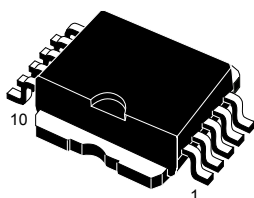


### Single channel high-side driver with analog current sense for 24 V automotive applications



PowerSO-10

### Features

| Description                            | Parameter | Value               |
|----------------------------------------|-----------|---------------------|
| Max. transient supply voltage          | $V_{CC}$  | 58 V                |
| Operating voltage range                | $V_{CC}$  | 8 to 36 V           |
| Typ. on-state resistance (per channel) | $R_{ON}$  | 6 mΩ                |
| Current limitation (typ.)              | $I_{LIM}$ | 115 A               |
| Off-state supply current               | $I_S$     | 2 μA <sup>(1)</sup> |

1. Typical value with all loads connected.

- AEC-Q100 qualified 
- General
  - Very low standby current
  - 3.0 V CMOS compatible input
  - Optimized electromagnetic emission
  - Very low electromagnetic susceptibility
  - Compliant with European directive 2002/95/EC
  - Fault reset standby pin (FR\_Stby)
- Diagnostic functions
  - Proportional load current sense
  - Current sense precision for wide range currents
  - Off-state openload detection
  - Output short to  $V_{CC}$  detection
  - Overload and short to ground latch-off
  - Thermal shutdown latch-off
  - Very low current sense leakage
- Protections
  - Undervoltage shutdown
  - Overvoltage clamp
  - Load current limitation
  - Self limiting of fast thermal transients
  - Protection against loss of ground and loss of  $V_{CC}$
  - Thermal shutdown
  - Reverse battery protected with self switch of the Power MOSFET
  - Electrostatic discharge protection

| Product status link |                |
|---------------------|----------------|
| VN5T006ASP-E        |                |
| Product summary     |                |
| Order code          | VN5T006ASP-E   |
| Package             | PowerSSO-24    |
| Packing             | Tube           |
| Order code          | VN5T006ASPTR-E |
| Package             | PowerSSO-24    |
| Packing             | Tape and reel  |

### Applications

- All types of resistive, inductive and capacitive loads

## Description

The VN5T006ASP-E is a device made using STMicroelectronics VIPower technology, intended for driving resistive or inductive loads with one side connected to the ground. Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes.

The device integrates an analog current sense, which delivers a current proportional to the load current.

Fault conditions such as overload, overtemperature, or short to  $V_{CC}$  are reported via the current sense pin.

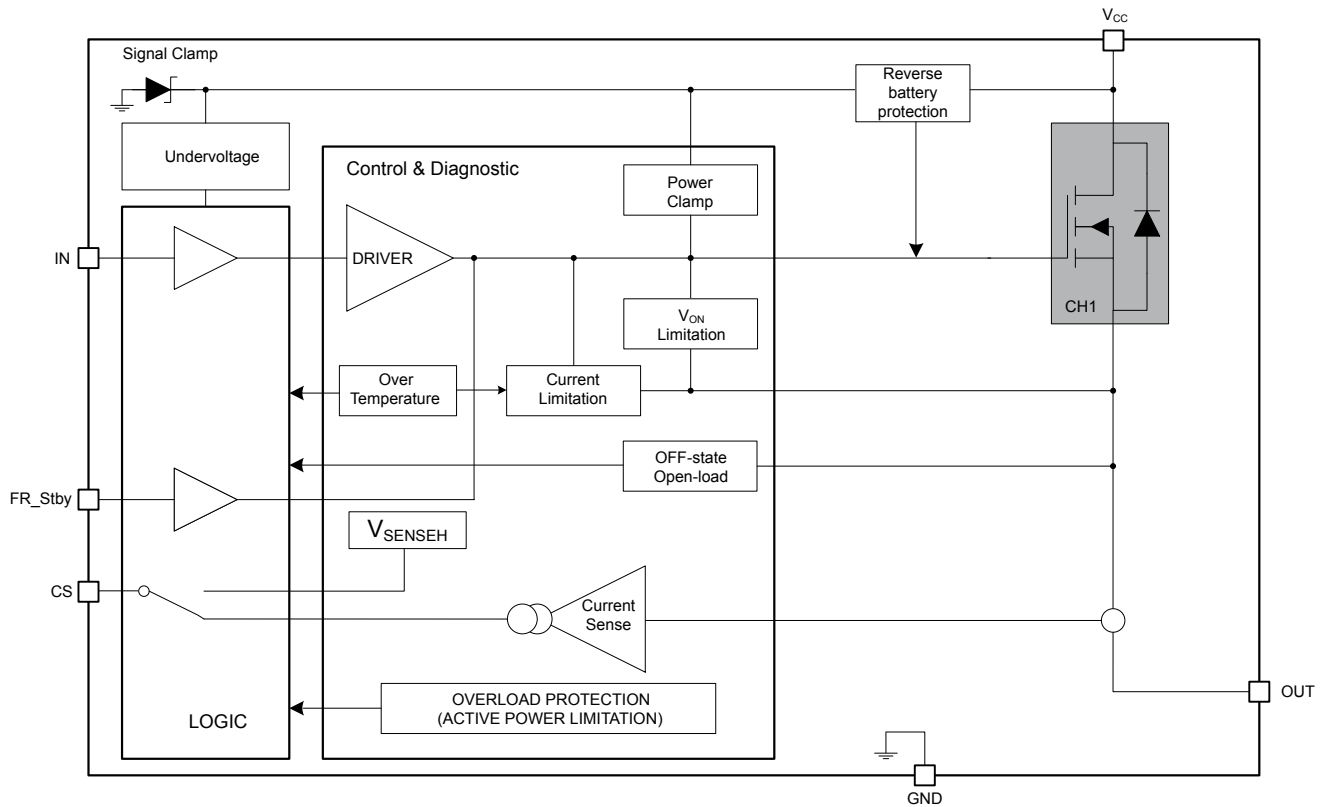
Output current limitation protects the device in overload conditions. The device latches off in case of overload or thermal shutdown.

The device is reset by a low level pass on the fault reset standby pin.

A permanent low level on the inputs and on the fault reset standby pin disables all outputs and sets the device in standby mode.

## 1 Block diagram and pin description

Figure 1. Block diagram

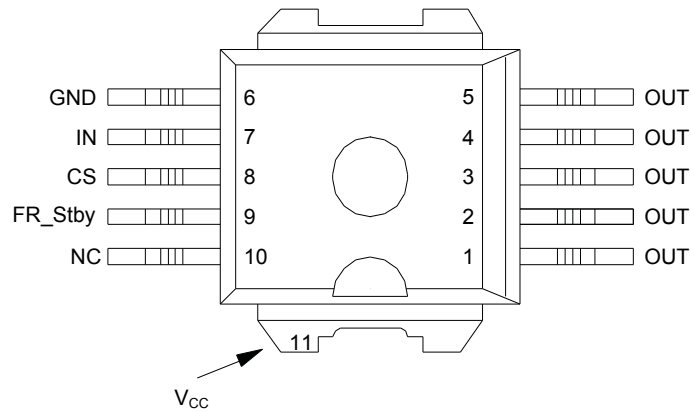


GAPGCFT00198

Table 1. Pin function

| Name            | Function                                                                                                                                                                                                       |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| V <sub>CC</sub> | Battery connection.                                                                                                                                                                                            |
| OUT             | Power output.                                                                                                                                                                                                  |
| GND             | Ground connection.                                                                                                                                                                                             |
| IN              | Voltage controlled input pin with hysteresis, CMOS compatible. It controls output switch state.                                                                                                                |
| CS              | Analog current sense pin, it delivers a current proportional to the load current.                                                                                                                              |
| FR_Stby         | In case of latch-off for overtemperature/overcurrent condition, a low pulse on the FR_Stby pin is needed to reset the channel.<br>The device enters in standby mode if all inputs and the FR_Stby pin are low. |

**Figure 2. Configuration diagram PowerSO-10 (top view)**



GAPGCFT00194

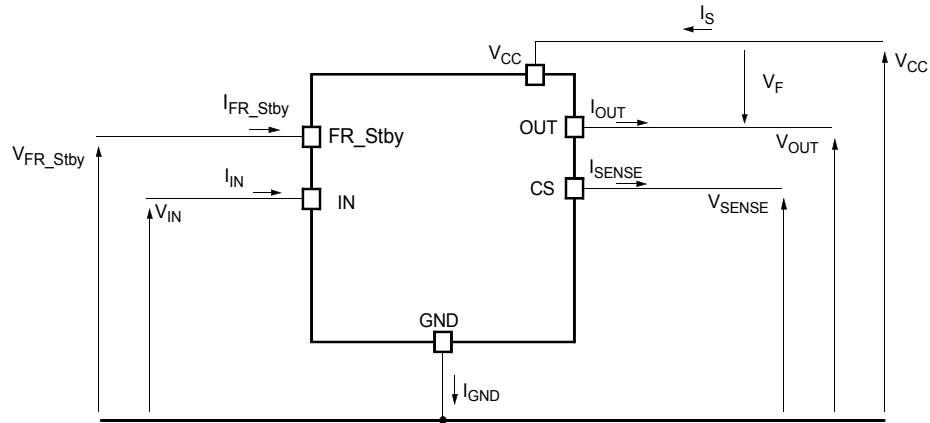
**Table 2. Suggested connections for unused and not connected pins**

| Connection/pin | CurrentSense           | NC               | Output      | Input                  | FR_Stby                |
|----------------|------------------------|------------------|-------------|------------------------|------------------------|
| Floating       | Not allowed            | X <sup>(1)</sup> | X           | X                      | X                      |
| To ground      | Through 10 kΩ resistor | X                | Not allowed | Through 10 kΩ resistor | Through 10 kΩ resistor |

1. X: do not care.

## 2 Electrical specification

**Figure 3. Current and voltage conventions**



GAPGCFT00195

### 2.1 Absolute maximum ratings

Stressing the device above the ratings listed in the [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 the conditions reported in this section for extended periods may affect device reliability.

