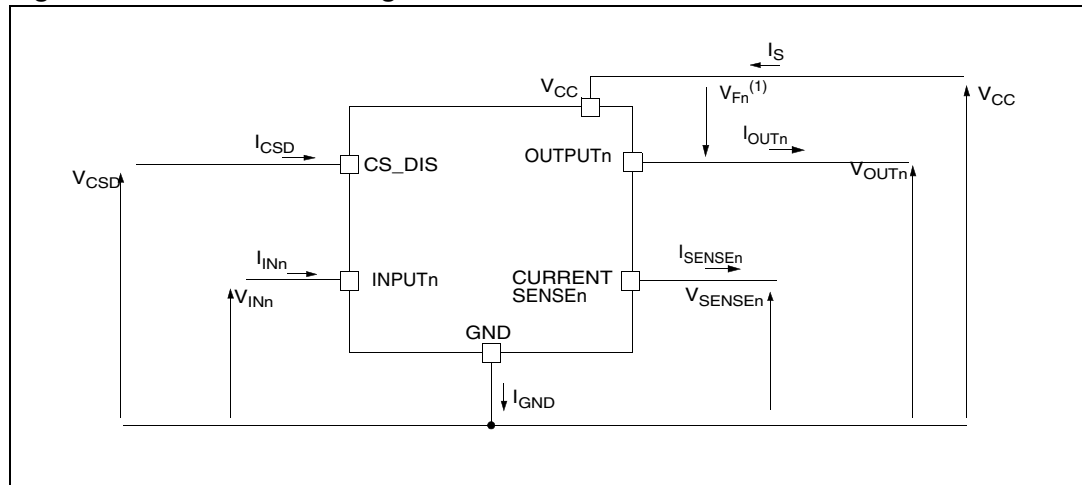
Table 3. Suggested connections for unused and N.C. pins

| Connection / Pin | Current Sense        | N.C. | Output              | Input                 | CS_DIS                |
|------------------|----------------------|------|---------------------|-----------------------|-----------------------|
| Floating         | N.R. <sup>(1)</sup>  | X    | X                   | X                     | X                     |
| To ground        | Through 1kΩ resistor | X    | N.R. <sup>(1)</sup> | Through 10kΩ resistor | Through 10kΩ resistor |

1. Not recommended.

## 2 Electrical specifications

Figure 3. Current and voltage conventions



Note:  $V_{Fn} = V_{OUTn} - V_{CC}$  during reverse battery condition.

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in the “Absolute maximum ratings” table 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 the conditions in table below for extended periods may affect device reliability. Refer also to the STMicroelectronics SURE Program and other relevant quality document.

Table 4. Absolute maximum ratings

| Symbol        | Parameter                                                                                                                                                             | Value                    | Unit   |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------|
| $V_{CC}$      | DC supply voltage                                                                                                                                                     | 41                       | V      |
| $-V_{CC}$     | Reverse DC supply voltage                                                                                                                                             | 0.3                      | V      |
| $-I_{GND}$    | DC reverse ground pin current                                                                                                                                         | 200                      | mA     |
| $I_{OUT}$     | DC output current                                                                                                                                                     | Internally limited       | A      |
| $-I_{OUT}$    | Reverse DC output current                                                                                                                                             | 6                        | A      |
| $I_{IN}$      | DC input current                                                                                                                                                      | -1 to 10                 | mA     |
| $I_{CSD}$     | DC current sense disable input current                                                                                                                                | -1 to 10                 | mA     |
| $-I_{CSENSE}$ | DC reverse CS pin current                                                                                                                                             | 200                      | mA     |
| $V_{CSENSE}$  | Current sense maximum voltage                                                                                                                                         | $V_{CC}-41$<br>$+V_{CC}$ | V<br>V |
| $E_{MAX}$     | Maximum switching energy (single pulse)<br>( $L=12\text{mH}$ ; $R_L=0\Omega$ ; $V_{bat}=13.5\text{V}$ ; $T_{jstart}=150^\circ\text{C}$ ; $I_{OUT} = I_{limL}(Typ.)$ ) | 34                       | mJ     |

**Table 4. Absolute maximum ratings (continued)**

| Symbol           | Parameter                                                    | Value      | Unit |
|------------------|--------------------------------------------------------------|------------|------|
| V <sub>ESD</sub> | Electrostatic discharge (Human Body Model: R=1.5KΩ; C=100pF) |            |      |
|                  | - INPUT                                                      | 4000       | V    |
|                  | - CURRENT SENSE                                              | 2000       | V    |
|                  | - CS_DIS                                                     | 4000       | V    |
|                  | - OUTPUT                                                     | 5000       | V    |
|                  | - V <sub>CC</sub>                                            | 5000       | V    |
| V <sub>ESD</sub> | Charge device model (CDM-AEC-Q100-011)                       | 750        | V    |
| T <sub>j</sub>   | Junction operating temperature                               | -40 to 150 | °C   |
| T <sub>stg</sub> | Storage temperature                                          | -55 to 150 | °C   |

## 2.2 Thermal data

**Table 5. Thermal data**

| Symbol                | Parameter                                                    | Max value                     | Unit |
|-----------------------|--------------------------------------------------------------|-------------------------------|------|
| R <sub>thj-case</sub> | Thermal resistance junction-case (MAX) (With one channel ON) | 8                             | °C/W |
| R <sub>thj-amb</sub>  | Thermal resistance junction-ambient (MAX)                    | See <a href="#">Figure 29</a> | °C/W |

## 2.3 Electrical characteristics

The values specified in this section are for  $8V < V_{CC} < 36V$ ;  $-40^{\circ}C < T_j < 150^{\circ}C$ , unless otherwise stated.

**Table 6. Power section**

| Symbol        | Parameter                                      | Test conditions                                                                                                                                                 | Min.   | Typ.                  | Max.                  | Unit           |
|---------------|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------|-----------------------|----------------|
| $V_{CC}$      | Operating supply voltage                       |                                                                                                                                                                 | 4.5    | 13                    | 36                    | V              |
| $V_{USD}$     | Undervoltage shutdown                          |                                                                                                                                                                 |        | 3.5                   | 4.5                   | V              |
| $V_{USDhyst}$ | Undervoltage shut-down hysteresis              |                                                                                                                                                                 |        | 0.5                   |                       | V              |
| $R_{ON}$      | On state resistance <sup>(1)</sup>             | $I_{OUT} = 0.5A$ ; $T_j = 25^{\circ}C$<br>$I_{OUT} = 0.5A$ ; $T_j = 150^{\circ}C$<br>$I_{OUT} = 0.5A$ ; $V_{CC} = 5V$ ; $T_j = 25^{\circ}C$                     |        |                       | 160<br>320<br>210     | mΩ<br>mΩ<br>mΩ |
| $V_{clamp}$   | Clamp voltage                                  | $I_S = 20\text{ mA}$                                                                                                                                            | 41     | 46                    | 52                    | V              |
| $I_S$         | Supply current                                 | Off State; $V_{CC} = 13V$ ; $T_j = 25^{\circ}C$ ;<br>$V_{IN} = V_{OUT} = V_{SENSE} = V_{CSD} = 0V$<br>On State; $V_{CC} = 13V$ ; $V_{IN} = 5V$ ; $I_{OUT} = 0A$ |        | 2 <sup>(2)</sup><br>3 | 5 <sup>(2)</sup><br>6 | μA<br>mA       |
| $I_{L(off)}$  | Off state output current <sup>(1)</sup>        | $V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ; $T_j = 25^{\circ}C$<br>$V_{IN} = V_{OUT} = 0V$ ; $V_{CC} = 13V$ ; $T_j = 125^{\circ}C$                               | 0<br>0 | 0.01                  | 3<br>5                | μA             |
| $V_F$         | Output - $V_{CC}$ diode voltage <sup>(1)</sup> | $-I_{OUT} = 0.6A$ ; $T_j = 150^{\circ}C$                                                                                                                        |        |                       | 0.7                   | V              |

1. For each channel.

2. PowerMOS leakage included.

**Table 7. Switching ( $V_{CC} = 13V$ ,  $T_j = 25^{\circ}C$ )**

| Symbol                | Parameter                                 | Test conditions                                   | Min. | Typ.                           | Max. | Unit |
|-----------------------|-------------------------------------------|---------------------------------------------------|------|--------------------------------|------|------|
| $t_{d(on)}$           | Turn- On delay time                       | $R_L = 26\Omega$ (see <a href="#">Figure 8.</a> ) |      | 10                             |      | μs   |
| $t_{d(off)}$          | Turn- Off delay time                      | $R_L = 26\Omega$ (see <a href="#">Figure 8.</a> ) |      | 15                             |      | μs   |
| $(dV_{OUT}/dt)_{on}$  | Turn- On voltage slope                    | $R_L = 26\Omega$                                  |      | See <a href="#">Figure 20.</a> |      | V/μs |
| $(dV_{OUT}/dt)_{off}$ | Turn- Off voltage slope                   | $R_L = 26\Omega$                                  |      | See <a href="#">Figure 22.</a> |      | V/μs |
| $W_{ON}$              | Switching energy losses during $t_{won}$  | $R_L = 26\Omega$ (see <a href="#">Figure 8.</a> ) |      | 0.03                           |      | mJ   |
| $W_{OFF}$             | Switching energy losses during $t_{woff}$ | $R_L = 26\Omega$ (see <a href="#">Figure 8.</a> ) |      | 0.02                           |      | mJ   |

**Table 8. Logic input**

| Symbol          | Parameter                 | Test conditions                     | Min. | Typ. | Max. | Unit    |
|-----------------|---------------------------|-------------------------------------|------|------|------|---------|
| $V_{IL}$        | Input low level voltage   |                                     |      |      | 0.9  | V       |
| $I_{IL}$        | Low level input current   | $V_{IN} = 0.9V$                     | 1    |      |      | $\mu A$ |
| $V_{IH}$        | Input high level voltage  |                                     | 2.1  |      |      | V       |
| $I_{IH}$        | High level input current  | $V_{IN} = 2.1V$                     |      |      | 10   | $\mu A$ |
| $V_{I(hyst)}$   | Input hysteresis voltage  |                                     | 0.25 |      |      | V       |
| $V_{ICL}$       | Input clamp voltage       | $I_{IN} = 1mA$<br>$I_{IN} = -1mA$   | 5.5  | -0.7 | 7    | V<br>V  |
| $V_{CSDL}$      | CS_DIS low level voltage  |                                     |      |      | 0.9  | V       |
| $I_{CSDL}$      | Low level CS_DIS current  | $V_{CSD} = 0.9V$                    | 1    |      |      | $\mu A$ |
| $V_{CSDH}$      | CS_DIS high level voltage |                                     | 2.1  |      |      | V       |
| $I_{CSDH}$      | High level CS_DIS current | $V_{CSD} = 2.1V$                    |      |      | 10   | $\mu A$ |
| $V_{CSD(hyst)}$ | CS_DIS hysteresis voltage |                                     | 0.25 |      |      | V       |
| $V_{CSCL}$      | CS_DIS clamp voltage      | $I_{CSD} = 1mA$<br>$I_{CSD} = -1mA$ | 5.5  | -0.7 | 7    | V<br>V  |

