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1 Block diagram and pin description

Figure 1. Block diagram

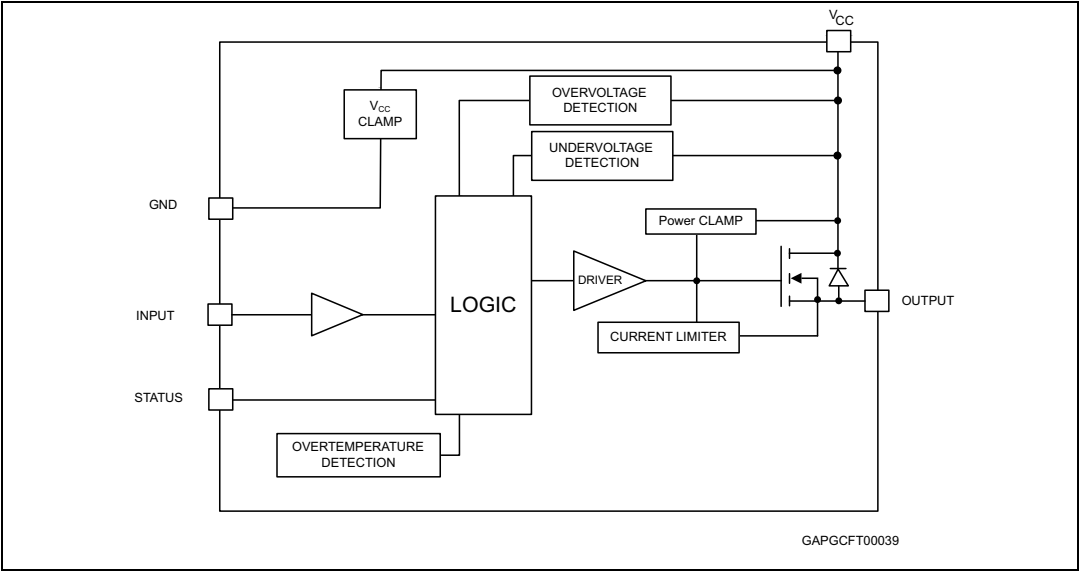


Figure 2. Configuration diagram (top view)

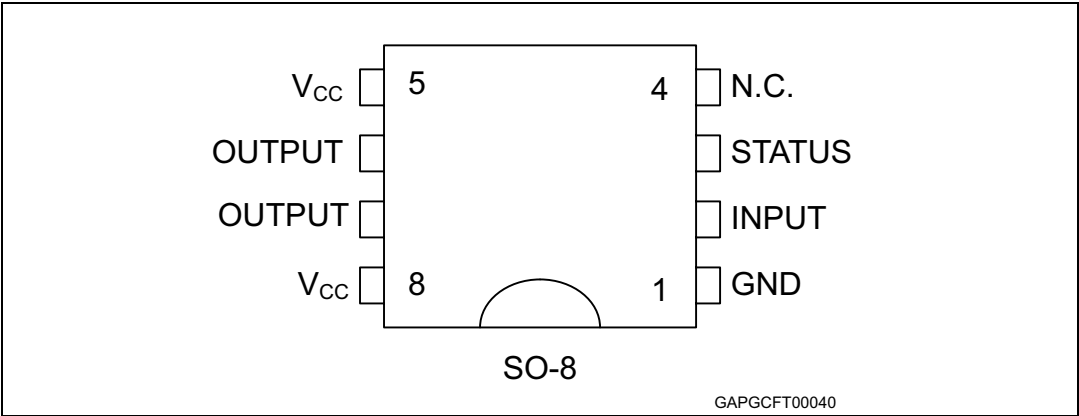
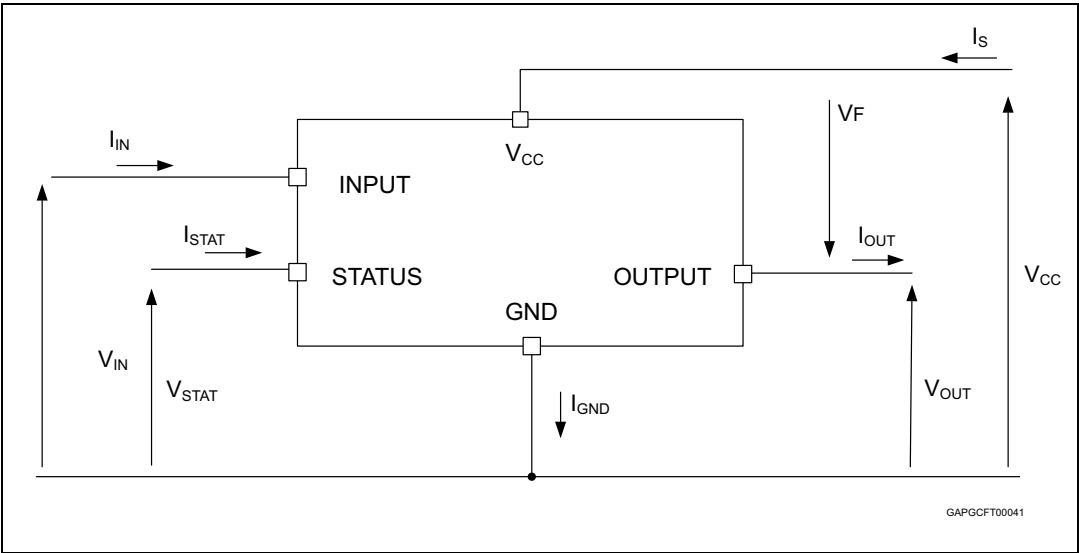


Table 2. Suggested connections for unused and not connected pins

| Connection/pin | Status | N.C. | Output | Input                  |
|----------------|--------|------|--------|------------------------|
| Floating       | X      | X    | X      | X                      |
| To ground      |        | X    |        | Through 10 KΩ resistor |

# 2 Electrical specifications

Figure 3. Current and voltage conventions



## 2.1 Absolute maximum ratings

Table 3. Absolute maximum ratings

| Symbol     | Parameter                                                                                                                                                                    | Value              | Unit |
|------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------|
|            |                                                                                                                                                                              | SO-8               |      |
| $V_{CC}$   | DC supply voltage                                                                                                                                                            | 41                 | V    |
| $-V_{CC}$  | Reverse DC supply voltage                                                                                                                                                    | -0.3               | V    |
| $-I_{GND}$ | DC reverse ground pin current                                                                                                                                                | -200               | mA   |
| $I_{OUT}$  | DC output current                                                                                                                                                            | Internally limited | A    |
| $-I_{OUT}$ | Reverse DC output current                                                                                                                                                    | -6                 | A    |
| $I_{IN}$   | DC input current                                                                                                                                                             | +/- 10             | mA   |
| $V_{IN}$   | Input voltage range                                                                                                                                                          | -3/+ $V_{CC}$      | V    |
| $V_{STAT}$ | DC status voltage                                                                                                                                                            | + $V_{CC}$         | V    |
| $V_{ESD}$  | Electrostatic discharge (human body model: $R = 1.5\text{ K}\Omega$ ; $C = 100\text{ pF}$ )                                                                                  |                    |      |
|            | - Input                                                                                                                                                                      | 4000               | V    |
|            | - Status                                                                                                                                                                     | 4000               | V    |
|            | - Output                                                                                                                                                                     | 5000               | V    |
|            | - $V_{CC}$                                                                                                                                                                   | 5000               | V    |
| $P_{tot}$  | Power dissipation $T_C = 25\text{ }^\circ\text{C}$                                                                                                                           | 4.2                | W    |
| $E_{MAX}$  | Maximum switching energy<br>( $L = 77.5\text{ mH}$ ; $R_L = 0\text{ }\Omega$ ; $V_{bat} = 13.5\text{ V}$ ; $T_{jstart} = 150\text{ }^\circ\text{C}$ ; $I_L = 1.5\text{ A}$ ) | 121                | mJ   |

Table 3. Absolute maximum ratings (continued)

| Symbol    | Parameter                      | Value              | Unit |
|-----------|--------------------------------|--------------------|------|
|           |                                | SO-8               |      |
| $T_j$     | Junction operating temperature | Internally limited | °C   |
| $T_c$     | Case operating temperature     | -40 to 150         | °C   |
| $T_{stg}$ | Storage temperature            | -55 to 150         | °C   |

## 2.2 Thermal data

Table 4. Thermal data

| Symbol         | Parameter                               | Value             | Unit |
|----------------|-----------------------------------------|-------------------|------|
|                |                                         | SO-8              |      |
| $R_{thj-lead}$ | Thermal resistance junction-lead max    | 30                | °C/W |
| $R_{thj-amb}$  | Thermal resistance junction-ambient max | 93 <sup>(1)</sup> | °C/W |
|                |                                         | 82 <sup>(2)</sup> | °C/W |

1. When mounted on FR4 printed circuit board with 0.5 cm<sup>2</sup> of copper area (at least 35 μm thick) connected to all V<sub>CC</sub> pins.
2. When mounted on FR4 printed circuit board with 2 cm<sup>2</sup> of copper area (at least 35 μm thick).

