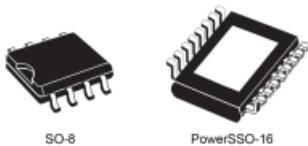


## High-side driver with MultiSense analog feedback for automotive applications



### Features

|                                   |            |                |
|-----------------------------------|------------|----------------|
| Max transient supply voltage      | $V_{CC}$   | 40 V           |
| Operating voltage range           | $V_{CC}$   | 4 to 28 V      |
| Typ. on-state resistance (per Ch) | $R_{ON}$   | 140 m $\Omega$ |
| Current limitation (typ)          | $I_{LIMH}$ | 12 A           |
| Standby current (max)             | $I_{STBY}$ | 0.5 $\mu$ A    |

- AEC-Q100 qualified
- General
  - Single channel smart high-side driver with MultiSense analog feedback
  - Very low standby current
  - Compatible with 3 V and 5 V CMOS outputs
- MultiSense diagnostic functions
  - Multiplexed analog feedback of: load current with high precision proportional current mirror,  $V_{CC}$  supply voltage and  $T_{CHIP}$  device temperature
  - Overload and short to ground (power limitation) indication
  - Thermal shutdown indication
  - OFF-state open-load detection
  - Output short to  $V_{CC}$  detection
  - Sense enable/disable
- Protections
  - Undervoltage shutdown
  - Overvoltage clamp
  - Load current limitation
  - Self limiting of fast thermal transients
  - Configurable latch-off on overtemperature or power limitation with dedicated fault reset pin
  - Loss of ground and loss of  $V_{CC}$
  - Reverse battery with external components
  - Electrostatic discharge protection



#### Product status link

[VN7140AJ](#)
[VN7140AS](#)

### Applications

- All types of automotive resistive, inductive and capacitive loads
- Specially intended for automotive signal lamps (up to R10W or LED Rear Combinations)
- Protected supply for ADAS systems: radars and sensors

### Description

The devices are single channel high-side drivers manufactured using ST proprietary VIPower M0-7 technology and housed in PowerSSO-16 and SO-8 packages. The

devices are designed to drive 12 V automotive grounded loads through a 3 V and 5 V CMOS-compatible interface, and to provide protection and diagnostics.

The devices integrate advanced protective functions such as load current limitation, overload active management by power limitation and overtemperature shutdown with configurable latch-off.

A  $\overline{\text{FaultRST}}$  pin unlatches the output in case of fault or disables the latch-off functionality.

A dedicated multifunction multiplexed analog output pin delivers sophisticated diagnostic functions including high precision proportional load current sense, supply voltage feedback and chip temperature sense, in addition to the detection of overload and short circuit to ground, short to  $V_{CC}$  and OFF-state open-load.

A sense enable pin allows OFF-state diagnosis to be disabled during the module low-power mode as well as external sense resistor sharing among similar devices.

## 1 Block diagram and pin description

Figure 1. Block diagram

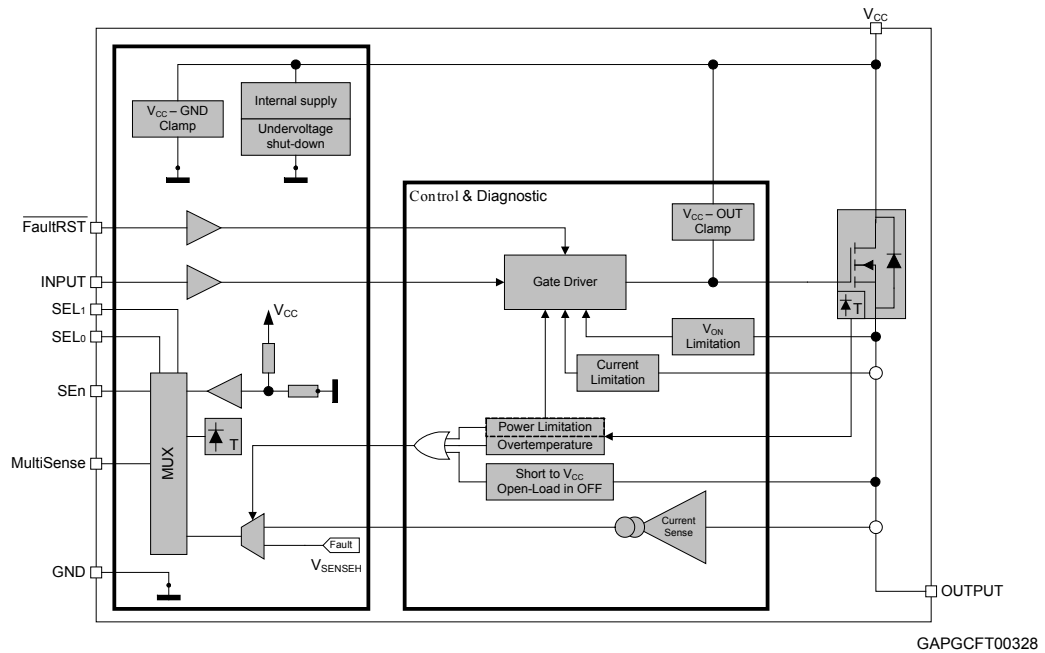
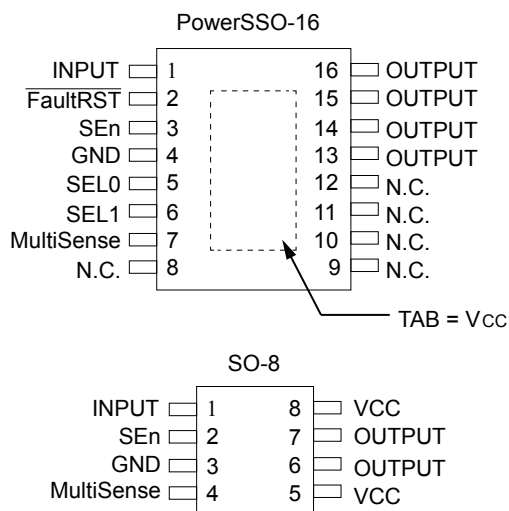


Table 1. Pin functions

| Name                         | Function                                                                                                                                               |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| V <sub>CC</sub>              | Battery connection.                                                                                                                                    |
| OUTPUT                       | Power outputs.                                                                                                                                         |
| GND                          | Ground connection. Must be reverse battery protected by an external diode / resistor network.                                                          |
| INPUT                        | Voltage controlled input pin with hysteresis, compatible with 3 V and 5 V CMOS outputs. It controls output switch state.                               |
| MultiSense                   | Multiplexed analog sense output pin; it delivers a current proportional to the selected diagnostic: load current, supply voltage or chip temperature.  |
| SEn                          | Active high compatible with 3 V and 5 V CMOS outputs pin; it enables the MultiSense diagnostic pin.                                                    |
| SEL <sub>0,1</sub>           | Active high compatible with 3 V and 5 V CMOS outputs pin; they address the MultiSense multiplexer.                                                     |
| $\overline{\text{FaultRST}}$ | Active low compatible with 3 V and 5 V CMOS outputs pin; it unlatches the output in case of fault; If kept low, sets the outputs in auto-restart mode. |

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



GAPG2601151129CFT

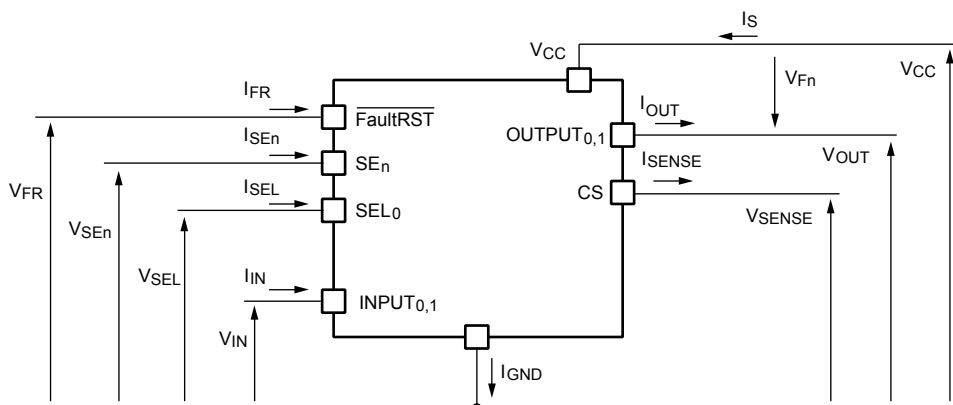
**Table 2. Suggested connections for unused and not connected pins**

| Connection / pin | MultiSense            | N.C.             | Output      | Input                  | SEn, SELx, FaultRST    |
|------------------|-----------------------|------------------|-------------|------------------------|------------------------|
| Floating         | Not allowed           | X <sup>(1)</sup> | X           | X                      | X                      |
| To ground        | Through 1 kΩ resistor | X                | Not allowed | Through 15 kΩ resistor | Through 15 kΩ resistor |

1. X: do not care.

## 2 Electrical specification

**Figure 3. Current and voltage conventions**



GADG2203170950PS

**Note:**  $V_F = V_{OUT} - V_{CC}$  during reverse battery condition.

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 3. Absolute maximum ratings](#) 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.

**Table 3. Absolute maximum ratings**

| Symbol      | Parameter                                                                                     | Value              | Unit |
|-------------|-----------------------------------------------------------------------------------------------|--------------------|------|
| $V_{CC}$    | DC supply voltage                                                                             | 38                 | V    |
| $-V_{CC}$   | Reverse DC supply voltage                                                                     | 0.3                |      |
| $V_{CCPK}$  | Maximum transient supply voltage (ISO 16750-2:2010 Test B clamped to 40 V; $R_L = 4 \Omega$ ) | 40                 | V    |
| $V_{CCJS}$  | Maximum jump start voltage for single pulse short circuit protection                          | 28                 | V    |
| $-I_{GND}$  | DC reverse ground pin current                                                                 | 200                | mA   |
| $I_{OUT}$   | OUTPUT DC output current                                                                      | Internally limited | A    |
| $-I_{OUT}$  | Reverse DC output current                                                                     | 3                  |      |
| $I_{IN}$    | INPUT DC input current                                                                        | -1 to 10           | mA   |
| $I_{SEn}$   | SEn DC input current                                                                          |                    |      |
| $I_{SEL}$   | SEL <sub>0,1</sub> DC input current                                                           |                    |      |
| $I_{FR}$    | FaultRST DC input current                                                                     |                    |      |
| $V_{FR}$    | FaultRST DC input voltage                                                                     | 7.5                | V    |
| $I_{SENSE}$ | MultiSense pin DC output current ( $V_{GND} = V_{CC}$ and $V_{SENSE} < 0$ V)                  | 10                 | mA   |
|             | MultiSense pin DC output current in reverse ( $V_{CC} < 0$ V)                                 | -20                |      |

| Symbol           | Parameter                                                                                           | Value      | Unit |
|------------------|-----------------------------------------------------------------------------------------------------|------------|------|
| E <sub>MAX</sub> | Maximum switching energy (single pulse) (T <sub>DEMAG</sub> = 0.4 ms; T <sub>jstart</sub> = 150 °C) | 10         | mJ   |
| V <sub>ESD</sub> | Electrostatic discharge (JEDEC 22A-114F)                                                            |            | V    |
|                  | INPUT                                                                                               | 4000       |      |
|                  | MultiSense                                                                                          | 2000       |      |
|                  | SEn, SEL <sub>0,1</sub> , FaultRST                                                                  | 4000       |      |
|                  | OUTPUT                                                                                              |            |      |
|                  | V <sub>CC</sub>                                                                                     |            |      |
| 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 |      |

## 2.2 Thermal data

**Table 4. Thermal data**

| Symbol          | Parameter                                                            | Typ. value |             | Unit                 |
|-----------------|----------------------------------------------------------------------|------------|-------------|----------------------|
|                 |                                                                      | SO-8       | PowerSSO-16 |                      |
| $R_{thj-board}$ | Thermal resistance junction-board (JEDEC JESD 51-8) <sup>(1)</sup>   | 31         | 7.9         | $^{\circ}\text{C/W}$ |
| $R_{thj-amb}$   | Thermal resistance junction-ambient (JEDEC JESD 51-2) <sup>(2)</sup> | 71         | 61          |                      |
| $R_{thj-amb}$   | Thermal resistance junction-ambient (JEDEC JESD 51-2)                | 48.5       | 26.5        |                      |

1. Device mounted on four-layers 2s2p PCB
2. Device mounted on two-layers 2s0p PCB with 2 cm<sup>2</sup> heatsink copper trace

## 2.3 Main electrical characteristics

7 V < V<sub>CC</sub> < 28 V; -40°C < T<sub>j</sub> < 150°C, unless otherwise specified.

All typical values refer to V<sub>CC</sub> = 13 V; T<sub>j</sub> = 25°C, unless otherwise specified.

**Table 5. Power section**

| Symbol                | Parameter                        | Test conditions                                                      | Min. | Typ. | Max. | Unit |
|-----------------------|----------------------------------|----------------------------------------------------------------------|------|------|------|------|
| V <sub>CC</sub>       | Operating supply voltage         |                                                                      | 4    | 13   | 28   | V    |
| V <sub>USD</sub>      | Undervoltage shutdown            |                                                                      |      |      | 4    | V    |
| V <sub>USDReset</sub> | Undervoltage shutdown reset      |                                                                      |      |      | 5    | V    |
| V <sub>USDhyst</sub>  | Undervoltage shutdown hysteresis |                                                                      |      | 0.3  |      | V    |
| R <sub>ON</sub>       | On-state resistance              | I <sub>OUT</sub> = 1 A; T <sub>j</sub> = 25°C                        |      | 140  |      | mΩ   |
|                       |                                  | I <sub>OUT</sub> = 1 A; T <sub>j</sub> = 150°C                       |      |      | 280  |      |
|                       |                                  | I <sub>OUT</sub> = 1 A; V <sub>CC</sub> = 4 V; T <sub>j</sub> = 25°C |      |      | 210  |      |
| V <sub>clamp</sub>    | Clamp voltage                    | I <sub>S</sub> = 20 mA; 25°C < T <sub>j</sub> < 150°C                | 41   | 46   | 52   | V    |
|                       |                                  | I <sub>S</sub> = 20 mA; T <sub>j</sub> = -40°C                       | 38   |      |      | V    |

| Symbol        | Parameter                                                           | Test conditions                                                                                                                                    | Min. | Typ. | Max. | Unit          |
|---------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|---------------|
| $I_{STBY}$    | Supply current in standby at $V_{CC} = 13\text{ V}$ <sup>(1)</sup>  | $V_{CC} = 13\text{ V};$<br>$V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$<br>$V_{SEL0,1} = 0\text{ V}; T_j = 25^\circ\text{C}$                |      |      | 0.5  | $\mu\text{A}$ |
|               |                                                                     | $V_{CC} = 13\text{ V};$<br>$V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$<br>$V_{SEL0,1} = 0\text{ V}; T_j = 85^\circ\text{C}$ <sup>(2)</sup> |      |      | 0.5  |               |
|               |                                                                     | $V_{CC} = 13\text{ V};$<br>$V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$<br>$V_{SEL0,1} = 0\text{ V}; T_j = 125^\circ\text{C}$               |      |      | 3    |               |
| $t_{D\_STBY}$ | Standby mode blanking time                                          | $V_{CC} = 13\text{ V}; V_{IN} = V_{OUT}$<br>$= V_{FR} = V_{SEL0,1} = 0\text{ V};$<br>$V_{SEn} = 5\text{ V to } 5\text{ V}$                         | 60   | 300  | 550  | $\mu\text{s}$ |
| $I_{S(ON)}$   | Supply current                                                      | $V_{CC} = 13\text{ V}; V_{SEn} = 0\text{ V};$<br>$V_{SEL0,1} = V_{FR} = 0\text{ V}; V_{IN} = 5\text{ V};$<br>$I_{OUT} = 0\text{ A}$                |      | 3    | 5    | $\text{mA}$   |
| $I_{GND(ON)}$ | Control stage current consumption in ON-state. All channels active. | $V_{CC} = 13\text{ V}; V_{SEn} = 5\text{ V};$<br>$V_{FR} = V_{SEL0,1} = 0\text{ V}; V_{IN} = 5\text{ V};$<br>$I_{OUT} = 1\text{ A}$                |      |      | 6    | $\text{mA}$   |
| $I_{L(off)}$  | Off-state output current at $V_{CC} = 13\text{ V}$                  | $V_{IN} = V_{OUT} = 0\text{ V}; V_{CC} = 13\text{ V};$<br>$T_j = 25^\circ\text{C}$                                                                 | 0    | 0.01 | 0.5  | $\mu\text{A}$ |
|               |                                                                     | $V_{IN} = V_{OUT} = 0\text{ V}; V_{CC} = 13\text{ V};$<br>$T_j = 125^\circ\text{C}$                                                                | 0    |      | 3    |               |
| $V_F$         | Output - $V_{CC}$ diode voltage                                     | $I_{OUT} = -1\text{ A}; T_j = 150^\circ\text{C}$                                                                                                   |      |      | 0.7  | $\text{V}$    |

