

## Contents

|          |                                                          |           |
|----------|----------------------------------------------------------|-----------|
| <b>1</b> | <b>Block diagram and pin description .....</b>           | <b>5</b>  |
| <b>2</b> | <b>Electrical specification.....</b>                     | <b>7</b>  |
| 2.1      | Absolute maximum ratings .....                           | 7         |
| 2.2      | Thermal data .....                                       | 8         |
| 2.3      | Main electrical characteristics .....                    | 8         |
| 2.4      | Waveforms .....                                          | 18        |
| 2.5      | Electrical characteristics curves .....                  | 19        |
| <b>3</b> | <b>Protections.....</b>                                  | <b>23</b> |
| 3.1      | Power limitation .....                                   | 23        |
| 3.2      | Thermal shutdown.....                                    | 23        |
| 3.3      | Current limitation .....                                 | 23        |
| 3.4      | Negative voltage clamp .....                             | 23        |
| <b>4</b> | <b>Application information .....</b>                     | <b>24</b> |
| 4.1      | GND protection network against reverse battery.....      | 24        |
| 4.1.1    | Diode (DGND) in the ground line .....                    | 25        |
| 4.2      | Immunity against transient electrical disturbances ..... | 25        |
| 4.3      | MCU I/Os protection.....                                 | 26        |
| 4.4      | Behaviour during engine start transients.....            | 26        |
| 4.5      | CurrentSense - analog current sense .....                | 28        |
| 4.5.1    | Principle of CurrenSense signal generation .....         | 29        |
| 4.5.2    | Short to VCC and OFF-state open-load detection .....     | 31        |
| <b>5</b> | <b>Maximum demagnetization energy (VCC = 16 V) .....</b> | <b>33</b> |
| <b>6</b> | <b>Package and PCB thermal data .....</b>                | <b>34</b> |
| 6.1      | PowerSSO-12 thermal data .....                           | 34        |
| <b>7</b> | <b>Package information .....</b>                         | <b>37</b> |
| 7.1      | PowerSSO-12 package information .....                    | 37        |
| 7.2      | PowerSSO-12 packing information .....                    | 38        |
| 7.3      | PowerSSO-12 marking information .....                    | 40        |
| <b>8</b> | <b>Order codes .....</b>                                 | <b>41</b> |
| <b>9</b> | <b>Revision history .....</b>                            | <b>42</b> |

## List of tables

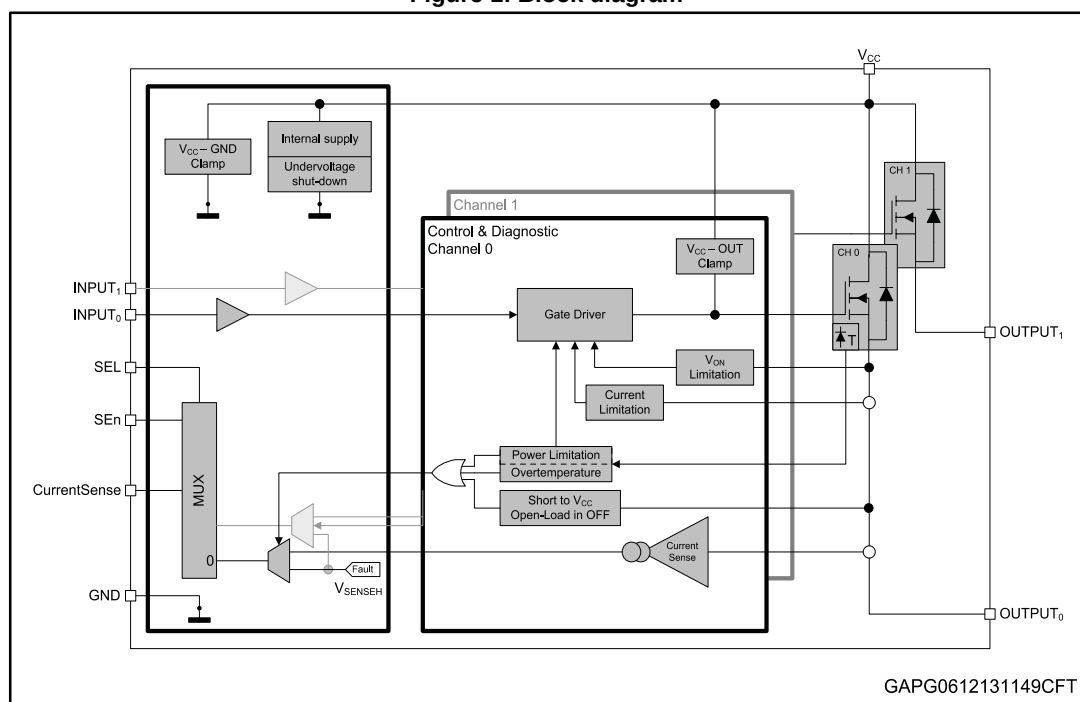
|                                                                               |    |
|-------------------------------------------------------------------------------|----|
| Table 1: Pin functions .....                                                  | 5  |
| Table 2: Suggested connections for unused and not connected pins.....         | 6  |
| Table 3: Absolute maximum ratings .....                                       | 7  |
| Table 4: Thermal data.....                                                    | 8  |
| Table 5: Electrical characteristics during cranking .....                     | 8  |
| Table 6: Power section .....                                                  | 9  |
| Table 7: Switching.....                                                       | 9  |
| Table 8: Logic inputs.....                                                    | 10 |
| Table 9: Protections .....                                                    | 11 |
| Table 10: CurrentSense.....                                                   | 11 |
| Table 11: Truth table .....                                                   | 17 |
| Table 12: CurrentSense multiplexer addressing .....                           | 18 |
| Table 13: ISO 7637-2 - electrical transient conduction along supply line..... | 26 |
| Table 14: Test parameters, E-11 Start pulses .....                            | 27 |
| Table 15: Cranking operating mode .....                                       | 28 |
| Table 16: CurrentSense pin levels in off-state .....                          | 31 |
| Table 17: PCB properties .....                                                | 34 |
| Table 18: Thermal parameters .....                                            | 36 |
| Table 19: PowerSSO-12 mechanical data.....                                    | 38 |
| Table 20: Reel dimensions .....                                               | 38 |
| Table 21: PowerSSO-12 carrier tape dimensions .....                           | 39 |
| Table 22: Device summary .....                                                | 41 |
| Table 23: Document revision history .....                                     | 42 |

## List of figures

|                                                                                               |    |
|-----------------------------------------------------------------------------------------------|----|
| Figure 1: Block diagram .....                                                                 | 5  |
| Figure 2: Configuration diagram (top view).....                                               | 6  |
| Figure 3: Current and voltage conventions.....                                                | 7  |
| Figure 4: IOUT/ISENSE versus IOUT .....                                                       | 15 |
| Figure 5: Current sense accuracy versus IOUT .....                                            | 15 |
| Figure 6: Switching times and Pulse skew .....                                                | 16 |
| Figure 7: CurrentSense timings .....                                                          | 16 |
| Figure 8: TDSTKON.....                                                                        | 17 |
| Figure 9: Standby mode activation .....                                                       | 18 |
| Figure 10: Standby state diagram.....                                                         | 19 |
| Figure 11: OFF-state output current .....                                                     | 19 |
| Figure 12: Standby current .....                                                              | 19 |
| Figure 13: IGND(ON) vs. Tcase .....                                                           | 20 |
| Figure 14: Logic Input high level voltage .....                                               | 20 |
| Figure 15: Logic Input low level voltage.....                                                 | 20 |
| Figure 16: High level logic input current .....                                               | 20 |
| Figure 17: Low level logic input current .....                                                | 20 |
| Figure 18: Logic Input hysteresis voltage .....                                               | 20 |
| Figure 19: Undervoltage shutdown.....                                                         | 21 |
| Figure 20: On-state resistance vs. Tcase.....                                                 | 21 |
| Figure 21: On-state resistance vs. Vcc.....                                                   | 21 |
| Figure 22: Turn-on voltage slope.....                                                         | 21 |
| Figure 23: Turn-off voltage slope.....                                                        | 21 |
| Figure 24: Won vs Tcase .....                                                                 | 21 |
| Figure 25: Woff vs Tcase .....                                                                | 22 |
| Figure 26: ILIMH vs. Tcase.....                                                               | 22 |
| Figure 27: OFF-state open-load voltage detection threshold .....                              | 22 |
| Figure 28: Vsense clamp vs Tcase.....                                                         | 22 |
| Figure 29: Vsenseh vs Tcase .....                                                             | 22 |
| Figure 30: Application diagram .....                                                          | 24 |
| Figure 31: Simplified internal structure - GND network protection with Schottky diode .....   | 24 |
| Figure 32: Simplified internal structure - GND network protection with MOSFET .....           | 25 |
| Figure 33: Cranking profile .....                                                             | 27 |
| Figure 34: CurrentSense and diagnostic – block diagram.....                                   | 28 |
| Figure 35: CurrentSense block diagram.....                                                    | 29 |
| Figure 36: Analogue HSD – open-load detection in off-state .....                              | 30 |
| Figure 37: Open-load / short to VCC condition.....                                            | 31 |
| Figure 38: Maximum turn off current versus inductance .....                                   | 33 |
| Figure 39: PowerSSO-12 on two-layers PCB (2s0p to JEDEC JESD 51-5) .....                      | 34 |
| Figure 40: PowerSSO-12 on four-layers PCB (2s2p to JEDEC JESD 51-7) .....                     | 34 |
| Figure 41: Rthj-amb vs PCB copper area in open box free air condition (one channel on) .....  | 35 |
| Figure 42: PowerSSO-12 thermal impedance junction ambient single pulse (one channel on) ..... | 35 |
| Figure 43: Thermal fitting model of a double-channel HSD in PowerSSO-12.....                  | 36 |
| Figure 44: PowerSSO-12 package dimensions.....                                                | 37 |
| Figure 45: PowerSSO-12 reel 13" .....                                                         | 38 |
| Figure 46: PowerSSO-12 carrier tape .....                                                     | 39 |
| Figure 47: PowerSSO-12 schematic drawing of leader and trailer tape .....                     | 40 |
| Figure 48: PowerSSO-12 marking information .....                                              | 40 |

## 1 Block diagram and pin description

**Figure 1: Block diagram**



### Table 1: Pin functions

| Name                  | Function                                                                                                                   |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------|
| V <sub>CC</sub>       | Battery connection.                                                                                                        |
| OUTPUT <sub>0,1</sub> | Power output.                                                                                                              |
| GND                   | Ground connection. Must be reverse battery protected by an external diode/resistor network.                                |
| INPUT <sub>0,1</sub>  | Voltage controlled input pins with hysteresis, compatible with 3 V and 5 V CMOS outputs. They control output switch state. |
| CurrentSense          | Multiplexed analog sense output pin; it delivers a current proportional to the load current.                               |
| SEn                   | Active high compatible with 3 V and 5 V CMOS outputs pin; it enables the CurrentSense diagnostic pin.                      |
| SEL                   | Active high compatible with 3 V and 5 V CMOS outputs pin; it addresses the CurrentSense multiplexer.                       |

Figure 2: Configuration diagram (top view)

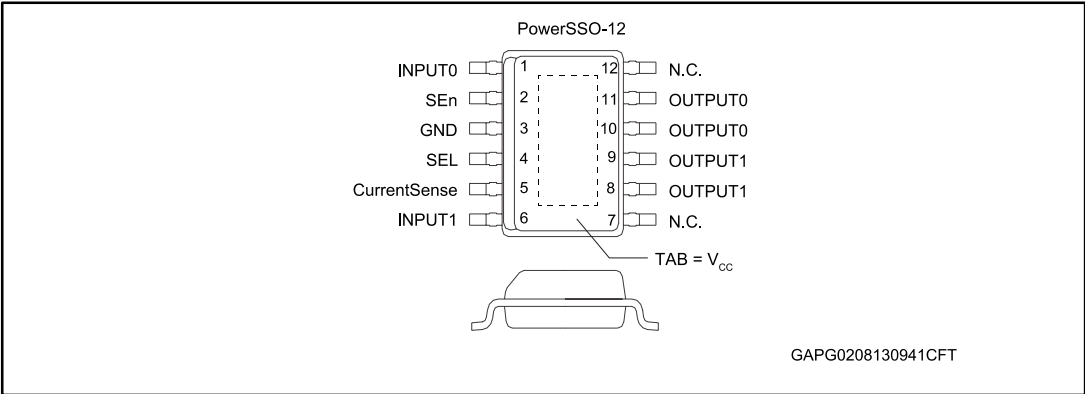


Table 2: Suggested connections for unused and not connected pins

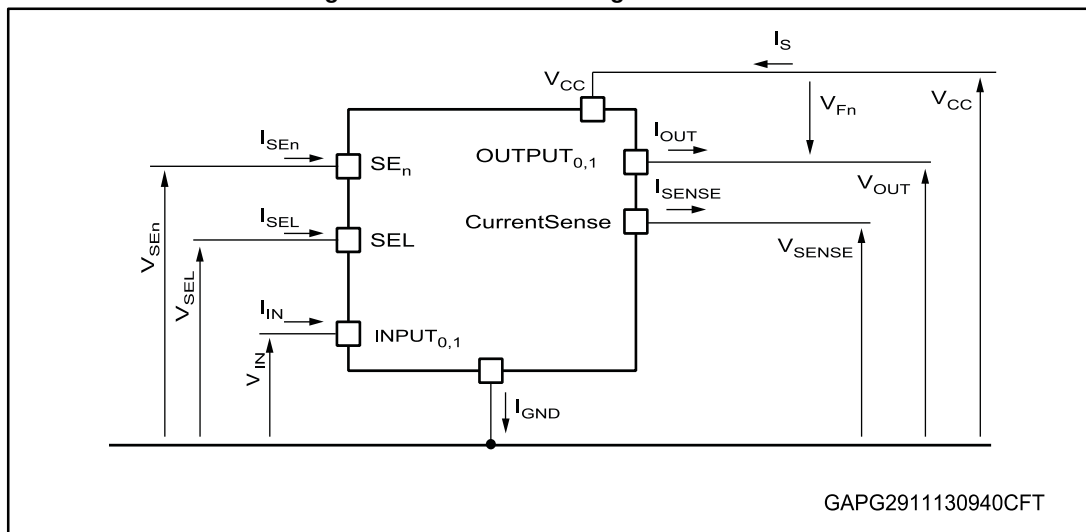
| Connection/pin | CurrentSense          | N.C.             | Output      | Input                  | SEn, SEL               |
|----------------|-----------------------|------------------|-------------|------------------------|------------------------|
| Floating       | Not allowed           | X <sup>(1)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

Notes:

<sup>(1)</sup>X: do not care.