**Table 3. Absolute maximum ratings**

| Symbol         | Parameter                                                                                                                                   |          | Value                       | Unit |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------------------------|------|
| $V_{CC}$       | DC supply voltage                                                                                                                           |          | 58                          | V    |
| $-V_{CC}$      | Reverse DC supply voltage                                                                                                                   |          | -32                         | V    |
| $I_{OUT}$      | DC output current                                                                                                                           |          | Internally limited          | A    |
| $-I_{OUT}$     | Reverse DC output current                                                                                                                   |          | 90                          | A    |
| $I_{IN}$       | DC input current                                                                                                                            |          | -1 to 10                    | mA   |
| $I_{FR\_Stby}$ | Fault reset standby DC input current                                                                                                        |          | -1 to 1.5                   | mA   |
| $V_{CSSENSE}$  | Current sense maximum voltage                                                                                                               |          | $(V_{CC} - 58)$ to $V_{CC}$ | V    |
| $E_{MAX}$      | Maximum switching energy<br>( $L = 10$ mH; $V_{BAT} = 32$ V; $T_{Jstart} = 150$ °C; $I_{OUT} = 8.9$ A)                                      |          | 880                         | mJ   |
| $L_{smax}$     | Maximum stray inductance in short circuit condition<br>$R_L = 300$ mΩ, $V_{BAT} = 32$ V, $T_{Jstart} = 150$ °C, $I_{OUT} = I_{limH}$ (max.) |          | 40                          | μH   |
| $V_{ESD}$      | Electrostatic discharge (human body model: $R = 1.5$ kΩ, $C = 100$ pF)                                                                      | IN       | 4000                        | V    |
|                |                                                                                                                                             | CS       | 2000                        |      |
|                |                                                                                                                                             | FR_Stby  | 4000                        |      |
|                |                                                                                                                                             | OUT      | 5000                        |      |
|                |                                                                                                                                             | $V_{CC}$ | 5000                        |      |
| $V_{ESD}$      | Charge device model (CDM-AEC-Q100-011)                                                                                                      |          | 750                         | V    |
| $T_J$          | Junction operating temperature                                                                                                              |          | -40 to 150                  | °C   |
| $T_{stg}$      | Storage temperature                                                                                                                         |          | -55 to 150                  | °C   |

## 2.2 Thermal data

**Table 4. Thermal data**

| Symbol     | Parameter                                                  | Value         | Unit |
|------------|------------------------------------------------------------|---------------|------|
| $R_{thJC}$ | Thermal resistance, junction-to-case (with one channel ON) | 0.8           | °C/W |
| $R_{thJA}$ | Thermal resistance, junction-to-ambient                    | See Figure 27 | °C/W |

## 2.3 Electrical characteristics

8 V <  $V_{CC}$  < 36 V, -40 °C <  $T_J$  < 150 °C, unless otherwise specified.

**Table 5. Power section**

| Symbol        | Parameter                           | Test conditions                                                                                             | Min. | Typ.             | Max.             | Unit |
|---------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------|------|------------------|------------------|------|
| $V_{CC}$      | Operating supply voltage            |                                                                                                             | 8    | 24               | 36               | V    |
| $V_{USD}$     | Undervoltage shutdown               |                                                                                                             |      | 3.5              | 5                | V    |
| $V_{USDhyst}$ | Undervoltage shutdown hysteresis    |                                                                                                             |      | 0.5              |                  | V    |
| $R_{ON}$      | On-state resistance                 | $I_{OUT} = 10$ A, $T_J = 25$ °C<br>8 V < $V_{CC}$ < 36 V                                                    |      | 6                |                  | mΩ   |
|               |                                     | $I_{OUT} = 10$ A, $T_J = 150$ °C<br>8 V < $V_{CC}$ < 36 V                                                   |      |                  | 12               |      |
| $R_{ON REV}$  | Reverse battery on-state resistance | $V_{CC} = -24$ V, $I_{OUT} = -10$ A, $T_J = 25$ °C                                                          |      |                  | 6                | mΩ   |
| $V_{clamp}$   | Clamp voltage                       | $I_S = 20$ mA                                                                                               | 58   | 64               | 70               | V    |
| $I_S$         | Supply current                      | Off-state, $V_{CC} = 24$ V, $T_J = 25$ °C,<br>$V_{IN} = V_{OUT} = V_{SENSE} = 0$ V,<br>$V_{FR\_Stby} = 0$ V |      | 2 <sup>(1)</sup> | 5 <sup>(1)</sup> | μA   |
|               |                                     | On-state, $V_{CC} = 24$ V,<br>$V_{IN} = 5$ V, $I_{OUT} = 0$ A                                               |      | 3                | 6                | mA   |
| $I_{L(off1)}$ | Off-state output current            | $V_{IN} = V_{OUT} = 0$ V,<br>$V_{CC} = 24$ V, $T_J = 25$ °C                                                 | 0    | 0.01             | 3                | μA   |
|               |                                     | $V_{IN} = V_{OUT} = 0$ V,<br>$V_{CC} = 24$ V, $T_J = 125$ °C                                                | 0    |                  | 5                |      |

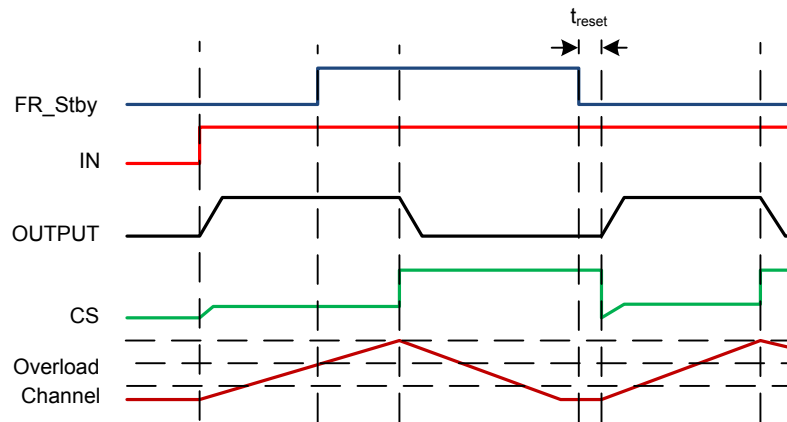
1. Power MOSFET leakage included.

**Table 6. Switching ( $V_{CC} = 24\text{ V}$ ,  $T_J = 25\text{ °C}$ )**

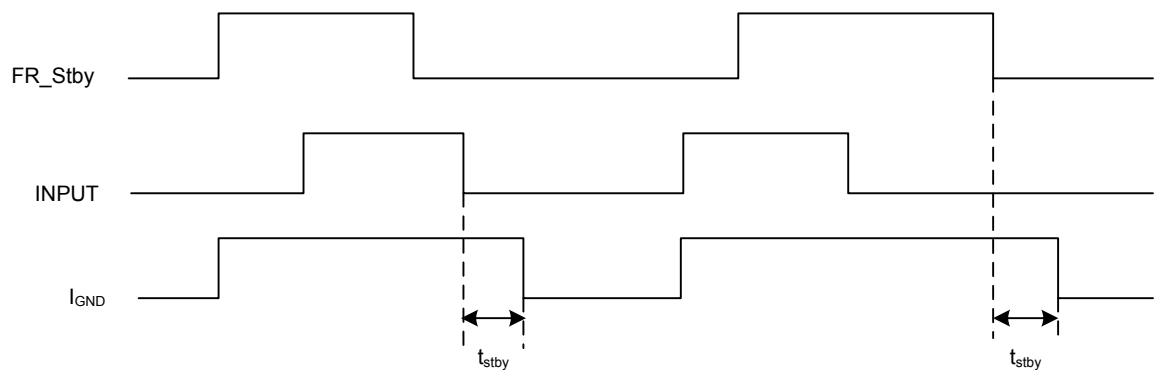
| Symbol                  | Parameter                                 | Test conditions     | Min. | Typ. | Max. | Unit                   |
|-------------------------|-------------------------------------------|---------------------|------|------|------|------------------------|
| $t_{d(on)}$             | Turn-on delay time                        | $R_L = 2.4\ \Omega$ |      | 32   |      | $\mu\text{s}$          |
| $t_{d(off)}$            | Turn-off delay time                       | $R_L = 2.4\ \Omega$ |      | 67   |      | $\mu\text{s}$          |
| $(dV_{OUT}/dt)_{(on)}$  | Turn-on voltage slope                     | $R_L = 2.4\ \Omega$ |      | 0.7  |      | $\text{V}/\mu\text{s}$ |
| $(dV_{OUT}/dt)_{(off)}$ | Turn-off voltage slope                    | $R_L = 2.4\ \Omega$ |      | 0.46 |      | $\text{V}/\mu\text{s}$ |
| $W_{ON}$                | Switching energy losses during $t_{won}$  | $R_L = 2.4\ \Omega$ |      | 4.15 |      | mJ                     |
| $W_{OFF}$               | Switching energy losses during $t_{woff}$ | $R_L = 2.4\ \Omega$ |      | 2.7  |      | mJ                     |

**Table 7. Logic inputs**

| Symbol               | Parameter                              | Test conditions                                      | Min. | Typ. | Max. | Unit          |
|----------------------|----------------------------------------|------------------------------------------------------|------|------|------|---------------|
| $V_{IL}$             | Input low level voltage                |                                                      |      |      | 0.9  | V             |
| $I_{IL}$             | Low level input current                | $V_{IN} = 0.9\text{ V}$                              | 1    |      |      | $\mu\text{A}$ |
| $V_{IH}$             | Input high level voltage               |                                                      | 2.1  |      |      | V             |
| $I_{IH}$             | High level input current               | $V_{IN} = 2.1\text{ V}$                              |      |      | 10   | $\mu\text{A}$ |
| $V_{I(hyst)}$        | Input hysteresis voltage               |                                                      | 0.25 |      |      | V             |
| $V_{ICL}$            | Input clamp voltage                    | $I_{IN} = 1\text{ mA}$                               | 5.5  |      | 7    | V             |
|                      |                                        | $I_{IN} = -1\text{ mA}$                              |      | -0.7 |      |               |
| $V_{FR\_Stby\_L}$    | Fault_reset_standby low level voltage  |                                                      |      |      | 0.9  | V             |
| $I_{FR\_Stby\_L}$    | Low level fault_reset_standby current  | $V_{FR\_Stby} = 0.9\text{ V}$                        | 1    |      |      | $\mu\text{A}$ |
| $V_{FR\_Stby\_H}$    | Fault_reset_standby high level voltage |                                                      | 2.1  |      |      | V             |
| $I_{FR\_Stby\_H}$    | High level fault_reset_standby current | $V_{FR\_Stby} = 2.1\text{ V}$                        |      |      | 10   | $\mu\text{A}$ |
| $V_{FR\_Stby(hyst)}$ | Fault_reset_standby hysteresis voltage |                                                      | 0.25 |      |      | V             |
| $V_{FR\_Stby\_CL}$   | Fault_reset_standby clamp voltage      | $I_{FR\_Stby} = 15\text{ mA}$ ( $t < 10\text{ ms}$ ) | 11   |      | 15   | V             |
|                      |                                        | $I_{FR\_Stby} = -1\text{ mA}$                        |      | -0.7 |      | V             |
| $t_{reset}$          | Overload latch-off reset time          | See <a href="#">Figure 4</a>                         | 2    |      | 24   | $\mu\text{s}$ |
| $t_{stby}$           | Standby delay                          | See <a href="#">Figure 5</a>                         | 120  |      | 1200 | $\mu\text{s}$ |