## 2.3 Electrical characteristics

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

**Table 5. Power**

| Symbol        | Parameter                  | Test conditions                                                                                                                                                                                | Min. | Typ.      | Max.             | Unit                      |
|---------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----------|------------------|---------------------------|
| $V_{CC}$      | Operating supply voltage   |                                                                                                                                                                                                | 5.5  |           | 36               | V                         |
| $V_{USD}$     | Undervoltage shutdown      |                                                                                                                                                                                                | 3    | 4         | 5.5              | V                         |
| $V_{OV}$      | Overvoltage shutdown       |                                                                                                                                                                                                | 36   | 42        |                  | V                         |
| $R_{ON}$      | On-state resistance        | $I_{OUT} = 0.5\text{ A}$ ; $T_j = 25\text{ }^{\circ}\text{C}$<br>$I_{OUT} = 0.5\text{ A}$                                                                                                      |      |           | 135<br>270       | m $\Omega$<br>m $\Omega$  |
| $I_S$         | Supply current             | Off-state; $V_{CC} = 24\text{ V}$ ; $T_{case} = 25\text{ }^{\circ}\text{C}$<br>On-state; $V_{CC} = 24\text{ V}$<br>On-state; $V_{CC} = 24\text{ V}$ ; $T_{case} = 100\text{ }^{\circ}\text{C}$ |      | 10<br>1.5 | 20<br>3.5<br>2.6 | $\mu\text{A}$<br>mA<br>mA |
| $I_{LGND}$    | Output current at turn-off | $V_{CC} = V_{STAT} = V_{IN} = V_{GND} = 24\text{ V}$ ;<br>$V_{OUT} = 0\text{ V}$                                                                                                               |      |           | 1                | mA                        |
| $I_{L(off1)}$ | Off-state output current   | $V_{IN} = V_{OUT} = 0\text{ V}$                                                                                                                                                                | 0    |           | 50               | $\mu\text{A}$             |
| $I_{L(off2)}$ | Off-state output current   | $V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$T_j = 125\text{ }^{\circ}\text{C}$                                                                                              |      |           | 5                | $\mu\text{A}$             |
| $I_{L(off3)}$ | Off-state output current   | $V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ;<br>$T_j = 25\text{ }^{\circ}\text{C}$                                                                                               |      |           | 3                | $\mu\text{A}$             |

**Table 6. Switching ( $V_{CC} = 24\text{ V}$ )**

| Symbol                | Parameter              | Test conditions                                                                        | Min. | Typ.                       | Max. | Unit             |
|-----------------------|------------------------|----------------------------------------------------------------------------------------|------|----------------------------|------|------------------|
| $t_{d(on)}$           | Turn-on delay time     | $R_L = 48\text{ }\Omega$ from $V_{IN}$ rising edge to<br>$V_{OUT} = 2.4\text{ V}$      | -    | 10                         | -    | $\mu\text{s}$    |
| $t_{d(off)}$          | Turn-off delay time    | $R_L = 48\text{ }\Omega$ from $V_{IN}$ falling edge to<br>$V_{OUT} = 21.6\text{ V}$    | -    | 40                         | -    | $\mu\text{s}$    |
| $dV_{OUT}/dt_{(on)}$  | Turn-on voltage slope  | $R_L = 48\text{ }\Omega$ from $V_{OUT} = 2.4\text{ V}$ to<br>$V_{OUT} = 19.2\text{ V}$ | -    | See<br>relative<br>diagram | -    | V/ $\mu\text{s}$ |
| $dV_{OUT}/dt_{(off)}$ | Turn-off voltage slope | $R_L = 48\text{ }\Omega$ from $V_{OUT} = 21.6\text{ V}$ to<br>$V_{OUT} = 2.4\text{ V}$ | -    | See<br>relative<br>diagram | -    | V/ $\mu\text{s}$ |

**Table 7. Input pin**

| Symbol    | Parameter               | Test conditions          | Min. | Typ. | Max. | Unit          |
|-----------|-------------------------|--------------------------|------|------|------|---------------|
| $V_{INL}$ | Input low level         |                          |      | -    | 1.25 | V             |
| $I_{INL}$ | Low level input current | $V_{IN} = 1.25\text{ V}$ | 1    | -    |      | $\mu\text{A}$ |
| $V_{INH}$ | Input high level        |                          | 3.25 | -    |      | V             |

Table 7. Input pin (continued)

| Symbol        | Parameter                | Test conditions                 | Min. | Typ. | Max. | Unit          |
|---------------|--------------------------|---------------------------------|------|------|------|---------------|
| $I_{INH}$     | High level input current | $V_{IN}=3.25\text{ V}$          |      | -    | 10   | $\mu\text{A}$ |
| $V_{I(hyst)}$ | Input hysteresis voltage |                                 | 0.5  | -    |      | V             |
| $I_{IN}$      | Input current            | $V_{IN} = V_{CC} = 36\text{ V}$ |      | -    | 200  | $\mu\text{A}$ |

Table 8.  $V_{CC}$  - output diode

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

Table 9. Status pin

| Symbol      | Parameter                    | Test conditions                                     | Min. | Typ. | Max. | Unit          |
|-------------|------------------------------|-----------------------------------------------------|------|------|------|---------------|
| $V_{STAT}$  | Status low output voltage    | $I_{STAT} = 1.6\text{ mA}$                          | -    | -    | 0.5  | V             |
| $I_{LSTAT}$ | Status leakage current       | Normal operation; $V_{STAT} = V_{CC} = 36\text{ V}$ | -    | -    | 10   | $\mu\text{A}$ |
| $C_{STAT}$  | Status pin input capacitance | Normal operation; $V_{STAT} = 5\text{ V}$           | -    | -    | 30   | pF            |

Table 10. Protections<sup>(1)</sup>

| Symbol      | Parameter                          | Test conditions                                         | Min.          | Typ.          | Max.          | Unit             |
|-------------|------------------------------------|---------------------------------------------------------|---------------|---------------|---------------|------------------|
| $T_{TSD}$   | Shutdown temperature               |                                                         | 150           | 175           | 200           | $^\circ\text{C}$ |
| $T_R$       | Reset temperature                  |                                                         | 135           |               |               | $^\circ\text{C}$ |
| $T_{hyst}$  | Thermal hysteresis                 |                                                         | 7             | 15            |               | $^\circ\text{C}$ |
| $T_{SDL}$   | Status delay in overload condition | $T_J > T_{jsh}$                                         |               |               | 20            | $\mu\text{s}$    |
| $I_{lim}$   | DC short circuit current           | $V_{CC} = 24\text{ V}$ ; $R_{LOAD} = 10\text{ m}\Omega$ | 0.7           |               | 2             | A                |
| $V_{demag}$ | Turn-off output clamp voltage      | $I_{OUT} = 0.5\text{ A}$ ; $L = 6\text{ mH}$            | $V_{CC} - 47$ | $V_{CC} - 52$ | $V_{CC} - 57$ | V                |