## 2 Electrical specification

Figure 3: Current and voltage conventions



$V_{Fn} = V_{OUTn} - V_{CC}$  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    |
| $V_{CCPK}$  | 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 <sub>0,1</sub> DC output current                                                       | Internally limited | A    |
| $-I_{OUT}$  | Reverse DC output current                                                                     | 4                  |      |
| $I_{IN}$    | INPUT <sub>0,1</sub> DC input current                                                         | -1 to 10           | mA   |
| $I_{SEn}$   | SEn DC input current                                                                          |                    |      |
| $I_{SEL}$   | SEL DC input current                                                                          |                    |      |
| $I_{SENSE}$ | CurrentSense pin DC output current ( $V_{GND} = V_{CC}$ and $V_{SENSE} < 0$ V)                | 10                 | mA   |
|             | CurrentSense pin DC output current in reverse ( $V_{CC} < 0$ V)                               | -20                |      |

| Symbol    | Parameter                                                                                                                 | Value      | Unit               |
|-----------|---------------------------------------------------------------------------------------------------------------------------|------------|--------------------|
| $E_{MAX}$ | Maximum switching energy (single pulse)<br>( $T_{DEMAG} = 0.4 \text{ ms}$ ; $T_{jstart} = 150 \text{ }^{\circ}\text{C}$ ) | 10         | mJ                 |
| $V_{ESD}$ | Electrostatic discharge (JEDEC 22A-114F)                                                                                  |            |                    |
|           | • $INPUT_{0,1}$                                                                                                           | 4000       | V                  |
|           | • CurrentSense                                                                                                            | 2000       | V                  |
|           | • $SEn, SEL$                                                                                                              | 4000       | V                  |
|           | • $OUTPUT_{0,1}$                                                                                                          | 4000       | V                  |
|           | • $V_{CC}$                                                                                                                | 4000       | V                  |
| $V_{ESD}$ | Charge device model (CDM-AEC-Q100-011)                                                                                    | 750        | V                  |
| $T_j$     | Junction operating temperature                                                                                            | -40 to 150 | $^{\circ}\text{C}$ |
| $T_{stg}$ | Storage temperature                                                                                                       | -55 to 150 |                    |

## 2.2 Thermal data

Table 4: Thermal data

| Symbol          | Parameter                                                                    | Typ. value | Unit                 |
|-----------------|------------------------------------------------------------------------------|------------|----------------------|
| $R_{thj-board}$ | Thermal resistance junction-board (JEDEC JESD 51-5 / 51-8) <sup>(1)(2)</sup> | 7.7        | $^{\circ}\text{C/W}$ |
| $R_{thj-amb}$   | Thermal resistance junction-ambient (JEDEC JESD 51-5) <sup>(1)(3)</sup>      | 61         |                      |
| $R_{thj-amb}$   | Thermal resistance junction-ambient (JEDEC JESD 51-7) <sup>(1)(2)</sup>      | 26.5       |                      |

### Notes:

<sup>(1)</sup>One channel ON.

<sup>(2)</sup>Device mounted on four-layers 2s2p PCB.

<sup>(3)</sup>Device mounted on two-layers 2s0p PCB with 2 cm<sup>2</sup> heatsink copper trace.

## 2.3 Main electrical characteristics

7 V <  $V_{CC}$  < 28 V; -40  $^{\circ}\text{C}$  <  $T_j$  < 150  $^{\circ}\text{C}$ , unless otherwise specified.

All typical values refer to  $V_{CC} = 13 \text{ V}$ ;  $T_j = 25^{\circ}\text{C}$ , unless otherwise specified.

Table 5: Electrical characteristics during cranking

| Symbol                   | Parameter                                              | Test conditions                                                                | Min. | Typ. | Max. | Unit               |
|--------------------------|--------------------------------------------------------|--------------------------------------------------------------------------------|------|------|------|--------------------|
| $V_{USD\_Cranking}$      | Minimum cranking supply voltage ( $V_{CC}$ decreasing) |                                                                                |      |      | 2.85 | V                  |
| $R_{ON}$                 | On-state resistance <sup>(1)</sup>                     | $I_{OUT} = 0.2 \text{ A}$ ; $V_{CC} = 2.85 \text{ V}$ ;<br>$V_{CC}$ decreasing |      |      | 1400 | m $\Omega$         |
| $T_{TSD}$ <sup>(2)</sup> | Shutdown temperature ( $V_{CC}$ decreasing)            | $V_{CC} = 2.85 \text{ V}$                                                      | 140  |      |      | $^{\circ}\text{C}$ |

### Notes:

<sup>(1)</sup>For each channel.

<sup>(2)</sup>Parameter guaranteed by design and characterization; not subject to production test.

Table 6: 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                                               |                                                                                                                                                                          |      |      | 2.85 |      |
| V <sub>USDReset</sub> | Undervoltage shutdown reset                                         |                                                                                                                                                                          |      |      | 5    |      |
| V <sub>USDhyst</sub>  | Undervoltage shutdown hysteresis                                    |                                                                                                                                                                          |      | 0.3  |      |      |
| R <sub>ON</sub>       | On-state resistance <sup>(1)</sup>                                  | 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; T <sub>J</sub> = -40 °C                                                                                                                          | 38   |      |      | V    |
|                       |                                                                     | I <sub>S</sub> = 20 mA; 25°C < T <sub>J</sub> < 150°C                                                                                                                    | 41   | 46   | 52   |      |
| I <sub>STBY</sub>     | Supply current in standby at V <sub>CC</sub> = 13 V <sup>(2)</sup>  | V <sub>CC</sub> = 13 V; V <sub>IN</sub> = V <sub>OUT</sub> = V <sub>SEn</sub> = 0 V; V <sub>SEL</sub> = 0 V; T <sub>J</sub> = 25 °C                                      |      |      | 0.5  | μA   |
|                       |                                                                     | V <sub>CC</sub> = 13 V; V <sub>IN</sub> = V <sub>OUT</sub> = V <sub>SEn</sub> = 0 V; V <sub>SEL</sub> = 0 V; T <sub>J</sub> = 85 °C <sup>(3)</sup>                       |      |      | 0.5  | μA   |
|                       |                                                                     | V <sub>CC</sub> = 13 V; V <sub>IN</sub> = V <sub>OUT</sub> = V <sub>SEn</sub> = 0 V; V <sub>SEL</sub> = 0 V; T <sub>J</sub> = 125 °C                                     |      |      | 3    | μA   |
| t <sub>d_STBY</sub>   | Standby mode blanking time                                          | V <sub>CC</sub> = 13 V; V <sub>IN</sub> = V <sub>OUT</sub> = V <sub>SEL</sub> = 0 V; V <sub>SEn</sub> = 5 V to 0 V                                                       | 60   | 300  | 550  | μA   |
| I <sub>S(ON)</sub>    | Supply current                                                      | V <sub>CC</sub> = 13 V; V <sub>SEn</sub> = V <sub>SEL</sub> = 0 V; V <sub>IN0</sub> = 5 V; V <sub>IN1</sub> = 5 V; I <sub>OUT0</sub> = 0 A; I <sub>OUT1</sub> = 0 A      |      | 5    | 8    | mA   |
| I <sub>GND(ON)</sub>  | Control stage current consumption in ON state. All channels active. | V <sub>CC</sub> = 13 V; V <sub>SEn</sub> = 5 V; V <sub>SEL</sub> = 0 V; V <sub>IN0</sub> = 5 V; V <sub>IN1</sub> = 5 V; I <sub>OUT0</sub> = 1 A; I <sub>OUT1</sub> = 1 A |      |      | 12   | mA   |
| I <sub>L(off)</sub>   | Off-state output current at V <sub>CC</sub> = 13 V <sup>(1)</sup>   | V <sub>IN</sub> = V <sub>OUT</sub> = 0 V; V <sub>CC</sub> = 13 V; T <sub>J</sub> = 25 °C                                                                                 | 0    | 0.01 | 0.5  | μA   |
|                       |                                                                     | V <sub>IN</sub> = V <sub>OUT</sub> = 0 V; V <sub>CC</sub> = 13 V; T <sub>J</sub> = 125 °C                                                                                | 0    |      | 3    |      |
| V <sub>F</sub>        | Output - V <sub>CC</sub> diode voltage <sup>(1)</sup>               | I <sub>OUT</sub> = -1 A; T <sub>J</sub> = 150 °C                                                                                                                         |      |      | 0.7  | V    |

**Notes:**<sup>(1)</sup>For each channel.<sup>(2)</sup>PowerMOS leakage included.<sup>(3)</sup>Parameter specified by design; not subject to production test.

Table 7: Switching

| V <sub>CC</sub> = 13 V; -40°C < T <sub>J</sub> < 150°C, unless otherwise specified |                                                 |                       |      |      |      |      |
|------------------------------------------------------------------------------------|-------------------------------------------------|-----------------------|------|------|------|------|
| Symbol                                                                             | Parameter                                       | Test conditions       | Min. | Typ. | Max. | Unit |
| t <sub>d(on)</sub> <sup>(2)</sup>                                                  | Turn-on delay time at T <sub>J</sub> = 25°C     | R <sub>L</sub> = 13 Ω | 10   | 70   | 120  | μs   |
| t <sub>d(off)</sub> <sup>(2)</sup>                                                 | Turn-off delay time at T <sub>J</sub> = 25°C    |                       | 10   | 40   | 100  |      |
| (dV <sub>OUT</sub> /dt) <sub>on</sub> <sup>(1)</sup>                               | Turn-on voltage slope at T <sub>J</sub> = 25°C  | R <sub>L</sub> = 13 Ω | 0.1  | 0.27 | 0.7  | V/μs |
| (dV <sub>OUT</sub> /dt) <sub>off</sub> <sup>(1)</sup>                              | Turn-off voltage slope at T <sub>J</sub> = 25°C |                       | 0.1  | 0.35 | 0.7  |      |



| $V_{CC} = 13\text{ V}$ ; $-40^{\circ}\text{C} < T_J < 150^{\circ}\text{C}$ , unless otherwise specified |                                                    |                    |      |      |                     |               |
|---------------------------------------------------------------------------------------------------------|----------------------------------------------------|--------------------|------|------|---------------------|---------------|
| Symbol                                                                                                  | Parameter                                          | Test conditions    | Min. | Typ. | Max.                | Unit          |
| $W_{ON}$                                                                                                | Switching energy losses at turn-on ( $t_{won}$ )   | $R_L = 13\ \Omega$ | —    | 0.15 | 0.18 <sup>(2)</sup> | mJ            |
| $W_{OFF}$                                                                                               | Switching energy losses at turn-off ( $t_{woff}$ ) | $R_L = 13\ \Omega$ | —    | 0.1  | 0.18 <sup>(2)</sup> | mJ            |
| $t_{SKEW}^{(1)}$                                                                                        | Differential pulse skew ( $t_{PHL} - t_{PLH}$ )    | $R_L = 13\ \Omega$ | -100 | -50  | 0                   | $\mu\text{s}$ |

**Notes:**

<sup>(1)</sup>See [Figure 6: "Switching times and Pulse skew"](#)

<sup>(2)</sup>Parameter guaranteed by design and characterization; not subject to production test.

**Table 8: Logic inputs**

| 7 V < V <sub>CC</sub> < 28 V; -40°C < T <sub>j</sub> < 150°C |                          |                         |      |      |      |      |
|--------------------------------------------------------------|--------------------------|-------------------------|------|------|------|------|
| Symbol                                                       | Parameter                | Test conditions         | Min. | Typ. | Max. | Unit |
| INPUT <sub>0,1</sub> characteristics                         |                          |                         |      |      |      |      |
| 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 |      |      |
| SEL characteristics (7 V < V <sub>CC</sub> < 18 V)           |                          |                         |      |      |      |      |
| 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 9: 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>                                   |                      |                      | 16                   |      |
| 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>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    |
| V <sub>DEMAG</sub>                                           | Turn-off output voltage clamp                                          | I <sub>OUT</sub> = 1 A; L = 6 mH;<br>T <sub>j</sub> = -40 °C                  | V <sub>CC</sub> - 38 |                      |                      | V    |
|                                                              |                                                                        | I <sub>OUT</sub> = 1 A; L = 6 mH;<br>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 <sub>ON</sub>                                              | Output voltage drop limitation                                         | I <sub>OUT</sub> = 0.07 A                                                     |                      | 20                   |                      | mV   |

**Notes:**

<sup>(1)</sup>Parameter guaranteed by design and characterization; not subject to production test.

Table 10: CurrentSense

| 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>                                        | CurrentSense 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    |      | V    |
| CurrentSense characteristics                                 |                                                |                                                                                                                            |      |      |      |      |
| K <sub>OL</sub>                                              | I <sub>OUT</sub> /I <sub>SENSE</sub>           | I <sub>OUT</sub> = 0.01 A;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 0.5 V; 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;<br>V <sub>SENSE</sub> = 4 V; 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;<br>V <sub>SENSE</sub> = 4 V; 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;<br>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;<br>V <sub>SEN</sub> = 5 V                                                                                                                                                                                                                                 | -5   |      | 5    | %    |
| I <sub>SENSE0</sub>                                          | CurrentSense leakage current                | CurrentSense disabled:<br>V <sub>SEN</sub> = 0 V                                                                                                                                                                                                                                                            | 0    |      | 0.5  | μA   |
|                                                              |                                             | CurrentSense disabled:<br>-1 V < V <sub>SENSE</sub> < 5 V <sup>(1)</sup>                                                                                                                                                                                                                                    | -0.5 |      | 0.5  | μA   |
|                                                              |                                             | CurrentSense enabled:<br>V <sub>SEN</sub> = 5 V;<br>All channel ON;<br>I <sub>OUTX</sub> = 0 A;<br>Ch <sub>x</sub> diagnostic selected;<br>• E.g. Ch <sub>0</sub> :<br>V <sub>IN0</sub> = 5 V;<br>V <sub>IN1</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V;<br>I <sub>OUT0</sub> = 0 A;<br>I <sub>OUT1</sub> = 1 A | 0    |      | 2    | μA   |
| V <sub>OUT_MSD</sub> <sup>(1)</sup>                          | Output Voltage for<br>CurrentSense shutdown | CurrentSense enabled:<br>V <sub>SEN</sub> = 5 V;<br>Ch <sub>x</sub> channel OFF;<br>Ch <sub>x</sub> diagnostic selected;<br>• E.g. Ch <sub>0</sub> :<br>V <sub>IN0</sub> = 0 V;<br>V <sub>IN1</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V;<br>I <sub>OUT1</sub> = 1 A                                            | 0    |      | 2    | μA   |
|                                                              |                                             | V <sub>SEN</sub> = 5 V;<br>R <sub>SENSE</sub> = 2.7 kΩ<br>• E.g. Ch <sub>0</sub> :<br>V <sub>IN0</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V;<br>I <sub>OUT0</sub> = 1 A                                                                                                                                         |      | 5    |      | V    |
| V <sub>SENSE_SAT</sub>                                       | CurrentSense saturation<br>voltage          | V <sub>CC</sub> = 7 V;<br>R <sub>SENSE</sub> = 2.7 kΩ;<br>V <sub>SEN</sub> = 5 V; V <sub>IN0</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V; I <sub>OUT0</sub> = 1 A;<br>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;<br>V <sub>IN0</sub> = 5 V; V <sub>SEN</sub> = 5 V;<br>V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V;<br>T <sub>j</sub> = 150°C                                                                                                                          | 4    |      |      | mA   |