**Figure 4.  $t_{\text{reset}}$  definition**


GAPGCFT000112

**Figure 5.  $t_{\text{stby}}$  definition**


GAPGCFT000111

**Table 8. Protections and diagnostics**

| Symbol            | Parameter                                              | Test conditions                                                                  | Min.                 | Typ.                 | Max.                 | Unit |
|-------------------|--------------------------------------------------------|----------------------------------------------------------------------------------|----------------------|----------------------|----------------------|------|
| $I_{\text{limH}}$ | DC short circuit current                               | $V_{\text{CC}} = 24 \text{ V}$                                                   | 81                   | 115                  | 162                  | A    |
|                   |                                                        | $5 \text{ V} < V_{\text{CC}} < 36 \text{ V}$                                     |                      |                      | 162                  |      |
| $I_{\text{limL}}$ | Short circuit current during thermal cycling           | $V_{\text{CC}} = 24 \text{ V}, T_{\text{R}} < T_{\text{J}} < T_{\text{TSD}}$     |                      | 29                   |                      | A    |
| $T_{\text{TSD}}$  | Shutdown temperature                                   |                                                                                  | 150                  | 175                  | 200                  | °C   |
| $T_{\text{R}}$    | Reset temperature                                      |                                                                                  | $T_{\text{RS}} + 1$  | $T_{\text{RS}} + 5$  |                      | °C   |
| $T_{\text{RS}}$   | Thermal reset of status                                |                                                                                  | 135                  |                      |                      | °C   |
| $T_{\text{HYST}}$ | Thermal hysteresis ( $T_{\text{TSD}} - T_{\text{R}}$ ) |                                                                                  |                      | 7                    |                      | °C   |
| $V_{\text{DEMG}}$ | Turn-off output voltage clamp                          | $I_{\text{OUT}} = 10 \text{ A}, V_{\text{IN}} = 0 \text{ V}, L = 6 \text{ mH}$   | $V_{\text{CC}} - 58$ | $V_{\text{CC}} - 64$ | $V_{\text{CC}} - 70$ | V    |
| $V_{\text{ON}}$   | Output voltage drop limitation                         | $I_{\text{OUT}} = 1 \text{ A}, T_{\text{J}} = -40 \text{ °C to } 150 \text{ °C}$ |                      | 25                   |                      | mV   |

**Table 9. Current sense ( $8\text{ V} < V_{CC} < 36\text{ V}$ )**

| Symbol               | Parameter                 | Test conditions                                                                                                                                                             | Min. | Typ.  | Max.  | Unit |
|----------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|-------|------|
| $K_0$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 0.6\text{ A}$ , $V_{SENSE} = 0.5\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                             | 3930 | 11250 | 19850 |      |
|                      |                           | $I_{OUT} = 0.6\text{ A}$ , $V_{SENSE} = 0.5\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                              | 5035 |       | 17055 |      |
| $dK_0/K_0^{(1)}$     | Current sense ratio drift | $I_{OUT} = 0.6\text{ A}$ , $V_{SENSE} = 0.5\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                             | -30  |       | 30    | %    |
| $K_1$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 1.6\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                               | 5600 | 10750 | 16940 |      |
|                      |                           | $I_{OUT} = 1.6\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | 6215 |       | 14660 |      |
| $dK_1/K_1^{(1)}$     | Current sense ratio drift | $I_{OUT} = 1.6\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                               | -28  |       | 25    | %    |
| $K_2$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 2.4\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                               | 6030 | 10370 | 15865 |      |
|                      |                           | $I_{OUT} = 2.4\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | 6200 |       | 13635 |      |
| $dK_2/K_2^{(1)}$     | Current sense ratio drift | $I_{OUT} = 2.4\text{ A}$ , $V_{SENSE} = 1\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                               | -26  |       | 23    | %    |
| $K_3$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 3\text{ A}$ , $V_{SENSE} = 2\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                 | 6040 | 10070 | 15285 |      |
|                      |                           | $I_{OUT} = 3\text{ A}$ , $V_{SENSE} = 2\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                  | 6040 |       | 13090 |      |
| $dK_3/K_3^{(1)}$     | Current sense ratio drift | $I_{OUT} = 3\text{ A}$ , $V_{SENSE} = 2\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                 | -25  |       | 22    | %    |
| $K_4$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 6\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                 | 5845 | 8670  | 13630 |      |
|                      |                           | $I_{OUT} = 6\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                  | 6000 |       | 10895 |      |
| $dK_4/K_4^{(1)}$     | Current sense ratio drift | $I_{OUT} = 6\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                 | -20  |       | 20    | %    |
| $K_5$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 10\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | 5920 | 8400  | 11520 |      |
|                      |                           | $I_{OUT} = 10\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = 25\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                 | 6730 |       | 9765  |      |
| $dK_5/K_5^{(1)}$     | Current sense ratio drift | $I_{OUT} = 10\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | -15  |       | 15    | %    |
| $K_6$                | $I_{OUT}/I_{SENSE}$       | $I_{OUT} = 20\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | 6960 | 8330  | 10090 |      |
| $dK_6/K_6^{(1)}$     | Current sense ratio drift | $I_{OUT} = 20\text{ A}$ , $V_{SENSE} = 4\text{ V}$ ,<br>$T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$                                                | -8   |       | 8     | %    |
| $dK/K_{BULB1}^{(1)}$ | Current sense ratio drift | $I_{OUT} = 0.6\text{ A}$ to $6\text{ A}$ , $I_{OUTCAL} = 3\text{ A}$ ,<br>$V_{SENSE} = 0.5\text{ V}$ , $T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$ | -30  |       | 50    | %    |
| $dK/K_{BULB2}^{(1)}$ | Current sense ratio drift | $I_{OUT} = 1.6\text{ A}$ to $4.2\text{ A}$ , $I_{OUTCAL} = 3\text{ A}$ ,<br>$V_{SENSE} = 2\text{ V}$ , $T_J = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$ | -30  |       | 26    | %    |

| Symbol                | Parameter                                                                                  | Test conditions                                                                                                                                             | Min. | Typ. | Max. | Unit          |
|-----------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $dK/K_{BULB3}^{(1)}$  | Current sense ratio drift                                                                  | $I_{OUT} = 0.6\text{ A to }2.4\text{ A}$ , $I_{OUTCAL} = 1.6\text{ A}$ ,<br>$V_{SENSE} = 2\text{ V}$ , $T_J = -40\text{ °C to }150\text{ °C}$               | -27  |      | 25   | %             |
| $I_{SENSE0}$          | Analog sense leakage current                                                               | $I_{OUT} = 0\text{ A}$ , $V_{SENSE} = 0\text{ V}$ ,<br>$V_{IN} = 0\text{ V}$ , $T_J = -40\text{ °C to }150\text{ °C}$                                       | 0    |      | 1    | $\mu\text{A}$ |
|                       |                                                                                            | $I_{OUT} = 0\text{ A}$ , $V_{SENSE} = 0\text{ V}$ ,<br>$V_{IN} = 5\text{ V}$ , $T_J = -40\text{ °C to }150\text{ °C}$                                       | 0    |      | 2    |               |
| $V_{SENSE}$           | Max. analog sense output voltage                                                           | $I_{OUT} = 40\text{ A}$ , $R_{SENSE} = 3.9\text{ k}\Omega$                                                                                                  | 5    |      |      | V             |
| $V_{SENSEH}$          | Analog sense output voltage in fault condition <sup>(2)</sup>                              | $V_{CC} = 24\text{ V}$ , $R_{SENSE} = 3.9\text{ k}\Omega$                                                                                                   |      | 8    |      | V             |
| $I_{SENSEH}$          | Analog sense output current in fault condition <sup>(2)</sup>                              | $V_{CC} = 24\text{ V}$ , $V_{SENSE} = 5\text{ V}$                                                                                                           |      | 9    | 12   | mA            |
| $t_{DSENSE2H}$        | Delay response time from rising edge of INPUT pin                                          | $V_{SENSE} < 4\text{ V}$ , $1\text{ A} < I_{OUT} < 40\text{ A}$ ,<br>$I_{SENSE} = 90\%$ of $I_{SENSEMAX}$<br>(see Figure 6)                                 |      | 300  | 600  | $\mu\text{s}$ |
| $\Delta t_{DSENSE2H}$ | Delay response time between rising edge of output current and rising edge of current sense | $V_{SENSE} < 4\text{ V}$ ,<br>$I_{SENSE} = 90\%$ of $I_{SENSEMAX}$ ,<br>$I_{OUT} = 90\%$ of $I_{OUTMAX}$ ,<br>$I_{OUTMAX} = 10\text{ A}$<br>(see Figure 10) |      |      | 450  | $\mu\text{s}$ |
| $t_{DSENSE2L}$        | Delay response time from falling edge of INPUT pin                                         | $V_{SENSE} < 4\text{ V}$ , $1\text{ A} < I_{OUT} < 40\text{ A}$ ,<br>$I_{SENSE} = 10\%$ of $I_{SENSEMAX}$<br>(see Figure 6)                                 |      | 5    | 20   | $\mu\text{s}$ |

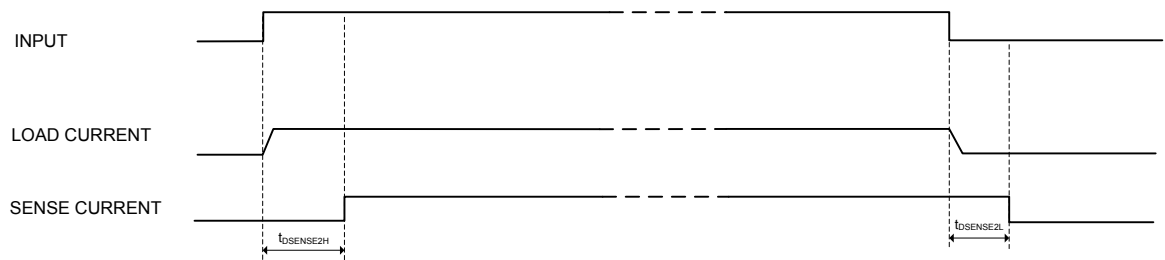
1. Specified by design, not tested in production.