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



Figure 4. Status timing

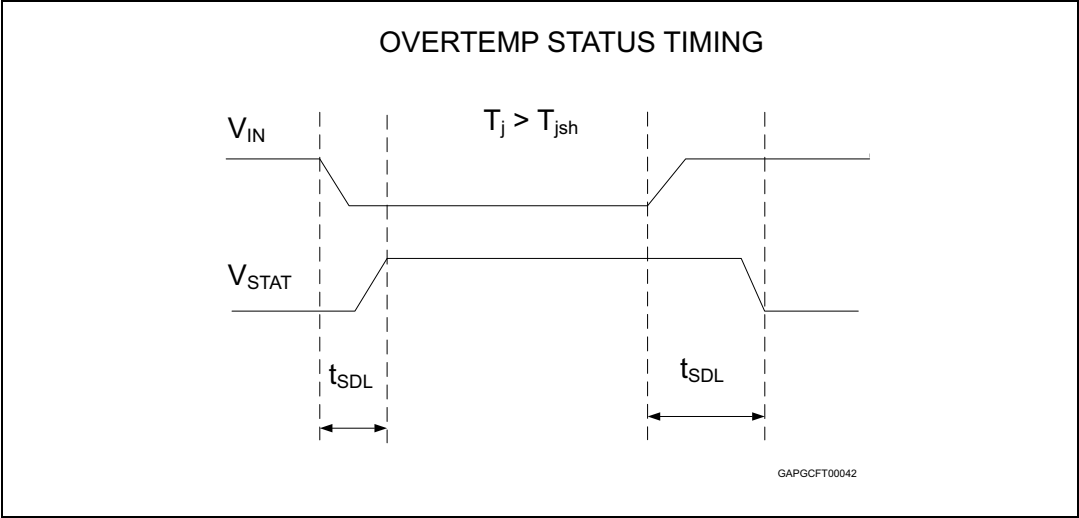
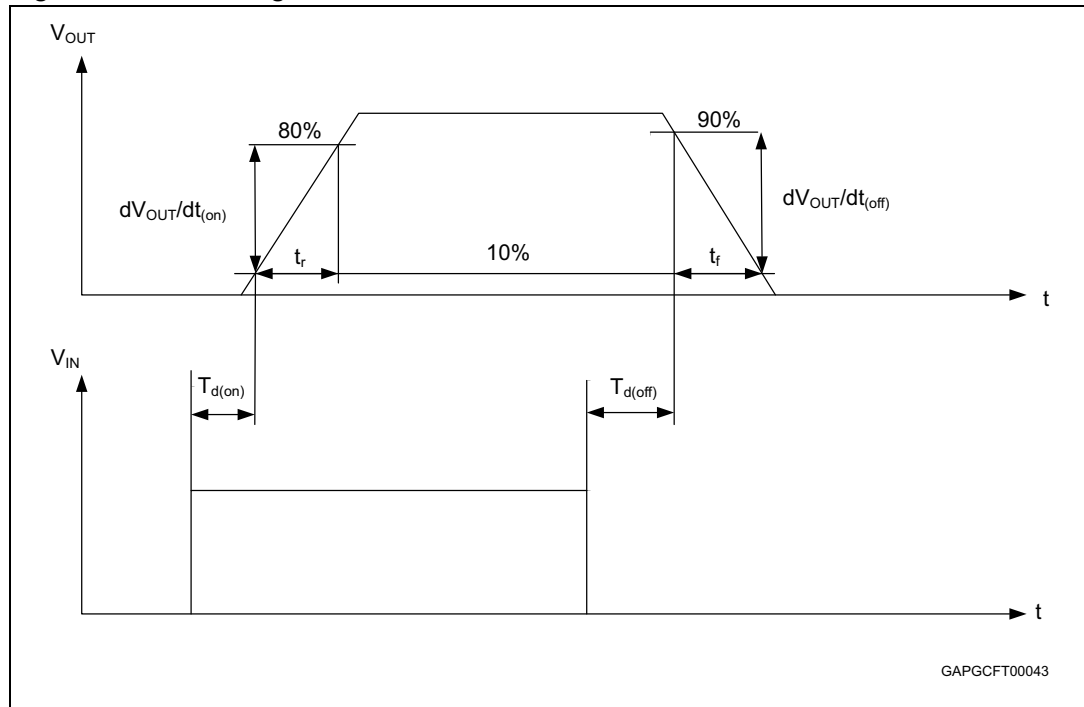


Table 11. Truth table

| Conditions         | Input | Output | Status                |
|--------------------|-------|--------|-----------------------|
| Normal operation   | L     | L      | H                     |
|                    | H     | H      | H                     |
| Current limitation | L     | L      | H                     |
|                    | H     | X      | ( $T_j < T_{TSD}$ ) H |
|                    | H     | X      | ( $T_j > T_{TSD}$ ) L |
| Over temperature   | L     | L      | H                     |
|                    | H     | L      | L                     |
| Undervoltage       | L     | L      | X                     |
|                    | H     | L      | X                     |
| Overvoltage        | L     | L      | H                     |
|                    | H     | L      | H                     |