| 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>OUT_SAT</sub> <sup>(1)</sup>                                                                                   | Output saturation current                                                                             | V <sub>CC</sub> = 7 V; V <sub>SENSE</sub> = 4 V;<br>V <sub>IN0</sub> = 5 V; V <sub>SEn</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V; T <sub>j</sub> = 150°C                                                                                            | 2.2  |      |      | A    |
| <b>Off-state diagnostic</b>                                                                                           |                                                                                                       |                                                                                                                                                                                                                                                  |      |      |      |      |
| V <sub>OL</sub>                                                                                                       | Off-state open-load voltage detection threshold                                                       | V <sub>SEn</sub> = 5 V; Ch <sub>X</sub> OFF;<br>Ch <sub>X</sub> diagnostic selected<br>• E.g: Ch <sub>0</sub><br>V <sub>IN0</sub> = 0 V;<br>V <sub>SEL</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> ;<br>T <sub>j</sub> = -40 °C to 125 °C                                                                                                                                                 | -100 |      | -15  | μA   |
| t <sub>DSTKON</sub>                                                                                                   | Off-state diagnostic delay time from falling edge of INPUT (see <a href="#">Figure 8: "TDSTKON"</a> ) | V <sub>SEn</sub> = 5 V; Ch <sub>X</sub> ON to OFF transition<br>Ch <sub>X</sub> diagnostic selected<br>• E.g: Ch <sub>0</sub><br>V <sub>IN0</sub> = 5 V to 0 V;<br>V <sub>SEL</sub> = 0 V;<br>I <sub>OUT0</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-state open load diagnostic indication from rising edge of SE <sub>n</sub> | V <sub>IN0</sub> = 0 V; V <sub>IN1</sub> = 0 V;<br>V <sub>SEL</sub> = 0 V; V <sub>OUT0</sub> = 4 V;<br>V <sub>SEn</sub> = 0 V to 5 V                                                                                                             |      |      | 60   | μs   |
| t <sub>D_VOL</sub>                                                                                                    | Off-state diagnostic delay time from rising edge of V <sub>OUT</sub>                                  | V <sub>SEn</sub> = 5 V; Ch <sub>X</sub> OFF<br>Ch <sub>X</sub> diagnostic selected<br>• E.g: Ch <sub>0</sub><br>V <sub>IN0</sub> = 0 V;<br>V <sub>SEL</sub> = 0 V;<br>V <sub>OUT</sub> = 0 V to 4 V                                              |      | 5    | 30   | μs   |
| <b>Fault diagnostic feedback (see <a href="#">Table 11: "Truth table"</a>)</b>                                        |                                                                                                       |                                                                                                                                                                                                                                                  |      |      |      |      |
| V <sub>SENSEH</sub>                                                                                                   | CurrentSense output voltage in fault condition                                                        | V <sub>CC</sub> = 13 V; R <sub>SENSE</sub> = 1 kΩ<br>• E.g: Ch <sub>0</sub> in open load<br>V <sub>IN0</sub> = 0 V;<br>V <sub>SEn</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V;<br>I <sub>OUT0</sub> = 0 A;<br>V <sub>OUT</sub> = 4 V                  | 5    |      | 6.6  | V    |
| I <sub>SENSEH</sub>                                                                                                   | CurrentSense output current in fault condition                                                        | V <sub>CC</sub> = 13 V; V <sub>SENSE</sub> = 5 V                                                                                                                                                                                                 | 7    | 20   | 30   | mA   |
| <b>CurrentSense timings (current sense mode - see <a href="#">Figure 7: "CurrentSense timings"</a>)<sup>(3)</sup></b> |                                                                                                       |                                                                                                                                                                                                                                                  |      |      |      |      |
| t <sub>DSSENSE1H</sub>                                                                                                | Current sense settling time from rising edge of SE <sub>n</sub>                                       | V <sub>IN</sub> = 5 V;<br>V <sub>SEn</sub> = 0 V to 5 V;<br>R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                                                                     |      |      | 60   | μs   |
| t <sub>DSSENSE1L</sub>                                                                                                | Current sense disable delay time from falling edge of SE <sub>n</sub>                                 | V <sub>IN</sub> = 5 V;<br>V <sub>SEn</sub> = 5 V to 0 V;<br>R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω                                                                                                                                     |      | 5    | 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 |
| t <sub>DSSENSE2H</sub>                                             | Current sense settling time from rising edge of INPUT                                                                     | V <sub>IN</sub> = 0 V to 5 V;<br>V <sub>SEN</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ;<br>R <sub>L</sub> = 13 Ω                                                                                   |      | 100  | 250  | μs   |
| Δt <sub>DSSENSE2H</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;<br>R <sub>SENSE</sub> = 1 kΩ;<br>I <sub>SENSE</sub> = 90 % of I <sub>SENSEMAX</sub> ;<br>R <sub>L</sub> = 13 Ω                                  |      |      | 100  | μs   |
| t <sub>DSSENSE2L</sub>                                             | Current sense turn-off delay time from falling edge of INPUT                                                              | V <sub>IN</sub> = 5 V to 0 V;<br>V <sub>SEN</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ;<br>R <sub>L</sub> = 13 Ω                                                                                   |      | 50   | 250  | μs   |
| CurrentSense timings (Multiplexer transition times) <sup>(3)</sup> |                                                                                                                           |                                                                                                                                                                                                |      |      |      |      |
| t <sub>D_XtoY</sub>                                                | CurrentSense transition delay from Ch <sub>X</sub> to Ch <sub>Y</sub>                                                     | V <sub>IN0</sub> = 5 V; V <sub>IN1</sub> = 5 V;<br>V <sub>SEN</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V to 5 V;<br>I <sub>OUT0</sub> = 0 A; I <sub>OUT1</sub> = 1 A;<br>R <sub>SENSE</sub> = 1 kΩ |      |      | 20   | μs   |
| t <sub>D_CStoVSENSEH</sub>                                         | CurrentSense transition delay from stable current sense on Ch <sub>X</sub> to V <sub>SENSEH</sub> on Ch <sub>Y</sub>      | V <sub>IN0</sub> = 5 V; V <sub>IN1</sub> = 0 V;<br>V <sub>SEN</sub> = 5 V;<br>V <sub>SEL</sub> = 0 V to 5 V;<br>I <sub>OUT0</sub> = 1 A; V <sub>OUT1</sub> = 4 V;<br>R <sub>SENSE</sub> = 1 kΩ |      |      | 60   | μs   |

**Notes:**

<sup>(1)</sup>Parameter guaranteed by design and characterization; not subject to production test.

<sup>(2)</sup>All values refer to V<sub>CC</sub> = 13 V; T<sub>j</sub> = 25°C, unless otherwise specified.

<sup>(3)</sup>Transition delays are measured up to +/- 10% of final conditions.

Figure 4: IOUT/ISENSE versus IOUT

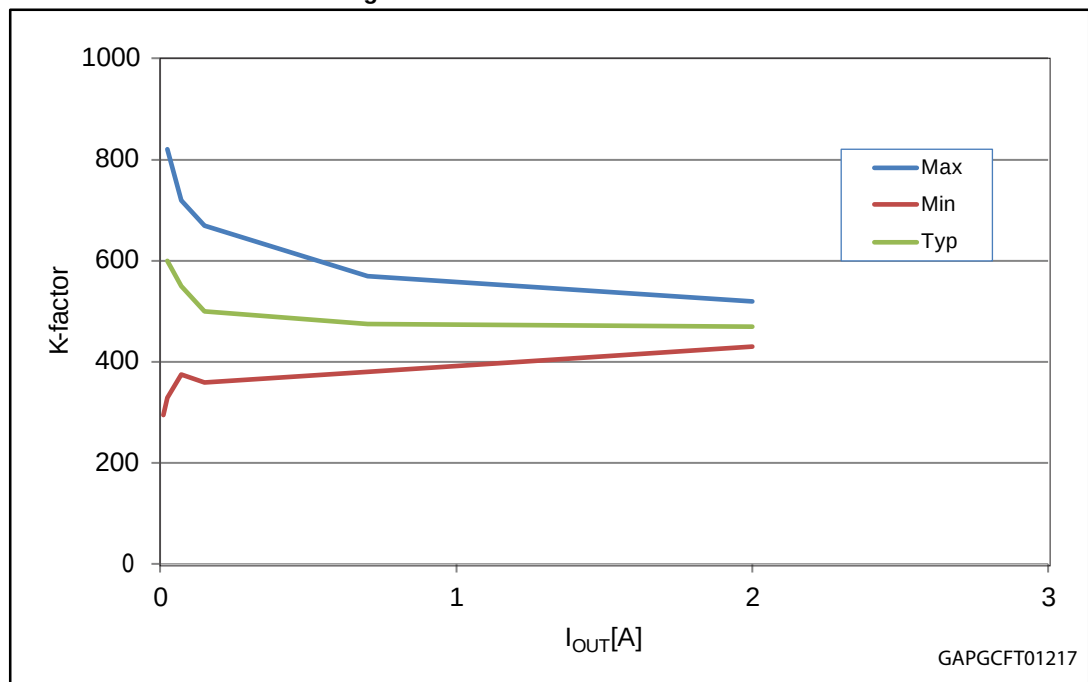


Figure 5: Current sense accuracy versus IOUT

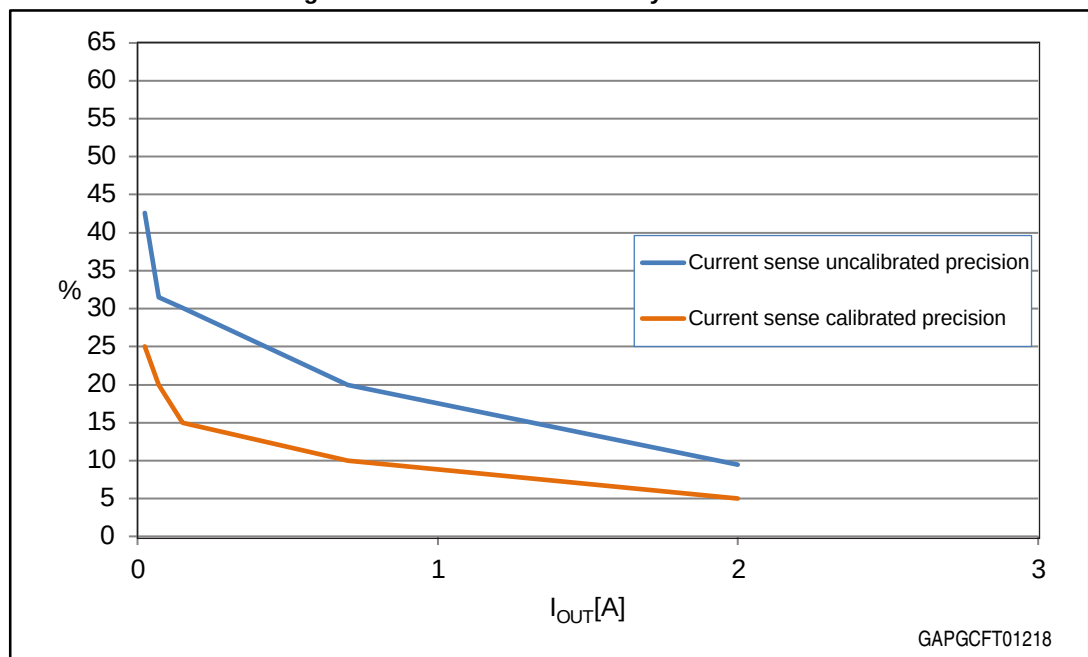


Figure 6: Switching times and Pulse skew

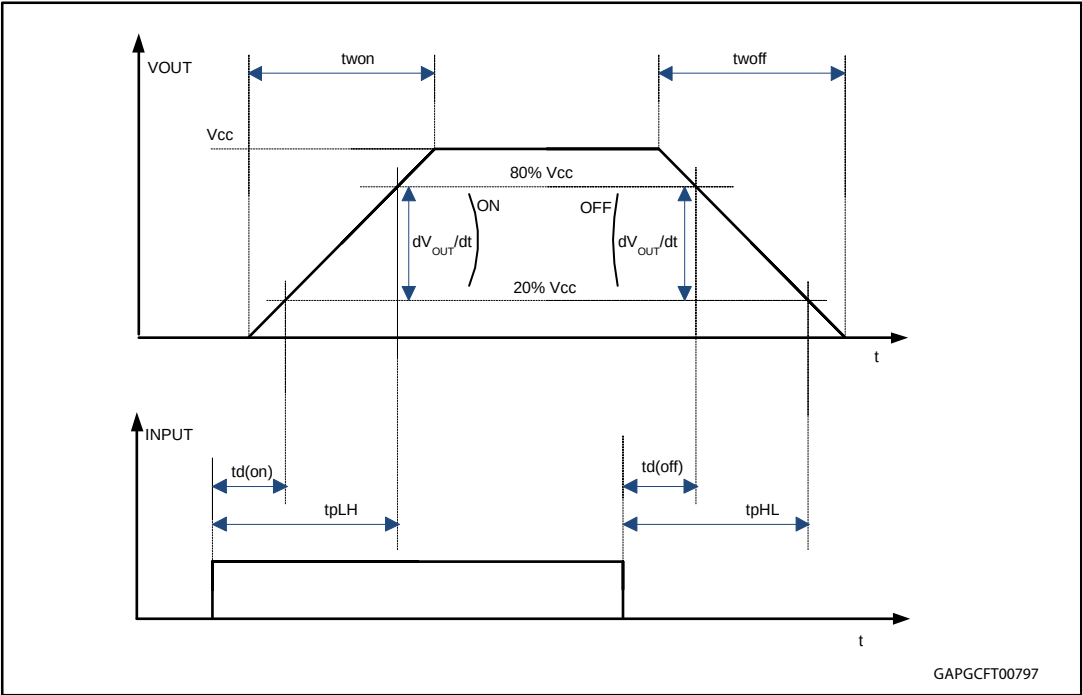


Figure 7: CurrentSense timings

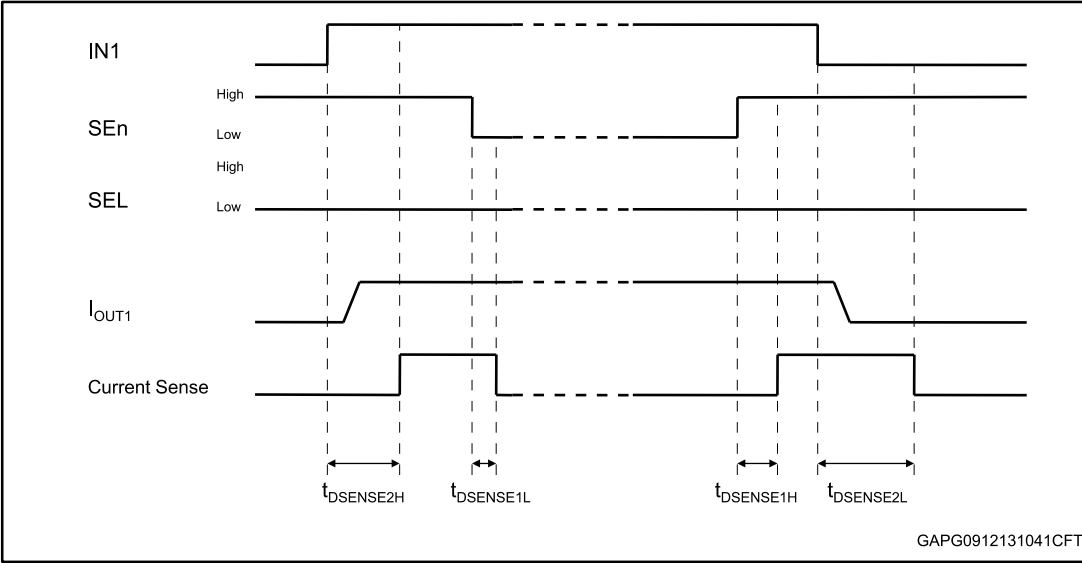


Figure 8: TDSTKON

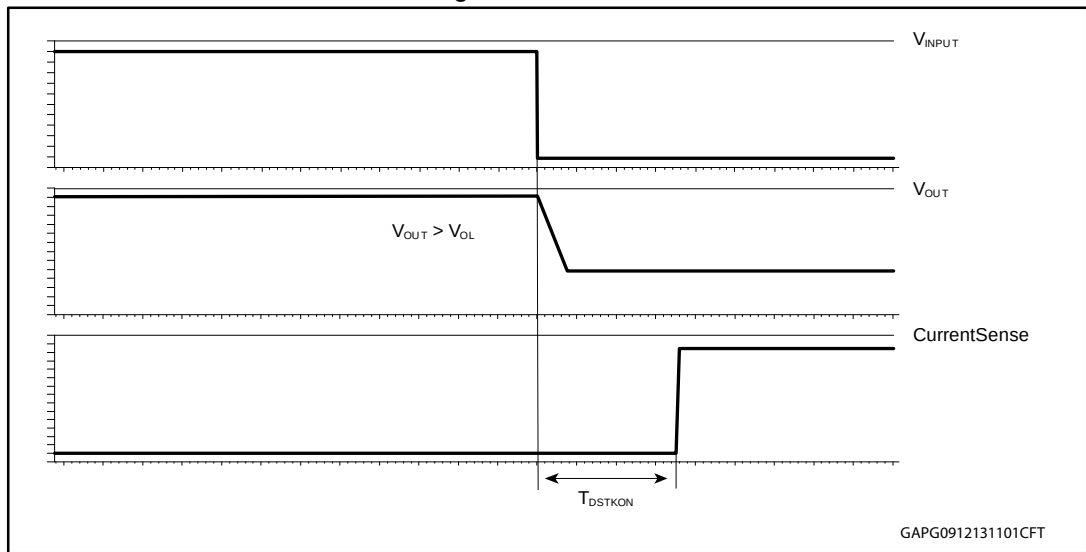


Table 11: Truth table

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

**Notes:**(1) Refer to [Table 12: "CurrentSense multiplexer addressing"](#)



Table 12: CurrentSense multiplexer addressing

| SEn | SEL | MUX channel          | CurrentSense output          |                          |                          |                 |
|-----|-----|----------------------|------------------------------|--------------------------|--------------------------|-----------------|
|     |     |                      | Normal mode                  | Overload                 | Off-state diag.          | Negative output |
| L   | X   |                      | Hi-Z                         |                          |                          |                 |
| H   | L   | Channel 0 diagnostic | $I_{SENSE} = 1/K * I_{OUT0}$ | $V_{SENSE} = V_{SENSEH}$ | $V_{SENSE} = V_{SENSEH}$ | Hi-Z            |
| H   | H   | Channel 1 diagnostic | $I_{SENSE} = 1/K * I_{OUT1}$ | $V_{SENSE} = V_{SENSEH}$ | $V_{SENSE} = V_{SENSEH}$ | Hi-Z            |