2. Fault condition includes: power limitation, overtemperature and openload in off-state condition.

**Table 10. Openload detection ( $V_{FR\_Stby} = 5\text{ V}$ )**

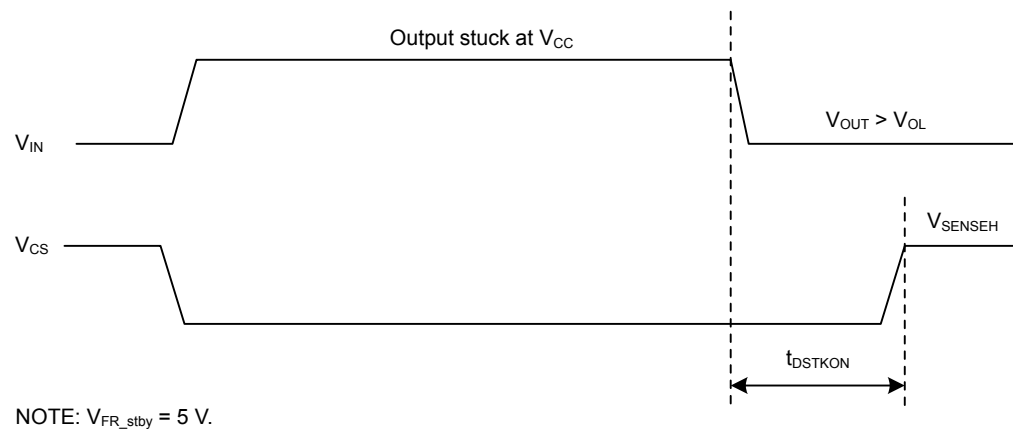
| Symbol           | Parameter                                                                     | Test conditions                                                                                                              | Min. | Typ. | Max. | Unit          |
|------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $V_{OL}$         | Openload off-state voltage detection threshold                                | $V_{IN} = 0\text{ V}$ , $8\text{ V} < V_{CC} < 36\text{ V}$                                                                  | 2    | -    | 4    | V             |
| $t_{DSTKON}$     | Output short circuit to VCC detection delay at turn off                       | See Figure 7                                                                                                                 | 180  | -    | 1800 | $\mu\text{s}$ |
| $I_{L(off2)}$    | Off-state output current at $V_{OUT} = 4\text{ V}$                            | $V_{IN} = 0\text{ V}$ , $V_{SENSE} = 0\text{ V}$ ,<br>$V_{OUT}$ rising from $0\text{ V}$ to $4\text{ V}$                     | -120 | -    | 0    | $\mu\text{A}$ |
| $t_{d\_vol}$     | Delay response from output rising edge to $V_{SENSE}$ rising edge in openload | $V_{OUT} = 4\text{ V}$ , $V_{IN} = 0\text{ V}$ ,<br>$V_{SENSE} = 90\%$ of $V_{SENSEH}$ ,<br>$R_{SENSE} = 3.9\text{ k}\Omega$ |      | -    | 20   | $\mu\text{s}$ |
| $t_{DFRSTK\_ON}$ | Output short circuit to $V_{CC}$ detection delay at $FR\_Stby$ activation     | Input = low<br>(see Figure 9)                                                                                                |      | -    | 50   | $\mu\text{s}$ |