Figure 5. Switching time waveforms



**Table 12. Electrical transient requirements on  $V_{CC}$  pin (part 1/3)**

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

**Table 13. Electrical transient requirements on  $V_{CC}$  pin (part 2/3)**

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

**Table 14. Electrical transient requirements on  $V_{CC}$  pin (part 3/3)**

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

Figure 6. Peak short circuit current test circuit

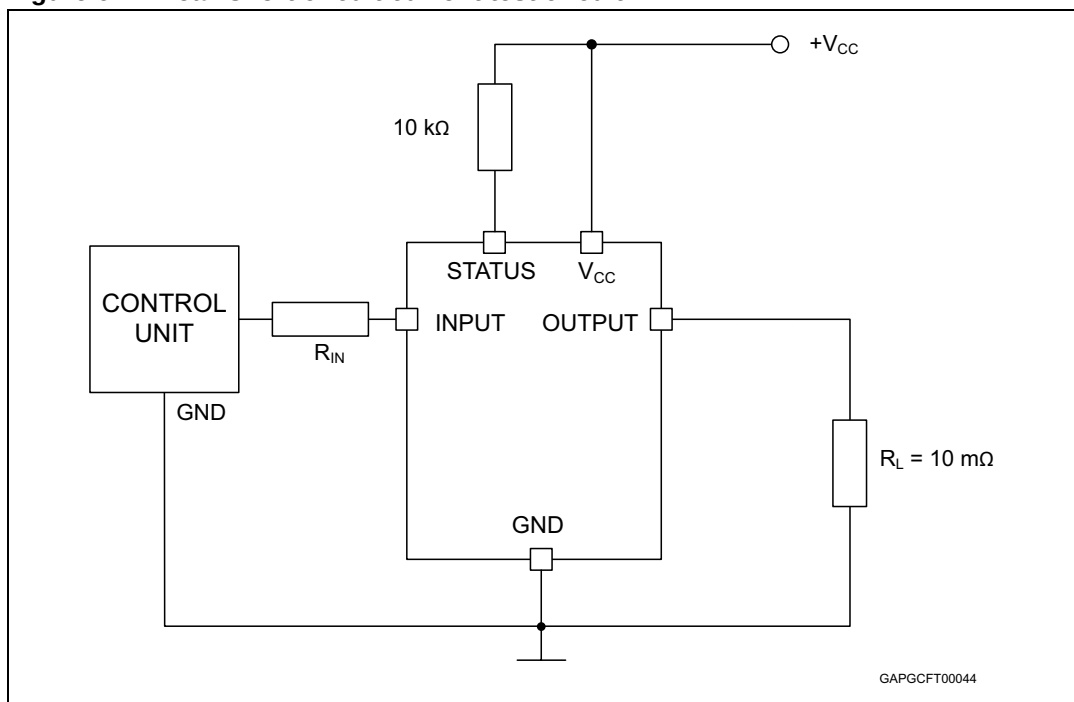


Figure 7. Avalanche energy test circuit

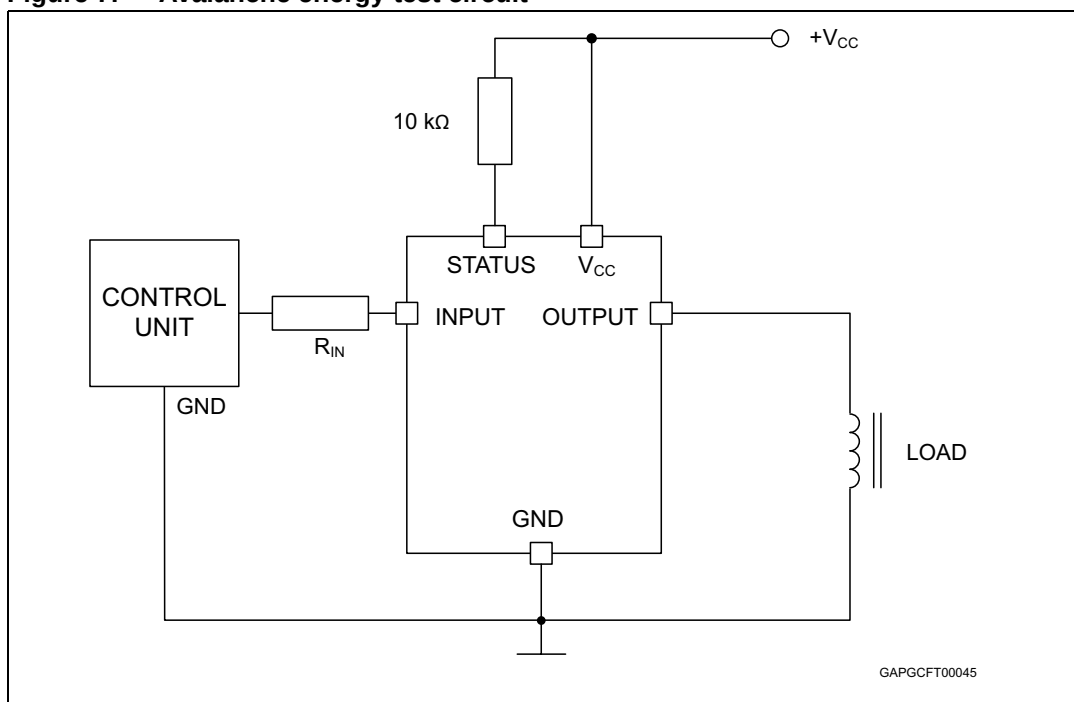
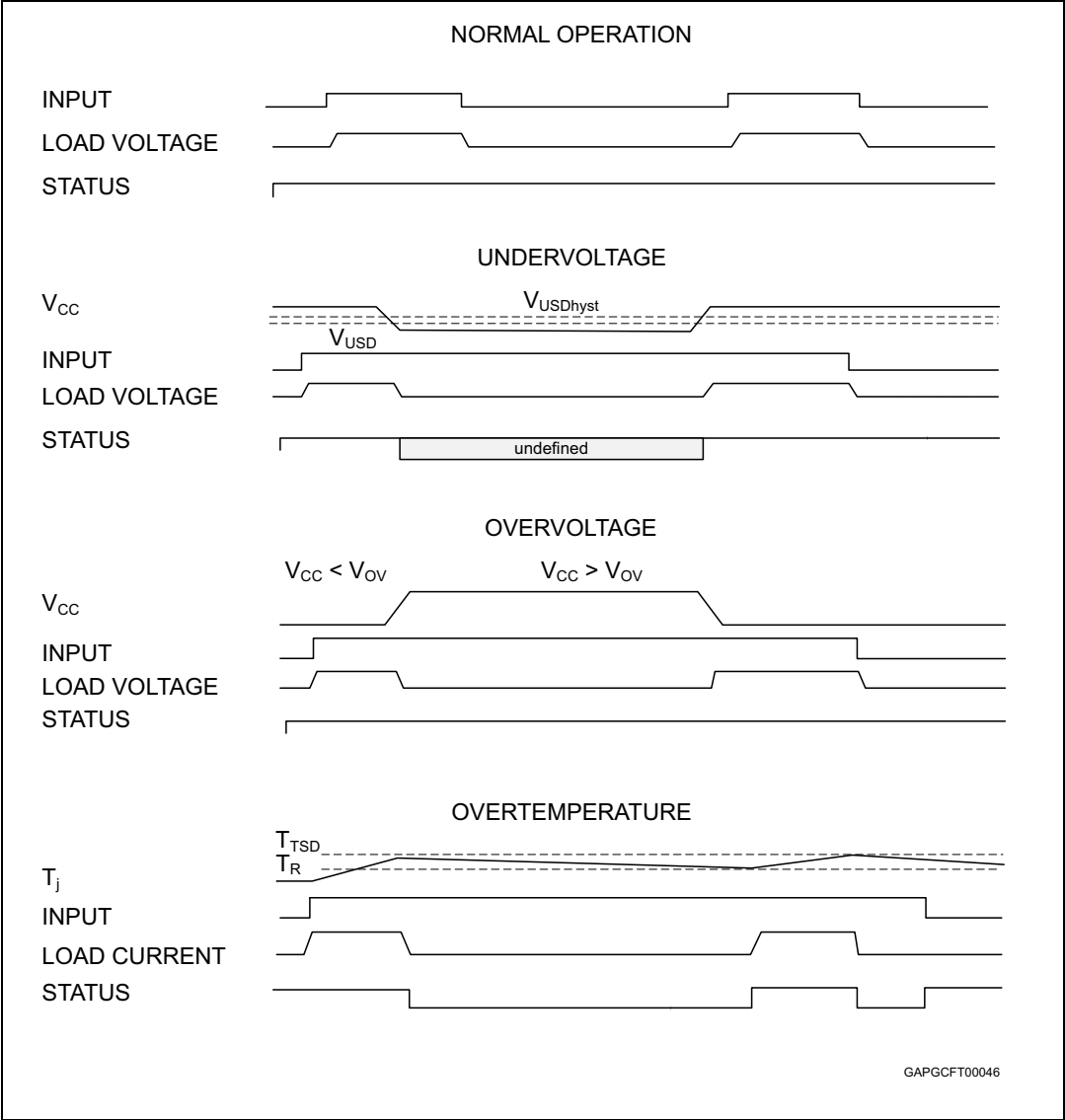
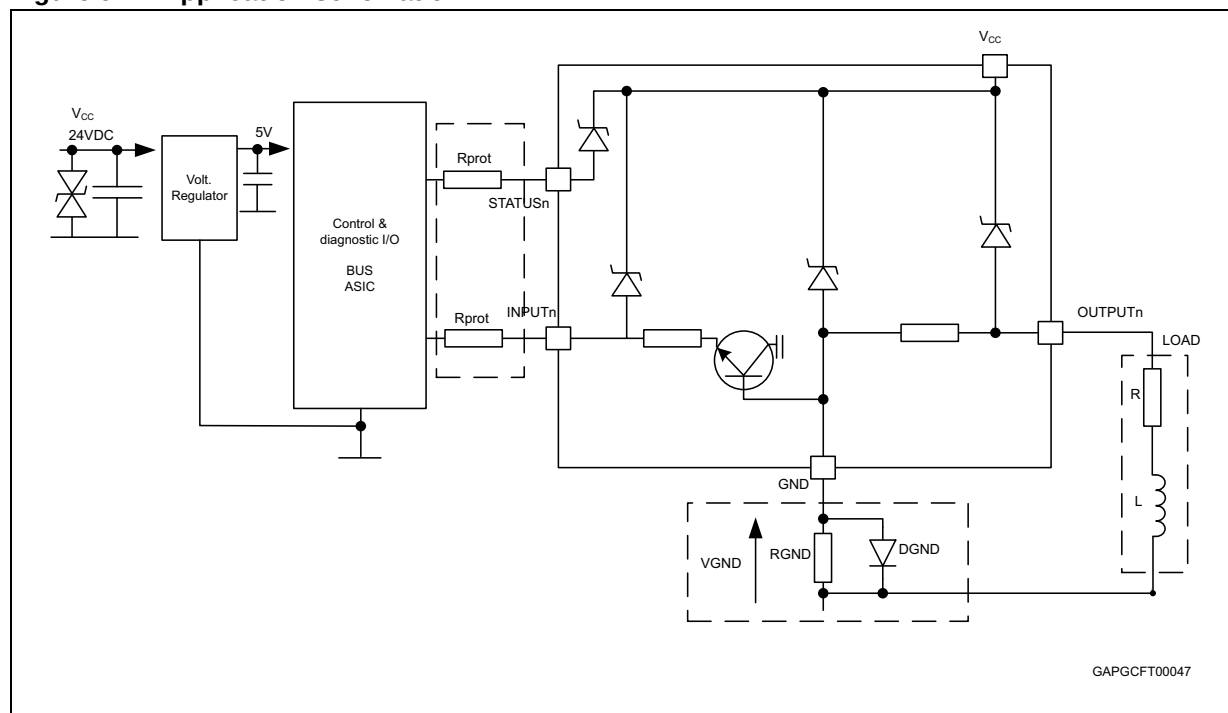


Figure 8. Waveforms



### 3 Application information

Figure 9. Application schematic



#### 3.1 GND protection network against reverse battery

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

This can be used with any type of load.

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

$$1) R_{GND} \leq 600 \text{ mV} / (I_{S(on)max})$$

$$2) R_{GND} \geq (-V_{CC}) / (-I_{GND})$$

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

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

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

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

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

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

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

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

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

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

Safest configuration for unused input and status pin is to leave them unconnected.

## 3.2 Microcontroller I/Os protection

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

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

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

Calculation example:

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

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

Recommended  $R_{prot}$  value is  $10\text{ k}\Omega$ .