2.4 Waveforms

Figure 9: Standby mode activation

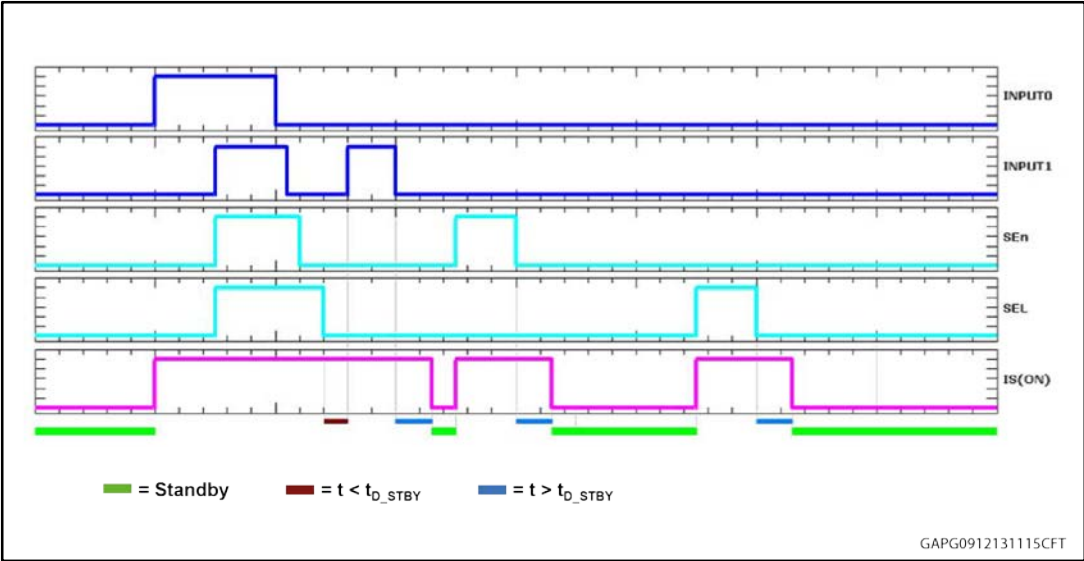
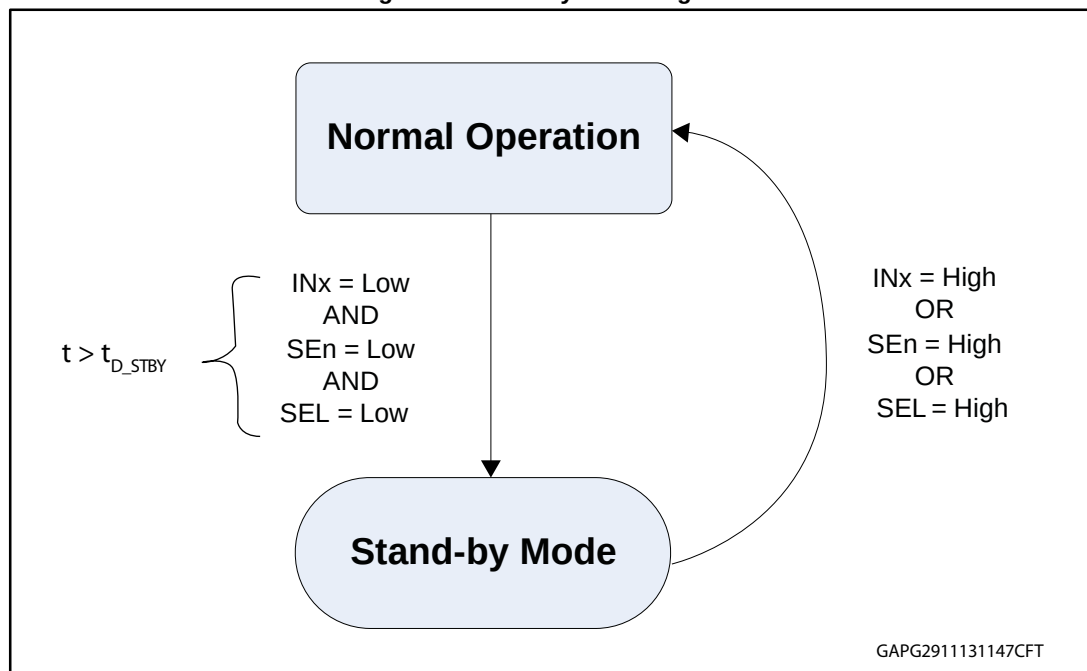