**Figure 6. Current sense delay characteristics**



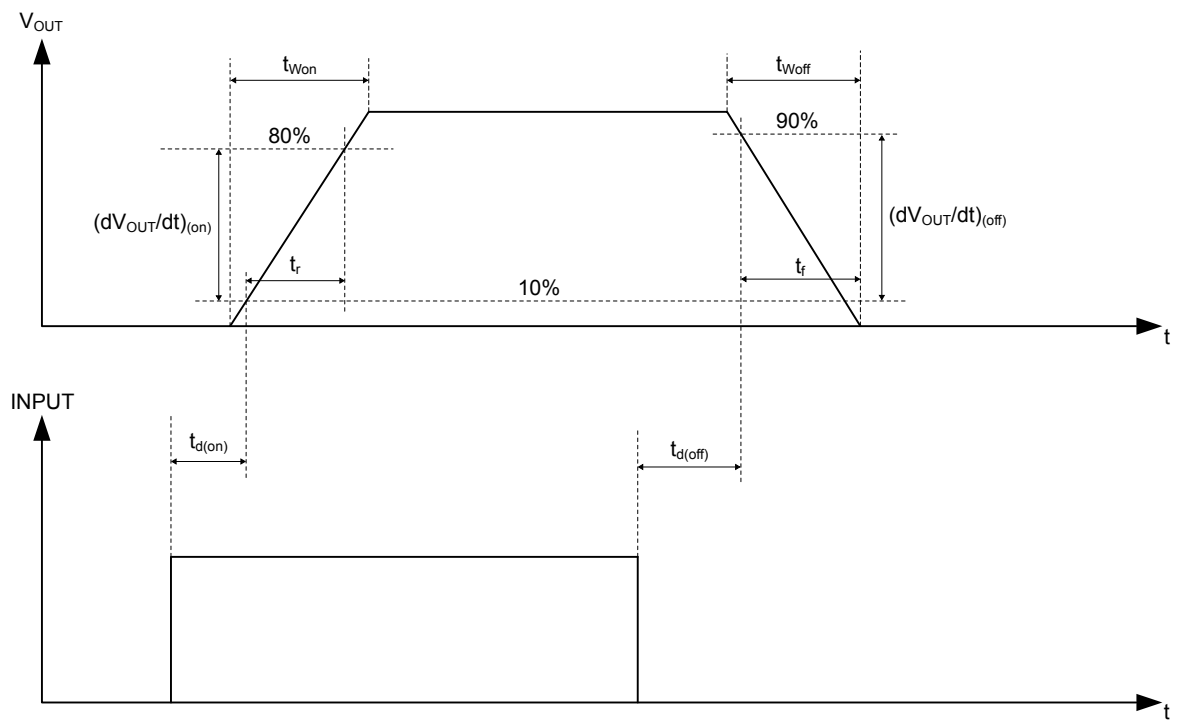
GAPGCFT000117

**Figure 7. Openload off-state delay timing**



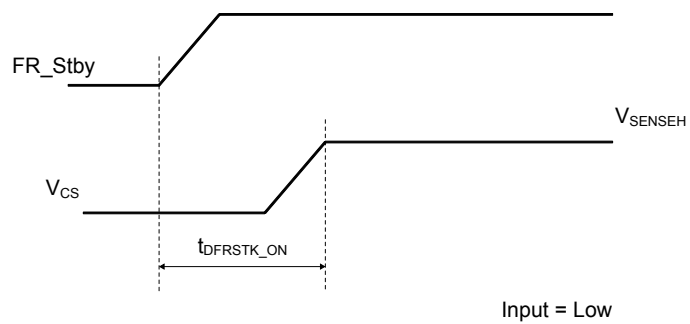
GAPGCFT000113

Figure 8. Switching characteristics



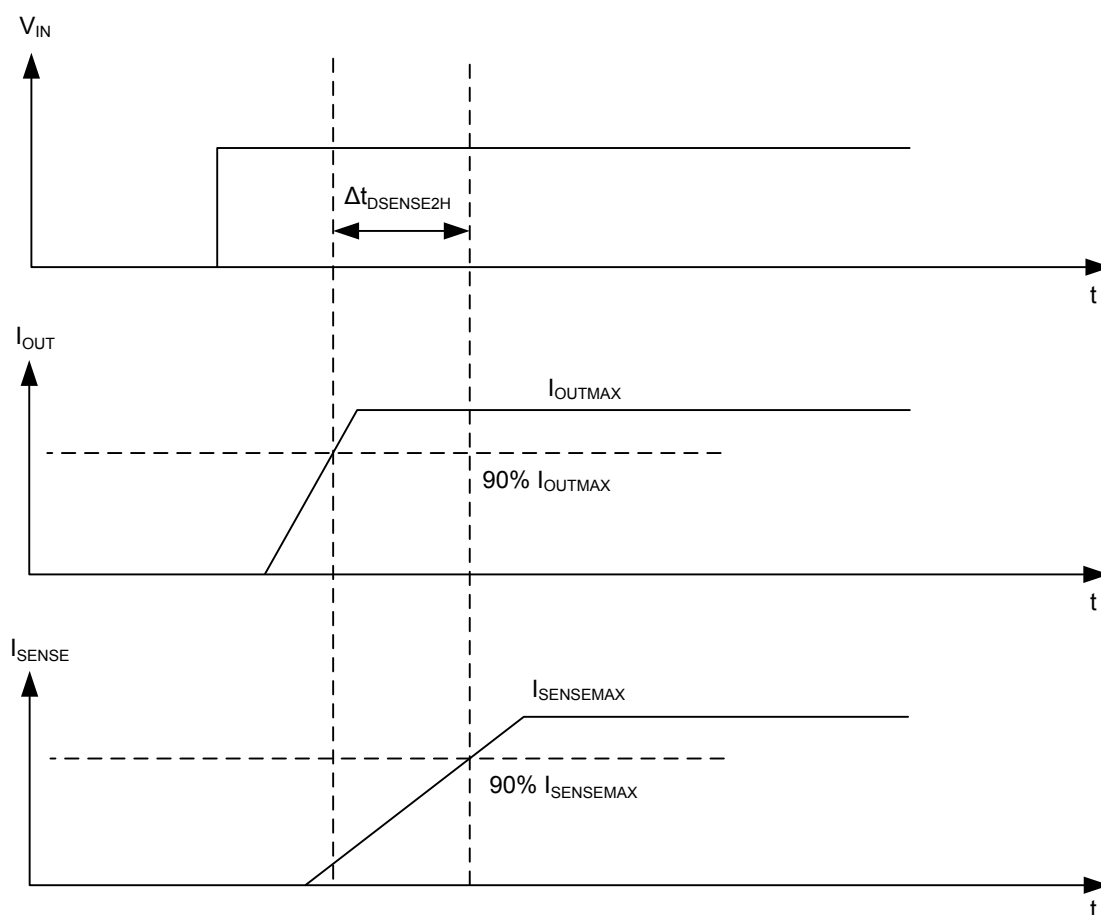
GAPGCFT000114

Figure 9. Output stuck to  $V_{CC}$  detection delay time at FR\_Stby activation



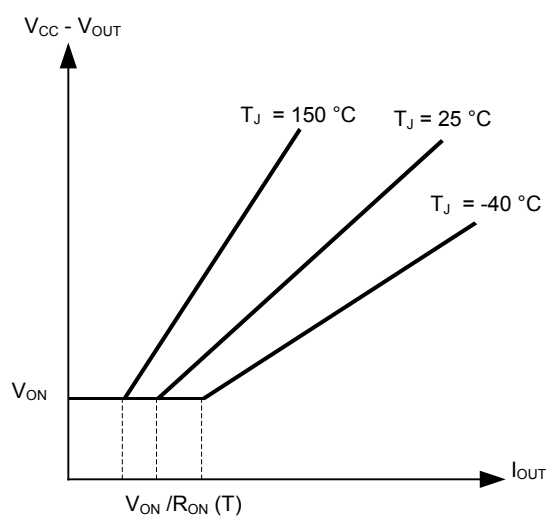
GAPGCFT00038

Figure 10. Delay response time between rising edge of output current and rising edge of current sense

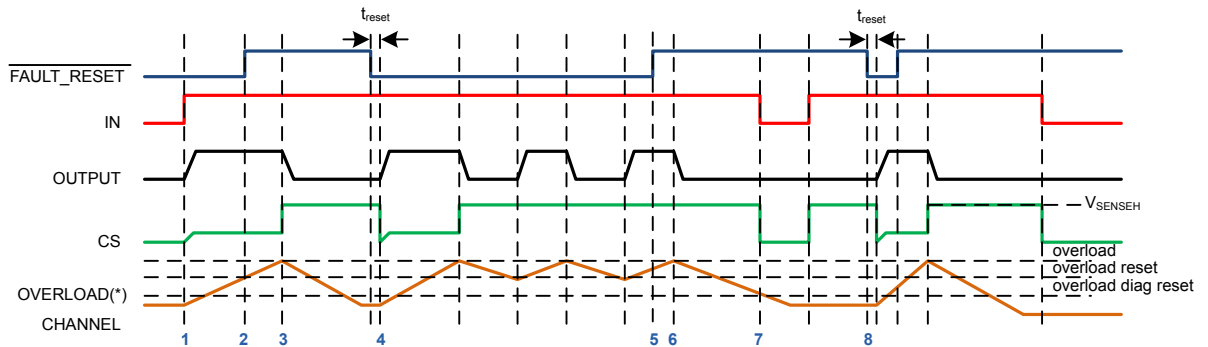


GAPGCFT000115

Figure 11. Output voltage drop limitation



AG00074V1

**Figure 12. Device behavior in overload condition**


- 1: OUTPUT and CS controlled by IN
- 2: FAULT\_RESET from '0' to '1' → no action on CS pin
- 3: overload latch-off. IN high → CS high
- 4: FAULT\_RESET low AND Temp channel < overload\_reset → overload latch reset after  $t_{reset}$
- 4 to 5: FAULT\_RESET low AND IN high → thermal cycling, CS high
- 5: FAULT\_RESET high → latch-off reset disabled
- 6 to 7: overload event and FAULT\_RESET high → latch-off, no thermal cycling
- 7 to 8: overload diagnostic disabled/enabled by the input
- 8: overload latch-off reset by FAULT\_RESET

(\*) OVERLOAD = thermal shutdown OR power limitation

GAPGCFT000116

**Table 11. Truth table**

| Conditions                        | Fault reset standby | Input | Output   | Sense        |
|-----------------------------------|---------------------|-------|----------|--------------|
| Standby                           | L                   | L     | L        | 0            |
| Normal operation                  | X                   | L     | L        | 0            |
|                                   | X                   | H     | H        | Nominal      |
| Overload                          | X                   | L     | L        | 0            |
|                                   | X                   | H     | H        | > Nominal    |
| Overtemperature/short to ground   | X                   | L     | L        | 0            |
|                                   | L                   | H     | Cycling  | $V_{SENSEH}$ |
|                                   | H                   | H     | Latched  | $V_{SENSEH}$ |
| Undervoltage                      | X                   | X     | L        | 0            |
| Short to $V_{BAT}$                | L                   | L     | H        | 0            |
|                                   | H                   | L     | H        | $V_{SENSEH}$ |
|                                   | X                   | H     | H        | < Nominal    |
| Openload off-state (with pull-up) | L                   | L     | H        | 0            |
|                                   | H                   | L     | H        | $V_{SENSEH}$ |
|                                   | X                   | H     | H        | 0            |
| Negative output voltage clamp     | X                   | L     | Negative | 0            |

**Table 12. Electrical transient requirements (part 1)**

| 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                                     | -450 V                     | -600 V  | 5000<br>pulses                       | 0.5 s                                | 5 s    | 1 ms, 50 $\Omega$        |
| 2a                                    | 37 V                       | 50 V    | 5000<br>pulses                       | 0.2 s                                | 5 s    | 50 $\mu$ s, 2 $\Omega$   |
| 3a                                    | - 150 V                    | - 200 V | 1 h                                  | 90 ms                                | 100 ms | 0.1 $\mu$ s, 50 $\Omega$ |
| 3b                                    | + 150 V                    | + 200 V | 1 h                                  | 90 ms                                | 100 ms | 0.1 $\mu$ s, 50 $\Omega$ |
| 4                                     | - 12 V                     | - 16 V  | 1 pulse                              |                                      |        | 100 ms, 0.01 $\Omega$    |
| 5b <sup>(2)</sup>                     | + 123 V                    | + 174 V | 1 pulse                              |                                      |        | 350 ms, 1 $\Omega$       |

1. The above test levels must be considered referred to  $V_{CC} = 24.5$  V except for pulse 5b.
2. Valid in case of external load dump clamp: 58 V maximum referred to ground.

**Table 13. Electrical transient requirements (part 2)**

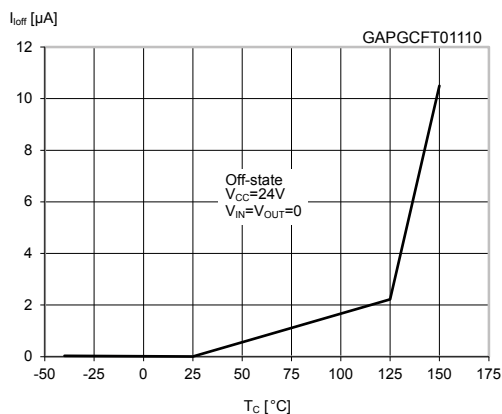
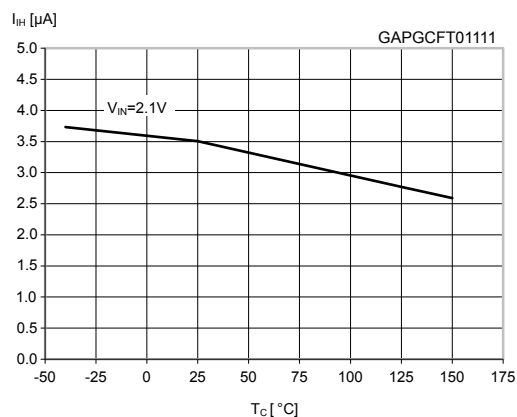
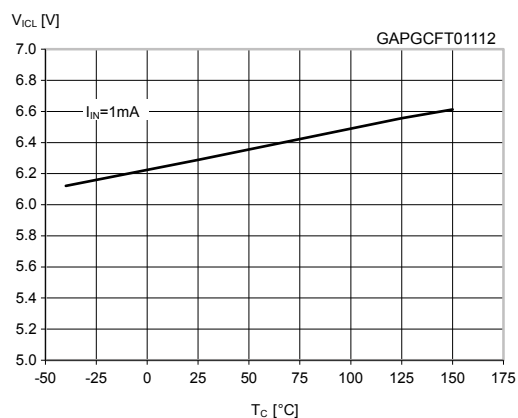
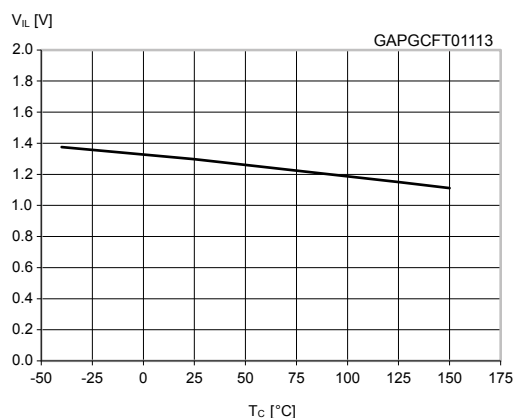
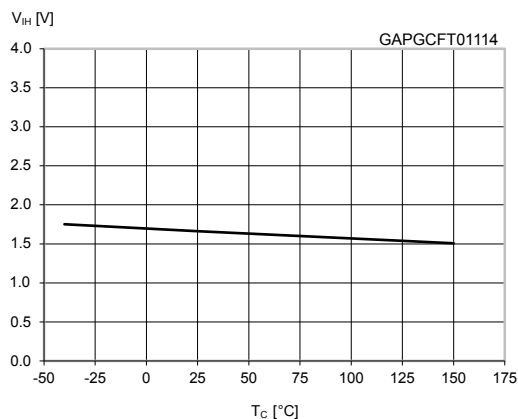
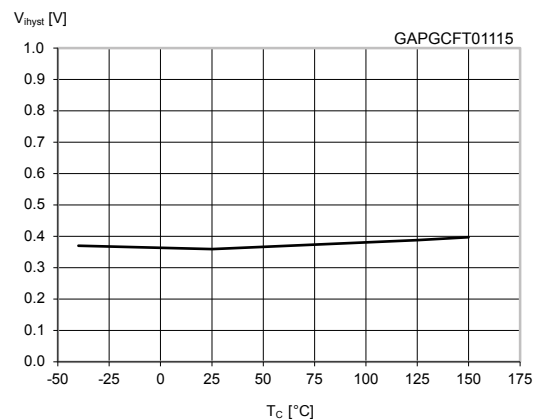
| ISO 7637-2: 2004 (E)<br>Test pulse | Test level results |                  |
|------------------------------------|--------------------|------------------|
|                                    | III                | IV               |
| 1                                  | C                  | C <sup>(1)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