3.3 Electrical characteristics curves

Figure 10. Off-state output current

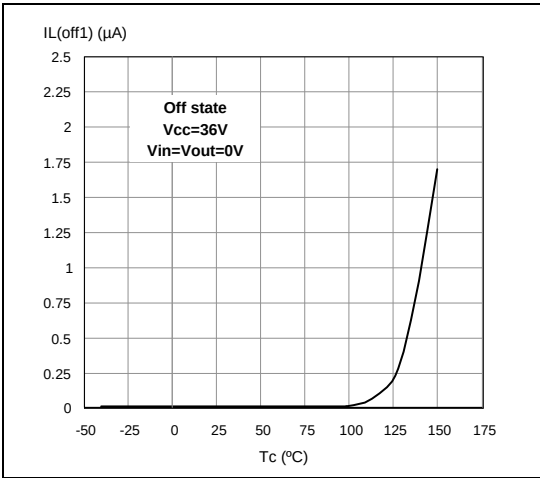


Figure 11. High level input current

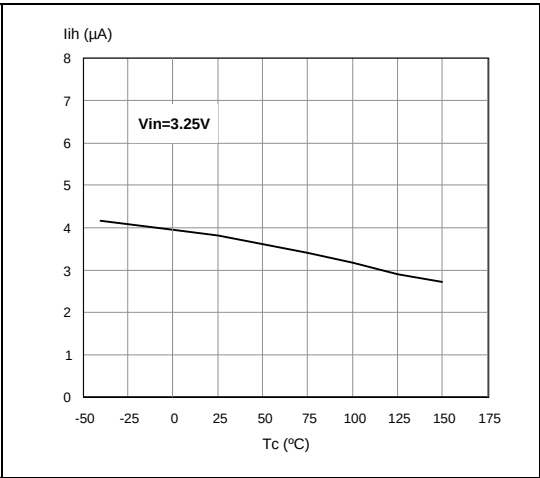


Figure 12. Status leakage current

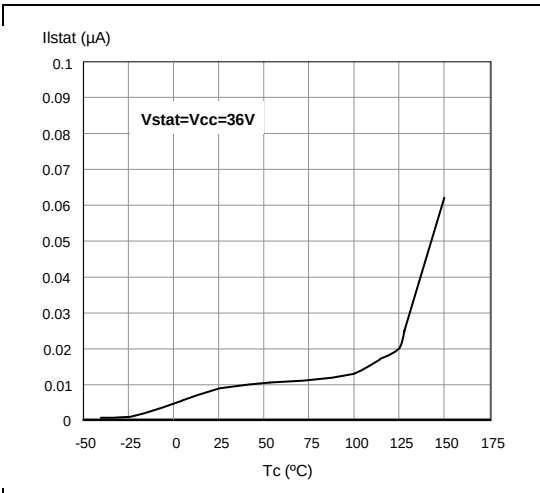


Figure 13. On-state resistance vs  $T_{case}$

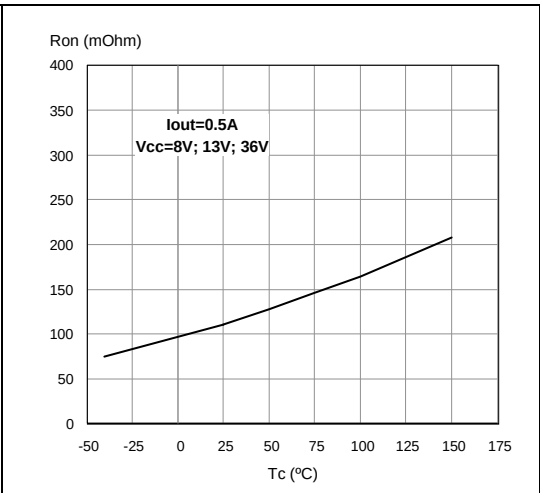


Figure 14. On-state resistance vs  $V_{CC}$

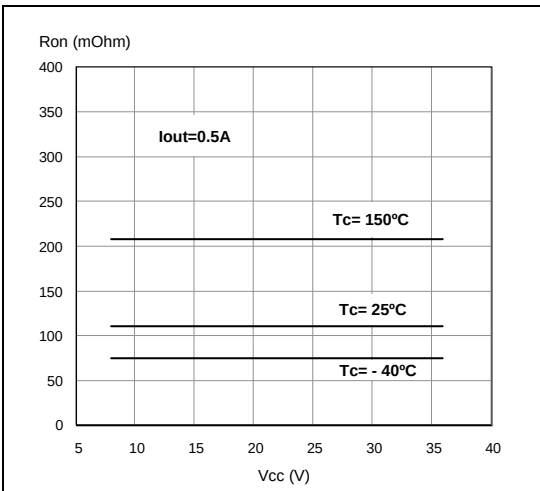


Figure 15. Input high level

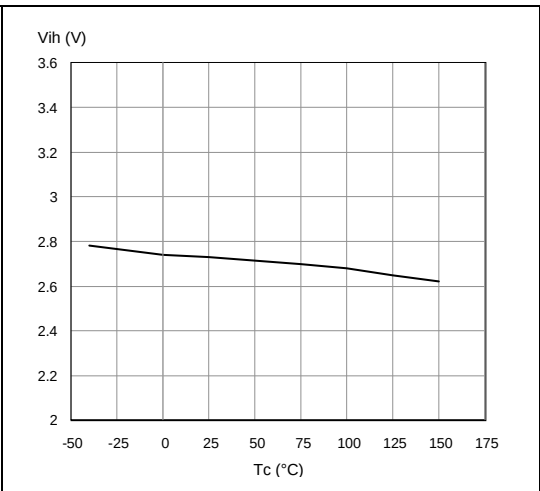




Figure 16. Input low level

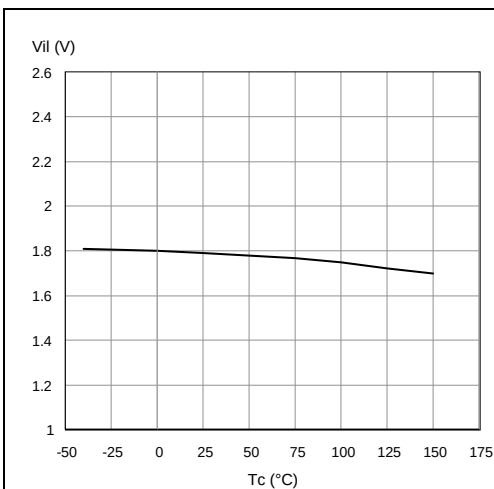


Figure 17. Turn-on voltage slope

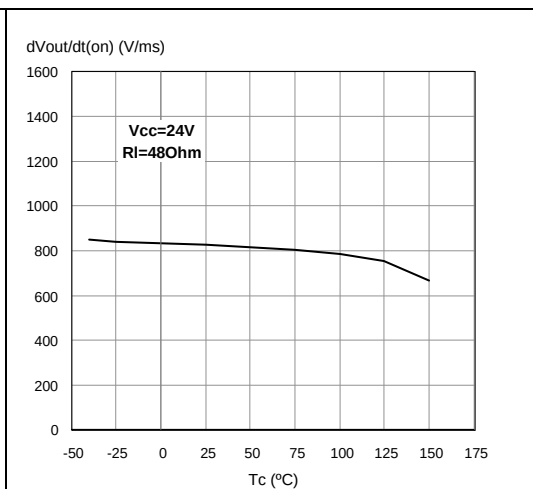


Figure 18. Overvoltage shutdown

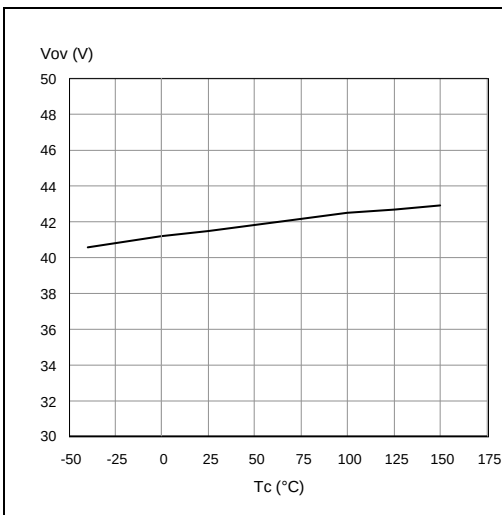


Figure 19. Input hysteresis voltage

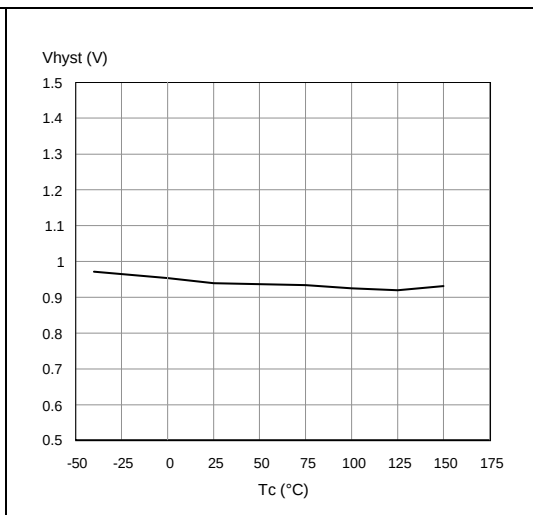
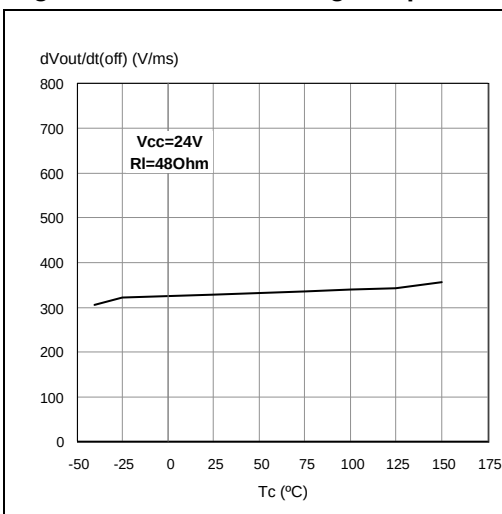
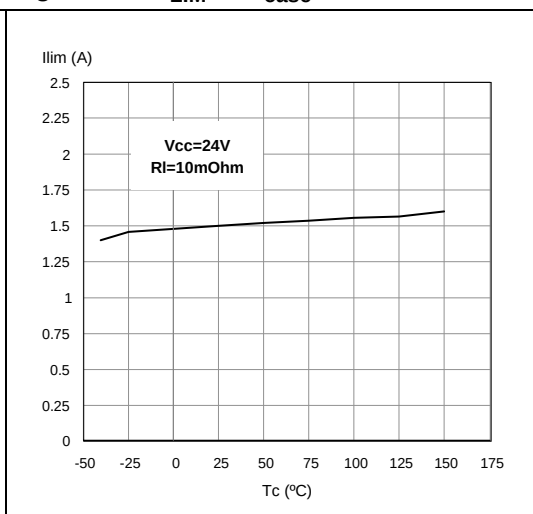
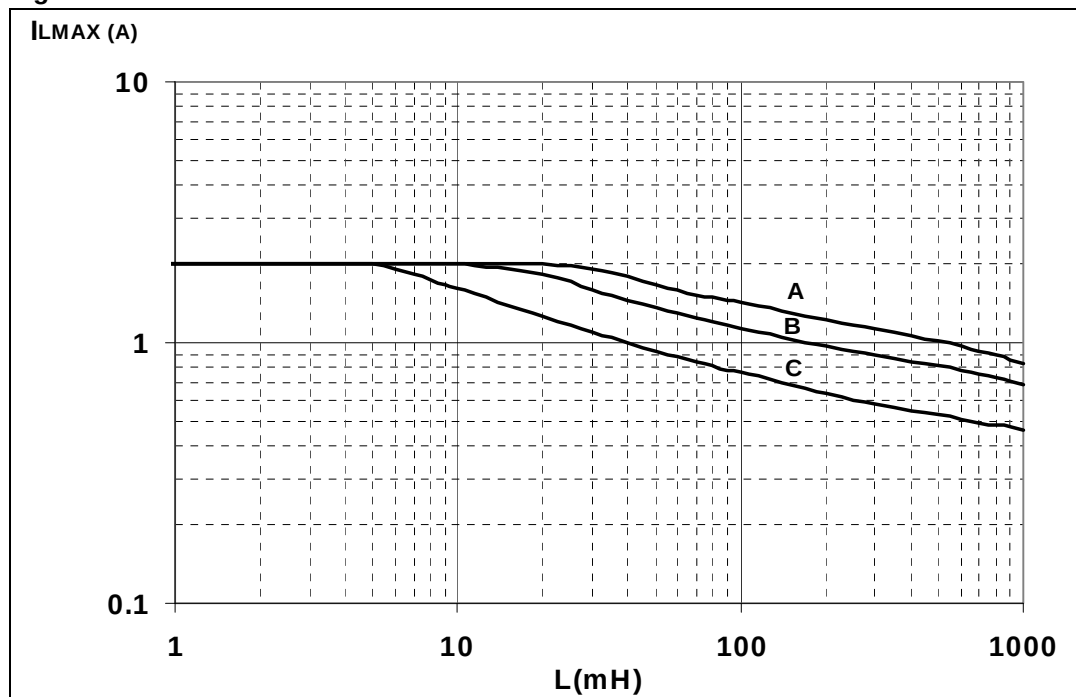