**Table 9. Protection and diagnostics<sup>(1)</sup>**

| Symbol      | Parameter                                    | Test conditions                                                                                    | Min.          | Typ.          | Max.          | Unit        |
|-------------|----------------------------------------------|----------------------------------------------------------------------------------------------------|---------------|---------------|---------------|-------------|
| $I_{limH}$  | DC short circuit current                     | $V_{CC} = 13V$<br>$5V < V_{CC} < 36V$                                                              | 3.8           | 5             | 7.5<br>7.5    | A<br>A      |
| $I_{limL}$  | Short circuit current during thermal cycling | $V_{CC} = 13V$ ; $T_R < T_J < T_{TSD}$                                                             |               | 2             |               | A           |
| $T_{TSD}$   | Shutdown temperature                         |                                                                                                    | 150           | 175           | 200           | $^{\circ}C$ |
| $T_R$       | Reset temperature                            |                                                                                                    | $T_{RS} + 1$  | $T_{RS} + 5$  |               | $^{\circ}C$ |
| $T_{RS}$    | Thermal reset of STATUS                      |                                                                                                    | 135           |               |               | $^{\circ}C$ |
| $T_{HYST}$  | Thermal hysteresis ( $T_{TSD} - T_R$ )       |                                                                                                    |               | 7             |               | $^{\circ}C$ |
| $V_{DEMAG}$ | Turn-Off output voltage clamp                | $I_{OUT} = 1A$ ; $V_{IN} = 0$ ;<br>$L = 20mH$                                                      | $V_{CC} - 41$ | $V_{CC} - 46$ | $V_{CC} - 52$ | V           |
| $V_{ON}$    | Output voltage drop limitation               | $I_{OUT} = 0.03A$ ;<br>$T_J = -40^{\circ}C \dots 150^{\circ}C$<br>(see <a href="#">Figure 9.</a> ) |               | 25            |               | 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 10. Current sense (8V&lt;VCC&lt;16V)

| Symbol           | Parameter                                                | Test conditions                                                                                     | Min. | Typ. | Max. | Unit    |
|------------------|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------|------|------|---------|
| $K_0$            | $I_{OUT}/I_{SENSE}$                                      | $I_{OUT}=0.025A$ ; $V_{SENSE}=0.5V$ ; $V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C...150^{\circ}C$           | 260  | 500  | 750  |         |
| $K_1$            | $I_{OUT}/I_{SENSE}$                                      | $I_{OUT}=0.35A$ ; $V_{SENSE}=0.5V$ ; $V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C...150^{\circ}C$            | 320  | 450  | 590  |         |
|                  |                                                          | $I_{OUT}=0.35A$ ; $V_{SENSE}=0.5V$ ; $V_{CSD}=0V$ ;<br>$T_j=25^{\circ}C...150^{\circ}C$             | 360  | 450  | 540  |         |
| $dK_1/K_1^{(1)}$ | Current sense ratio drift                                | $I_{OUT}=0.35A$ ; $V_{SENSE}=0.5V$ ;<br>$V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C$ to $150^{\circ}C$      | -13  |      | +13  | %       |
| $K_2$            | $I_{OUT}/I_{SENSE}$                                      | $I_{OUT}=0.5A$ ; $V_{SENSE}=4V$ ; $V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C...150^{\circ}C$               | 360  | 440  | 540  |         |
|                  |                                                          | $I_{OUT}=0.5A$ ; $V_{SENSE}=4V$ ; $V_{CSD}=0V$ ;<br>$T_j=25^{\circ}C...150^{\circ}C$                | 380  | 440  | 510  |         |
| $dK_2/K_2^{(1)}$ | Current sense ratio drift                                | $I_{OUT}=0.5A$ ; $V_{SENSE}=4V$ ;<br>$V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C$ to $150^{\circ}C$         | -8   |      | +8   | %       |
| $K_3$            | $I_{OUT}/I_{SENSE}$                                      | $I_{OUT}=1.5A$ ; $V_{SENSE}=4V$ ; $V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C...150^{\circ}C$               | 410  | 440  | 480  |         |
|                  |                                                          | $I_{OUT}=1.5A$ ; $V_{SENSE}=4V$ ; $V_{CSD}=0V$ ;<br>$T_j=25^{\circ}C...150^{\circ}C$                | 420  | 440  | 460  |         |
| $dK_3/K_3^{(1)}$ | Current sense ratio drift                                | $I_{OUT}=1.5A$ ; $V_{SENSE}=4V$ ;<br>$V_{CSD}=0V$ ;<br>$T_j=-40^{\circ}C$ to $150^{\circ}C$         | -4   |      | +4   | %       |
| $I_{SENSE0}$     | Analog sense leakage current                             | $I_{OUT}=0A$ ; $V_{SENSE}=0V$ ;<br>$V_{CSD}=5V$ ; $V_{IN}=0V$ ; $T_j=-40^{\circ}C...150^{\circ}C$   | 0    |      | 1    | $\mu A$ |
|                  |                                                          | $V_{CSD}=0V$ ; $V_{IN}=5V$ ; $T_j=-40^{\circ}C...150^{\circ}C$                                      | 0    |      | 2    | $\mu A$ |
|                  |                                                          | $I_{OUT}=0.6A$ ; $V_{SENSE}=0V$ ;<br>$V_{CSD}=5V$ ; $V_{IN}=5V$ ; $T_j=-40^{\circ}C...150^{\circ}C$ | 0    |      | 1    | $\mu A$ |
| $I_{OL}$         | Openload ON state current detection threshold            | $V_{IN}=5V$ , $I_{SENSE}=5\mu A$                                                                    | 1    |      | 5    | mA      |
| $V_{SENSE}$      | Max analog sense output voltage                          | $I_{OUT}=1.5A$ ; $V_{CSD}=0V$ ;                                                                     | 5    |      |      | V       |
| $V_{SENSEH}$     | Analog sense output voltage in overtemperature condition | $V_{CC}=13V$ ; $R_{SENSE}=3.9K\Omega$ ;                                                             |      | 9    |      | V       |
| $I_{SENSEH}$     | Analog sense output current in overtemperature condition | $V_{CC}=13V$ ; $V_{SENSE}=5V$ ;                                                                     |      | 8    |      | mA      |

**Table 10. Current sense (8V<VCC<16V) (continued)**

| Symbol                       | Parameter                                                                                  | Test conditions                                                                                                                                                                                               | Min. | Typ. | Max. | Unit          |
|------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $t_{\text{DSENSE1H}}$        | Delay response time from falling edge of CS_DIS pin                                        | $V_{\text{SENSE}} < 4\text{V}$ , $0.08\text{A} < I_{\text{out}} < 1.5\text{A}$<br>$I_{\text{SENSE}} = 90\%$ of $I_{\text{SENSE max}}$<br>(see <a href="#">Figure 4.</a> )                                     |      | 50   | 100  | $\mu\text{s}$ |
| $t_{\text{DSENSE1L}}$        | Delay response time from rising edge of CS_DIS pin                                         | $V_{\text{SENSE}} < 4\text{V}$ , $0.08\text{A} < I_{\text{out}} < 1.5\text{A}$<br>$I_{\text{SENSE}} = 10\%$ of $I_{\text{SENSE max}}$<br>(see <a href="#">Figure 4.</a> )                                     |      | 5    | 20   | $\mu\text{s}$ |
| $t_{\text{DSENSE2H}}$        | Delay response time from rising edge of INPUT pin                                          | $V_{\text{SENSE}} < 4\text{V}$ , $0.08\text{A} < I_{\text{out}} < 1.5\text{A}$<br>$I_{\text{SENSE}} = 90\%$ of $I_{\text{SENSE max}}$<br>(see <a href="#">Figure 4.</a> )                                     |      | 80   | 150  | $\mu\text{s}$ |
| $\Delta t_{\text{DSENSE2H}}$ | Delay response time between rising edge of output current and rising edge of current sense | $V_{\text{SENSE}} < 4\text{V}$ ,<br>$I_{\text{SENSE}} = 90\%$ of $I_{\text{SENSEMAX}}$ ,<br>$I_{\text{OUT}} = 90\%$ of $I_{\text{OUTMAX}}$<br>$I_{\text{OUTMAX}} = 2\text{A}$ (see <a href="#">Figure 5</a> ) |      |      | 20   | $\mu\text{s}$ |
| $t_{\text{DSENSE2L}}$        | Delay response time from falling edge of INPUT pin                                         | $V_{\text{SENSE}} < 4\text{V}$ , $0.08\text{A} < I_{\text{out}} < 1.5\text{A}$<br>$I_{\text{SENSE}} = 10\%$ of $I_{\text{SENSE max}}$<br>(see <a href="#">Figure 4.</a> )                                     |      | 100  | 250  | $\mu\text{s}$ |

1. Parameter guaranteed by design; it is not tested.

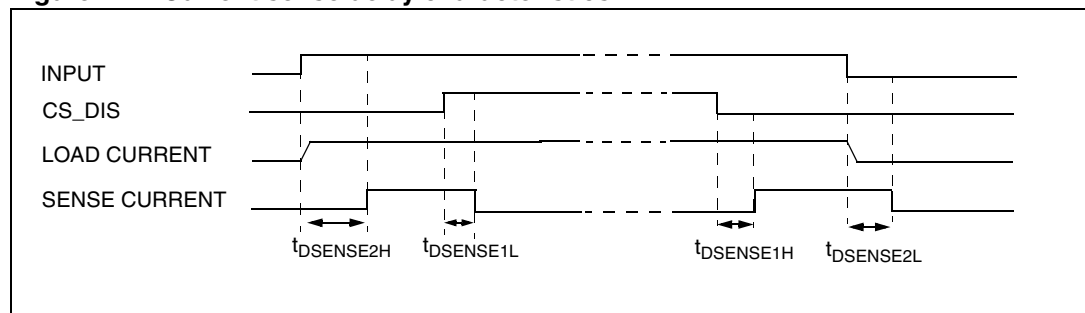
**Figure 4. Current sense delay characteristics**

Figure 5. Delay response time between rising edge of output current and rising edge of current sense (CS enabled)