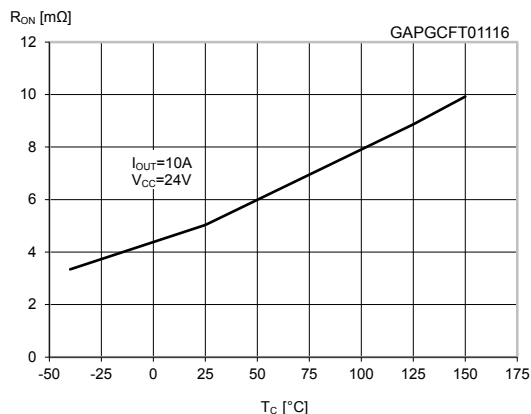
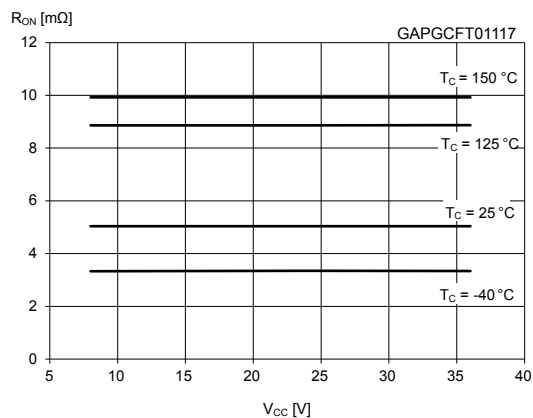
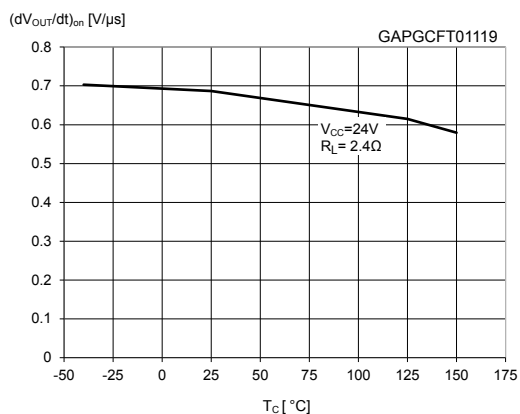
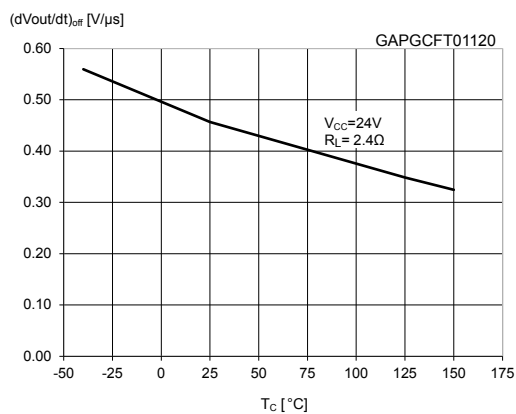
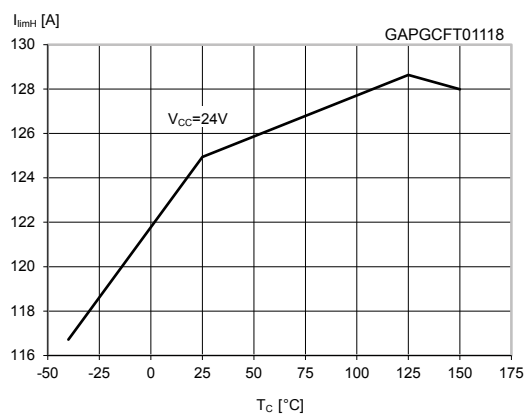
1. With  $R_{LOAD} < 24$   $\Omega$ .
2. Without capacitor between  $V_{CC}$  and GND.
3. With 10 nF between  $V_{CC}$  and GND.
4. External load dump clamp, 58 V maximum, referred to ground.

**Table 14. Electrical transient requirements (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 are not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device. |

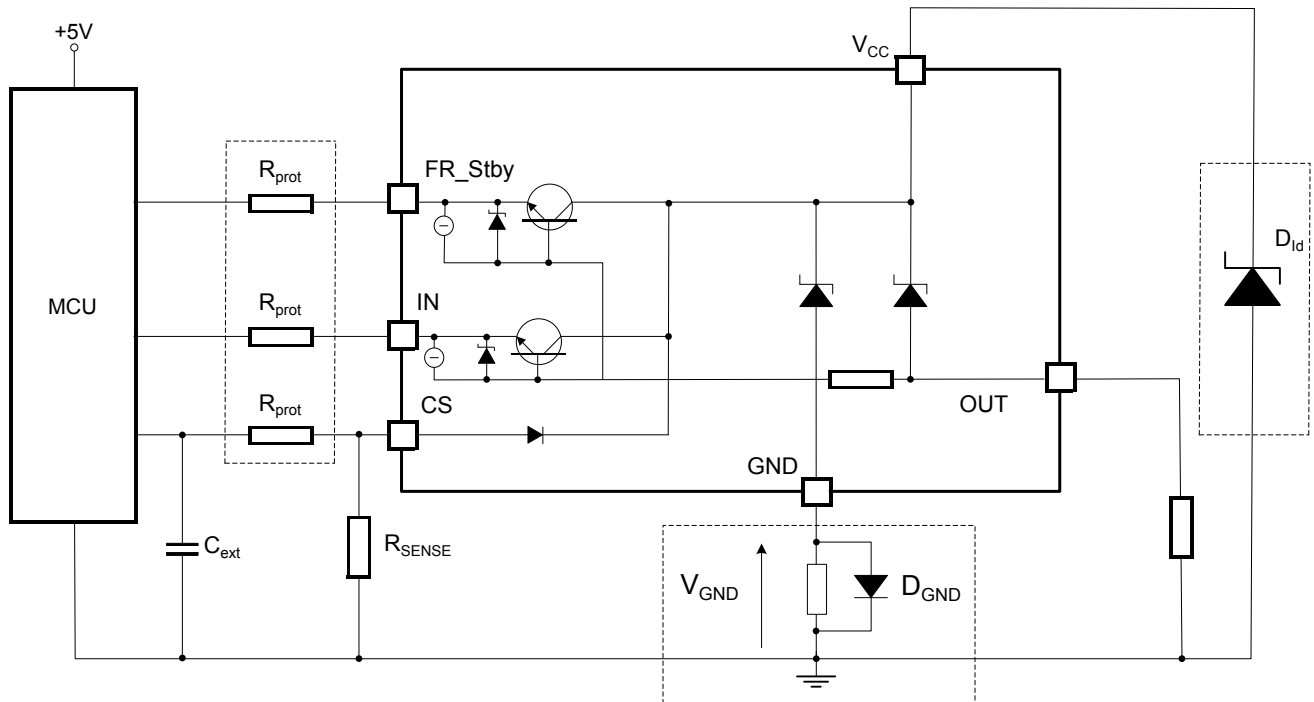
## 2.4 Electrical characteristics (curves)

**Figure 13. Off-state output current**

**Figure 14. High level input current**

**Figure 15. Input clamp voltage**

**Figure 16. Low level input voltage**

**Figure 17. High level input voltage**

**Figure 18. Input hysteresis voltage**


**Figure 19. On-state resistance vs  $T_C$** 

**Figure 20. On-state resistance vs  $V_{CC}$** 

**Figure 21. Turn-on voltage slope**

**Figure 22. Turn-off voltage slope**

**Figure 23.  $I_{LIMH}$  vs  $T_C$** 


### 3 Application information

Figure 24. Application schematic



GAPGCFT000119

#### 3.1 Load dump protection

$D_{Id}$  is necessary (voltage transient suppressor) if the load dump peak voltage exceeds the  $V_{CC}$  maximum 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 12](#), [Table 13](#) and [Table 14](#).

#### 3.2 MCU I/Os protection

When negative transients are present on the  $V_{CC}$  line, the control pins is pulled negative. ST suggests that a resistor ( $R_{prot}$ ) has to be inserted in line to prevent the microcontroller I/Os pins from latching-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.

##### Equation: $R_{prot}$ range calculation

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

##### Calculation example:

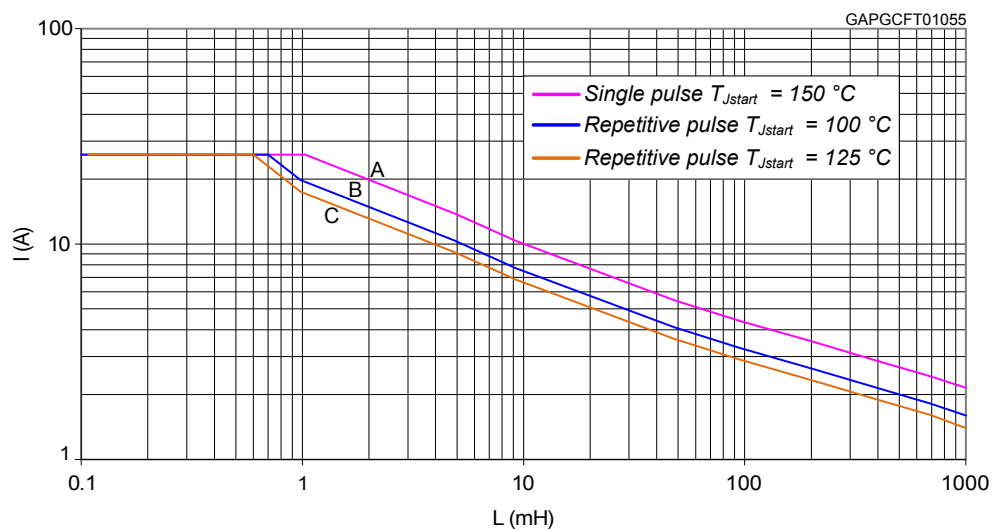
For  $V_{CCpeak} = -600$  V and  $I_{latchup} \geq 20$  mA;  $V_{OH\mu C} \geq 4.5$  V

$$30 \text{ k}\Omega \leq R_{prot} \leq 190 \text{ k}\Omega.$$

Recommended value:  $R_{prot} = 56 \text{ k}\Omega$ .