Figure 20. Turn-off voltage slope

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

### 3.4 SO-8 maximum demagnetization energy

Figure 22. SO-8 maximum turn off current versus load inductance



Note:

Legend

A = Single pulse at  $T_{Jstart} = 150\text{ }^{\circ}\text{C}$

B = Repetitive pulse at  $T_{Jstart} = 100\text{ }^{\circ}\text{C}$

C = Repetitive Pulse at  $T_{Jstart} = 125\text{ }^{\circ}\text{C}$

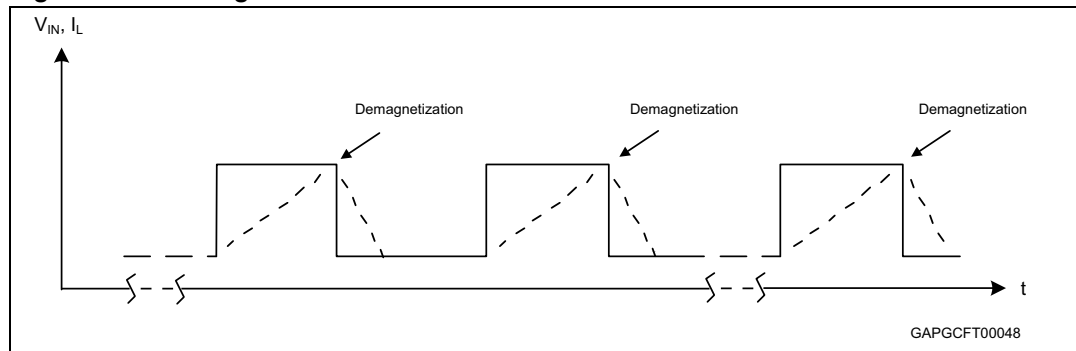
Conditions:

$V_{CC} = 13.5\text{ V}$

Values are generated with  $R_L = 0\text{ }\Omega$

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

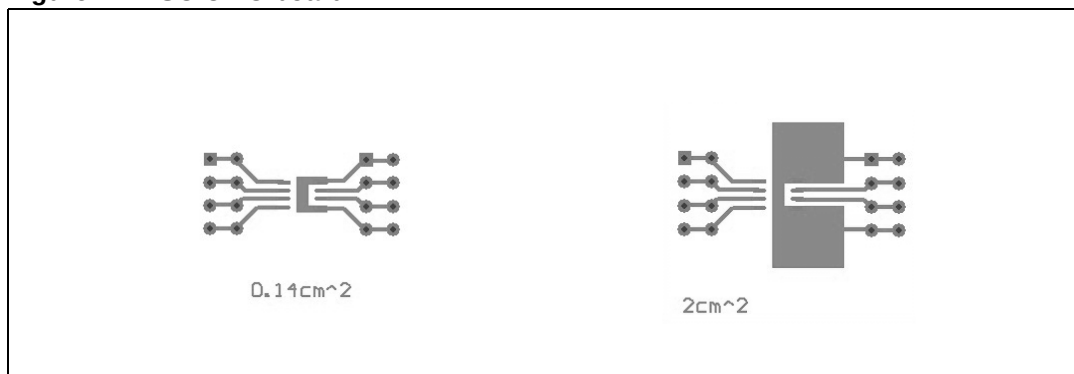
Figure 23. Demagnetization



## 4 Package and PCB thermal data

### 4.1 SO-8 thermal data

Figure 24. SO-8 PC board<sup>(1)</sup>



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 58 mm x 58 mm, PCB thickness = 2 mm, Cu thickness = 35  $\mu$ m, Copper areas: 0.14 cm<sup>2</sup>, 2 cm<sup>2</sup>).