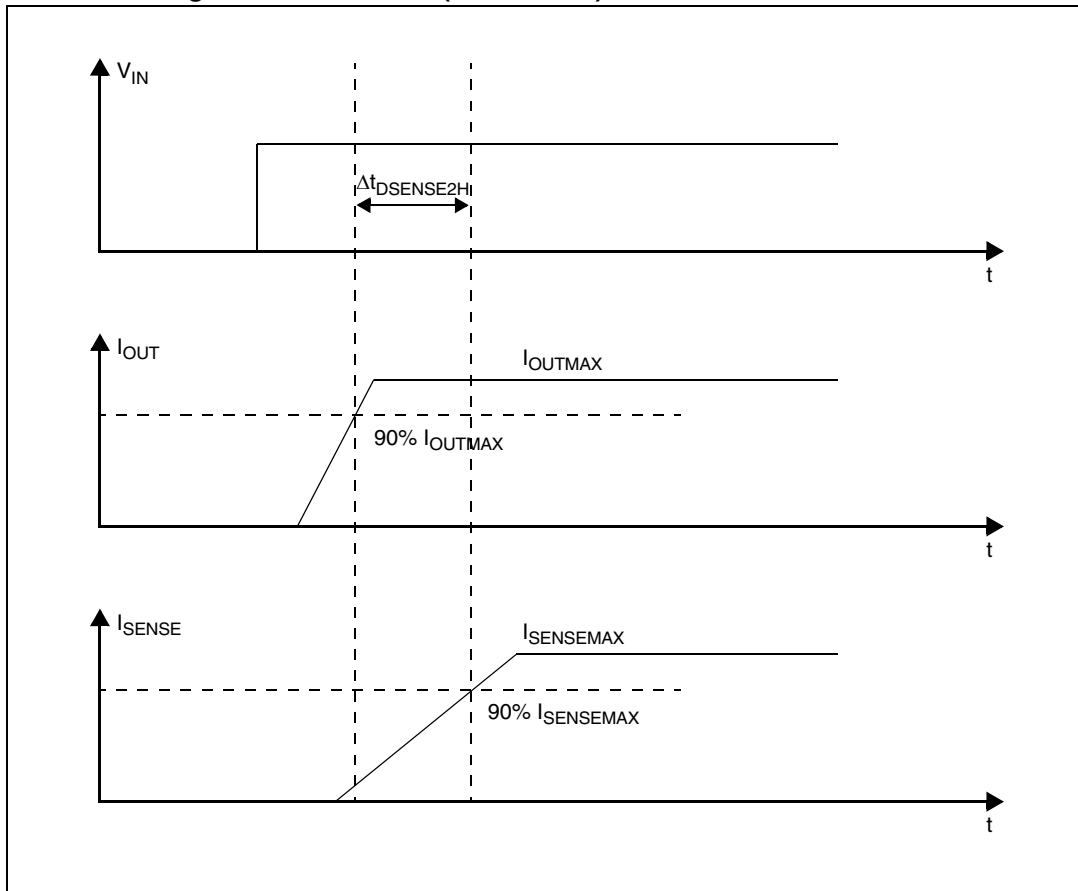


Figure 6.  $I_{out} / I_{sense}$  vs.  $I_{out}$  (see [Table 10](#) for details)

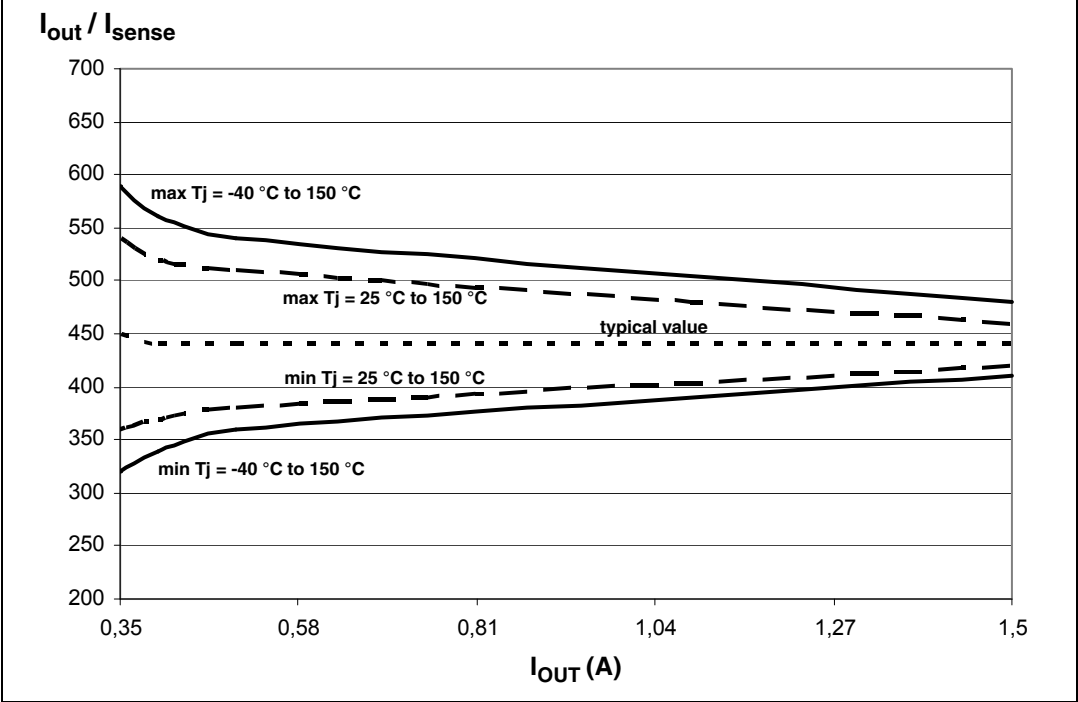
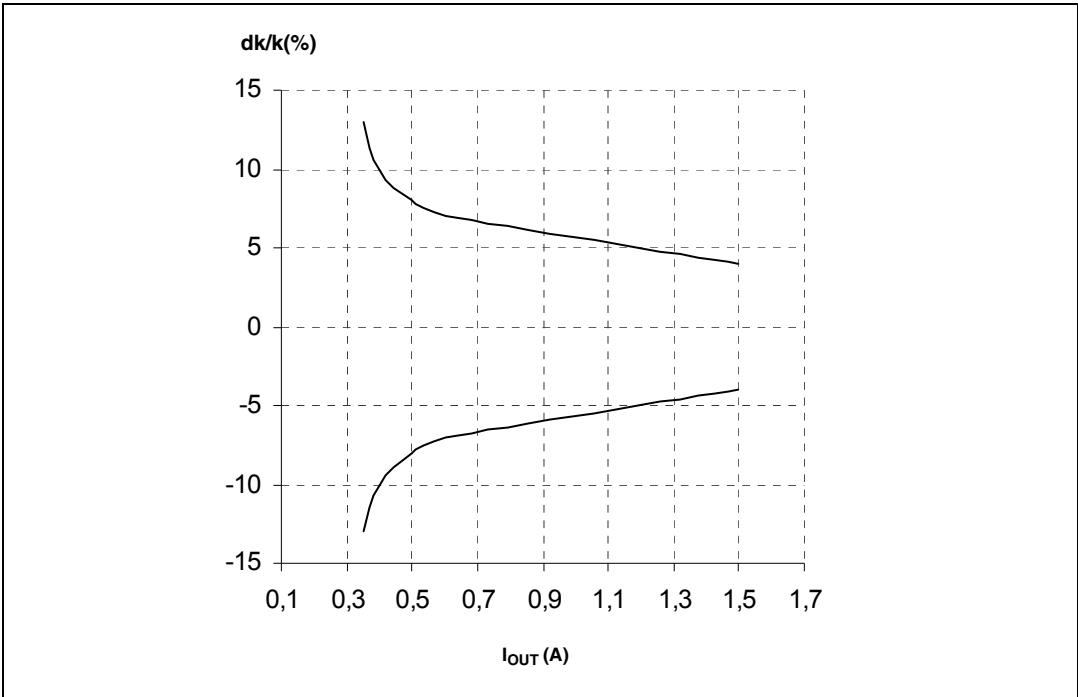


Figure 7. Maximum current sense ratio drift vs load current



Note: Parameter guaranteed by design; it is not tested.

Table 11. Truth table

| Conditions                                                  | INPUT | OUTPUT | SENSE ( $V_{CSD}=0V$ ) <sup>(1)</sup> |
|-------------------------------------------------------------|-------|--------|---------------------------------------|
| Normal operation                                            | L     | L      | 0                                     |
|                                                             | H     | H      | Nominal                               |
| Overtemperature                                             | L     | L      | 0                                     |
|                                                             | H     | L      | $V_{SENSEH}$                          |
| Undervoltage                                                | L     | L      | 0                                     |
|                                                             | H     | L      | 0                                     |
| Short circuit to GND<br>( $R_{SC} \leq 10\text{ m}\Omega$ ) | L     | L      | 0                                     |
|                                                             | H     | L      | 0 if $T_j < T_{TSD}$                  |
|                                                             | H     | L      | $V_{SENSEH}$ if $T_j > T_{TSD}$       |
| Short circuit to $V_{CC}$                                   | L     | H      | 0                                     |
|                                                             | H     | H      | < Nominal                             |
| Negative output voltage clamp                               | L     | L      | 0                                     |

1. If the  $V_{CSD}$  is high, the SENSE output is at a high impedance, its potential depends on leakage currents and external circuit.