Figure 10: Standby state diagram



## 2.5 Electrical characteristics curves

Figure 11: OFF-state output current

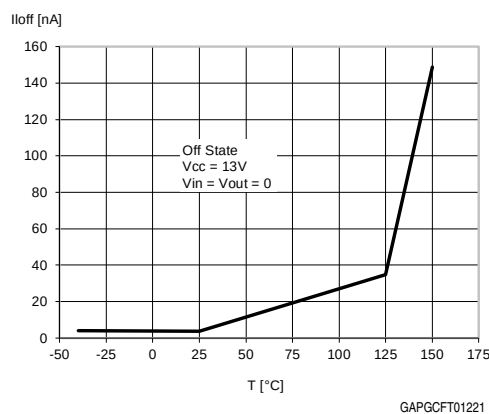


Figure 12: Standby current

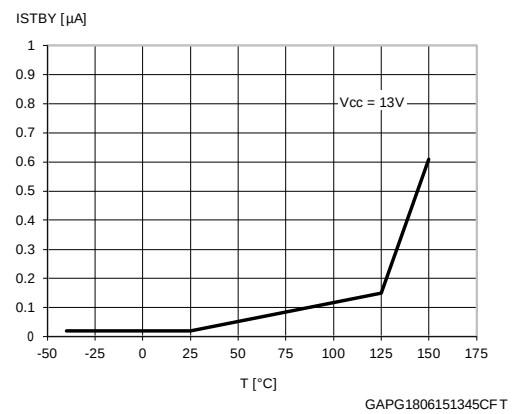


Figure 13: IGND(ON) vs. Tcase

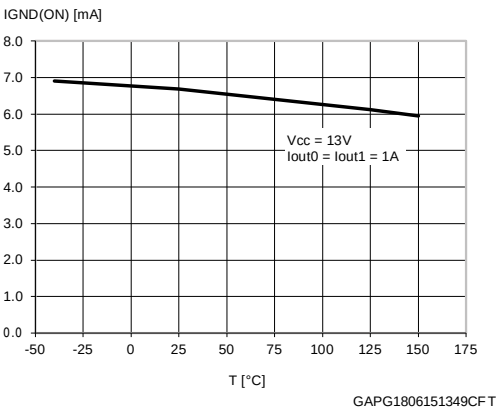


Figure 14: Logic Input high level voltage

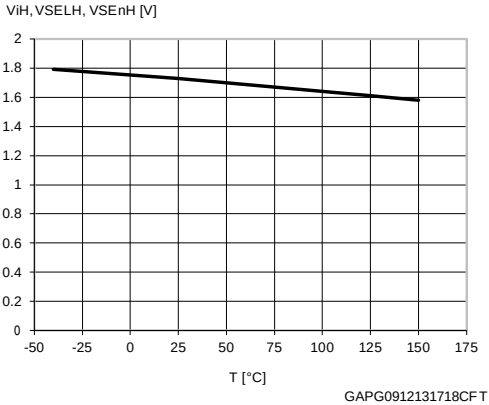


Figure 15: Logic Input low level voltage

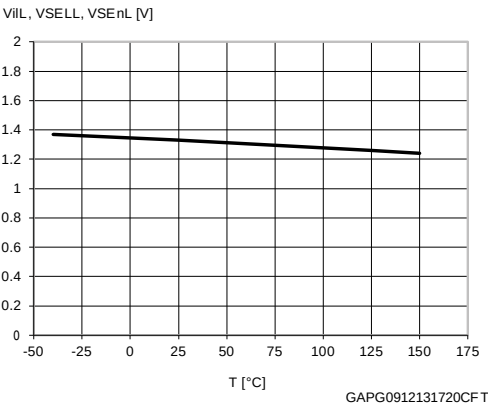


Figure 16: High level logic input current

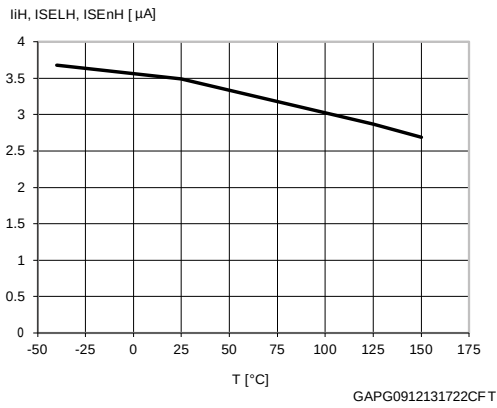


Figure 17: Low level logic input current

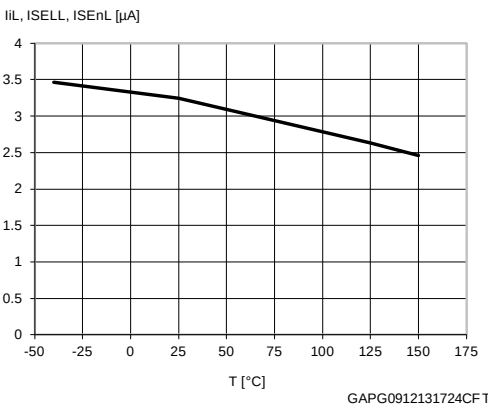


Figure 18: Logic Input hysteresis voltage

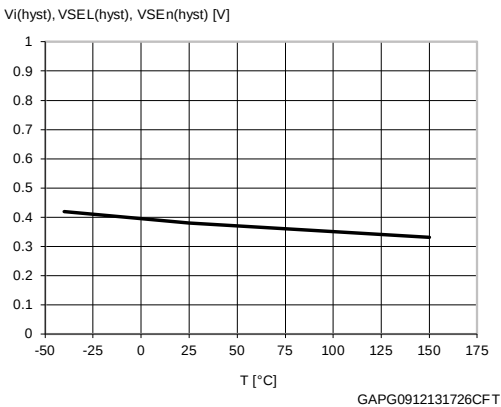


Figure 19: Undervoltage shutdown

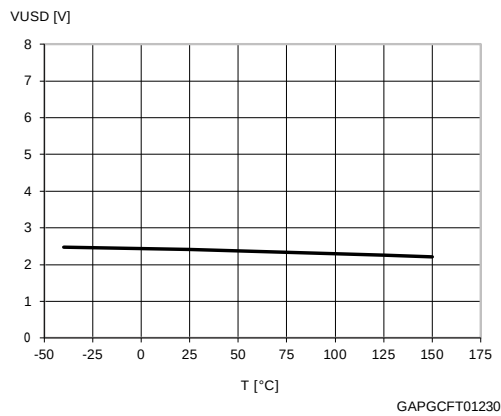


Figure 20: On-state resistance vs. Tcase

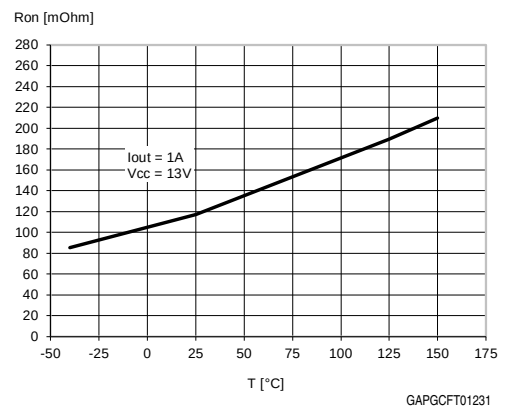


Figure 21: On-state resistance vs. Vcc

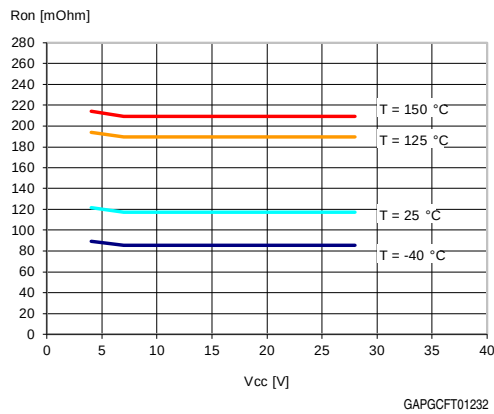


Figure 22: Turn-on voltage slope

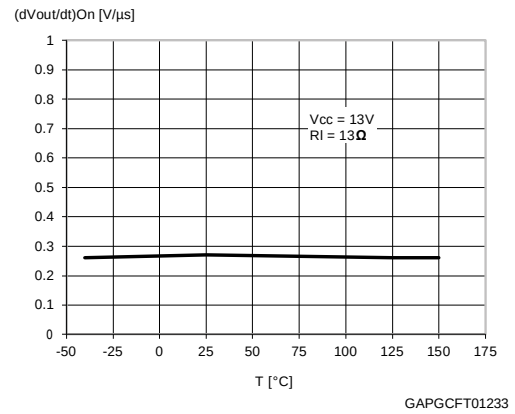


Figure 23: Turn-off voltage slope

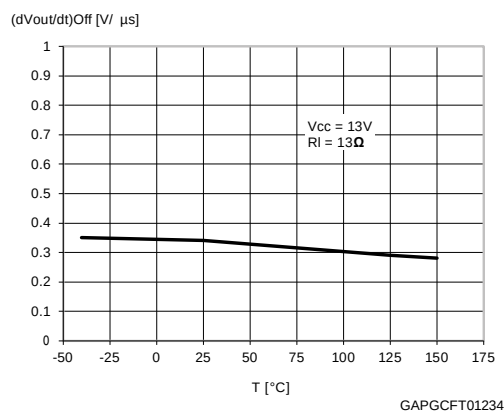


Figure 24: Won vs Tcase

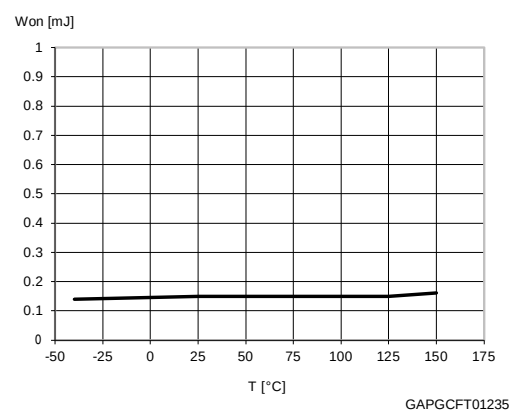


Figure 25: Woff vs Tcase

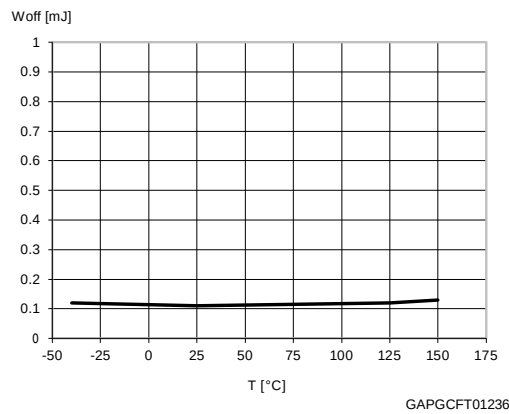


Figure 26: Ilimh vs. Tcase

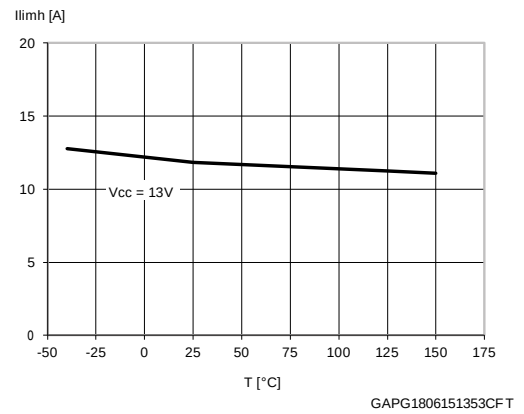


Figure 27: OFF-state open-load voltage detection threshold

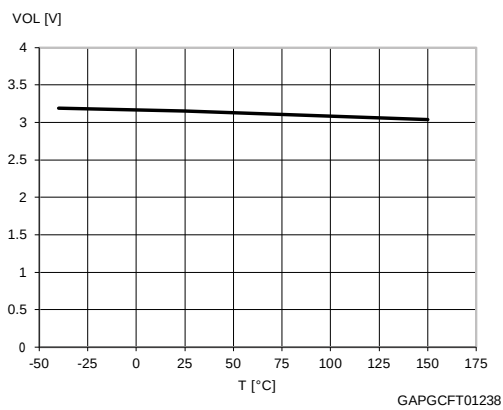


Figure 28: Vsense clamp vs Tcase

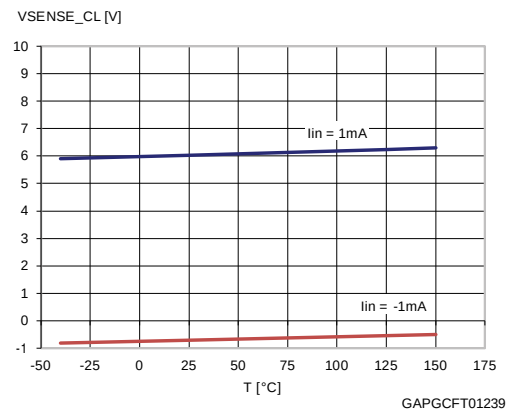
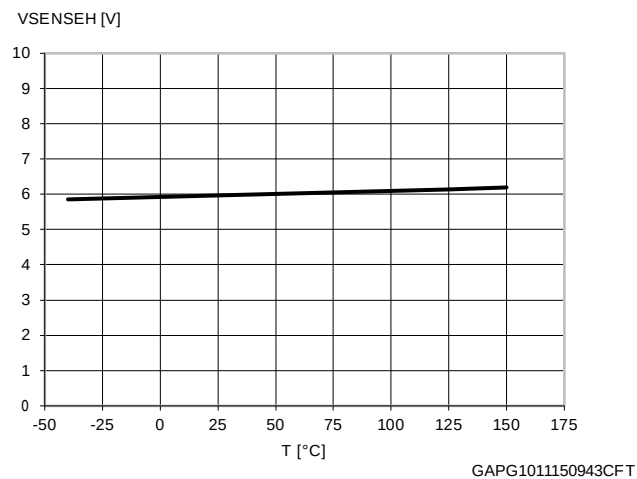


Figure 29: Vsenseh vs Tcase



## 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  $\Delta T_{j\_SD}$ . The output MOSFET switches on and cycles with a thermal hysteresis according to the maximum instantaneous power which can be handled. 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. The device switches on again as soon as its junction temperature drops to  $T_R$ .

### 3.3 Current limitation

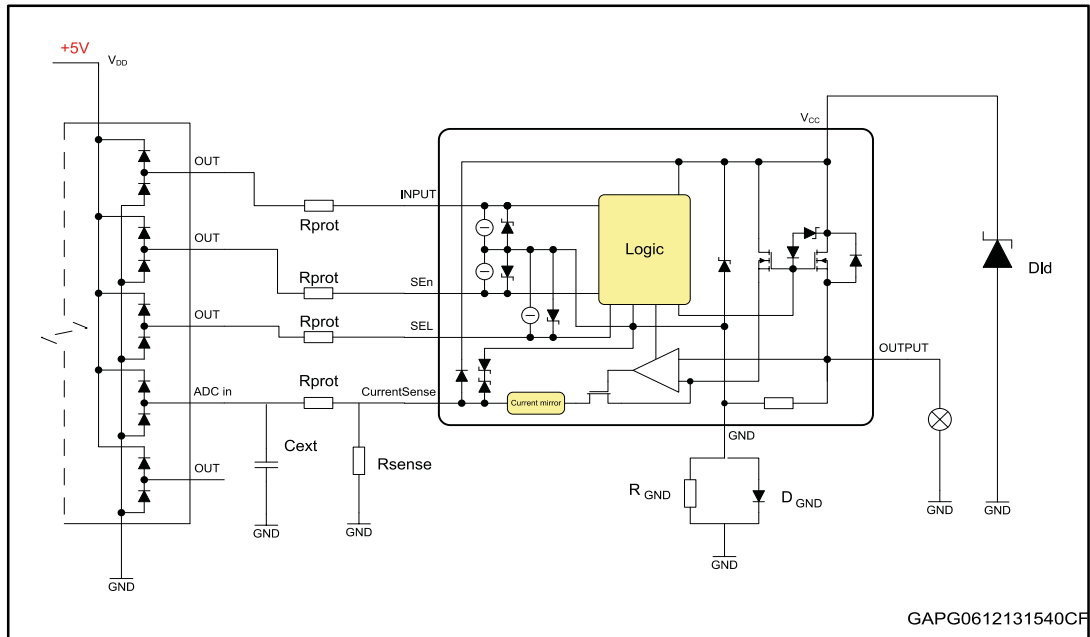
The device is equipped with an output current limiter in order to protect the silicon as well as the other components of the system (e.g. bonding wires, wiring harness, connectors, loads, etc.) from excessive current flow. Consequently, in case of short circuit, overload or during load power-up, the 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,  $V_{DEMAG}$ , allowing the inductor energy to be dissipated without damaging the device.

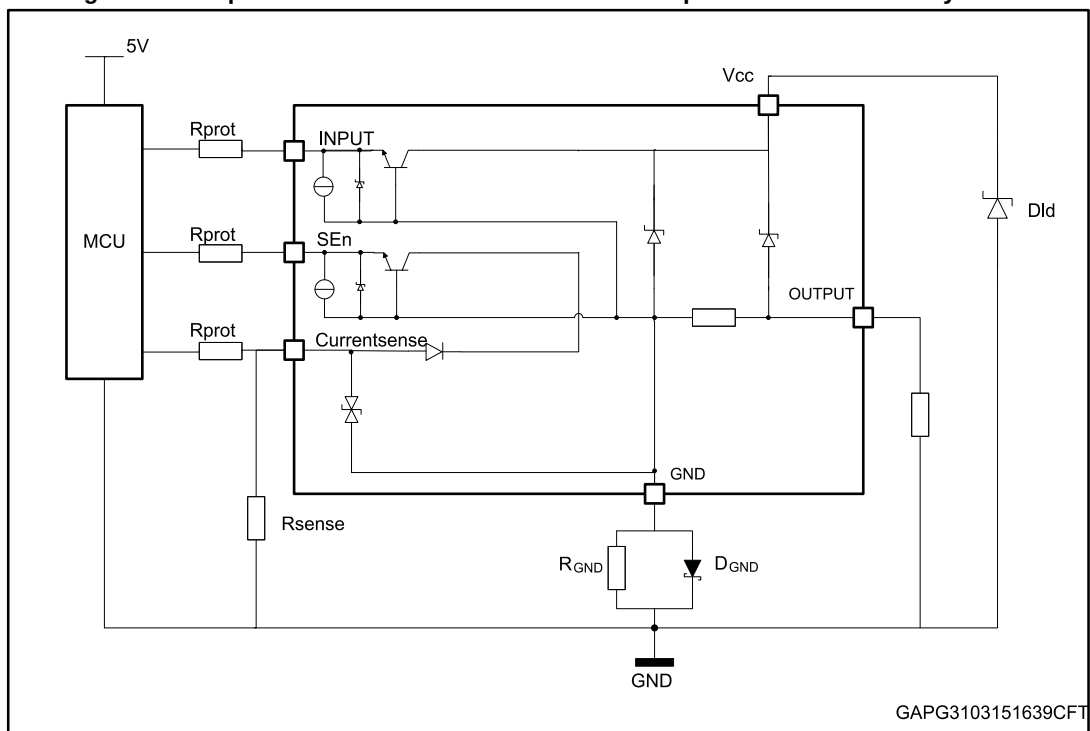
## 4 Application information

Figure 30: Application diagram



### 4.1 GND protection network against reverse battery

Figure 31: Simplified internal structure - GND network protection with Schottky diode







Status II is defined in ISO 7637-1 Function Performance Status Classification (FPSC) as follows: "The function does not perform as designed during the test but returns automatically to normal operation after the test".

**Table 13: ISO 7637-2 - electrical transient conduction along supply line**

| Test Pulse 2011(E)                             | Test pulse severity level with Status II functional performance status |                               | Minimum number of pulses or test time | Burst cycle / pulse repetition time |        | Pulse duration and pulse generator internal impedance |
|------------------------------------------------|------------------------------------------------------------------------|-------------------------------|---------------------------------------|-------------------------------------|--------|-------------------------------------------------------|
|                                                | Level                                                                  | U <sub>S</sub> <sup>(1)</sup> |                                       | min                                 | max    |                                                       |
| 1                                              | III                                                                    | -112V                         | 500 pulses                            | 0,5 s                               |        | 2ms, 10Ω                                              |
| 2a                                             | III                                                                    | +55V                          | 500 pulses                            | 0,2 s                               | 5 s    | 50μs, 2Ω                                              |
| 3a                                             | IV                                                                     | -220V                         | 1h                                    | 90 ms                               | 100 ms | 0.1μs, 50Ω                                            |
| 3b                                             | IV                                                                     | +150V                         | 1h                                    | 90 ms                               | 100 ms | 0.1μs, 50Ω                                            |
| 4 <sup>(2)</sup>                               | IV                                                                     | -7V                           | 1 pulse                               |                                     |        | 100ms, 0.01Ω                                          |
| <b>Load dump according to ISO 16750-2:2010</b> |                                                                        |                               |                                       |                                     |        |                                                       |
| Test B <sup>(3)</sup>                          |                                                                        | 40V                           | 5 pulse                               | 1 min                               |        | 400ms, 2Ω                                             |

**Notes:**

<sup>(1)</sup>U<sub>S</sub> is the peak amplitude as defined for each test pulse in ISO 7637-2:2011(E), chapter 5.6.

<sup>(2)</sup>Test pulse from ISO 7637-2:2004(E).

<sup>(3)</sup>With 40 V external suppressor referred to ground (-40°C < T<sub>j</sub> < 150°C).

## 4.3 MCU I/Os protection

If a ground protection network is used and negative transients are present on the V<sub>CC</sub> line, the control pins will be pulled negative. ST suggests to insert a resistor (R<sub>prot</sub>) in line both to prevent the microcontroller I/O pins to latch-up and to protect the HSD inputs.

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

### Equation

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

Calculation example:

For V<sub>CCpeak</sub> = -150 V; I<sub>latchup</sub> ≥ 20 mA; V<sub>OHμC</sub> ≥ 4.5 V

7.5 kΩ ≤ R<sub>prot</sub> ≤ 140 kΩ.

Recommended values: R<sub>prot</sub> = 15 kΩ

## 4.4 Behaviour during engine start transients

The battery voltage drops every time an engine start occurs as well as in start&stop automotive systems.

The device is designed to operate during engine start pulses without external components.

In particular, the device achieves functional status A, for both E-11 start pulses, "normal" and "severe" as defined in [Table 14: "Test parameters, E-11 Start pulses"](#).

Functional status A is defined as follows: the DUT (device under test) must fulfill all functions during and after exposure to the test parameters.