1. PowerMOS leakage included.

2. Parameter specified by design; not subjected to production test.

**Table 6. Switching**

| $V_{CC} = 13\text{ V}; -40^\circ\text{C} < T_j < 150^\circ\text{C}$ , unless otherwise specified |                                                    |                    |      |      |                     |                        |
|--------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------|------|------|---------------------|------------------------|
| Symbol                                                                                           | Parameter                                          | Test conditions    | Min. | Typ. | Max.                | Unit                   |
| $t_{d(on)}$ <sup>(1)</sup>                                                                       | Turn-on delay time at $T_j = 25^\circ\text{C}$     | $R_L = 13\ \Omega$ | 10   | 70   | 120                 | $\mu\text{s}$          |
| $t_{d(off)}$ <sup>(1)</sup>                                                                      | Turn-off delay time at $T_j = 25^\circ\text{C}$    |                    | 10   | 40   | 100                 |                        |
| $(dV_{OUT}/dt)_{on}$ <sup>(1)</sup>                                                              | Turn-on voltage slope at $T_j = 25^\circ\text{C}$  | $R_L = 13\ \Omega$ | 0.1  | 0.27 | 0.7                 | $\text{V}/\mu\text{s}$ |
| $(dV_{OUT}/dt)_{off}$ <sup>(1)</sup>                                                             | Turn-off voltage slope at $T_j = 25^\circ\text{C}$ |                    | 0.1  | 0.35 | 0.7                 |                        |
| $W_{ON}$                                                                                         | Switching energy losses at turn-on ( $t_{won}$ )   | $R_L = 13\ \Omega$ | —    | 0.15 | 0.18 <sup>(2)</sup> | $\text{mJ}$            |
| $W_{OFF}$                                                                                        | Switching energy losses at turn-off ( $t_{woff}$ ) | $R_L = 13\ \Omega$ | —    | 0.1  | 0.18 <sup>(2)</sup> | $\text{mJ}$            |
| $t_{SKEW}$ <sup>(1)</sup>                                                                        | Differential Pulse skew ( $t_{PHL} - t_{PLH}$ )    | $R_L = 13\ \Omega$ | -100 | -50  | 0                   | $\mu\text{s}$          |

1. See Figure 6. Switching time and Pulse skew.

2. Parameter guaranteed by design and characterization; not subjected to production test.

**Table 7. Logic inputs**

| $7\text{ V} < V_{CC} < 28\text{ V}; -40^\circ\text{C} < T_j < 150^\circ\text{C}$ |           |                 |      |      |      |      |
|----------------------------------------------------------------------------------|-----------|-----------------|------|------|------|------|
| Symbol                                                                           | Parameter | Test conditions | Min. | Typ. | Max. | Unit |
| INPUT characteristics                                                            |           |                 |      |      |      |      |

| 7 V < V <sub>CC</sub> < 28 V; -40°C < T <sub>j</sub> < 150°C                      |                          |                         |      |      |      |      |
|-----------------------------------------------------------------------------------|--------------------------|-------------------------|------|------|------|------|
| Symbol                                                                            | Parameter                | Test conditions         | Min. | Typ. | Max. | Unit |
| V <sub>IL</sub>                                                                   | Input low level voltage  |                         |      |      | 0.9  | V    |
| I <sub>IL</sub>                                                                   | Low level input current  | V <sub>IN</sub> = 0.9 V | 1    |      |      | μA   |
| V <sub>IH</sub>                                                                   | Input high level voltage |                         | 2.1  |      |      | V    |
| I <sub>IH</sub>                                                                   | High level input current | V <sub>IN</sub> = 2.1 V |      |      | 10   | μA   |
| V <sub>I(hyst)</sub>                                                              | Input hysteresis voltage |                         | 0.2  |      |      | V    |
| V <sub>ICL</sub>                                                                  | Input clamp voltage      | I <sub>IN</sub> = 1 mA  | 5.3  |      | 7.2  | V    |
|                                                                                   |                          | I <sub>IN</sub> = -1 mA |      | -0.7 |      |      |
| FaultRST characteristics (VN7140AJ only)                                          |                          |                         |      |      |      |      |
| V <sub>FRL</sub>                                                                  | Input low level voltage  |                         |      |      | 0.9  | V    |
| I <sub>FRL</sub>                                                                  | Low level input current  | V <sub>IN</sub> = 0.9 V | 1    |      |      | μA   |
| V <sub>FRH</sub>                                                                  | Input high level voltage |                         | 2.1  |      |      | V    |
| I <sub>FRH</sub>                                                                  | High level input current | V <sub>IN</sub> = 2.1 V |      |      | 10   | μA   |
| V <sub>FR(hyst)</sub>                                                             | Input hysteresis voltage |                         | 0.2  |      |      | V    |
| V <sub>FRCL</sub>                                                                 | Input clamp voltage      | I <sub>IN</sub> = 1 mA  | 5.3  |      | 7.5  | V    |
|                                                                                   |                          | I <sub>IN</sub> = -1 mA |      | -0.7 |      |      |
| SEL <sub>0,1</sub> characteristics (7 V < V <sub>CC</sub> < 18 V) (VN7140AJ only) |                          |                         |      |      |      |      |
| V <sub>SELL</sub>                                                                 | Input low level voltage  |                         |      |      | 0.9  | V    |
| I <sub>SELL</sub>                                                                 | Low level input current  | V <sub>IN</sub> = 0.9 V | 1    |      |      | μA   |
| V <sub>SELH</sub>                                                                 | Input high level voltage |                         | 2.1  |      |      | V    |
| I <sub>SELH</sub>                                                                 | High level input current | V <sub>IN</sub> = 2.1 V |      |      | 10   | μA   |
| V <sub>SEL(hyst)</sub>                                                            | Input hysteresis voltage |                         | 0.2  |      |      | V    |
| V <sub>SELCL</sub>                                                                | Input clamp voltage      | I <sub>IN</sub> = 1 mA  | 5.3  |      | 7.2  | V    |
|                                                                                   |                          | I <sub>IN</sub> = -1 mA |      | -0.7 |      |      |
| SEn characteristics (7 V < V <sub>CC</sub> < 18 V)                                |                          |                         |      |      |      |      |
| V <sub>SEnL</sub>                                                                 | Input low level voltage  |                         |      |      | 0.9  | V    |
| I <sub>SEnL</sub>                                                                 | Low level input current  | V <sub>IN</sub> = 0.9 V | 1    |      |      | μA   |
| V <sub>SEnH</sub>                                                                 | Input high level voltage |                         | 2.1  |      |      | V    |
| I <sub>SEnH</sub>                                                                 | High level input current | V <sub>IN</sub> = 2.1 V |      |      | 10   | μA   |
| V <sub>SEn(hyst)</sub>                                                            | Input hysteresis voltage |                         | 0.2  |      |      | V    |
| V <sub>SEnCL</sub>                                                                | Input clamp voltage      | I <sub>IN</sub> = 1 mA  | 5.3  |      | 7.2  | V    |
|                                                                                   |                          | I <sub>IN</sub> = -1 mA |      | -0.7 |      |      |

**Table 8. Protections**

| 7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C |                                                                           |                                                                                                                                  |                      |                      |                      |      |
|--------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|----------------------|------|
| Symbol                                                       | Parameter                                                                 | Test conditions                                                                                                                  | Min.                 | Typ.                 | Max.                 | Unit |
| I <sub>LIMH</sub>                                            | DC short circuit current                                                  | V <sub>CC</sub> = 13 V                                                                                                           | 8                    | 12                   | 16                   | A    |
|                                                              |                                                                           | 4 V < V <sub>CC</sub> < 18 V <sup>(1)</sup>                                                                                      |                      |                      |                      |      |
| I <sub>LIML</sub>                                            | Short circuit current during thermal cycling                              | V <sub>CC</sub> = 13 V;<br>T <sub>R</sub> < T <sub>j</sub> < T <sub>TSD</sub>                                                    |                      | 4                    |                      |      |
| T <sub>TSD</sub>                                             | Shutdown temperature                                                      |                                                                                                                                  | 150                  | 175                  | 200                  | °C   |
| T <sub>R</sub>                                               | Reset temperature <sup>(1)</sup>                                          |                                                                                                                                  | T <sub>RS</sub> + 1  | T <sub>RS</sub> + 7  |                      |      |
| T <sub>RS</sub>                                              | Thermal reset of fault diagnostic indication                              | V <sub>FR</sub> = 0 V; V <sub>SEn</sub> = 5 V                                                                                    | 135                  |                      |                      |      |
| T <sub>HYST</sub>                                            | Thermal hysteresis(T <sub>TSD</sub> - T <sub>R</sub> ) <sup>(1)</sup>     |                                                                                                                                  |                      | 7                    |                      |      |
| ΔT <sub>J_SD</sub>                                           | Dynamic temperature                                                       | T <sub>j</sub> = -40°C; V <sub>CC</sub> = 13 V                                                                                   |                      | 60                   |                      | K    |
| t <sub>LATCH_RST</sub>                                       | Fault reset time for output unlatch (only for VN7140AJ)<br><sup>(1)</sup> | V <sub>FR</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V;<br>V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V | 3                    | 10                   | 20                   | μs   |
| V <sub>DEMAG</sub>                                           | Turn-off output voltage clamp                                             | I <sub>OUT</sub> = 1 A; L = 6 mH; T <sub>j</sub> = -40°C                                                                         | V <sub>CC</sub> - 38 |                      |                      | V    |
|                                                              |                                                                           | I <sub>OUT</sub> = 1 A; L = 6 mH; T <sub>j</sub> = 25°C to 150°C                                                                 | V <sub>CC</sub> - 41 | V <sub>CC</sub> - 46 | V <sub>CC</sub> - 52 | V    |
| V <sub>ON</sub>                                              | Output voltage drop limitation                                            | I <sub>OUT</sub> = 0.07 A                                                                                                        |                      | 20                   |                      | mV   |

1. Parameter guaranteed by design and characterization; not subjected to production test.

**Table 9. MultiSense**

| 7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>J</sub> < 150°C |                                                |                                                                                                                            |      |      |      |      |
|--------------------------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| Symbol                                                       | Parameter                                      | Test conditions                                                                                                            | Min. | Typ. | Max. | Unit |
| V <sub>SENSE_CL</sub>                                        | MultiSense clamp voltage                       | V <sub>SEn</sub> = 0 V; I <sub>SENSE</sub> = 1 mA                                                                          | -17  |      | -12  | V    |
|                                                              |                                                | V <sub>SEn</sub> = 0 V; I <sub>SENSE</sub> = -1 mA                                                                         |      | 7    |      |      |
| CurrentSense characteristics                                 |                                                |                                                                                                                            |      |      |      |      |
| K <sub>OL</sub>                                              | I <sub>OUT</sub> /I <sub>SENSE</sub>           | I <sub>OUT</sub> = 0.01 A; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V                                           | 295  |      |      |      |
| dK <sub>cal</sub> /K <sub>cal</sub> <sup>(1) (2)</sup>       | Current sense ratio drift at calibration point | I <sub>OUT</sub> = 0.01 A to 0.025 A;<br>I <sub>cal</sub> = 17.5 mA; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V | -30  |      | 30   | %    |
| K <sub>LED</sub>                                             | I <sub>OUT</sub> /I <sub>SENSE</sub>           | I <sub>OUT</sub> = 0.025 A; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V                                          | 330  | 580  | 820  |      |
| dK <sub>LED</sub> /K <sub>LED</sub> <sup>(1) (2)</sup>       | Current sense ratio drift                      | I <sub>OUT</sub> = 0.025 A; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V                                          | -25  |      | 25   | %    |
| K <sub>0</sub>                                               | I <sub>OUT</sub> /I <sub>SENSE</sub>           | I <sub>OUT</sub> = 0.07 A; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V                                           | 375  | 550  | 720  |      |
| dK <sub>0</sub> /K <sub>0</sub> <sup>(1) (2)</sup>           | Current sense ratio drift                      | I <sub>OUT</sub> = 0.07 A; V <sub>SENSE</sub> = 0.5 V;<br>V <sub>SEn</sub> = 5 V                                           | -20  |      | 20   | %    |
| K <sub>1</sub>                                               | I <sub>OUT</sub> /I <sub>SENSE</sub>           | I <sub>OUT</sub> = 0.15 A; V <sub>SENSE</sub> = 4 V;<br>V <sub>SEn</sub> = 5 V                                             | 360  | 500  | 670  |      |

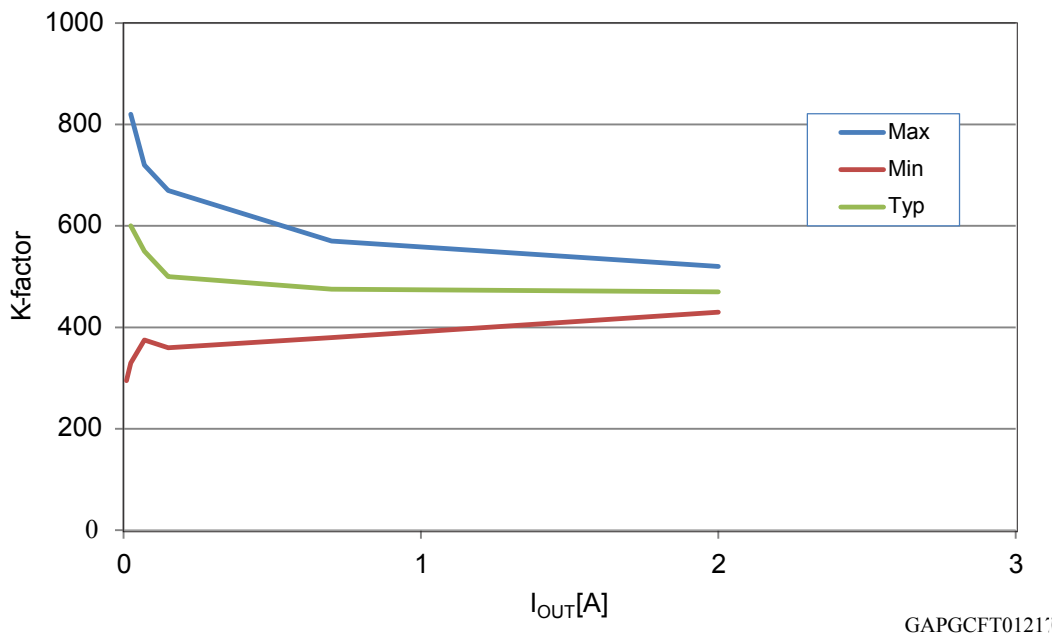
| 7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C |                                                                                                          |                                                                                                                                                                                                               |      |      |      |      |
|--------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| Symbol                                                       | Parameter                                                                                                | Test conditions                                                                                                                                                                                               | Min. | Typ. | Max. | Unit |
| dK <sub>1</sub> /K <sub>1</sub> <sup>(1) (2)</sup>           | Current sense ratio drift                                                                                | I <sub>OUT</sub> = 0.15 A; V <sub>SENSE</sub> = 4 V;<br>V <sub>SEn</sub> = 5 V                                                                                                                                | -15  |      | 15   | %    |
| K <sub>2</sub>                                               | I <sub>OUT</sub> /I <sub>SENSE</sub>                                                                     | I <sub>OUT</sub> = 0.7 A; V <sub>SENSE</sub> = 4 V;<br>V <sub>SEn</sub> = 5 V                                                                                                                                 | 380  | 475  | 570  |      |
| dK <sub>2</sub> /K <sub>2</sub> <sup>(1) (2)</sup>           | Current sense ratio drift                                                                                | I <sub>OUT</sub> = 0.7 A; V <sub>SENSE</sub> = 4 V;<br>V <sub>SEn</sub> = 5 V                                                                                                                                 | -10  |      | 10   | %    |
| K <sub>3</sub>                                               | I <sub>OUT</sub> /I <sub>SENSE</sub>                                                                     | I <sub>OUT</sub> = 2 A; V <sub>SENSE</sub> = 4 V; V <sub>SEn</sub> = 5 V                                                                                                                                      | 430  | 470  | 520  |      |
| dK <sub>3</sub> /K <sub>3</sub> <sup>(1) (2)</sup>           | Current sense ratio drift                                                                                | I <sub>OUT</sub> = 2 A; V <sub>SENSE</sub> = 4 V; V <sub>SEn</sub> = 5 V                                                                                                                                      | -5   |      | 5    | %    |
| I <sub>SENSE0</sub>                                          | MultiSense leakage current                                                                               | MultiSense disabled: V <sub>SEn</sub> = 0 V                                                                                                                                                                   | 0    |      | 0.5  | μA   |
|                                                              |                                                                                                          | MultiSense disabled:<br>-1 V < V <sub>SENSE</sub> < 5 V <sup>(1)</sup>                                                                                                                                        | -0.5 |      | 0.5  |      |
|                                                              |                                                                                                          | MultiSense enabled: V <sub>SEn</sub> = 5 V;<br>Channel ON; I <sub>OUT</sub> = 0 A; Diagnostic<br>selected; V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A | 0    |      | 2    |      |
|                                                              |                                                                                                          | MultiSense enabled: V <sub>SEn</sub> = 5 V;<br>Channel OFF; Diagnostic selected;<br>V <sub>IN</sub> = 0 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V                                                   | 0    |      | 2    |      |
| V <sub>OUT_MSD</sub> <sup>(1)</sup>                          | Output voltage for MultiSense<br>shutdown                                                                | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V; R <sub>SENSE</sub> = 2.7 kΩ; I <sub>OUT</sub> =<br>1 A                                                    |      | 5    |      | V    |
| V <sub>SENSE_SAT</sub>                                       | Multisense saturation voltage                                                                            | V <sub>CC</sub> = 7 V; R <sub>SENSE</sub> = 2.7 kΩ;<br>V <sub>SEn</sub> = 5 V; V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 2 A; T <sub>j</sub> = 150°C     | 5    |      |      | V    |
| I <sub>SENSE_SAT</sub> <sup>(1)</sup>                        | CS saturation current                                                                                    | V <sub>CC</sub> = 7 V; V <sub>SENSE</sub> = 4 V; V <sub>IN</sub> = 5 V;<br>V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V;<br>T <sub>j</sub> = 150°C                                | 4    |      |      | mA   |
| I <sub>OUT_SAT</sub> <sup>(1)</sup>                          | Output saturation current                                                                                | V <sub>CC</sub> = 7 V; V <sub>SENSE</sub> = 4 V; V <sub>IN</sub> = 5 V;<br>V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V;<br>T <sub>j</sub> = 150°C                                | 2.2  |      |      | A    |
| OFF-state diagnostic                                         |                                                                                                          |                                                                                                                                                                                                               |      |      |      |      |
| V <sub>OL</sub>                                              | OFF-state open-load voltage<br>detection threshold                                                       | V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V                                                                                                            | 2    | 3    | 4    | V    |
| I <sub>L(off2)</sub>                                         | OFF-state output sink current                                                                            | V <sub>IN</sub> = 0 V; V <sub>OUT</sub> = V <sub>OL</sub> ; T <sub>j</sub> = -40 °C to<br>150°C                                                                                                               | -100 |      | -15  | μA   |
| t <sub>DSTKON</sub>                                          | OFF-state diagnostic delay<br>time from falling edge of<br>INPUT<br>(see Figure 9. T <sub>DSTKON</sub> ) | V <sub>IN</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V;<br>V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A;<br>V <sub>OUT</sub> = 4 V                                                  | 100  | 350  | 700  | μs   |
| t <sub>D_OL_V</sub>                                          | Settling time for valid OFF-<br>state open load diagnostic<br>indication from rising edge of<br>SEn      | V <sub>IN</sub> = 0 V; V <sub>FR</sub> = 0 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V; V <sub>OUT</sub> = 4 V;<br>V <sub>SEn</sub> = 0 V to 5 V                                                   |      |      | 60   | μs   |
| t <sub>D_VOL</sub>                                           | OFF-state diagnostic delay<br>time from rising edge of V <sub>OUT</sub>                                  | V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V;<br>V <sub>SEL1</sub> = 0 V; V <sub>OUT</sub> = 0 V to 4 V                                                                             |      | 5    | 30   | μs   |
| Chip temperature analog feedback (VN7140AJ only)             |                                                                                                          |                                                                                                                                                                                                               |      |      |      |      |