Figure 25. SO-8  $R_{thj-amb}$  vs PCB copper area in open box free air condition

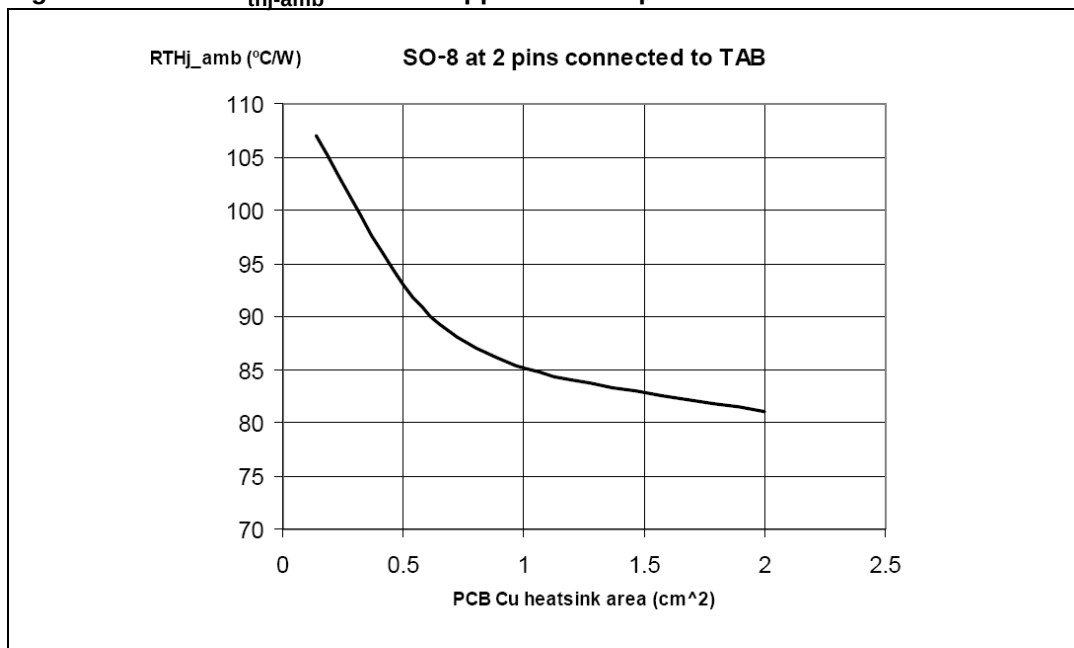


Figure 26. SO-8 thermal impedance junction ambient single pulse

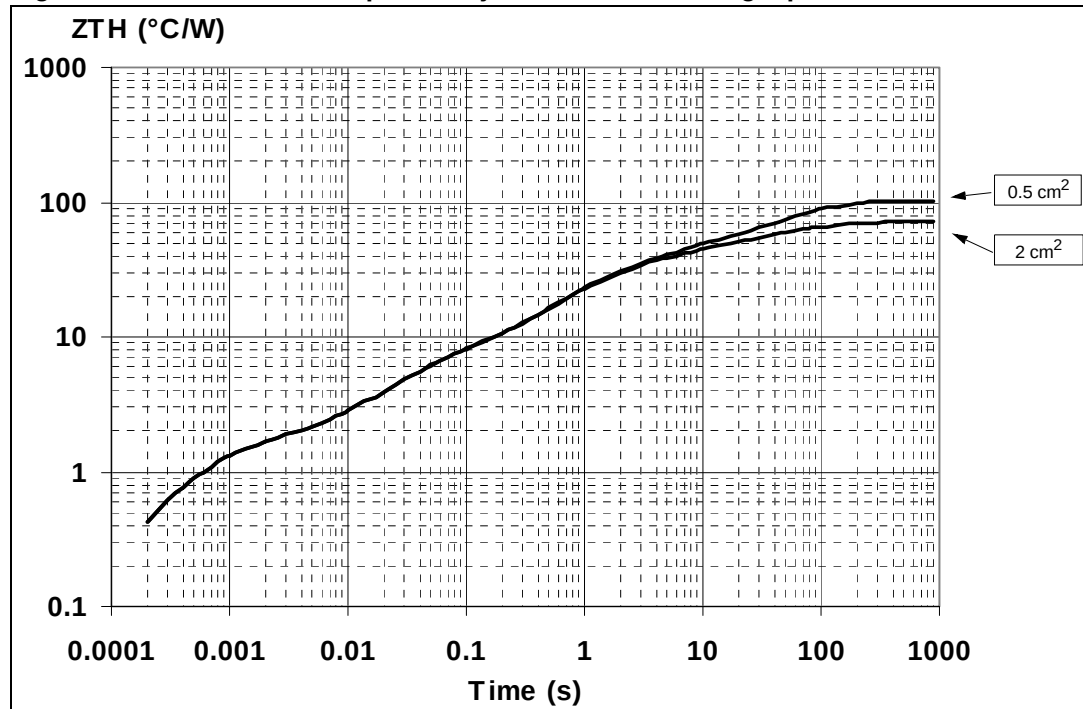
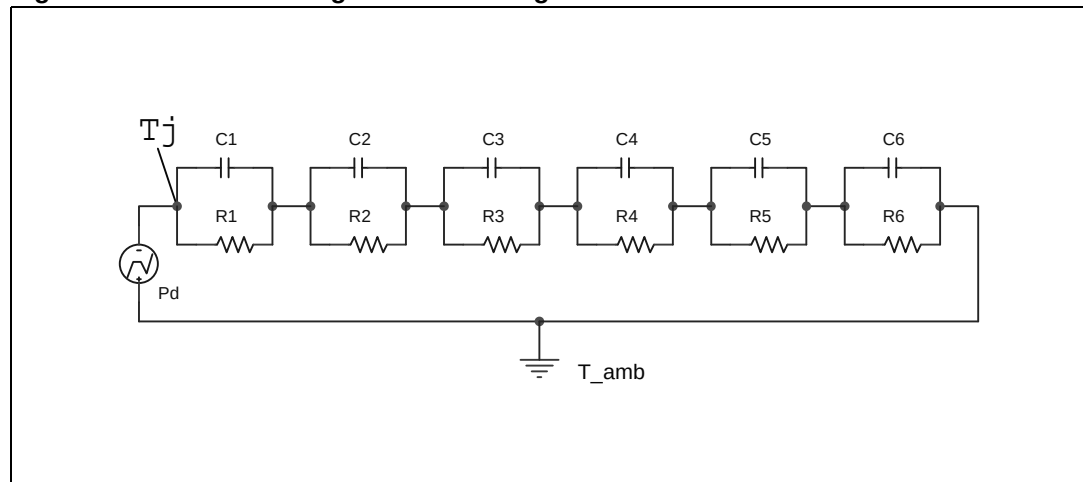


Figure 27. Thermal fitting model of a single channel HSD in SO-8

**Equation 1 Pulse calculation formula**

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

where

$$\delta = t_p/T$$

Table 15. Thermal parameter

| Area/island (cm <sup>2</sup> ) | 0.14     | 2  |
|--------------------------------|----------|----|
| R1 (°C/W)                      | 0.24     |    |
| R2 (°C/W)                      | 1.2      |    |
| R3 (°C/W)                      | 4.5      |    |
| R4 (°C/W)                      | 21       |    |
| R5 (°C/W)                      | 16       |    |
| R6 (°C/W)                      | 58       | 28 |
| C1 (W.s/°C)                    | 0.00015  |    |
| C2 (W.s/°C)                    | 0.0005   |    |
| C3 (W.s/°C)                    | 7.50E-03 |    |
| C4 (W.s/°C)                    | 0.045    |    |
| C5 (W.s/°C)                    | 0.35     |    |
| C6 (W.s/°C)                    | 1.05     | 2  |