Figure 8. Switching characteristics

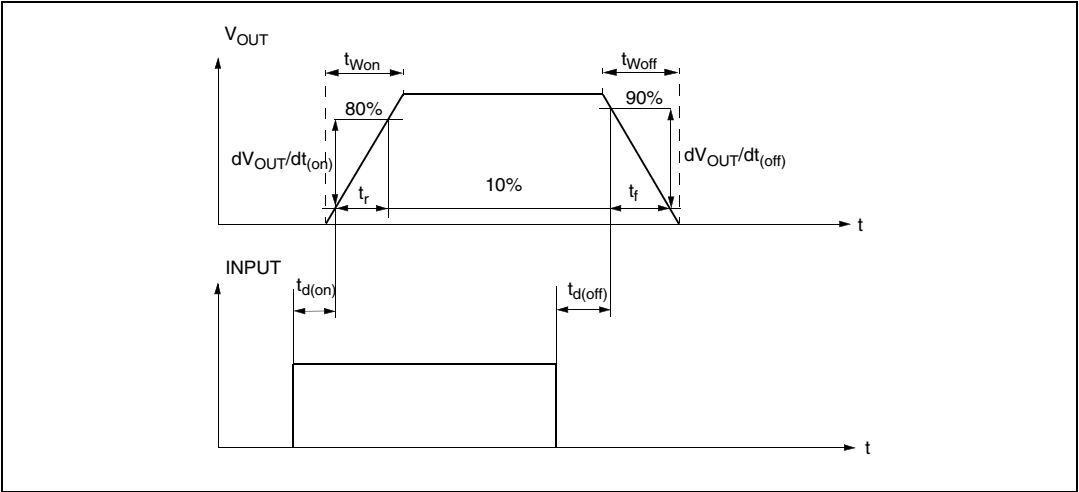


Figure 9. Output voltage drop limitation

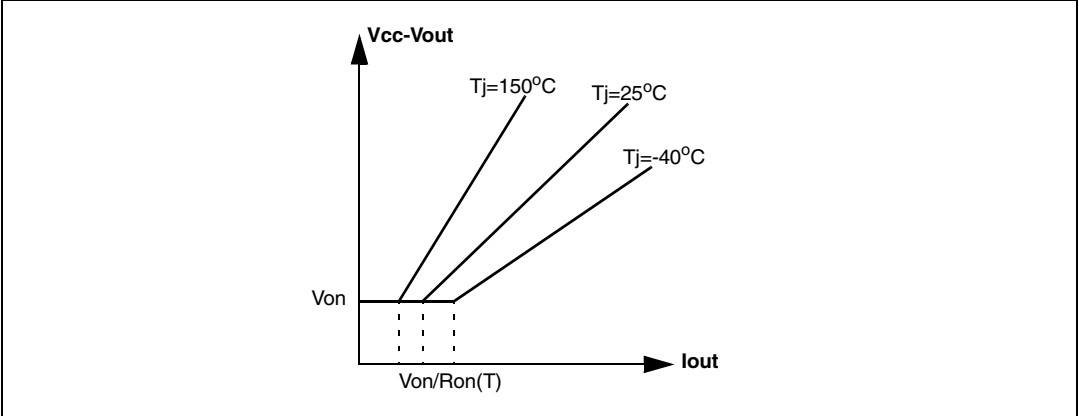


Table 12. Electrical transient requirements

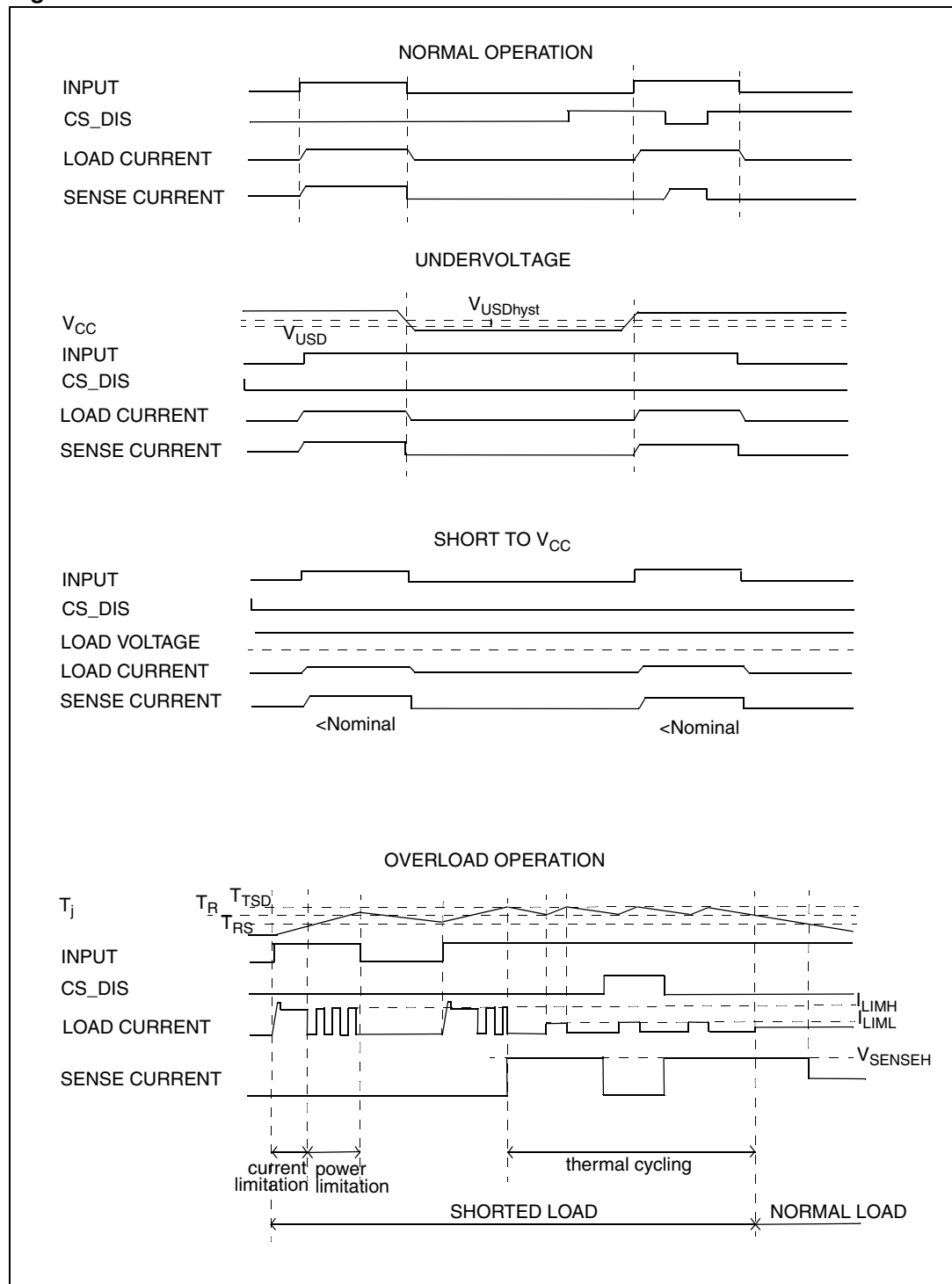
| ISO 7637-2:<br>2004(E)<br>Test pulse | Test levels <sup>(1)</sup> |       | Number of<br>pulses or<br>test times | Burst cycle/pulse<br>repetition time |        | Delays and<br>impedance  |
|--------------------------------------|----------------------------|-------|--------------------------------------|--------------------------------------|--------|--------------------------|
|                                      | III                        | IV    |                                      |                                      |        |                          |
| 1                                    | -75V                       | -100V | 5000<br>pulses                       | 0.5 s                                | 5 s    | 2 ms, 10 $\Omega$        |
| 2a                                   | +37V                       | +50V  | 5000<br>pulses                       | 0.2 s                                | 5 s    | 50 $\mu$ s, 2 $\Omega$   |
| 3a                                   | -100V                      | -150V | 1h                                   | 90 ms                                | 100 ms | 0.1 $\mu$ s, 50 $\Omega$ |
| 3b                                   | +75V                       | +100V | 1h                                   | 90 ms                                | 100 ms | 0.1 $\mu$ s, 50 $\Omega$ |
| 4                                    | -6V                        | -7V   | 1 pulse                              |                                      |        | 100 ms, 0.01<br>$\Omega$ |
| 5b <sup>(2)</sup>                    | +65V                       | +87V  | 1 pulse                              |                                      |        | 400 ms, 2 $\Omega$       |

| ISO 7637-2:<br>2004(E)<br>Test pulse | Test level results <sup>(1)</sup> |    |
|--------------------------------------|-----------------------------------|----|
|                                      | III                               | IV |
| 1                                    | C                                 | C  |
| 2a                                   | C                                 | C  |
| 3a                                   | C                                 | C  |
| 3b                                   | C                                 | C  |
| 4                                    | C                                 | C  |
| 5b <sup>(2)</sup>                    | C                                 | C  |

1. The above test levels must be considered referred to  $V_{CC} = 13.5V$  except for pulse 5b.
2. Valid in case of external load dump clamp: 40V maximum referred to ground.