| 7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C                                                                                                                |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|------|-------|------|
| Symbol                                                                                                                                                                      | Parameter                                                                                                                 | Test conditions                                                                                                                                                                                     | Min.  | Typ. | Max.  | Unit |
| V <sub>SENSE_TC</sub>                                                                                                                                                       | MultiSense output voltage proportional to chip temperature                                                                | V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = -40°C                                                  | 2.325 | 2.41 | 2.495 | V    |
|                                                                                                                                                                             |                                                                                                                           | V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = 25°C                                                   | 1.985 | 2.07 | 2.155 | V    |
|                                                                                                                                                                             |                                                                                                                           | V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = 125°C                                                  | 1.435 | 1.52 | 1.605 | V    |
| dV <sub>SENSE_TC</sub> /dT <sup>(1)</sup>                                                                                                                                   | Temperature coefficient                                                                                                   | T <sub>j</sub> = -40°C to 150°C                                                                                                                                                                     |       | -5.5 |       | mV/K |
| Transfer function                                                                                                                                                           |                                                                                                                           | V <sub>SENSE_TC</sub> (T) = V <sub>SENSE_TC</sub> (T <sub>0</sub> ) + dV <sub>SENSE_TC</sub> / dT * (T - T <sub>0</sub> )                                                                           |       |      |       |      |
| V <sub>CC</sub> supply voltage analog feedback (VN7140AJ only)                                                                                                              |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
| V <sub>SENSE_VCC</sub>                                                                                                                                                      | MultiSense output voltage proportional to V <sub>CC</sub> supply voltage                                                  | V <sub>CC</sub> = 13 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ                                                  | 3.16  | 3.23 | 3.3   | V    |
| Transfer function <sup>(3)</sup>                                                                                                                                            |                                                                                                                           | V <sub>SENSE_VCC</sub> = V <sub>CC</sub> / 4                                                                                                                                                        |       |      |       |      |
| Fault diagnostic feedback (see Table 10. Truth table)                                                                                                                       |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
| V <sub>SENSEH</sub>                                                                                                                                                         | MultiSense output voltage in fault condition                                                                              | V <sub>CC</sub> = 13 V; V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A; V <sub>OUT</sub> = 4 V; R <sub>SENSE</sub> = 1 kΩ; | 5     |      | 6.6   | V    |
| I <sub>SENSEH</sub>                                                                                                                                                         | MultiSense output current in fault condition                                                                              | V <sub>CC</sub> = 13 V; V <sub>SENSE</sub> = 5 V                                                                                                                                                    | 7     | 20   | 30    | mA   |
| MultiSense timings (current sense mode - see Figure 7. MultiSense timings (current sense mode)) <sup>(4)</sup>                                                              |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
| t <sub>DSENSE1H</sub>                                                                                                                                                       | Current sense settling time from rising edge of SE <sub>n</sub>                                                           | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 0 V to 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                              |       |      | 60    | μs   |
| t <sub>DSENSE1L</sub>                                                                                                                                                       | Current sense disable delay time from falling edge of SE <sub>n</sub>                                                     | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V to 0 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                              |       | 5    | 20    | μs   |
| t <sub>DSENSE2H</sub>                                                                                                                                                       | Current sense settling time from rising edge of INPUT                                                                     | V <sub>IN</sub> = 0 V to 5 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                              |       | 100  | 250   | μs   |
| Δt <sub>DSENSE2H</sub>                                                                                                                                                      | Current sense settling time from rising edge of I <sub>OUT</sub> (dynamic response to a step change of I <sub>OUT</sub> ) | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; I <sub>SENSE</sub> = 90 % of I <sub>SENSEMAX</sub> ; R <sub>L</sub> = 13 Ω                                                |       |      | 100   | μs   |
| t <sub>DSENSE2L</sub>                                                                                                                                                       | Current sense turn-off delay time from falling edge of INPUT                                                              | V <sub>IN</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                              |       | 50   | 250   | μs   |
| MultiSense timings (chip temperature sense mode - see Figure 8. Multisense timings (chip temperature and V <sub>CC</sub> sense mode) (VN7140AJ only) ) <sup>(4)</sup>       |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
| t <sub>DSENSE3H</sub>                                                                                                                                                       | V <sub>SENSE_TC</sub> settling time from rising edge of SE <sub>n</sub>                                                   | V <sub>SEn</sub> = 0 V to 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ                                                                                          |       |      | 60    | μs   |
| t <sub>DSENSE3L</sub>                                                                                                                                                       | V <sub>SENSE_TC</sub> disable delay time from falling edge of SE <sub>n</sub>                                             | V <sub>SEn</sub> = 5 V to 0 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ                                                                                          |       |      | 20    | μs   |
| MultiSense timings (V <sub>CC</sub> voltage sense mode - see Figure 8. Multisense timings (chip temperature and V <sub>CC</sub> sense mode) (VN7140AJ only)) <sup>(4)</sup> |                                                                                                                           |                                                                                                                                                                                                     |       |      |       |      |
| t <sub>DSENSE4H</sub>                                                                                                                                                       | V <sub>SENSE_VCC</sub> settling time from rising edge of SE <sub>n</sub>                                                  | V <sub>SEn</sub> = 0 V to 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ                                                                                          |       |      | 60    | μs   |
| t <sub>DSENSE4L</sub>                                                                                                                                                       | V <sub>SENSE_VCC</sub> disable delay time from falling edge of SE <sub>n</sub>                                            | V <sub>SEn</sub> = 5 V to 0 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ                                                                                          |       |      | 20    | μs   |

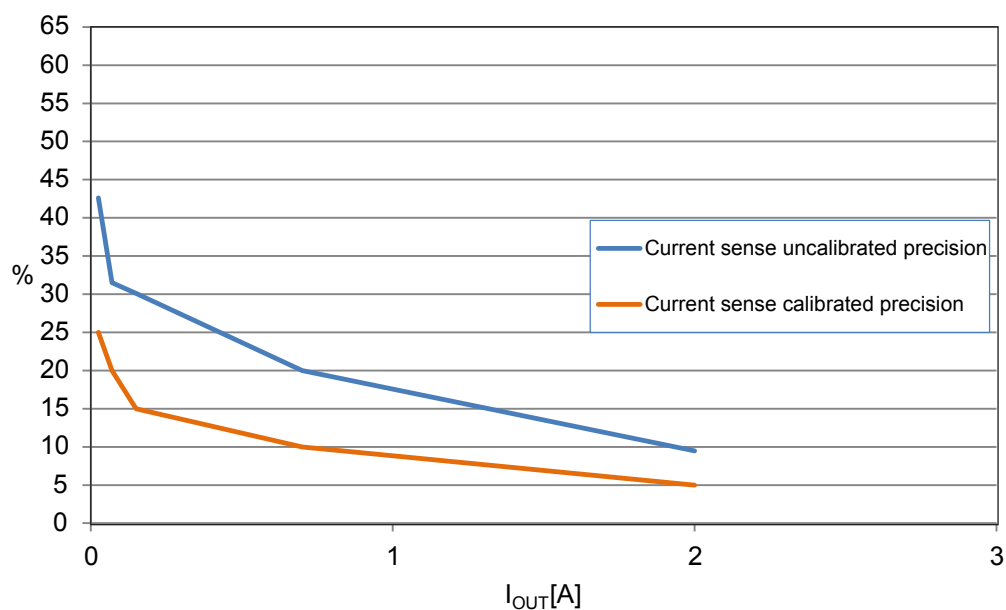
| 7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C                     |                                                                                |                                                                                                                                                             |      |      |      |      |
|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|------|
| Symbol                                                                           | Parameter                                                                      | Test conditions                                                                                                                                             | Min. | Typ. | Max. | Unit |
| MultiSense timings (Multiplexer transition times) (VN7140AJ only) <sup>(4)</sup> |                                                                                |                                                                                                                                                             |      |      |      |      |
| t <sub>D_CStoTC</sub>                                                            | MultiSense transition delay from current sense to T <sub>C</sub> sense         | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V to 5 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ |      |      | 60   | μs   |
| t <sub>D_TCtoCS</sub>                                                            | MultiSense transition delay from T <sub>C</sub> sense to current sense         | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V to 0 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ |      |      | 20   | μs   |
| t <sub>D_CStoVCC</sub>                                                           | MultiSense transition delay from current sense to V <sub>CC</sub> sense        | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 0 V to 5 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ |      |      | 60   | μs   |
| t <sub>D_VCCtoCS</sub>                                                           | MultiSense transition delay from V <sub>CC</sub> sense to current sense        | V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V to 0 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ |      |      | 20   | μs   |
| t <sub>D_TCtoVCC</sub>                                                           | MultiSense transition delay from T <sub>C</sub> sense to V <sub>CC</sub> sense | V <sub>CC</sub> = 13 V; T <sub>j</sub> = 125°C; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V to 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ  |      |      | 20   | μs   |
| t <sub>D_VCCtoTC</sub>                                                           | MultiSense transition delay from V <sub>CC</sub> sense to T <sub>C</sub> sense | V <sub>CC</sub> = 13 V; T <sub>j</sub> = 125°C; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V to 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ  |      |      | 20   | μs   |

1. Parameter specified by design; not subjected to production test.
2. All values refer to V<sub>CC</sub> = 13 V; T<sub>j</sub> = 25°C, unless otherwise specified.
3. V<sub>CC</sub> sensing and T<sub>C</sub> are referred to GND potential.
4. Transition delays are measured up to +/- 10% of final conditions.

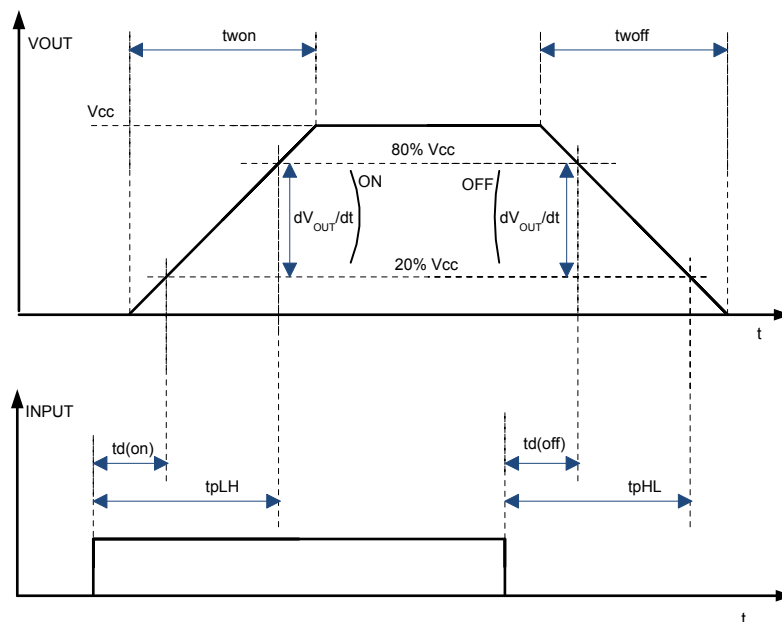
**Figure 4. I<sub>OUT</sub>/I<sub>SENSE</sub> versus I<sub>OUT</sub>**

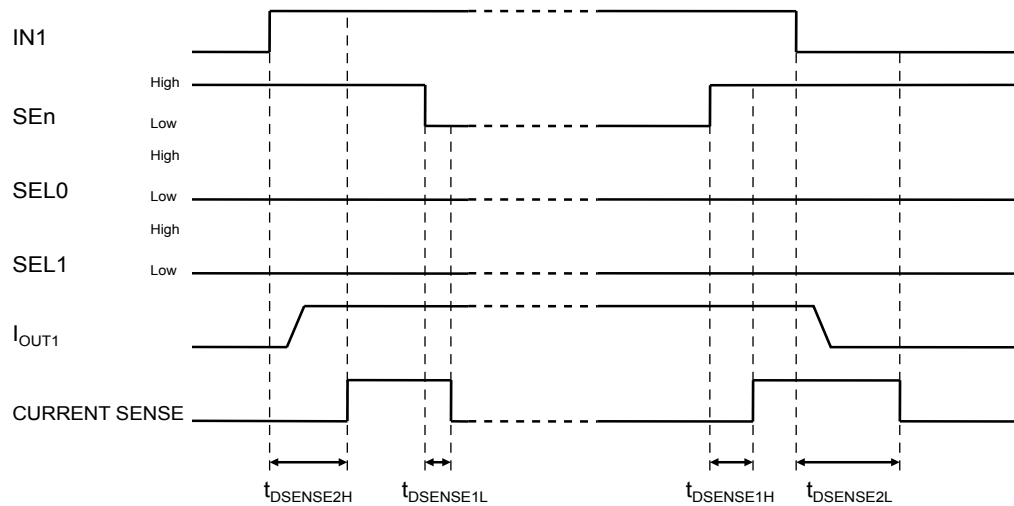
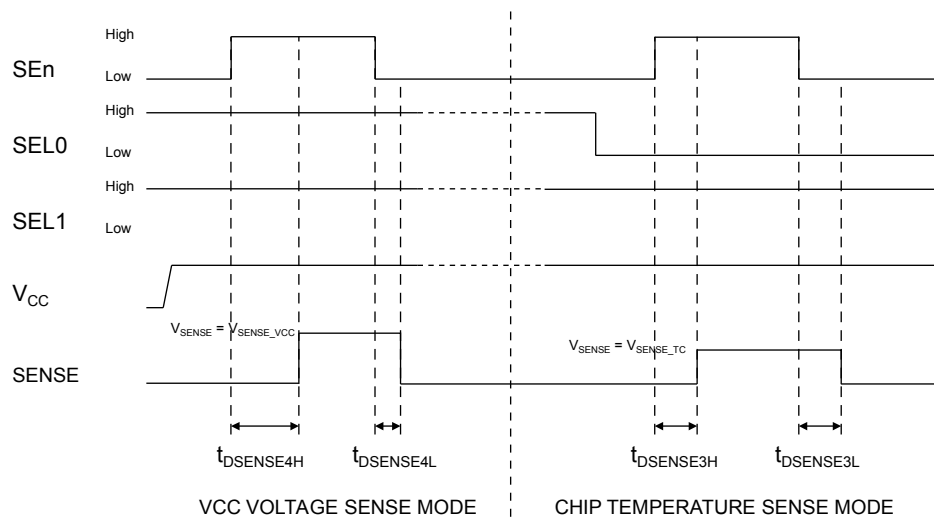