## 5 Package and packing information

### 5.1 ECOPACK®

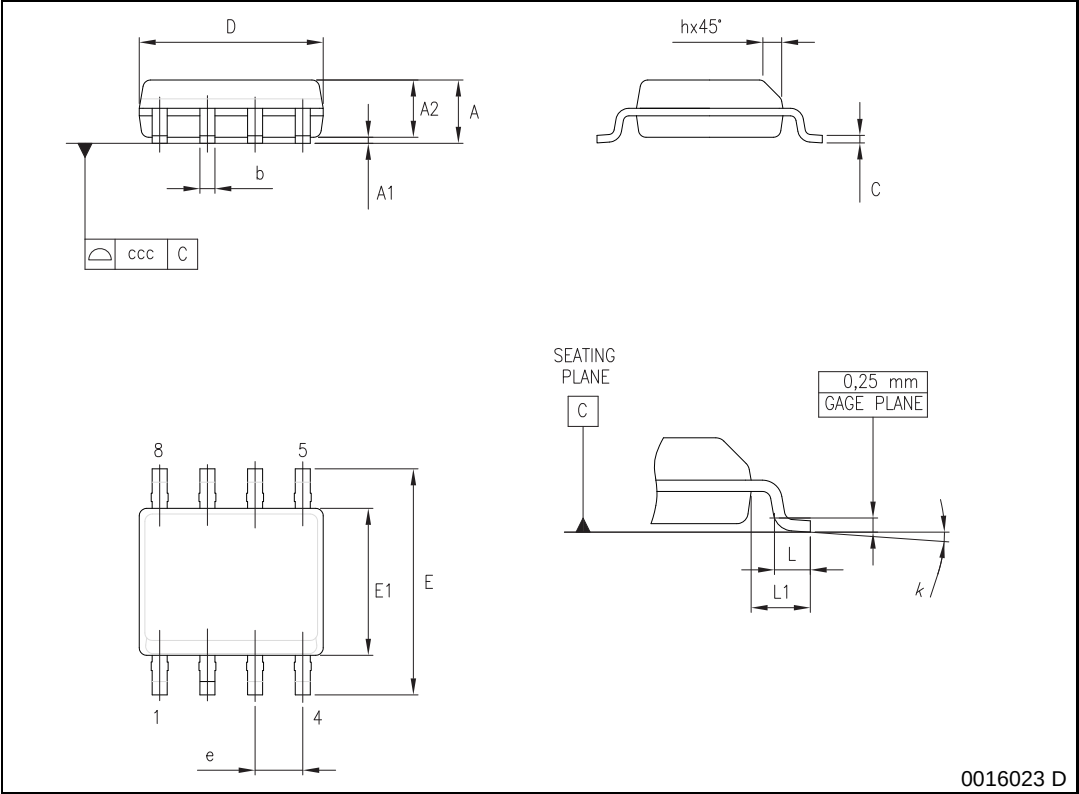
In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 5.2 SO-8 package information

Table 16. SO-8 mechanical data

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    |      |      | 1.75 |
| a1   | 0.1  |      | 0.25 |
| a2   |      |      | 1.65 |
| a3   | 0.65 |      | 0.85 |
| b    | 0.35 |      | 0.48 |
| b1   | 0.19 |      | 0.25 |
| C    | 0.25 |      | 0.5  |
| c1   |      | 45   |      |
| D    | 4.8  |      | 5    |
| E    | 5.8  |      | 6.2  |
| e    |      | 1.27 |      |
| e3   |      | 3.81 |      |
| F    | 3.8  |      | 4    |
| L    | 0.4  |      | 1.27 |
| M    |      |      | 0.6  |
| S    |      |      | 8    |
| L1   | 0.8  |      | 1.2  |

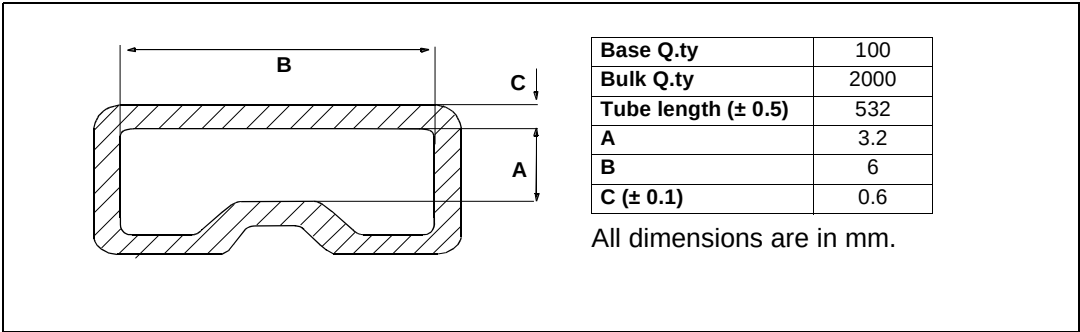
Figure 28. SO-8 package dimensions



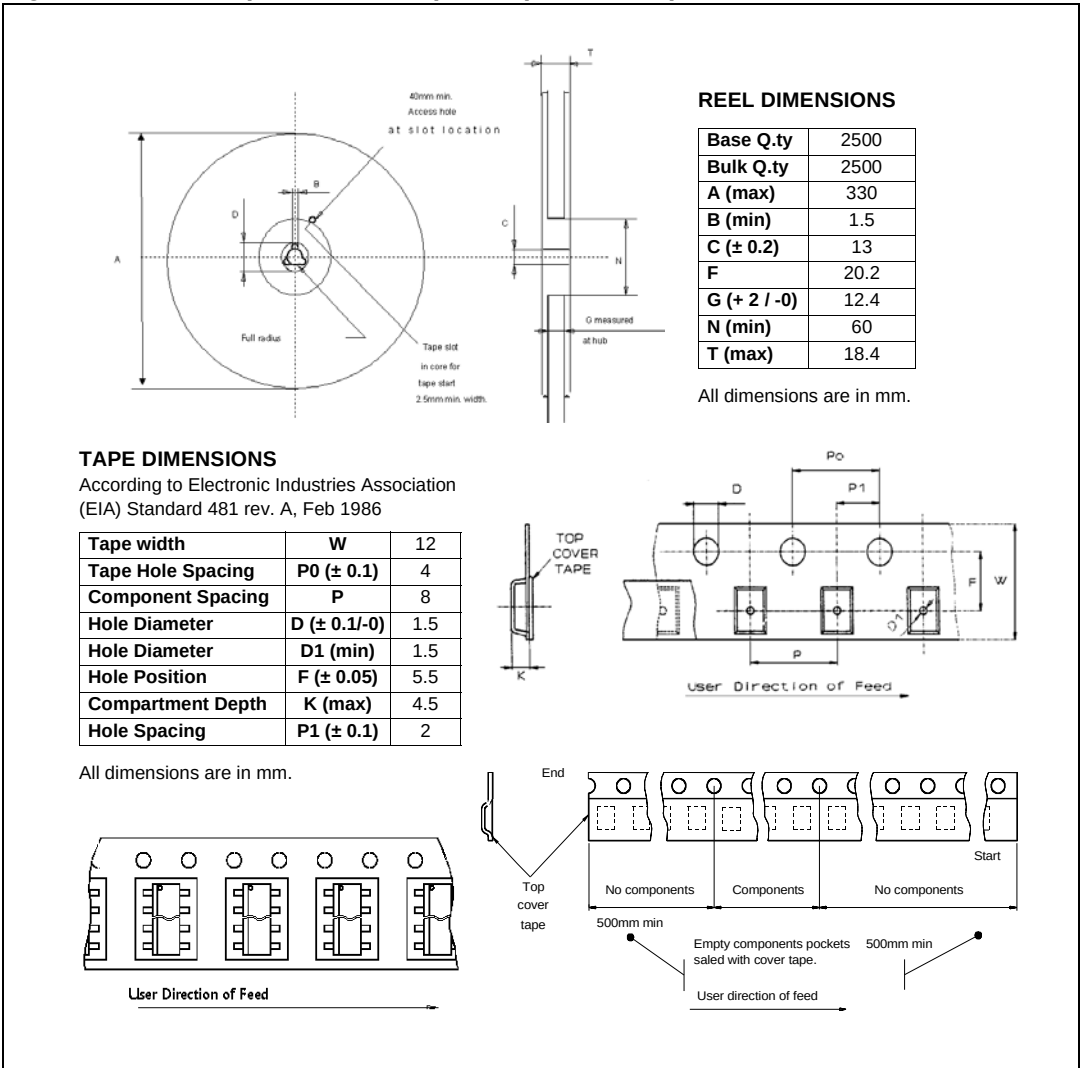
### 5.3 SO-8 packing information

The devices can be packed in tube or tape and reel shipments (see the [Device summary on page 1](#)).

**Figure 29. SO-8 tube shipment (no suffix)**



**Figure 30. SO-8 tape and reel shipment (suffix "TR")**





## 6 Revision history

**Table 17. Document revision history**

| Date        | Revision | Changes                                                                                                                                                            |
|-------------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 21-Apr-2009 | 1        | Initial release                                                                                                                                                    |
| 31-May-2010 | 2        | Updated <a href="#">Features</a> list.<br>Updated <a href="#">Table 3: Absolute maximum ratings</a> .<br>Reformatted entire document.                              |
| 07-Feb-2011 | 3        | Updated <a href="#">Features</a> list.<br>Updated following tables:<br>– <a href="#">Table 4: Thermal data</a><br>– <a href="#">Table 16: SO-8 mechanical data</a> |
| 18-Sep-2013 | 4        | Updated Disclaimer.                                                                                                                                                |

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