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

Figure 10. Waveforms



2.4 Electrical characteristics curves

Figure 11. Off state output current

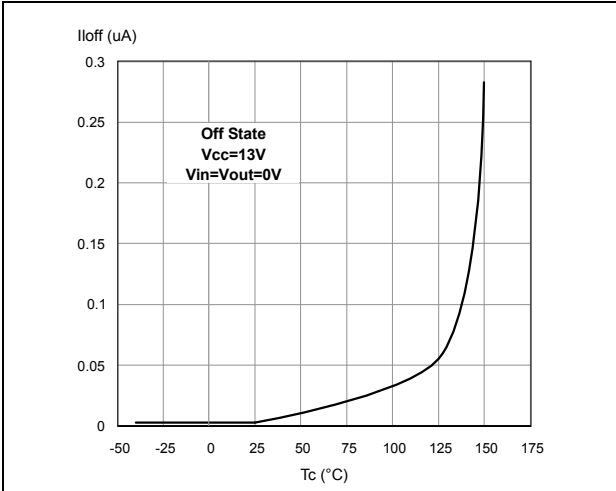


Figure 12. High level input current

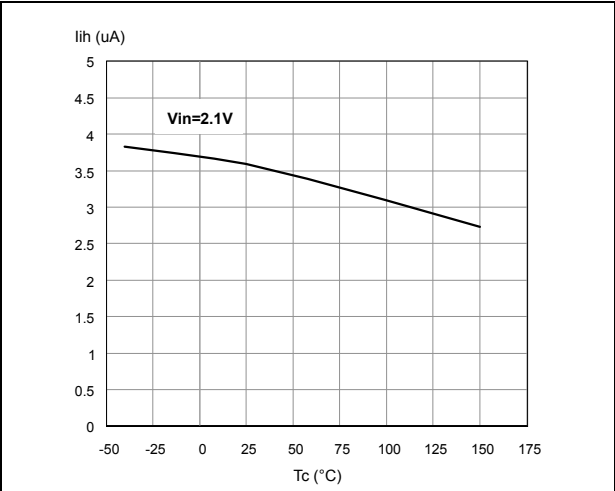


Figure 13. Input clamp voltage

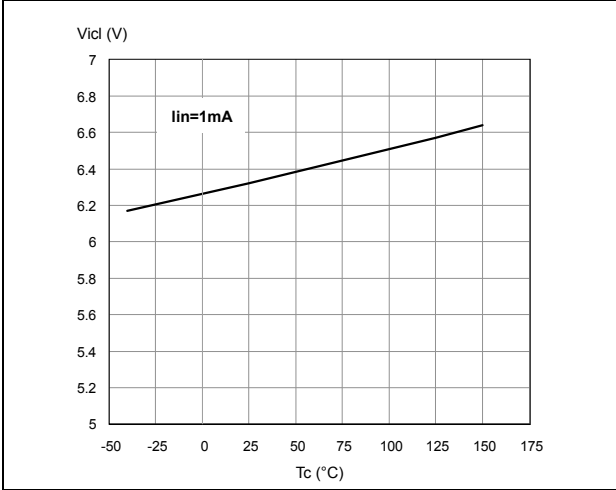


Figure 14. Input low level

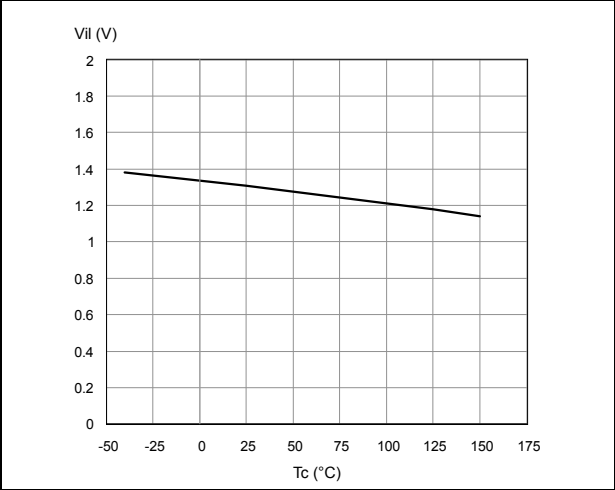


Figure 15. Input high level

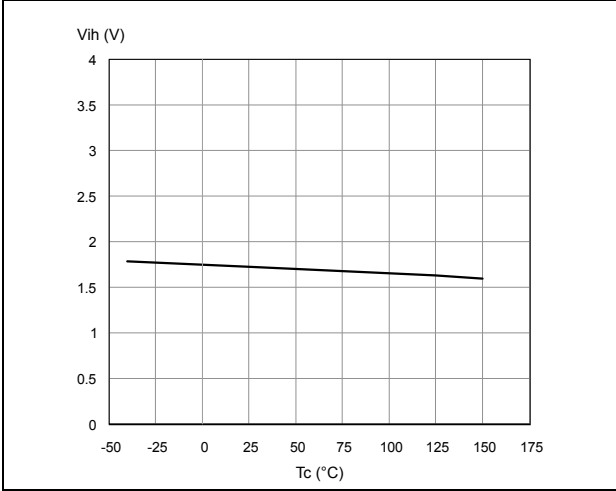


Figure 16. Input hysteresis voltage

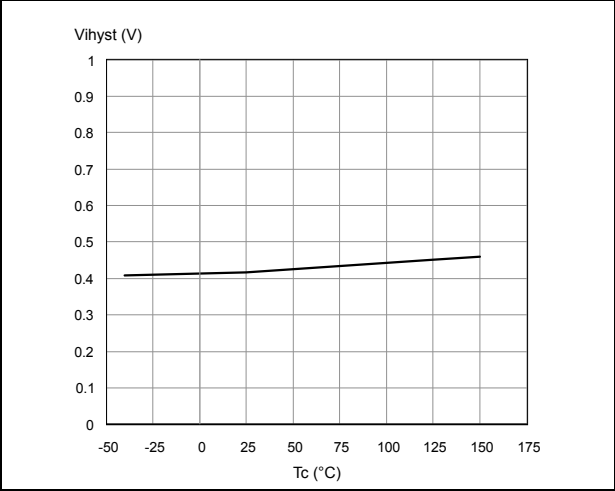


Figure 17. On state resistance vs.  $T_{case}$

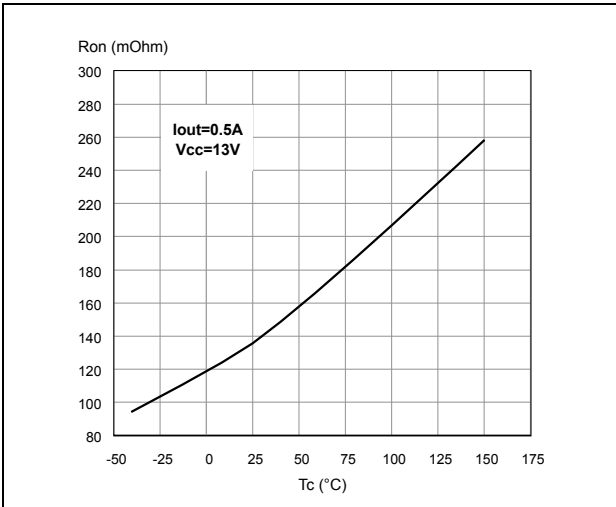


Figure 18. On state resistance vs.  $V_{CC}$

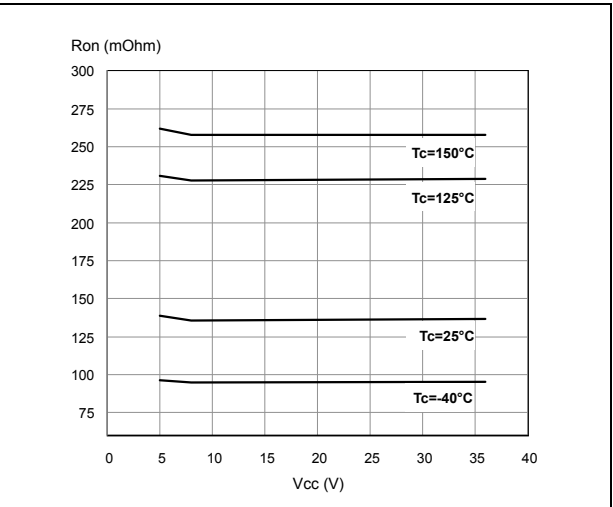


Figure 19. Undervoltage shutdown

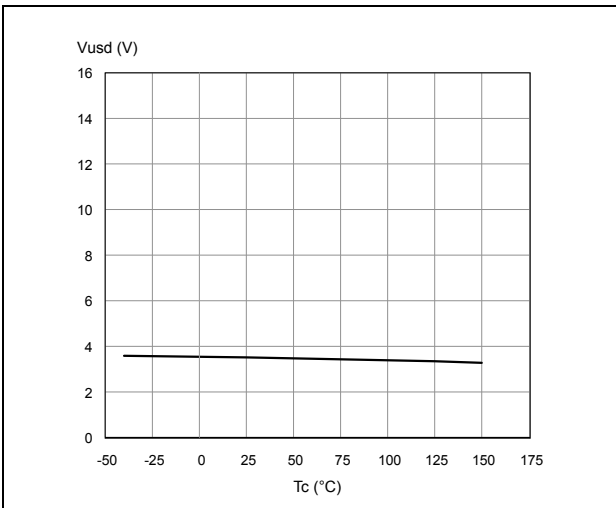


Figure 20. Turn-On voltage slope

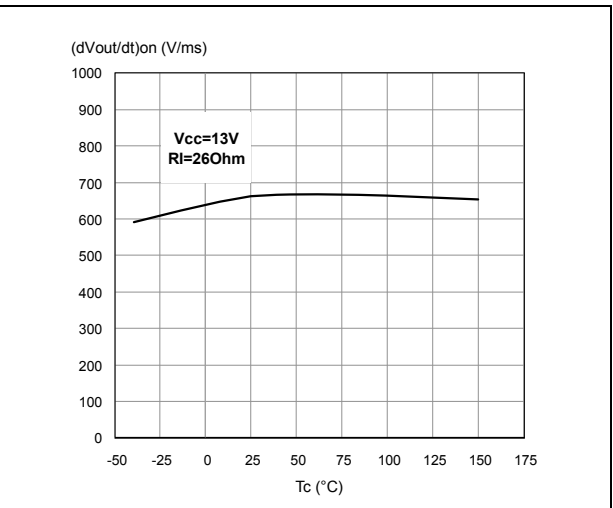


Figure 21.  $I_{LIMH}$  vs.  $T_{case}$

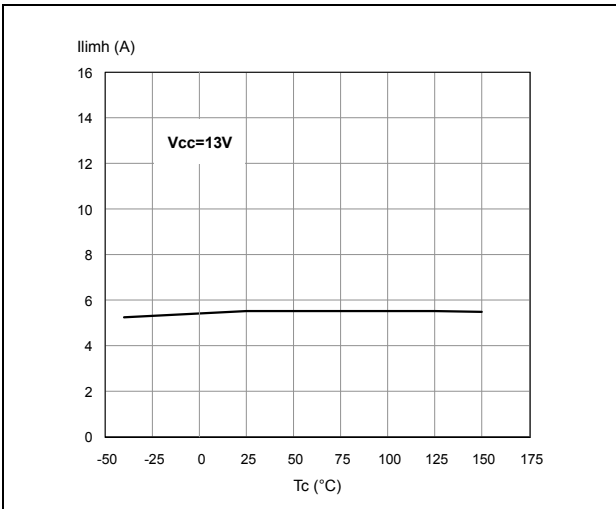


Figure 22. Turn-Off voltage slope

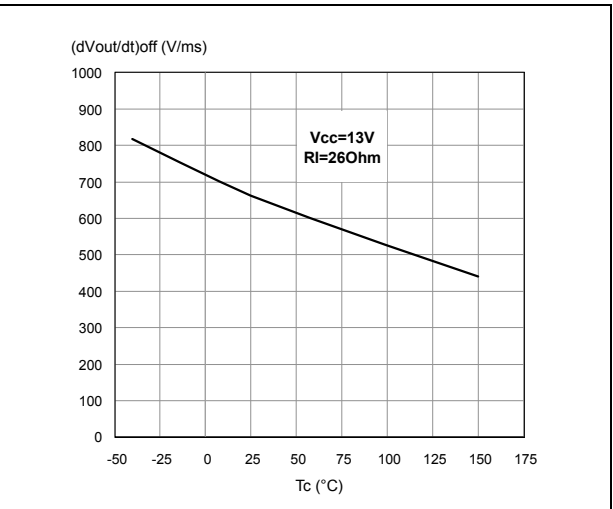


Figure 23. CS\_DIS high level voltage

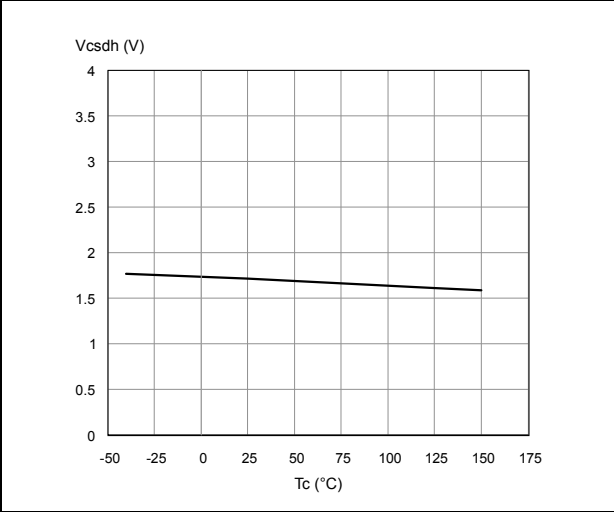


Figure 24. CS\_DIS clamp voltage

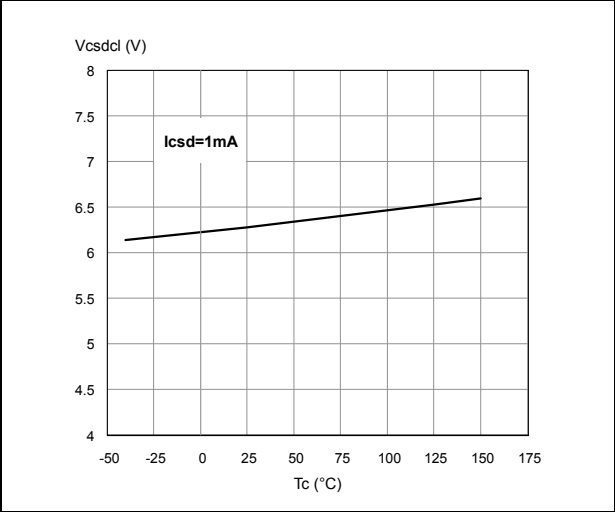
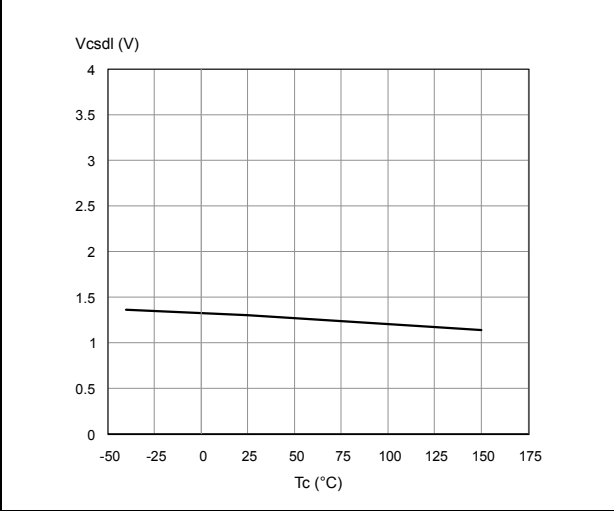
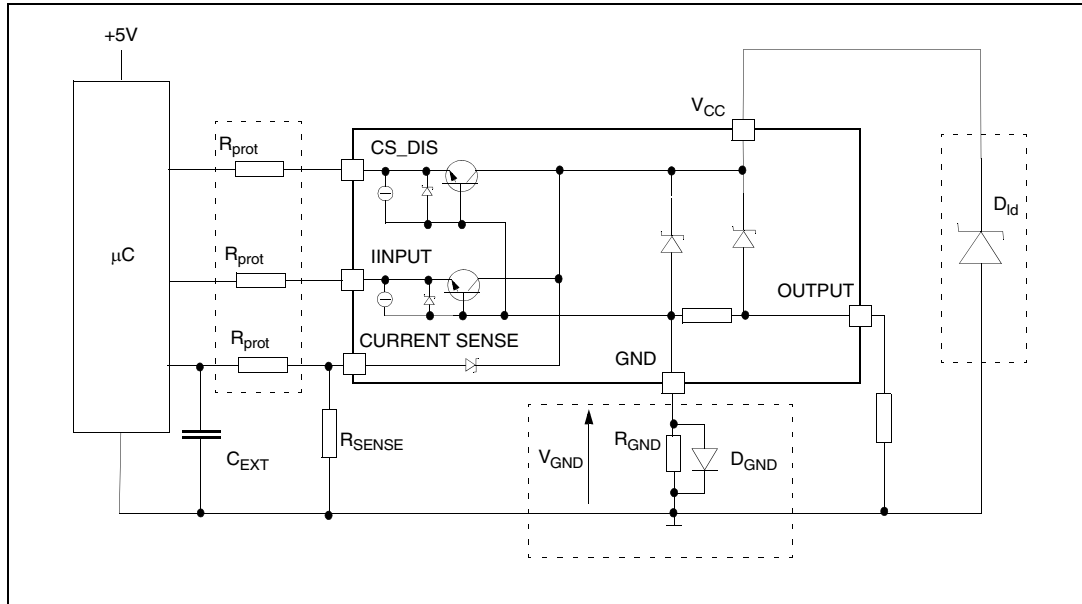


Figure 25. CS\_DIS low level voltage



### 3 Application information

Figure 26. Application schematic



Note: Channel 2 has the same internal circuit as channel 1.