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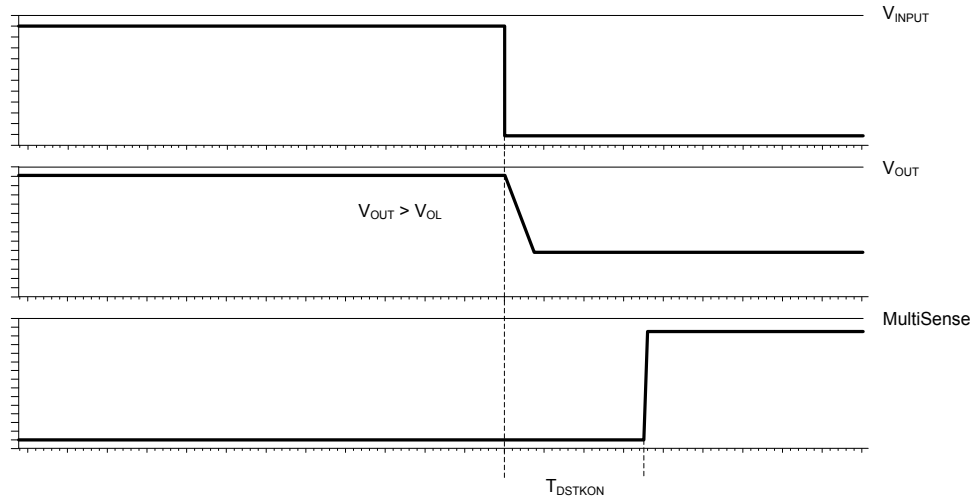
**Figure 5. Current sense accuracy versus  $I_{OUT}$** 


GAPGCFT01218

**Figure 6. Switching time and Pulse skew**


**Figure 7. MultiSense timings (current sense mode)**

**Figure 8. Multisense timings (chip temperature and  $V_{CC}$  sense mode) (VN7140AJ only)**


GAPGCFT00319

**Figure 9.  $T_{DSTKON}$** 


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**Table 10. Truth table**

| Mode                    | Conditions                                                                                 | IN <sub>x</sub> | FR <sup>(1)</sup> | SEn                | SEL <sub>x</sub> <sup>(1)</sup> | OUT <sub>x</sub> | MultiSense         | Comments                                                   |
|-------------------------|--------------------------------------------------------------------------------------------|-----------------|-------------------|--------------------|---------------------------------|------------------|--------------------|------------------------------------------------------------|
| Standby                 | All logic inputs low                                                                       | L               | L                 | L                  | L                               | L                | Hi-Z               | Low quiescent current consumption                          |
| Normal                  | Nominal load connected;<br>$T_j < 150\text{ °C}$                                           | L               | X                 | See <sup>(2)</sup> |                                 | L                | See <sup>(2)</sup> |                                                            |
|                         |                                                                                            | H               | L                 |                    |                                 | H                | See <sup>(2)</sup> | Outputs configured for auto-restart                        |
|                         |                                                                                            | H               | H                 |                    |                                 | H                | See <sup>(2)</sup> | Outputs configured for latch-off <sup>(1)</sup>            |
| Overload                | Overload or short to GND causing:<br>$T_j > T_{TSD}$ or<br>$\Delta T_j > \Delta T_{j\_SD}$ | L               | X                 | See <sup>(2)</sup> |                                 | L                | See <sup>(2)</sup> |                                                            |
|                         |                                                                                            | H               | L                 |                    |                                 | H                | See <sup>(2)</sup> | Output cycles with temperature hysteresis                  |
|                         |                                                                                            | H               | H                 |                    |                                 | L                | See <sup>(2)</sup> | Output latches-off <sup>(1)</sup>                          |
| Undervoltage            | $V_{CC} < V_{USD}$ (falling)                                                               | X               | X                 | X                  | X                               | L<br>L           | Hi-Z<br>Hi-Z       | Re-start when<br>$V_{CC} > V_{USD} + V_{USDhyst}$ (rising) |
| OFF-state diagnostics   | Short to $V_{CC}$                                                                          | L               | X                 | See <sup>(2)</sup> |                                 | H                | See <sup>(2)</sup> |                                                            |
|                         | Open-load                                                                                  | L               | X                 |                    |                                 | H                | See <sup>(2)</sup> | External pull-up                                           |
| Negative output voltage | Inductive loads turn-off                                                                   | L               | X                 | See <sup>(2)</sup> |                                 | < 0 V            | See <sup>(2)</sup> |                                                            |

1. VN7140AJ only

2. Refer to Table 11. MultiSense multiplexer addressing

**Table 11. MultiSense multiplexer addressing**

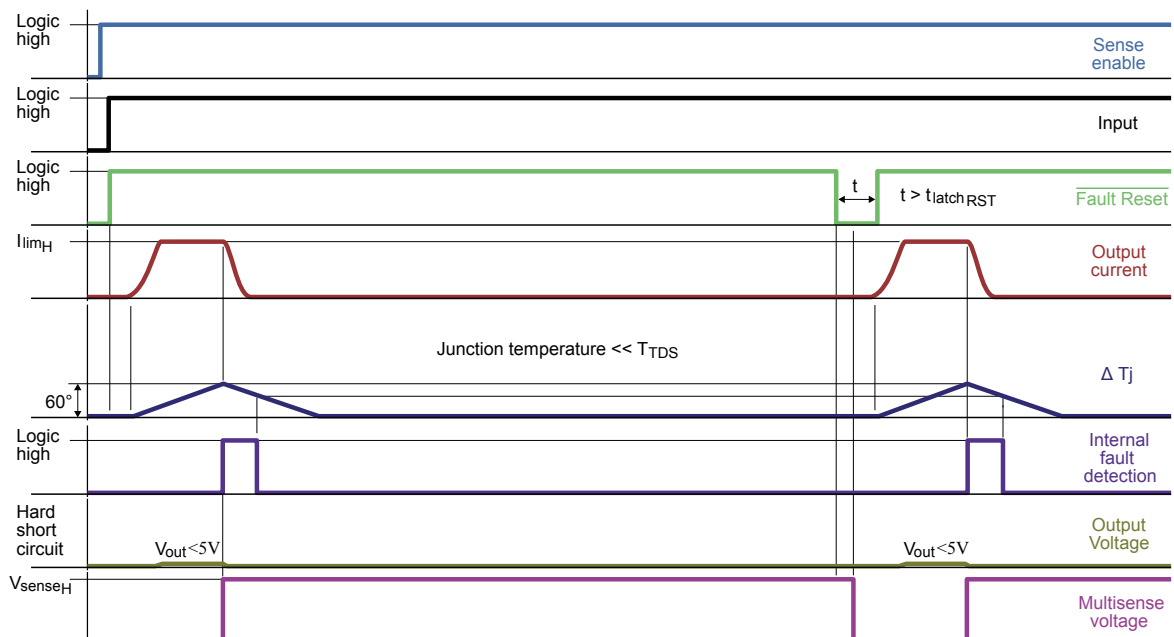
| SEn  | SEL <sub>1</sub> | SEL <sub>0</sub> | MUX channel | MultiSense output |          |                                |                 |
|------|------------------|------------------|-------------|-------------------|----------|--------------------------------|-----------------|
|      |                  |                  |             | Normal mode       | Overload | OFF-state diag. <sup>(1)</sup> | Negative output |
| SO-8 |                  |                  |             |                   |          |                                |                 |

| SEn         | SEL <sub>1</sub> | SEL <sub>0</sub> | MUX channel             | MultiSense output            |                          |                                |                 |
|-------------|------------------|------------------|-------------------------|------------------------------|--------------------------|--------------------------------|-----------------|
|             |                  |                  |                         | Normal mode                  | Overload                 | OFF-state diag. <sup>(1)</sup> | Negative output |
| L           | N.A.             | N.A.             | N.A.                    | Hi-Z                         |                          |                                |                 |
| H           | N.A.             | N.A.             | Channel diagnostic      | $I_{SENSE} = 1/K * I_{OUT}$  | $V_{SENSE} = V_{SENSEH}$ | $V_{SENSE} = V_{SENSEH}$       | Hi-Z            |
| PowerSSO-16 |                  |                  |                         |                              |                          |                                |                 |
| H           | L                | L                | Channel diagnostic      | $I_{SENSE} = 1/K * I_{OUT}$  | $V_{SENSE} = V_{SENSEH}$ | $V_{SENSE} = V_{SENSEH}$       | Hi-Z            |
| H           | L                | H                | Channel diagnostic      | $I_{SENSE} = 1/K * I_{OUT}$  | $V_{SENSE} = V_{SENSEH}$ | $V_{SENSE} = V_{SENSEH}$       | Hi-Z            |
| H           | H                | L                | T <sub>CHIP</sub> Sense | $V_{SENSE} = V_{SENSE\_TC}$  |                          |                                |                 |
| H           | H                | H                | V <sub>CC</sub> Sense   | $V_{SENSE} = V_{SENSE\_VCC}$ |                          |                                |                 |

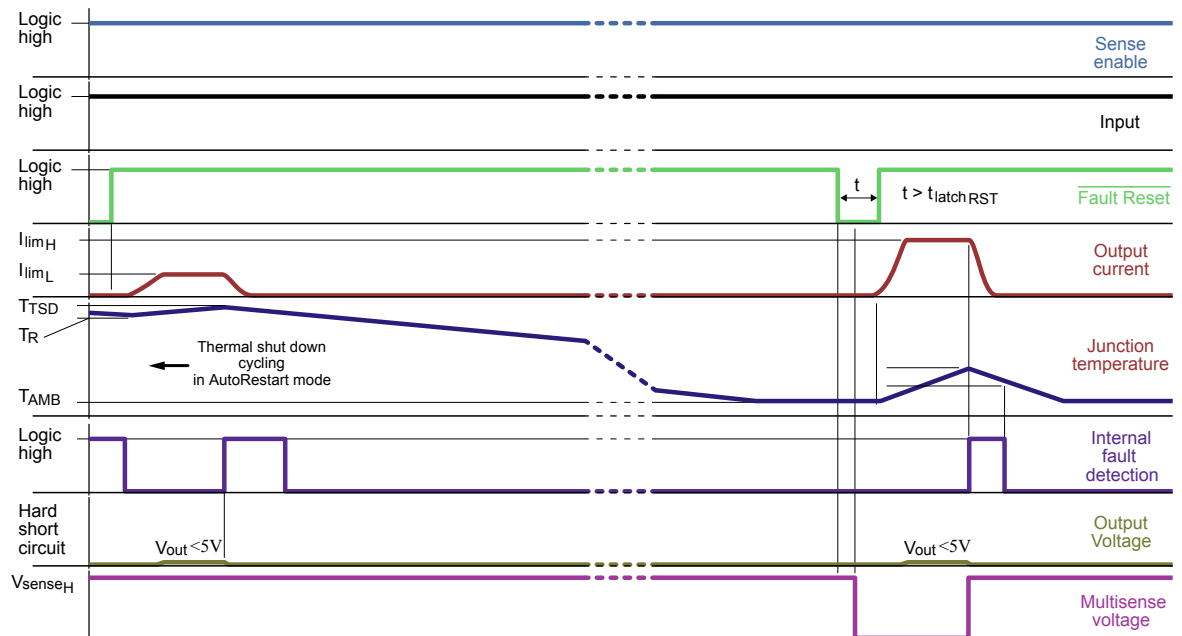
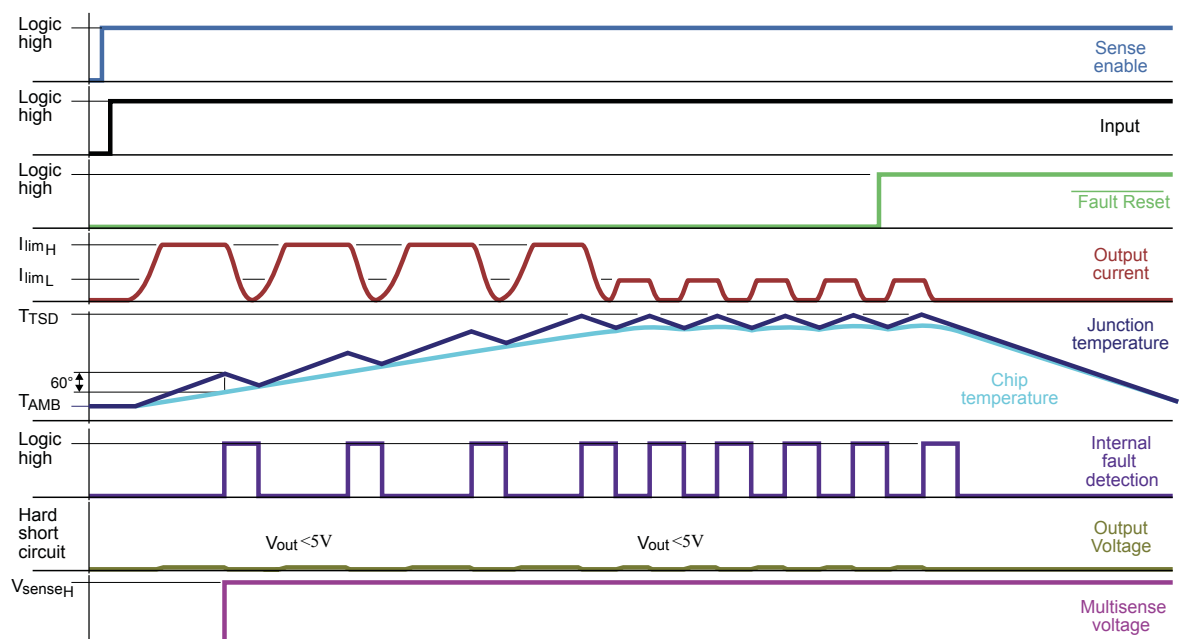
1. In case the output channel corresponding to the selected MUX channel is latched off while the relevant input is low, Multisense pin delivers feedback according to OFF-State diagnostic. Example 1: FR = 1; IN = 0; OUT = L (latched); MUX channel = channel 0 diagnostic; Mutisense = 0. Example 2: FR = 1; IN = 0; OUT = latched,  $V_{OUT} > V_{OL}$ ; MUX channel = channel 0 diagnostic; Mutisense =  $V_{SENSEH}$