## 4 Maximum demagnetization energy ( $V_{CC} = 24\text{ V}$ )

**Figure 25. Maximum turn off current versus inductance**

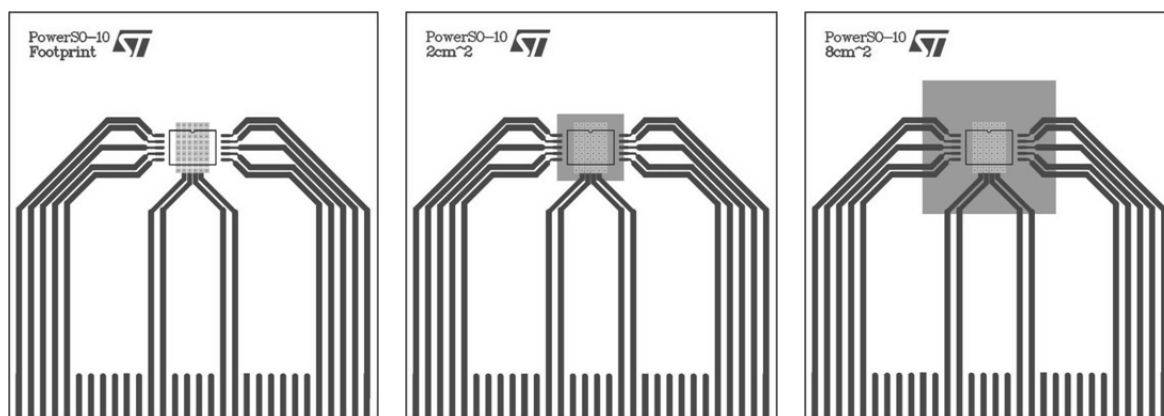


**Note:** Values are generated with  $R_L = 0\ \Omega$ . In case of repetitive pulses,  $T_{Jstart}$  (at the beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

## 5 Package and PCB thermal data

### 5.1 PowerSO-10 thermal data

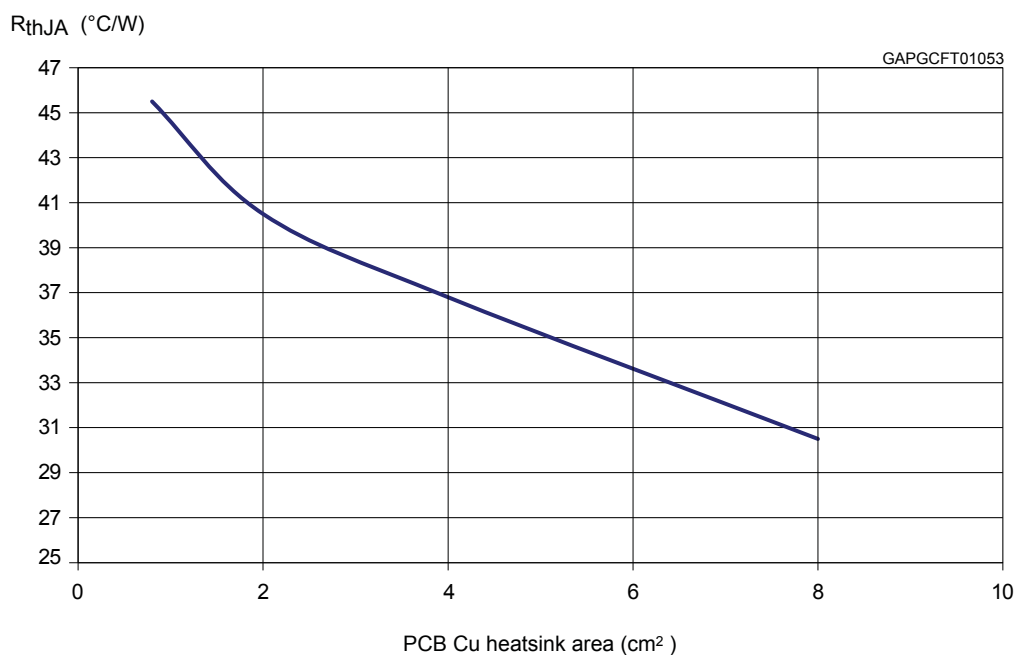
Figure 26. PowerSO-10 PCB



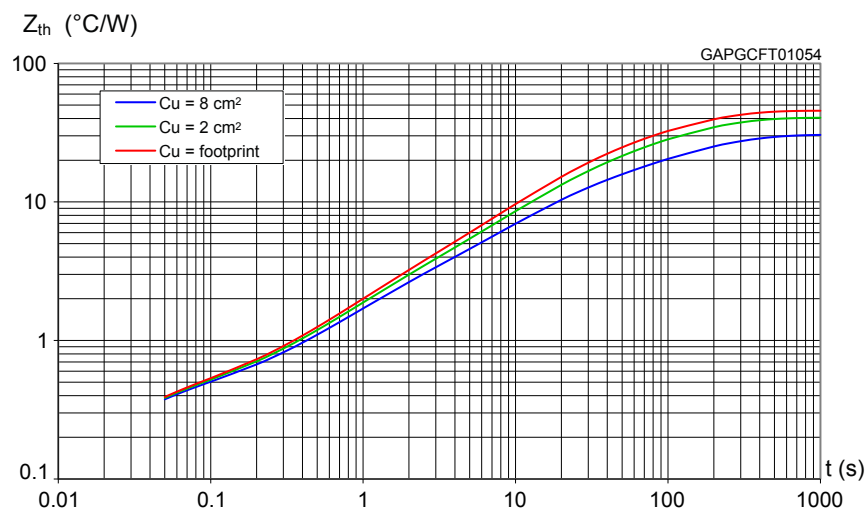
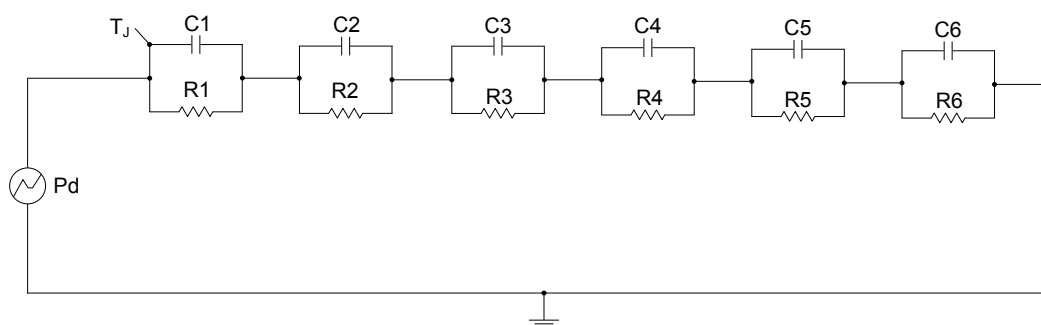
GAPGCFT00277

Layout condition of  $R_{th}$  and  $Z_{th}$  measurements: board finish thickness 1.6 mm  $\pm 10\%$ ; board double layer; board dimension 77 x 86; board material FR4; Cu thickness 0.070 mm (front and back side); thermal via separation 1.2 mm; thermal via diameter 0.3 mm  $\pm 0.08$  mm; Cu thickness on vias 0.025 mm.