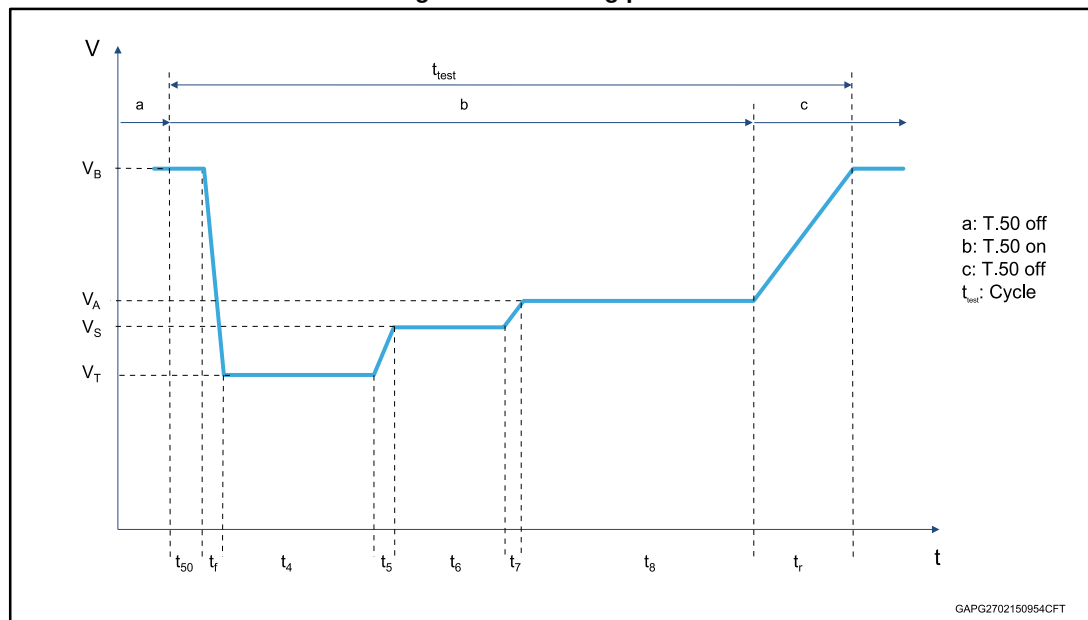
Table 14: Test parameters, E-11 Start pulses

| Parameter                | Test pulse "normal" | Test pulse "severe"    |
|--------------------------|---------------------|------------------------|
| $V_B$                    | 11,0 V              | 11,0 V                 |
| $V_T$                    | 4,5 V (0%, -4%)     | 3,2 V <sup>+0,2V</sup> |
| $V_S$                    | 4,5 V (0%, -4%)     | 5,0 V (0%, -4%)        |
| $V_A$                    | 6,5 V (0%, -4%)     | 6,0 V (0%, -4%)        |
| $V_R$                    | 2 V                 | 2 V                    |
| $t_f$                    | $\leq 1$ ms         | $\leq 1$ ms            |
| $t_4$                    | 0 ms                | 19 ms                  |
| $t_5$                    | 0 ms                | $\leq 1$ ms            |
| $t_6$                    | 19 ms               | 329 ms                 |
| $t_7$                    | 50 ms               | 50 ms                  |
| $t_8$                    | 10 s                | 10 s                   |
| $t_r$                    | 100 ms              | 100 ms                 |
| f                        | 2 Hz                | 2 Hz                   |
| Break between two cycles | 2 s                 | 2 s                    |
| Test cycles              | 10                  | 10                     |



For more details see standard norm "LV124 - Electric and Electronic Components in Motor Vehicles up to 3.5 t".

Figure 33: Cranking profile



The extremely low  $V_{USD\_Cranking}$ , minimum cranking supply voltage ( $V_{CC}$  decreasing), specification of 2.85 V, much lower than the standard requirement, allows the device

operating in all the applications where a ground network protection is required (see [Section 4.1: "GND protection network against reverse battery"](#)).

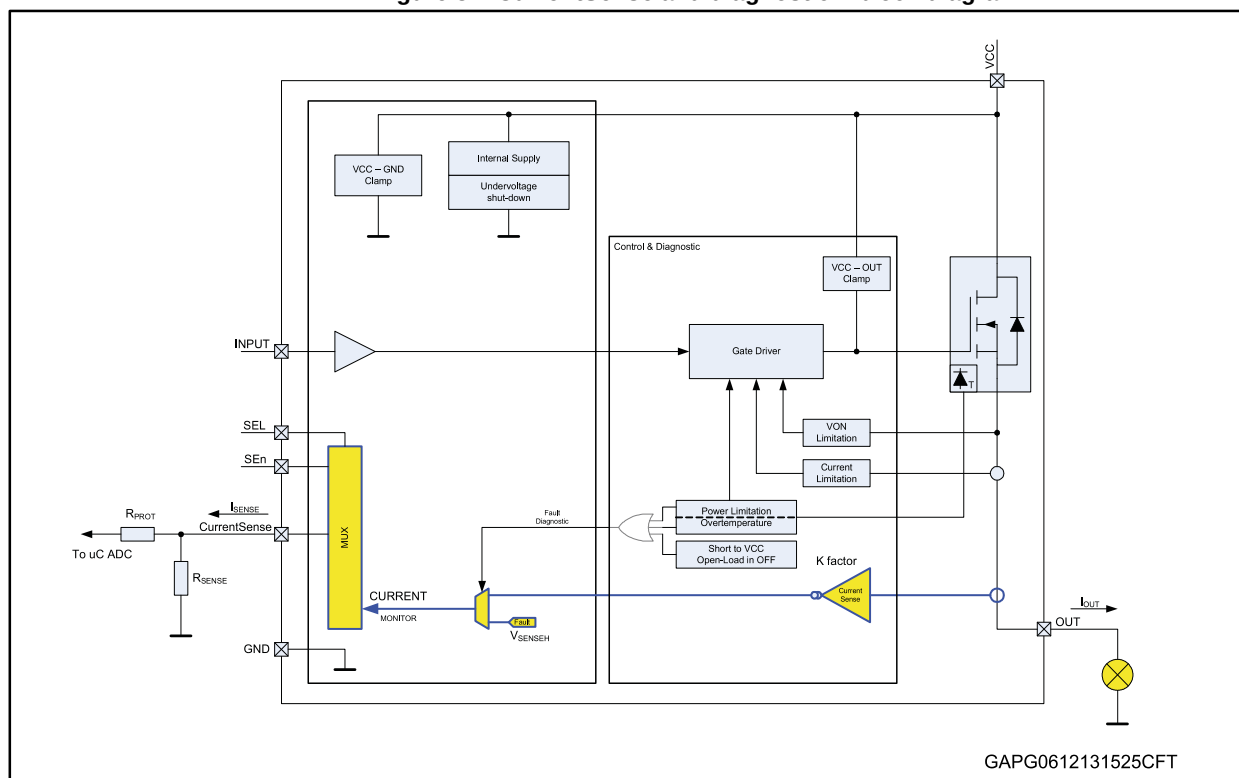
Table 15: Cranking operating mode

| Operating range             | Voltage range | Operating mode                                                                                                    |
|-----------------------------|---------------|-------------------------------------------------------------------------------------------------------------------|
| Normal mode 4 V to 28 V     | 18 V - 28 V   | All functions are performed as specified. Some deviations of the electrical characteristics.                      |
|                             | 7 V - 18 V    | All functions are performed as specified. All parameters in range.                                                |
|                             | 4 V - 7 V     | All functions are performed as specified. Some deviations of the electrical characteristics.                      |
| Cranking mode 2.85 V to 4 V | 2.85 V - 4 V  | Device is operating ( $V_{CC}$ decreasing). Device is protected. No diagnostic. Electrical parameters deviations. |

## 4.5 CurrentSense - analog current sense

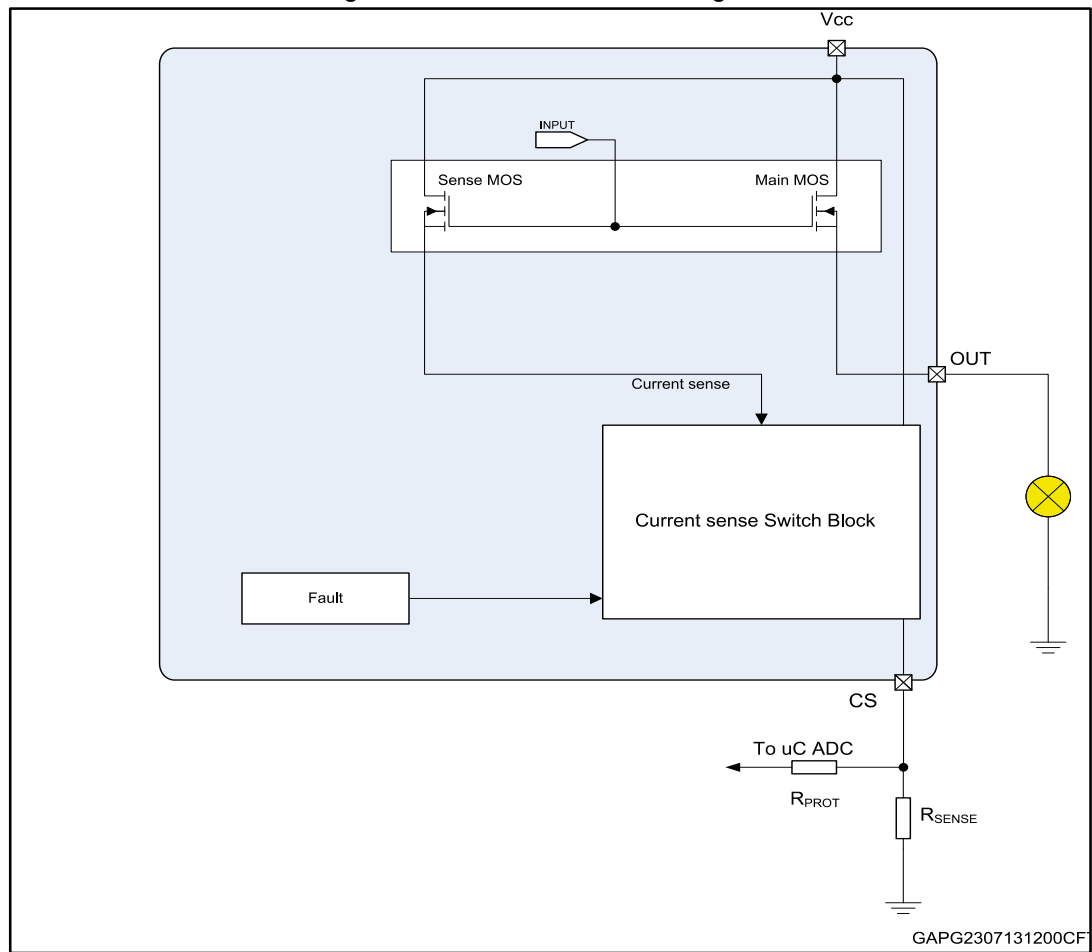
Diagnostic information on device and load status are provided by an analog output pin (CurrentSense) delivering a current mirror of channel output current

Figure 34: CurrentSense and diagnostic – block diagram



### 4.5.1 Principle of CurrenSense signal generation

Figure 35: CurrentSense block diagram



#### Current monitor

This output is capable of providing:

- **Current mirror proportional to the load current in normal operation**, delivering current proportional to the load according to known ratio named **K**
- **Diagnostics flag in fault conditions** delivering fixed voltage  $V_{SENSEH}$

The current delivered by the current sense circuit,  $I_{SENSE}$ , can be easily converted to a voltage  $V_{SENSE}$  by using an external sense resistor,  $R_{SENSE}$ , allowing continuous load monitoring and abnormal condition detection.

#### Normal operation (channel ON, no fault, SEn active)

While device is operating in normal conditions (no fault intervention),  $V_{SENSE}$  calculation can be done using simple equations

Current provided by CurrentSense output:  $I_{SENSE} = I_{OUT}/K$

Voltage on  $R_{SENSE}$  :  $V_{SENSE} = R_{SENSE} \cdot I_{SENSE} = R_{SENSE} \cdot I_{OUT}/K$

Where :

- $V_{SENSE}$  is voltage measurable on  $R_{SENSE}$  resistor

- $I_{SENSE}$  is current provided from CurrentSense pin in current output mode
- $I_{OUT}$  is current flowing through output
- K factor represents the ratio between PowerMOS cells and SenseMOS cells; its spread includes geometric factor spread, current sense amplifier offset and process parameters spread of overall circuitry specifying ratio between  $I_{OUT}$  and  $I_{SENSE}$ .

## Failure flag indication

In case of power limitation/overtemperature, the fault is indicated by the CurrentSense pin which is switched to a “current limited” voltage source,  $V_{SENSEH}$ .

In any case, the current sourced by the CurrentSense in this condition is limited to  $I_{SENSEH}$ .

The typical behavior in case of overload or hard short circuit is shown in *Waveforms section*.

**Figure 36: Analogue HSD – open-load detection in off-state**

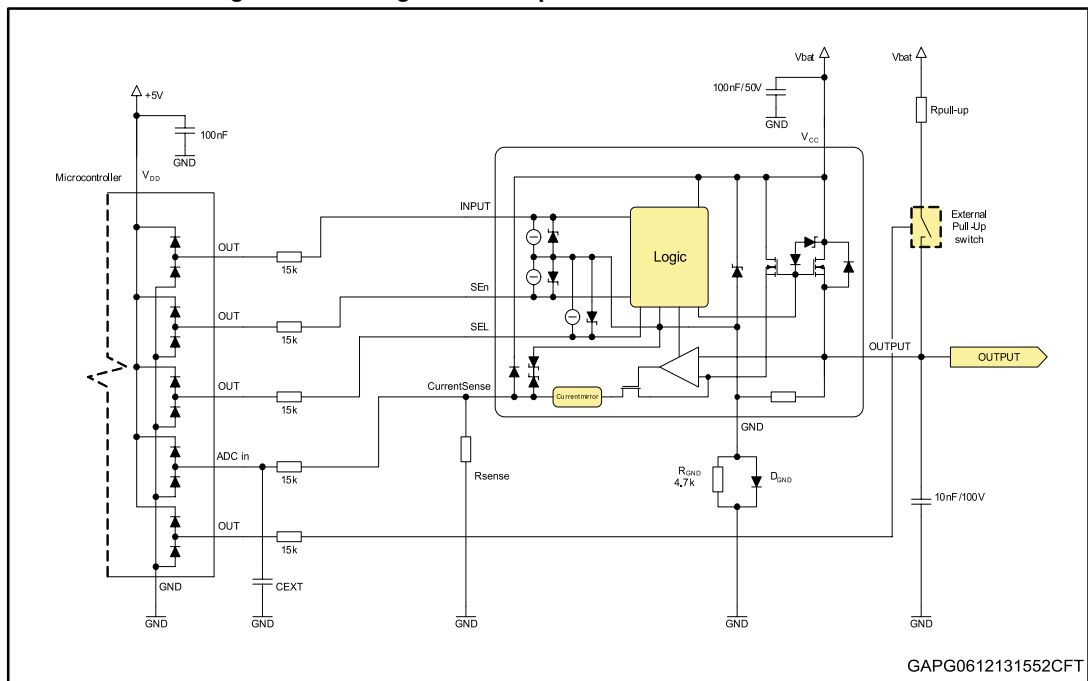


Figure 37: Open-load / short to VCC condition

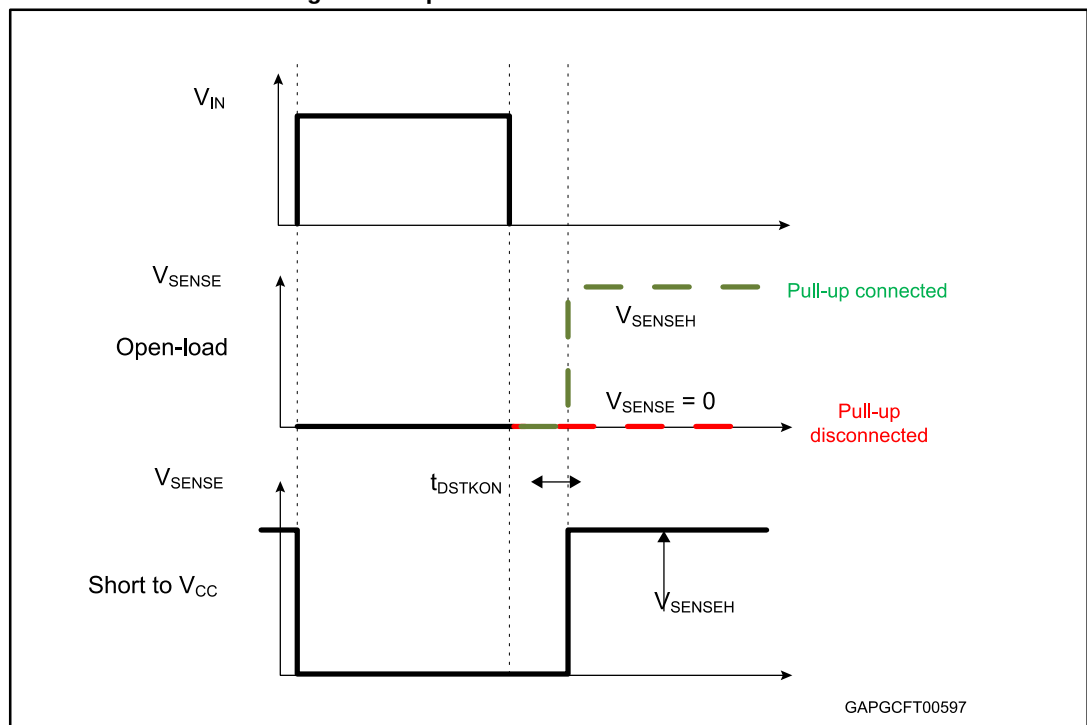


Table 16: CurrentSense pin levels in off-state

| Condition         | Output             | CurrentSense | SEn |
|-------------------|--------------------|--------------|-----|
| Open-load         | $V_{OUT} > V_{OL}$ | Hi-Z         | L   |
|                   |                    | $V_{SENSEH}$ | H   |
|                   | $V_{OUT} < V_{OL}$ | Hi-Z         | L   |
|                   |                    | 0            | H   |
| Short to $V_{CC}$ | $V_{OUT} > V_{OL}$ | Hi-Z         | L   |
|                   |                    | $V_{SENSEH}$ | H   |
| Nominal           | $V_{OUT} < V_{OL}$ | Hi-Z         | L   |
|                   |                    | 0            | H   |

#### 4.5.2 Short to VCC and OFF-state open-load detection

##### Short to $V_{CC}$

A short circuit between  $V_{CC}$  and output is indicated by the relevant current sense pin set to  $V_{SENSEH}$  during the device off-state. Small or no current is delivered by the current sense during the on-state depending on the nature of the short circuit.