## 2.4 Waveforms

**Figure 10. Latch functionality - behavior in hard short-circuit condition ( $T_{AMB} \ll T_{TSD}$ )**

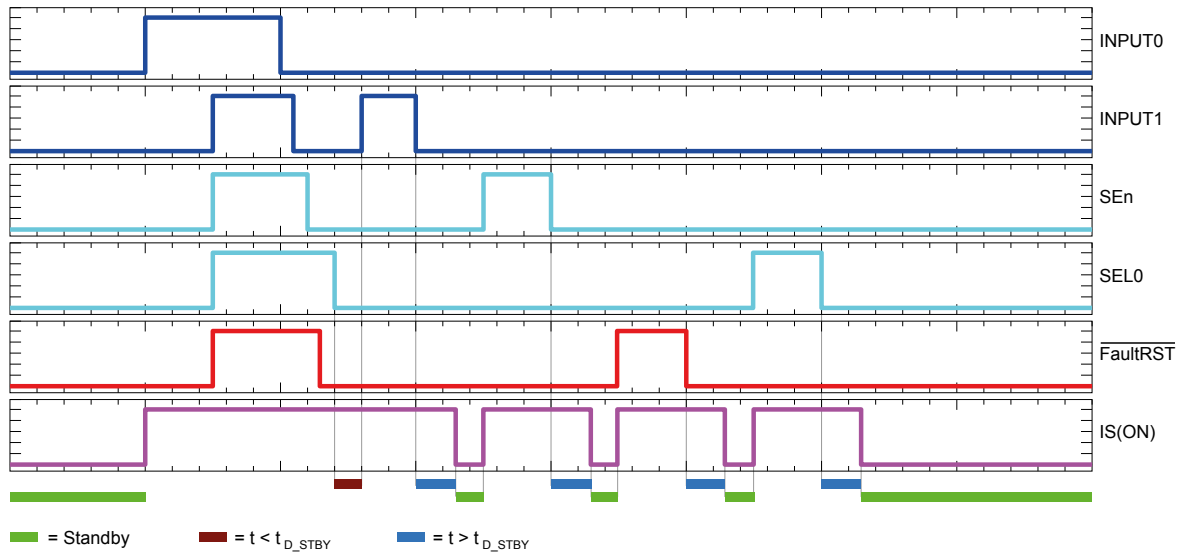


GADG1703171451PS

**Figure 11. Latch functionality - behavior in hard short-circuit condition**

**Figure 12. Latch functionality - behavior in hard short-circuit condition (autorestart mode + latch off)**


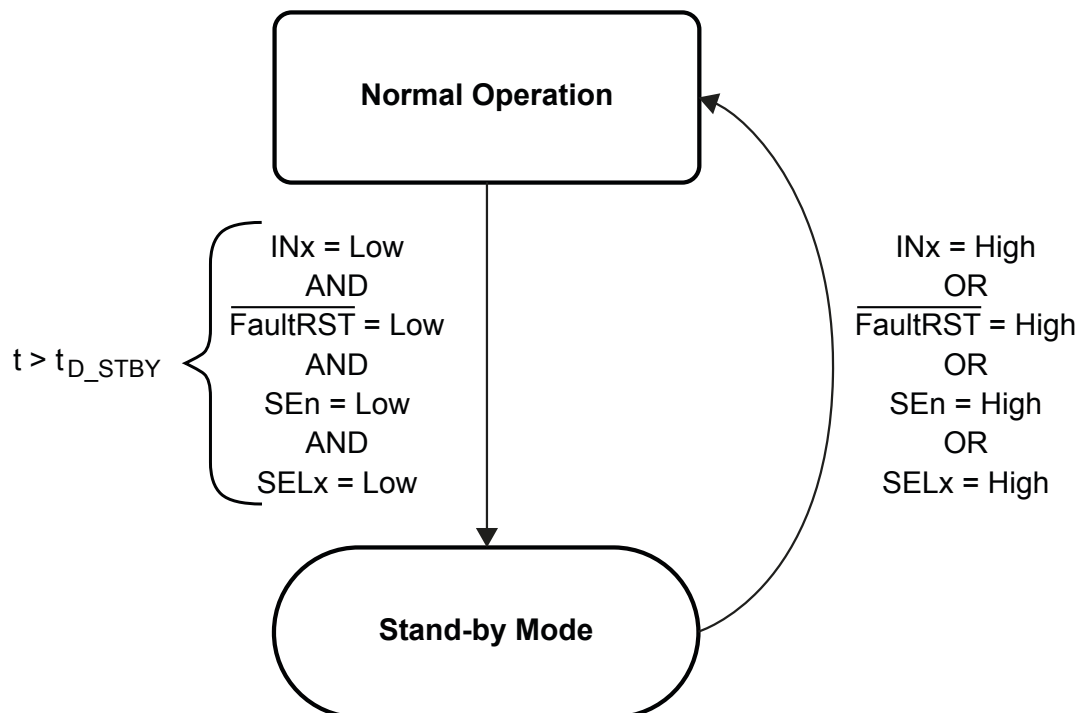
GADG2103171742PS

Figure 13. Standby mode activation



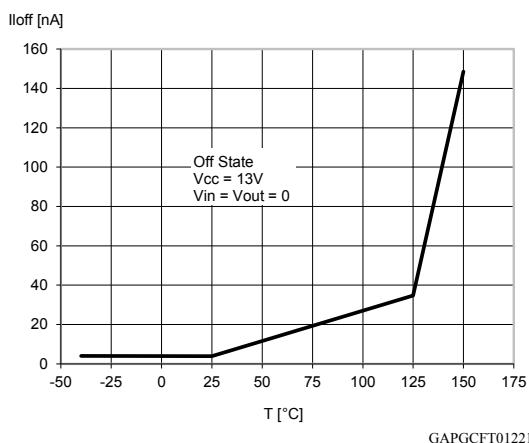
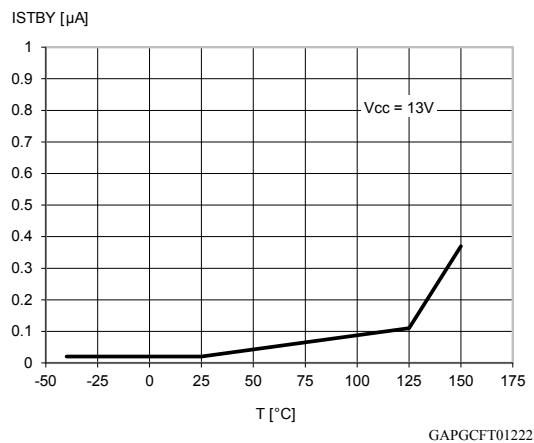
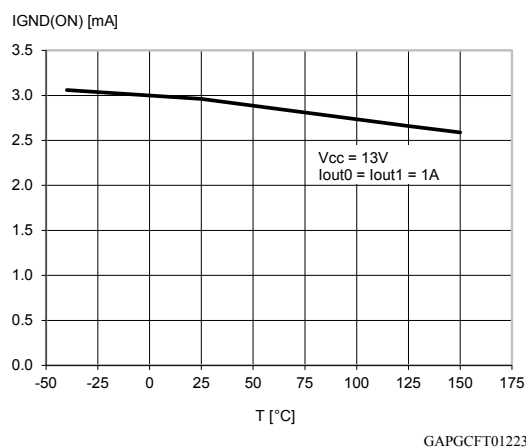
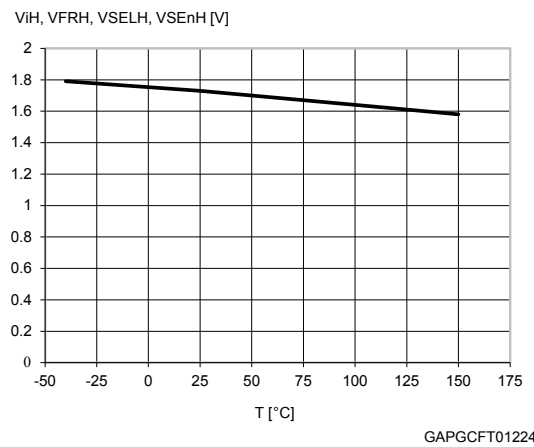
GADG1703171116PS

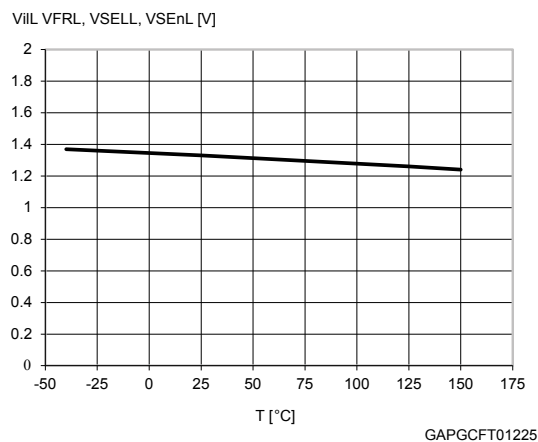
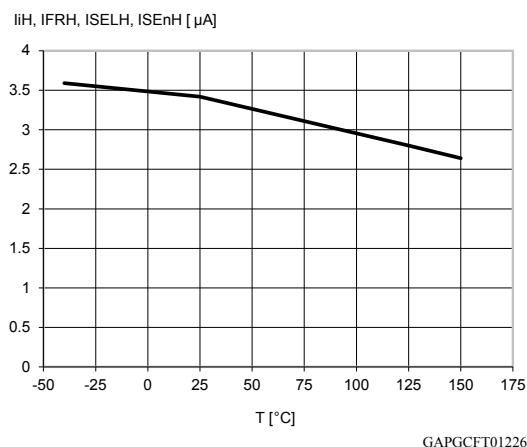
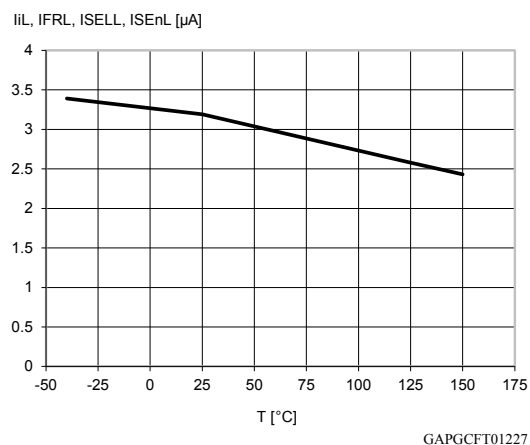
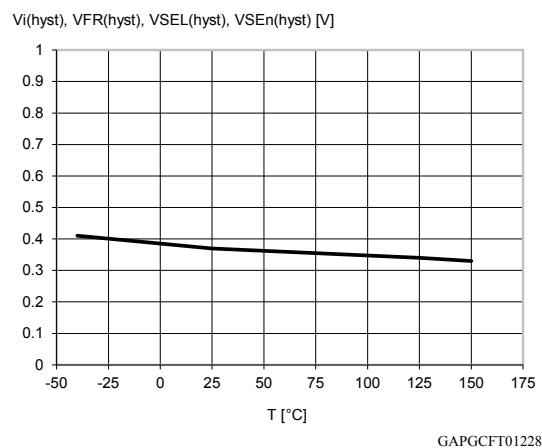
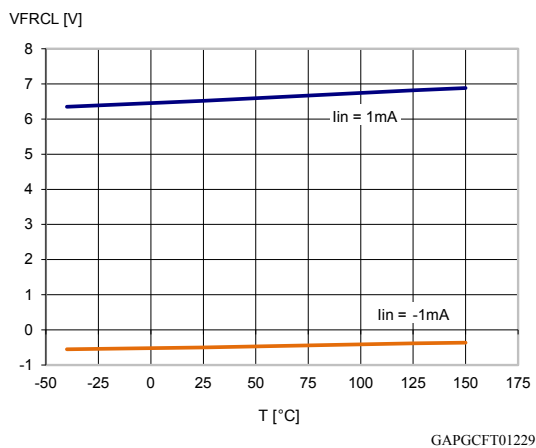
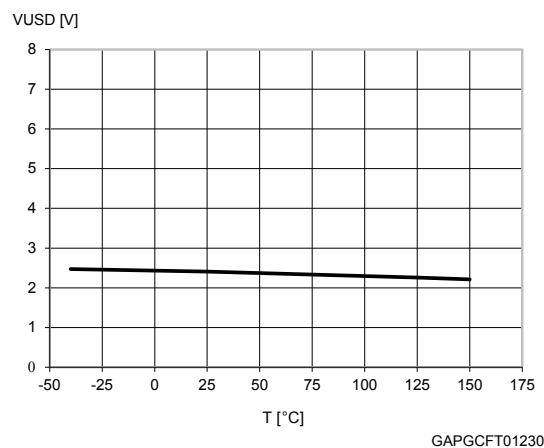
Figure 14. Standby state diagram

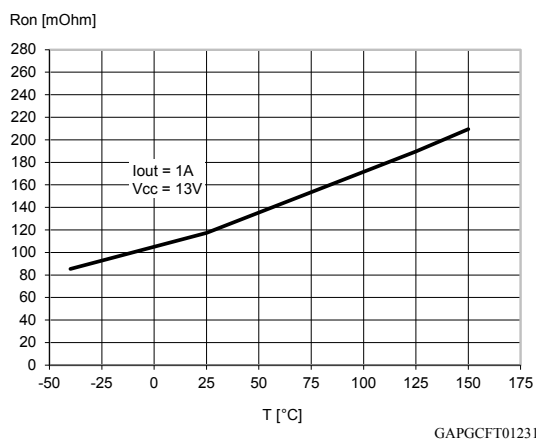


GAPGCFT00598

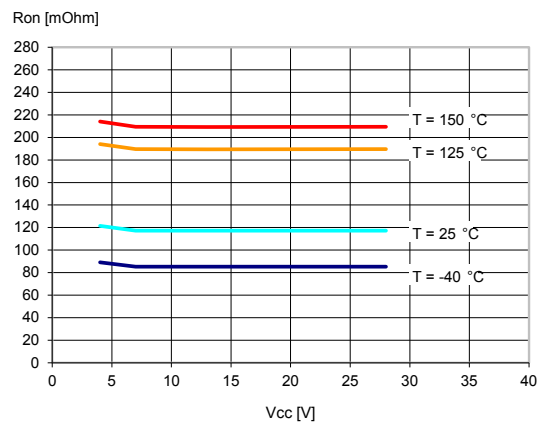
## 2.5 Electrical characteristics curves

**Figure 15. OFF-state output current**

**Figure 16. Standby current**

**Figure 17.  $I_{GND(ON)}$  vs.  $T_{case}$** 

**Figure 18. Logic Input high level voltage**


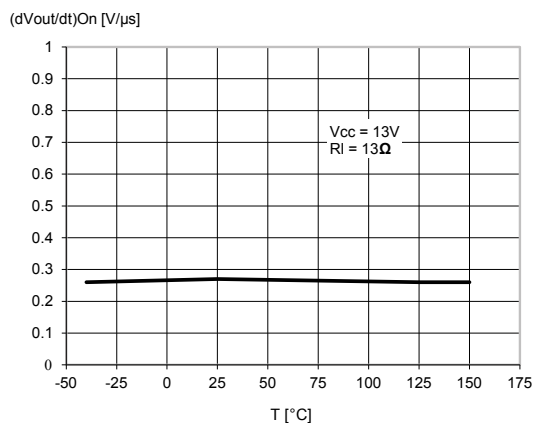
**Figure 19. Logic Input low level voltage**

**Figure 20. High level logic input current**

**Figure 21. Low level logic input current**

**Figure 22. Logic Input hysteresis voltage**

**Figure 23. FaultRST Input clamp voltage**

**Figure 24. Undervoltage shutdown**


**Figure 25. On-state resistance vs.  $T_{case}$** 


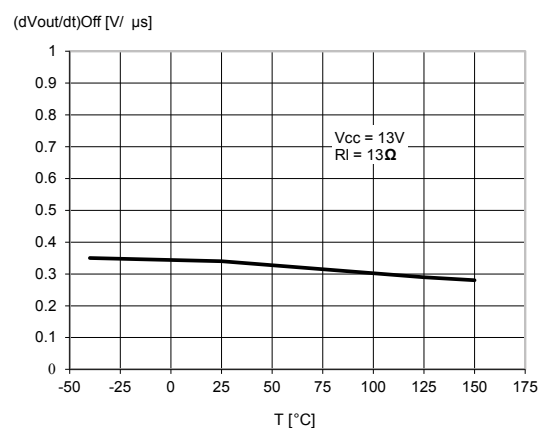
GAPGCFT01231

**Figure 26. On-state resistance vs.  $V_{CC}$** 


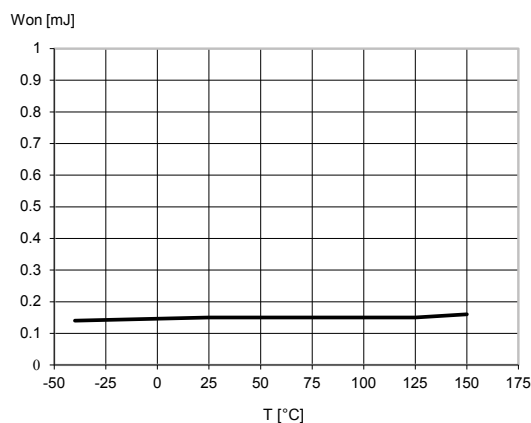
GAPGCFT01232

**Figure 27. Turn-on voltage slope**


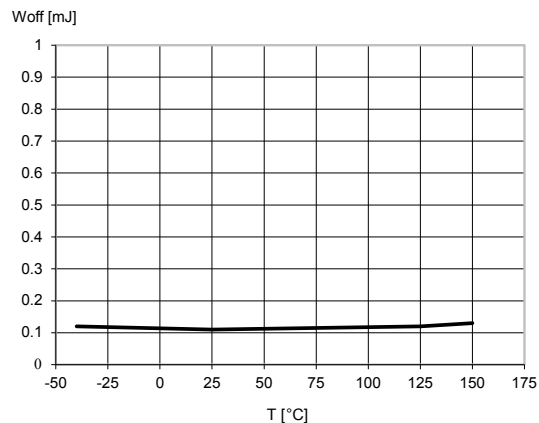
GAPGCFT01233

**Figure 28. Turn-off voltage slope**


GAPGCFT01234

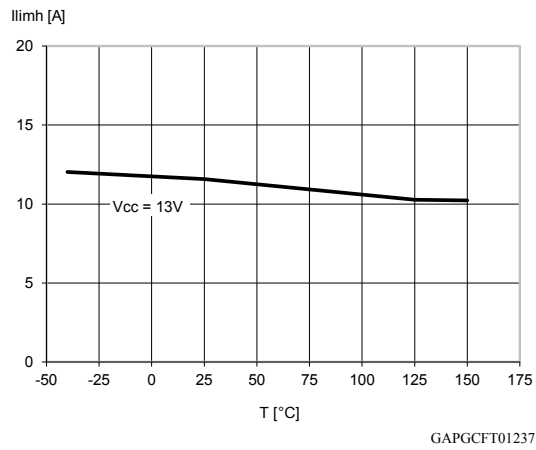
**Figure 29.  $W_{on}$  vs.  $T_{case}$** 


GAPGCFT01235

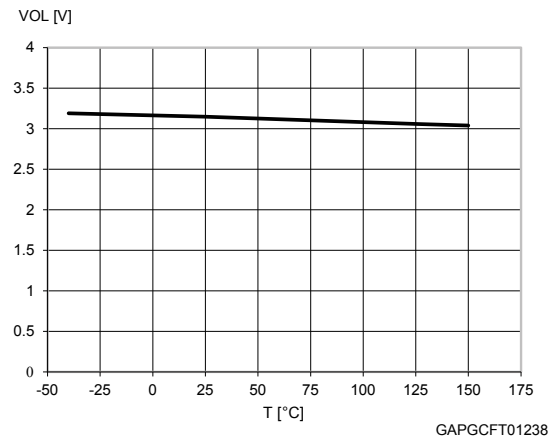
**Figure 30.  $W_{off}$  vs.  $T_{case}$** 