### 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 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  $R_{GND}$  will produce a shift ( $I_{S(on)max} * R_{GND}$ ) in the input thresholds and the status output values. This shift will vary 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 below).

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

A resistor ( $R_{GND}=1k\Omega$ ) 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 will produce a shift ( $\approx 600mV$ ) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift will not vary if more than one HSD shares the same diode/resistor network.

## 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 the ISO 7637-2: 2004(E) table.

## 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 will be pulled negative. ST suggests to insert a resistor ( $R_{prot}$ ) in line to prevent the MCU I/Os pins to latch-up.

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

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

Calculation example:

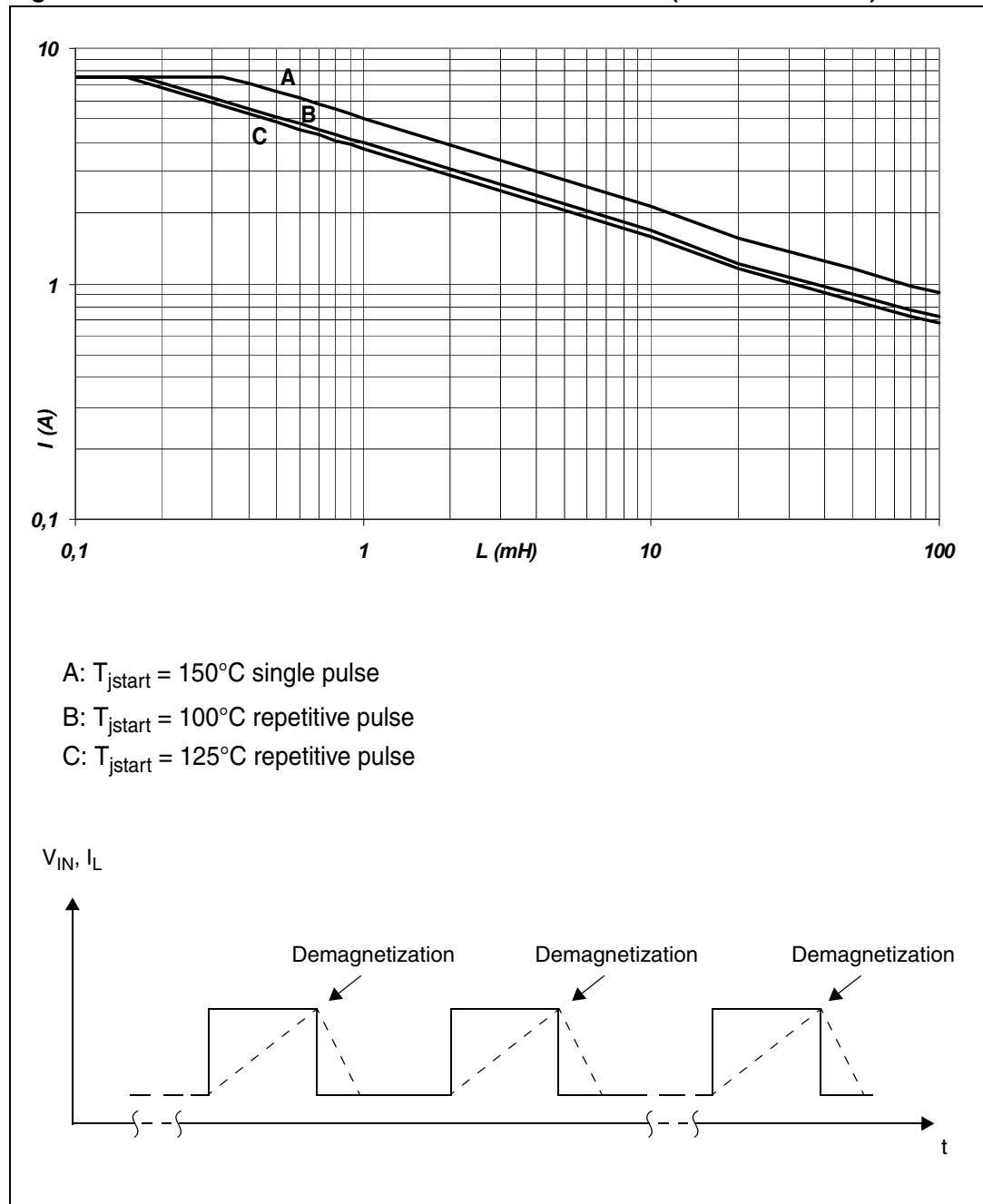
For  $V_{CCpeak} = -100V$  and  $I_{latchup} \geq 20mA$ ;  $V_{OH\mu C} \geq 4.5V$

$$5k\Omega \leq R_{prot} \leq 180k\Omega.$$

Recommended values:  $R_{prot}=10k\Omega$ ,  $C_{EXT}=10nF$ .

### 3.4 Maximum demagnetization energy ( $V_{CC} = 13.5V$ )

Figure 27. Maximum turn-Off current versus inductance (for each channel)



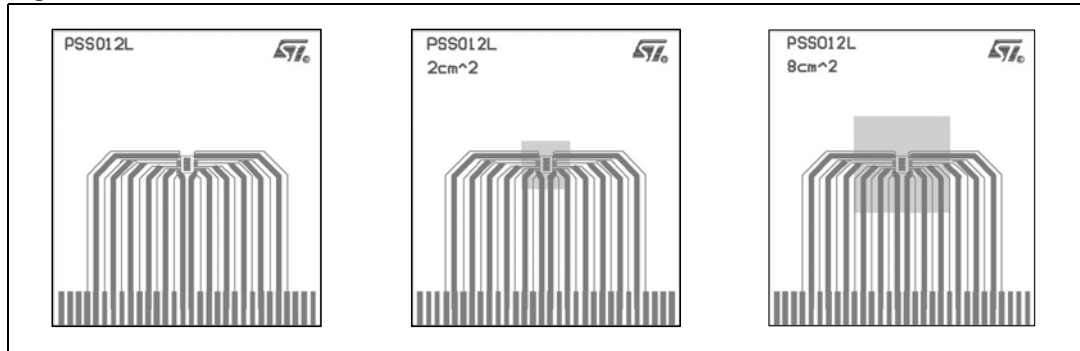
Note: Values are generated with  $R_L = 0 \Omega$ .