##### OFF-state open-load with external circuitry

Detection of an open-load in off mode requires an external pull-up resistor  $R_{PU}$  connecting the output to a positive supply voltage  $V_{PU}$ .

It is preferable  $V_{PU}$  to be switched off during the module standby mode in order to avoid the overall standby current consumption to increase in normal conditions, i.e. when load is connected.

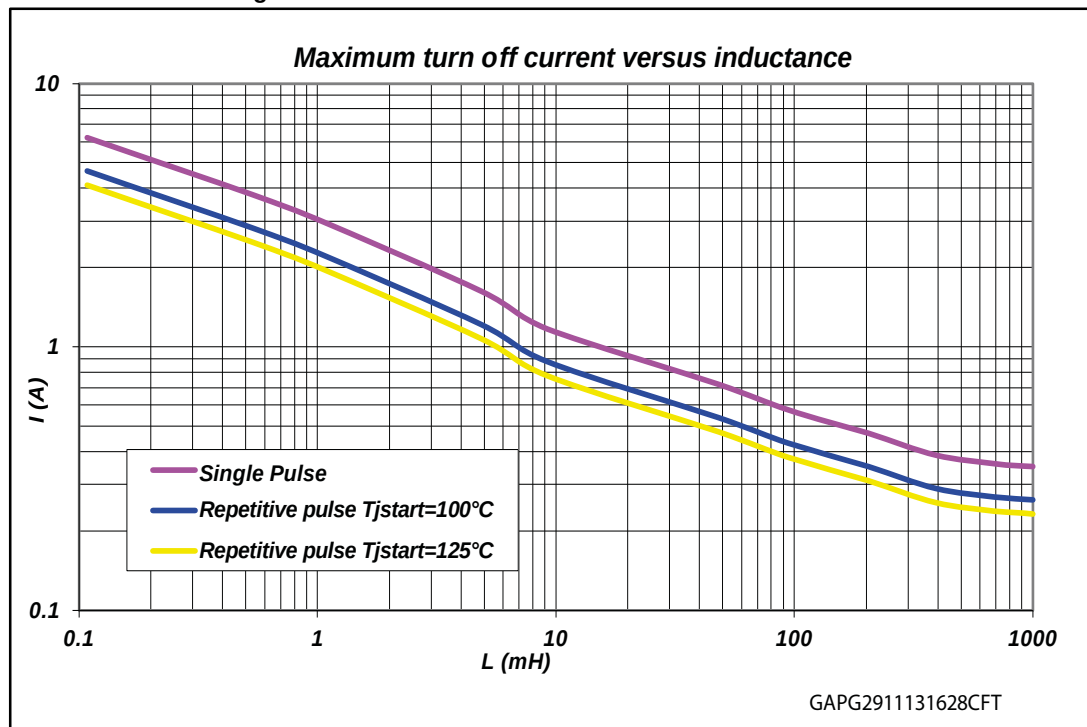
R<sub>PU</sub> must be selected in order to ensure V<sub>OUT</sub> > V<sub>OLmax</sub> in accordance with the following equation:

**Equation**

$$R_{PU} < \frac{V_{PU} - 4}{I_{L(off2)min @ 4V}}$$

## 5 Maximum demagnetization energy (VCC = 16 V)

Figure 38: Maximum turn off current versus inductance



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.



## 6 Package and PCB thermal data

### 6.1 PowerSSO-12 thermal data

Figure 39: PowerSSO-12 on two-layers PCB (2s0p to JEDEC JESD 51-5)

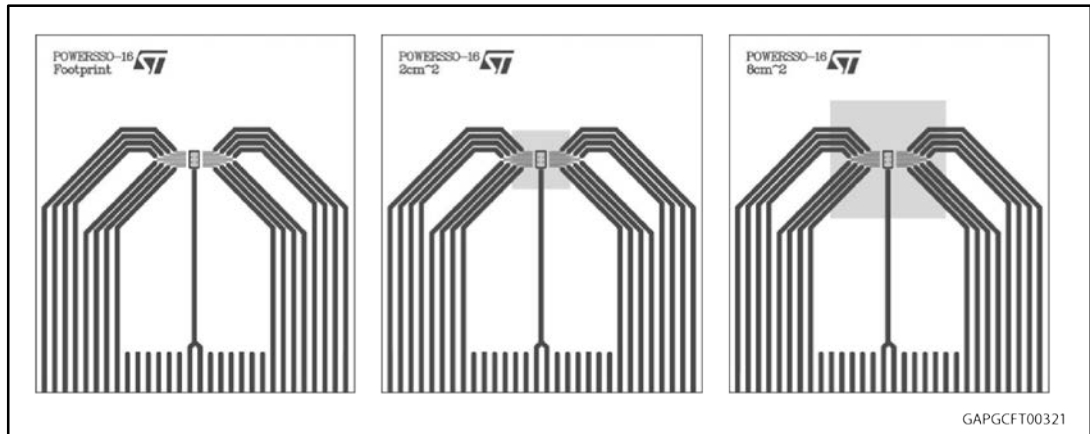


Figure 40: PowerSSO-12 on four-layers PCB (2s2p to JEDEC JESD 51-7)

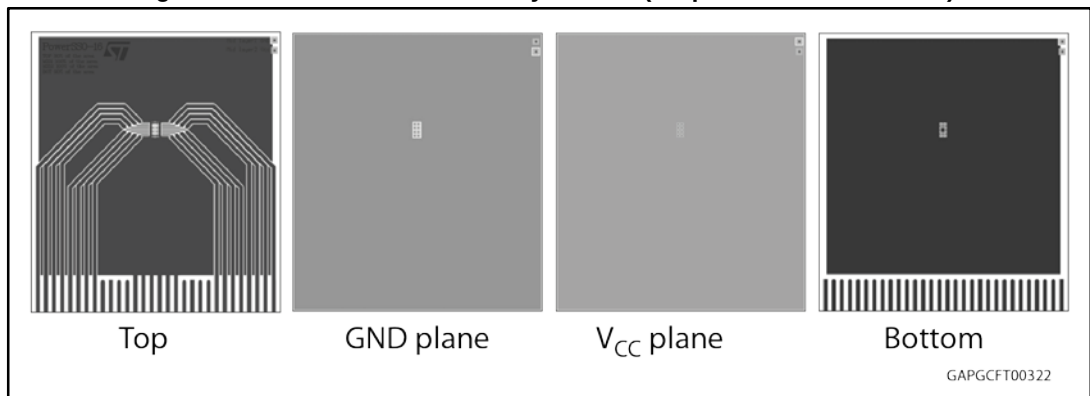


Table 17: PCB properties

| 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 via separation                        | 1.2 mm                                            |
| Thermal via diameter                          | 0.3 mm +/- 0.08 mm                                |
| Copper thickness on via                       | 0.025 mm                                          |
| Footprint dimension (top layer)               | 2.2 mm x 3.9 mm                                   |
| Heatsink copper area dimension (bottom layer) | Footprint, 2 cm <sup>2</sup> or 8 cm <sup>2</sup> |

Figure 41: Rthj-amb vs PCB copper area in open box free air condition (one channel on)

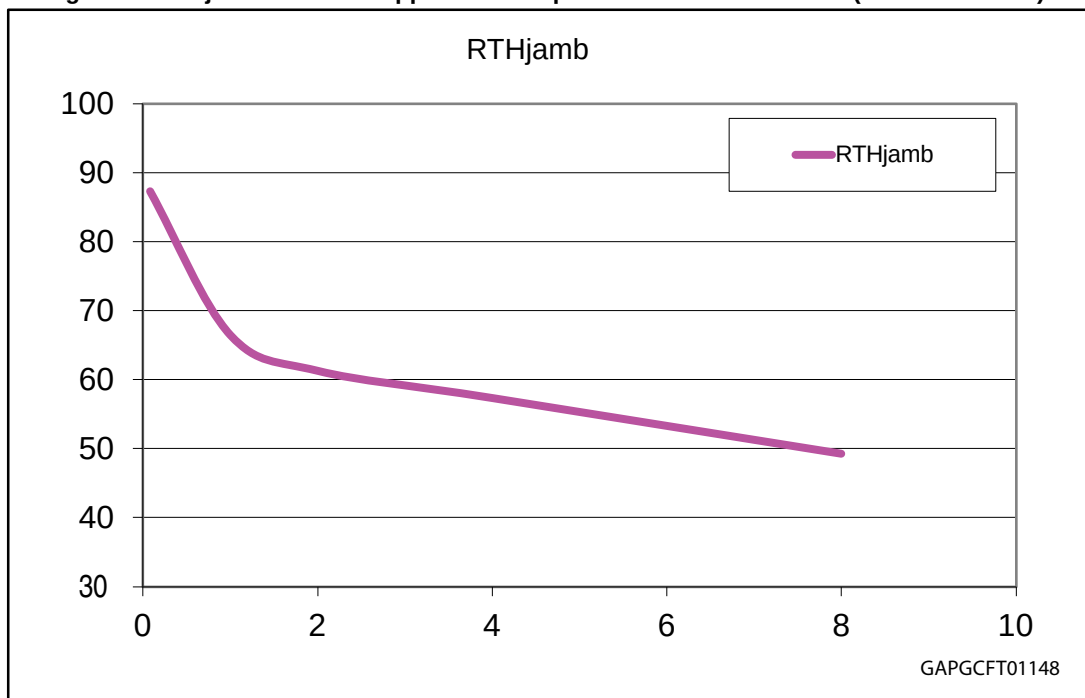
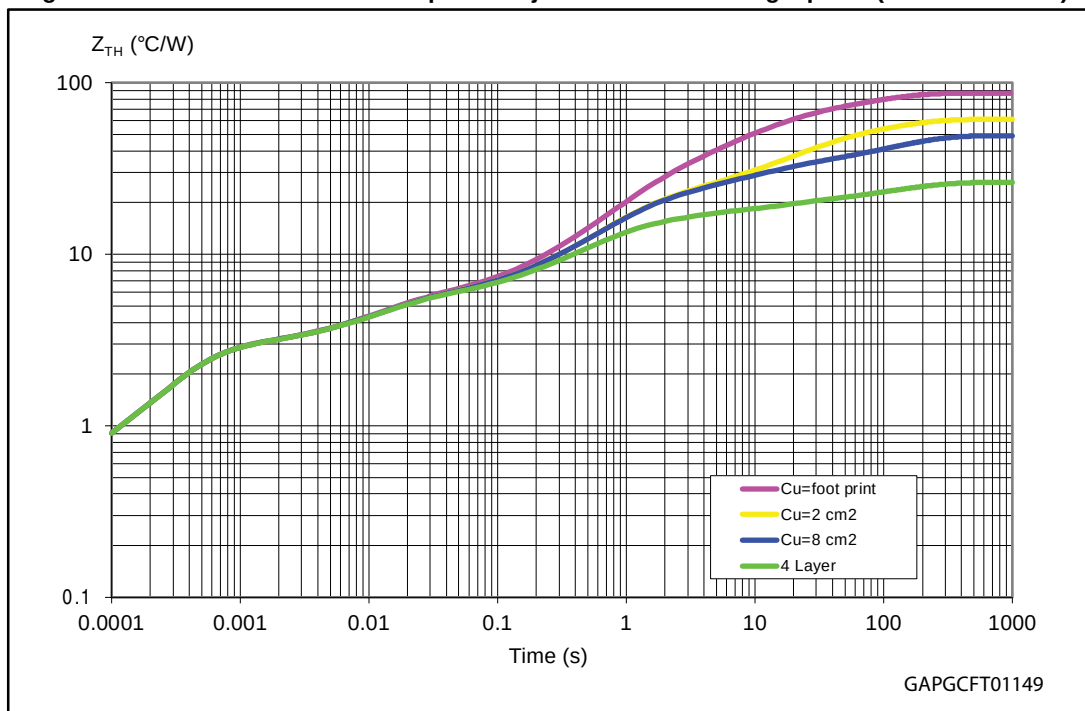


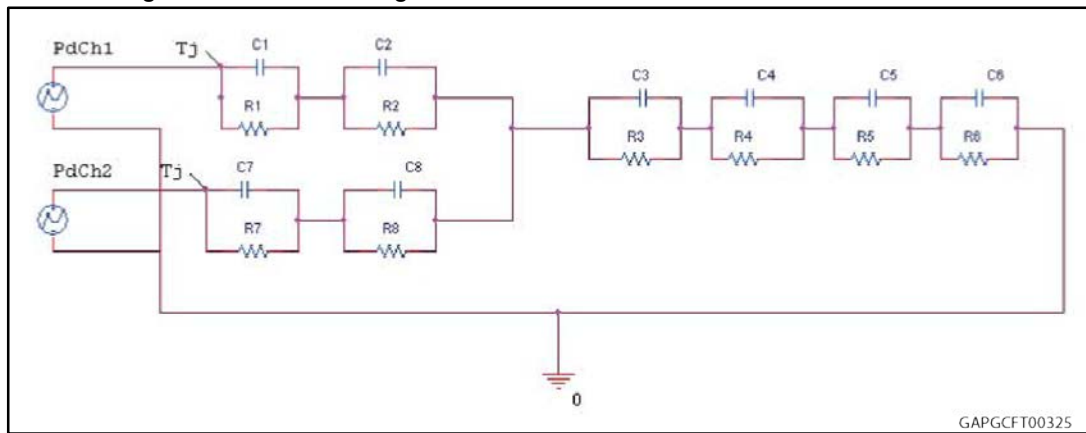
Figure 42: PowerSSO-12 thermal impedance junction ambient single pulse (one channel on)