GAPGCFT01236

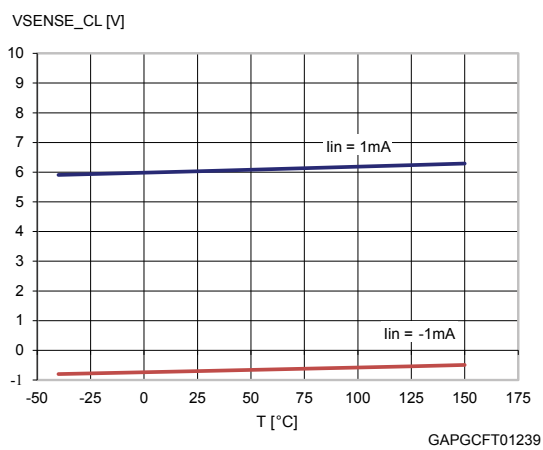
**Figure 31.  $I_{LIMH}$  vs.  $T_{case}$**



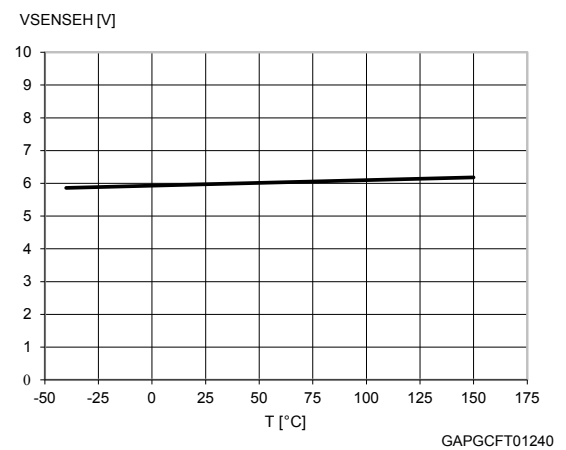
**Figure 32. OFF-state open-load voltage detection threshold**



**Figure 33.  $V_{sense}$  clamp vs.  $T_{case}$**



**Figure 34.  $V_{senseh}$  vs.  $T_{case}$**



## 3 Protections

### 3.1 Power limitation

The basic working principle of this protection consists of an indirect measurement of the junction temperature swing  $\Delta T_j$  through the direct measurement of the spatial temperature gradient on the device surface in order to automatically shut off the output MOSFET as soon as  $\Delta T_j$  exceeds the safety level of  $\Delta T_{j\_SD}$ . According to the voltage level on the  $\overline{\text{FaultRST}}$  pin, the output MOSFET switches on and cycles with a thermal hysteresis according to the maximum instantaneous power which can be handled ( $\overline{\text{FaultRST}} = \text{Low}$ ) or remains off ( $\overline{\text{FaultRST}} = \text{High}$ ). The protection prevents fast thermal transient effects and, consequently, reduces thermo-mechanical fatigue.

### 3.2 Thermal shutdown

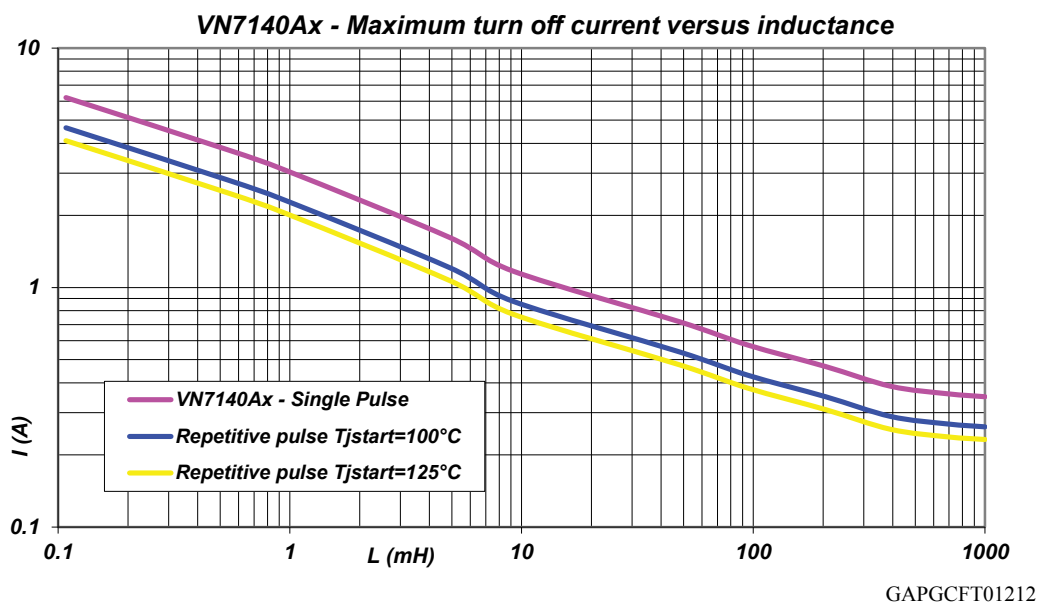
In case the junction temperature of the device exceeds the maximum allowed threshold (typically 175°C), it automatically switches off and the diagnostic indication is triggered. According to the voltage level on the  $\overline{\text{FaultRST}}$  pin, the device switches on again as soon as its junction temperature drops to  $T_R$  ( $\overline{\text{FaultRST}} = \text{Low}$ ) or remains off ( $\overline{\text{FaultRST}} = \text{High}$ ).

### 3.3 Current limitation

The device is equipped with an output current limiter in order to protect the silicon as well as the other components of the system (e.g. bonding wires, wiring harness, connectors, loads, etc.) from excessive current flow. Consequently, in case of short circuit, overload or during load power-up, the output current is clamped to a safety level,  $I_{LIMH}$ , by operating the output power MOSFET in the active region.

### 3.4 Negative voltage clamp

In case the device drives inductive load, the output voltage reaches a negative value during turn off. A negative voltage clamp structure limits the maximum negative voltage to a certain value,  $V_{\text{DEMAG}}$ , allowing the inductor energy to be dissipated without damaging the device.

**4**
**Maximum demagnetization energy (VCC = 16 V)**
**Figure 35. Maximum turn off current versus inductance**


*Note:*

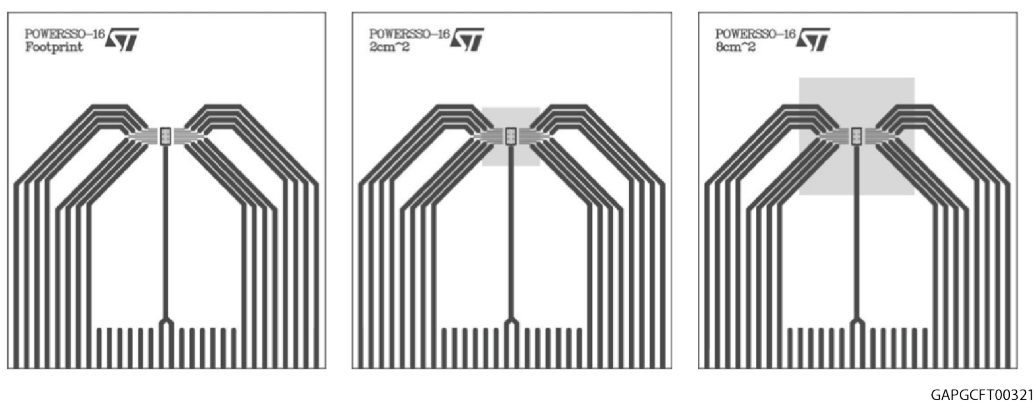
Values are generated with  $R_L = 0 \Omega$ .

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.

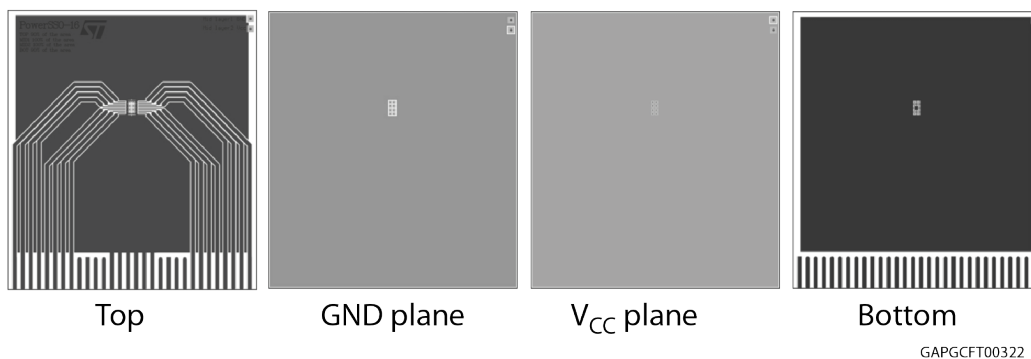
## 5 Package and PCB thermal data

### 5.1 PowerSSO-16 thermal data

**Figure 36. PowerSSO-16 on two-layers PCB (2s0p to JEDEC JESD 51-5)**



**Figure 37. PowerSSO-16 on four-layers PCB (2s2p to JEDEC JESD 51-7)**

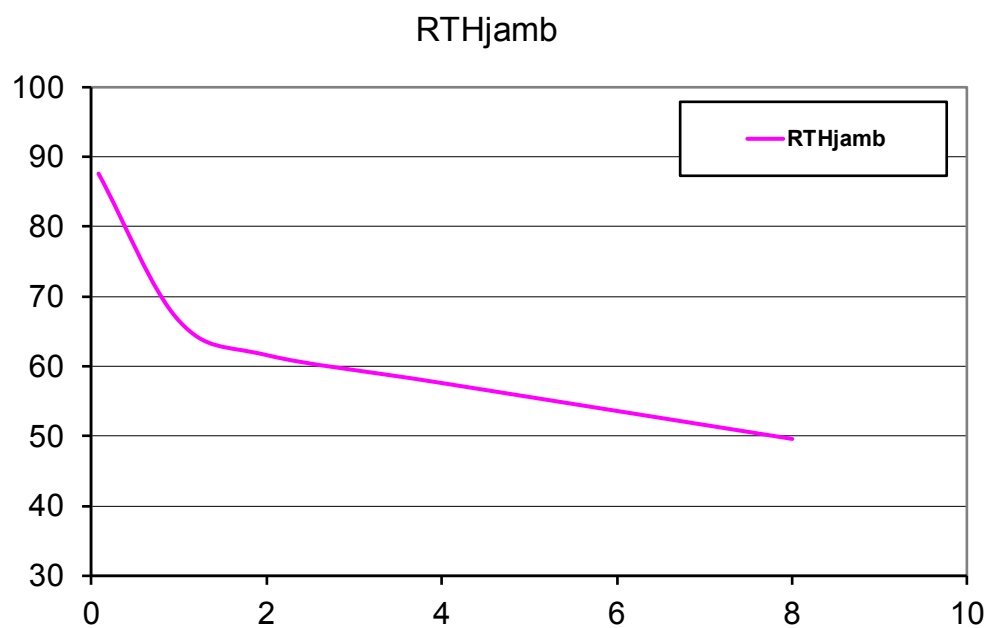


**Table 12. PCB properties**

| Dimension                                | Value              |
|------------------------------------------|--------------------|
| Board finish thickness                   | 1.6 mm +/- 10%     |
| Board dimension                          | 77 mm x 86 mm      |
| Board Material                           | FR4                |
| Copper thickness (top and bottom layers) | 0.070 mm           |
| Copper thickness (inner layers)          | 0.035 mm           |
| Thermal vias separation                  | 1.2 mm             |
| Thermal via diameter                     | 0.3 mm +/- 0.08 mm |
| Copper thickness on vias                 | 0.025 mm           |
| Footprint dimension (top layer)          | 2.2 mm x 3.9 mm    |

| Dimension                                     | Value                                             |
|-----------------------------------------------|---------------------------------------------------|
| Heatsink copper area dimension (bottom layer) | Footprint, 2 cm <sup>2</sup> or 8 cm <sup>2</sup> |

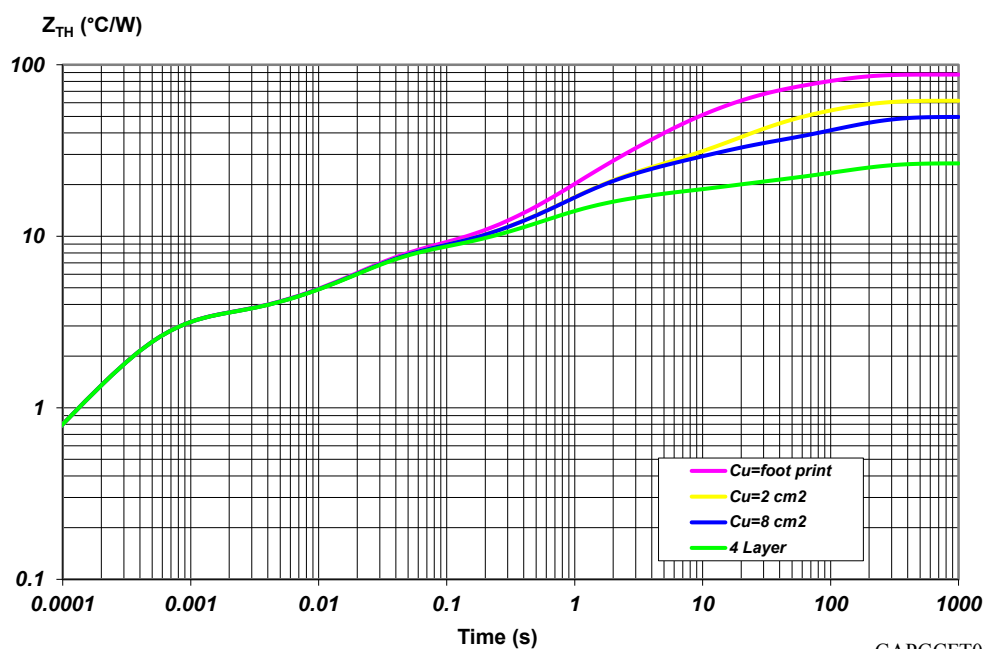
**Figure 38. PowerSSO-16  $R_{thj-amb}$  vs PCB copper area in open box free air condition (one channel on)**



$R_{thj\_amb}$  on 4Layer PCB: 26.8°C/W

GAPGCFT01213

**Figure 39. PowerSSO-16 thermal impedance junction ambient single pulse (one channel on)**

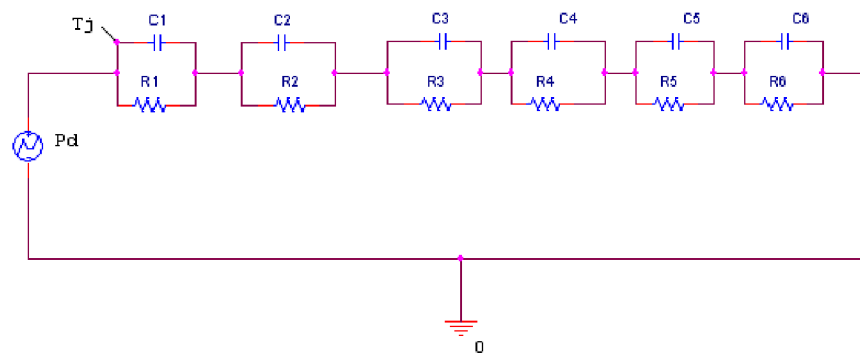


GAPGCFT01214

**Equation: pulse calculation formula**

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

where  $\delta = t_p/T$

**Figure 40. Thermal fitting model of a double-channel HSD in PowerSSO-16**


TAPG2001151031CFT

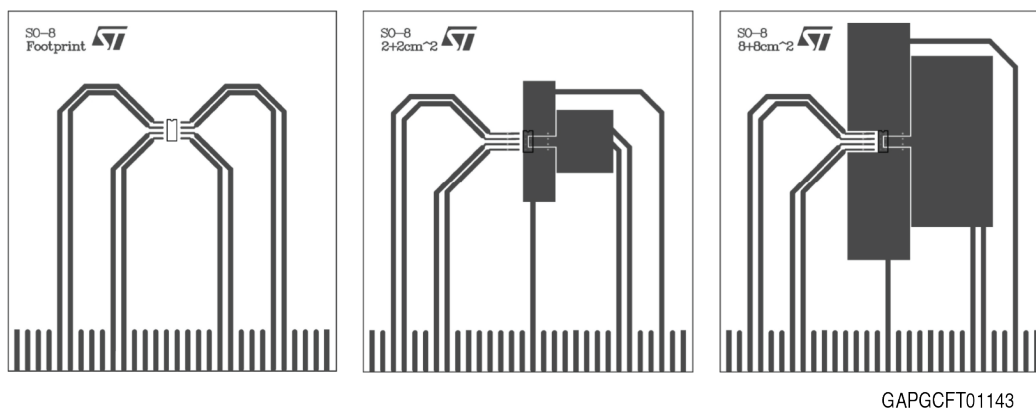
**Note:** The fitting model is a simplified thermal tool and is valid for transient evolutions where the embedded protections (power limitation or thermal cycling during thermal shutdown) are not triggered.