In case of repetitive pulses,  $T_{jstart}$  (at beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

## 4 Package and PC board thermal data

### 4.1 PowerSSO-12™ thermal data

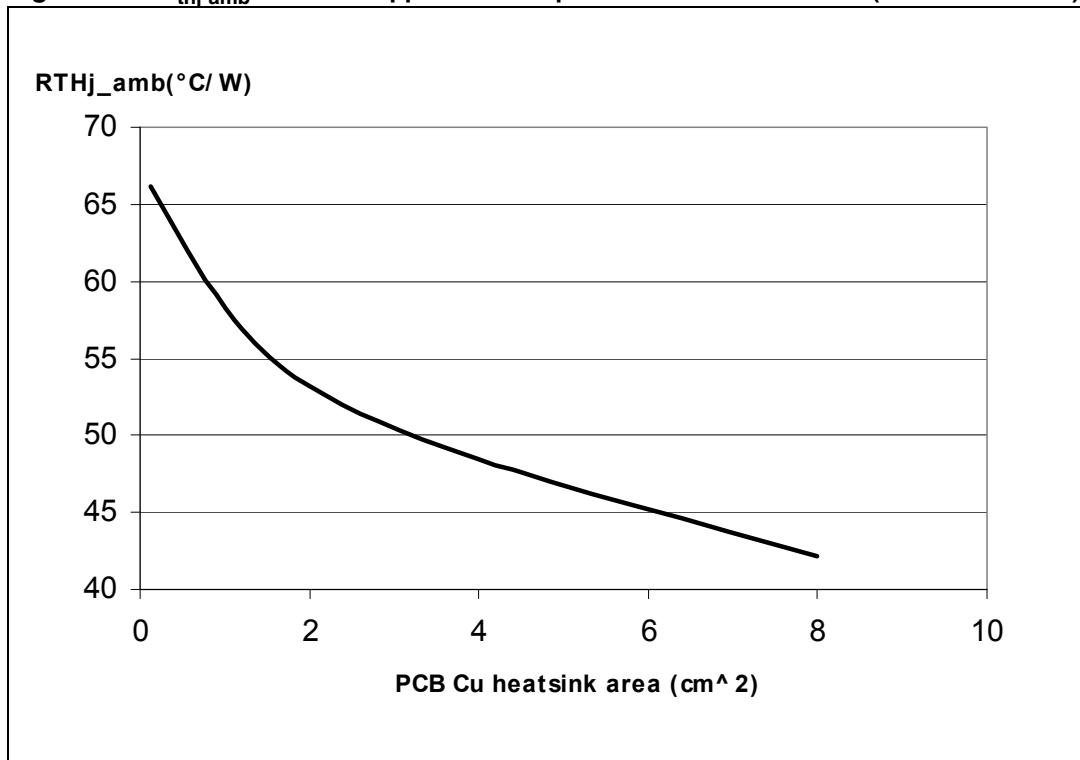
Figure 28. PowerSSO-12™ PC board



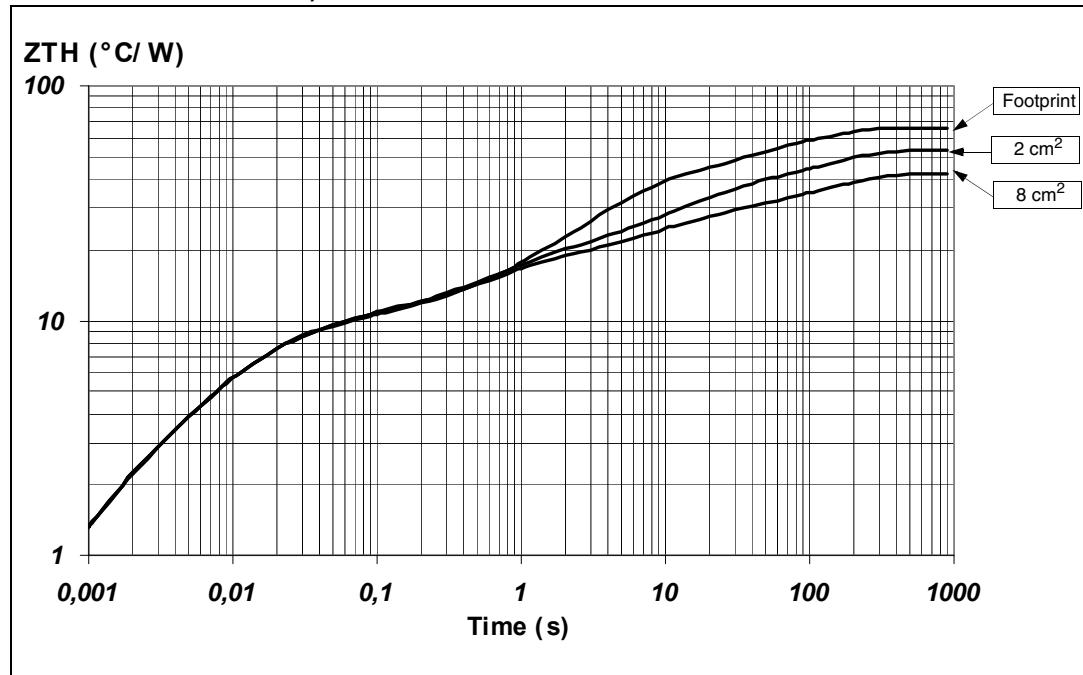
Note:

Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB: Double layer, Thermal Vias, FR4 area= 77mm x 86mm, PCB thickness=1.6mm, Cu thickness=70μm (front and back side), Copper areas: from minimum pad lay-out to 8cm²).

Figure 29.  $R_{thj-amb}$  vs. PCB copper area in open box free air condition (one channel ON)



**Figure 30. PowerSSO-12™ thermal impedance junction ambient single pulse (one channel ON)**

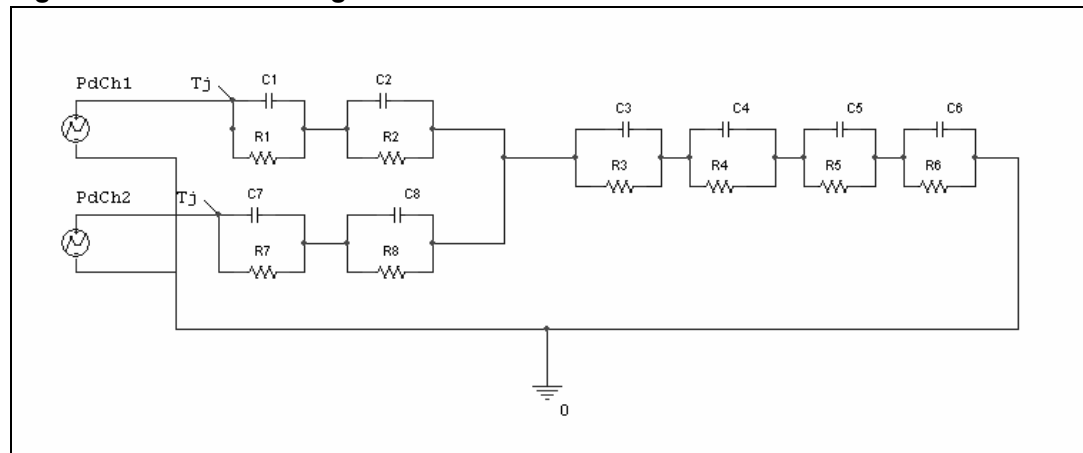


**Equation 1: pulse calculation formula**

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

where  $\delta = t_p/T$

**Figure 31. Thermal fitting model of a double channel HSD in PowerSSO-12™ (a)**



- a. The fitting model is a simplified thermal tool and is valid for transient evolutions where the embedded protections (power limitation or thermal cycling during thermal shutdown) are not triggered.

**Table 13. Thermal parameters**

| Area/island (cm <sup>2</sup> ) | Footprint | 2   | 8   |
|--------------------------------|-----------|-----|-----|
| R1= R7 (°C/W)                  | 1.2       |     |     |
| R2= R8 (°C/W)                  | 6         |     |     |
| R3 (°C/W)                      | 3         |     |     |
| R4 (°C/W)                      | 8         | 8   | 7   |
| R5 (°C/W)                      | 22        | 15  | 10  |
| R6 (°C/W)                      | 26        | 20  | 15  |
| C1= C7 (W.s/°C)                | 0.0008    |     |     |
| C2= C8 (W.s/°C)                | 0.0016    |     |     |
| C3 (W.s/°C)                    | 0.0166    |     |     |
| C4 (W.s/°C)                    | 0.2       | 0.1 | 0.1 |
| C5 (W.s/°C)                    | 0.27      | 0.8 | 1   |
| C6 (W.s/°C)                    | 3         | 6   | 9   |

## 5 Package and packing information

### 5.1 ECOPACK® packages

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a Lead-free second-level interconnect. The category of Second-Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97.

The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: [www.st.com](http://www.st.com).