Figure 27.  $R_{thJA}$  vs PCB copper area in open box free air condition



GAPGCFT01053

**Figure 28. PowerSO-10 thermal impedance junction ambient single pulse**

**Figure 29. Thermal fitting model of a single channel HSD in PowerSO-10**


GAPGCFT00280

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

**Equation: pulse calculation formula**

$$Z_{th\delta} = R_{th} \cdot \delta + Z_{thtp} (1 - \delta)$$

where  $\delta = t_p/T$

**Table 15. Thermal parameters**

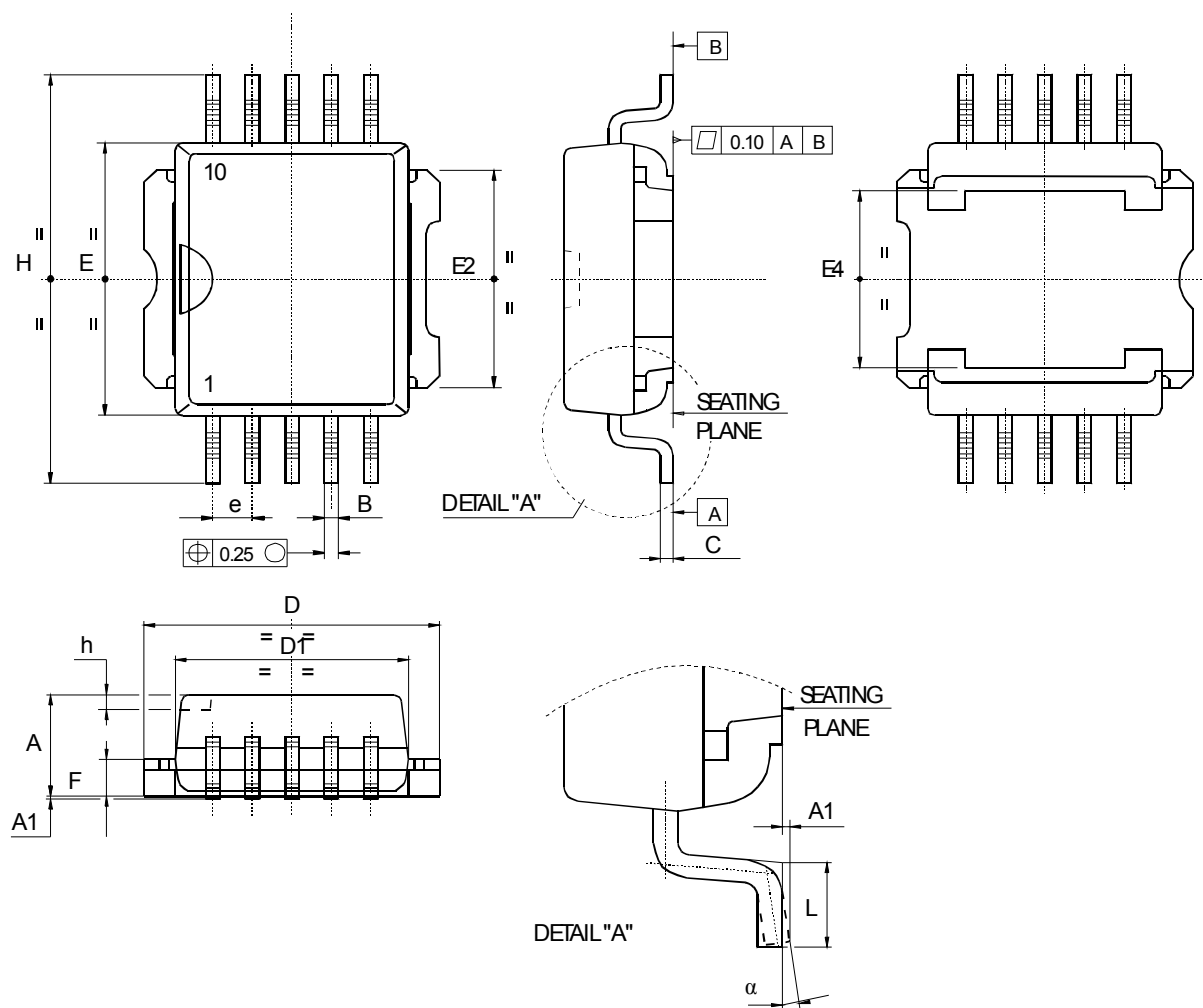
| Area/island (cm <sup>2</sup> ) | Footprint | 4  | 8  |
|--------------------------------|-----------|----|----|
| R1 (°C/W)                      | 0.05      |    |    |
| R2 (°C/W)                      | 0.3       |    |    |
| R3 (°C/W)                      | 1.2       |    |    |
| R4 (°C/W)                      | 7         |    |    |
| R5 (°C/W)                      | 13        | 12 | 8  |
| R6 (°C/W)                      | 24        | 20 | 14 |
| C1 (W.s/°C)                    | 0.05      |    |    |
| C2 (W.s/°C)                    | 0.1       |    |    |
| C3 (W.s/°C)                    | 1         |    |    |
| C4 (W.s/°C)                    | 2         |    |    |
| C5 (W.s/°C)                    | 3         | 4  | 8  |
| C6 (W.s/°C)                    | 6         | 8  | 14 |

## 6 Package information

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.

### 6.1 PowerSO-10 package information

**Figure 30. PowerSO-10 package dimensions**



GAPGCF00197

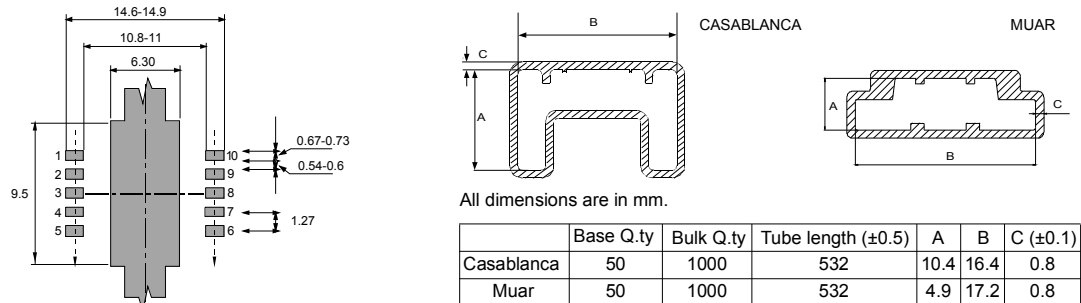
**Table 16. PowerSO-10 mechanical data**

| Symbol            | Millimeters |      |       |
|-------------------|-------------|------|-------|
|                   | Min.        | Typ. | Max.  |
| A                 | 3.35        |      | 3.65  |
| A <sup>(1)</sup>  | 3.4         |      | 3.6   |
| A1                | 0.00        |      | 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.

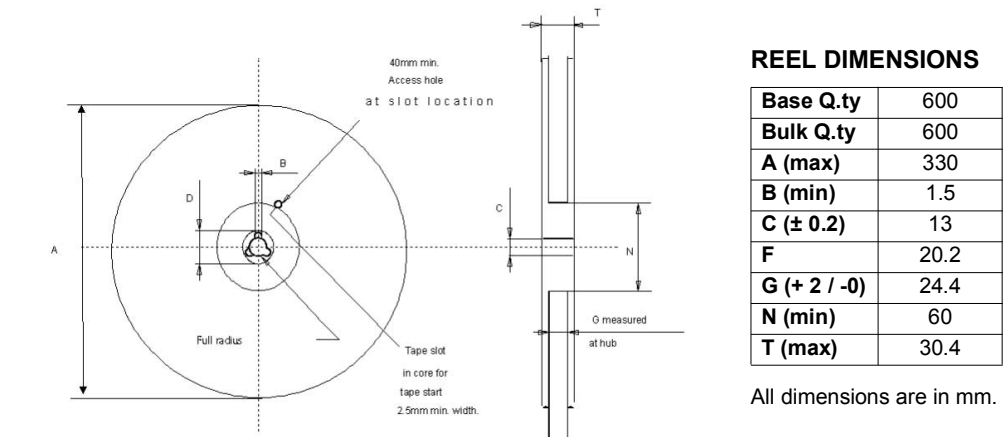
## 6.2 PowerSO-10 packing information

**Figure 31. PowerSO-10 tube shipment (no suffix)**



GAPGCFT00179

**Figure 32. PowerSO-10 tape and reel shipment (suffix "TR")**

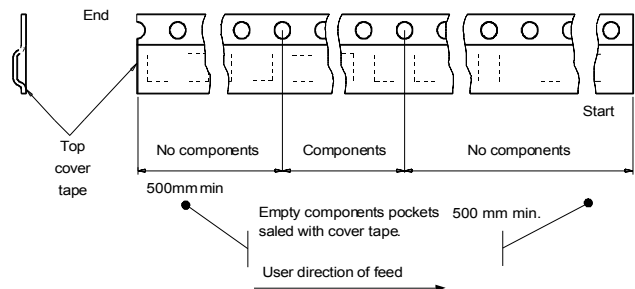
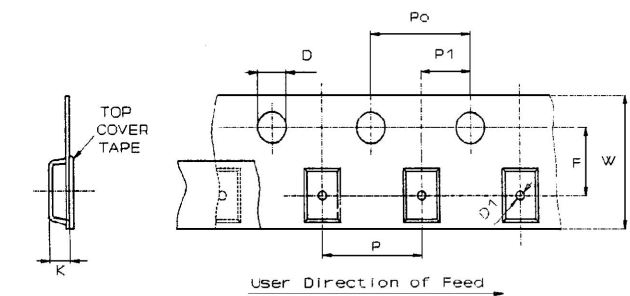
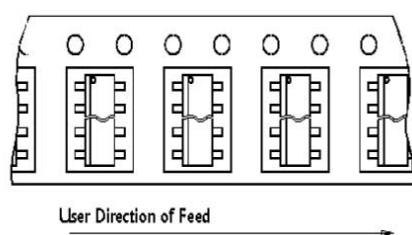


### TAPE DIMENSIONS

According to Electronic Industries Association (EIA) Standard 481 rev. A, Feb 1986

|                   |              |      |
|-------------------|--------------|------|
| Tape width        | W            | 24   |
| Tape Hole Spacing | P0 (± 0.1)   | 4    |
| Component Spacing | P            | 24   |
| Hole Diameter     | D (± 0.1/-0) | 1.5  |
| Hole Diameter     | D1 (min)     | 1.5  |
| Hole Position     | F (± 0.05)   | 11.5 |
| Compartment Depth | K (max)      | 6.5  |
| Hole Spacing      | P1 (± 0.1)   | 2    |

All dimensions are in mm.



GAPGCFT00180

## Revision history

**Table 17. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 19-Dec-2012 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 16-Jan-2013 | 2        | Updated <i>Figure 3: Current and voltage conventions</i><br><i>Table 6: Switching</i> ( $V_{CC} = 24\text{ V}$ ; $T_J = 25\text{ }^{\circ}\text{C}$ ):<br>– $dV_{OUT}/dt_{(on)}$ , $dV_{OUT}/dt_{(off)}$ : updated values<br><i>Table 9: Current sense</i> ( $8\text{ V} < V_{CC} < 36\text{ V}$ ):<br>– $I_{OL}$ : removed row<br>– $dK/K_{BULB2}$ , $dK/K_{BULB3}$ : updated test conditions<br>Updated <i>Table 22: Turn-On voltage slope</i> and <i>Table 23: Turn-Off voltage slope</i> . |
| 16-Jun-2013 | 3        | Changed document status from “preliminary data” to “production data”.                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 17-Sep-2013 | 4        | Updated Disclaimer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 11-Apr-2016 | 5        | Added AEC-Q101 qualified in <i>Features</i> section<br><i>Table 9: Current sense</i> ( $8\text{ V} < V_{CC} < 36\text{ V}$ ):<br>– $dK_6/K_6$ : updated test conditions                                                                                                                                                                                                                                                                                                                        |
| 17-May-2022 | 6        | Updated <i>Figure 9</i> and <i>Figure 12</i><br>Moved <i>Section 3.3: Maximum demagnetization energy</i> ( $V_{CC} = 24\text{ V}$ ) to <i>Section 4 Maximum demagnetization energy</i> ( $V_{CC} = 24\text{ V}$ ).<br>Updated title of <i>Figure 28</i> and <i>Figure 29</i><br>Minor text changes.                                                                                                                                                                                            |

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