**Table 13. Thermal parameters**

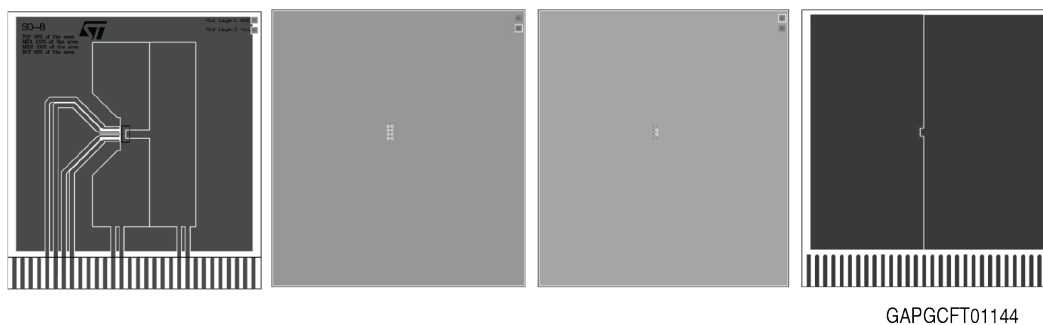
| Area/island (cm <sup>2</sup> ) | Footprint | 2   | 8   | 4L  |
|--------------------------------|-----------|-----|-----|-----|
| R1 (°C/W)                      | 3.2       |     |     |     |
| R2 (°C/W)                      | 4.4       |     |     |     |
| R3 (°C/W)                      | 8         | 8   | 8   | 5   |
| R4 (°C/W)                      | 16        | 6   | 6   | 4   |
| R5 (°C/W)                      | 30        | 20  | 10  | 3   |
| R6 (°C/W)                      | 26        | 20  | 18  | 7   |
| C1 (W.s/°C)                    | 0.00012   |     |     |     |
| C2 (W.s/°C)                    | 0.005     |     |     |     |
| C3 (W.s/°C)                    | 0.1       |     |     |     |
| C4 (W.s/°C)                    | 0.2       | 0.3 | 0.3 | 0.4 |
| C5 (W.s/°C)                    | 0.4       | 1   | 1   | 4   |
| C6 (W.s/°C)                    | 3         | 5   | 7   | 18  |

## 5.2 SO-8 thermal data

**Figure 41. SO-8 on two-layers PCB (2s0p to JEDEC JESD 51-5)**

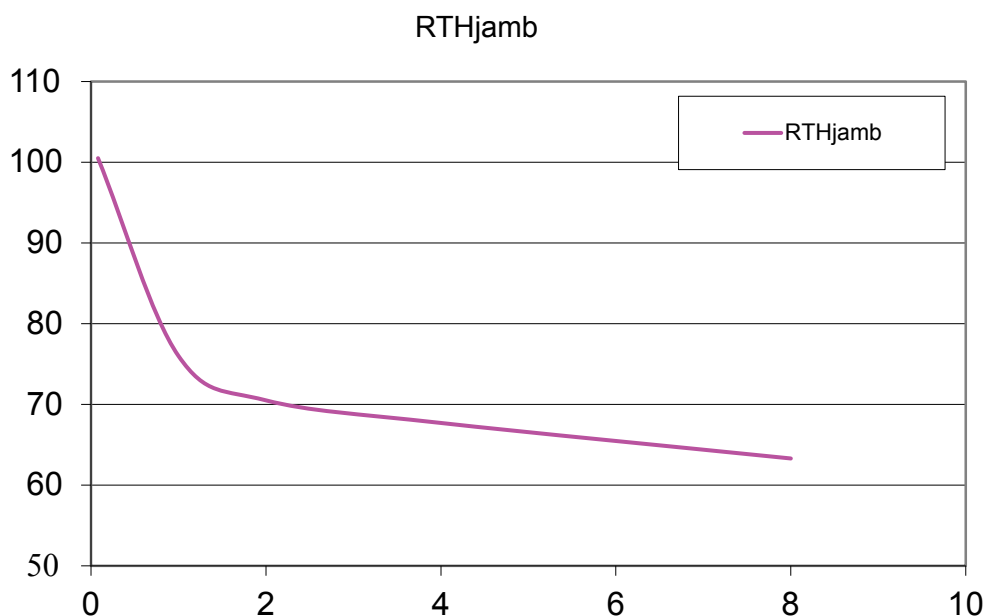


**Figure 42. SO-8 on four-layers PCB (2s2p to JEDEC JESD 51-7)**



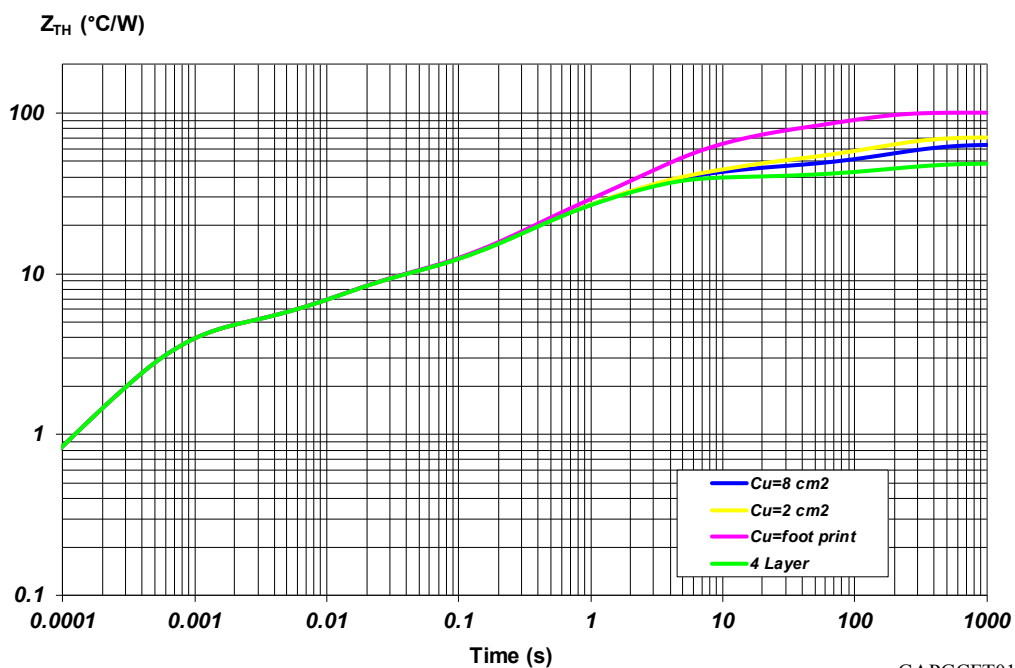
**Table 14. PCB properties**

| Dimension                                     | Value                                                     |
|-----------------------------------------------|-----------------------------------------------------------|
| Board finish thickness                        | 1.6 mm +/- 10%                                            |
| Board dimension                               | 77 mm x 86 mm                                             |
| Board Material                                | FR4                                                       |
| Copper thickness (top and bottom layers)      | 0.070 mm                                                  |
| Copper thickness (inner layers)               | 0.035 mm                                                  |
| Thermal vias separation                       | 1.2 mm                                                    |
| Thermal via diameter                          | 0.3 mm +/- 0.08 mm                                        |
| Copper thickness on vias                      | 0.025 mm                                                  |
| Heatsink copper area dimension (bottom layer) | Footprint, 2 + 2 cm <sup>2</sup> or 8 + 8 cm <sup>2</sup> |

**Figure 43. SO-8  $R_{thj-amb}$  vs PCB copper area in open box free air condition (one channel on)**


$R_{thj-amb}$  on 4Layer PCB: 48.5°C/W

GAPGCFT01152

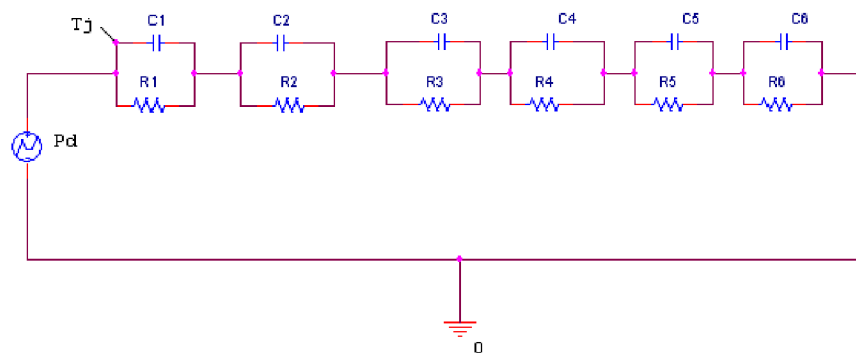
**Figure 44. SO-8 thermal impedance junction ambient single pulse (one channel on)**


GAPGCFT01153

**Equation: pulse calculation formula**

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

where  $\delta = t_p/T$

**Figure 45. Thermal fitting model of a double-channel HSD in SO-8**


TAPG2001151031CFT

**Note:** 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 15. Thermal parameters**

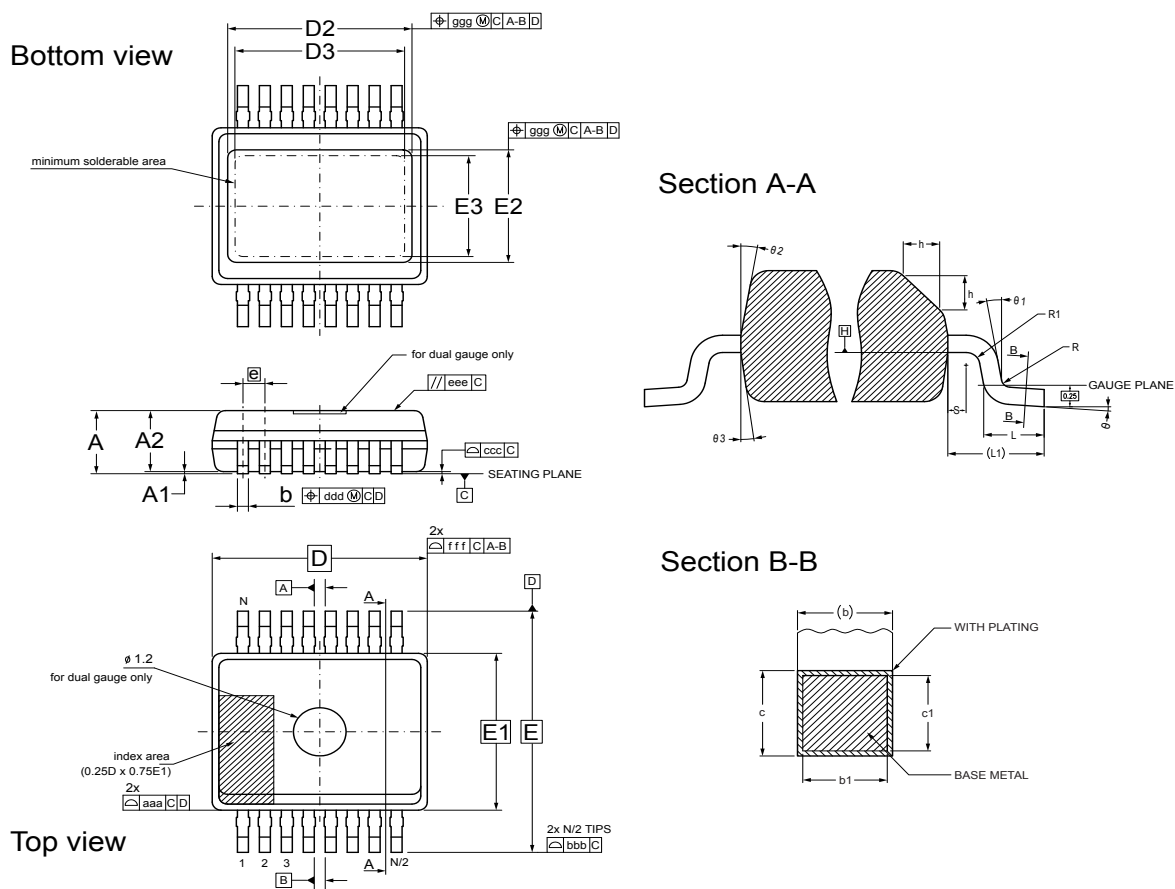
| Area/island (cm <sup>2</sup> ) | Footprint | 2   | 8   | 4L  |
|--------------------------------|-----------|-----|-----|-----|
| R1 (°C/W)                      | 4.2       |     |     |     |
| R2 (°C/W)                      | 4.3       |     |     |     |
| R3 (°C/W)                      | 10        |     |     |     |
| R4 (°C/W)                      | 28        | 17  | 17  | 17  |
| R5 (°C/W)                      | 24        | 12  | 9   | 4   |
| R6 (°C/W)                      | 30        | 23  | 19  | 9   |
| C1 (W.s/°C)                    | 0.00012   |     |     |     |
| C2 (W.s/°C)                    | 0.003     |     |     |     |
| C3 (W.s/°C)                    | 0.03      |     |     |     |
| C4 (W.s/°C)                    | 0.1       |     |     |     |
| C5 (W.s/°C)                    | 0.4       | 0.8 | 0.8 | 0.8 |
| C6 (W.s/°C)                    | 3         | 7   | 11  | 22  |

## 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 PowerSSO-16 package information

**Figure 46. PowerSSO-16 package outline**



8017965\_Rev\_9

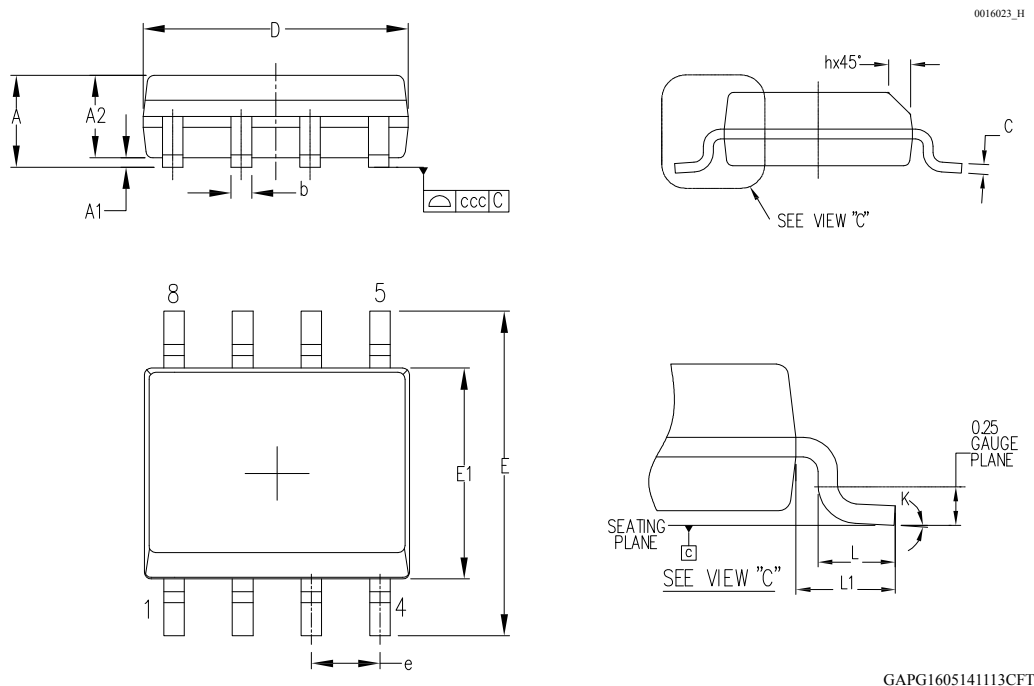
GAPG1605141159CFT

**Table 16. PowerSSO-16 mechanical data**

| Symbol                         | Millimeters |      |      |
|--------------------------------|-------------|------|------|
|                                | Min.        | Typ. | Max. |
| $\Theta$                       | 0°          |      | 8°   |
| $\Theta 1$                     | 0°          |      |      |
| $\Theta 2$                     | 5°          |      | 15°  |
| $\Theta 3$                     | 5°          |      | 15°  |
| A                              |             |      | 1.70 |
| A1                             | 0.00        |      | 0.10 |
| A2                             | 1.10        |      | 1.60 |
| b                              | 0.20        |      | 0.30 |
| b1                             | 0.20        | 0.25 | 0.28 |
| c                              | 0.19        |      | 0.25 |
| c1                             | 0.19        | 0.20 | 0.23 |
| D                              | 4.9 BSC     |      |      |
| D2                             | 2.90        |      | 3.50 |
| D3                             | 2.20        |      |      |
| e                              | 0.50 BSC    |      |      |
| E                              | 6.00 BSC    |      |      |
| E1                             | 3.90 BSC    |      |      |
| E2                             | 2.20        |      | 2.80 |
| E3                             | 1.50        |      |      |
| h                              | 0.25        |      | 0.50 |
| L                              | 0.40        | 0.60 | 0.85 |
| L1                             | 1.00 REF    |      |      |
| N                              | 16          |      |      |
| R                              | 0.07        |      |      |
| R1                             | 0.07        |      |      |
| S                              | 0.20        |      |      |
| Tolerance of form and position |             |      |      |
| aaa                            | 0.10        |      |      |
| bbb                            | 0.10        |      |      |
| ccc                            | 0.08        |      |      |
| ddd                            | 0.08        |      |      |
| eee                            | 0.10        |      |      |
| fff                            | 0.10        |      |      |
| ggg                            | 0.15        |      |      |