**Equation: pulse calculation formula**

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

where  $\delta = t_p/T$

Figure 43: Thermal fitting model of a double-channel HSD in PowerSSO-12



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 18: Thermal parameters

| Area/island (cm <sup>2</sup> ) | Footprint | 2   | 8   | 4L  |
|--------------------------------|-----------|-----|-----|-----|
| R1 = R7 (°C/W)                 | 2.8       |     |     |     |
| R2 = R8 (°C/W)                 | 2.5       |     |     |     |
| R3 (°C/W)                      | 10        | 10  | 10  | 7   |
| R4 (°C/W)                      | 16        | 6   | 6   | 4   |
| R5 (°C/W)                      | 30        | 20  | 10  | 3   |
| R6 (°C/W)                      | 26        | 20  | 18  | 7   |
| C1 = C7 (W.s/°C)               | 0.00012   |     |     |     |
| C2 = C8 (W.s/°C)               | 0.005     |     |     |     |
| C3 (W.s/°C)                    | 0.07      |     |     |     |
| 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  |

## 7 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.

### 7.1 PowerSSO-12 package information

Figure 44: PowerSSO-12 package dimensions

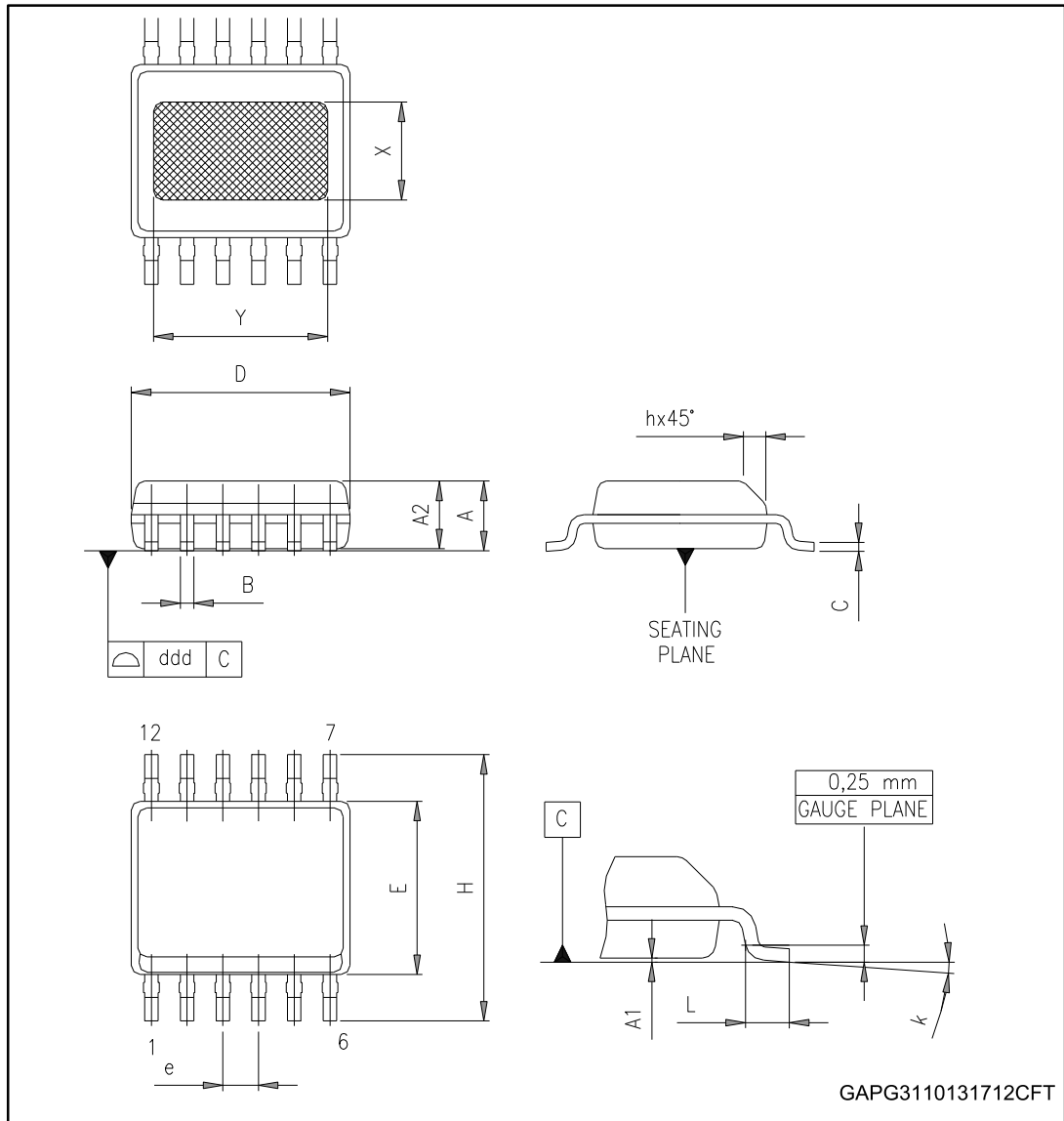


Table 19: PowerSSO-12 mechanical data

| Symbol | Millimeters |       |       |
|--------|-------------|-------|-------|
|        | Min.        | Typ.  | Max.  |
| A      | 1.250       |       | 1.700 |
| A1     | 0.000       |       | 0.100 |
| A2     | 1.100       |       | 1.600 |
| B      | 0.230       |       | 0.410 |
| C      | 0.190       |       | 0.250 |
| D      | 4.800       |       | 5.000 |
| E      | 3.800       |       | 4.000 |
| e      |             | 0.800 |       |
| H      | 5.800       |       | 6.200 |
| h      | 0.250       |       | 0.500 |
| L      | 0.400       |       | 1.270 |
| k      | 0°          |       | 8°    |
| X      | 2.200       |       | 2.800 |
| Y      | 2.900       |       | 3.500 |
| ddd    |             |       | 0.100 |

## 7.2 PowerSSO-12 packing information

Figure 45: PowerSSO-12 reel 13"

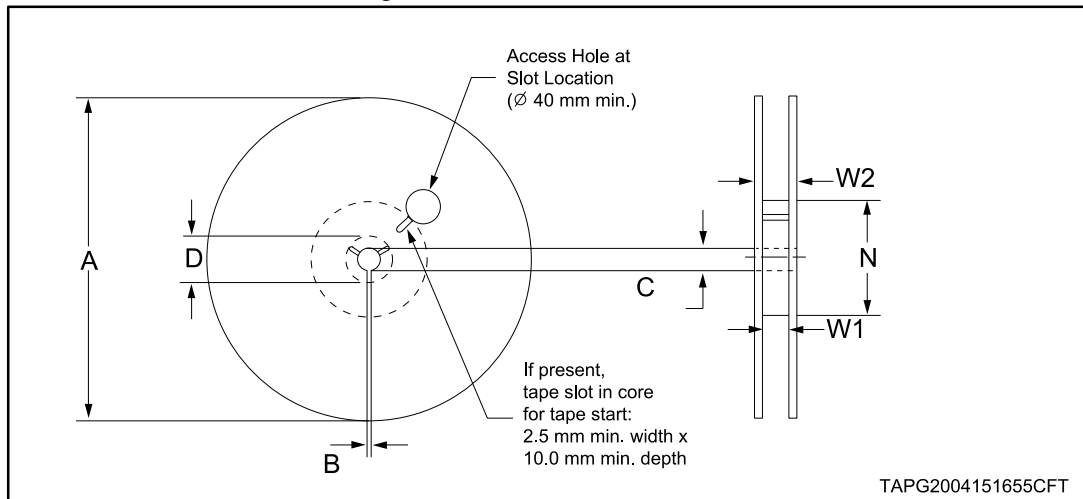


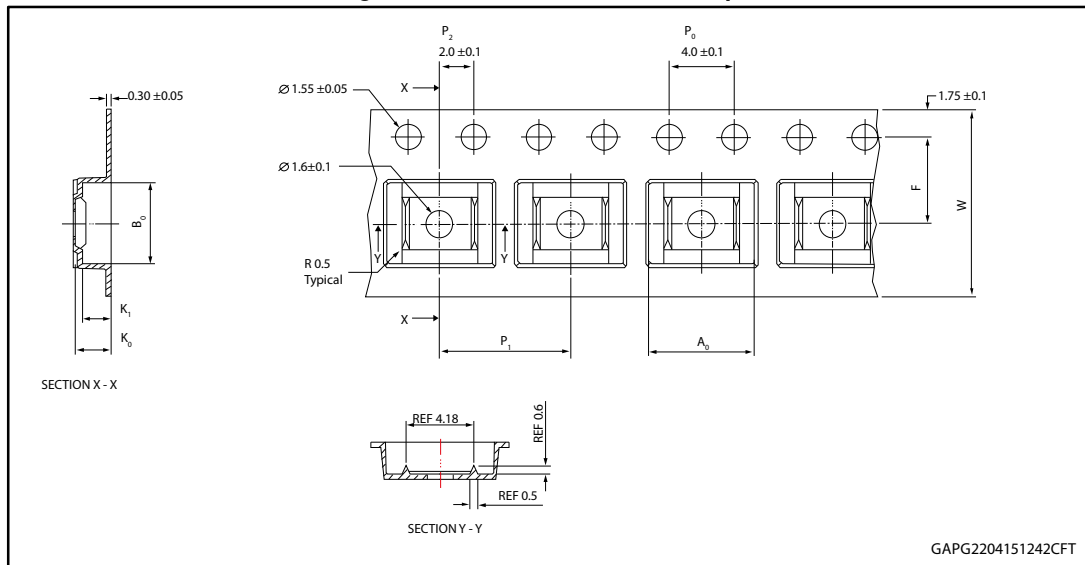
Table 20: Reel dimensions

| Description   | Value <sup>(1)</sup> |
|---------------|----------------------|
| Base quantity | 2500                 |
| Bulk quantity | 2500                 |
| A (max)       | 330                  |
| B (min)       | 1.5                  |

| Description    | Value <sup>(1)</sup> |
|----------------|----------------------|
| C (+0.5, -0.2) | 13                   |
| D (min)        | 20.2                 |
| N              | 100                  |
| W1 (+2 /-0)    | 12.4                 |
| W2 (max)       | 18.4                 |

**Notes:**

<sup>(1)</sup>All dimensions are in mm.

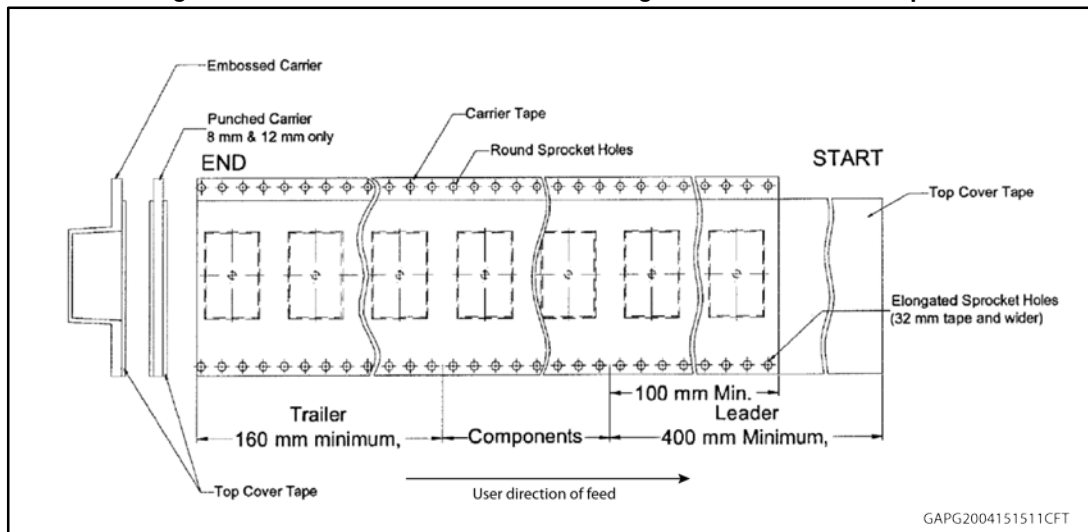
**Figure 46: PowerSSO-12 carrier tape****Table 21: PowerSSO-12 carrier tape dimensions**

| Description    | Value <sup>(1)</sup> |
|----------------|----------------------|
| A <sub>0</sub> | 6.50 ± 0.1           |
| B <sub>0</sub> | 5.25 ± 0.1           |
| K <sub>0</sub> | 2.10 ± 0.1           |
| K <sub>1</sub> | 1.80 ± 0.1           |
| F              | 5.50 ± 0.1           |
| P <sub>1</sub> | 8.00 ± 0.1           |
| W              | 12.00 ± 0.3          |

**Notes:**

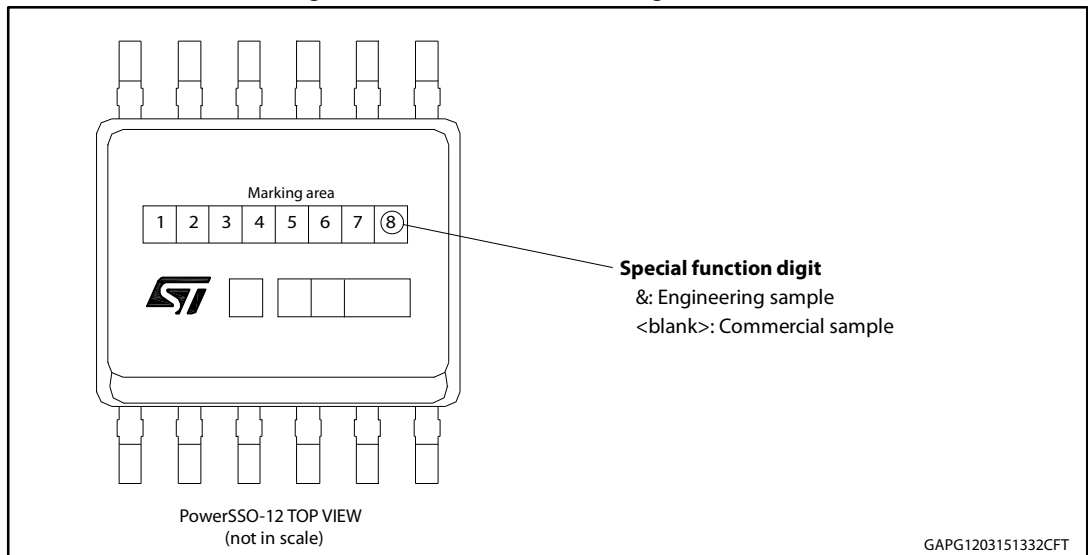
<sup>(1)</sup>All dimensions are in mm.

Figure 47: PowerSSO-12 schematic drawing of leader and trailer tape



### 7.3 PowerSSO-12 marking information

Figure 48: PowerSSO-12 marking information



**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

## 8 Order codes

Table 22: Device summary

| Package     | Order codes   |
|-------------|---------------|
|             | Tape and reel |
| PowerSSO-12 | VND7140AJ12TR |



## 9 Revision history

Table 23: Document revision history

| Date        | Revision | Changes                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 09-Jun-2015 | 1        | Initial release.                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 18-Jun-2015 | 2        | <a href="#">Table 5: "Electrical characteristics during cranking"</a> : <ul style="list-style-type: none"><li>• <math>T_{TSD}</math>: updated value</li></ul> <a href="#">Table 10: "CurrentSense"</a> : <ul style="list-style-type: none"><li>• <math>K_{OL}</math>, <math>K_{LED}</math>, <math>K_0</math>, <math>K_1</math>: updated values</li></ul> Updated <a href="#">Section 2.5: "Electrical characteristics curves"</a> |
| 14-Sep-2015 | 3        | Updated <a href="#">Table 1: "Pin functions"</a><br><a href="#">Table 5: "Electrical characteristics during cranking"</a> : <ul style="list-style-type: none"><li>• <math>R_{ON}</math>: updated test conditions</li></ul>                                                                                                                                                                                                        |

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