### 5.2 Package mechanical data

Figure 32. PowerSSO-12™ package dimensions

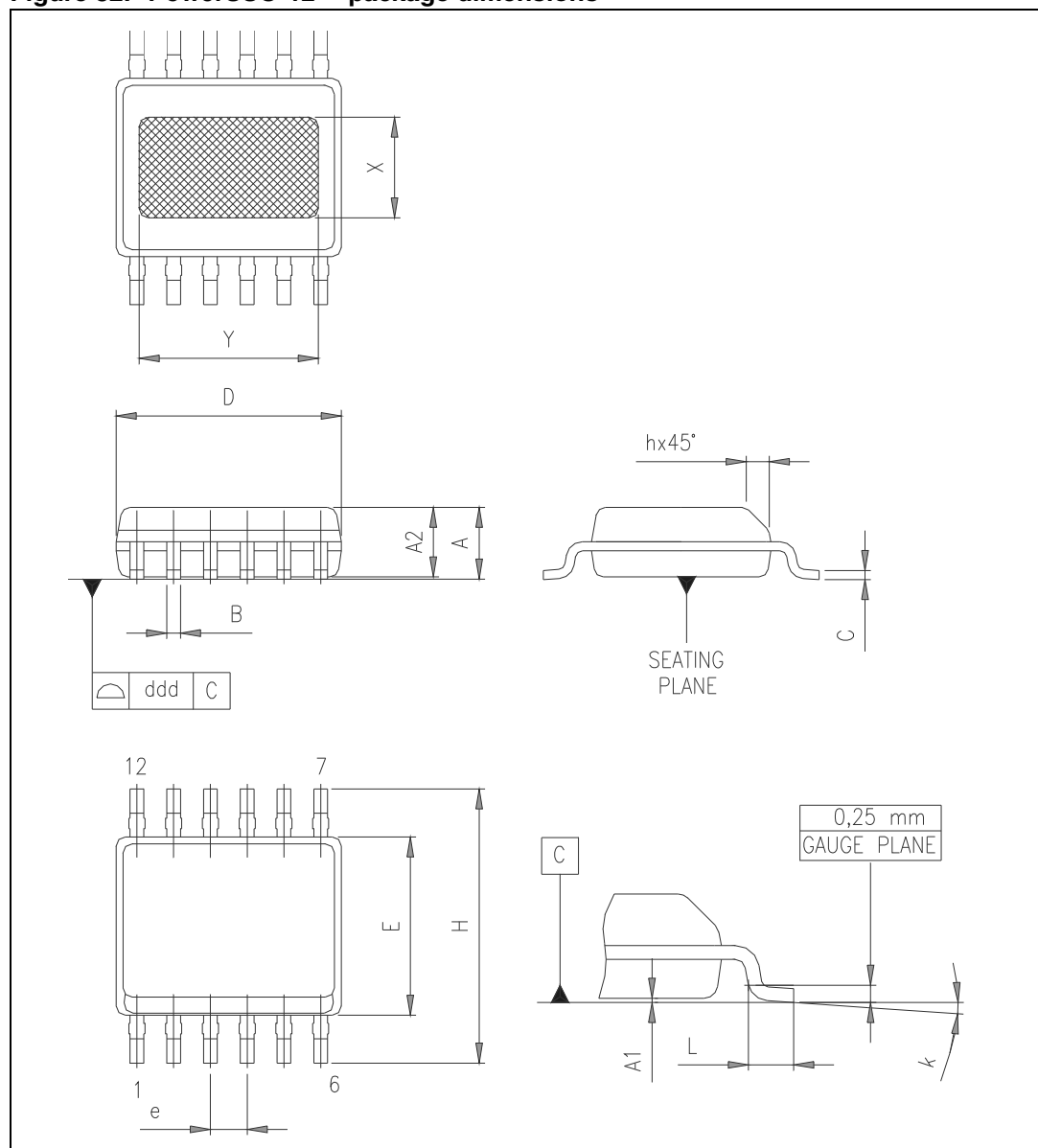


Table 14. PowerSSO-12™ mechanical data

| Symbol | Millimeters |       |       |
|--------|-------------|-------|-------|
|        | Min.        | Typ.  | Max.  |
| A      | 1.250       |       | 1.620 |
| A1     | 0.000       |       | 0.100 |
| A2     | 1.100       |       | 1.650 |
| B      | 0.230       |       | 0.410 |
| C      | 0.190       |       | 0.250 |
| D      | 4.800       |       | 5.000 |
| E      | 3.800       |       | 4.000 |
| e      |             | 0.800 |       |
| H      | 5.800       |       | 6.200 |
| h      | 0.250       |       | 0.500 |
| L      | 0.400       |       | 1.270 |
| k      | 0°          |       | 8°    |
| X      | 2.200       |       | 2.800 |
| Y      | 2.900       |       | 3.500 |
| ddd    |             |       | 0.100 |

### 5.3 Packing information

Figure 33. PowerSSO-12™ tube shipment (no suffix)

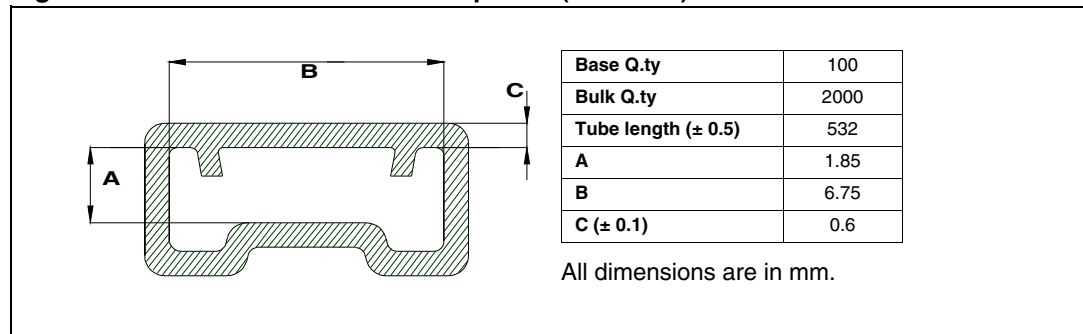
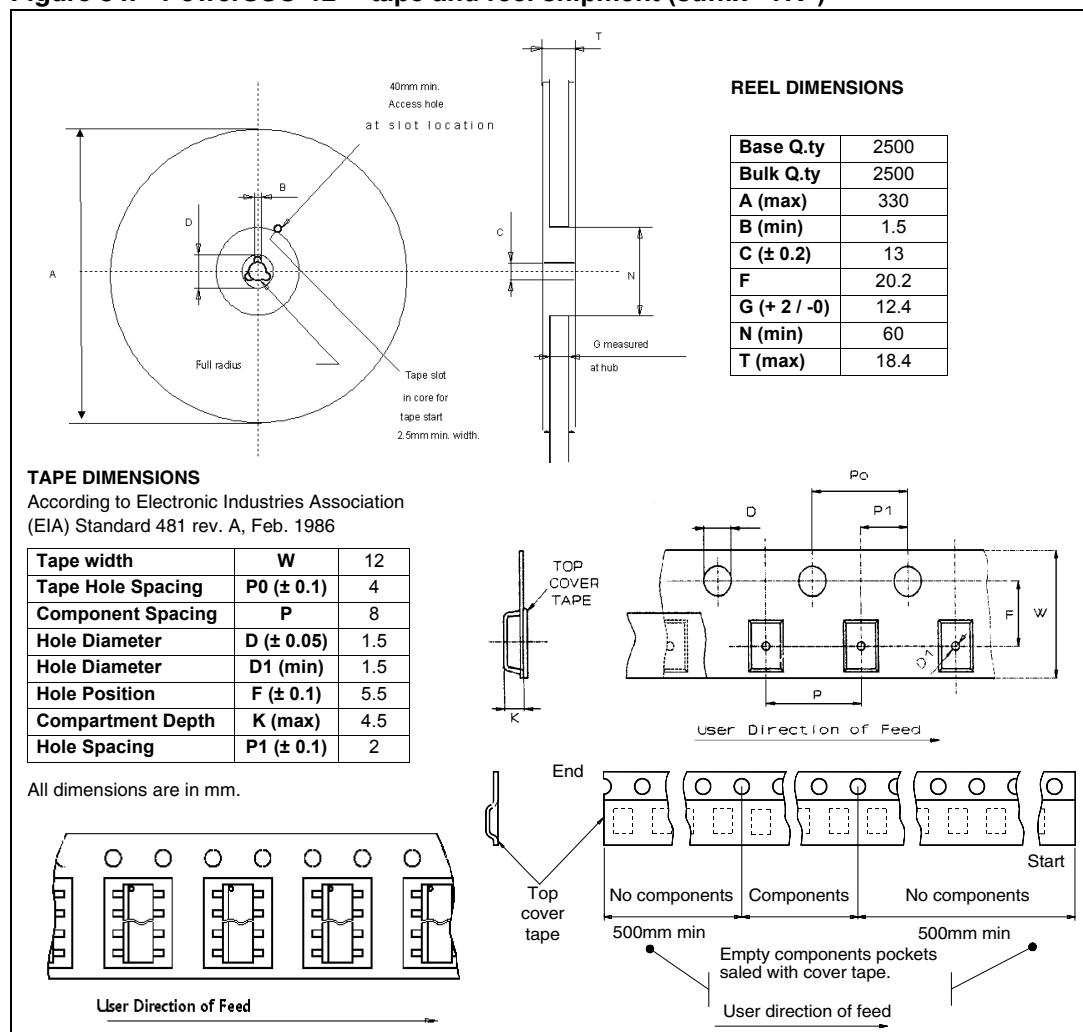


Figure 34. PowerSSO-12™ tape and reel shipment (suffix “TR”)



## 6 Revision history

**Table 15. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 13-Sep-2004 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 10-Apr-2006 | 2        | Layout changed.<br>Major update to <a href="#">Section 2: Electrical specifications</a> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 01-Mar-2007 | 3        | Reformatted.<br>Contents, List of tables and List of figures added.<br>Added <a href="#">Section 3.4: Maximum demagnetization energy (VCC = 13.5V)</a> .<br>ECOPACK <sup>®</sup> package information added.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 10-Dec-2007 | 4        | Document reformatted and restructured.<br>Updated <a href="#">Figure 2: Configuration diagram (top view)</a> : pins 7-12 left unconnected (N.C) and added note.<br><a href="#">Table 4: Absolute maximum ratings</a> : corrected E <sub>MAX</sub> value from 14 to 34 mJ.<br>Added <a href="#">Figure 5: Delay response time between rising edge of output current and rising edge of current sense (CS enabled)</a> .<br>Updated <a href="#">Figure 6: I<sub>out</sub>/ I<sub>sense</sub> vs. I<sub>out</sub> (see Table 10 for details)</a> .<br>Added <a href="#">Figure 7: Maximum current sense ratio drift vs load current</a> .<br>Updated <a href="#">Table 10: Current sense (8V&lt;VCC&lt;16V)</a> :<br>– changed t <sub>DSENSE2H</sub> max value from 300 μs to 150 μs.<br>– added dk1/k1, dk2/k2, dk3/k3, Δt <sub>DSENSE2H</sub> , I <sub>OL</sub> parameters.<br><a href="#">Table 12: Electrical transient requirements</a> : updated test level values III and IV for test pulse 5b and notes.<br>Updated <a href="#">Section 4.1: PowerSSO-12™ thermal data</a> :<br>– changed <a href="#">Figure 29: R<sub>thj-amb</sub> vs. PCB copper area in open box free air condition (one channel ON)</a> .<br>– changed <a href="#">Figure 30: PowerSSO-12™ thermal impedance junction ambient single pulse (one channel ON)</a> .<br>– <a href="#">Figure 31: Thermal fitting model of a double channel HSD in PowerSSO-12™</a> : added note.<br>– updated <a href="#">Table 13: Thermal parameters</a> :<br>R3 value changed from 7 to 3 °C/W.<br>R4 values changed from 10 /10 /9 to 8 /8 /7 °C/W.<br>C3 value changed from 0.05 to 0.0166 W.s/°C. |
| 12-Feb-2008 | 5        | Corrected typing error in <a href="#">Table 10: Current sense (8V&lt;VCC&lt;16V)</a> :<br>changed I <sub>OL</sub> test condition from V <sub>IN</sub> = 0V to V <sub>IN</sub> = 5V.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 24-Sep-2013 | 6        | Updated disclaimer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

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