## 6.2 SO-8 package information

**Figure 47. SO-8 package outline**

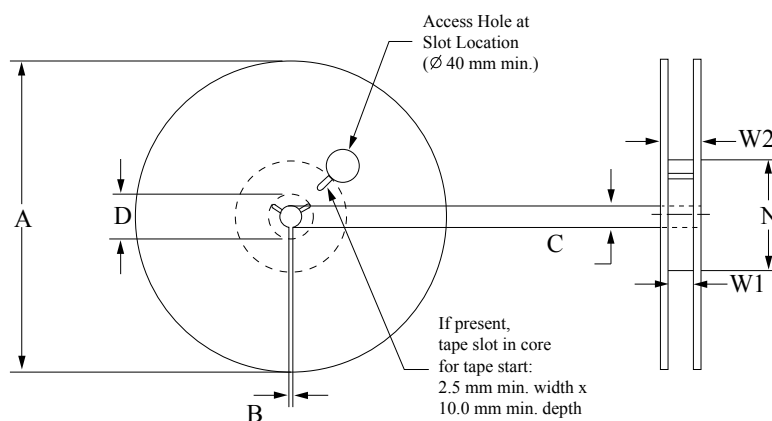


**Table 17. SO-8 mechanical data**

| Ref. | Dimensions  |      |      |
|------|-------------|------|------|
|      | Millimeters |      |      |
|      | Min.        | Typ. | Max. |
| A    |             |      | 1.75 |
| A1   | 0.10        |      | 0.25 |
| A2   | 1.25        |      |      |
| b    | 0.28        |      | 0.48 |
| c    | 0.17        |      | 0.23 |
| D    | 4.80        | 4.90 | 5.00 |
| E    | 5.80        | 6.00 | 6.20 |
| E1   | 3.80        | 3.90 | 4.00 |
| e    |             | 1.27 |      |
| h    | 0.25        |      | 0.50 |
| L    | 0.40        |      | 1.27 |
| L1   |             | 1.04 |      |
| k    | 0°          |      | 8°   |
| ccc  |             |      | 0.10 |

### 6.3 PowerSSO-16 packing information

**Figure 48. PowerSSO-16 reel 13"**



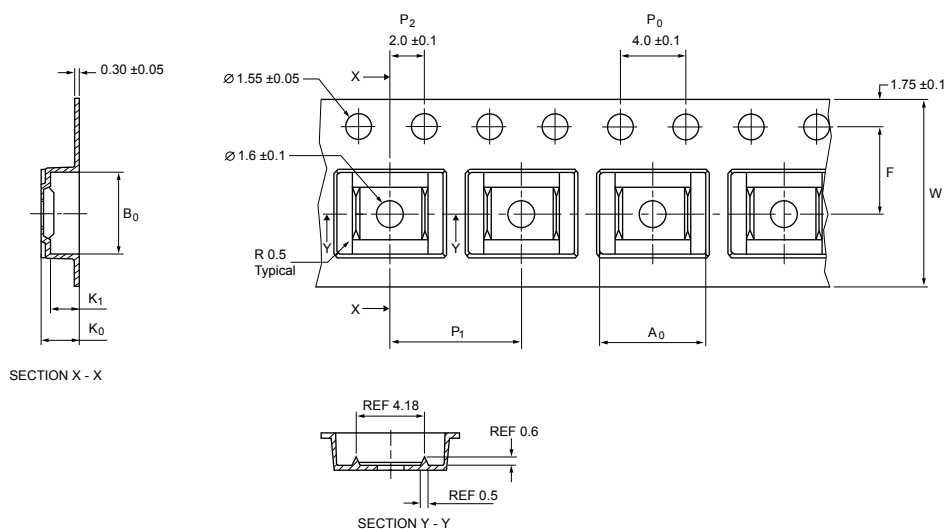
TAPG2004151655CFT

**Table 18. Reel dimensions**

| Description    | Value <sup>(1)</sup> |
|----------------|----------------------|
| Base quantity  | 2500                 |
| Bulk quantity  | 2500                 |
| A (max)        | 330                  |
| B (min)        | 1.5                  |
| C (+0.5, -0.2) | 13                   |
| D (min)        | 20.2                 |
| N              | 100                  |
| W1 (+2 /-0)    | 12.4                 |
| W2 (max)       | 18.4                 |

1. All dimensions are in mm.

**Figure 49. PowerSSO-16 carrier tape**



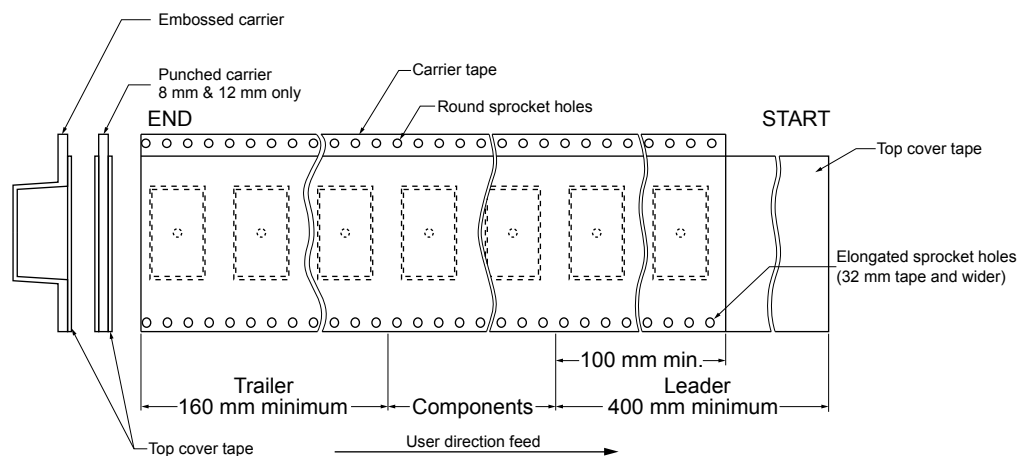
GAPG2204151242CFT

**Table 19. PowerSSO-16 carrier tape dimensions**

| Description | Value <sup>(1)</sup> |
|-------------|----------------------|
| $A_0$       | $6.50 \pm 0.1$       |
| $B_0$       | $5.25 \pm 0.1$       |
| $K_0$       | $2.10 \pm 0.1$       |
| $K_1$       | $1.80 \pm 0.1$       |
| $F$         | $5.50 \pm 0.1$       |
| $P_1$       | $8.00 \pm 0.1$       |
| $W$         | $12.00 \pm 0.3$      |

1. All dimensions are in mm.

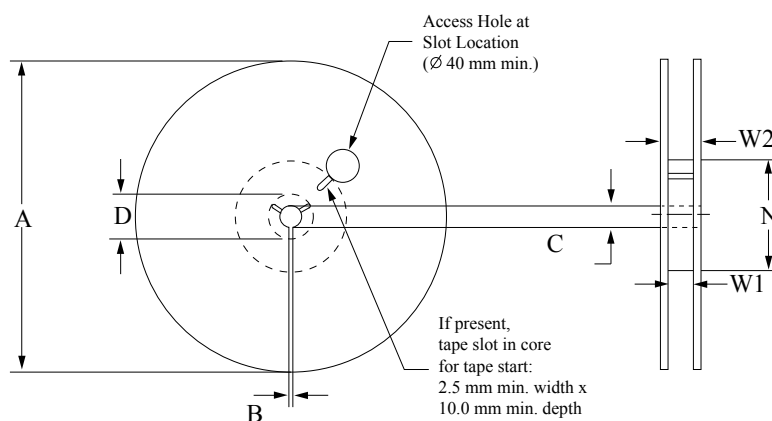
**Figure 50. PowerSSO-16 schematic drawing of leader and trailer tape**



GAPG2004151511CFT

## 6.4 SO-8 packing information

**Figure 51. Reel for SO-8**

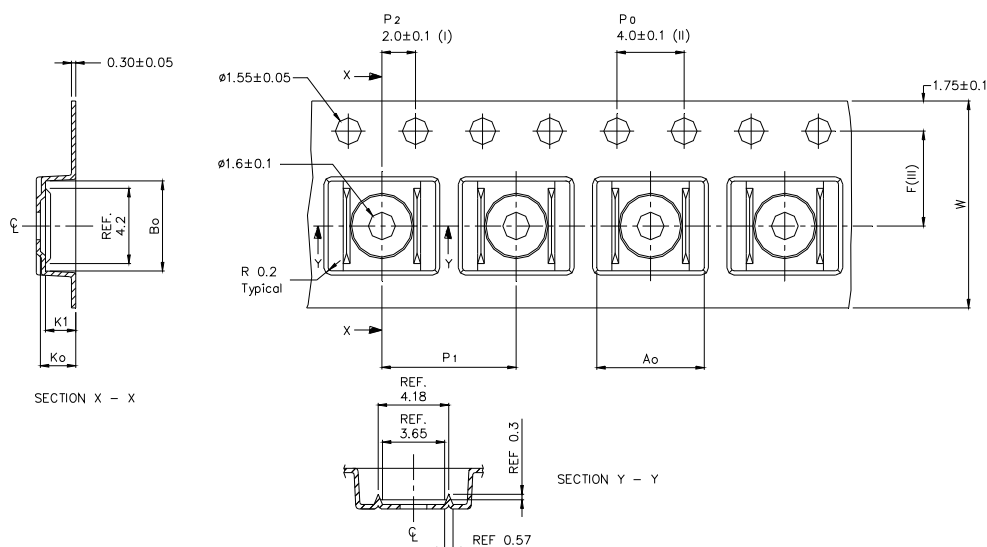


TAPG2004151655CFT

**Table 20. Reel dimensions**

| Description    | Value <sup>(1)</sup> |
|----------------|----------------------|
| Base quantity  | 2500                 |
| Bulk quantity  | 2500                 |
| A (max)        | 330                  |
| B (min)        | 1.5                  |
| C (+0.5, -0.2) | 13                   |
| D (min)        | 20.2                 |
| N              | 100                  |
| W1 (+2/-0)     | 12.4                 |
| W2 (max)       | 18.4                 |

1. All dimensions are in mm.

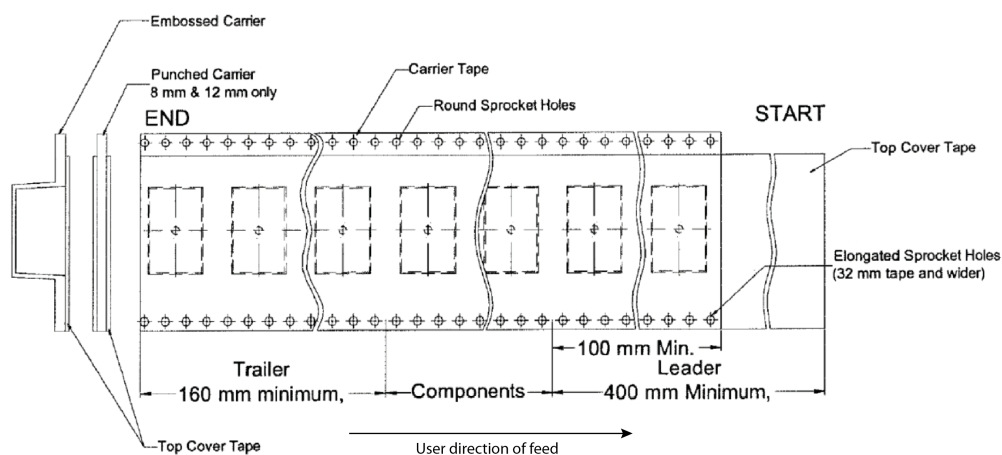
**Figure 52. SO-8 carrier tape**


GAPG2105151447CFT

**Table 21. SO-8 carrier tape dimensions**

| Description | Value <sup>(1)</sup> |
|-------------|----------------------|
| $A_0$       | $6.50 \pm 0.1$       |
| $B_0$       | $5.30 \pm 0.1$       |
| $K_0$       | $2.20 \pm 0.1$       |
| $K_1$       | $1.90 \pm 0.1$       |
| $F$         | $5.50 \pm 0.1$       |
| $P_1$       | $8.00 \pm 0.1$       |
| $W$         | $12.00 \pm 0.3$      |

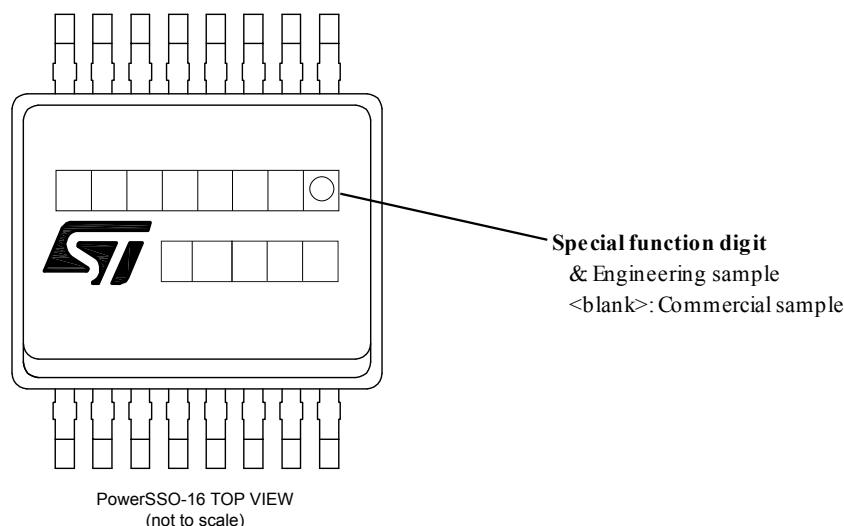
1. All dimensions are in mm.

**Figure 53. SO-8 schematic drawing of leader and trailer tape**


GAPG2004151511CFT

## 6.5 PowerSSO-16 marking information

Figure 54. PowerSSO-16 marking information

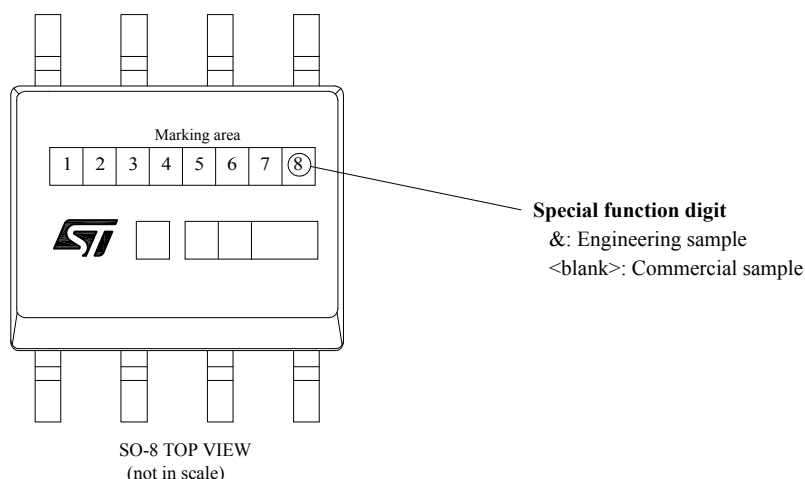


GADG0310161234SMD

Parts marked as '&' are not yet qualified and therefore not approved for use in production. ST is not responsible for any consequences resulting from such use. In no event will ST be liable for the customer using any of these engineering samples in production. ST's Quality department must be contacted prior to any decision to use these engineering samples to run a qualification activity.

## 6.6 SO-8 marking information

Figure 55. SO-8 marking information



GAPG2705151558CFT

**Note:** *Engineering Samples: these samples can be clearly identified by a dedicated special symbol in the marking of each unit. These samples are intended to be used for electrical compatibility evaluation only; usage for any other purpose may be agreed only upon written authorization by ST. ST is not liable for any customer usage in production and/or in reliability qualification trials.*

*Commercial Samples: fully qualified parts from ST standard production with no usage restrictions*

## 7 Order codes

**Table 22. Device summary**

| Package     | Order codes   |
|-------------|---------------|
|             | Tape and reel |
| PowerSSO-16 | VN7140AJTR    |
| SO-8        | VN7140ASTR    |

## Revision history

**Table 23. Document revision history**

| Date        | Revision | Changes                                                                                                                                                                                                                           |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 03-Jun-2015 | 1        | Initial release.                                                                                                                                                                                                                  |
| 22-Jul-2015 | 2        | Updated cover image.<br>Updated <i>Table 4: "Thermal data"</i><br>Updated following sections: <ul style="list-style-type: none"> <li>Section 6.1: "PowerSSO-16 thermal data"</li> <li>Section 6.2: "SO-8 thermal data"</li> </ul> |
| 13-Oct-2016 | 3        | <ul style="list-style-type: none"> <li>Added AEC Q100 qualified in Features section</li> <li>Updated <i>Figure 61: "PowerSSO-16 marking information"</i></li> </ul>                                                               |
| 28-Jun-2018 | 4        | Minor text changes in TCASE and VCC monitor.                                                                                                                                                                                      |
| 04-Apr-2019 | 5        | Updated <a href="#">Table 16. PowerSSO-16 mechanical data</a>                                                                                                                                                                     |

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